A-SERIES TIER 4 TECHNICAL MANUALS

Operations, Maintenance, Schematics, Parts, Safety

OPERATIONS/ MAINTENANCE

- Introduction
- Warranty
- Safety
- Operation
- Main Controls
- Priming
- Pumping
- Clean-up
- Maintenance
- Check-List

SCHEMATICS/ PARTS LISTS

- Pumping Train Group
- Power Train Group
- Electrical Group
- Controls
- Frame Installation
- Available Options

SAFTEY MANUAL

AMERICAN CONCRETE PUMPING ASSOCIATION

- Introduction
- General Safety Rules
- Appendix

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INTRODUCTION

This manual introduces the warranty policy, safe operation, safe maintenance, parts, and other aspects of the concrete pump.

Reading and understanding this operation manual will help maximize performance and reliability, and help minimize dangers, improper operation, and repair costs. Contact REED Customer Service for additional replacement manuals.

All safety guidelines, product descriptions, illustrations, and specifications found throughout this manual were in effect at the time the manual was released for printing. It should be noted; REED RESERVES THE RIGHT TO MAKE CHANGES IN DESIGN OR TO MAKE ADDITIONS TO OR IMPROVEMENTS IN THE PRODUCT WITHOUT IMPOSING ANY OBLIGATIONS UPON ITSELF TO INSTALL THEM ON PRODUCTS PREVIOUSLY MANUFACTURED.

Everyone involved with the operation, maintenance, inspection, and repair of the concrete pump MUST READ and UNDERSTANDS this manual and the accompanying Safety Manual.

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WARRANTY

REED warrants each new A, B, and C Series Concrete Pump to be free of defects in material and workmanship under normal use and service for a period as follows:

A Series Pumps
- 1 year or 1200 pumping hours whichever occurs first

B and C Series Pumps
- "Hitch to Hopper" for 1 year or 1200 pumping hours, whichever occurs first
- All Structural Parts for 3 years

The warranty is issued **ONLY** to the **INITIAL USER**. The warranty period begins when the product is delivered to the initial user or when first put into service, whichever occurs first. Said warranty is void if the machine is subject to misuse, neglect, accident, and/or abuse.

REED's obligation under this warranty is limited to correcting without charge, at its factory, any parts or parts thereof which shall be returned to its factory, transportation prepaid and upon ***REED***'s examination proves to have been originally defective. Correction of such defects by repair or replacement shall constitute fulfillment of all obligations to the initial user. This warranty does not include labor or transportation charges unless specifically identified and authorized in writing by ***REED***. Nor does the warranty apply to any unit upon which repairs, or unauthorized alterations have been made.

This warranty does not apply to normal maintenance service or to normal replacement of certain machine parts which are subject to normal wear (such as concrete cylinders and wear components, valve mechanisms, delivery systems, hopper grate, etc.) ***REED*** makes no warranty in respect to trade accessories or outside vendor components, such being subject to the warranties of their respective manufacturers.

THIS IS A LIMITED WARRANTY AND IS IN LIEU OF ANY OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OF FITNESS FOR A PARTICULAR PURPOSE. In no event shall ***REED*** be made liable for incidental, general or consequential damage, loss or any expense directly or indirectly related and resulting from use or lack of use caused by delay in delivery, parts failure, or any other causes associated with the product use. No person, firm or corporation is authorized to assume for ***REED*** any other liability in connection with the sale of ***REED*** products.

Effective April 2010

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WARRANTY CLAIM FORM

Claim Number:	Date:
Distributor Account Number:	End User Account Number:
Distributor:	End User:
Address:	Address:
City: State: Zip:	City: State: Zip:
Phone ( )	Phone ( )
Pump Model:________________ Pump Serial Number:________________	In Service Date:__________ Hours of Operation:__________ Failure Date:__________ Repair Date:__________

Do not send part(s) until requested by ***REED*** or until claim is approved. All parts requested to be returned must have a Return Authorization Number provided by ***REED*** and shipping freight prepaid. Parts must ship within 30 days from ***REED*** request.
Return Authorization Number: Ship Date:

Part Number	Description	Qnty	Unit Price	Total Price	Replacement Part Invoice No.

Failure Description and Cause: ____

____

____

____

REED Comments:____

____

____

____

Claim Value Approved:$______________ Claim Value Denied:$______________
REED Print Name, Sign, and Date:____

Dealer Print Name, Sign, and Date:____

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SAFETY

Everyone involved with the operation, maintenance, inspection, and repair of the concrete pump MUST READ and UNDERSTANDS this manual and the accompanying Safety Manual.

SAFETY ALERT SYMBOLS AND SIGNAL WORDS

The following safety alert symbols, signals, and explanations are intended to warn the operator of hazardous and potentially hazardous situations.

The triangle with the exclamation points inside is used to alert the operator to an important safety point, and is called a safety alert symbol. One of the following signal words will appear after the safety alert symbol:

If the safety alert symbol is followed by the signal word **DANGER**, the safety alert symbol indicates a hazardous situation which, if not avoided, **WILL** lead to death or serious injury.

If the safety alert symbol is followed by the signal word **WARNING**, the safety alert symbol indicates a potentially hazardous situation which, if not avoided, **COULD** result in death or serious injury.

If the safety alert symbol is followed by the signal word **CAUTION**, the safety alert symbol indicates a potentially hazardous situation which, if not avoided, **COULD** result in minor to moderate injury.

The signal word **CAUTION**, but without safety alert symbol means the safety symbol alert addresses a hazard which, if not avoided, **COULD** cause damage to equipment or property.

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LOCKOUT / TAGOUT

The Lockout/Tagout procedure applies to all ***REED*** concrete placing equipment.
Before performing any maintenance and/or repair on equipment;

1. Unit must be OFF, and the ignition key must be removed from the control panel or dash.

2. Key must be securely stored in toolbox or with operator performing maintenance.

3. Signage must be posted to indicate machine is currently under Lockout/Tagout.

The following symbol is a reminder to Lock Out and Tag Out equipment before working on equipment.

GENERAL SAFETY GUIDELINES

Use Only Qualified, Experienced, and Trained Personnel
Wearing Protective Equipment At All Times

For Safe Use, Maintenance, Inspection, and Repair,
Only Operate, Maintain, Inspect, and Repair
In Accordance with This Operation Manual and the Safety Manual

Performance and Safety Features Must Never Be Altered, Disconnected, or Removed

Contact ***REED*** Technical Support and Service When Assistance Is Required

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SAFETY DECALS

Decals and placement of decals are standardized by the Concrete Pump Manufacturers Association (CPMA) for your protection. They are placed at appropriate areas on the concrete pump to be constant warnings of dangers. Know and adhere to the information they provide. Contact ***REED*** Customer Service for complimentary replacements of safety decals, shipping charges may apply.

DECALS PLACED NEAR CONTROL BOX AREA

⚠ WARNING

Do not operate this machine without training. Understand the warnings in safety manuals and on decals.

⚠ ADVERTENCIA

No use esta maquinaria sin estar capacitado. Entienda las advertencias de los manuales de seguridad y de las calcomanías.

Do not paint over this label/No pintar encima de ésta etiqueta 800925

IMPORTANT	IMPORTANTE
You can order additional operation manuals, spare parts books, safety manuals and decal sets by contacting us at: REED Manufacturing 1-(888)-779-7333 7:00 AM to 5:00 PM Pacific Time Monday through Friday	Usted puede solicitar manuales de operacion, catalogos de refacciones, manuales de seguridad y juegos de calcomanias adicionales contactando a: REED Manufacturing 1-(888)-779-7333 DE 7:00 AM a 5:00 PM Hora Pacifico LUNES A VIERNES

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WARNING
• Stay clear of pressurized concrete placing system.
• Wear eye protection.
• Do not operate at pressures exceeding the rating of any piece of the material delivery system.
ADVERTENCIA
• Permanezca alejado del sistema de distribución de concreto presurizado.
• Use protección para los ojos.
• No opere a presiones mayores que las de la capacidad de cualquier pieza del sistema de descarga.
SAFETY INSTRUCTIONS
1. Relieve system pressure before opening any system or coupling.
2. Regularly inspect system condition and wall thickness.
3. Wear reduces system burst pressure.
4. Use recommended clean out procedures - consult manufacturer.
5. Use retaining pins in delivery system snap couplings.
INSTRUCCIONES DE SEGURIDAD
1. Alivie la presión del sistema ante de abrir un sistema o un acoplamiento.
2. Inspeccione periódicamente el estado del sistema y el espesor de las paredes.
3. El desgaste reduce la presión de rotura por estallido.
4. Use los procedimientos de limpieza recomendados, consulte con el fabricante.
5. Use los pasadores de retención en los acoplamientos de fijación a presión.
803237


ADVERTENCIA WARNING
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DECALS PLACED NEAR HOPPER GRATE AREA

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DECALS PLACED NEAR WATERBOX AREA

DECALS PLACED NEAR OUTRIGGER CONTROL AREA

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DECALS PLACED NEAR HOPPER OUTLET AREA

⚠ WARNING

Do not operate at pressures exceeding the rating of the entire material delivery system.

⚠ ADVERTENCIA

No utilizar a presiones que excedan la presión nominal de todo el material de la linea de entrega.

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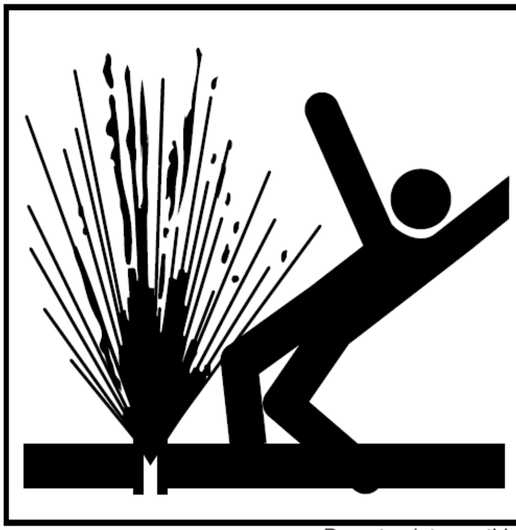

⚠ WARNING

Before opening a blocked pipeline, relieve pressure by reversing pump. See manual.

⚠ ADVERTENCIA

Alivie la presión antes de destapar una tubería bloqueada, invirtiendo para ello la bomba. Vea el manual.

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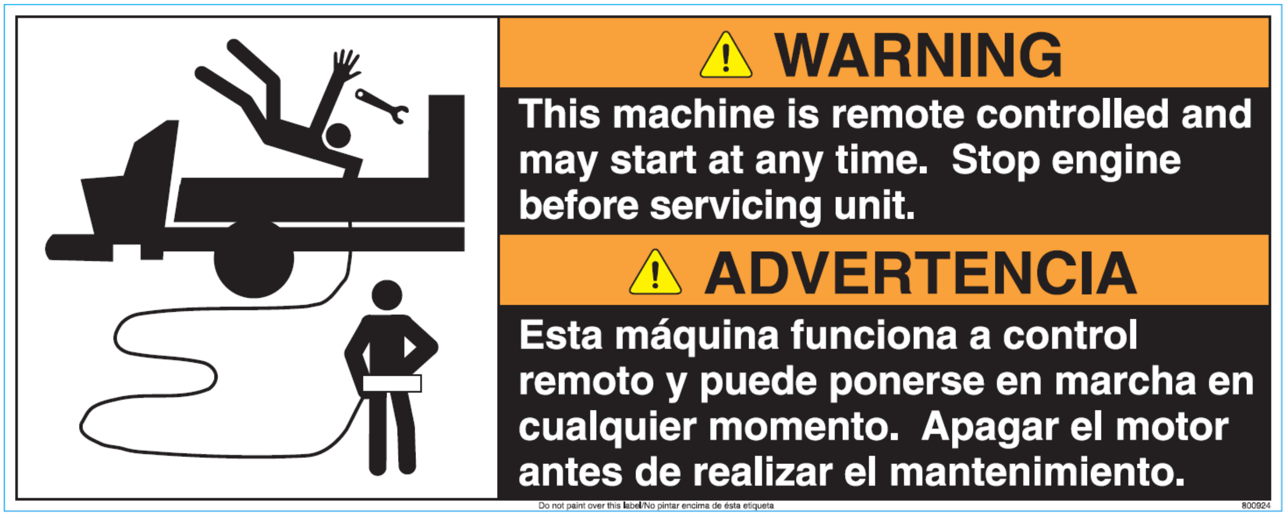
DECALS PLACED ON SIDE PANEL AREA



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Concrete Pump Manufacturers Association

CPMA

Certified

0039 803236

Certified Compliance with
CPMA 27-2000 Safety Standard

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OPERATION

OPERATOR QUALIFICATIONS

Everyone involved with the operation, maintenance, inspection, and repair of the concrete pump MUST READ and UNDERSTANDS this operation manual and the accompanying Safety Manual.

The following are a few general warnings for operator qualifications outlined in the Safety Manual.

⚠ WARNING

- Individuals who cannot read and understand this operation manual, Safety Manual, signs, warnings, notices, and operating instructions, in the language in which they are printed, must not be allowed to operate the concrete pump.

- Only qualified, experienced, and trained personnel may be allowed to operate the concrete pump.

- Operation, maintenance, inspections, and repair must only be made by qualified, experienced, and trained personnel.

- Obey all applicable local and government statutes and regulations applying to safe operation and towing of concrete pumps.

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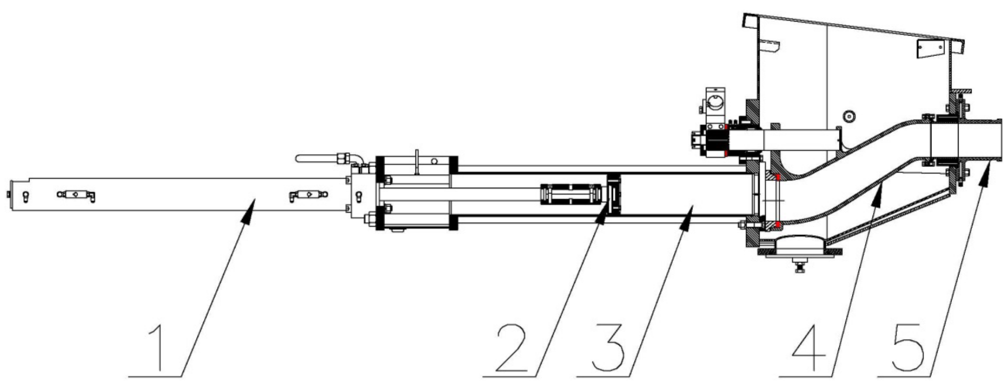
PRODUCT DESCRIPTION

The operation of the concrete pump encompasses the use of hydraulic and electrical systems. The concrete pump is designed to safely pump wet concrete through a delivery system of pipes and hoses within its published ratings and specifications.

Stability of the concrete pump during operation is provided by the outriggers and front jack. Controls for the outriggers are located on the sides of the concrete pump.

The pumping system employs an S-Tube design valve system. This system incorporates material cylinders linked to hydraulic cylinders that cycle alternately. With concrete material in the hopper and the pump operating, a material cylinder retracts, drawing material into the cylinder. At full retraction of the cylinder, a signal is sent to both the S-tube swing cylinder and the drive cylinder directional valves causing the s-tube to shift position to the fully loaded material cylinder and the drive cylinders to change direction. The concrete piston of the loaded cylinder then pushes the material through the s-tube and into the delivery lines. The shifting from one cylinder to the other cylinder takes place providing a continuous flow of material through the delivery piping system. The pump can be operated at the control panel or can be operated from the remote control.



The hydraulic oil flow created by the hydraulic pump pushes the drive cylinder pistons inside the drive cylinders (1) alternately back and forth. Because the drive cylinders and concrete pistons (2) inside the concrete cylinders (3) are linked together, the pistons move synchronously.
When a drive cylinder retracts along with the concrete piston, concrete will be sucked from the hopper into the concrete cylinder. Simultaneously, the other drive cylinder and concrete piston are extended toward the hopper. The concrete piston will push concrete from the concrete cylinders through the S-Tube (4) and out to delivery system (5).
Next, the pump switches at the end of the stroke, causing the s-tube valve to shift to the other concrete cylinder which has sucked and filled the cylinder with concrete, starting the next cycle.
Reverse pumping links the concrete piston in the suction stroke and S-Tube valve to suck concrete from the s-tube instead of the hopper. As a result, the concrete piston pumps concrete into the hopper.

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The power for operation of the concrete pump is provided by the engine, which drives the hydraulic pumps.

All functions for operation of the concrete pump can be accomplished from the local controls mounted on the side of the unit. Optional hand-held cable or radio remotes enable the pump to be operated away from a remote distance.

HYDRAULIC SYSTEM DESCRIPTION

The hydraulic system of the concrete pump consists of three separate circuits and although integrated, each is designed to perform a particular function within the operation of the concrete pump. The three circuits utilized are:

- Main Pump Circuit

Controls operation of the hydraulic drive cylinders.

- S-Tube Shift Circuit

Controls operation of shifting the s-tube from one material cylinder to the other.

- Auxiliary Circuit

Controls the operation of the agitator and other auxiliary equipment.

For the purpose of making the operation of each circuit easier to understand, they are being described separately.

MAIN PUMP CIRCUIT

The main hydraulic pump is a variable displacement axial piston pump of swashplate design. The pistons run along the swashplate which is capable of being tilted. This tilting changes the angle of the swashplate and thus the stroke length of the pistons, which in turn varies the displacement of fluid. The larger the angle of the swashplate, the greater the flow. The angle of the swashplate is varied by the volume control that works in conjunction with the load sense feature of this pump.

The main hydraulic pump is driven directly by the engine or electric motor. When the engine is running, PUMP switch in the OFF position and the VOLUME control minimized, there is no demand placed on the pump. This is referred to as the pump being de-stroked, meaning, it is only producing a minimal amount of flow to enable the lubrication of the pump. This lubrication exists regardless of whether the engine is at idle or maximum RPM.

The main pump circuit is equipped with a manifold that is drilled and ported to accommodate the relief valve, check valve, flow control and the pilot operated directional valve. The cycle valve is a directional spool valve with electrohydraulic solenoid operation. Its purpose is to direct the flow of oil from the main hydraulic pump to one or the other

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hydraulic drive cylinders.

To energize the pump circuit, use the adjustable throttle control to set the engine speed at maximum RPM. Open the VOLUME control to any range from 0 to FULL. In so doing, the load sense is alerted to the demand and places the pump on stroke. The pump will now produce the flow in proportion to the amount by which the volume control has been opened. Since the PUMP switch is OFF, the flow from the hydraulic pump is fed to the main directional valve, thru the valve, and then returns to the hydraulic tank.

To energize the cycling circuit, the PUMP switch must be ON. When this is done, an electrical signal is generated which in turn energizes the coils of the main directional pilot valve and also activates the S-Tube directional valve.

The material pumping action is the result of the two material cylinders cycling on an alternate basis. This alternating cycling is controlled by an electrical signal that is generated by the proximity sensors located in the flush box at the end of each material cylinder’s suction or retraction stroke.

As the piston coupler passes under the proximity sensor, it generates an electrical input signal that is sent to the logic controller, designed to control the alternating action of the material cylinders and to synchronize the movement of the s-tube. The output signal from the logic controller is used to energize the coils of the main directional pilot valve as well as that of the s-tube directional valve.

As protection to the main pump circuit against excessive pressure, a relief valve has been installed and set. Thus, when the system pressure reaches the maximum factory settings, the relief valve opens directing the oil back to the tank.

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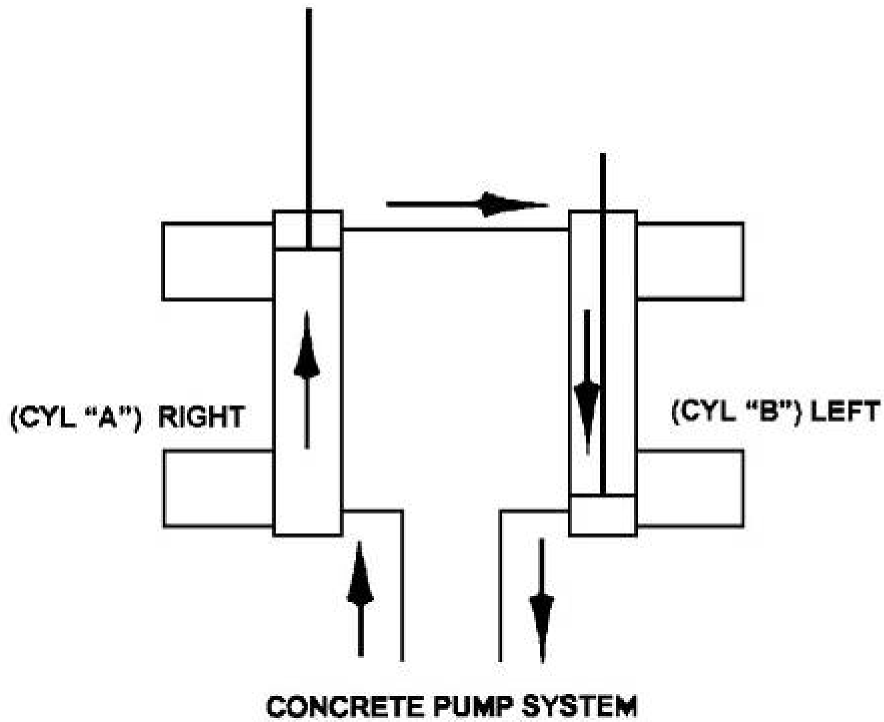
MAIN PUMP CIRCUIT OPERATIONAL SEQUENCE

It can be noted in the schematic and the diagram below that the main pressure and flow is only directed to one side of the hydraulic drive cylinder. In this instance, it is directed to the head side or piston side of the double acting drive cylinder.



The hydraulic drive cylinders are identical. Because only one cylinder is pressurized at a time, a means is required to assist in the retraction of the opposite cylinder. This is accomplished by connecting the rod sides of the cylinders together, forming a slave loop. In so doing, the hydraulic fluid that exists in the rod side of the extending cylinder (CYL "A") is transferred to the rod side of the other cylinder (CYL "B") causing it to retract simultaneously. The oil in the head side of CYL "B" is then forced out as it retracts and free flows through the directional valve back to the hydraulic tank or system.

With this arrangement of connecting the two cylinders together, it is possible for various reasons, such as leakage around the piston seals, that more oil exists on the rod side of the cylinder than is required. When this condition exists, some hydraulic oil remains at the rod end of the cylinder being extended while the other cylinder is fully retracted. As a result, the cylinder will not completely extend and thus short strokes, which will also happen to the other cylinder on the next cycle.

This condition can be corrected by actuating and holding the STROKE CHANGE switch on the electrical control box until extending cylinder is fully extended. Hydraulically, this is accomplished by use of the check valves installed on both cylinders. By holding the STROKE CHANGE switch, you have interrupted the cycle and are forcing more oil into the head side of the extending cylinder. Since that cavity is full, pressure is built up in the rod side of the fully retracted cylinder, which unseats the head-side check valve and forces the excess oil out of the slave loop and back to the tank. Once the extending cylinder has reached its full stroke, regular operation can continue.

Short stroking can also occur from incorrect proximity sensor location or leaking check valves.

S-TUBE CIRCUIT

Since there is only one outlet for the pumping material, a means is required to transfer the material from the material cylinder to the outlet and into the delivery line. To accomplish this, an s-tube is installed in the hopper. Since there are two material cylinders and one s-tube, the s-tube must be shifted from one material cylinder to the other, whichever one is loaded with the pumping material.

The s-tube shift hydraulic circuit is of the open center type, meaning that when the control valves are in the neutral position, the internal passages of the valves are open, allowing the hydraulic fluid to return to the tank. With the engine running the hydraulic pump is operating, producing a flow of oil which, with no control energized, will pass through the shift circuit on its way back to tank.

To meet the flow and pressure requirements of the shift circuit, one section of a tandem pump is used. Note: a single pump may be used if unit is not required for auxiliary equipment. The tandem hydraulic pump is of the gear pump design with a fixed displacement, meaning it is designed to constantly produce the same displacement at a pre-set maximum, depending on engine rpm. The tandem gear pump is directly connected to and driven through the main hydraulic pump. In addition to the hydraulic pump, the s-tube shift circuit consists of a manifold, an accumulator, solenoid valve cartridges, a solenoid directional valve, and 1 or 2 hydraulic shift cylinders. The following is offered to describe the function of each in the system.

S-TUBE CIRCUIT MANIFOLD

Like the main hydraulic circuit, the shift circuit is also equipped with a manifold block. It contains an unloader cartridge, relief cartridge and solenoid valve cartridges. A solenoid operated directional valve is mounted on top of the block and an s-tube selector control valve is located on front of the block. Each of these components is designed to perform a function in the swing circuit as explained in the following descriptions:

- RELIEF CARTRIDGE

  This cartridge is used to divert the pump flow from going to the accumulator once its capacity has been reached, directing it back to tank. It becomes operational when the unloader cartridge setting has been reached, acting as a dump valve.

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- UNLOADER CARTRIDGE

This pressure sensitive cartridge is used to protect the system from excessive pressure and to limit the amount of pressure being applied to the accumulator by hydraulically signaling the relief cartridge to open once the unloader setting has been reached. The unloader will also redirect the oil back to the accumulator when it senses a drop-in system pressure, when the hydraulic cylinder shifts for example.

- SOLENOID VALVE CARTRIDGE

There are two (2) of these cartridges used in the circuit. Both, which may be referred to as a dump valve, are designed into the circuit as SAFETY VALVES. Their purpose is to automatically relieve pressure from the shift circuit as commanded by the emergency stop circuit. At start up, the normally open cartridges are open to tank so the shift circuit cannot build any pressure. When the emergency stop circuit is reset, an electrical signal is generated which energizes the solenoids, closing the cartridges and allowing the shift circuit to pressurize. When the emergency stop function is activated or the key switch turned off, the power is taken away from solenoids, causing the cartridges to open and dump shift circuit pressure back to tank.

- SOLENOID DIRECTIONAL VALVE

This valve is a directional control valve that is shifted by electronically activated solenoids. Its purpose is to direct the flow of oil stored in the accumulator to one or the other end of the shift cylinder based on the signal received by the logic controller that was generated by the proximity sensor.

- ACCUMULATOR

The accumulator is incorporated into the shift circuit to provide instant pressure and volume for the shifting of the s-tube, which cannot be obtained under normal circumstances. An accumulator is a hydraulic reservoir that retains the hydraulic fluid under high pressure.
The accumulator contains a rubber bladder on the inside of the reservoir. The bladder is pre-charged with dry nitrogen. In the application of the shift circuit, the hydraulic fluid is pumped into the accumulator at a higher pressure than that inside the bladder. This compresses the bladder building up high pressure within the accumulator that is retained until released.

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S-TUBE CIRCUIT OPERATIONAL SEQUENCE

In the operational sequence of the shift circuit with the engine at full RPM, the tandem pump is producing its rated displacement. The flow is going through the system and is being dumped or directed back to the tank thru the solenoid cartridges of the s-tube circuit manifold.

When the HORN/RESET switch is placed to RESET, an electrical signal closes the solenoid cartridges. When this occurs, the hydraulic fluid is now directed to the accumulator where it starts compressing the bladder and building up pressure. When the pressure in the shift circuit reaches a setting of the unloader valve, the unloader valve activates causing the relief cartridge to open. The open relief valve now directs the oil flow from the pump back to the tank instead of continuing to pressurize the accumulator. A check valve retains the pressure in the swing circuit and prevents the fluid from going back into the pump line.

In the main pump circuit description, it was described how an electrical signal was generated by the proximity sensor which was sent to the logic controller and used to control the alternating action of the hydraulic drive cylinders. This same signal is also used to shift the s-tube so that its movement is synchronized with that of the hydraulic drive cylinder, shifting the s-tube to the material cylinder which is ready to extend (normal forward operation).

The electrical signal activates the solenoid coil of the directional valve, shifting the spool to the appropriate side. The accumulator then releases, exhausting the fluid which flows through the directional valve and is directed to the appropriate side of the shift cylinder. As soon as the shift is made the accumulator is refilled immediately and the sequence starts all over again.

AUXILIARY CIRCUIT

The auxiliary circuit has been designed and installed for the purpose of operating the hydraulic function of the auxiliary equipment on the unit, primarily the agitator. This function is that of the agitator rotation for mixing the material in the hopper and feeding of the concrete cylinders.

The flow and pressure requirements for the auxiliary circuit are met by employing the second stage or section of the same tandem pump used on the s-tube shift circuit. With the engine running and throttle set to maximum RPM, the flow from the tandem pump is directed to a single spool directional control valve. This circuit also utilizes a solenoid valve cartridge or dump valve, designed as a safety valve with the purpose of preventing flow to the auxiliary circuit as commanded by the emergency stop circuit. At start up, the normally open cartridge directs the oil flow from the tandem pump to tank, prohibiting

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function of the auxiliary circuit. When the emergency stop circuit is reset, an electrical signal is generated to energize the solenoid, closing the cartridge and blocking flow directly back to tank, instead allowing the flow to the single spool directional control valve for operation. The directional control valve has relief cartridge to protect the system against excessive pressure

When the valve lever is activated the agitator will rotate in forward direction as hydraulic fluid is

directed to that side of the motor. Rotation can be reversed by moving lever in other direction.

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SERIAL PLATE IDENIFICATION

A-SERIES

B-SERIES

C-SERIES

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A SERIES MAIN PANEL SERIAL IDENIFICATION

Serial Plate Identification

PLC CONTROL PANEL SERIAL PLATE

Panel serial # → **Panel Part # BW10533 Pump S/N**

Pump type → **Pump (A B C)** **Tier ver. (4)** ← Tier version

PLC program → **PLC program ver.**

MD4-5 Display (Reed p/n 88612) serial # ← Display serial #

MC42 Controller (Reed p/n 89613) serial # ← Controller module serial #

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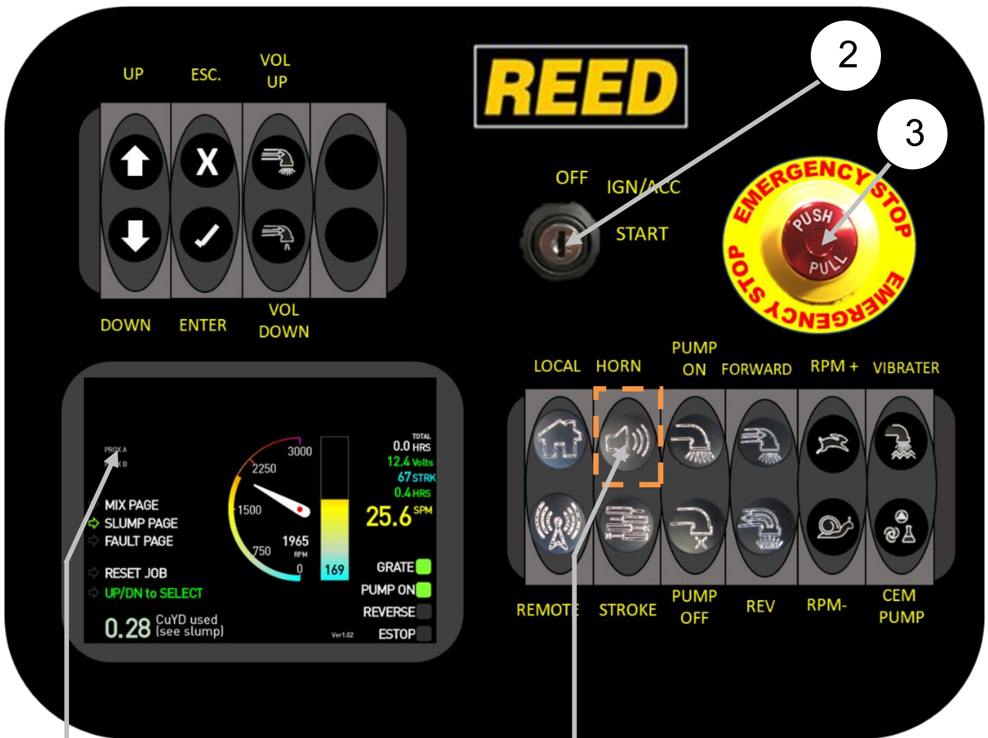
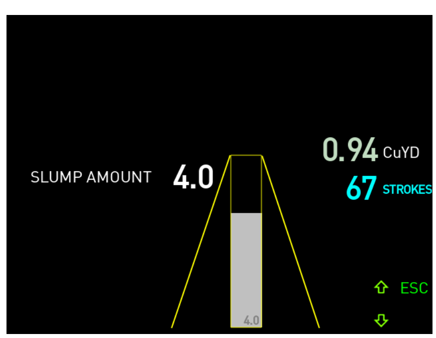
CONTROLS

PLC MAIN CONTROLS A-SERIES



1. **MAIN DIGITAL DISPLAY** this is where all the pumping statuses are displayed.



NOTE: Hopper grate safety switch engages EMERGERGENCY STOP when grate is lifted

2. MAIN POWER SWITCH this is a three (3) position key switch. Turn-key to the **ON** position to power control box. Shut down power by turning key to **OFF** position. **START** position. To start engine turn to start position and hold until engine starts.

3. **EMERGENCY STOP** This push/pull emergency switch is used to shut down the pump in an emergency by disabling the hydraulic systems. It does not shut the engine or motor off. Depress **PUSH** knob in to **STOP** operation. **PULL** knob out to **REACTIVATE** system.

4. **NOTE:** the **HORN/RESET** must be switched one time to restart pump operation

5. HORN/RESET Press button down to activate horn/reset, it is used to reactivate the control and **PUMP CIRCUIT** after machine has been shut down using the **EMERGENCY STOP** switch or when you start the pump. Once the emergency stop has been depressed it will be necessary to press downs the **HORN** button to **RESET.** It will be backlit when engaged**.**

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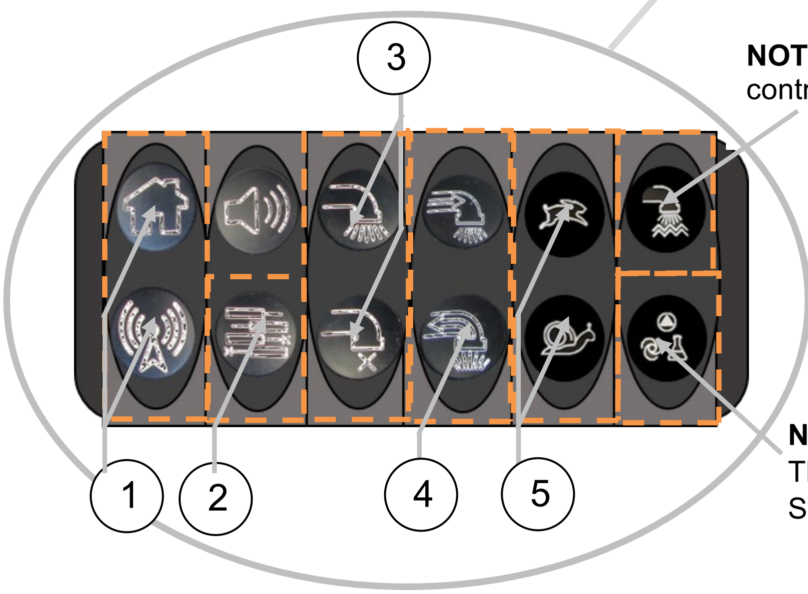
PLC MAIN CONTROLS A-SERIES



1. CONTROL SWITCH **(LOCAL/REMOTE)** this is used to select the pump control location. Press button to **LOCAL** to enable operation of concrete pump for main stationary panel. Press button to **REMOTE** for operation using the remote control.
2. STROKE-SWITCH Press button to test stroke change. It is used for the purpose of pressure testing the main drive cylinders. Both main and swing cylinders reverse direction when button is depressed. When the main cylinders reach the end of the stroke they will "dead head" until the button is released.
3. PUMP ON/OFF SWITCH this is to turn the pump on and off. Press button **PUMP ON** to turn pump on, and press button **PUMP OFF** to turn pump off.
4. PUMP DIRECTION SWITCHES this is used to select and controls of the cycle direction of the concrete pump. Press button **FORWARD** to control pump forward, and press button **REVERSE** to control pump reverse functions.
5. RPM +/-, controls increase and decrease of engine RPM**.**

NOTE: Vibrator on/off control (option only).

NOTE: Chemical Pump
THESE CONTROLS ARE USED FOR (OPTION SYNCHRONISED CHEMICAL PUMP)

- Manual mode is used when you can control the speed of the chemical pump.
- Auto mode is used when you need a specific amount of chemical to be pumped With each stroke of the concrete pump.

NOTE: Hopper grate safety switch engages EMERGERGENCY STOP when grate is lifted

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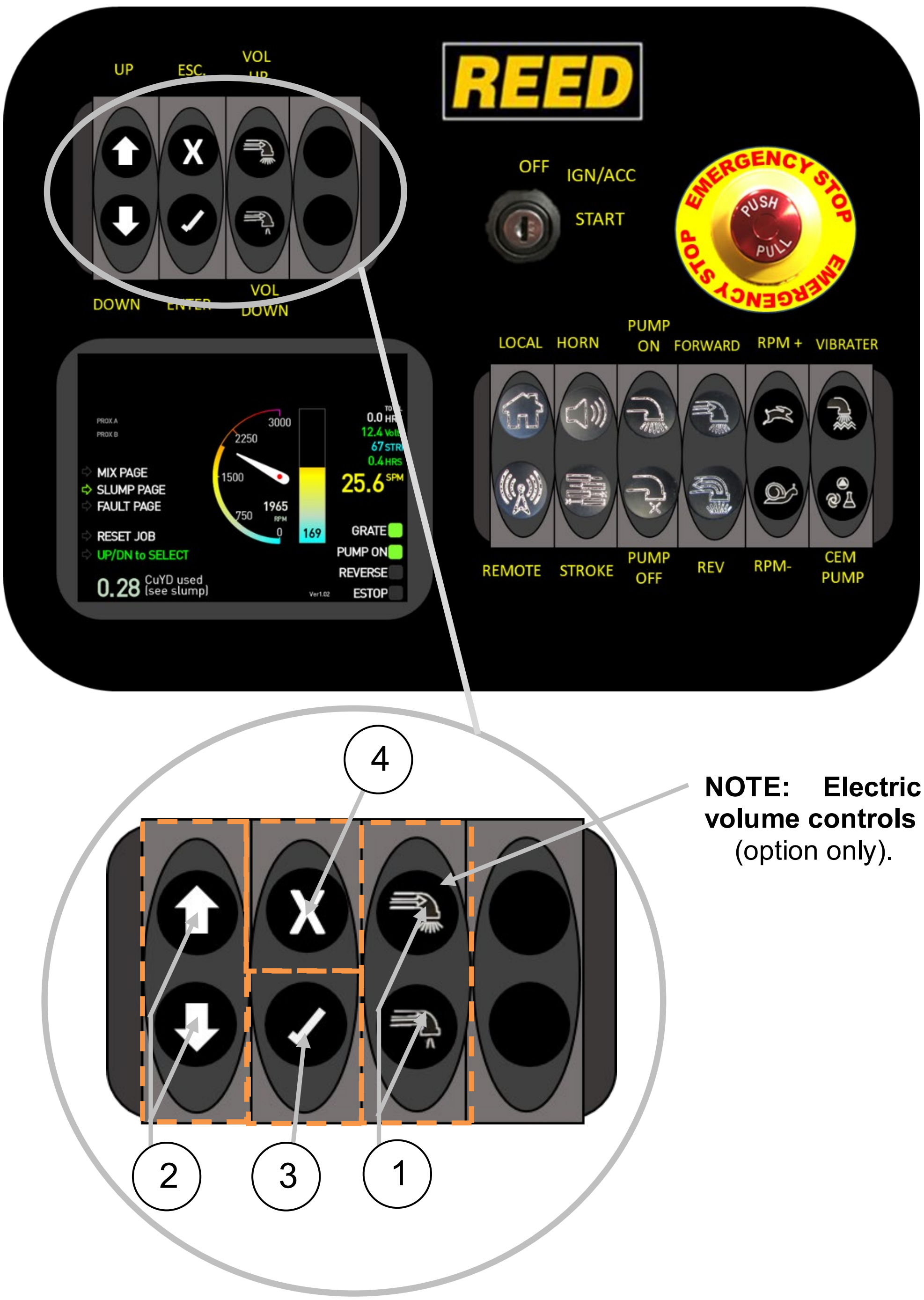
PLC MAIN CONTROLS A-SERIES

1. PUMP VOLUME, this is to turn the pump volume up or down. Press button **VOLUME UP** to increase volume, and press button **VOLUME DOWN** to reduce volume.
2. SCREEN NAVIGATION is to move UP and DOWN in screen menu.
3. ENTER, is to select enter in screen menu.
4. ESC. Is to select escape in screen menu.



NOTE: Electric volume controls (option only).

NOTE: Hopper grate safety switch engages EMERGERGENCY STOP when grate is lifted

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AGITATOR CONTROL controls agitator ON/OFF and FORWARD REVERSE functions.

GAUGES

PUMP or DRIVE CYLINDER GAUGE indicates the hydraulic pressure requirement of the pumping cylinders to push material. Gauge reading varies depending upon many circumstances such as: material slump, material line type, size and length, vertical, uphill, downhill or horizontal placement, pumping speed, etc.

S-TUBE GAUGE indicates amount of oil pressure stored in accumulator circuit. Pressure will build and stabilize at a set pressure once E-STOP is reset. Pressure will fluctuate as swing cylinder(s) shift but will always recharge to the same set pressure.

Works between a range of 90 PSI(6bar) min and 275 PSI (19 Bar max.

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SET-UP

Refer to the Safety Manual for set-up safety precautions not limited to the following guidelines:

WARNING

Ensure Machine Can Be Safely Operated In Set-Up Location
Away From Hazards and Dangers
Away From Slopes and Excavations

WARNING

Position Machine On As Solid and Level Ground As Possible

PRIMING

Priming consists of pumping a lubricant to coat the s-tube and delivery lines to assist the initial concrete material in getting through the delivery lines and avoid blockages. Once the delivery lines are full of concrete, that material will supply the lubrication necessary for the material to flow through the delivery lines. However, it is imperative that a primer be used ahead of the initial concrete material to pre-lubricate the lines in order to avoid blockages.

A suggested grout to use for priming and lubrication may consist of 2 parts sand and 1 part cement and mixed to a consistency of a thick cream.

The amount of grout required depends on the length of the delivery line as well as the material being pumped. Operator experience will eventually indicate the amount to be required.

In addition to grout, there is a wide variety of priming products available on the market.

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PUMPING

Everyone involved with the operation, maintenance, inspection, and repair of the concrete pump MUST READ and UNDERSTANDS this manual and the Safety Manual.

Refer to the Safety Manual for pumping and blockages safety precautions not limited to the following guidelines:

⚠ DANGER

Perform Required Inspection, Lubrication, and Maintenance
Before, During, and After Pumping Operations

⚠ DANGER

Do Not Remove Hopper Grate
Or Other Safety Components

⚠ DANGER

Do Not Insert Body Parts into Hopper, S-Tube, or Waterbox
Or Other Moving Components

⚠ WARNING

Turn Pump ON Only When Hopper Is Full Of Concrete

⚠ WARNING

Ensure the following conditions are met before activating pump:

- PUMP Switch Is OFF
- VOLUME CONTROL Is Set To MINIMUM
- AGITATOR Control Is In OFF Position
- EMERGENCY STOPS Are Not Activated
- Controls On LOCAL Position

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PUMPING Continued

1. Turn KEY operated SYSTEM POWER Switch to ON
2. Turn Key switch to start engine
3. Activate the HORN/RESET to prepare the concrete pump for operation
4. After engine warms up, increase RPM to desired engine RPM by adjusting THROTTLE CONTROL
5. Adjust VOLUME CONTROL to low output when starting pumping operations
6. Switch PUMP Switch to ON to pump concrete when hopper is full, maintain full level
7. Closely monitor the PUMP pressure gauge while pumping
8. Turn PUMP Switch to REVERSE to reverse the pumping action if necessary. REVERSE function is typically used to relieve pressure in the delivery line in the event of a blockage. A blockage will generally result in the main hydraulic system reaching maximum pressure as indicated on the PUMP PRESSURE GAUGE
9. Turn PUMP Switch OFF to stop cycling and stop pumping concrete
10. In the event of an emergency, push the EMERGENCY STOP Button IN to stop all functions of the concrete pump. Pull the EMERGENCY STOP Button OUT to enable system to reset; Horn/Reset function must be activated to reset pump operation.

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CLEANING

DANGER

Do Not Remove Hopper Grate
Or Other Safety Components

DANGER

Do Not Insert Body Parts into Hopper, S-Tube, or Waterbox
Or Other Moving Components

1. Set VOLUME CONTROL to LOW
2. Pump as much material as possible out of the delivery system
3. Turn PUMP Switch OFF
4. Disconnect delivery system. Disconnect the line right after the reducer if a reducer is used
5. Open hopper door and empty hopper
6. Flush out hopper, S-Tube, and cylinders with water
7. Place DIRECTION Switch in REVERSE. Place no more than two feet of the water hose into the pump discharge outlet then turn the PUMP switch ON Water will drain into the material cylinders and as pump cycles, any sand and rocks will be forced out through the open clean out door.
8. Stroke the pump to make sure all sand and other material has been cleaned out, and then turn the pump off.
9. Close the hopper clean out door.
10. Place a clean out sponge into the disconnected delivery line. Reconnect the line to the hopper outlet or reducer with the sponge inserted as close to the hopper outlet as possible.
11. Fill the hopper with water. Place the DIRECTION Switch to the FORWARD position and check that VOLUME control is set at low speed. Turn PUMP Switch ON and cycle the pump until the sponge passes through the entire delivery system into a sponge catcher
12. Turn off the pump and allow the water to drain from the system
13. Clean up the remaining areas of the machine as needed
14. After clean-up is complete lubricate all grease points to expel any grout before it cures

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MAINTENANCE

RECOMMENDED MAINTENANCE PRACTICES

MAINTENANCE MANAGEMENT

Schedule lubrication and maintenance inspections to anticipate maintenance issues. Maintenance management requires the assignment of responsibilities to individual personnel, training of personnel, keeping of records, and the exercise of judgment.

INSPECTION AND LUBRICATION CHECKLISTS AND OPERATOR REPORTS

Utilize checklists for scheduled inspection and lubrication and maintain a written record regarding observations and actions performed. Maintain all scheduled maintenance reports by the operator listing any malfunctions and observations.

PUMP HISTORY FILE NOTING PUMP SERIAL NUMBER

File the operator reports, inspection and lubrication checklists, shop repair, work orders and tickets, parts replacement and pump usage records. This file should also include the parts book for the specific serial number and engine.

ANNUAL REVIEW

Review the history records of each unit once every year to find evidence of repetitive failures, adjustments, problems, or excessive wear so that action can be taken to minimize breakdowns and reduce excessive maintenance costs. A review of the machine history will help in the stocking of spare parts and assemblies in advance of a possible need.

CAUTION

Engine Manufacturer Maintenance Schedule Must Be Followed
Read Engine Manufacturer Manual

REED has provided only general guidelines regarding engine maintenance, and will not cover engine warranty claims.

WARNING

Accumulator Pressure Must Be ZERO
Before And During Any Maintenance Procedures

WARNING

Engine Must Be Turned OFF and Lockout / Tagout Procedures Must Be Followed
Before And During Any Maintenance Procedures

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GENERAL MAINTENANCE AREAS

Perform scheduled inspections to identify and detect any potential problems. The list presented should be inspected and checked on a regular basis and is a recommended minimum.

TRAILER

- Frame integrity, visually check welds, cracks
- Torsion axle secure
- Wheels and tires, lug nuts tight, tire pressure
- Electric brakes, breakaway switch connected
- Front jack stand handle turns easily, smoothly
- Manual jacks slide freely, lock pins in place
- Lighting good condition, operational

ENGINE (refer to engine manufacturer manual)

- Inspect mounts, bolts, brackets and belts
- Oil and coolant fluids at proper level, check for leaks
- Fuel system, tank mounting, filter condition, leaks, damaged lines
- Battery hold down, condition, tightness of cables
- Key switch, indicator lights
- Throttle control functional
- Air cleaner and muffler securely mounted

PUMP CELL

- Visually check for structural damage, cracked welds
- Hydraulic drive cylinders in good condition, secure, check for leaks
- Material cylinders secure, tie rods tight
- Water box structurally sound, clean, cover in place
- S-Tube shift mechanism structurally sound, all pins and retainers in place
- Hydraulic shift cylinder(s) in good condition
- Bearing housing, seals etc. in good condition
- Hydraulic hoses secure no leaks

HOPPER ASSEMBLY

- Visually check for structural damage, cracked welds
- S-Tube secure, in good condition
- Check condition of wear plate, wear ring, seals
- Check connection of s-tube to outlet, seals, bearing
- Hopper drain is functional
- Cleaning hopper
- Zerk fittings accept grease

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MAIN CONTROLS
- Control box in good condition, sealed, not damaged
- All toggles in good condition, stay in position or momentarily return to center
- Control identification in good condition, legible
- Gauges in good condition

REMOTE CONTROLS
- Control console in good condition, not damaged
- Switch in good condition
- Cord in good condition, no cuts, securely mounted to box

HYDRAULIC SYSTEM
- Hydraulic tank securely mounted, covers tight
- Breather, filler cap and strainer in place, level sight gauge in proper condition
- Check filter condition indicators
- Hydraulic oil cooler securely mounted, connections tight
- Check accumulator condition, mounting brackets & clamps
- Hydraulic fluid to proper level and clean
- All hoses and tubing secure, check for leaks

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LUBRICATION

The ***REED*** concrete pump is equipped with several components that require frequent lubrication. These areas involve the s-tube shifting mechanism, swing components, the shift and outlet bearings and agitator. to insure the economical service and the long life of these components, grease fittings are installed at each point.

Rapid wear and possible shutdown will result if the unit is operated with inadequate lubrication. Follow the recommendations stated herein, and if needed increase the application of lubricants above these recommendations when the equipment is subject to heavy usage.

MINIMUM LUBRICATING INTERVALS
Recommended lubrication intervals are based on normal use under normal conditions. The lubrication interval must be increased to meet more challenging uses and uses which subject the equipment to high and/or unusual concentration of forces. The lubrication interval must be increased if the pump has been exposed to environmental conditions such as low humidity, high humidity, excessive dust, high temperatures, low temperatures, heavy rainfall, long term storage, ocean air, etc…
1) every hour of operation
2) after completion of every job
All lubrication points must be greased on each and every interval as recommended.

TYPE OF LUBRICANT

- Use EP grease, extreme pressure grease available for wheel bearings, general purpose grease, Shell Alvania EP (LFH2), or equivalent if this lubricant is unavailable in your area

- Do NOT use Moly grease, grease with Moly additives

LUBRICATION POINTS
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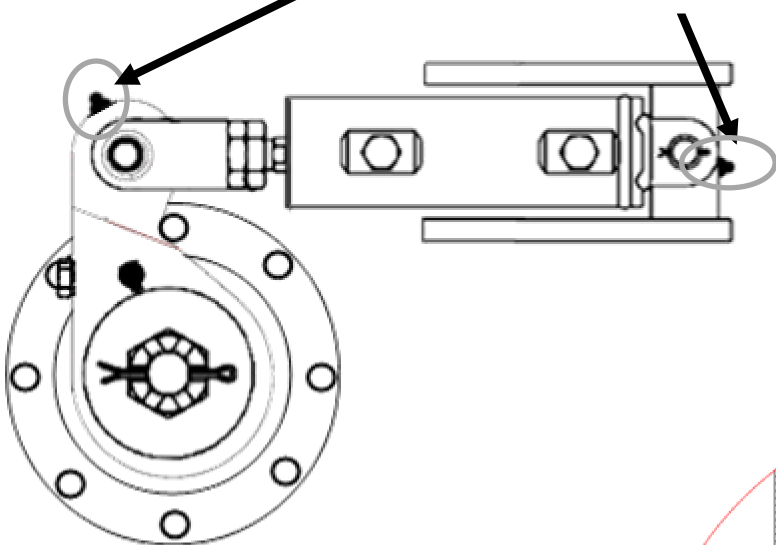
S-TUBE SHIFT LUBRICATION

CAUTION

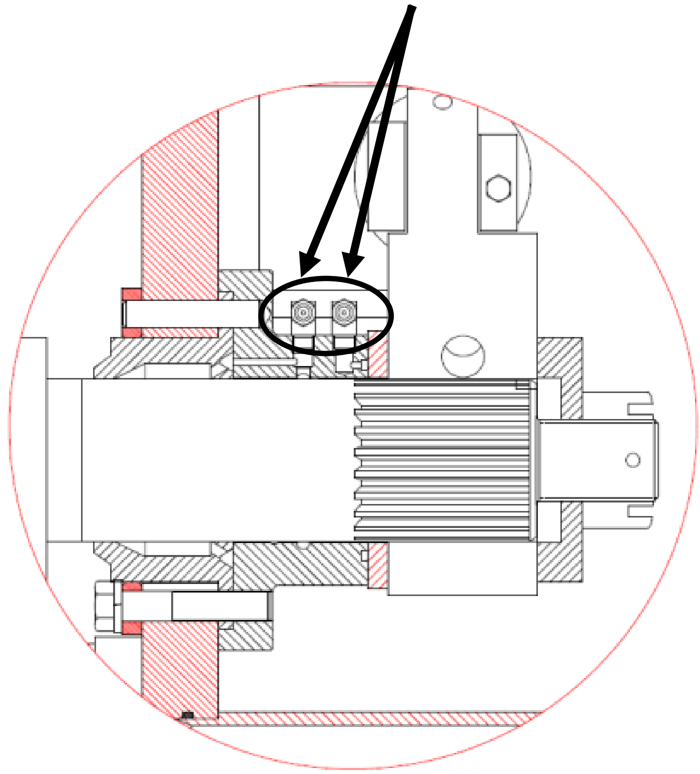
HYDRAULIC SHIFT CYLINDERS,
RELIEVE SHIFT CIRCUIT HYDRAULIC PRESSURE TO PROPERLY GREASE HYDRAULIC SHIFT CYLINDERS AND BELL CRANK

GREASE POINTS

BELL CRANK AND SHIFT CYLINDER GREASE POINTS



S-TUBE BEARING



NOTE:
RELIEVE S-TUBE CIRCUIT PRESSURE BEFORE APPLYING GREASE

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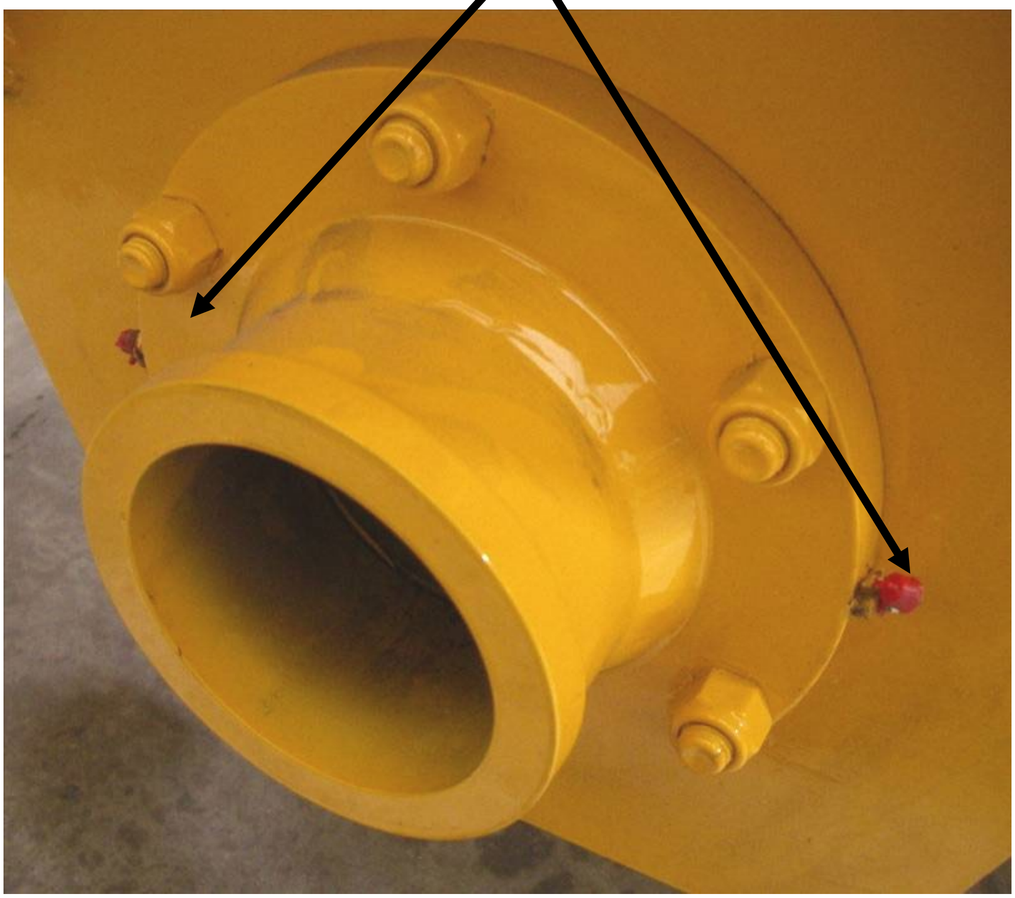
S-TUBE OUTLET LUBRICATION

S-TUBE OUTLET GREASE POINTS



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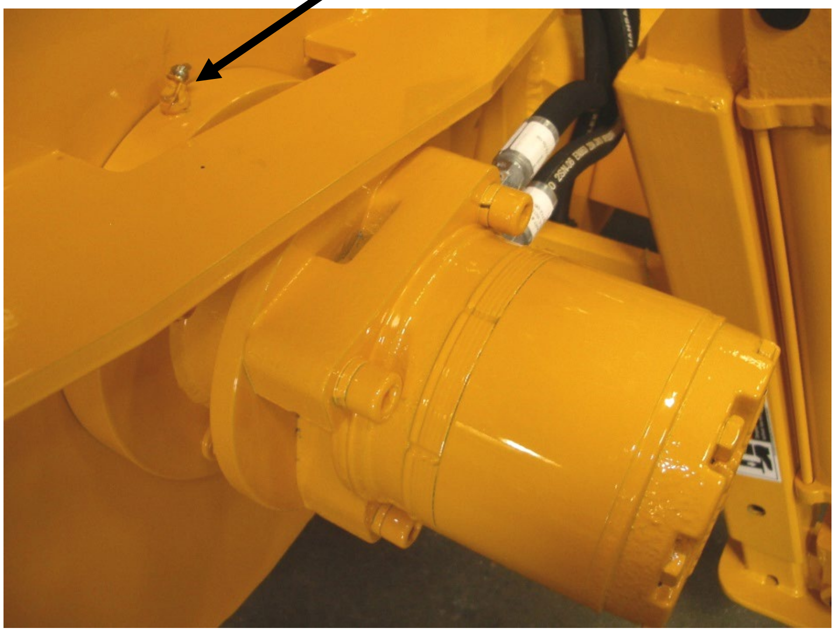
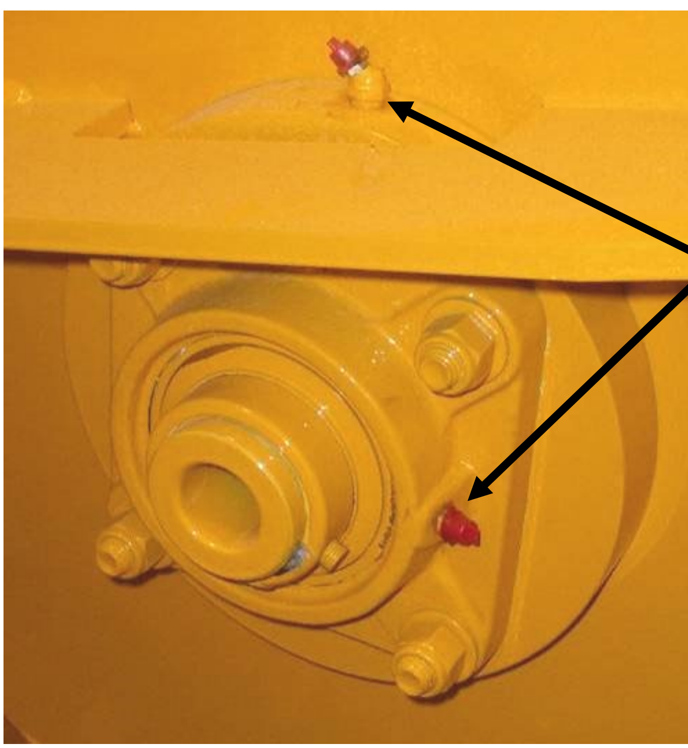
AGITATOR LUBRICATION

HYDRAULIC MOTOR SIDE
GREASE POINT





NON-HYDRAULIC MOTOR SIDE
GREASE POINTS

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HYDRAULIC SYSTEM

Hydraulic pumps are used to supply the flow of oil necessary to operate actuators of the concrete pump.

CAUTION

Contamination of the Oil Is the Leading Contributor to System Malfunctions

Extreme care must be exercised to prevent contaminants from entering the system. Always cap or plug open ports and hydraulic lines.

HYDRAULIC TANK

The hydraulic tank is equipped with an access cover with breather and magnetic suction strainers inside the tank. A sight and temperature gauge is installed on the tank to determine the fluid level and temperature inside the tank. The tank is also equipped with drain valve.

In addition to the magnetic suction strainers, filtration is accomplished by use of a hydraulic return filter located on top of the hydraulic tank. The return filter is equipped with an indicator gauge to monitor filter restriction. An oil cooler is adjacent to the engine cooling unit.

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HYDRAULIC SYSTEM MAINTENANCE ITEM DESCRIPTIONS

FLUID
Check fluid level and oil clarity daily with sight gauge provided. Maintain level at full mark. Add hydraulic oil through the return filter fill port when necessary.

TANK BREATHER
Clean every 50 hours of operation. Remove from tank, clean with solvent and air blow dry.

FILTER
Change after first 50 hours of operation. Thereafter change every 250 hours of operation or when condition gauge indicates change is necessary.

HYDRAULIC TANK
Change oil in tank every 500 hours of operation or yearly, whichever comes first.

HYDRAULIC FLUID

The hydraulic system is filled with Shell Oil Company TELLUS #46. It is to be used in ambient temperatures of 39-90° F (4-32° C). The normal fluid temperature will range from 100-167° F (38-75° C).

For ambient temperatures of 90° F (32° C) and above, use fluid designated with an ISO rating of 68. Use ISO 32 for ambient temperatures of 32° F (4° C) and below.

CAUTION

Use Only Shell Tellus 46 or Equivalent
Never Mix With Other Types of Fluids

CAUTION

Always Use Clean and New Fluid

Using impure or other type of fluids not specified will contaminate the hydraulic system and lead to eventual system malfunction and/or damage.

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ADDING HYDRAULIC FLUID

There are a few common methods for filling the hydraulic tank as described below. Exercise extreme care when adding fluid to the hydraulic tank to avoid contamination.

- To prevent any dirt or water from entering the hydraulic tank, thoroughly clean area around the return filter fill port plug, the vented fill cap or the inspection cover.
- Remove return filter fill port plug, vented cap or inspection cover.
- Fill system to MAX LEVEL mark on sight gauge with new clean hydraulic fluid.

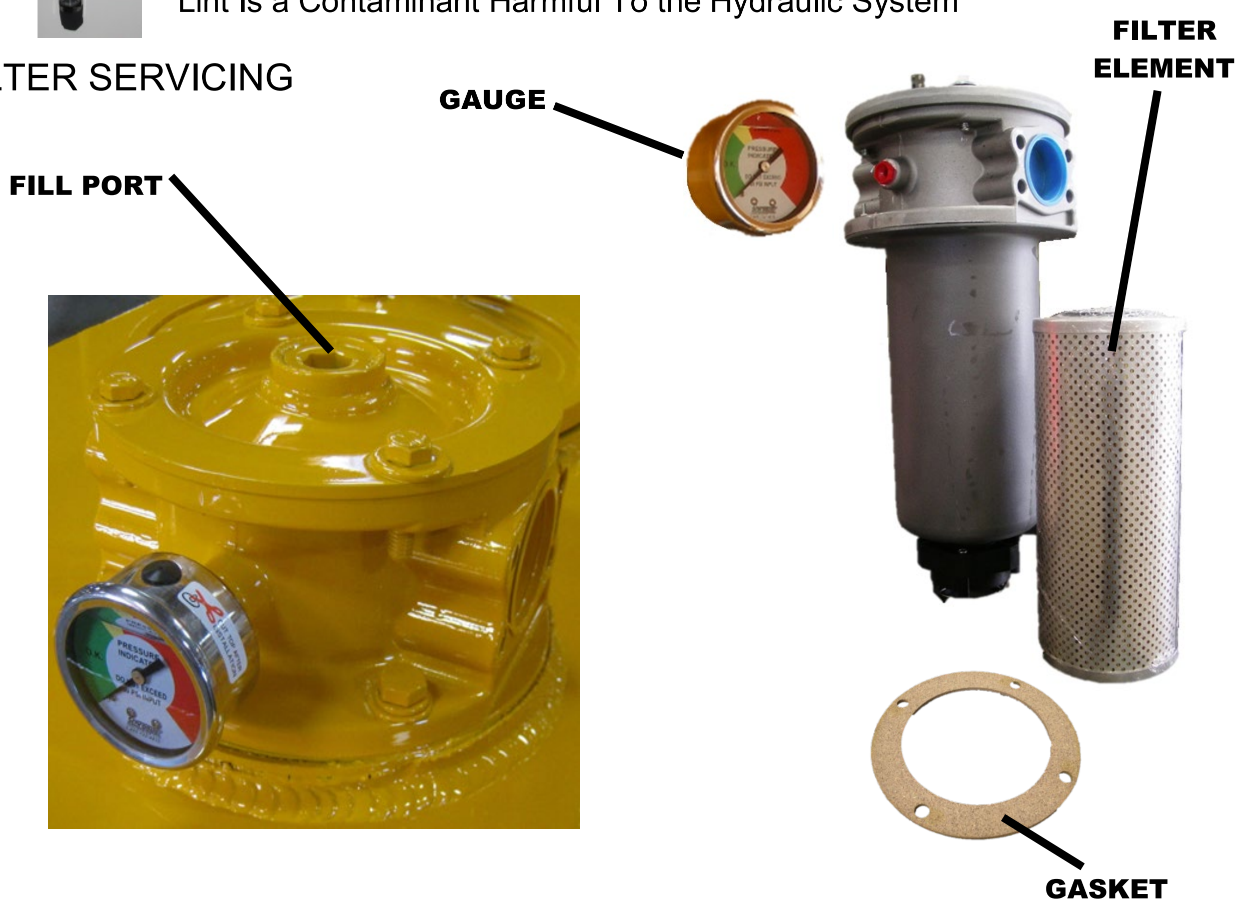
If a pump is used to transfer the fluid, ensure the pump filter is clean. If pouring fluid from a container, pour it through a fine wire mesh screen, 200 mesh or finer.

- Replace filter fill port plug, vented cap or inspection cover immediately after filling tank to proper level.

CAUTION

Do Not Use Cloth for Straining Fluid
Lint Is a Contaminant Harmful To the Hydraulic System

FILTER SERVICING



Hydraulic filters provide a means of continuous hydraulic fluid filtration in an effort to prevent recirculation of contamination which will cause rapid wear and component

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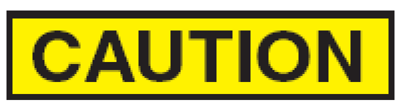
breakdown.

The filter is equipped with a condition indicator gauge which should be checked daily and the element changed when indicated.

To change the filter elements:

1. Shut off machine.
2. VERIFY PRESSURES IN ALL CIRCUITS READ ZERO!
3. Wipe clean any dirt and grime from area surrounding filter housing
4. Loosen the filter cover plate bolts
5. Carefully remove cover so as not to damage the gasket or O-ring
6. Remove and element bypass valve (if equipped)
7. Discard only element and discard responsibly
8. Install bypass valve (if equipped) and new element and replace cover
9. Wipe clean any contaminants around high pressure filter
10. Remove filter housing then remove and discard filter element
11. Check and replace O-ring or gasket if necessary
12. Replace filter element and install filter housing
13. Startup machine and observe for leakage



Do Not Wash Out and Reuse Disposable Filter Elements

CLEANING THE HYDRAULIC TANK

The hydraulic tank should be drained and cleaned after 500 hours of operation or yearly, whichever occurs first, to assist in keeping the systems clean and in proper condition.

1. Shut off machine
2. VERIFY PRESSURES IN ALL CIRCUITS READ ZERO!
3. Place a suitable size container under the hydraulic tank drain fitting and then remove drain plug. Dispose of used oil responsibly
4. After draining, remove the access cover on the hydraulic tank being careful not to damage the gasket
5. Remove, disassemble and clean magnetic suction strainers before reassembly (if equipped)
6. Flush the inside of hydraulic tank with clean solvent and wipe clean with lint free cloths
7. Install suction strainers (if equipped)

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8. Replace sight gauge
9. Install the tank drain plug and access cover with gasket.
10. Change the hydraulic system filter element(s) and breather cap
11. Refill the hydraulic tank with new clean hydraulic fluid to MAX LEVEL mark
12. Start machine and check for leaks

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COMPONENT REPLACEMENT

When parts are worn, do not delay in replacement. Continued usage with worn parts may lead to damage of other components.
This section is provided as a general guideline to assist in replacing major components that will wear. Please contact the ***REED*** Service Department or your local dealer for technical support.

S-TUBE, WEAR RING, AND WEAR PLATE

The sealing characteristics of the s-tube depend on the positive contact of the wear ring, located inside the s-tube, to the wear plate mounted inside of the hopper. The abrasiveness and friction of the concrete will cause wear and a breakdown of the sealing action. As this breakdown occurs, periodic adjustments to the s-tube can be made. This will help to improve the sealing quality; however, eventually the components will need to be replaced.

Adjustment or parts are required if:

- s-tube concrete build up
- deep grooves have developed on the face of the wear plate and/or on the wear ring
- When the output volume at the end of the delivery line noticeably begins to decrease or eventually stops
- When the material being pumped is being forced back into the hopper under pressure

Accumulator Pressure Must Be ZERO
BEFORE AND DURING Any Maintenance Procedures

Engine Must Be Turned OFF and Lockout / Tagout Procedures Must Be Followed
BEFORE AND DURING Any Maintenance Procedures

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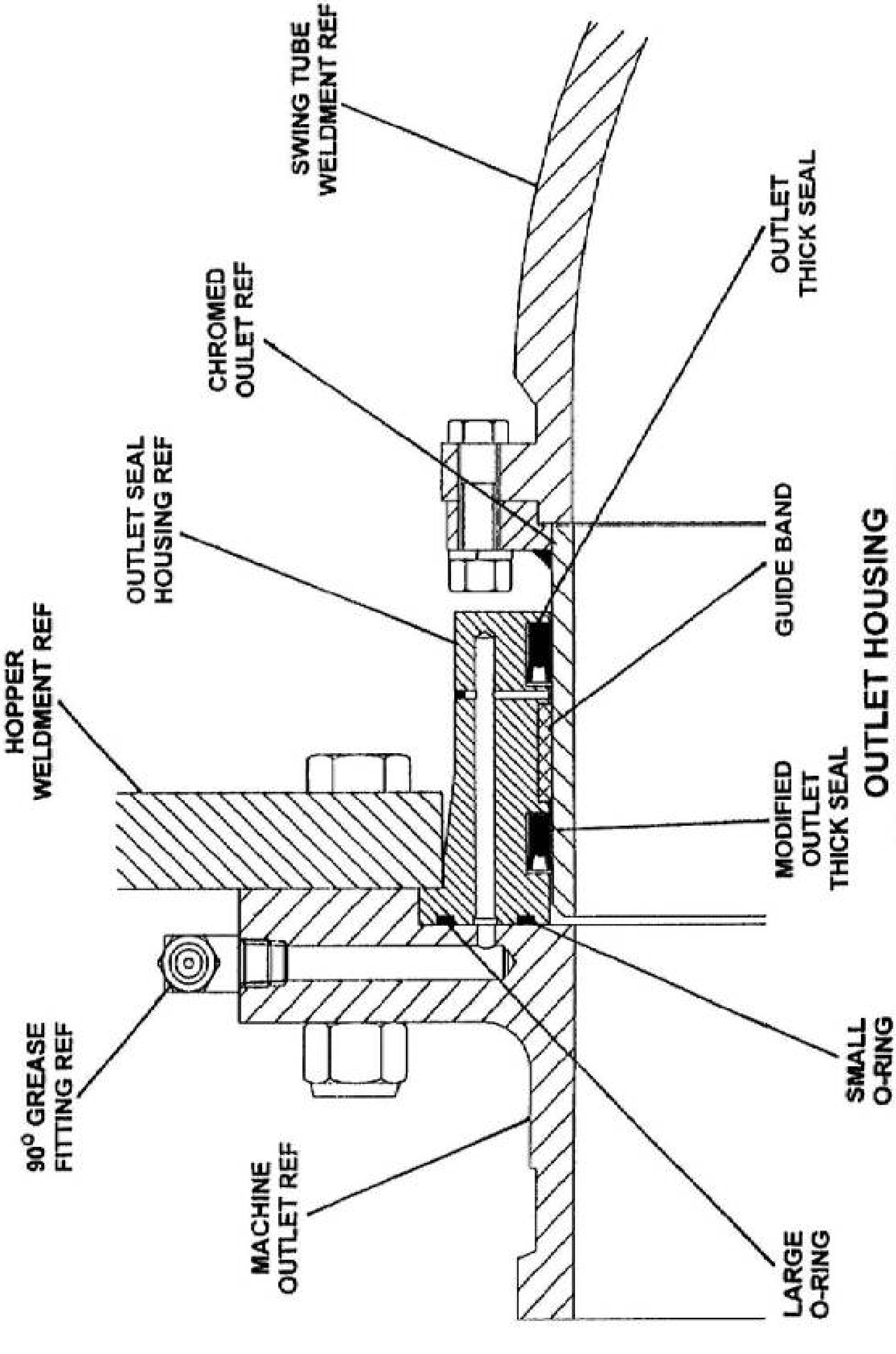

**OUTLET HOUSING
SEAL KIT INSTALLATION
SECTIONAL VIEW**

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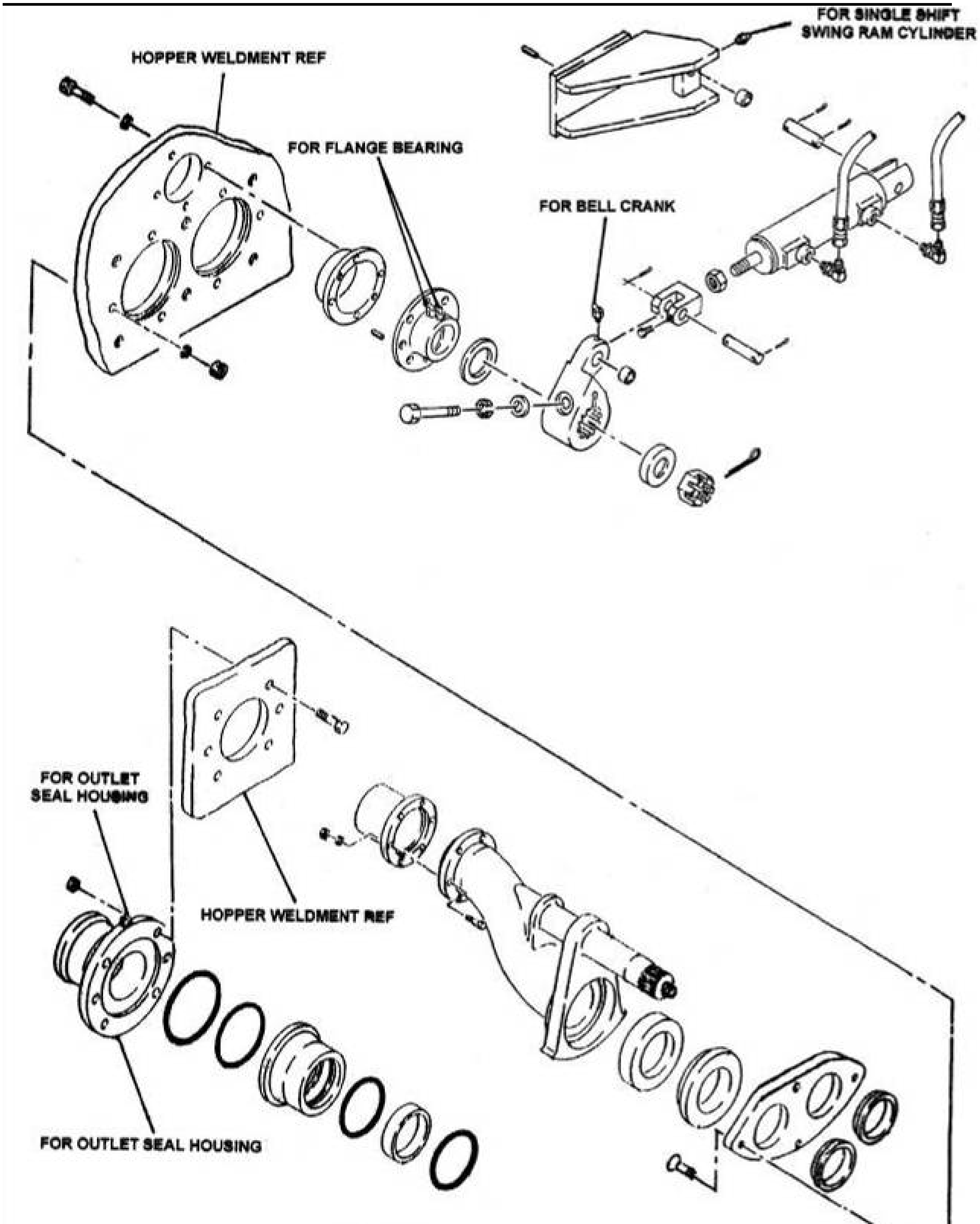

SINGLE SHIFT PUMPING TRAIN

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DANGER

LOCK OUT BEFORE WORKING ON EQUIPMENT

DANGER

Accumulator Pressure Must Be ZERO
BEFORE AND DURING Any Maintenance Procedures

DANGER

Engine Must Be Turned OFF and Lockout / Tagout Procedures Must Be Followed
BEFORE AND DURING Any Maintenance Procedures

1. Shut off machine
2. VERIFY PRESSURES IN ALL CIRCUITS READ ZERO!
3. Loosen bell crank pinch bolt (s), remove cotter pin, loosen s-tube nut 1 turn
4. Remove outlet bolts, remove outlet
5. Remove outlet seal housing followed by s-tube nut, spacer, bell crank, washer, swing ram(s)
6. Place a sling from an overhead hoist around the discharge end of s-tube to help support the tube.
7. Pry s-tube toward outlet, remove wear ring & thrust seal. The s-tube may be swung upside down to provide access to clean. Thrust seal groove or cavity must be properly cleaned

Note: for better access, the s-tube may be removed from hopper by removing flange bearing, seal and chromed outlet and hoisting it out of hopper

8. If wear plate is to be changed, remove wear plate mounting bolts. Pry wear plate from hopper using provided jack bolt.
9. Pry anti-chip rings out of hopper bore. Use caution not to damage chrome concrete cylinder. Clean anti-chip ring bore and wear plate area. Replace O-rings (if applicable). Test-fit new bolts in new wear plate-they should be below the surface of the wear plate and not protruding (grind if necessary).
10. Apply small bead of silicone to outer diameter of anti-chip rings, install into hopper bore with split at bottom
11. Apply small amount of silicone to hopper-side of wear plate and bolt-heads. Install wear plate, hand tighten bolts. A short pair of bolts with nuts may be

placed underneath new wear plate to adjust and align to concrete cylinders. Torque wear plate mounting bolts to 250 ft lbs, remove adjusting bolts.

12. Install new thrust seal & wear ring in s-tube.
13. Install shaft seal and flange bearing (if removed), torque bolts to 100 ft lbs
14. Slide s-tube forward against wear plate, install washer, align/ mount bell crank, install spacer and castle nut. Do not tighten yet.
15. Replace outlet seals in proper orientation, apply grease and install outlet seal housing. Install outlet, torque outlet bolts to 100 ft lbs. Grease all zerk fittings for s-tube until grease comes out of seals.
16. Remove sling, tighten s-tube nut/bolt. It may be helpful to start machine and cycle s-tube to help new parts seat. Do final tightening to s-tube nut/bolt, install cotter pin/retainer, tighten bell crank pinch bolt (s). The nut should be as tight as possible without hampering the shift of s-tube

S-TUBE ADJUSTMENT

Accumulator Pressure Must Be ZERO
BEFORE AND DURING Any Maintenance Procedures

Engine Must Be Turned OFF and Lockout / Tagout Procedures Must Be Followed
BEFORE AND DURING Any Maintenance Procedures

The s-tube will require periodic adjustment as the wear parts wear in order to ensure the good contact and sealing characteristics of the wear plate and wear ring, as well as maintaining a constant squeeze of the thrust seal behind the wear ring. S-tube adjustment is performed by tightening the castle nut. Generally, the castle nut should be as tight as it can be without slowing or hindering the throw of the s-tube.

1. With engine off and no pressure showing on gauges, loosen the bell crank pinch bolts
2. Remove cotter pin and tighten castle nut one flat or to next cotter pin slot.
3. Start and cycle machine to ensure proper s-tube operation. Adjust further if

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necessary, following lock out tag out rule for each adjustment.

4. When adjustment has been satisfied, install cotter pin and tighten bell crank pinch bolts.

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PISTON CUP AND GUIDE BAND REMOVAL/REPLACEMENT

Because of the abrasiveness of the material being pumped, it will be necessary to periodically replace the piston cups.

Signs and identifying systems of worn parts might be:

- Slurry of the material being pumped starts to appear in the flush box
- The water or lubricating oil in water box begins to rapidly lower level without any sign of leakage
- Operation is rough and erratic

Accumulator Pressure Must Be ZERO
BEFORE AND DURING Any Maintenance Procedures

Engine Must Be Turned OFF and Lockout / Tagout Procedures Must Be Followed
BEFORE AND DURING Any Maintenance Procedures

1. Drain all oil or water from the flush box.
2. Cycle machine using appropriate controls until one of the cylinders is completely retracted. Turn off engine and allow hydraulic systems to completely depressurize.
3. As a precaution, mark location of proximity sensor adjusting bracket. Remove proximity sensor cross bracket.
4. Mark the end of the piston coupler so that it can be placed in the same relation during reassembly.
5. Unbolt and remove top and bottom halves of coupler. Pry the piston assembly into flush box.
6. Disassemble and clean piston adapter and plate. Check flatness of plate, replace if necessary.
7. Install and grease new guide band. Push adapter/guide band squarely into cleaned and greased concrete cylinder.
8. Install coupler using medium strength Loctite on bolts and torque to 90 ft lbs.

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9. Start and completely extend the adapter and guide band to hopper side. Jog s-tube if necessary to expose fully extended piston adapter.
10. Turn off engine and allow hydraulic systems to completely depressurize
11. Install one alignment bolt (3/8"x24x5" with head cut off) into the piston adapter to assist in locating the cup in the correct position to line up the holes.
12. Slide new piston cup, small end first, over alignment bolt until it meets wear plate. Use a rubber hammer to drive piston cup into concrete cylinder until it seats against piston adapter
13. Slide piston plate into place.
14. Apply medium strength Loctite to bolts. After three bolts with lock washers are started, remove alignment bolt and thread in the last bolt. Tighten bolts equally and firmly using hand tools.
15. One concrete piston is complete. Follow steps 2-14 again for the other side.
16. Install proximity sensor cross bracket.
17. Install flush box plug, fill to top of rods with oil or water, and install flush box cover.

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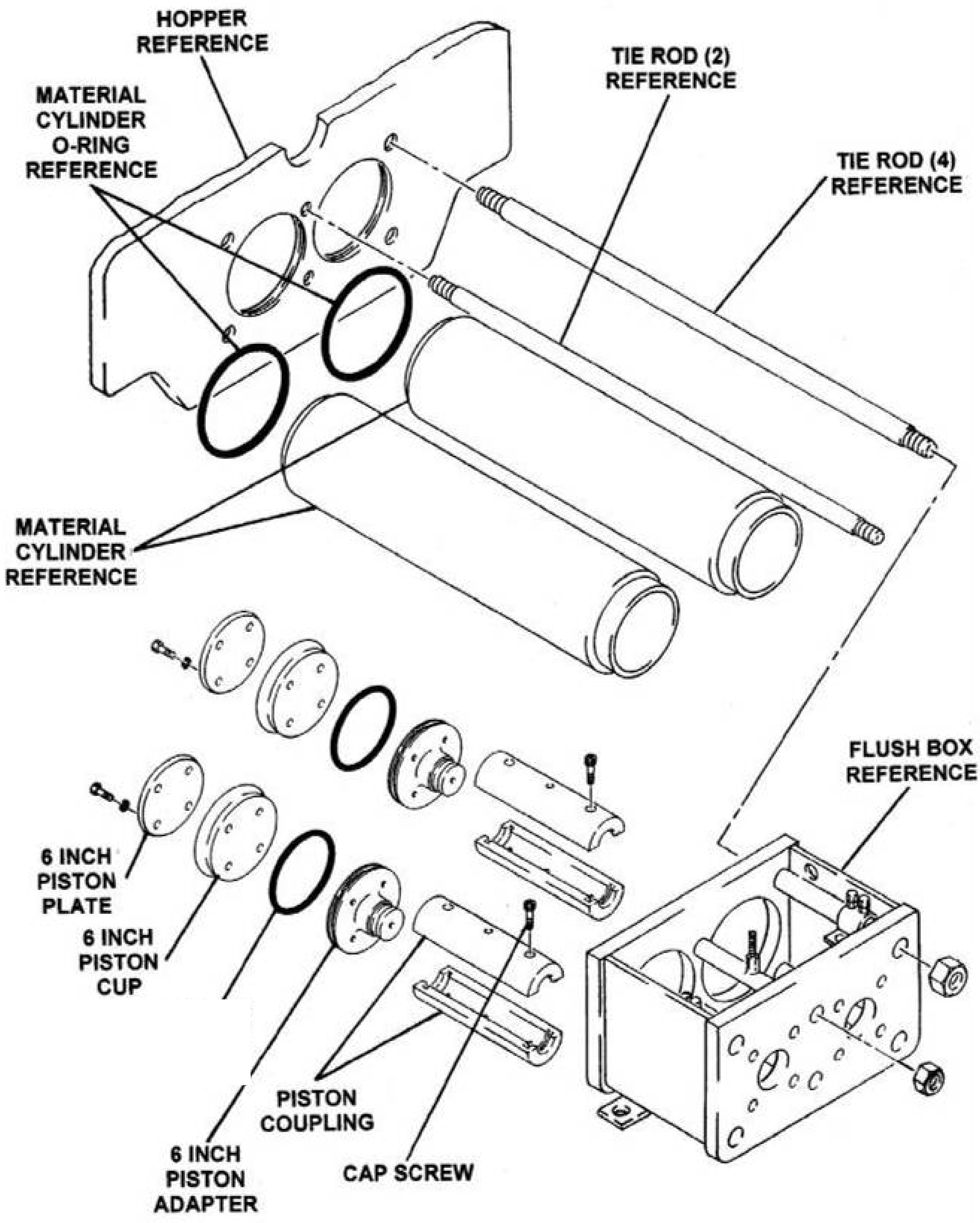

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ACCUMULATOR

WARNING

The hydraulic accumulator is a pressurized vessel and only QUALIFIED TECHNICIANS should perform the necessary repairs. Always drain the fluid COMPLETELY from the accumulator before performing any work on the component.

A qualified technician can check the pre-charge pressure of the accumulator using an accumulator charge kit if low pressure is suspected. Check the pre-charge pressure of the accumulator if the needle of the hydraulic s-tube gauge does not suddenly drop off at the specified pressure when the hydraulic s-tube circuit is depressurizing.

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PUMP MAINTENANCE SCHEDULE AND CHECKLISTS

Providing a maintenance schedule defined specifically by run hours or yardage pumped serves only as a general guideline given the large amount of variables a unit might be subject to, such as weather and ambient temperature conditions, jobsite conditions, material differences of concrete mix design, the load burden the unit is typically subject to, i.e. light, medium or heavy duty operation, etc.

The list that follows is to be used as a reference guide. However, the end user is encouraged to develop a preventative maintenance program that specifically suites their needs depending on the usage of the equipment.

DAILY PUMP MAINTENANCE CHECKLIST		
Actual Hours______	Date__/__/___	
#	Maintenance Description	Initials
1	Check engine fluid levels (see engine manufacturer maintenance schedule for additional requirements)	
2	Check hydraulic tank fluid levels	
3	Check flush box fluid levels	
4	Check condition of hydraulic oil for water or other contamination	
	Additional Notes:	
5	Drain water from tank	
6	Check hydraulic filter indicator condition	
7	Lubricate lubrication points, during and after pumping	
8	Inspect unit for fluid leaks, loose hoses, loose nuts, bolts, fasteners etc.	
	Additional Notes:	
9	Trailer Towing Safety Inspection a) brakes functional	
	b) air pressure in tires is adequate and tire condition	
	c) all “lug nuts” are secure and in place	
	d) tow hitch is secure and in good condition	
10	Additional Notes:	

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INITIAL 50 HOUR MAINTENANCE CHECKLIST		
Actual Hours______		Date__/__/____
#	Maintenance Description	Initials
1	Change engine oil and filters (see engine manufacturer maintenance schedule for additional requirements)	
	Additional Notes:	
2	Change hydraulic oil filters	
3	Inspect hydraulic hoses and fittings for any signs of external wear or damage	
	Additional Notes:	

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EVERY 100 HOUR MAINTENANCE CHECKLIST		
Actual Hours_______	Date__/__/____	
#	Maintenance Description	Initials
1	Clean hydraulic tank breather	
2	Inspect all structural components (check frame, hopper, axle, hood, towing hook, and other structural members for any damage)	
	Additional Notes:	
3	Adjust “S-Tube Nut” or “Castle Nut” (refer to “S-Tube Adjustment” in Maintenance Section)	
	Additional Notes:	
4	Change flush box oil and examine for excessive amounts of contamination (excessive contamination might indicate need to change the Piston Cups)	
	Additional Notes:	
5	Check coolers and radiators for dirt or debris. Clean as necessary	
6	Check condition of engine drive belts. Change if necessary (see engine manufacturer maintenance schedule for additional requirements)	
Additional Notes:		

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EVERY 250 HOUR MAINTENANCE CHECKLIST		
Actual Hours_______	Date__/__/____	
#	Maintenance Description	Initials
1	Change hydraulic filters (or change more frequently as indicated by indicator gauge on filter)	
2	Check that S-Tube, wear parts and seals in hopper are secure and adjusted well, rotate wear ring and replace seal if necessary	
	Additional Notes:	
3	Check swing cylinder components: cylinders, bell crank, pins, bushings, bearings and grease fittings are secure, tight, and not worn excessively	
	Additional Notes:	
4	Check piston cup wear (as indicated by analysis of contaminants found in flush box oil)	
	Additional Notes:	
5	Check that all electrical wires, cables, terminals, plugs are in good condition	
	Additional Notes:	
6	Change engine oil and filters (see engine manufacturer guide for all engine requirements)	
	Additional Notes:	
7	Check condition of fuel hoses, fittings, and clamps	
	Additional Notes:	
8	Inspect all safety decals to ensure that they are completely visible and legible	

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EVERY 250 HOUR MAINTENANCE CHECKLIST		
Actual Hours_______	Date__/__/____	
#	Maintenance Description	Initials
9	Perform complete inspection of the controls	
10	All toggles in good condition, stay in position or momentarily return to center	
11	Control identification in good condition, legible	
12	Gauges in good condition	
	Additional Notes:	
13	Remote controls, control console in good condition	
14	Switch in good condition	
15	Cord in good condition, no cuts, securely mounted to box	
	Additional Notes:	
16	Trailer frame integrity, visually check welds, cracks	
17	Torsion axle secure	
18	Wheels and tires, lug nuts tight, tire inflation	
19	Electric brakes, breakaway switch connected	
20	Front jack stand handle turns easily, smoothly	
21	Manual jacks slide freely, lock pins in place	
22	Lighting good condition operational	
Additional Notes:		

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EVERY 500 HOUR MAINTENANCE CHECKLIST		
Actual Hours_______		Date__/__/____
#	Maintenance Description	Initials
1	Inspect hydraulic hoses and fittings for any signs of external wear or damage	
	Additional Notes:	
2	Inspect all wear parts and change as necessary (excessive wear may cause inefficient performance and/or shutdown of operation)	
	Additional Notes:	
3	Change hydraulic fluid, clean the reservoir and the suction strainers within reservoir, and replace all hydraulic oil filters	
	Additional Notes:	
4	Complete inspection of the engine (refer to engine manufacturer maintenance schedule for details)	
5	Inspect mountings, bolts, brackets	
6	Oil level proper, coolant level proper, check for leaks	
7	Fuel system, tank mounting, filter condition, check for leaks, damaged lines	
8	Battery hold down, condition, tightness of cables	
9	Key switch, indicator lights operable	
10	Throttle control functional	
11	Air cleaner and muffler securely mounted	
Additional Notes:		

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EVERY 500 HOUR MAINTENANCE CHECKLIST		
Actual Hours_______		Date__/__/___
#	Maintenance Description	Initials
12	Pump cell check for structural damage, cracked welds	
13	Hydraulic drive cylinders in good condition, secure, check for leaks	
14	Material cylinders secure, tie rods tight	
15	Water box structurally sound, clean, cover in place	
16	S-Tube shift mechanism structurally sound, all pins and retainers in place	
17	Hydraulic shift cylinders in good condition	
18	Bearing housing, seals etc. in good condition	
19	Hydraulic hoses secure no leaks	
	Additional Notes:	
20	Hopper check for structural damage, cracked welds	
21	S-Tube secure, in good condition	
22	Check condition of wear plate, wear ring, seals	
23	Check connection of S-Tube to outlet, seals, bearing	
24	Hopper drain is functional	
Additional Notes:		

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EVERY 500 HOUR MAINTENANCE CHECKLIST
Actual Hours_______ Date__/__/____
ADDITIONAL GENERAL NOTES:

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NOTES

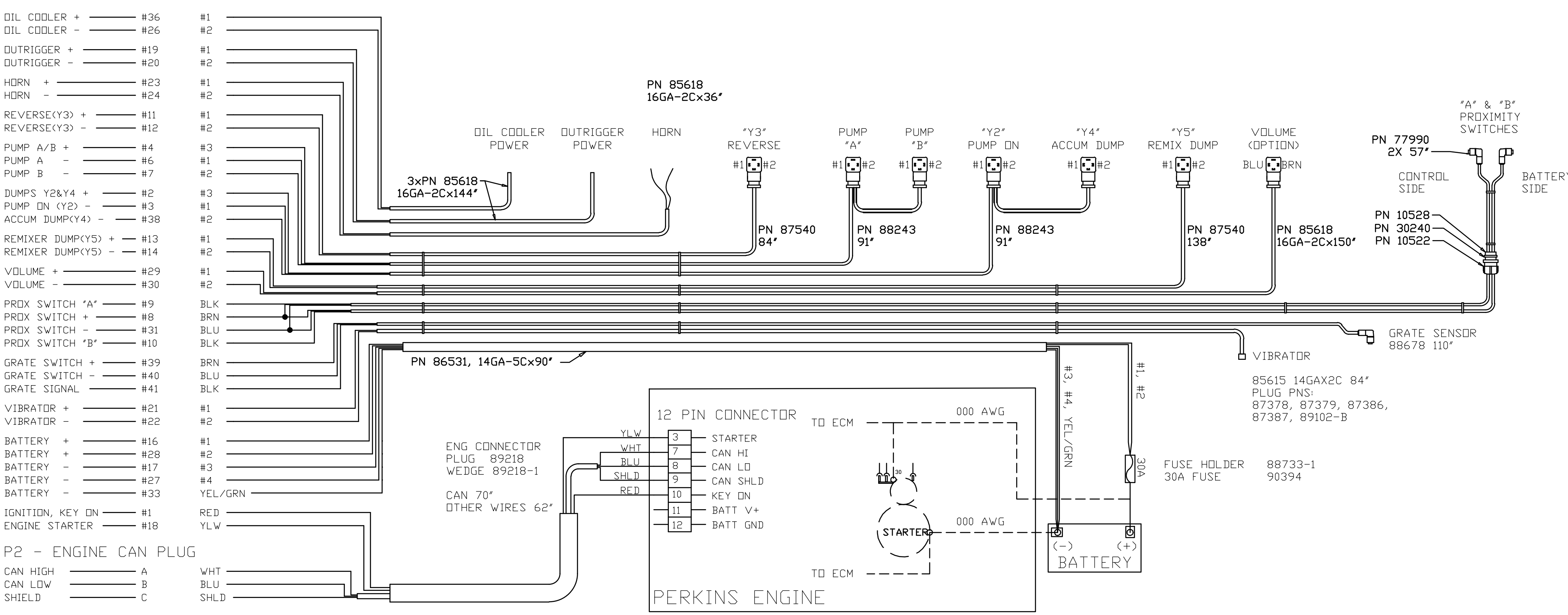
REED	PART NO.	REV.	DATE	A SERIES TIER 4
	BW10534		5/1/19	PUMP WIRE HARNESS

P1 - 24 PIN MAIN PLUG

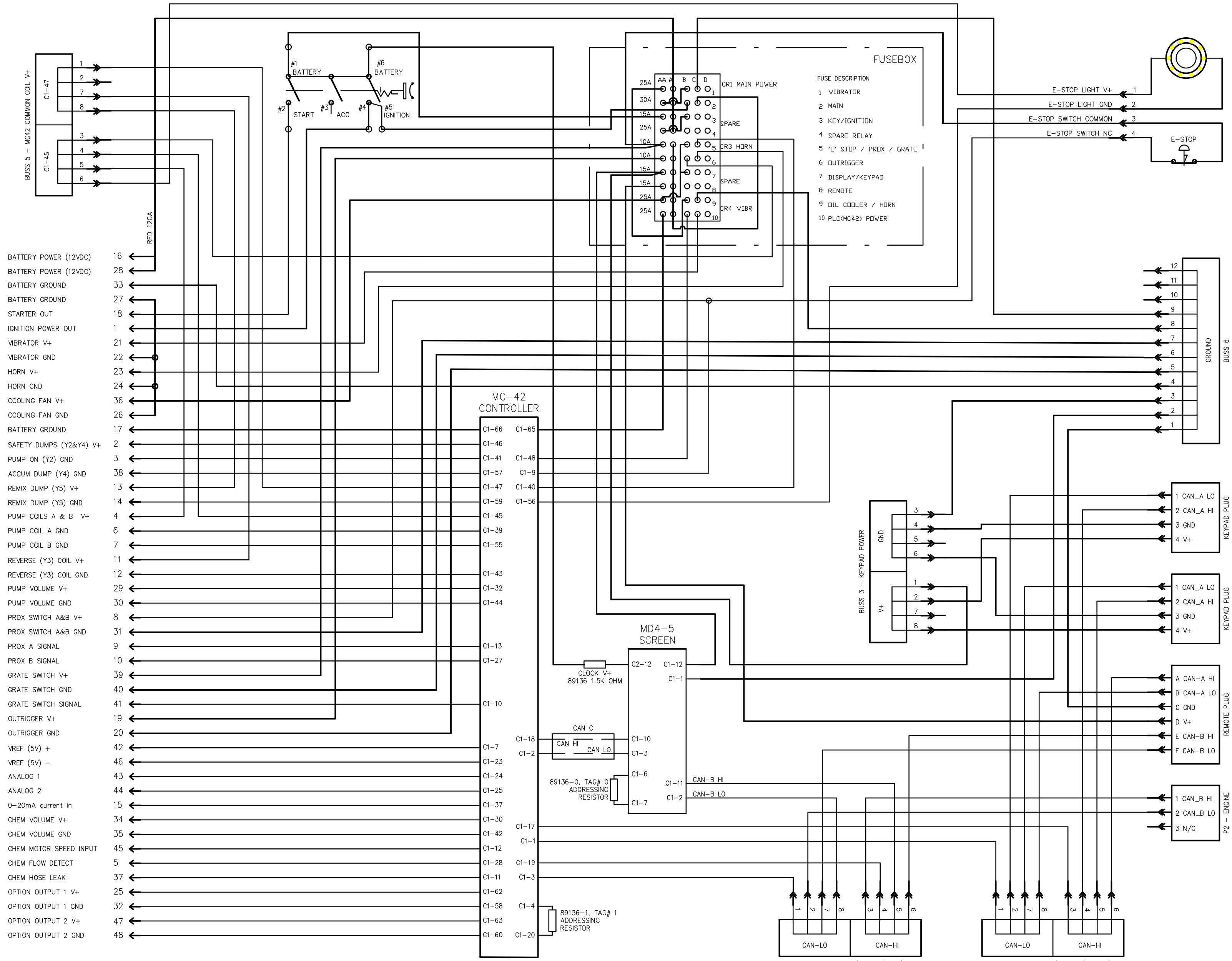
PLUG	89651
WEDGE	89651-W
BOOT	89651-B
PINS	87547/BW10147/88959

P2 - ENGINE CAN PLUG

PLUG	88935
WEDGE	88937
BOOT	88937-B
PINS	BW10147

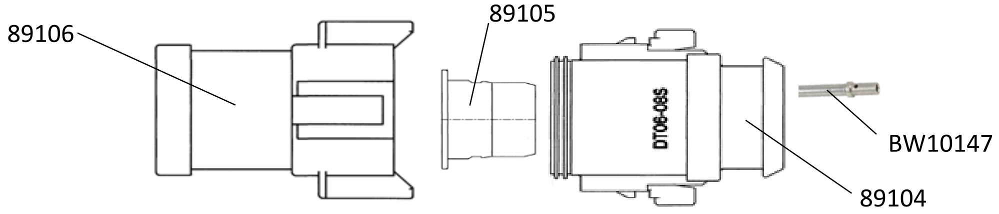


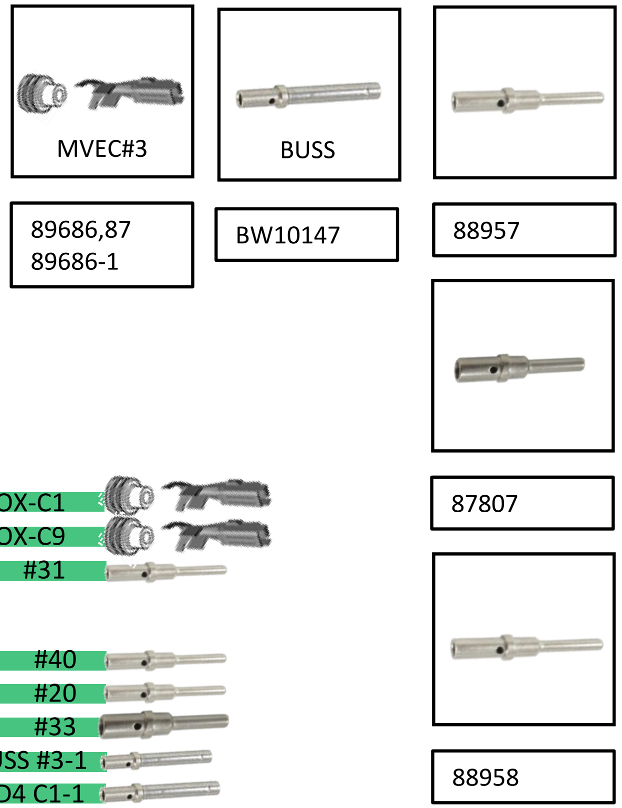
REED	PART NO. BW10533	REV.	DATE 5/1/19	A SERIES TIER 4 CONTROL BOX SCHEMATIC

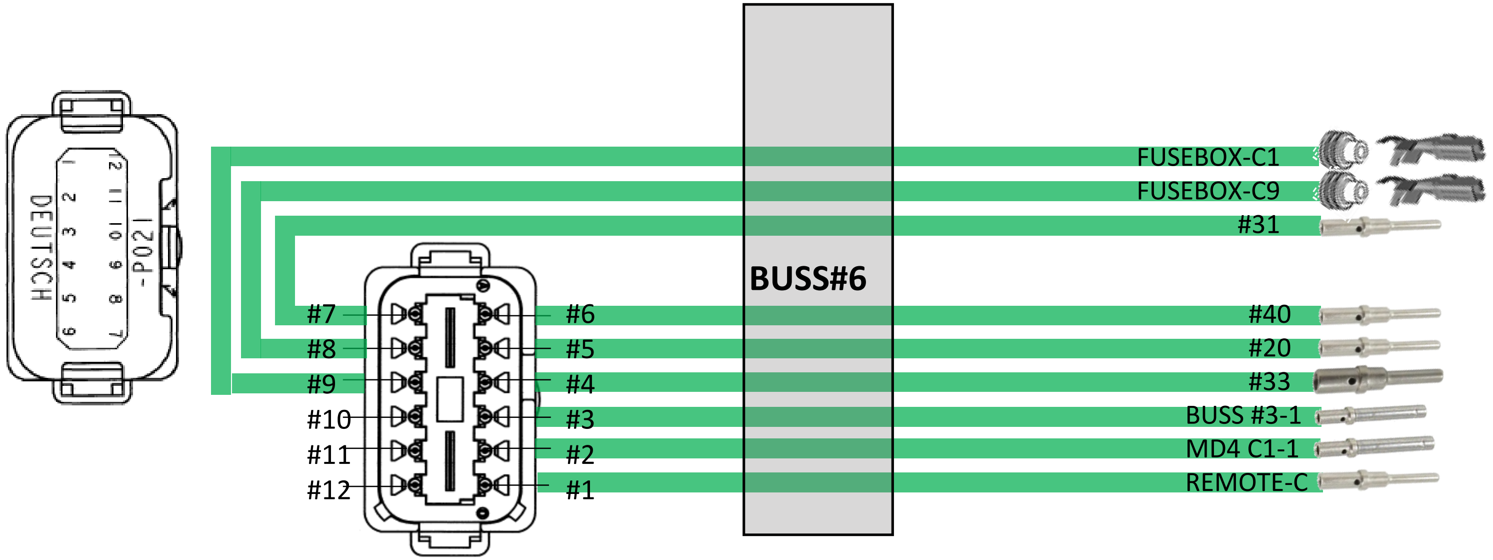


UNLESS OTHERWISE SPECIFIED:
ALL WIRES ARE 18 AWG

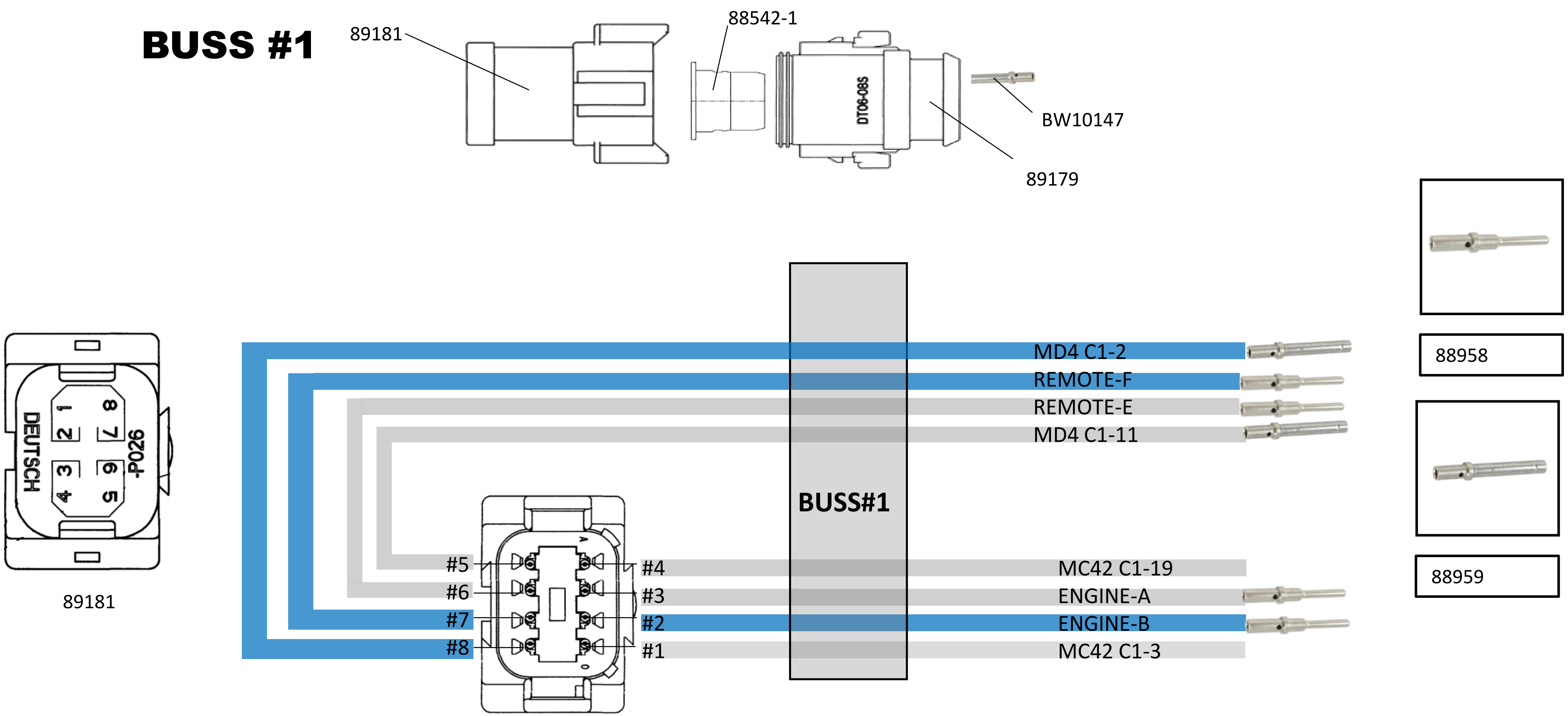
GROUND BUSS 6



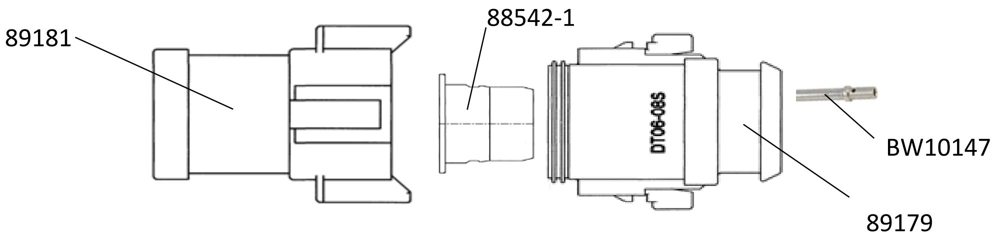


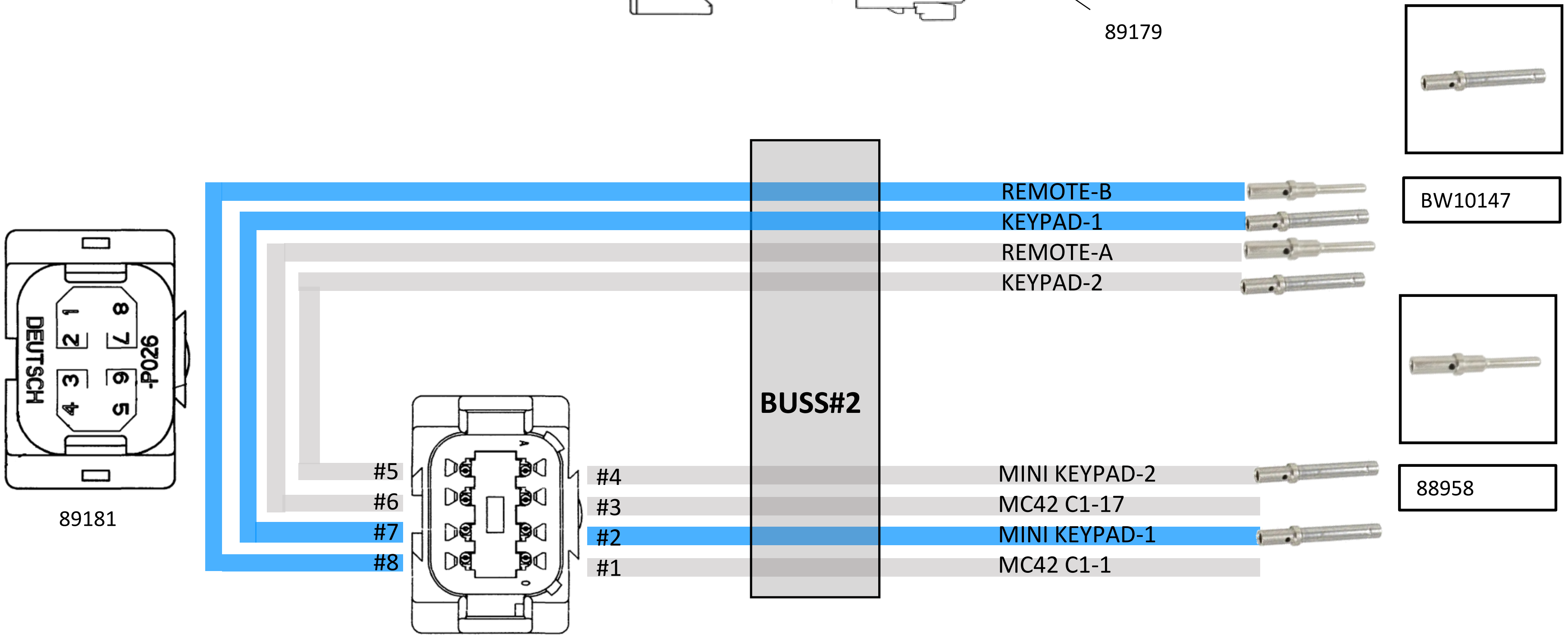


BUSS #1

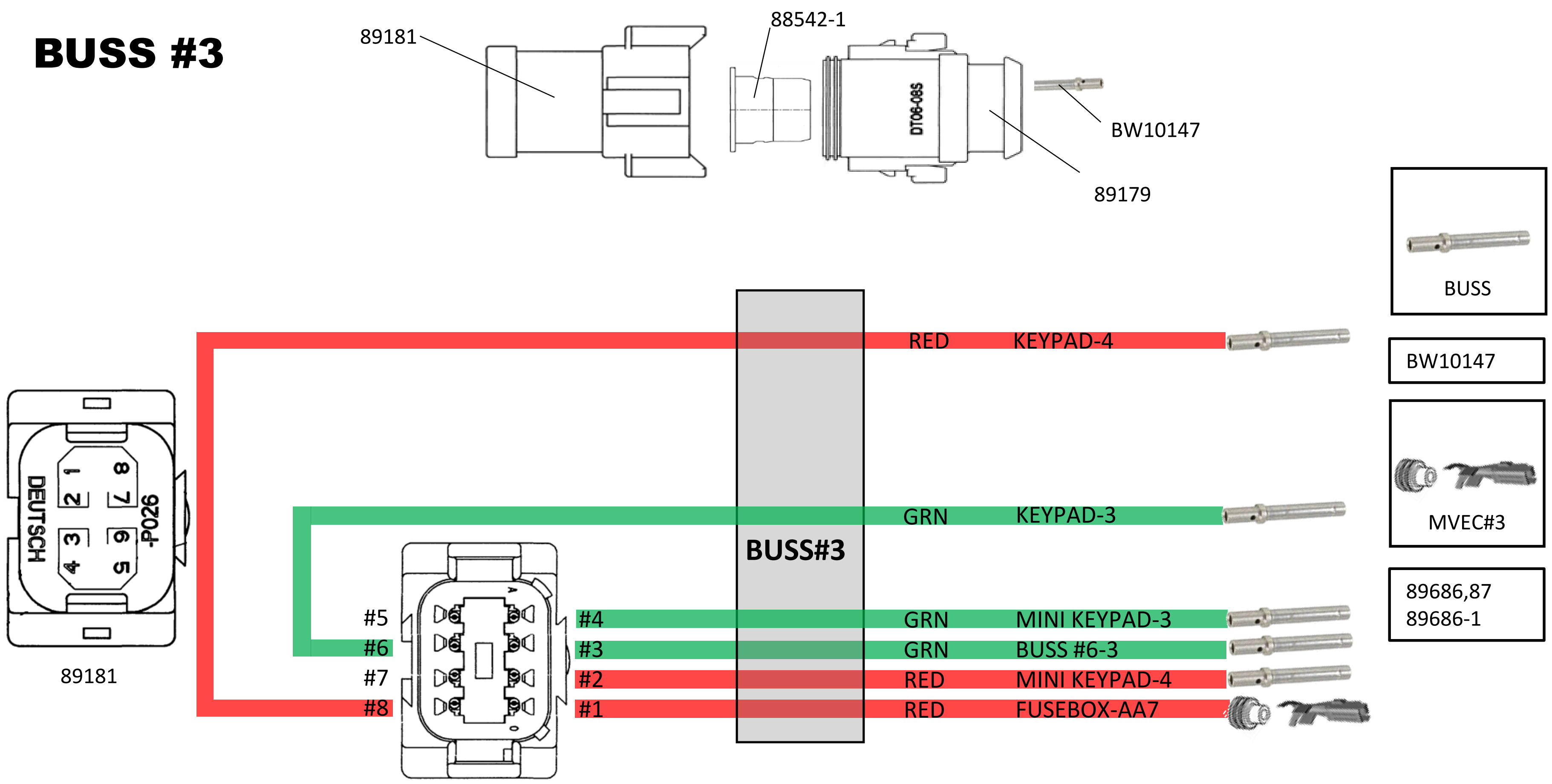

89181
88542-1
DT06-08S
BW10147
89179
DEUTSCH
-P026
1
2
3
4
5
6
7
8
89181
MD4 C1-2
REMOTE-F
REMOTE-E
MD4 C1-11
BUSS#1
#5
#6
#7
#8
#4
#3
#2
#1
MC42 C1-19
ENGINE-A
ENGINE-B
MC42 C1-3
88958
88959

BUSS #2

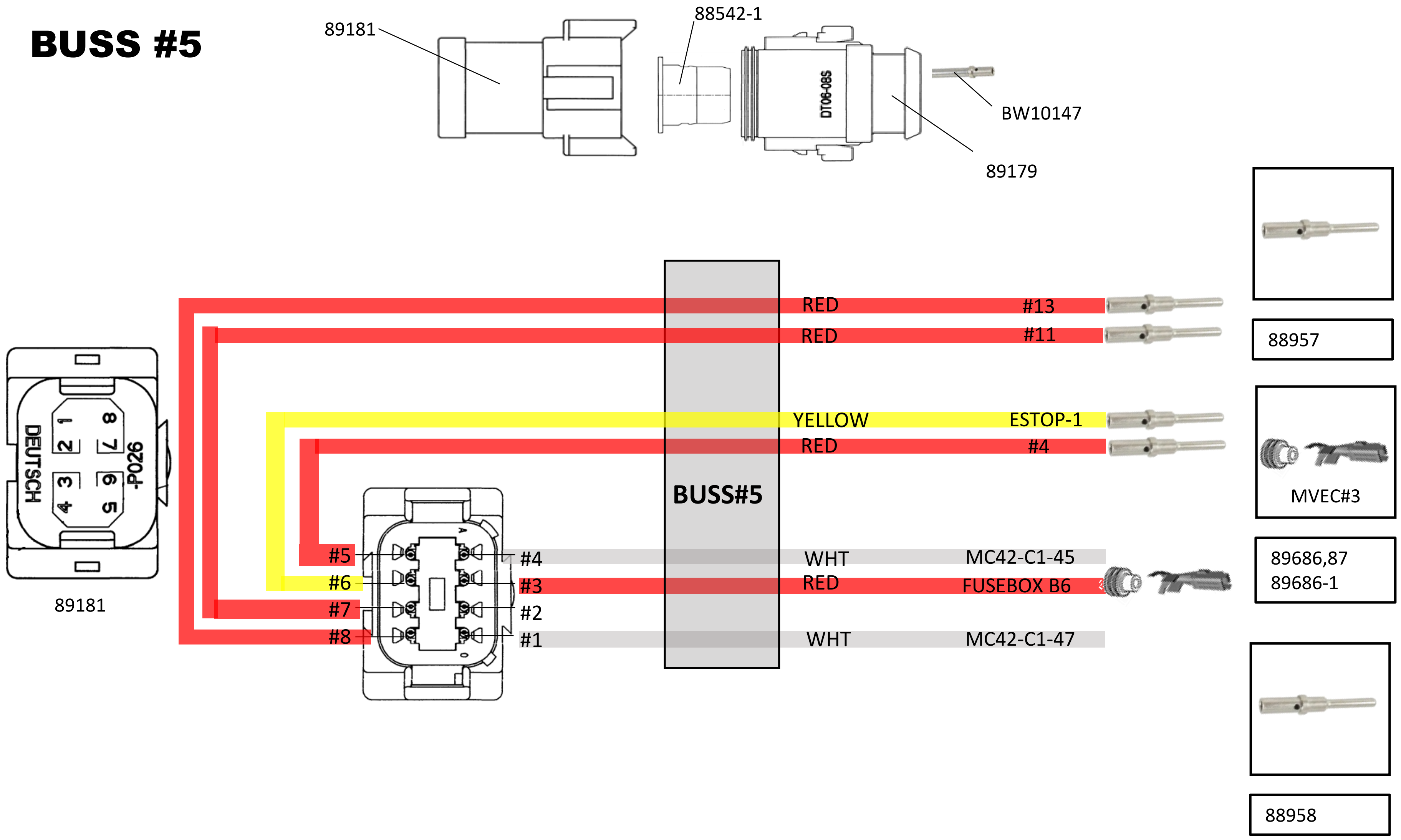

89181
88542-1
DT06-08S
BW10147
89179

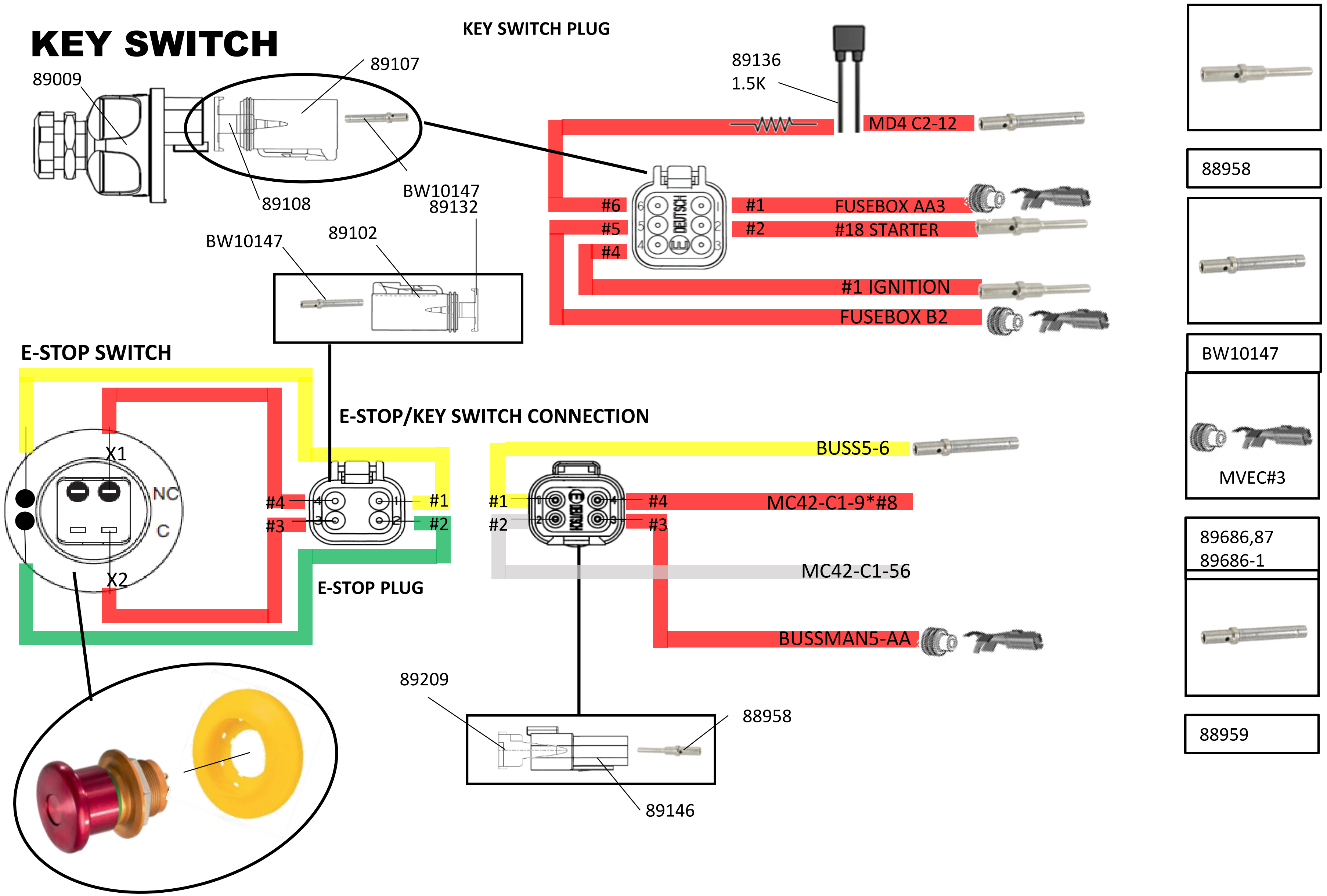

REMOTE-B
KEYPAD-1
REMOTE-A
KEYPAD-2
BW10147
DEUTSCH
-P026
89181
#5
#6
#7
#8
#4
#3
#2
#1
BUSS#2
MINI KEYPAD-2
MC42 C1-17
MINI KEYPAD-1
MC42 C1-1
88958

BUSS #3

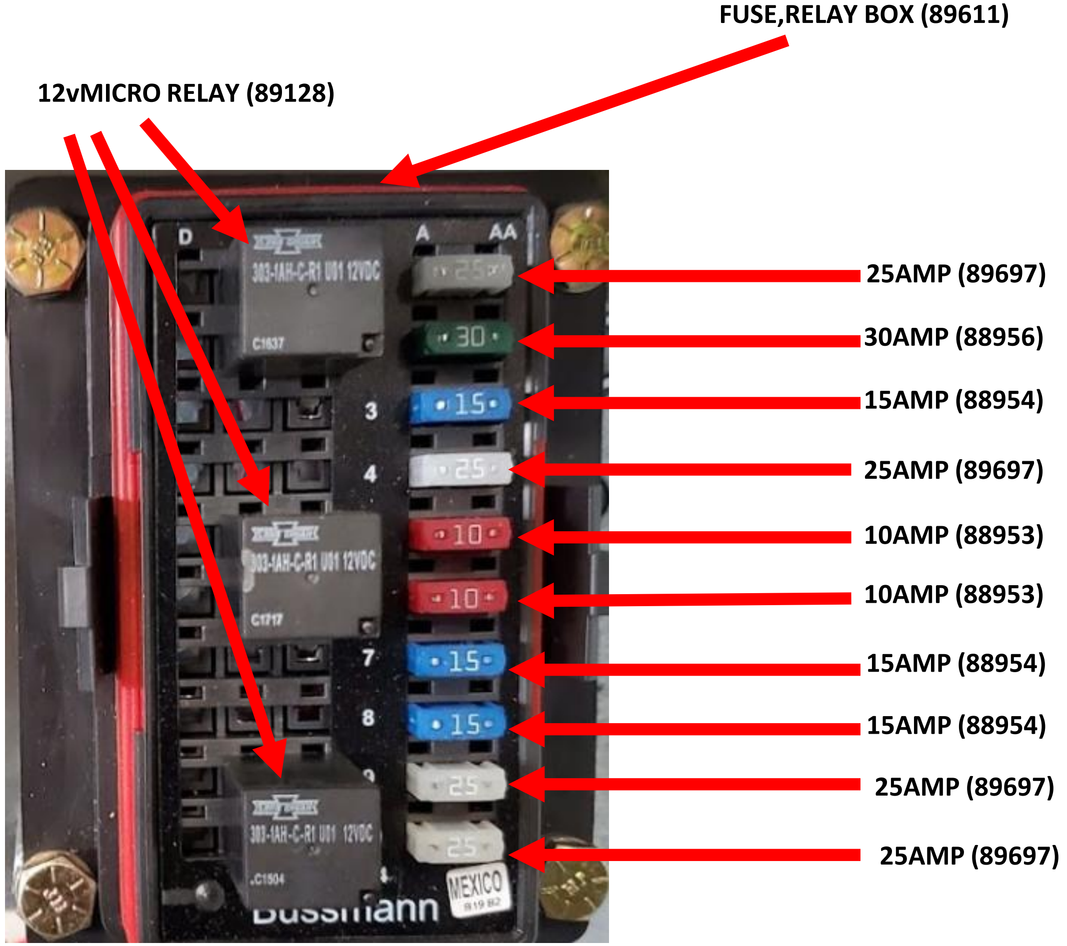

89181
88542-1
DT06-08S
BW10147
89179
BUSS
BW10147
MVEC#3
89686,87
89686-1
DEUTSCH
-P026
89181
BUSS#3
RED KEYPAD-4
GRN KEYPAD-3
#5 #4 GRN MINI KEYPAD-3
#6 #3 GRN BUSS #6-3
#7 #2 RED MINI KEYPAD-4
#8 #1 RED FUSEBOX-AA7

BUSS #5


89181
88542-1
DT06-08S
BW10147
89179
RED
#13
RED
#11
88957
YELLOW
ESTOP-1
RED
#4
MVEC#3
BUSS#5
DEUTSCH
-P026
89181
#5
#6
#7
#8
#4
#3
#2
#1
WHT
MC42-C1-45
RED
FUSEBOX B6
WHT
MC42-C1-47
89686,87
89686-1
88958


KEY SWITCH
89009
89107
89108
BW10147
89132
KEY SWITCH PLUG
89136
1.5K
MD4 C2-12
#6
#5
#4
#1
#2
FUSEBOX AA3
#18 STARTER
#1 IGNITION
FUSEBOX B2
BW10147
89102
E-STOP SWITCH
X1
NC
C
X2
E-STOP/KEY SWITCH CONNECTION
#4
#3
#1
#2
E-STOP PLUG
BUSS5-6
#1
#2
#4
#3
MC42-C1-9*#8
MC42-C1-56
BUSSMAN5-AA
89209
88958
89146
88958
BW10147
MVEC#3
89686,87
89686-1
88959

BUSSMAN CONTROL



FUSE DESCRIPTION

1 VIBRATOR

2 MAIN

3 KEY/IGNITION

4 SPARE RELAY

5 'E' STOP / PROX / GRATE

6 OUTRIGGER

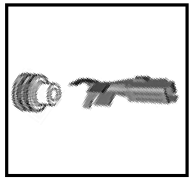
7 DISPLAY/KEYPAD

8 REMOTE

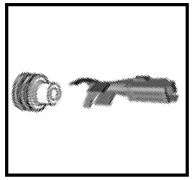
9 OIL COOLER / HORN

10 PLC(MC42) POWER

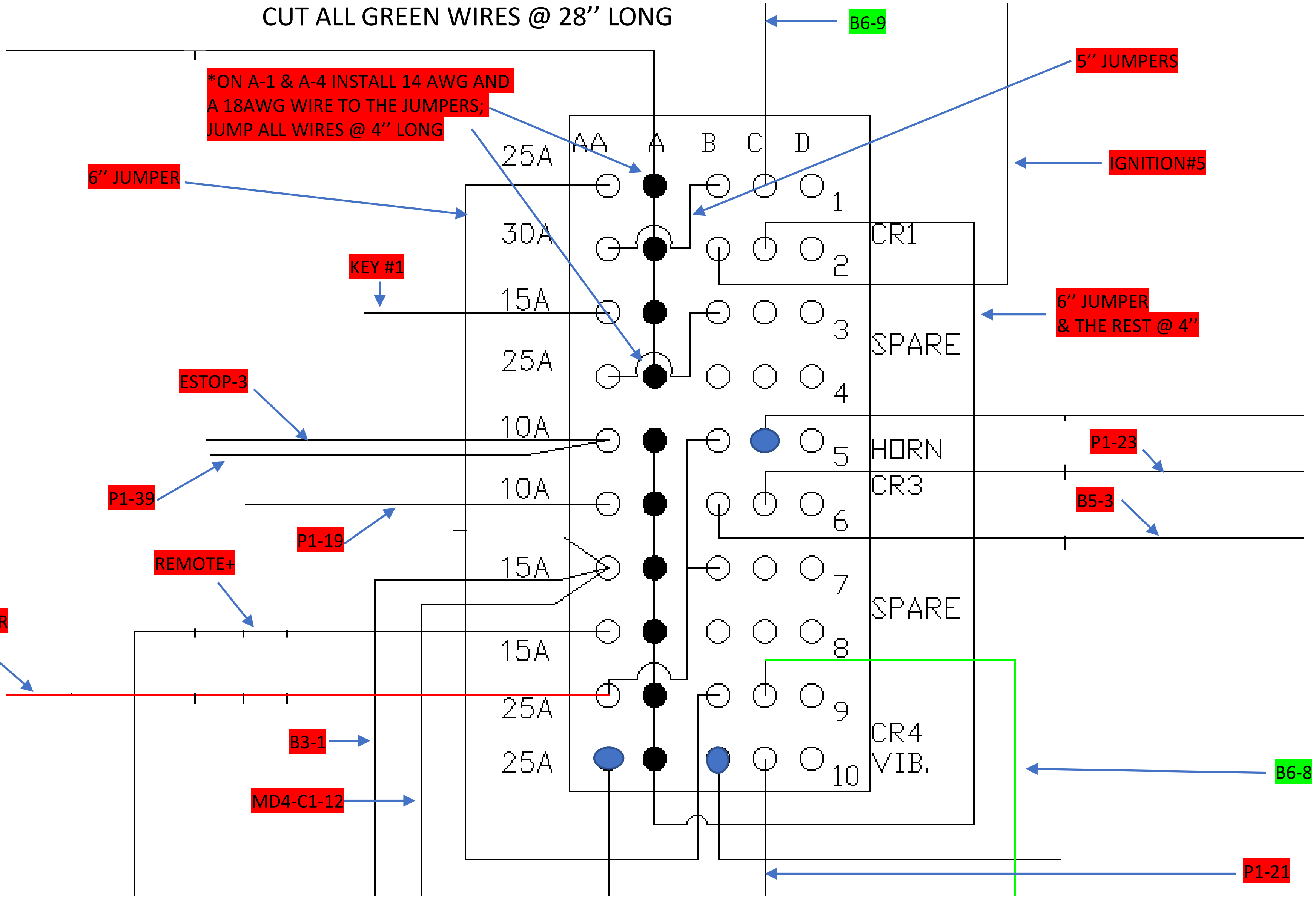
NOTE: ( ) THIS MEANS NO PINS @ THIS TIME!
CUT ALL RED WIRES @ 40'' LONG
CUT ALL GREEN WIRES @ 28'' LONG



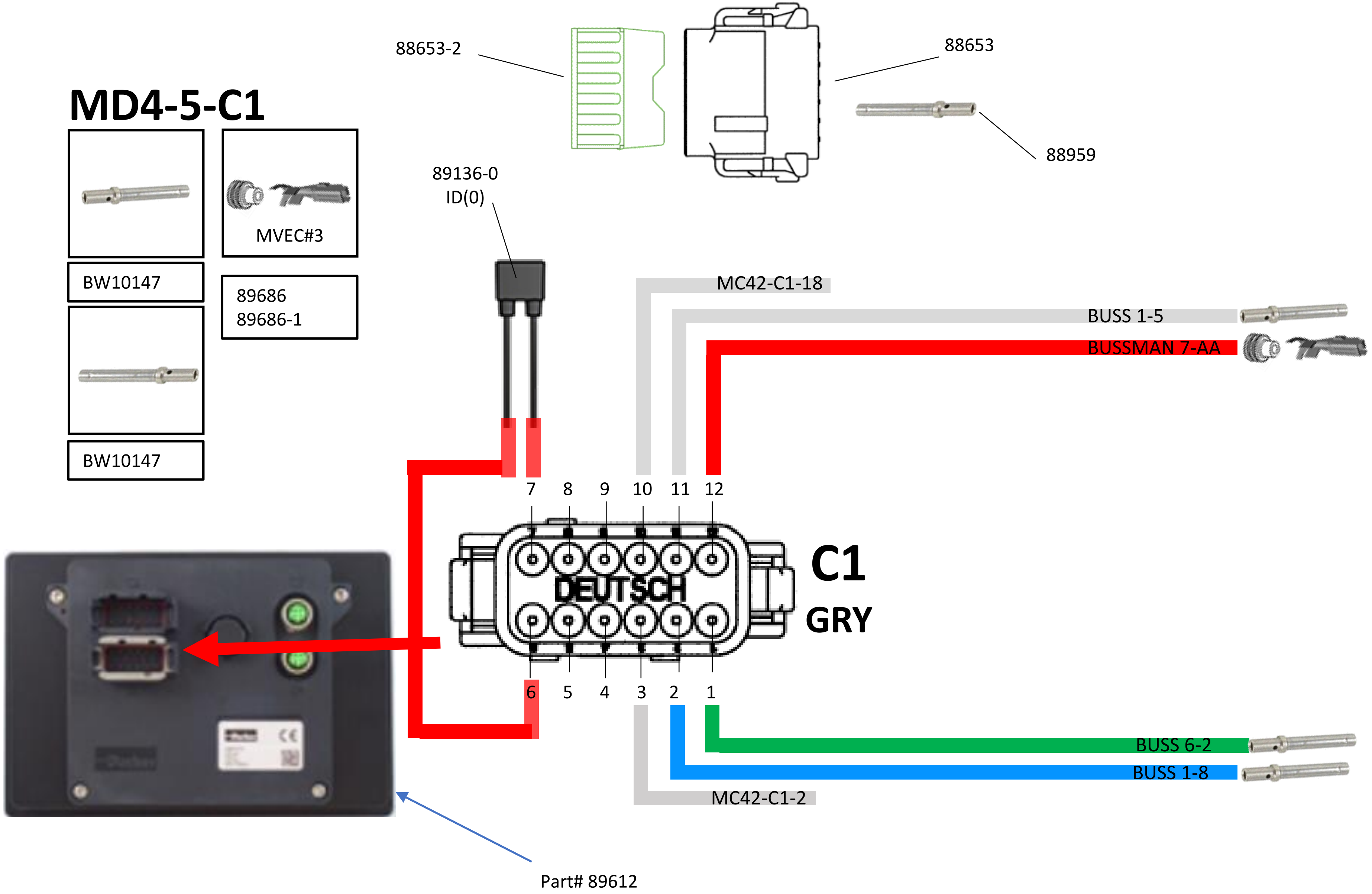
89686
89624-1



89687
89624-1

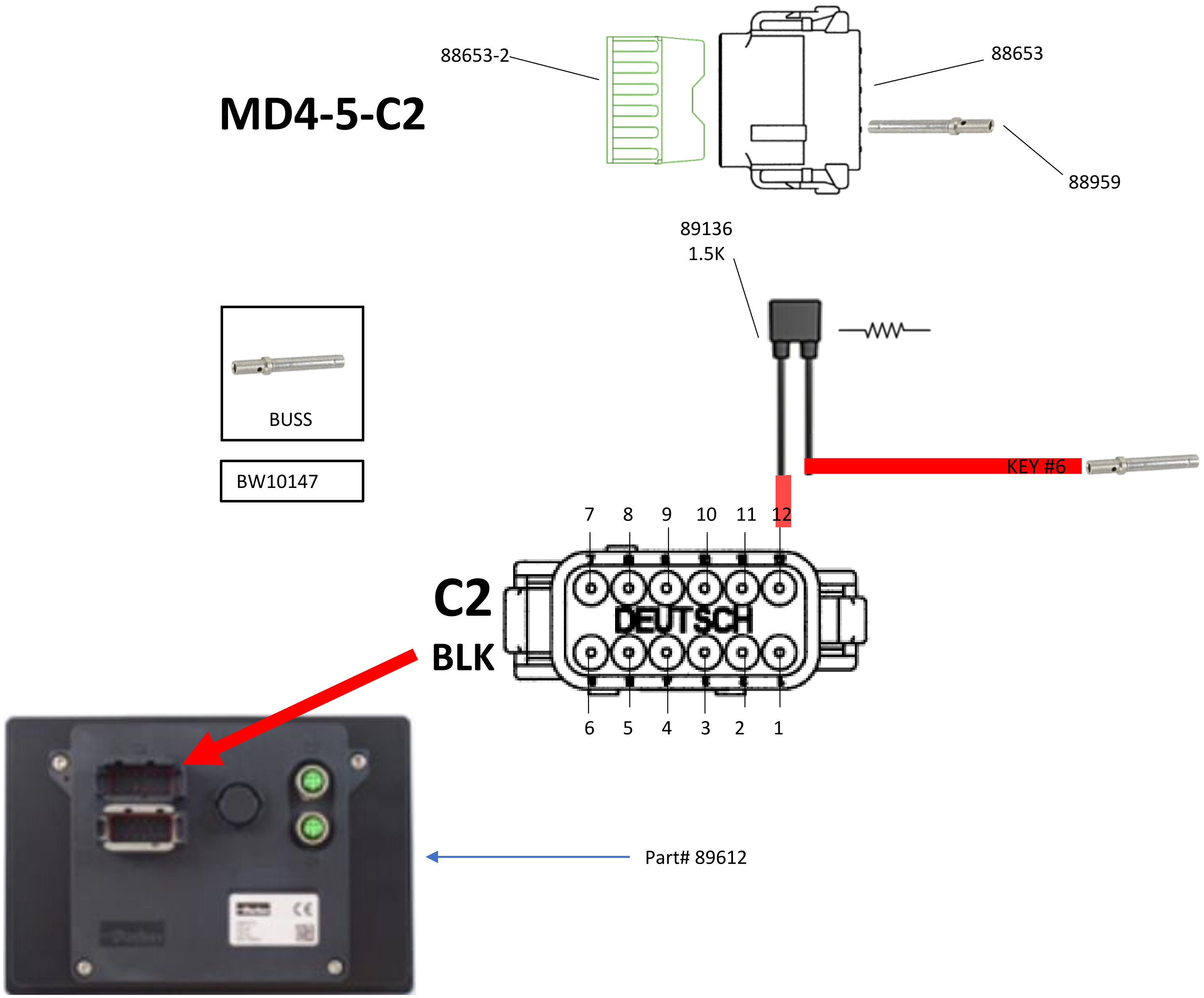


MD4-5-C1



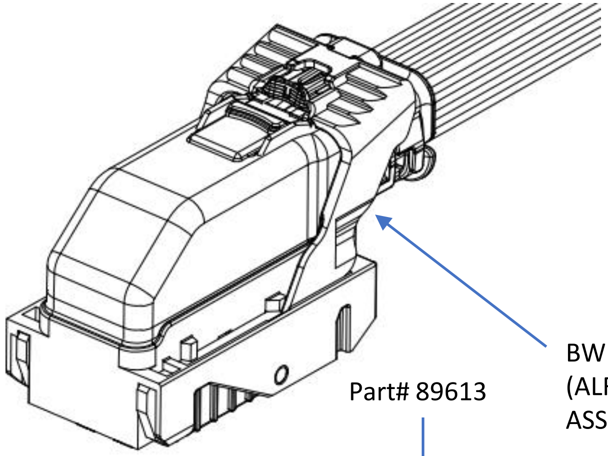
88653-2
88653
88959
89136-0
ID(0)
MVEC#3
BW10147
89686
89686-1
BW10147
MC42-C1-18
BUSS 1-5
BUSSMAN 7-AA
7
8
9
10
11
12
DEUTSCH
C1
GRY
6
5
4
3
2
1
BUSS 6-2
BUSS 1-8
MC42-C1-2
Part# 89612

MD4-5-C2



88653-2
88653
88959
89136
1.5K
BUSS
BW10147
KEY #6
7 8 9 10 11 12
C2
BLK
DEUTSCH
6 5 4 3 2 1
Part# 89612

MC42-C1

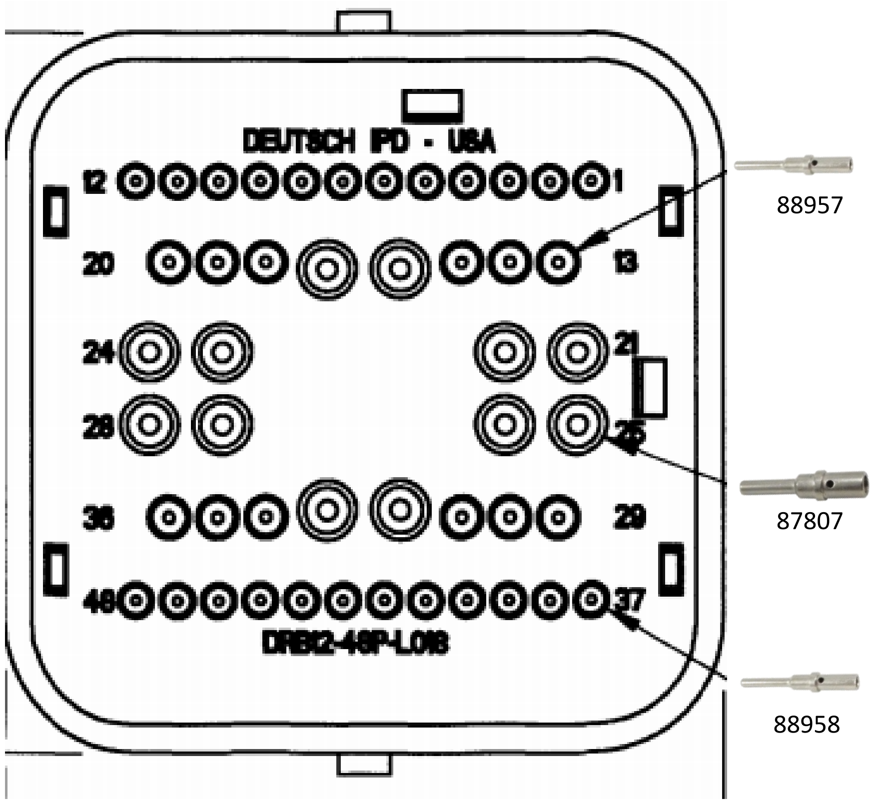


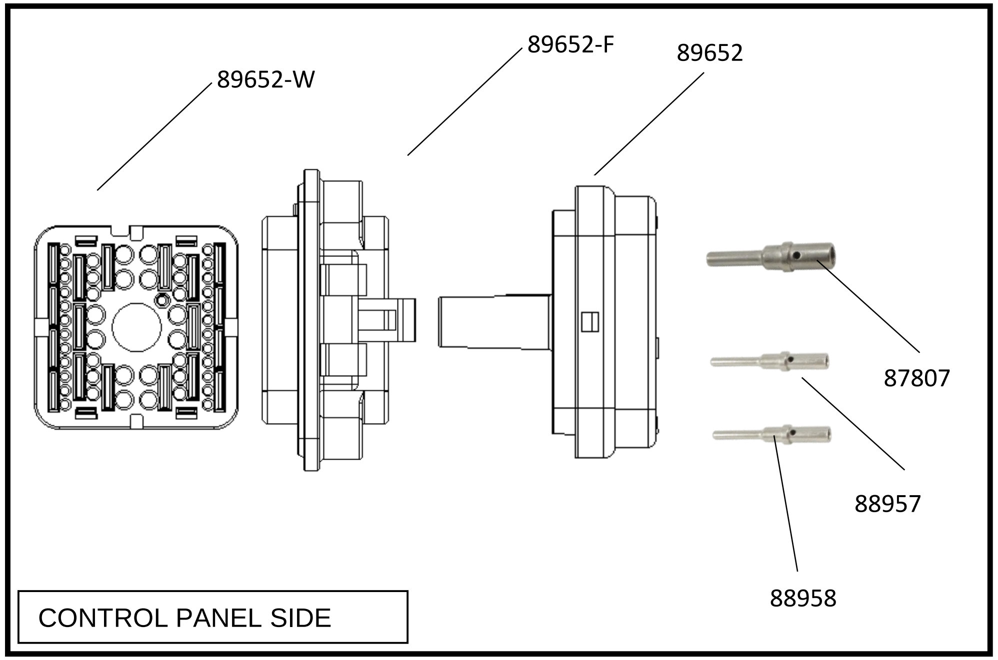
BW10547 (ALREADY PRE-ASSEBLED)

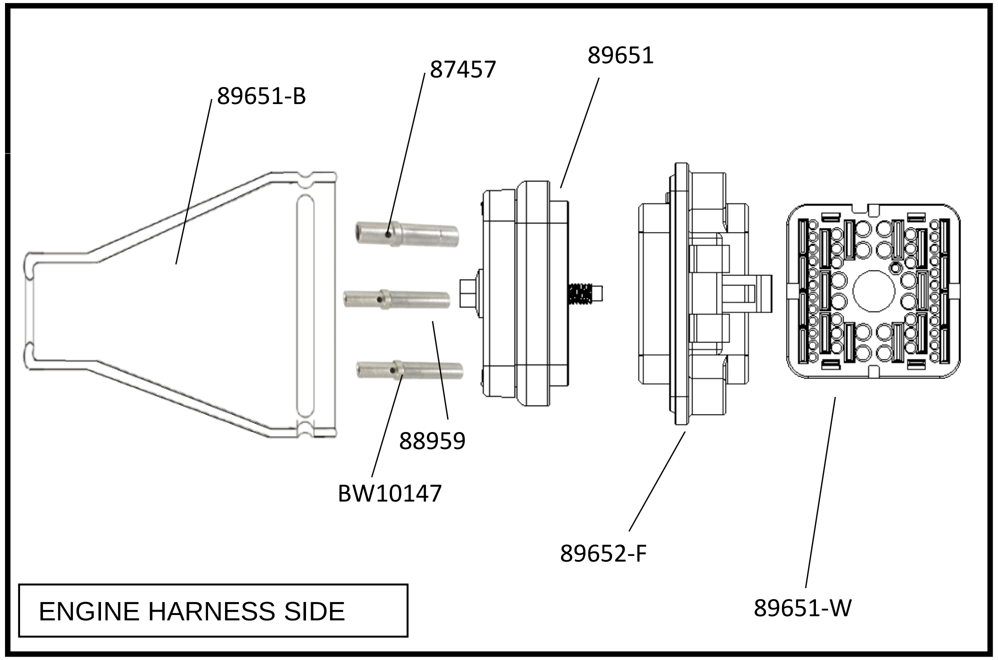
Part# 89613

MC42	Destination		MC42	Destination
C1: 1	BUSS 2- 1		C1: 37	P1-15
C1: 2	MD4 C1-3		C1: 38	N/A
C1: 3	BUSS 1-1		C1: 39	P1-6
C1: 4	ADRESSING RESIS. (1) W/ C1:20		C1: 40	FUSEBOX C-5
C1: 5	N/A		C1: 41	P1-3
C1: 6	N/A		C1: 42	P1-35
C1: 7	P1-42		C1: 43	P1-12
C1: 8	N/A		C1: 44	P1-30
C1: 9	ESTOP-4 * P1-8		C1: 45	BUSS 5-4
C1: 10	P1-41		C1: 46	P1-2
C1: 11	P1-37		C1: 47	BUSS 5-1
C1: 12	P1-45		C1: 48	FUSEBOX B-10
C1: 13	P1-9		C1: 49	N/A
C1: 14	N/A	MC-42	C1: 50	N/A
C1: 15	N/A	REV C	C1: 51	N/A
C1: 16	N/A	7/26/19	C1: 52	N/A
C1: 17	BUSS 2-4		C1: 53	N/A
C1: 18	MD4 C1-10		C1: 54	N/A
C1: 19	BUSS 1-4		C1: 55	P1-7
C1: 20	ADRESSING RESIS. (1) W/ C1:4		C1: 56	ESTOP-2
C1: 21	N/A		C1: 57	P1-38
C1: 22	N/A		C1: 58	P1-32
C1: 23	P1-46		C1: 59	P1-14
C1: 24	P1-43		C1: 60	P1-48
C1: 25	P1-44		C1: 61	N/A
C1: 26	N/A		C1: 62	P1-25
C1: 27	P1-10		C1: 63	P1-47
C1: 28	P1-5		C1: 64	N/A
C1: 29	N/A		C1: 65	FUSEBOX AA-10
C1: 30	P1-34		C1: 66	P1-17
C1: 31	N/A		NOTE:	
C1: 32	P1-29		28 WIRES TO P1	8 WIRES TO THE DOOR
C1: 33	N/A		14 WIRES NOT USED	3 WIRES TO FUSEBOX
C1: 34	N/A		2 WIRES TO BUSS 5	
C1: 35	N/A			
C1: 36	N/A			

DEUTSCH 48 PLUG







PIN	Description	PANEL	Size
	P1 MAIN PLUG		
1	IGN POWER	KEY:4	20
2	PUMP ON & ACCUM DUMP (Y2&Y4) V+	MC42 C1:46	20
3	PUMP ON GND (Y2)	MC42 C1:41	20
4	PUMP A & B V+	B5:5 (MC42 C1:45)	20
5	CHEM FLOW DETECT	MC42 C1:28	20
6	PUMP A GND	MC42 C1:39	20
7	PUMP B GND	MC42 C1:55	20
8	PROX A&B V+	ESTOP:4, C1:9	20
9	PROX A SIGNAL	MC42 C1:13	20
10	PROX B SIGNAL	MC42 C1:27	20
11	REVERSE (Y3) V+	B5:7 (MC42 C1:47)	20
12	REVERSE (Y3) GND	MC42 C1:43	20
13	REMIX DUMP (Y5) V+	B5:8 (MC42 C1:47)	16
14	REMIX DUMP (Y5) GND	MC42 C1:59	16
15	0-20mA current in	MC42 C1:37	16
16	BATTERY V+	FUSEBOX:A1	12
17	BATTERY GND	MC42 C1:66	12
18	ENGINE STARTER	KEY:2	16
19	OUTRIGGER V+	FUSEBOX:AA6	16
20	OUTRIGGER GND	B6:1	16
21	VIBR V+	FUSEBOX:C10	12
22	VIBR GND	P1:27**	12
23	HORN V+	FUSEBOX:C6	12
24	HORN GND	P1:27**	12

TIER4 A
48PIN PLUG
REV. B

23	HORN V+	FUSEBOX:C6	12
24	HORN GND	P1:27**	12
25	OPTION OUTPUT 1 +	MC42 C1: 62	12
26	COOLING FAN GND	P1:27**	12
27	BATTERY GND	P1:22, P1:24, & P1:26	12
28	BATTERY V+	FUSEBOX:A1	12
29	PUMP VOL V+	MC42 C1:32	16
30	PUMP VOL GND	MC42 C1:44	16
31	PROX A&B GND	B6:7	16
32	OPTION OUTPUT 1 GND	MC42 C1: 58	12
33	BATTERY GND	B6:4	12
34	CHEM VOLUME +	MC42 C1:30	16
35	CHEM VOLUME GND	MC42 C1: 42	16
36	COOLING FAN V+	FUSEBOX:AA9	16
37	CHEM HOSE LEAK	MC42 C1:11	20
38	ACCUM DUMP (Y4) GND	MC42 C1:57	20
39	GRATE SWITCH V+	FUSEBOX:AA5	20
40	GRATE SWITCH GND	B6:6	20
41	GRATE SWITCH SIGNAL	MC42 C1:10	20
42	VREF (5V) +	MC42 C1:7	20
43	ANALOG 1	MC42 C1:24	20
44	ANALOG 2	MC42 C1: 25	20
45	CHEM MOTOR SPEED INPUT	MC42 C1:12	20
46	VREF (5V) -	MC42 C1: 23	20
47	OPTION OUTPUT 2 V+	MC42 C1: 63	20
48	OPTION OUTPUT 2 GND	MC42 C1: 60	20

A40HP TIER 4

PARTS

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REV	DATE	DESCRIPTION	NAME
A40HP-V15-TIER-4	7/7/19	INITIAL	J. SLACK

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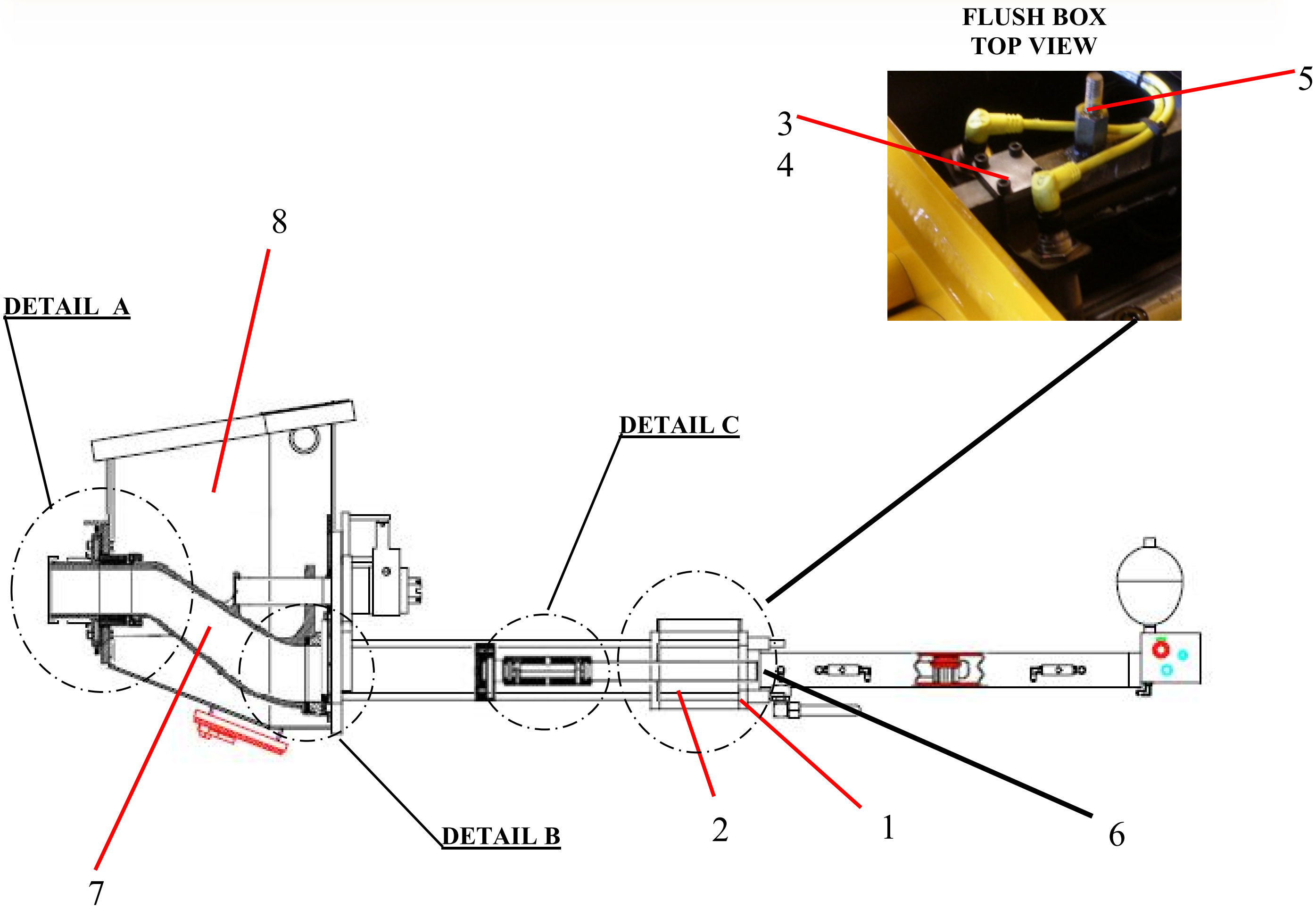
PUMPING TRAIN ASSEMBLY



ID #	PART #	PART DESCRIPTION	QUANTITY	
	BW28045-5	PUMP CELL ASSEMBLY A40 W/SAFTY SWITCH, JARP-HYDATECH		REF
1	10282	PLUGS-PIPE GALV 1”	1	EA
2	BW10368	FLUSH BOX WELDMENT, A40	1	EA
3	BW10102	BRACKET, PROX SWITCH	1	EA
4	BW10383	BRACKET, PROX SWITCH	1	EA
5	BW10193	STUD, 3/8-16 X 2” LONG	1	EA
6	BW10379	SPACER, TIE ROD, A40	2	EA
7	BW10391	S TUBE WELDMENT, 6X5 A40	1	EA
8	BW10363A	HOPPER, WELDMENT A40 SAFETY SWITCH	1	EA

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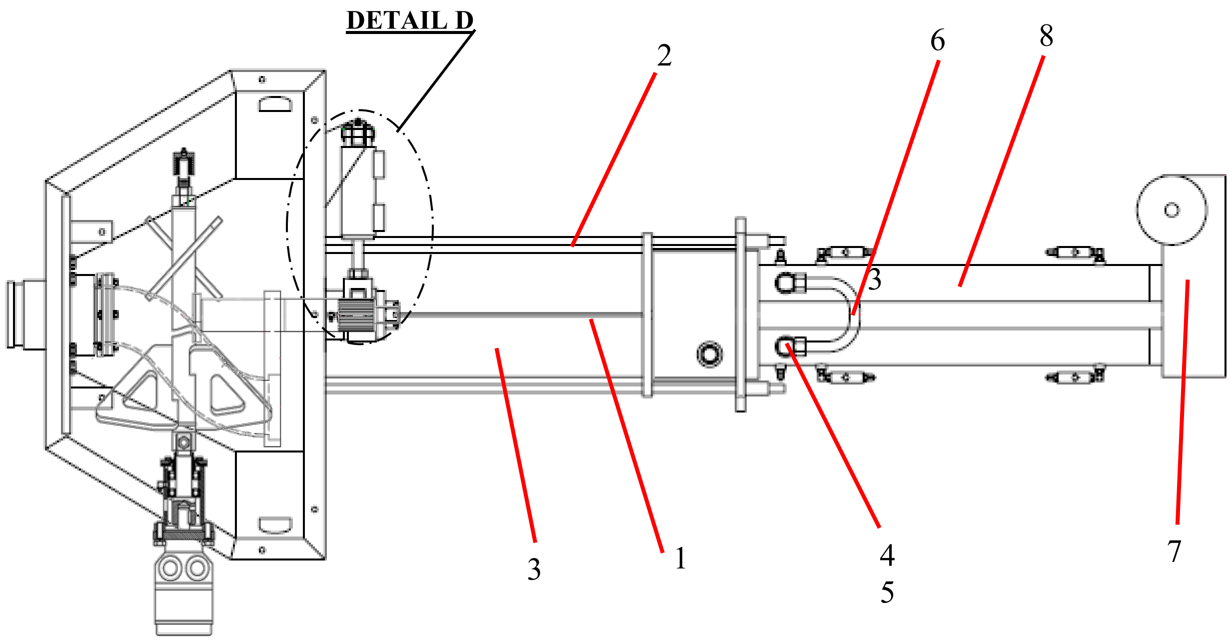
PUMPING TRAIN ASSEMBLY CONTINUED



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	BW10380	TIE ROD, SHORT, A40	4	EA
2	BW10381	TIE ROD, LONG, A40	2	EA
3	BW10376	CONCRETE CYLINDER, 6” X 30” A40	2	EA
4	86728-023	ELBOW, MB – MJ90-16-16	2	EA
5	87786	O-RING-348 BUNA 70	2	EA
6	BW10394	TUBE, HYD, LOOP LINE, A40	1	EA
7	BW10395	MANIFOLD CONTROL W/CARTRIDGES, A40	1	EA
8	BW10373HT	DRIVE CYLINDER 3.75 X 2.00 X 30.00 (HYDRATECH)	REF	

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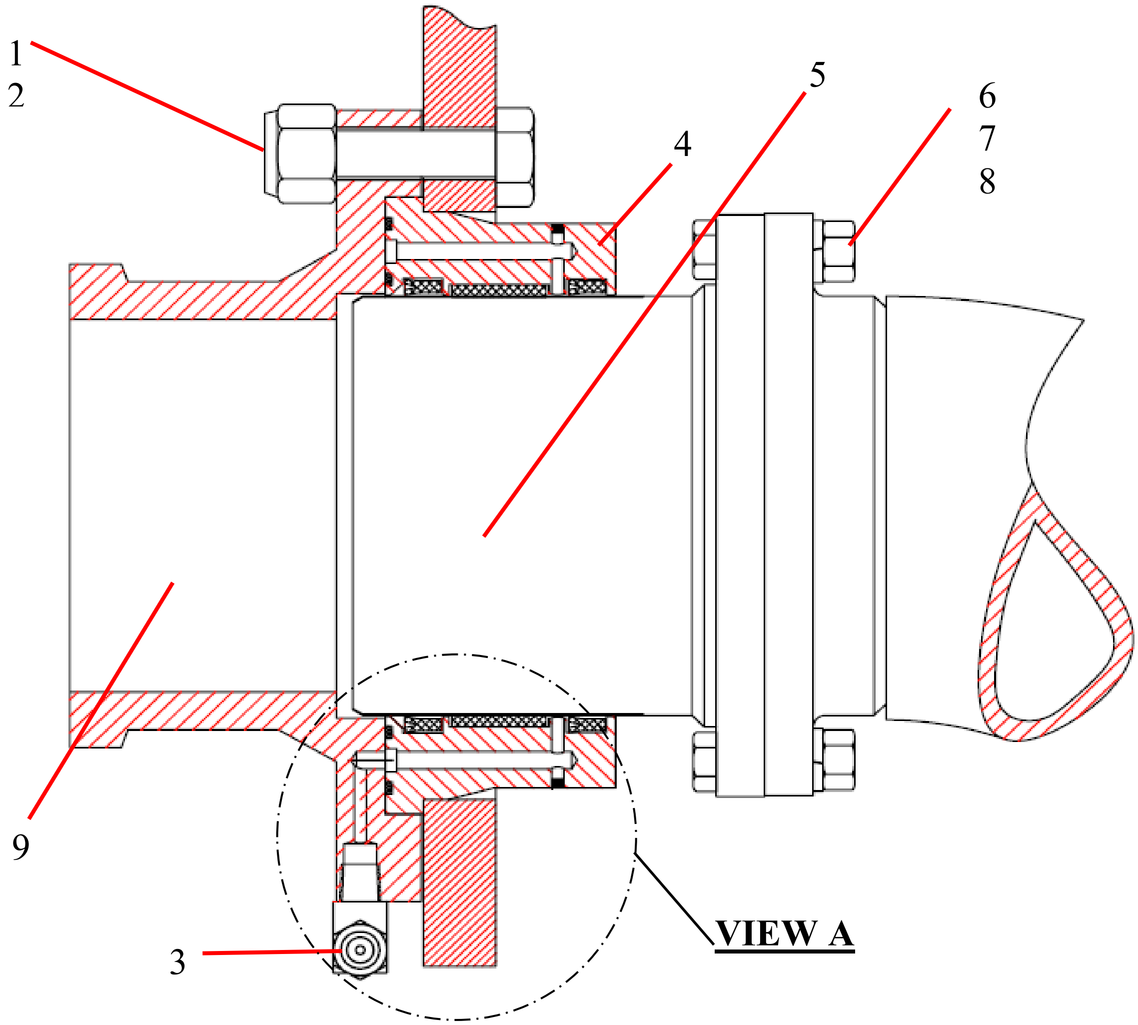
S-TUBE ASSEMBLY
5” OUTLET ASSEMBLY

DETAIL A



ID #	PART #	PART DESCRIPTION	QUANTITY	
	86321	OUTLET ASSEMBLY	1	EA
1		HHCS, 5/8-18 x 3” GR/8	6	EA
2		LOCK NUT, 5/8-18	6	EA
3		GREASE FITTING, 1/8” NPT 90°	2	EA
4	72309	OUTLET SEAL HOUSING	1	EA
5	70042	WELD. -CHROMED OUTLET	1	EA
6		HHCS, 3/8 – 16 X1 ½” GR 8	6	EA
7		HEX NUT, 3/8” - 16	6	EA
8		LOCK WASHER, 3/8”	6	EA
9	72482	OUTLET, 5" (1-PIECE)	1	EA

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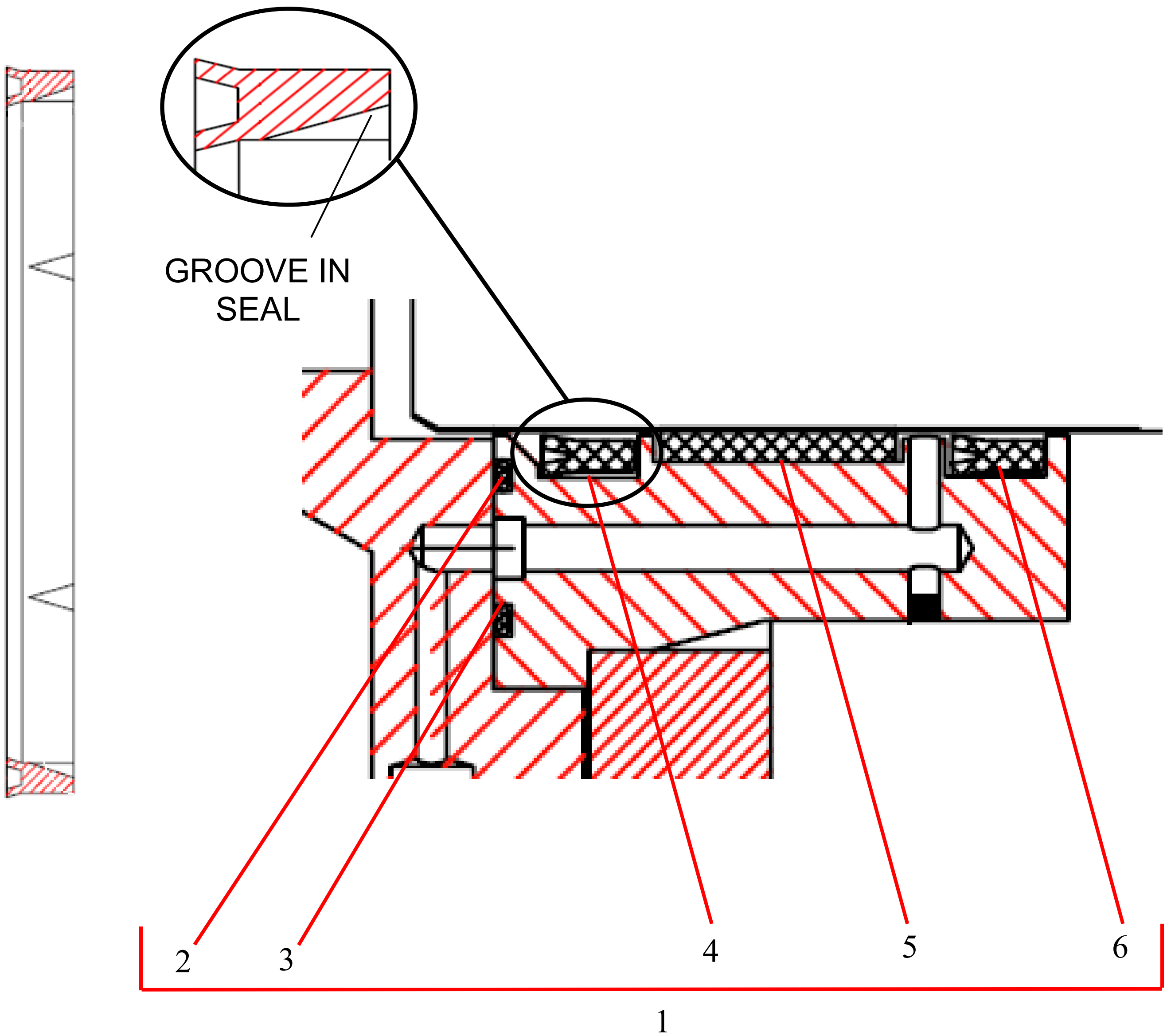
5" OUTLET SEAL KIT INSTALLATION

VIEW A



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	79895	SEAL KIT	1	EA
2	77762	O-RING-#257 BUNA 90	1	EA
3	77761	O-RING-#264 BUNA 90	1	EA
4	86504	SEAL-MODIFIED- 5 IN OUTLET	1	EA
5	77763	GUIDE BAND – 5.375 OD X 1.00W	1	EA
6	77765	LIP SEAL -5.50 ID X 6.00 OD X..56	1	EA

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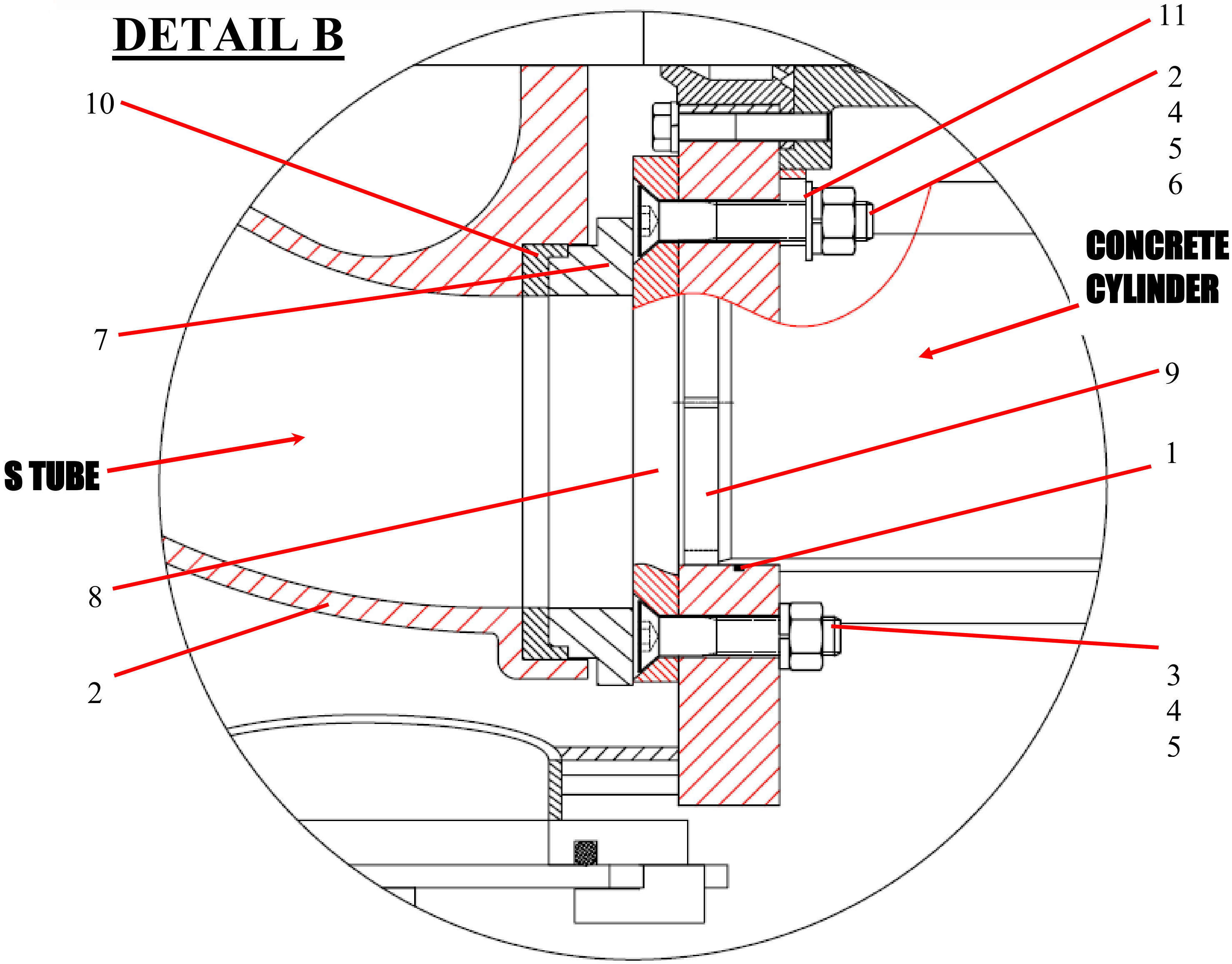
WEAR PLATE ASSEMBLY



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	86149	O-RING, #259 BUENA 70	1	EA
2		FHCS, ¾ - 10X 4½" GR 8	1	EA
3		FHCS, ¾ - 10X 3½" GR 8	3	EA
4		HEX NUT, ¾" - 10	4	EA
5		LOCK WASHER, ¾"	4	EA
6		FLATWASHER, ¾"	4	EA
7	72310	WEAR RING, CHROME, 6"-26% MACH'D	1	EA
8	BW10382	WEAR PLATE 6" A40 SELL W/2EA 86086 CHIP RING	1	EA
9	86086	CHIP RING, 6"	2	EA
10	86085	SEAL, SINGLE LIP, 6"	1	EA
11	86502	LOCATOR RING – FLANGE BEARING	1	EA

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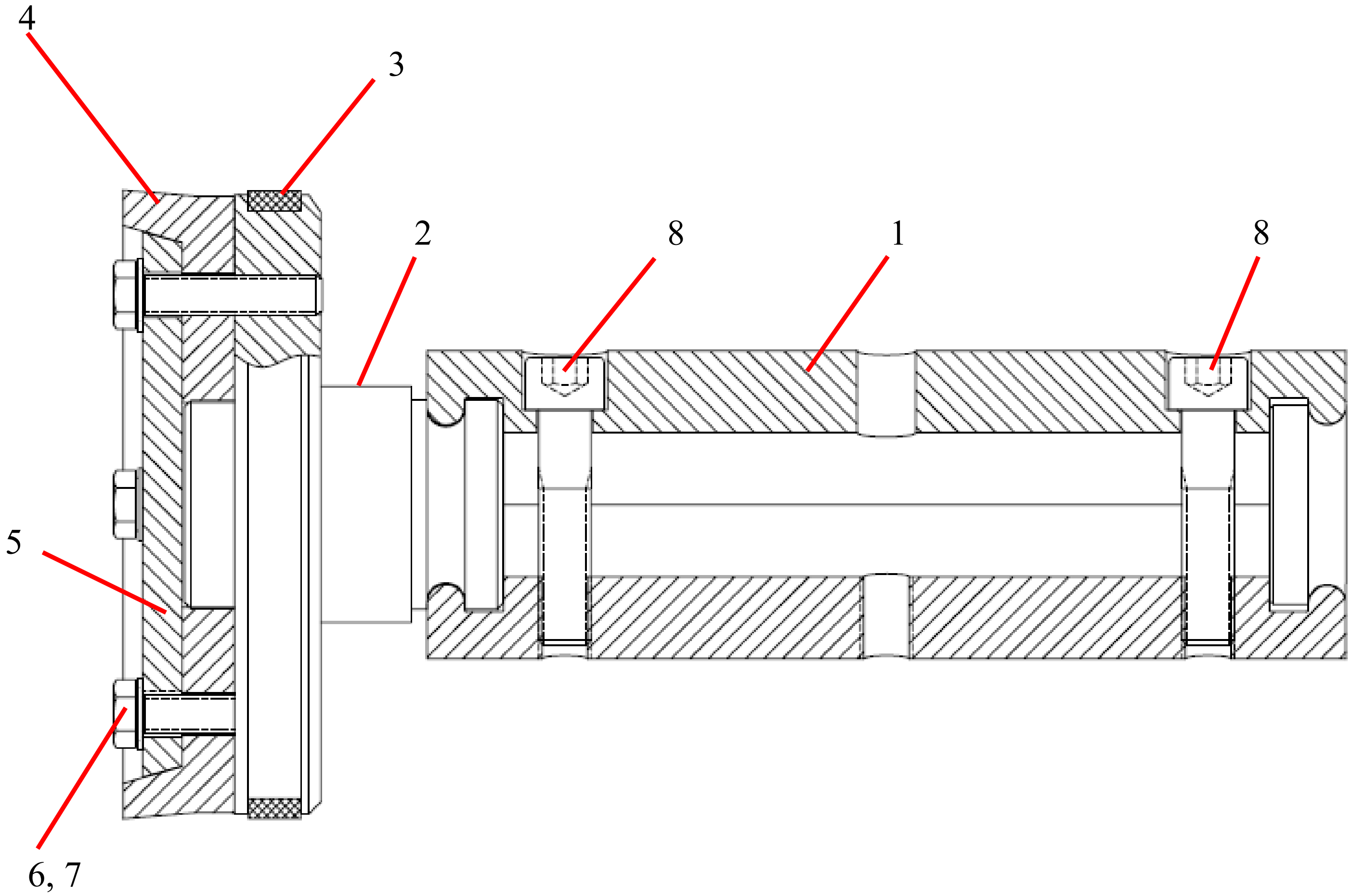
6” PISTION CUP ASSEMBLY

DETAIL C



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	73425	PISTON COUPLING	1	E/SIDE
2	77194	PISTON ADAPTER 6"	1	E/SIDE
3	77120	WEAR RING (GUIDE BAND) 6"	1	E/SIDE
4	70048	PISTON CUP, 6 IN.	1	E/SIDE
5	70057	PISTON PLATE 6”	1	E/SIDE
6		HHCS, 3/8-24 x1 3/4”” GR 8	4	E/SIDE
7		INTERNAL LOCKWASHER 3/8	4	E/SIDE
8		SHCS ½ - 20 x 2 ¼”	2	E/SIDE

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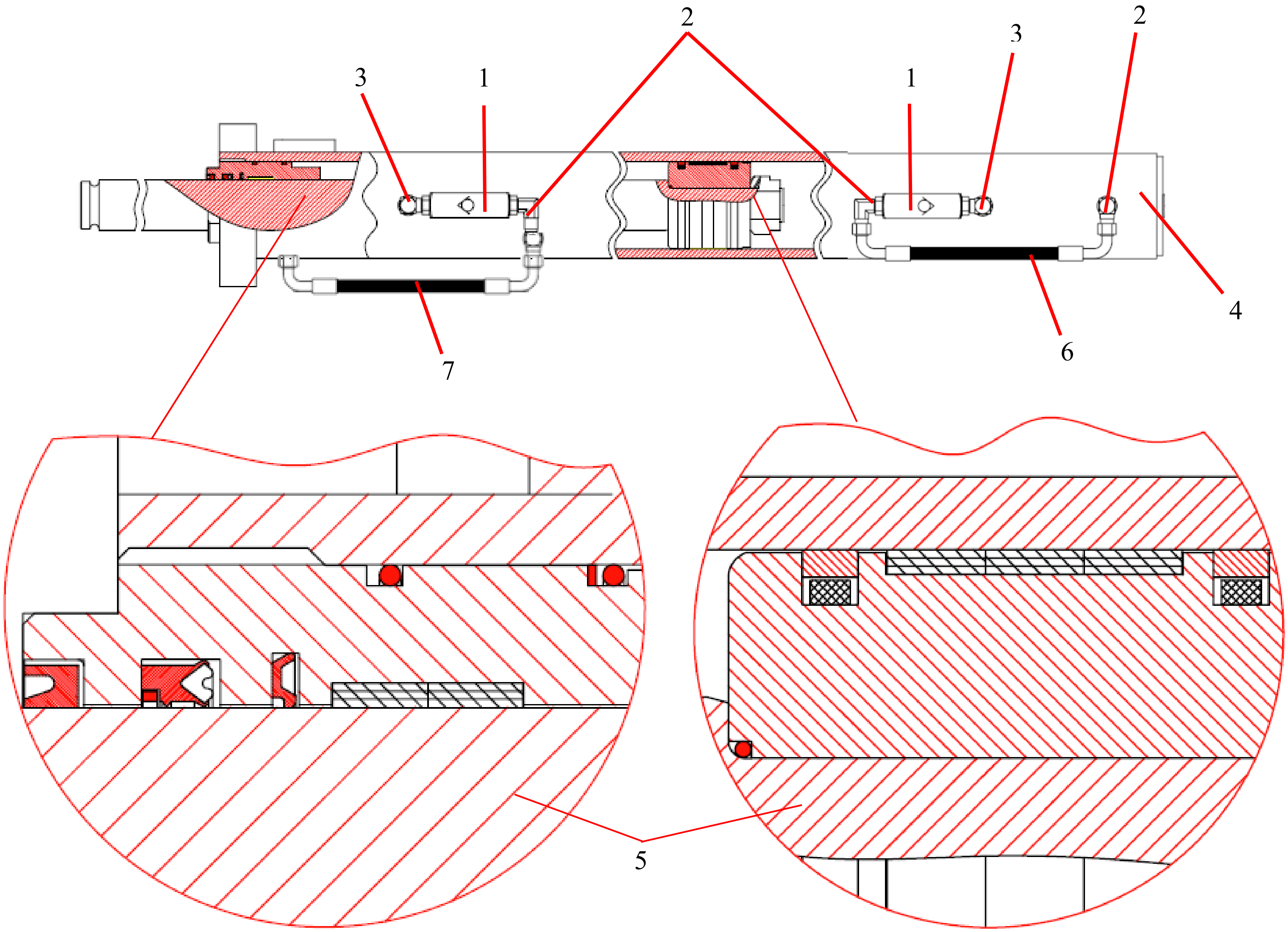
DRIVE CYLINDER ASSEMBLY



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	78961	CHECK VALVE-5K PSI O-RING	1	EA/SIDE
2	86748	FITTING-MB-MJ90-6-6	3	EA/SIDE
3		ELBOW, MB-MB90-6-6	1	EA/SIDE
4	BW10373HT	DRIVE CYL-3.75 X 2.00 X 30.00 (HYDRATECH)	1	EA/SIDE
5	BW10373A-SK	SEAL KIT FOR BW10373HT CYL	1	EA/SIDE
6	BW10051	HOSE-RT2-FJS90-FJS09-06-06-06-12”	1	EA/SIDE
7	BW10405	HOSE-RT2-FJS90-FJS09-06-06-06-14”	1	EA/SIDE

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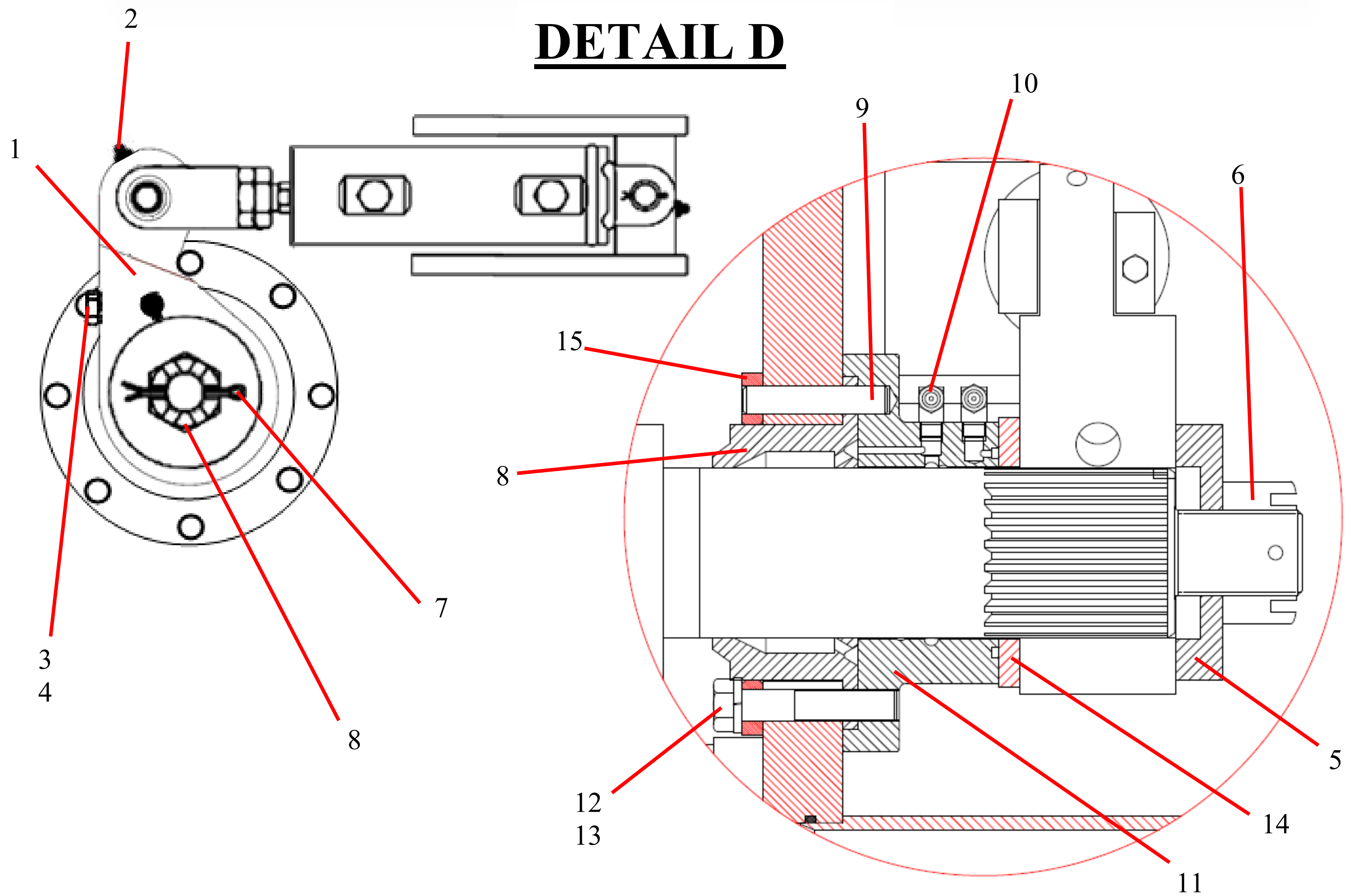
SINGLE SHIFT BELL CRANK ASSEMBLY



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	85131	BELL CRANK, 3 IN SPLINE, SINGLE	1	EA
2		GREASE FITTING, 1/8” NPT 45°	1	EA
3		HHCS, ¾ x 4” GR 8	1	EA
4		LOCK WASHER, ¾”	1	EA
5	85134	SPACER, S-TUBE NUT	1	EA
6	70825	NUT 1 ½” - 12 CASTLE	1	EA
7		COTTER PIN, ¼ x 4”	1	EA
8	85962	SEAL, FLANGE BEARING, 3” SHAFT	1	EA
9		DOWEL PIN, ½” DIA x 2”	2	EA
10		GREASE FITTING, 1/8” NPT	2	EA
11	85133	FLANGED BEARING, 3 IN SPLINE	1	EA
12		HHCS, 9/16 – 12x3” GR 8	4	EA
13		LOCK WASHER, 9/16”	4	EA
14	85294-1	THRUST WASHER, S –TUBE (NYLON)	1	EA
15	BW10384	SPACER RING A40	1	EA

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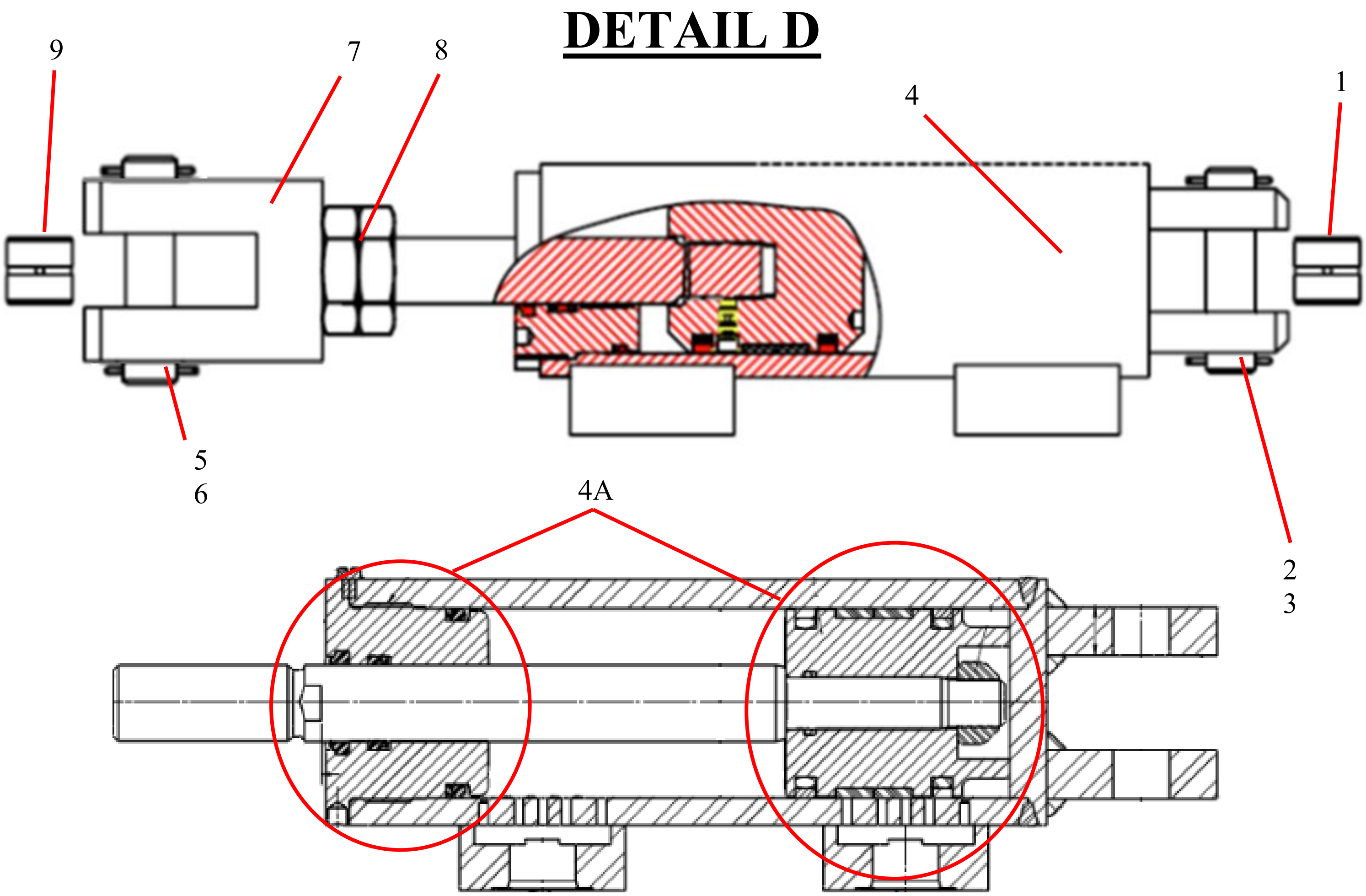
SINGLE SHIFT SWING CYLINDER ASSEMBLY



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	71011	BUSHING - SHIFT CYLINDER	1	EA
2	74207	PIN - CLEVIS - .750 DIA	1	EA
3		COTTER PIN, 3/32X1 ¾”	2	EA
4	BW10374HT	SWING CYLINDER – 2.50 X 1.00 X 5.15 HYDRATECH	1	EA
4A	86221A-SK	SEAL KIT FOR BW10374HT	1	EA
5	86150	PIN, CLEVIS 1.00 DIA	1	EA
6		COTTER PIN, 1/8X2.00	2	EA
7	86135	CLEVIS, SHIFT CYLINDER	1	EA
8		1”X14 JAM NUT	2	EA
9	85538	BUSHING, SHIFT CYLINDER	1	EA

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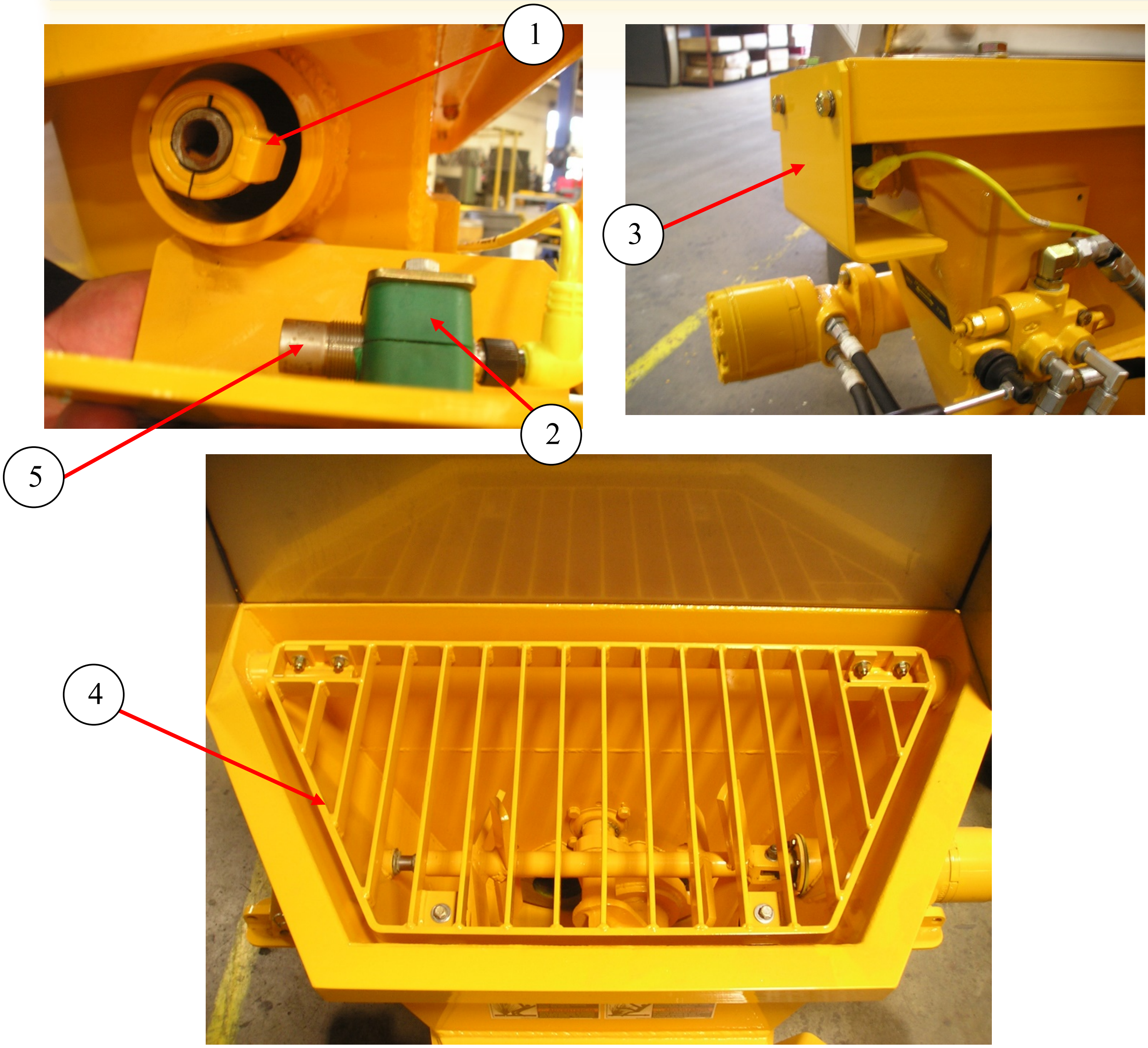
HOPPER GRATE WITH SAFETY SWITCH



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	87769	COLLAR SHAFT, 7/8” DIA	1	EA
2	801902-006	CLAMP, 18MM TUBE CLAMP SET	1	EA
3	87997	COVER WELD PROX SWITCH HOPPER	1	EA
4	BW10416	GRATE WELDMENT, A SER STD HOPPER	1	EA
5	87369	PROXIMITY SENSOR PMP	1	EA

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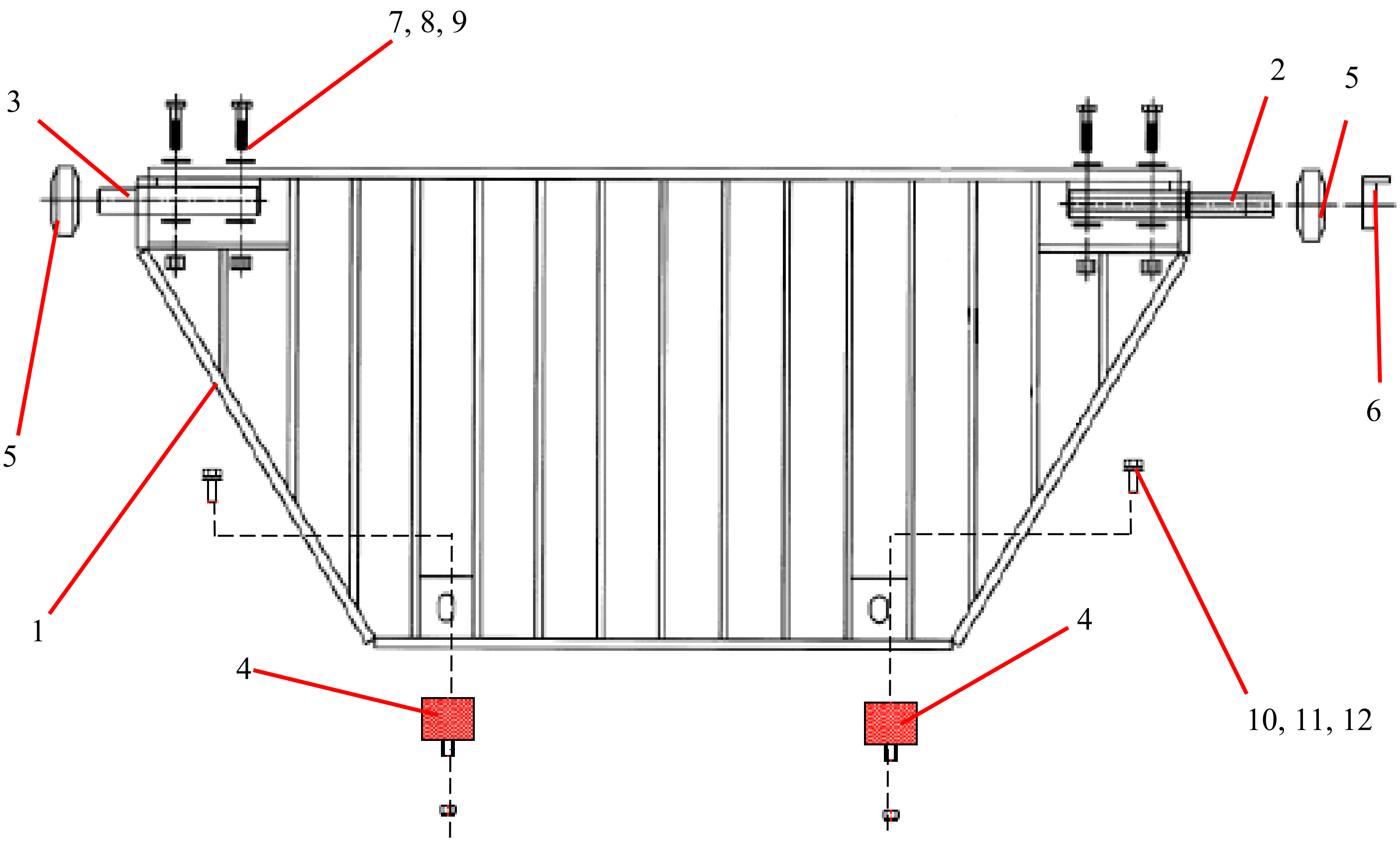
GRATE ASSEMBLY



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	BW10416	GRATE WELDMENT, A SER STD HOPPER		REF
2	87857	PIN WELDMENT LONG	1	EA
3	87858	PIN WELDMENT SHORT	1	EA
4	86083	BUMPER, HOPPER GRATE	2	EA
5	W-114850	RUBBER BUFFER 65X22.5X26	2	EA
6	87769	COLLAR SHAFT, 7/8” DIA	1	REF
7		3/8”-16 X 1 ¼” HEX BOLT	4	EA
8		3/8 FLAT WASHER	8	EA
9		3/8-16 LOCK NUT	4	EA
10		3/8”-16 X 1” HEX BOLT	2	EA
11		3/8” FLAT WASHER	2	EA
12		3/8” LOCK WASHER	2	EA

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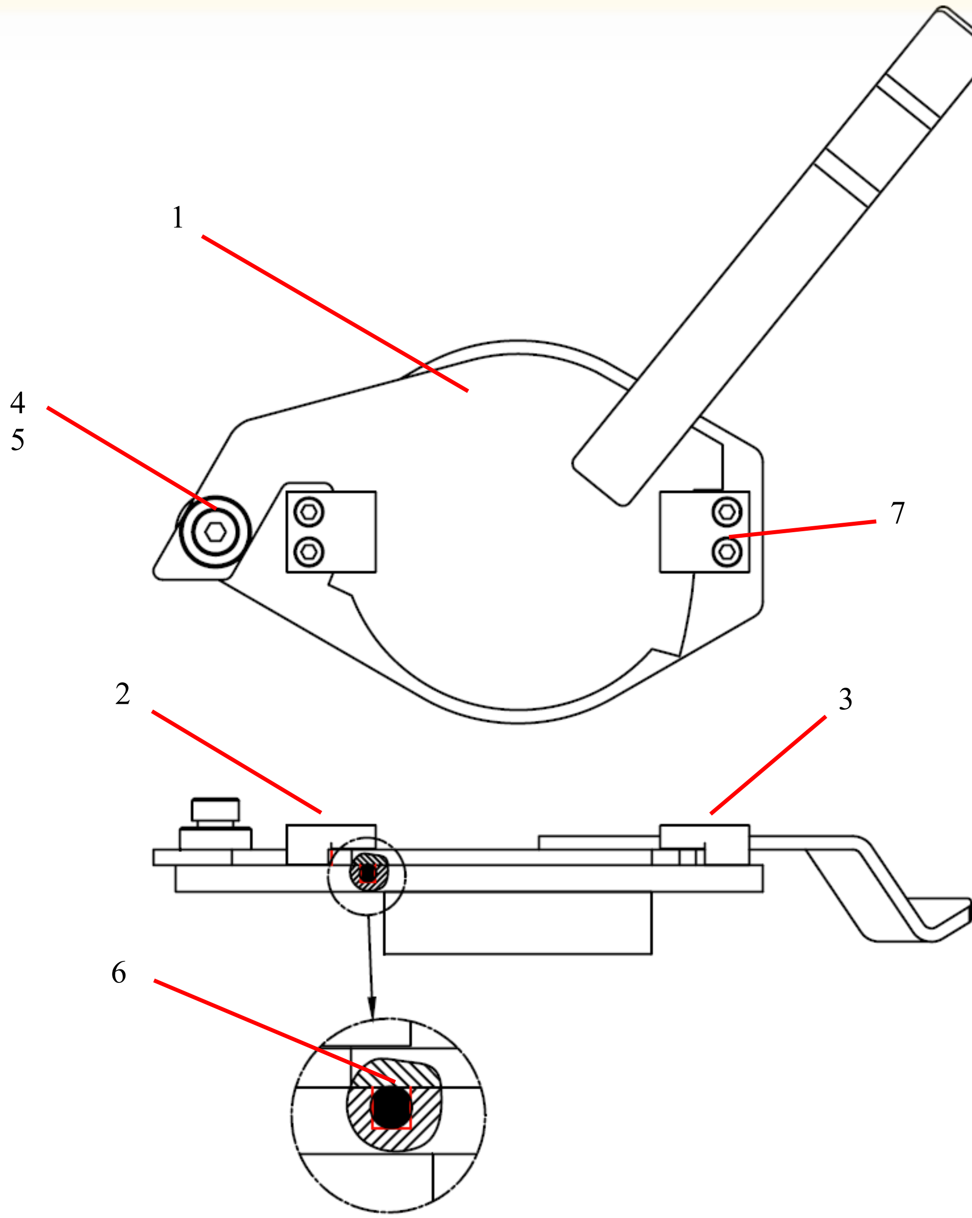
CLEAN OUTDOOR ASSEMBLY



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	85370	DOOR WELDMENT, CLEAN OUT	1	EA
2	86559	BLOCK, CLEAN OUTDOOR, LH	1	EA
3	86560	BLOCK, CLEAN OUTDOOR, RH	1	EA
4		SHOULDER SCREW 1" DIA-1 1/4"	1	EA
5	85367	BOSS, CLEAN OUTDOOR	1	EA
6	W102908A	O-RING CORD, HOPPER DOOR	2.21	FT
7		SHCS ½"-13 X 1 ¼"	4	EA

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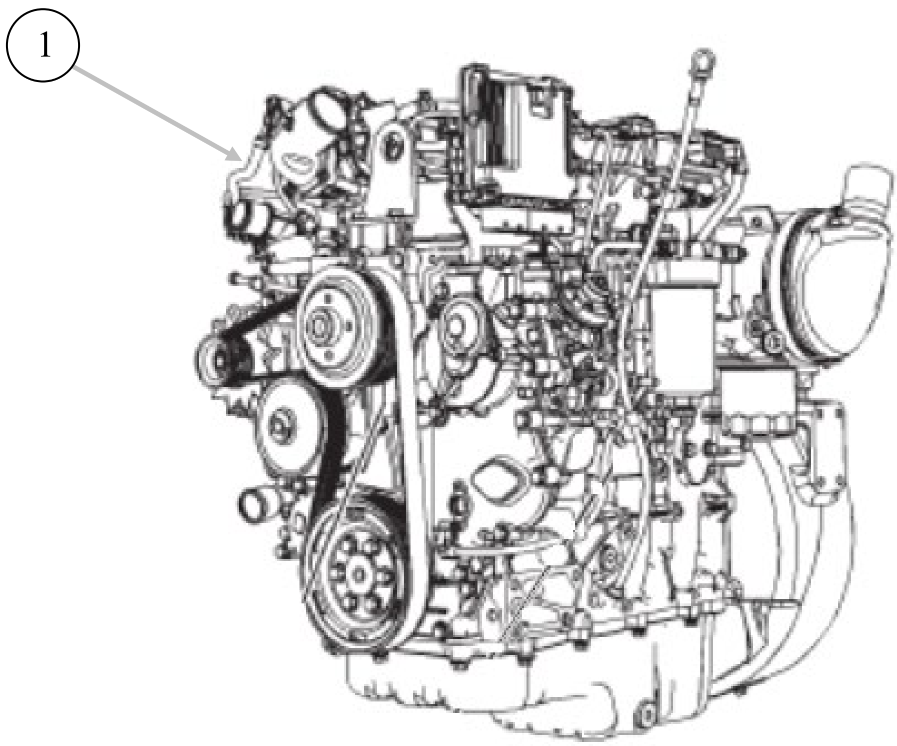
POWER TRAIN

ENGINE TIER 4 PERKINS



Designed to meet EU Stage IV/U.S. EPA Tier 4 Final emission standards
(reference Perkins manual for maintenance and troubleshooting)

ID #	PART #	PART DESCRIPTION	QUANTITY	
	BW31055	POWER TRAIN ASSY. A40HP W/SFTY GRT, HDRA	ASSY	
1	BW10511	ENGINE – PERKINS 8544F-E34T TIER-4	1	EA

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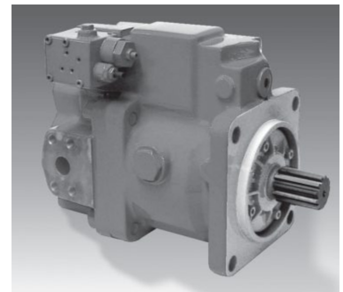
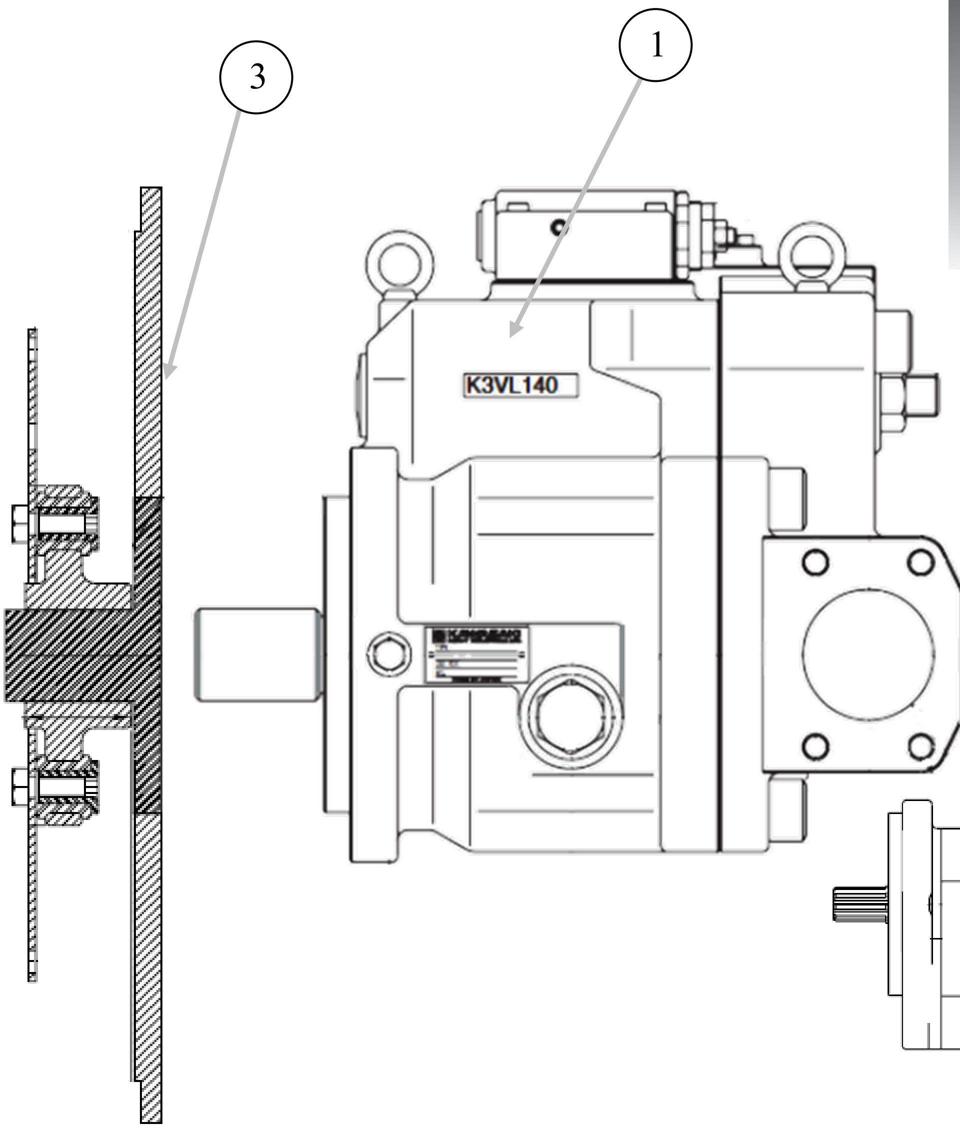
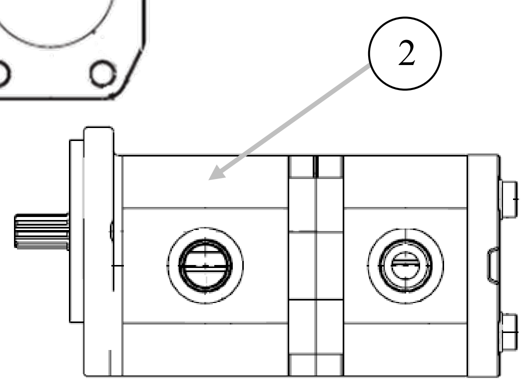
MAIN HYDRAULIC PUMP
GEAR PUMP/PUMP DRIVE

Kawasaki
Hydraulics



K3VL140





ID #	PART #	PART DESCRIPTION	QUANTITY	
1	85124-004	PUMP, KV3L112 KAWASAKI, 75HP	1	EA
2	87153-001	PUMP-RH-DBLE GEAR, 11.3/8.2 CC	1	EA
3	87360	PUMP DRIVE -SAE 3 - SAE D	1	EA

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EXHAUST

ID #	PART #	PART DESCRIPTION	QUANTITY	
1	77347A	HOSE- 5/16 SAE30R7 BLK (FUEL)	13	FT
2	10577	CLAMP-HOSE FOR ½" OD	6	EA
3	BW10540	RUBBER ELBOW 90 DEG 3.50" ID	1	EA
4	BW10541	ALUMINUM TUBING 3.50" ID	0.3	FT
5	74461	CLAMP #68H FOR R-4000	3	EA
6	74310	CLAMP - T-BOLT - 2.50 DIA	1	EA
7	70849	RAIN CAP 2.5"	1	EA
8	78213	CLAMP	1	EA
9	80003	3/8-16 NUT	4	EA
10	80043	FLATWASHER-3/8 USS PLATED	8	EA
11	80072	LOCKWASHER-3/8	8	EA
12	BW10179	SAFETY PLATE, EXHAUST PAINTED RED	1	EA
13	BW10554	EXHAUST PIPE T-4 PERKINS	1	EA

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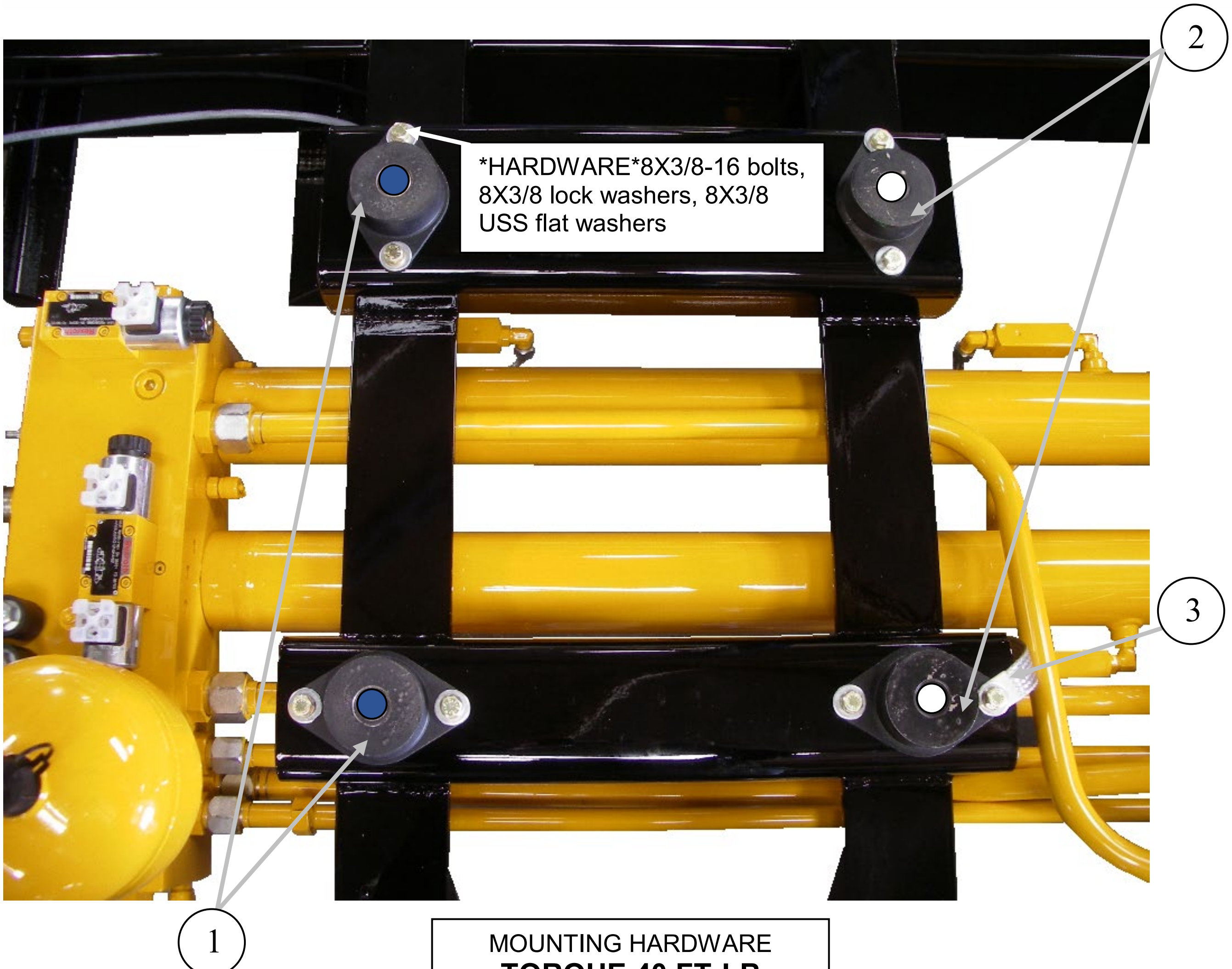
ENGINE MOUNTS



MOUNTING HARDWARE
TORQUE 40 FT-LB

ID #	PART #	PART DESCRIPTION	QUANTITY	
1	BW10266	ENGINE MOUNT-FRT, 840 LB-BLUE DOT	2	EA
2	BW10270	ENGINE MOUNT-REAR, 1020 LB-WHITE DOT	2	EA
3	73269	GROUND STRAP	1	EA

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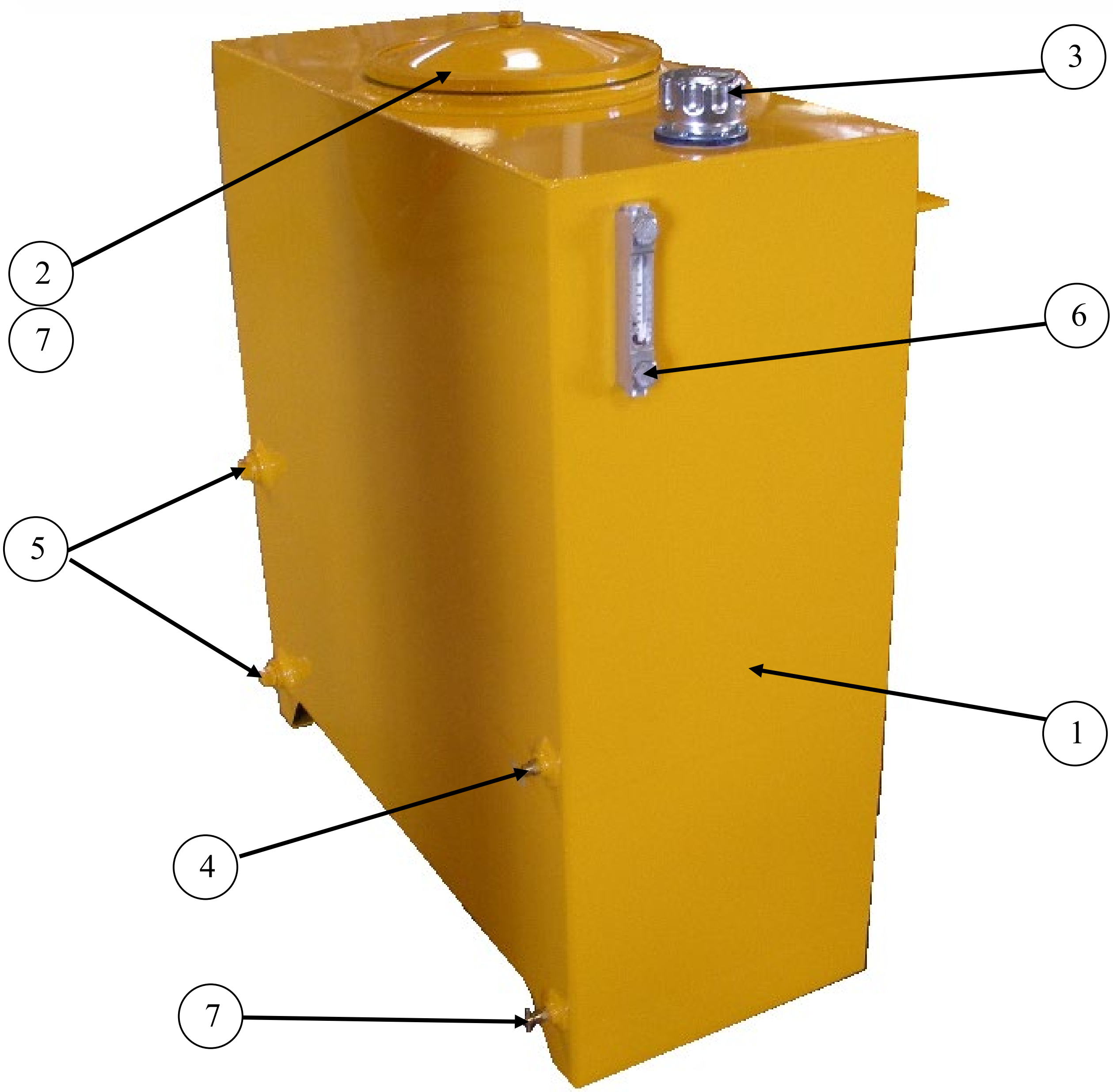
HYDRAULIC AND FUEL TANK ASSEMBLY



ID #	PART #	PART DESCRIPTION	QUANTITY	
	BW10432	HYD./FUEL TANK ASSY.	ASSY	
1	BW10386	HYD./FUEL TANK WELDMENT	1	EA
2	BW10171	KIT, 12 END COVER	1	EA
3	74508	FILLER BREATHER W/CAP	1	EA
4	801025	DRIAN COCK, ¼ NPT	2	EA
5	10282	PLUG-PIPE / GALV 1”	2	EA
6	74509	GAUGE-SIGHT/TEMPERATURE	1	EA
7	85867	GASKET, END COVER 12” (SPARE PART)	REF	EA

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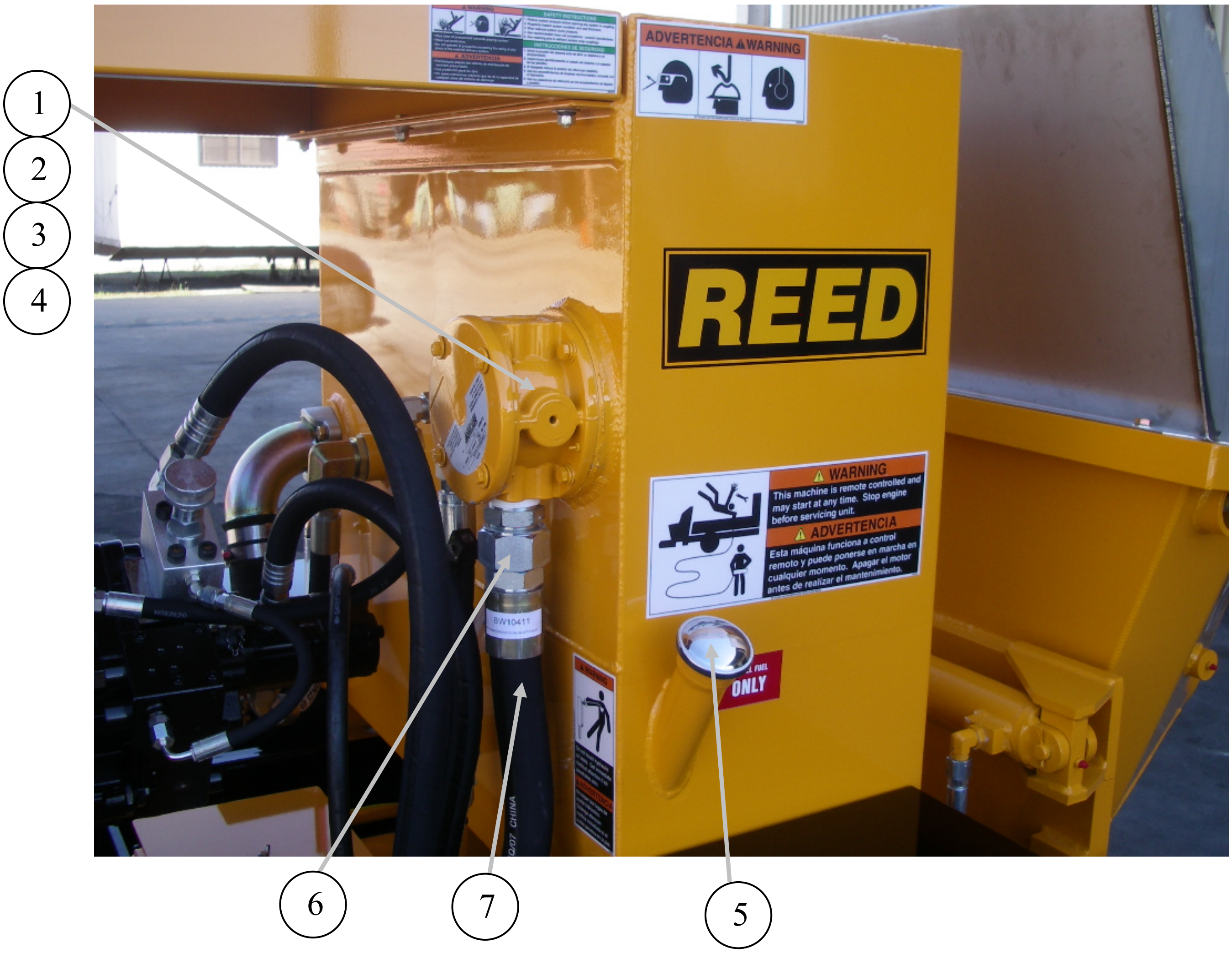
HYDRAULIC AND FUEL TANK ASSEMBLY CONTINUED



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	BW10027	FILTER, RETURN	1	EA
2	BW10241	SEAL KIT FOR BW10027 (RETURN FILTER)	1	EA
3	BW10242	GASKET FOR BW10027 (RETURN FILTER)	1	EA
4	BW10106-1	ELEMENT 25 MIKRON, FOR BW10027	1	EA
5	BW10256	CAP, FILLER	1	EA
6		FITTING, MP-MJ-24-24	1	EA
7	BW10411	HOSE, 24C1TH-24FJX-24FJX-70.00	1	EA

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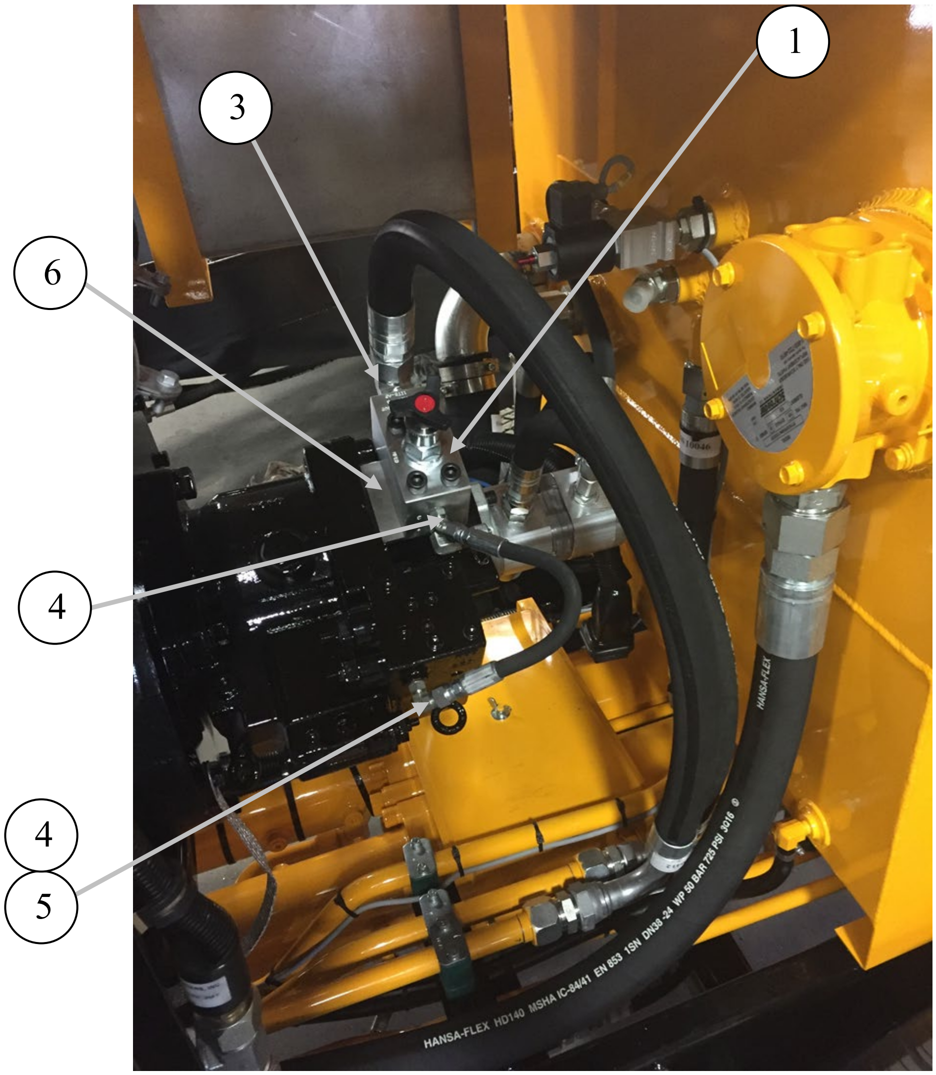
FLOW CONTROL VALVE



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	85125	FLOW CONTROL, HV10V0100 PUMP (HI SPEED)	1	EA
	79543	VOLUME CONTROL CARTRIDGE	1	EA
2		ADAPTER, 45 DEGREE –MB-MJ-4-6	1	EA
3	86728-023	ELBOW, MB-MJ90-16-16	1	EA
4		ELBOW, MB-MJ90-4-6	1	EA
5	85659-014	HOSE, 4M2T-6FJX-6FJX90S-12.50”	1	EA
6	BW10477	SPACER 85125 FLOW VALVE SPACER	1	EA

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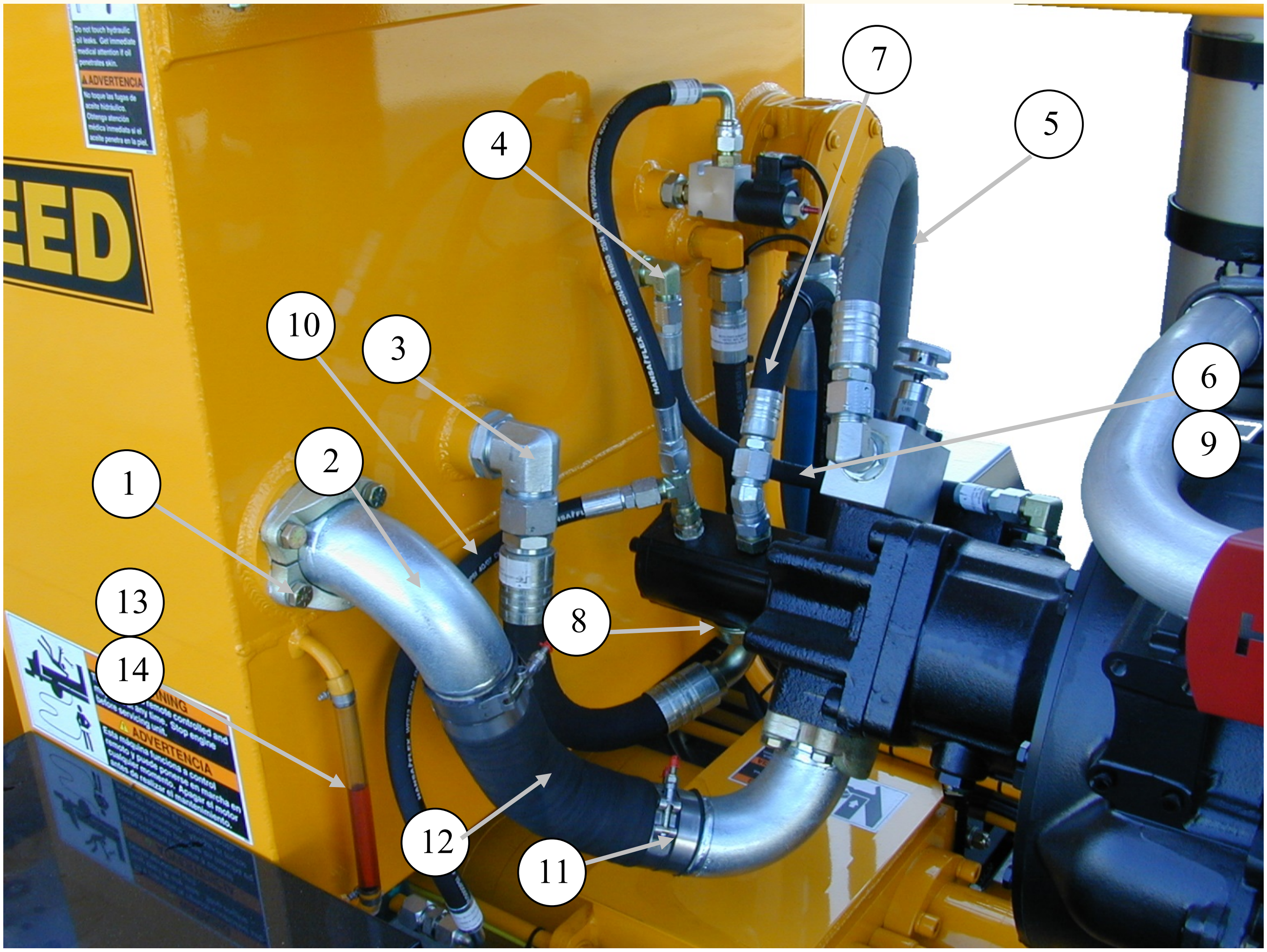
HYDRAULIC LINES, HOSES, AND FITTINGS



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	86264-007	SPIT FLANGE-CODE 61 -40 SAE	2	EA
2	86911-009	STEM, 2 1/2 “90 DEG. 40C4-40FL90	2	EA
3	86728-019	ELBOW MB-MJ90-12-12	2	EA
4		FITTING, MJ-MP90-16-16	1	EA
5	BW10412	HOSE, R12-FJS-FJS90-16-16-41”	1	EA
6	85667-004	HOSE, 12G5K-12FJX-12FJX90-32.00	1	EA
7	85657-002	HOSE, 8M2T-10FJX-10FJX90S-19.50	1	EA
8		FITTING, MB-MJ-10-12 (STRAIGHT)	1	EA
9		ADAPTER, MB-MJ-12-16	1	EA
10	85664-008	HOSE, 16G4H-16FJX-16FJX45-20”	1	EA
11	79803	CLAMP – T- BOLT -3.00 DIA	4	EA
12	85660-001	HOSE, 40G4H-NO ENDS-	12.00	EA
13	801978	TUBING, CLEAR PVC ½ ID X ¾ OD	0.83	FT
14	802289	CLAMP, WORM-0.38-0.68 DIA	2	EA

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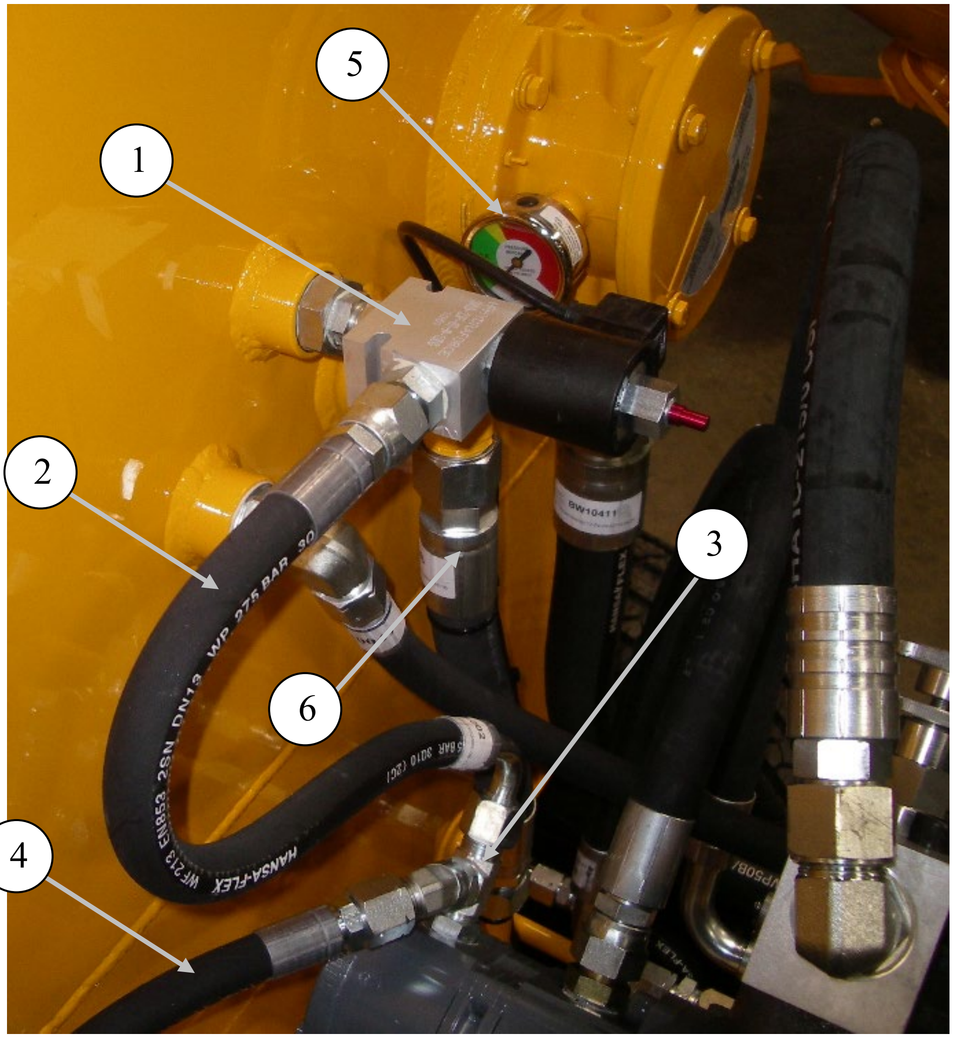
HYDRAULIC LINES, HOSES, AND FITTINGS CONT



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	87154	SOLENOID VALVE, 2P-2W, NO, 12V DIN	1	EA
2	85657-002	HOSE, 8M2T-10FJX-10FJX90S-19.50	1	EA
3		MJ-MB-MJT10	1	EA
4	85657-024	HOSE, 8M2T-10FJX-10FJX90S-24.50	1	EA
5	BW10249	GAUGE-RETURN FILTER BW10027	1	EA
6	BW10046	HOSE, R1T-FJS-MJ-16-16-16-14.5”	1	EA

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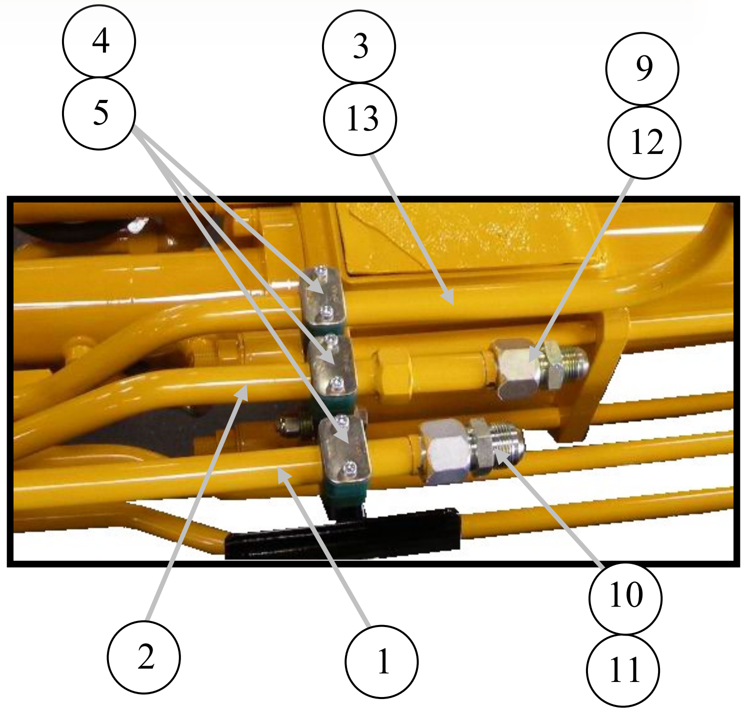
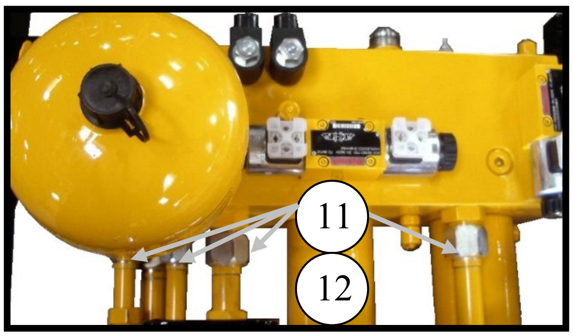
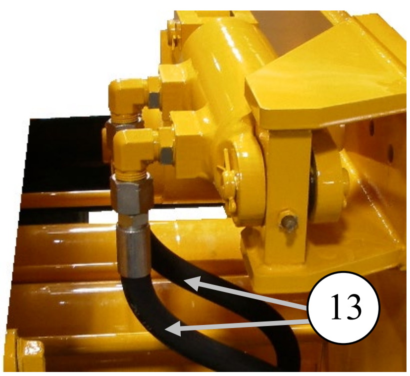
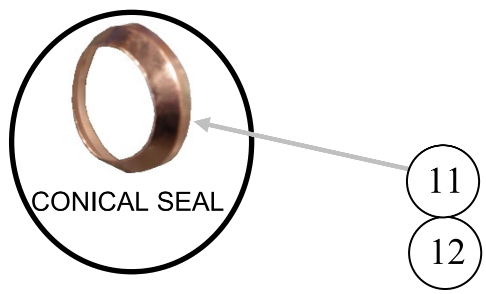
HYDRAULIC LINES, HOSES, AND FITTINGS CONTINUED









ID #	PART #	PART DESCRIPTION	QUANTITY	
1	BW10151	TUBE HYD, ACC.PUMP, PRESSURE-PAINTED	1	EA
2	BW10403	TUBE HYD, MAIN PUMP PRESSURE PAINTED	1	EA
3	BW10153	TUBE HYD, RETURN LINE-PAINTED	1	EA
4	801902-007	CLAMP, 25MM TUBE CLAMP SET	3	EA
5	801902-001	NUT, TEE TUBE CLAMP	6	EA
6	800897	CLAMP, ¾" TUBE, SINGLE	2	EA
7	BW10154	TUBE HYD, SWING CYLINDER-PAINTED	2	EA
8		UNION MALE, MJ-MJ-12-10	2	EA
9	87415-001	UNION MALE JIC, MJ-MJ-16-12	1	EA
10	87415-002	UNION MALE JIC, MJ-MJ-12-12	1	EA
11	BW10229	CONICAL SEAL, SIZE 12	5	EA
12	BW10230	CONICAL SEAL, SIZE 16	6	EA
13	BW10049	HOSE R2T-FJS-FJS-10-10-08-20"	2	EA

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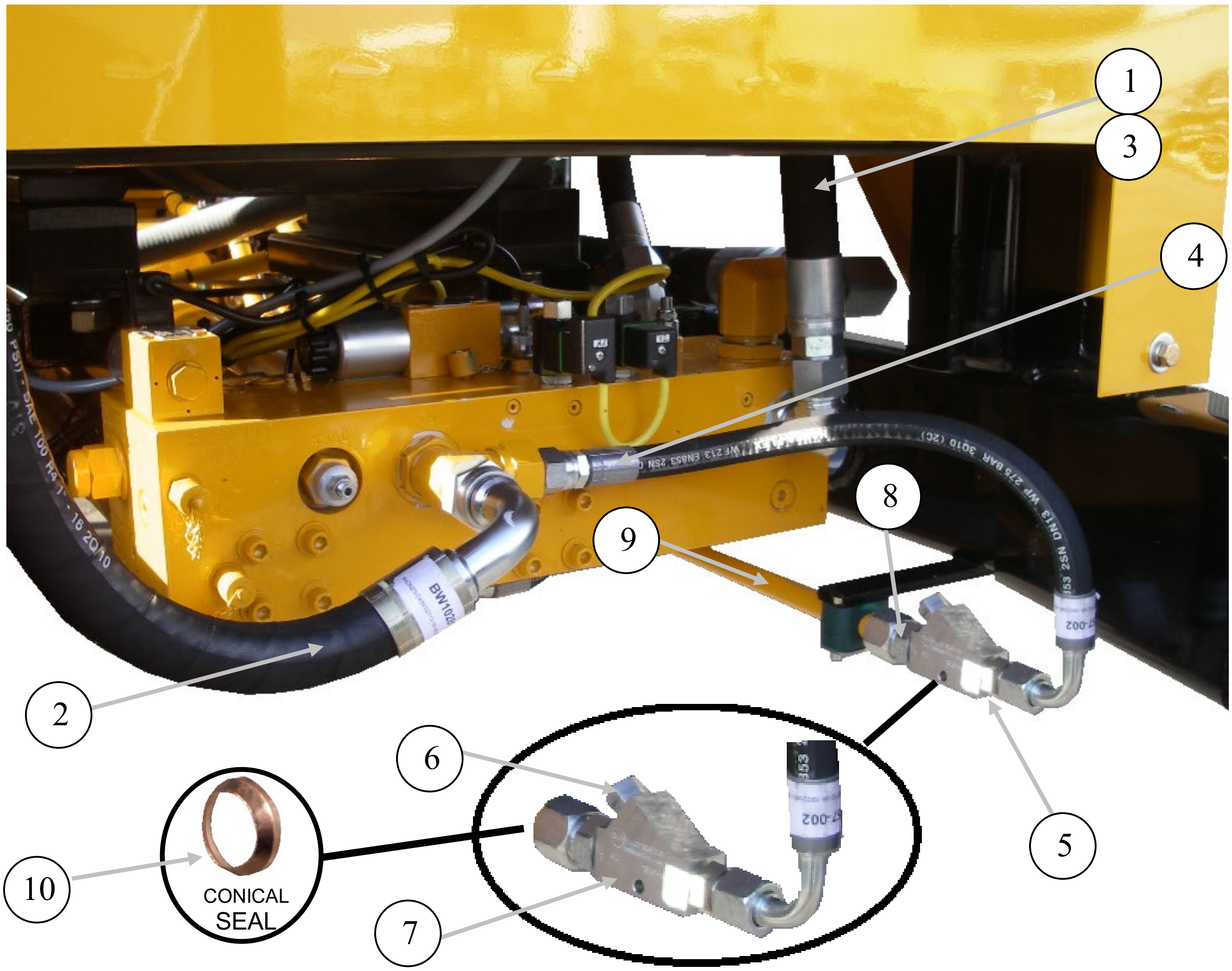
HYDRAULIC LINES, HOSES, AND FITTINGS CONTINUED



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	88138-008	HOSE, 16GMV=-20FJX-16FJX90S-24”	1	EA
2	88138-005	HOSE, 16GMV=-16FJX-16FJX	1	EA
3	86728-026	ELBOW, MB-MJ90-20-16	1	EA
4	85657-002	HOSE, 8M2T-10FJX-10FJX90S-19.50	1	EA
5		MB-MJ-6-10	1	EA
6	BW10471	CHECK VALVE	1	EA
7	BW10472	MANIFOLD FOR BW10471 (MUST BE MODIFIED)	1	EA
8		MB-MJ-6-12	1	EA
9	BW10409	TUBE HYD. MIXER VALVE RETURN	1	EA
10	BW10229	CONICAL SEAL, SIZE 12	2	EA

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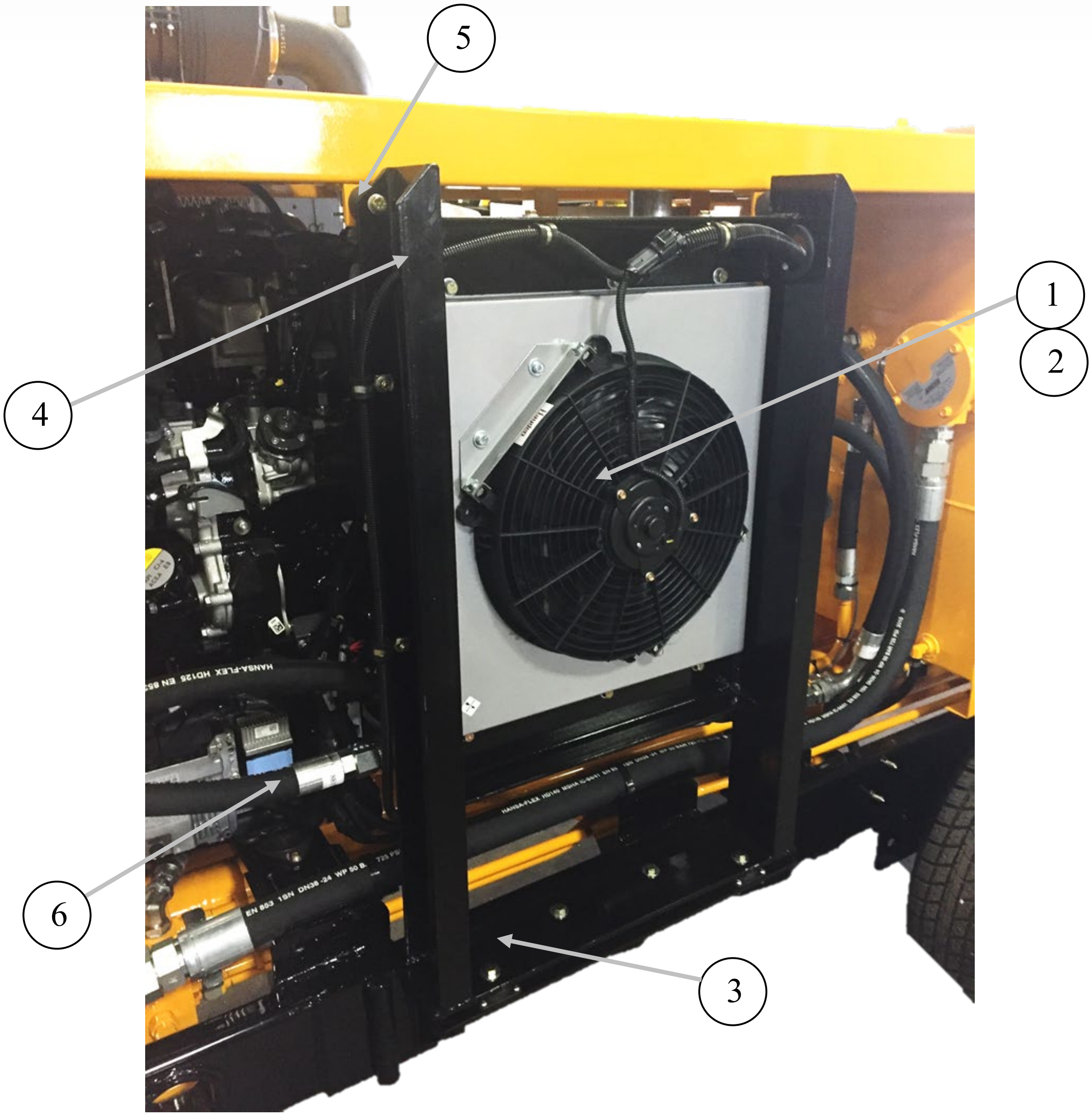
OIL COOLER ASSY



ID #	PART #	PART DESCRIPTION	QUANTITY	
	BW10537	OILCOOLER ASSY.	REF	
1	79433	OIL COOLER-ELECTRIC 12VDC	1	EA
2	89655	TEMPRATURE SWITCH 122-104F W/INTEG RELAY	1	EA
3	89653	MOUNT VIBRATION DAMPING	4	EA
4	BW10536	OIL COOLER MOUNTING BRACKET WELDMENT	1	EA
5	73748	BUMPERS	2	EA
6	88138-005	HOSE, 16M1T-16FJX-16FJX90-61.50”	1	EA
7	88138-008	HOSE, 16M1T-16FJX-16FJX90-32.0"	1	EA

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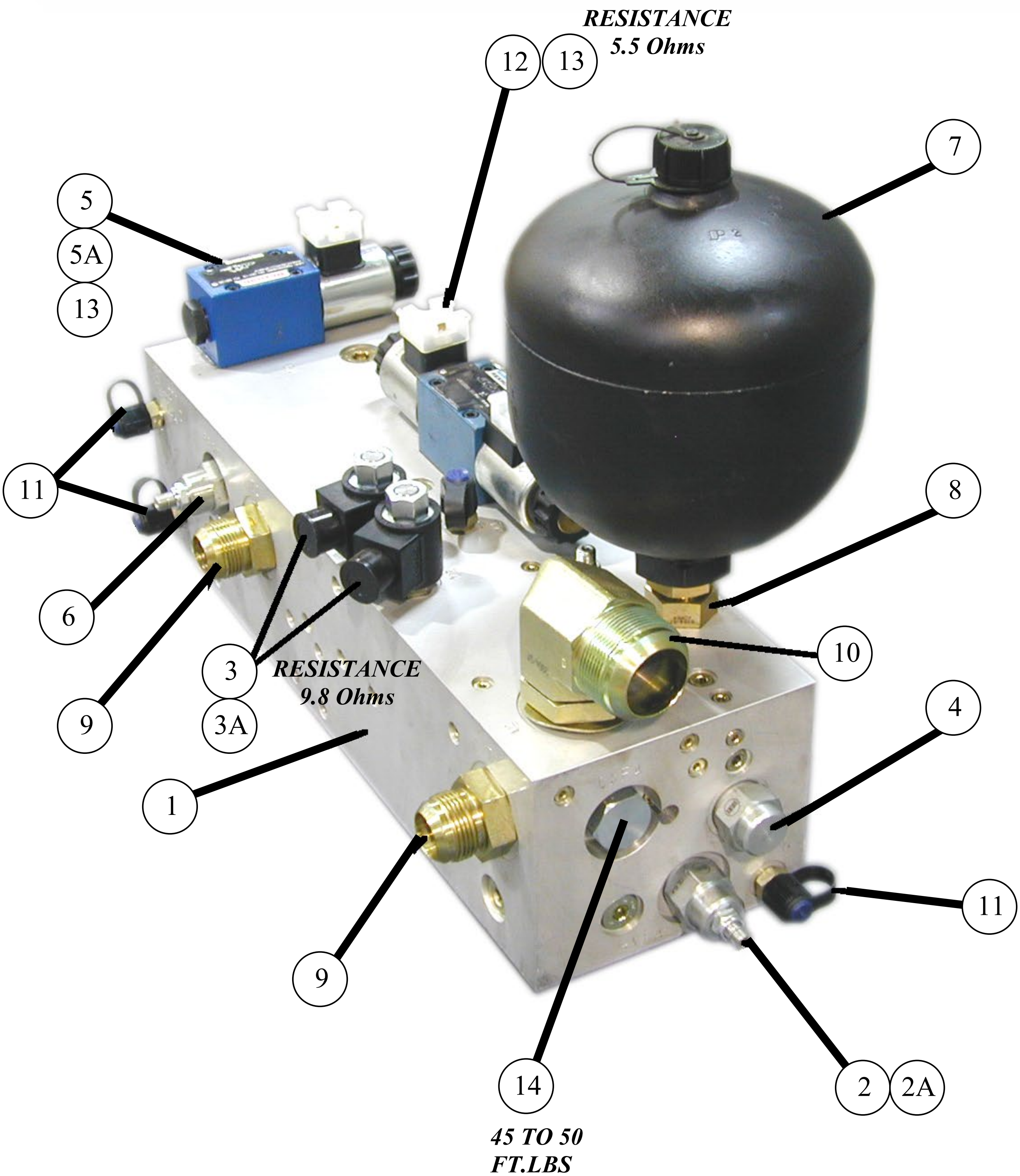
CONTROL MANIFOLD



CONTROL MANIFOLD CONTINUED

ID #	PART #	PART DESCRIPTION	QUANTITY	
	BW10395	MANIFOLD, CYLINDER CIRCUIT ASSEMBLY, A40	1	EA
1	BW10375	MANIFOLD MACHINED, A40 SERIES	1	EA
2	85703	RELIEF VALVE CARTRIDGE, FOR 85249	1	EA
2A	85703SK	RELEIF VALVE CARTRIDGE SEAL KIT	1	EA
3	BW10185	VALVE POPET, 2 WAY N/O FORBW10186	2	EA
3A	87247	COIL, 12VDC, FOR 87246 (9.8 Ohms))	2	EA
4	BW10182	DIRECTIONAL CARTRIDGE VALVE 2 POSIT	1	EA
4A	BW10182-SK	DIRECTIONAL CARTRIDGE VALVE SEAL KIT	1	EA
5	BW10183	VALVE PILOT, 2 POSITION	1	EA
5A	BW10183-SK	DIRECTIONAL CARTRIDGE VALVE SEAL KIT	1	EA
6	BW10326	RELIEF VALVE CARTRIDGE, FOR BW1004	1	EA
7	BW10184	ACCUMULATOR, 2 LITERS	1	EA
8	BW10328	ADAPTER, MB-MB-12-12	1	EA
9	86900-028	ADAPTER, MB-MJ-16-16	2	EA
10	86728-028	ELBOW, MB-MJ90-20-24	1	EA
11	78593	MINICHECK ADAPTER, SAE 4	2	EA
12	85691	VALVE PILOT, FOR 85691 (5.5 Ohms)	1	EA
13	BW10329	10-24X2" SHCS (TORQE 6.5 FT. LBS.)	8	EA
14	BW10327	CHECK VALVE CARTRIDGE FOR BW10004	1	EA

INSTALLATION TORQUE-CHART	
ITEM/CODE	TORQUE SETTING
RPGC	45 TO 50 FT. LBS.
CXFA	45 TO 50 FT. LBS.
RVEA	45 TO 50 FT. LBS.
QCDB	35 FT. LBS.
DCDD	50 FT. LBS.
DCEC	160 FT. LBS.
ITEM 4	20 FT. LBS.
ITEM 4A	5 FT. LBS.
ITEM 5&7	6.5 FT. LBS.

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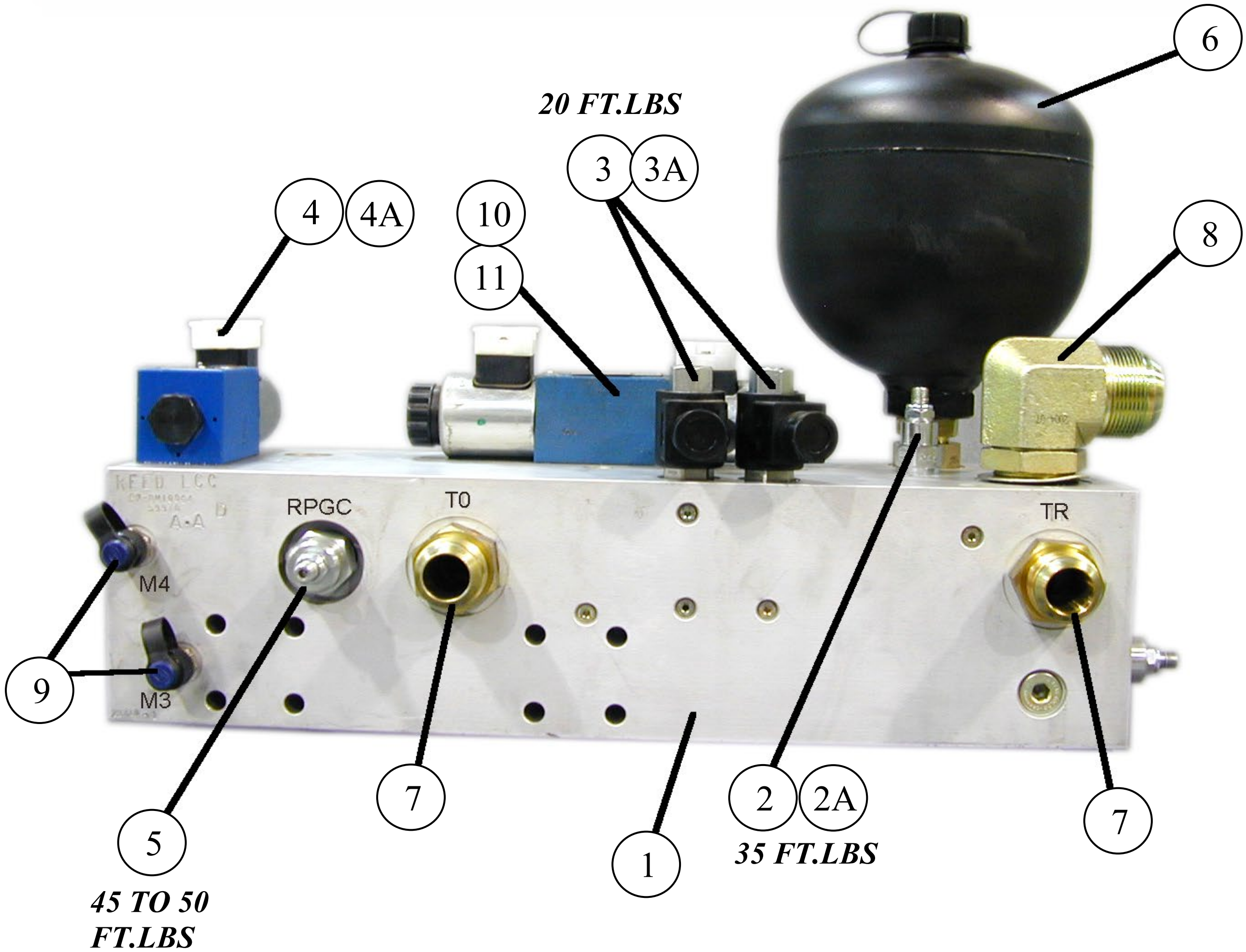
CONTROL MANIFOLD FRONT SIDE



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	BW10375	MANIFOLD MACHINED, A40 SERIES	1	REF
2	85704	UNLOADER VALVE CARTRIDGE, FOR 85249	1	REF
2A	85704-SK	UNLOADER VALVE CARTRIDGE SEAL KIT	1	EA
3	BW10185	VALVE POPET, 2 WAY N/O FORBW10186	2	REF
3A	87247	COIL, 12VDC, FOR 87246 (9.8 Ohms)	2	REF
4	BW10183	VALVE PILOT, 2 POSITION	1	REF
4A	BW10183-SK	DIRECTIONAL CARTRIDGE VALVE SEAL KIT	1	REF
5	BW10326	RELIEF VALVE CARTRIDGE, FOR BW1004	1	REF
6	BW10184	ACCUMULATOR, 2 LITERS	1	REF
7	86900-028	ADAPTER, MB-MJ-12-12	2	REF
8	86728-028	ELBOW, MB-MJ916-16	1	REF
9	78593	MINICHECK ADAPTER, SAE 4	2	REF
10	85691	VALVE PILOT, FOR 85689 (5.5 Ohms)	1	REF
11	BW10329	10-24X2” SHCS (TORQE 6.5 FT. LBS.)	8	REF

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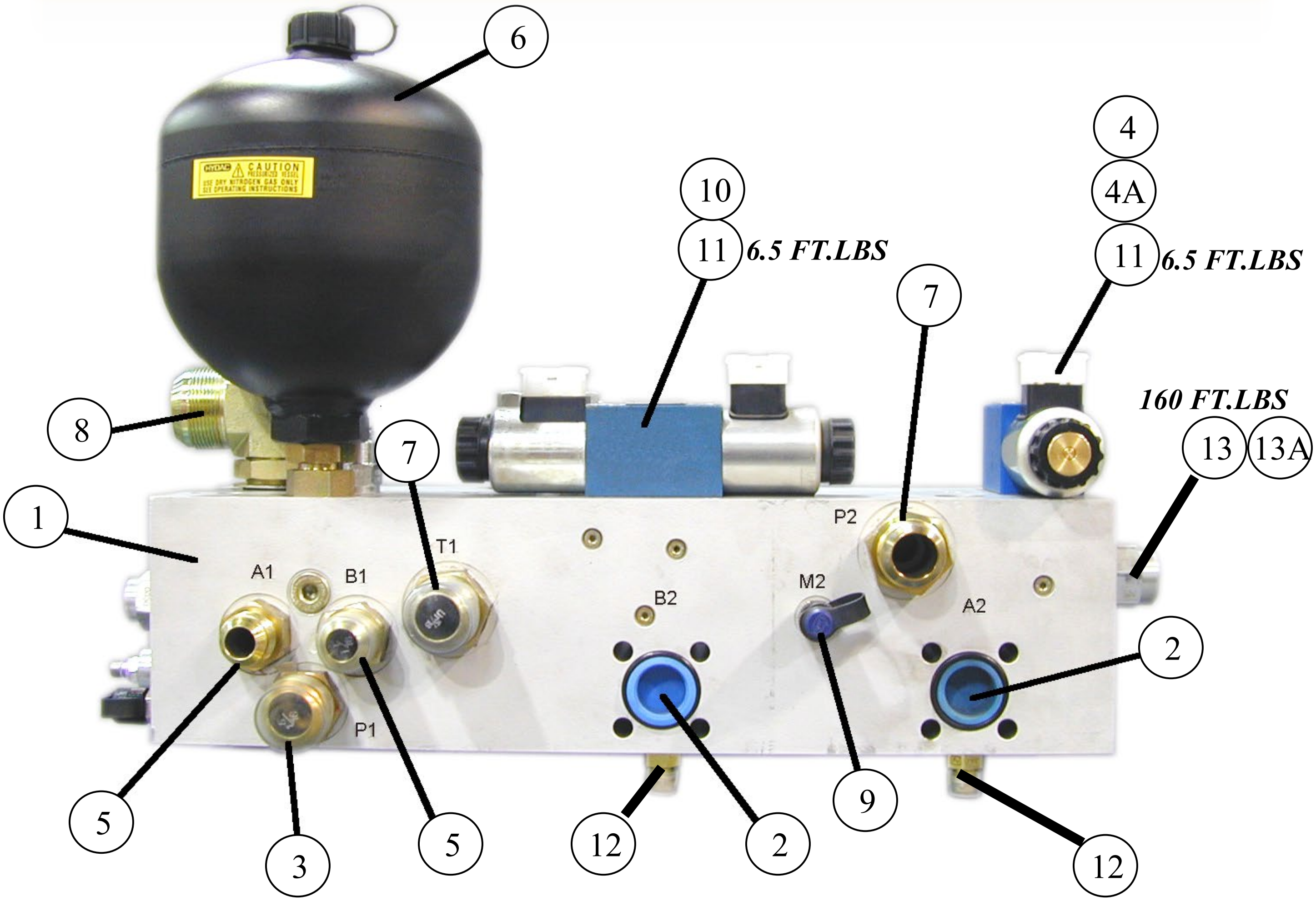
CONTROL MANIFOLD CYLINDER SIDE



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	BW10375	MANIFOLD MACHINED, A40 SERIES	1	REF
2	BW10177	O-RING, #219	2	EA
3	86900-024	ADAPTER, MB-MJ-12-16	1	EA
4	BW10183	VALVE PILOT, 2 POSITION	1	REF
4A	BW10183-SK	DIRECTIONAL CARTRIDGE VALVE SEAL KIT	1	REF
5	86900-23	ADAPTER, MB-MJ-12-12	2	EA
6	BW10184	ACCUMULATOR, 2 LITERS	1	REF
7	86900-028	ADAPTER, MB-MJ-16-16	2	REF
8	86728-028	ELBOW, MB-MJ90-20-24	1	REF
9	78593	MINICHECK ADAPTER, SAE 4	2	REF
10	85691	VALVE PILOT, FOR 85689 (5.5 Ohms)	1	REF
11	BW10329	10-24X2” SHCS (TORQE 6.5 FT. LBS.)	8	REF
12	86900-002	ADAPTER, MB-MJ-4-6	2	EA
13	BW10181	DIRECTIONAL CARTRIDGE VALVE 3 POSIT	1	EA
13A	BW10181-SK	DIRECTIONAL CARTRIDGE VALVE SEAL KIT	1	EA

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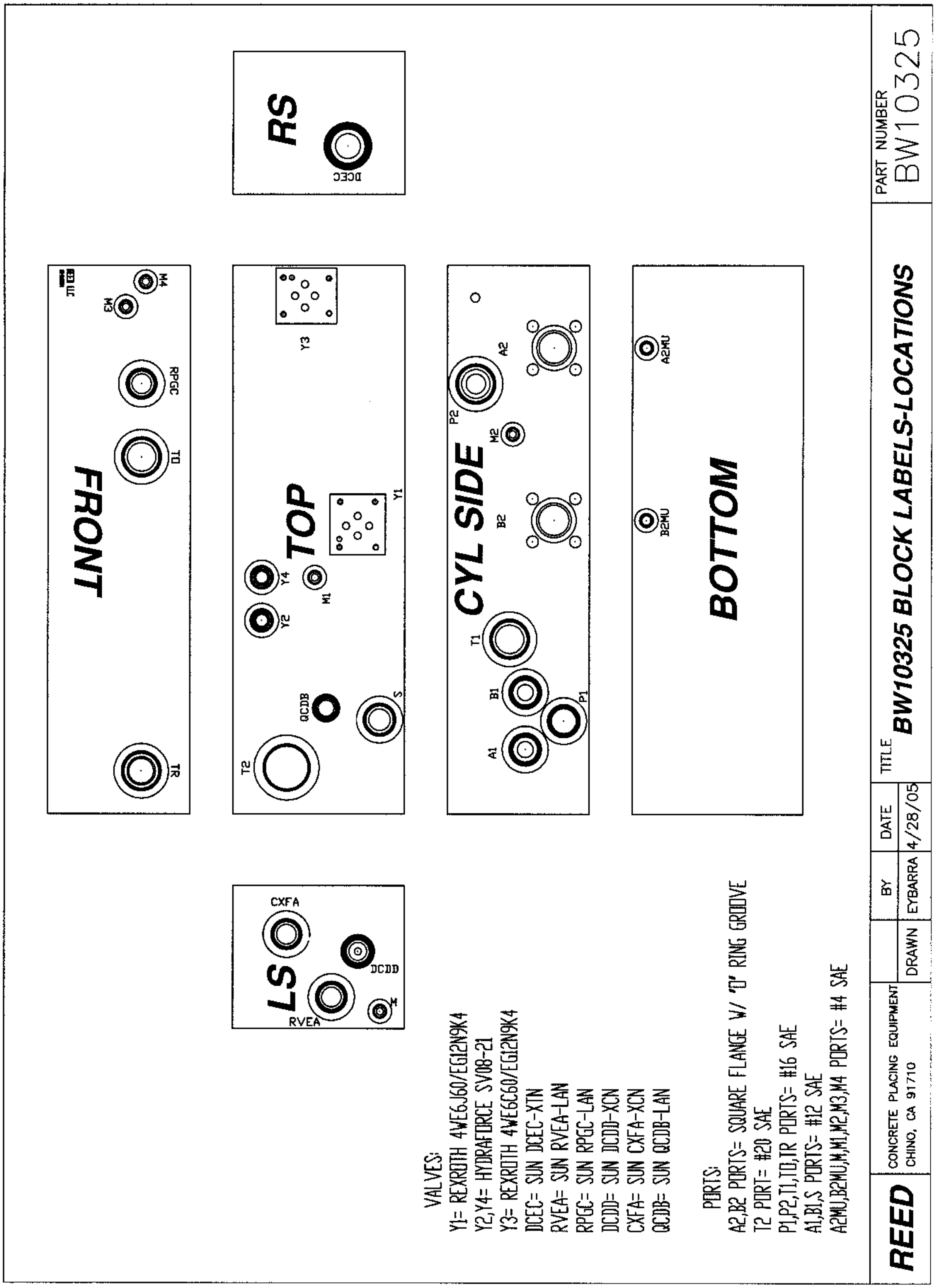
CONTROL MANIFOLD PORTING



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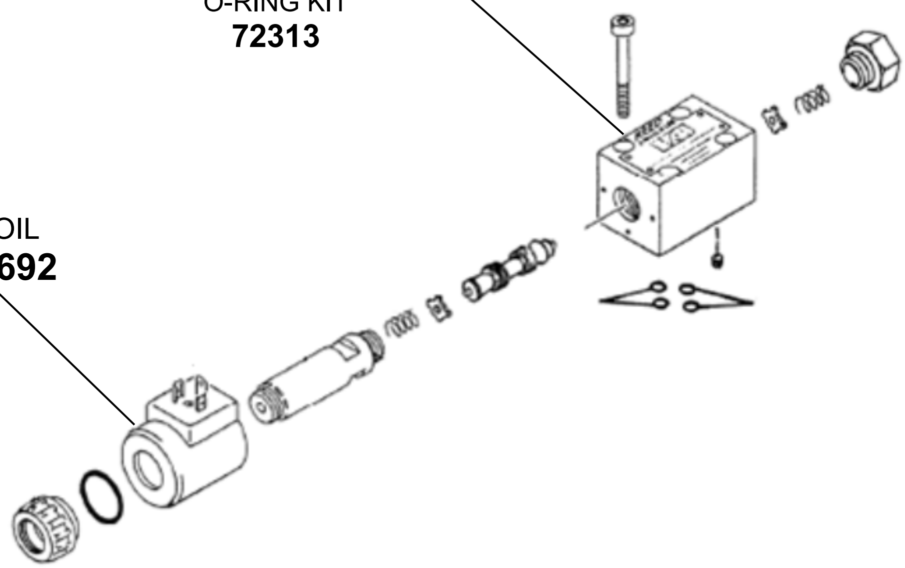
SOLENIOD VALVE ASSEMBLIES

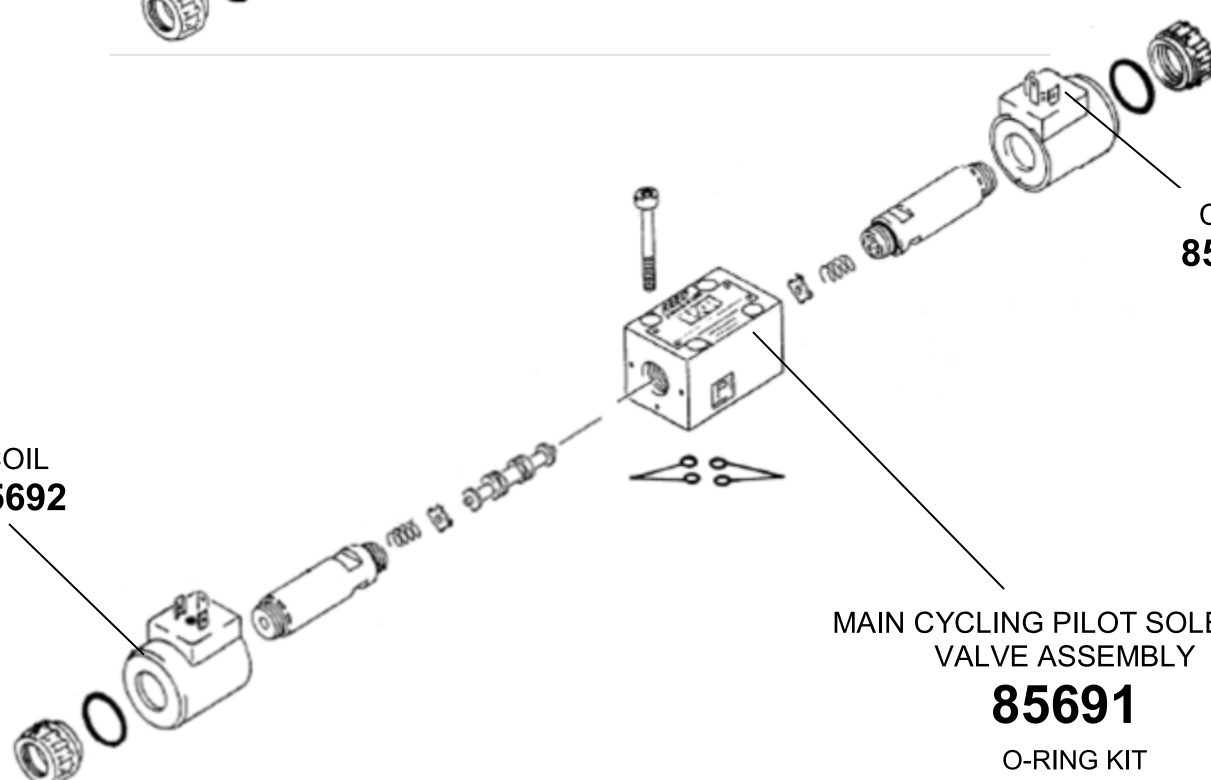
REVERSE CIRCUIT PILOT SOLENOID VALVE ASSEMBLY
BW10183
O-RING KIT
72313

COIL
85692



COIL
85692

COIL
85692



MAIN CYCLING PILOT SOLENOID VALVE ASSEMBLY
85691
O-RING KIT
72313

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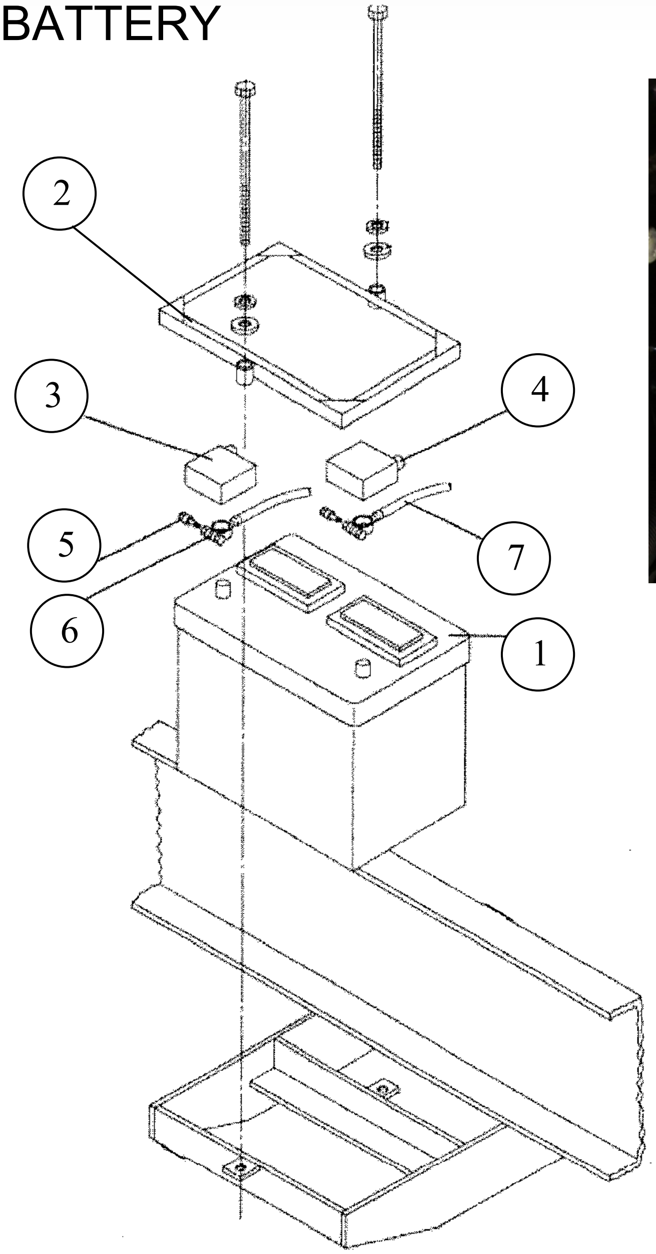
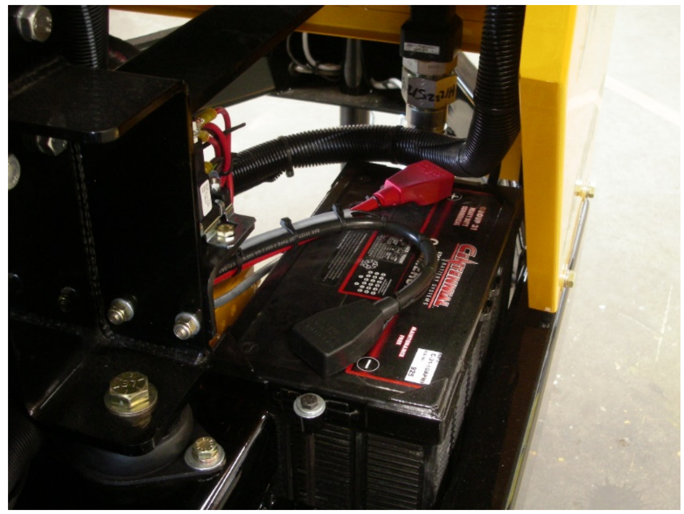
ELECTRICAL GROUP

BATTERY





ID #	PART #	PART DESCRIPTION	QUANTITY	
	BW44020	ELECTRICAL GROUP A SER BW10039-2	1	EA
1	77075	BATTERY-12V 1000 CCA31	1	EA
2	72945	BATTERY HOLD DOWN	1	EA
3	77719	COVER, POSITIVE BATT-RED	1	EA
4	77720	COVER, NEGATIVE BATT-BLACK	1	EA
5	87223	EXTENDER, TOP TERMINAL BOLT	2	EA
6	72014	CABLE-38" BATTERY-RED	1	EA
7	75116	CABLE-26" BATTERY-BLACK	1	EA

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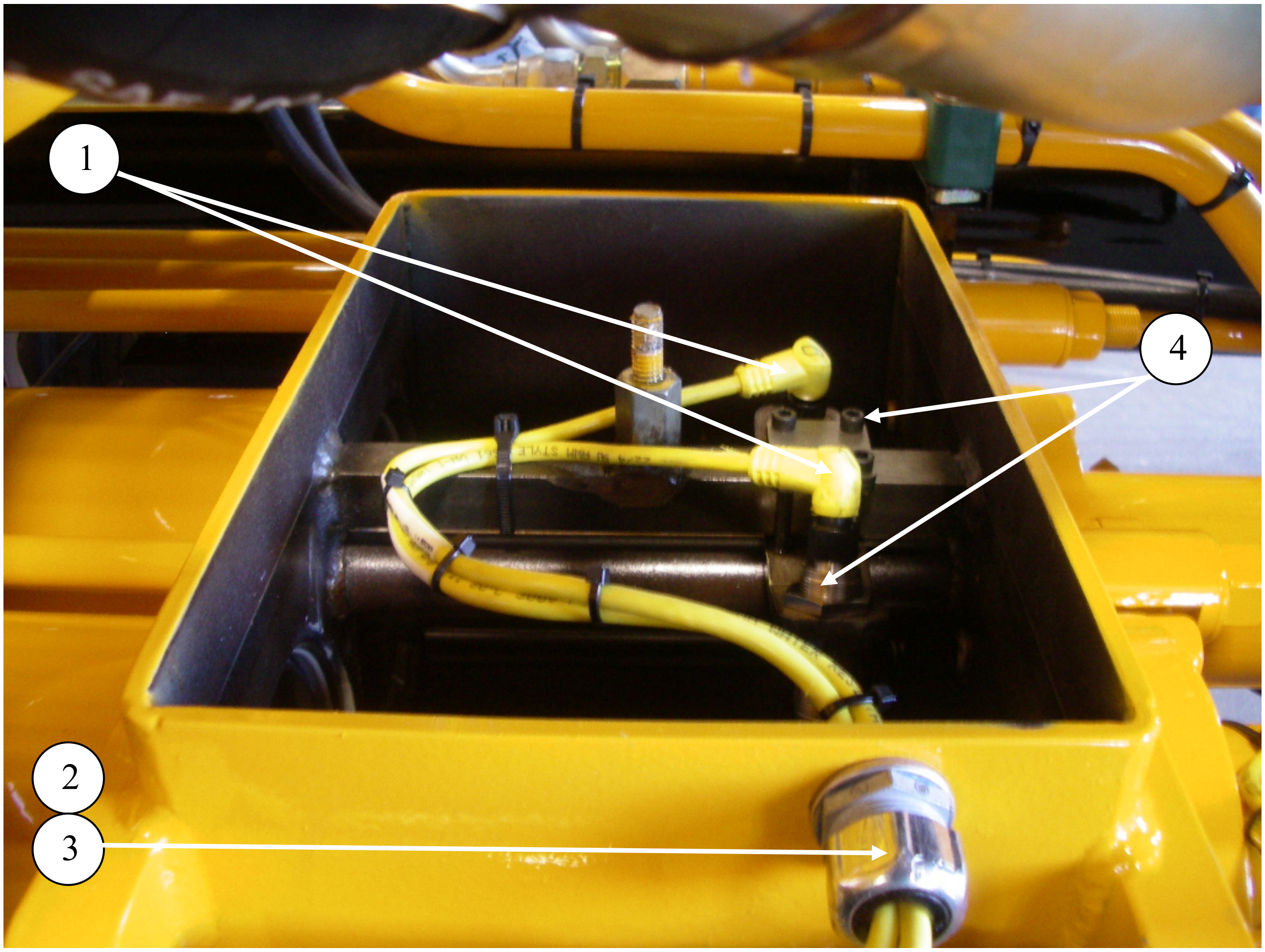
PROXIMITY SWITCHES



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	77990	CABLE, PROXIMITY SWITCH	2	EA
2	10522	STRAIN RELIEF	1	EA
3	10528	NUT ½" BONDING TYPE LOCK	1	EA
4	77998	PROXIMITY SENSOR NPN	2	EA

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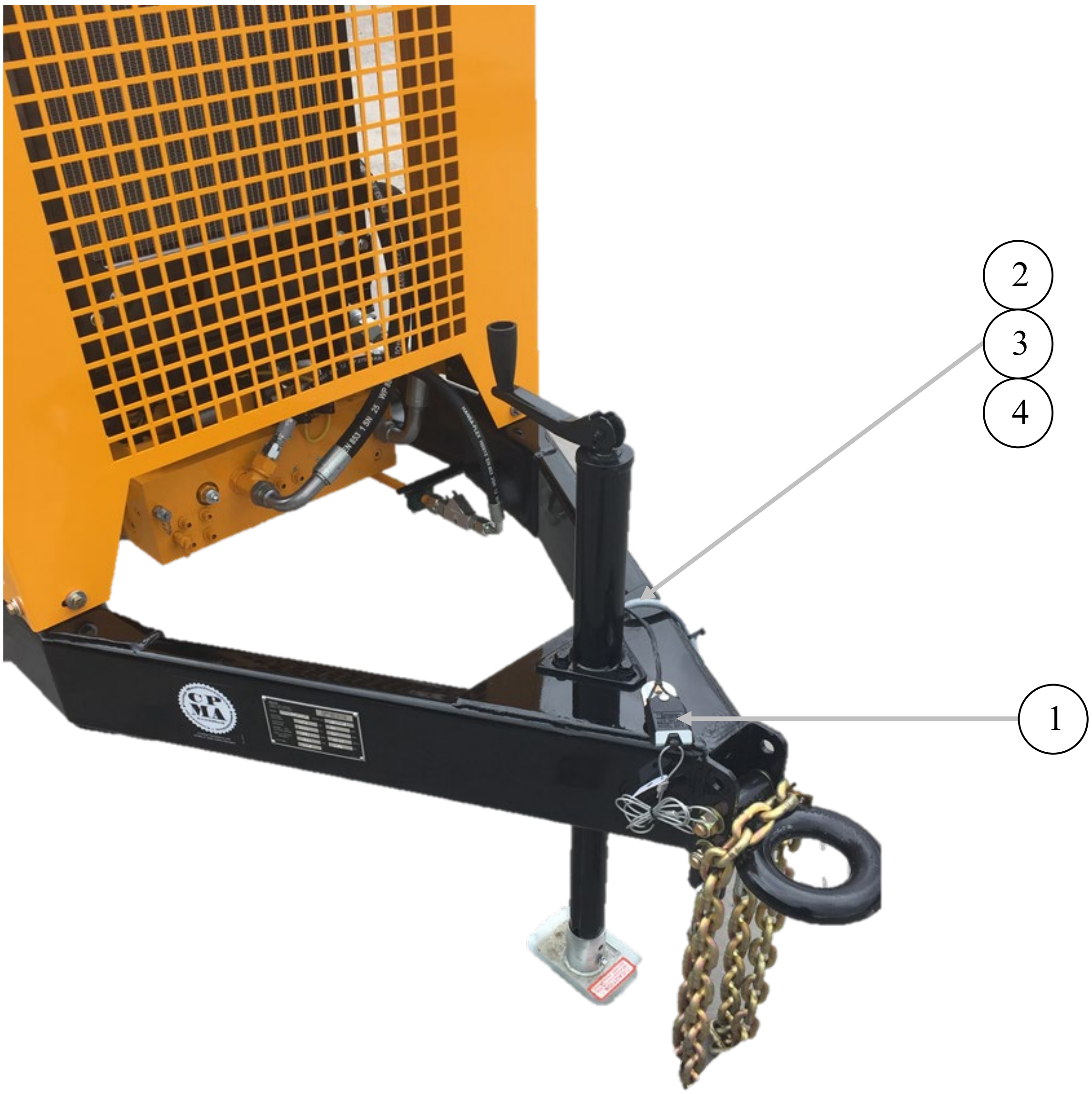
TRAILER HARNESS AND BREAKAWAY



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	77705	BREAK-AWAY KIT 5000 SERIES	1	EA
2	86579	TRAILER PLUG 7C FLAT PI	1	EA
3	BW10139	WIRING HARNESS, TRAILER A SERIES	1	EA
4	86759	GROMMET	1	EA

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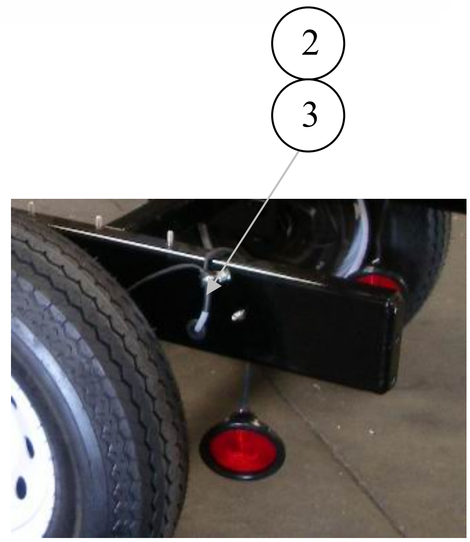
TAILLIGHTS



UNDERNEATH
FENDER

ID #	PART #	PART DESCRIPTION	QUANTITY	
1	72948	TAILLIGHT R3000 SERIES	2	EA
2	85981	LOOM CLAMP 5/8"	2	EA
3	86759	GROMMET	2	EA

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WIRING HARNESS

ID #	PART #	PART DESCRIPTION	QUANTITY	
	BW10534	WIRING HARNESS A SERIES, TIER 4 ASSY	1	EA
1	89651	PLUG, 48 SOCKET HARNESS SIDE	1	EA
2	89651-B	BOOT FOR 89651 PLUG	1	EA
3	89651-W	WEDGE FOR 89651 PLUG	24	EA
4	BW10147	CONTACT SOCKET SIZE-16,13 AMP	12	EA
5	88959	CONTACT SOCKET SIZ 20 7.5 AMP	24	EA
6	77990	CABLE, PROXIMITY SWITCH, 5M	3	EA
7	10528	NUT- ½” BONDING TYPE LOCK NUT	1	
8	30240	GASKET- LIQUID TITE- ELECT	1	EA
9	10522	STRAIN RELIEF	1	EA
10	87540	TURCK U7106-05 CABLES/CONNECTIVITY	6	EA
11	88935	3 WAY PLUG DT SER.	1	EA
12	88937	WEDGE LOCK, DT 3 PIN PLUG, BLUE	1	EA
13	88935-B	BOOT FOR 3 WAY DT SERIES PLUG	1	EA
14	89218	DEUSCH DT04 RECP, 12 PIN	1	EA
15	88958	CONTACT PIN SOLID SIZE 16	7	EA
16	89218-1	DEUTSCH WEDGE FOR 89218	1	EA
17	85617	CABLE, 14 AWG-4C, PVC-GRY	13	FT
18	89127	CABLE, BLUE HOSE, 20 AWG	13	FT
19	88678	CABLE SHIELD PROXIMITY SWITCH, 5M	1	EA
20	BW10254-125	1.25” DIA WIRING LOOM PLASTIC, SPLIT	3.5	FT
21	BW10254-062	.625” DIA WIRING LOOM PLASTIC, SPLIT	7	FT

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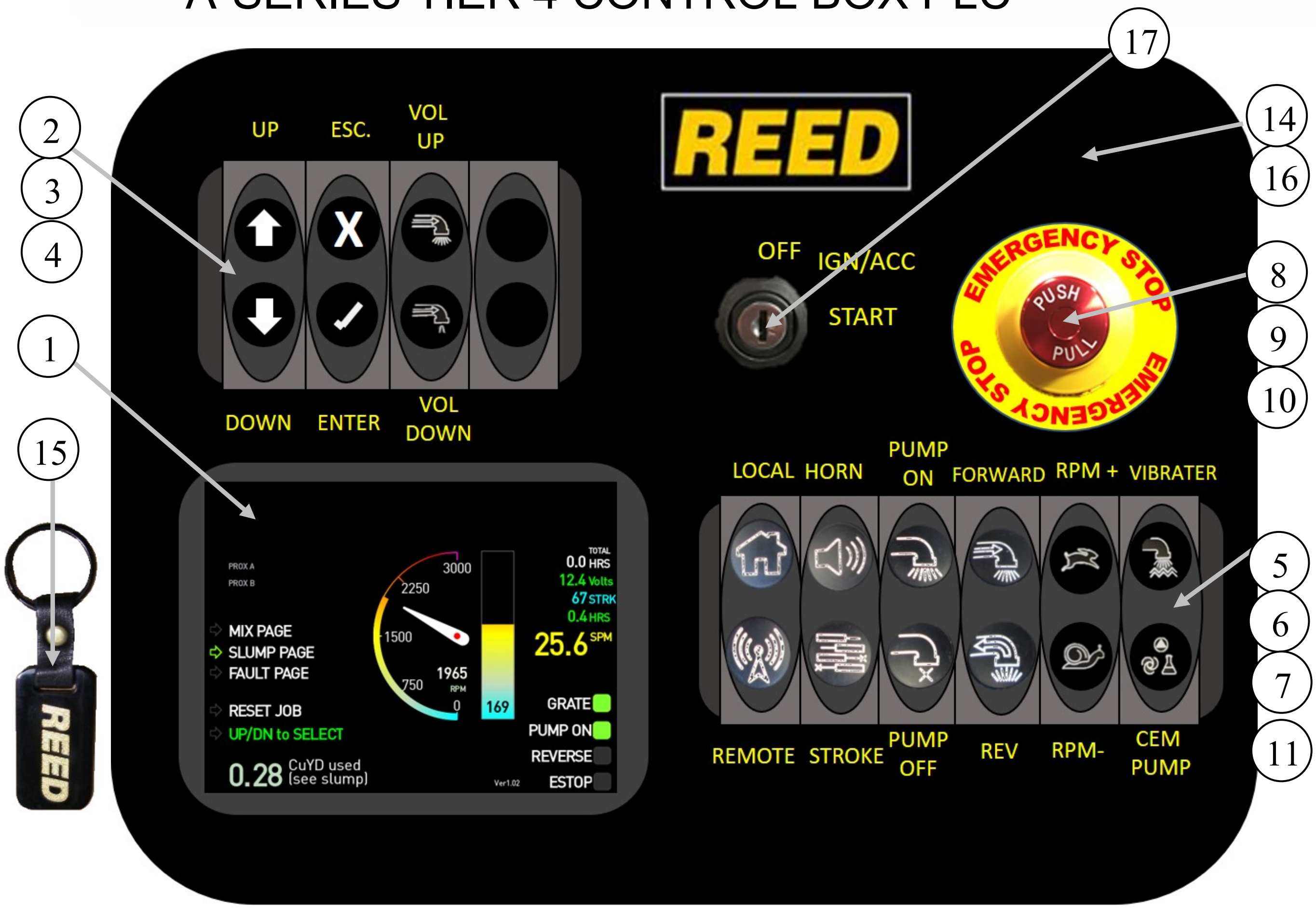
CONTROLS

A-SERIES TIER 4 CONTROL BOX PLC



ID #	PART #	PART DESCRIPTION	QUANTITY	
	BW10533	CONTROL BOX ASSY A SERIES TIER-4 PERKINS	ASSY	
1	89612	DISPLAY, 5”, MD4-5	1	EA
2	89615	KEYPAD 2X4, PKU	1	EA
3	89615-B	BACKPLATE, 2X4	1	EA
4	89616-FG	FINGER GUARD, 2X4	4	EA
5	89616	KEYPAD 2X6, PKU	1	EA
6	89616-B	BACKPLATE, 2X6	1	EA
7	89616-FG	FINGER GUARD, 2X6	6	EA
8	89090	EMERGENCY STOP PUSH BUTTON HEAVY DUTY	1	EA
9	89090-L	ILLUMINATED E-STOP RING	1	EA
10	89359	JAM NUT, FOR 89090 EMERGENCY SWITCH	1	EA
11	BW10514	INSERT KIT FOR PLC SWITCH FUNCTIONES	1	EA
13	BW10535	ELDON MM ENCLOSURE 400X300X155 MM	REF	
14	BW10559	ENCLOSURE MACHINED TIER-4	1	EA
15	72862	GAUGE FOR PROX.SENSOR SETTING	1	EA
16	BW10555	DECAL CONTROL PANEL A SER PLC TIER-4	1	EA
17	89004	KEY SWITCH	1	EA

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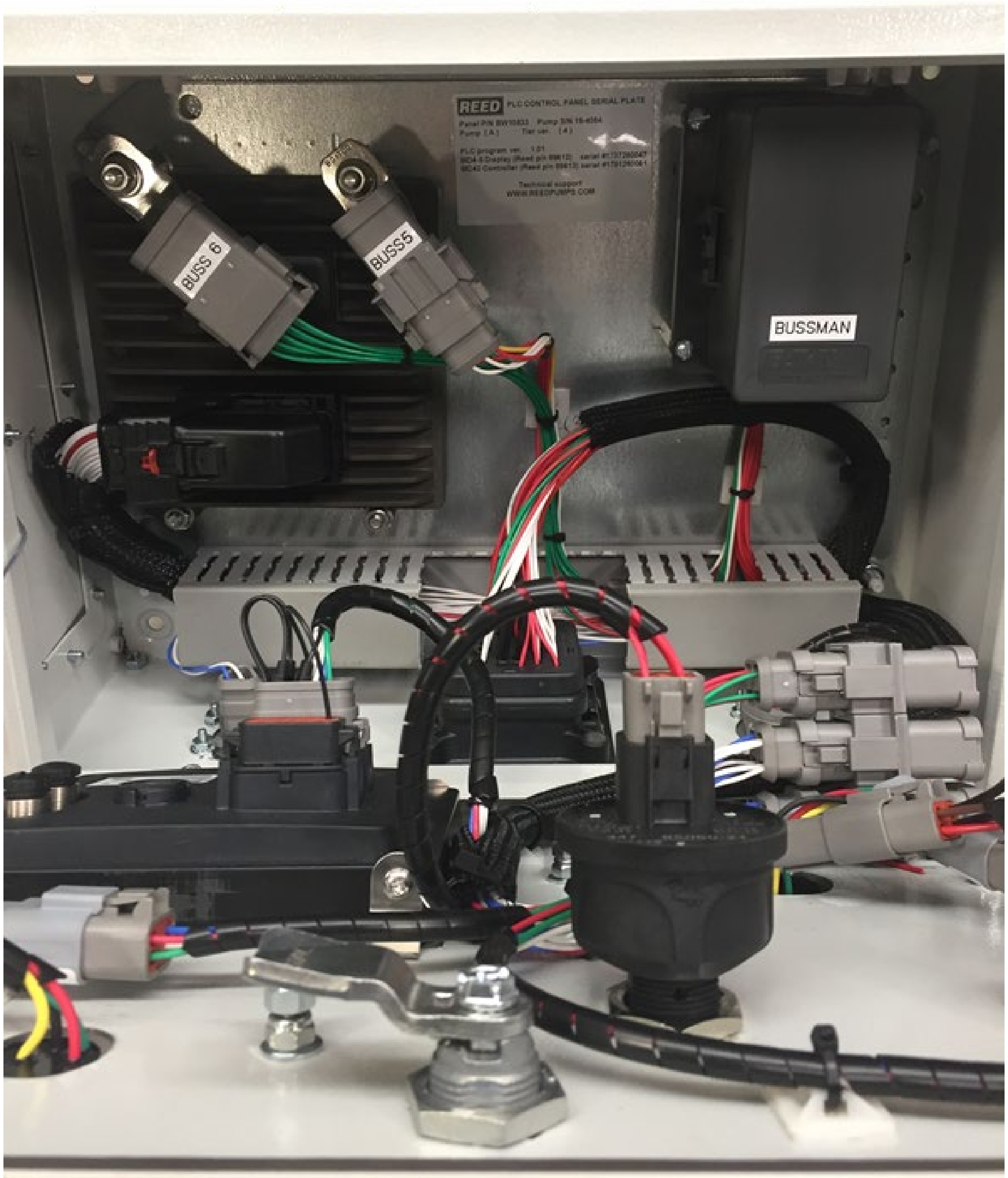
A-SERIES TIER 4 CONTROL BOX PLC CONTINUE



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	89307	LANYARD, 18" – NYLON COATED	1	EA
2	89567	LOOM, BRAIDED, 1/2"		

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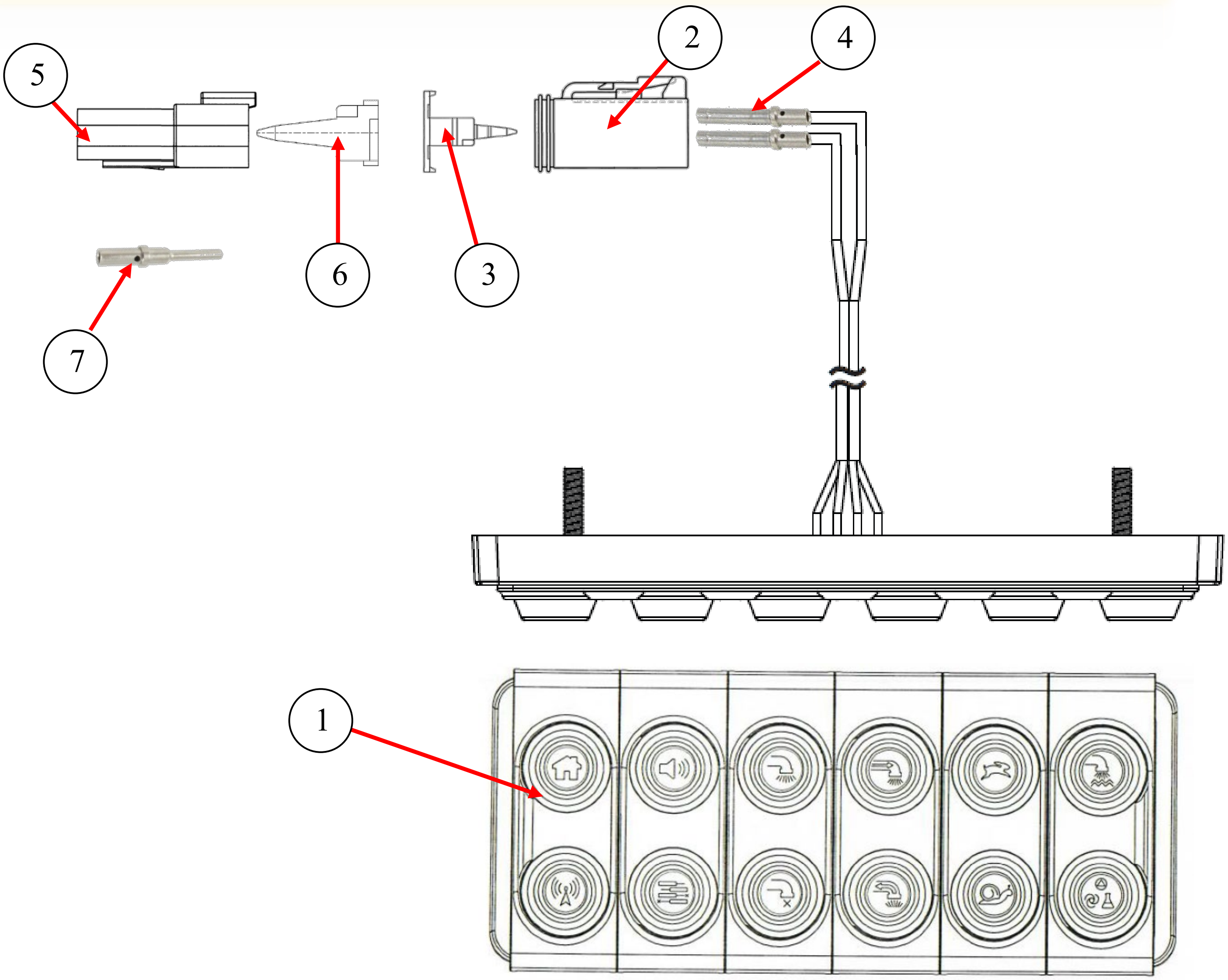
KEYPAD 2X6



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	89616	KEYPAD 2X6, PKU	ASSY	
2	89102	DEUTSCH DT04 PLUG, (FEMALE) 2X6	1	EA
3	89132	DEUTSCH WEDGE LOCK FOR 89102	1	EA
4	BW10147	CONTACT PIN 16 AWG (FEMALE)	4	EA
5	89146	DEUTSCH DT04 PLUG, (MALE) 2X6	1	EA
6	89209	DEUTSCH WEDGE LOCK FOR 89146	1	EA
7	88958	CONTACT PIN 16 AWG (MALE)	4	EA

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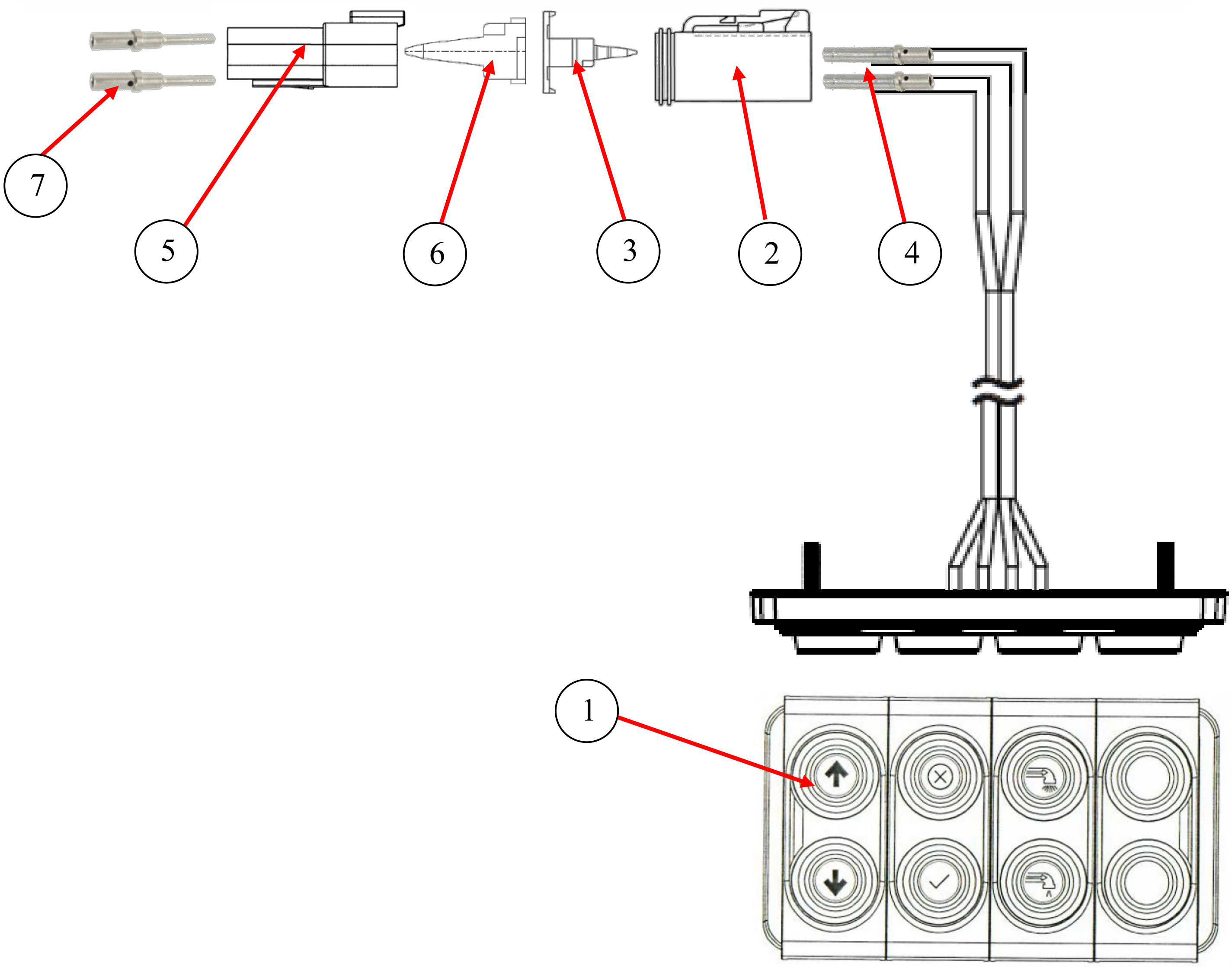
KEYPAD 2X4



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	89615	KEYPAD 2X4, PKU	ASSY	
2	89102	DEUTSCH DT04 PLUG, (FEMALE) 2X4	1	EA
3	89132	DEUTSCH WEDGE LOCK FOR 89102	1	EA
4	BW10147	CONTACT PIN 16 AWG (FEMALE)	4	EA
5	89146	DEUTSCH DT04 PLUG, (MALE) 2X4	1	EA
6	89209	DEUTSCH WEDGE LOCK FOR 89146	1	
7	88958	CONTACT PIN 16 AWG (MALE)	4	EA

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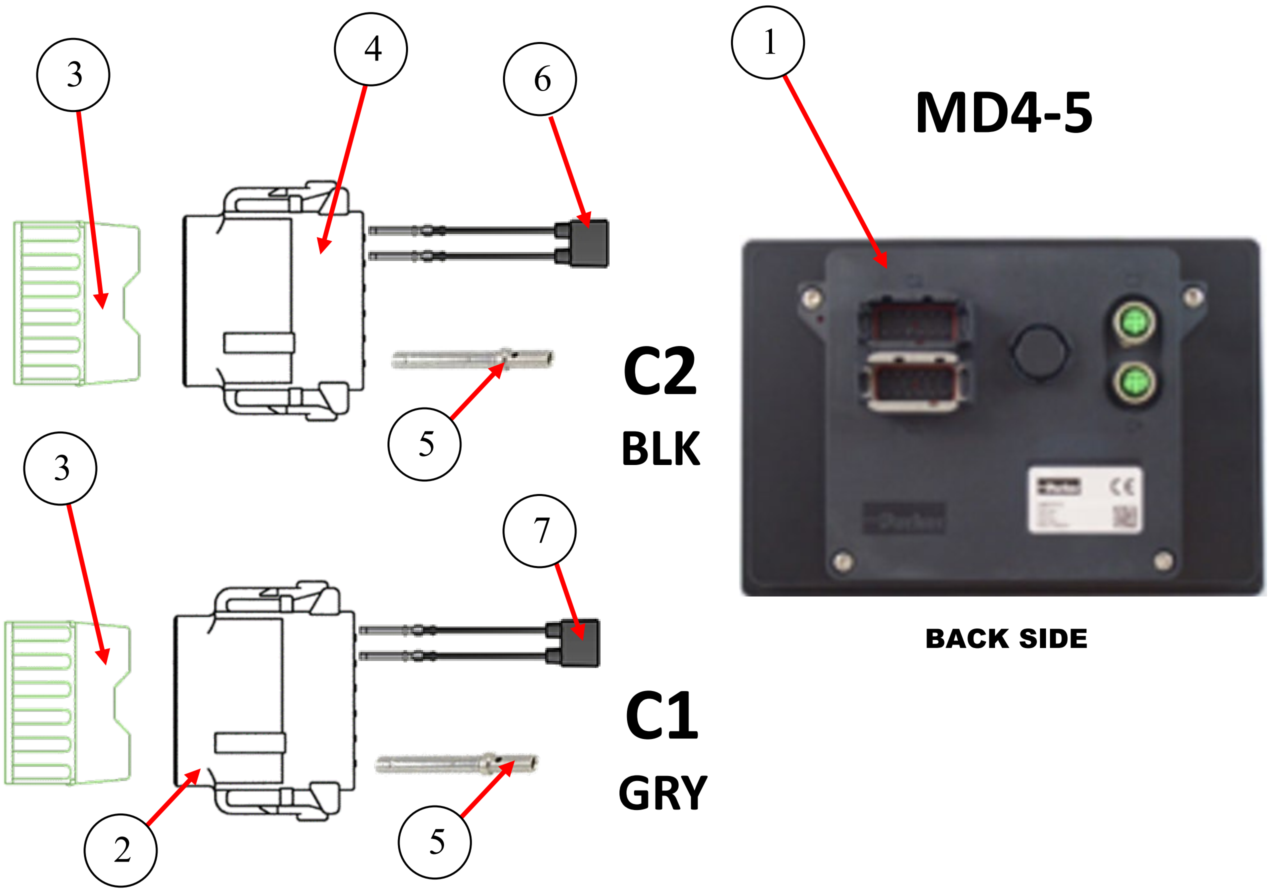
MD4-5 DISPLAY MODULE



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	89612	DISPLAY, 5", MD4-5	ASSY	
2	88653	GREY PLUG **C1**-GREY	1	EA
3	88653-2	WEDGE LOCK	2	EA
4	88652	BLACK PLUG **C2**-BLK?	1	EA
5	88959	PIN, SOLID (FEMALE)	9	EA
6	89136	MOLDED 1.5K RESISTOR, TAG #3	1	EA
7	89136-0	MOLDED 294 RESISTORS, TAG #0	1	EA

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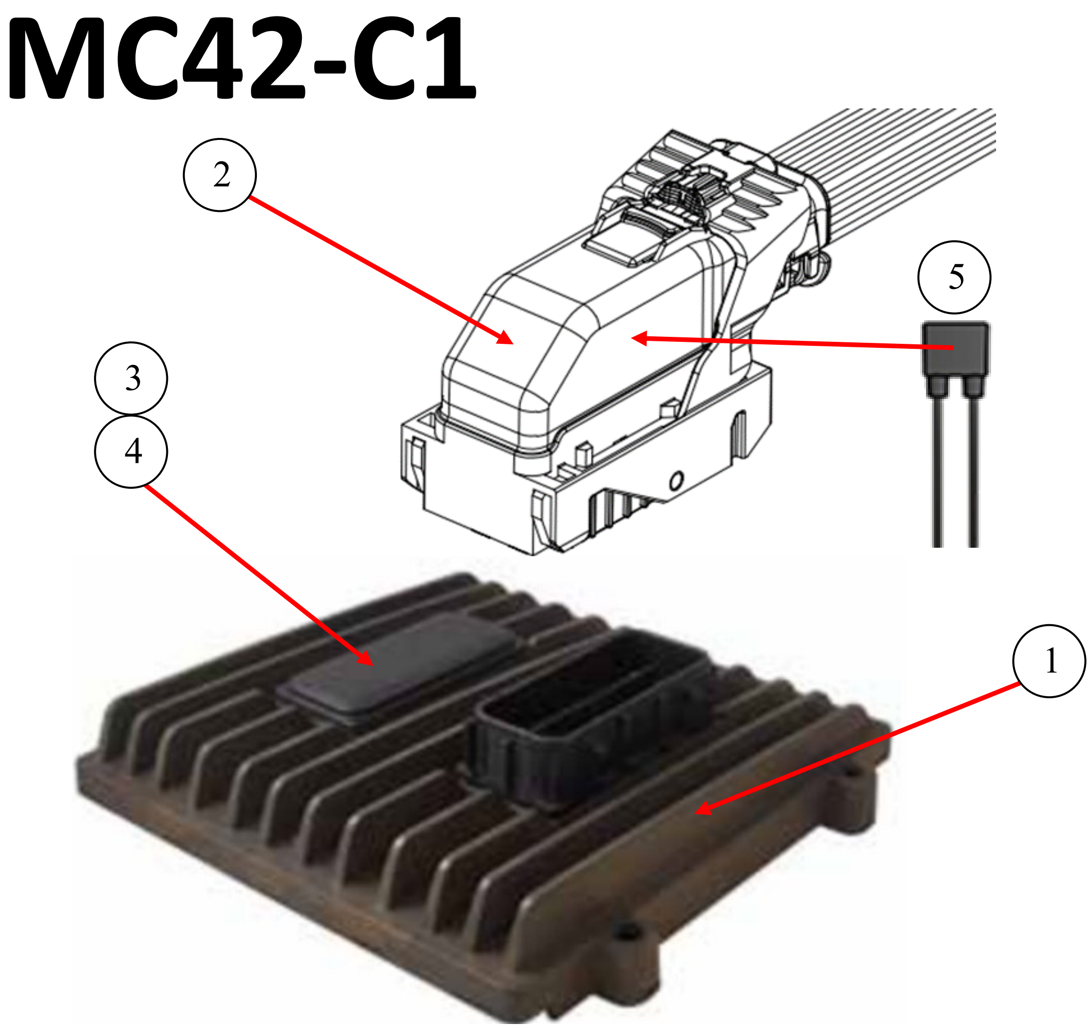
EXPANSION MODULE MC42



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	89613	CONTROLER, MC42	1	EA
2	BW10547	MC42 C1 CABLE HARNESS ASSY 2.5 M LONG	1	EA
3	89622	PLUG, FOR 89613 CONTROLER	0	EA
4	89622-C	COVER, FOR 89622	0	EA
5	89136-1	MOLDED 590 RESISTORS, TAG #1	1	EA

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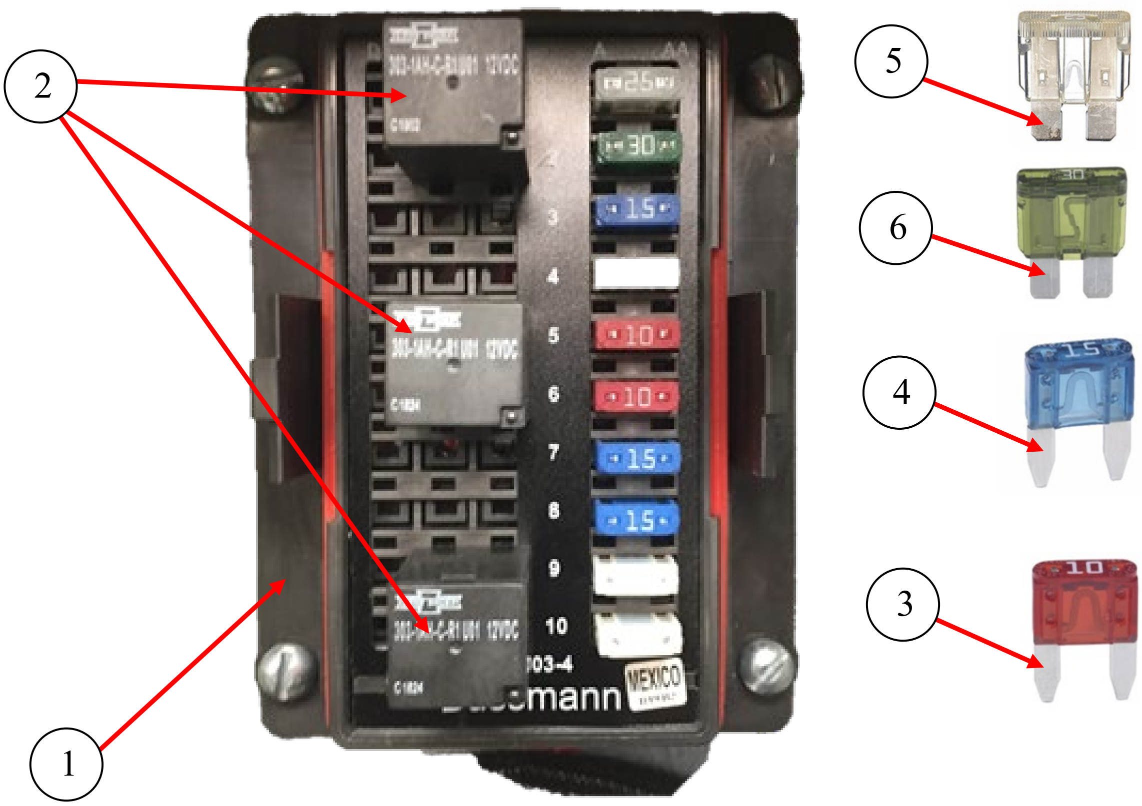
FUSE/RELAY



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	89611	BOX, FUSE & RELAY	1	EA
2	89128	MICRO RELAY	3	EA
3	88953	FUSE 10AMP AUTOMOTIVE MINIATURE BLADE	2	EA
4	88954	FUSE 15AMP AUTOMOTIVE MINIATURE BLADE	3	EA
5	89697	FUSE 25AMP AUTOMOTIVE MINIATURE BLADE	4	EA
6	88956	FUSE 30AMP AUTOMOTIVE MINIATURE BLADE	1	EA
7	89686	TERMINAL FEMALE TANGLESS 22-22 GA.	20	EA
8	89687	TERMINAL FEMALE TANGLESS 14-16 GA.	16	EA
9	89624-1	WIRE SEAL, FOR 89624	36	EA

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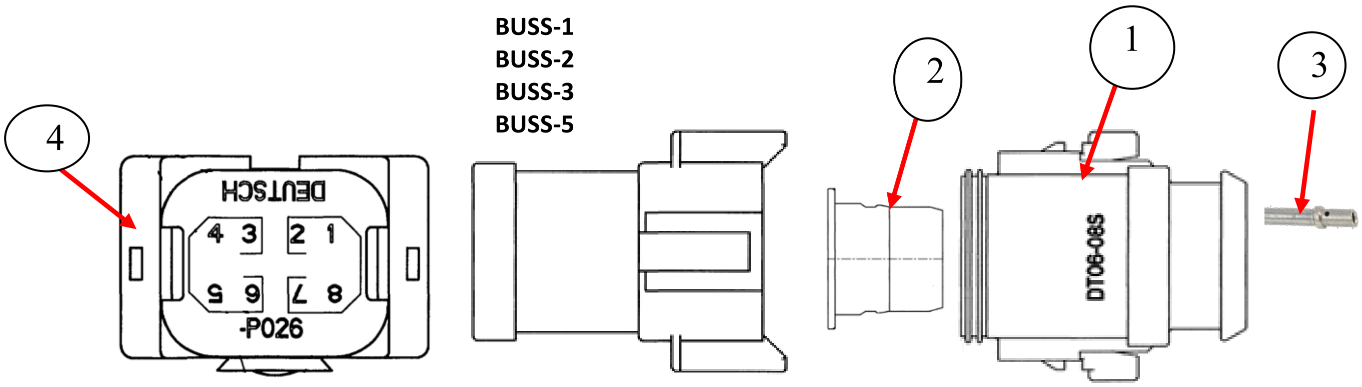
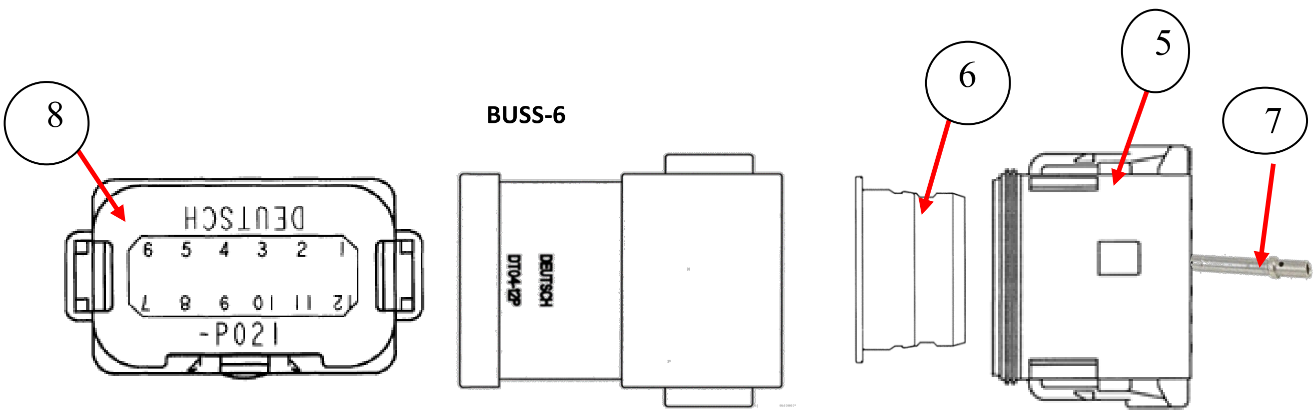
BUSSES, CONNECTORS, PINS





ID #	PART #	PART DESCRIPTION	QUANTITY	
1	89179	DEUTSCH DT06 PLUG, 2X4	4	EA
2	88542-1	WEDGE LOCK FOR 89179	4	EA
3	BW10147	CONTACT SOCKET PIN, SIZE16, 13 AMP	32	EA
4	89181	DEUTSCH DT04 BUS, 2X4	4	EA
5	89104	DEUTSCH DT06 PLUG, 2X6	1	EA
6	89105	DEUTSCH WEDGE FOR 89104	1	EA
7	BW10147	CONTACT SOCKET PIN, SIZE16, 13 AMP	9	EA
8	89106	DEUTSCH DT04 BUS, 1X12	1	EA

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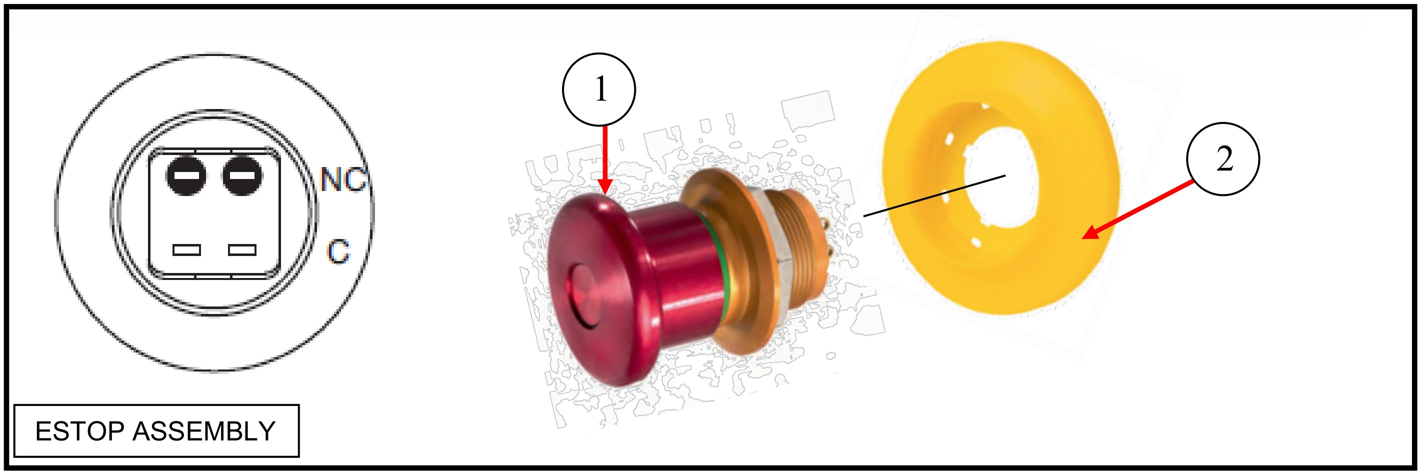
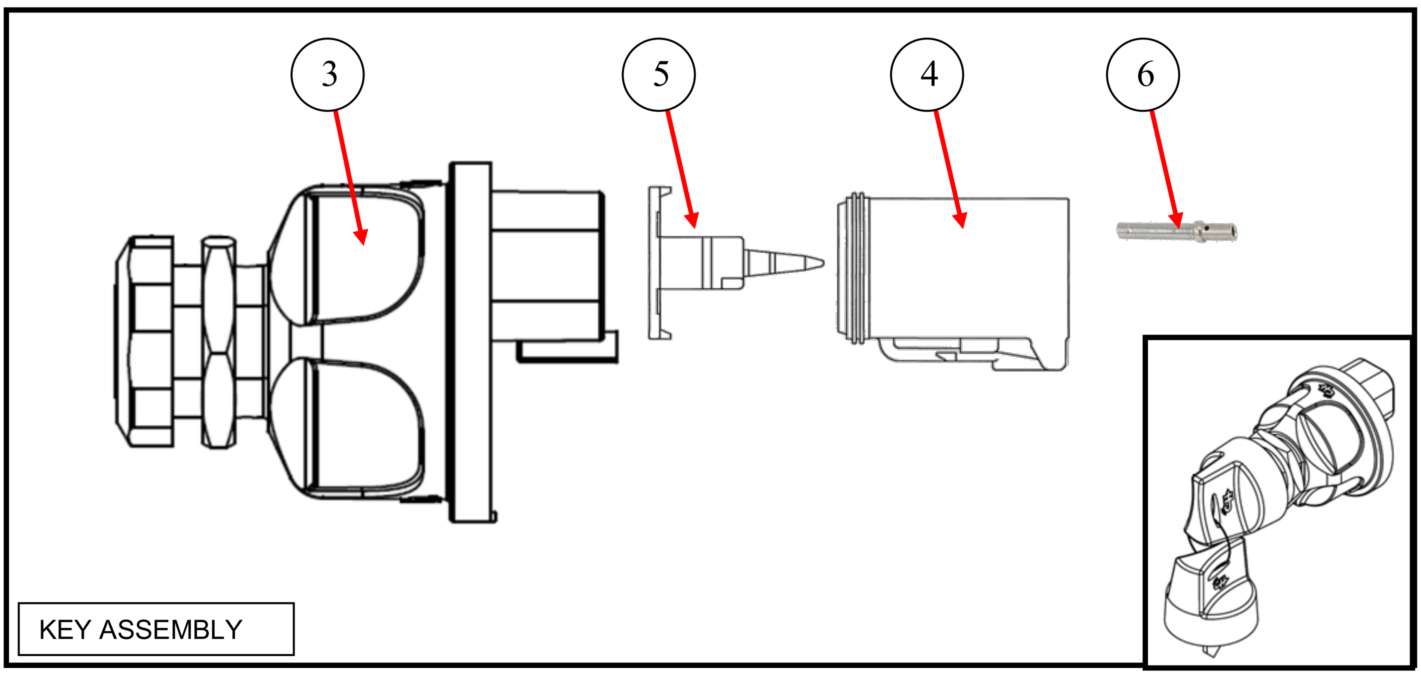
ESTOP, KEY ASSEMBLY, PLUGS





ID #	PART #	PART DESCRIPTION	QUANTITY	
1	89090	EMERGENCY STOP BUTTON HEAVY DUTY	1	ASSY
2	89090-L	ILLUMINATED E-STOP RING	1	ASSY
3	89004	KEY SWITCH SEALED	1	ASSY
4	89107	DEUSCH DT06, 1X6	1	QTY
5	89108	DEUTSCH WEDGE LOCK FOR 89107	1	QTY
6	BW10147	DEUTSCH CONTACT SOCKET, 16AWG	5	QTY

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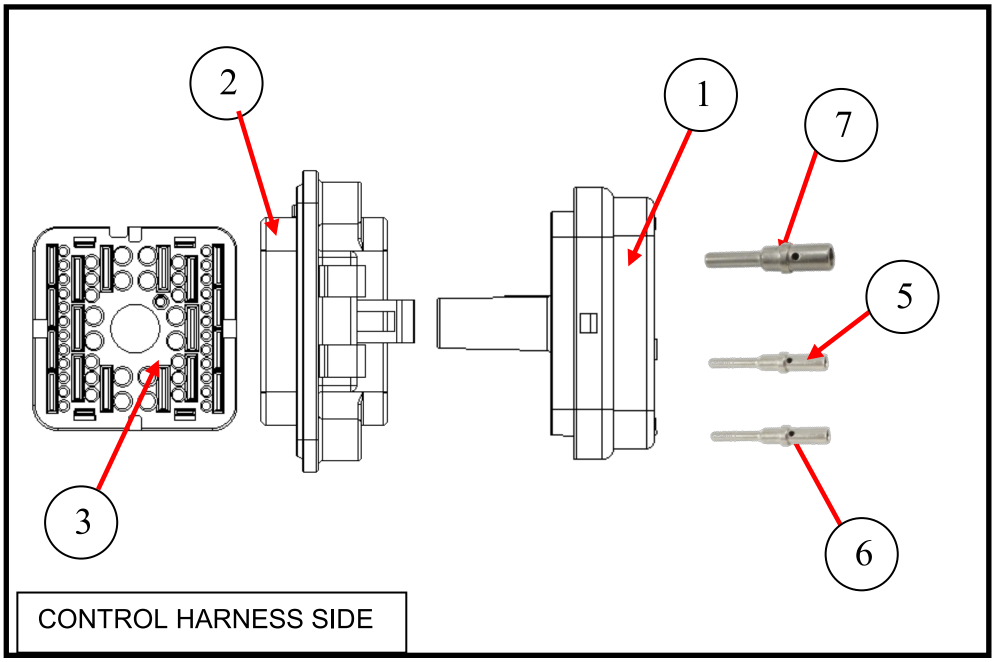
CONNECTORS

DUETSCH 48 MAIN PLUG PANEL SIDE



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	89652	PLUG 48 PIN	1	EA
2	89652-F	FLANGE FOR 89651 PLUG	1	EA
3	89652-W	WEDGE FOR 89652 PLUG	1	EA
5	88958	CONTACT PIN SOLID SIZE 16	12	EA
6	88957	CONTACT PIN SOLID SIZE 20	24	EA
7	87807	CONTACT PIN SOLID SIZE 12	14	EA

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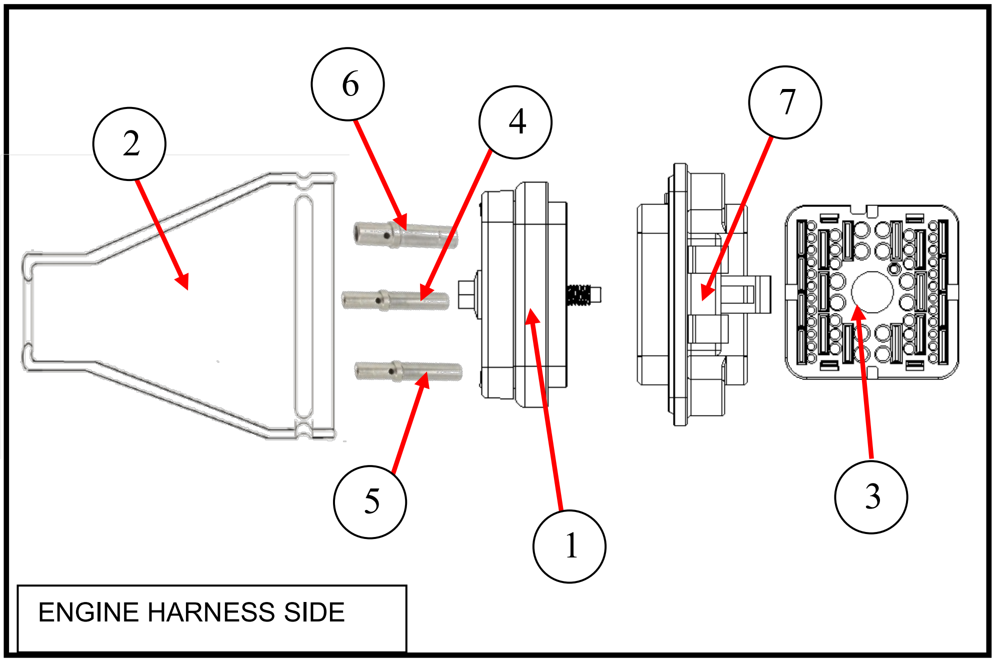
DUETSCH 48 MAIN PLUG HARNESS SIDE



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	89651	PLUG, 48 SOCKET HARNESS SIDE	1	EA
2	89651-B	BOOT FOR 89651 PLUG	1	EA
3	89651-W	WEDGE FOR 89651 PLUG	24	EA
4	BW10147	CONTACT SOCKET SIZE-16,13 AMP	12	EA
5	88959	CONTACT SOCKET SIZ 20 7.5 AMP	24	EA
6	87457	CONTACT SOCKET SIZ 12	?	EA
7	89652-F	CONNECTOR FOR 48 PIN PLUG	1	EA

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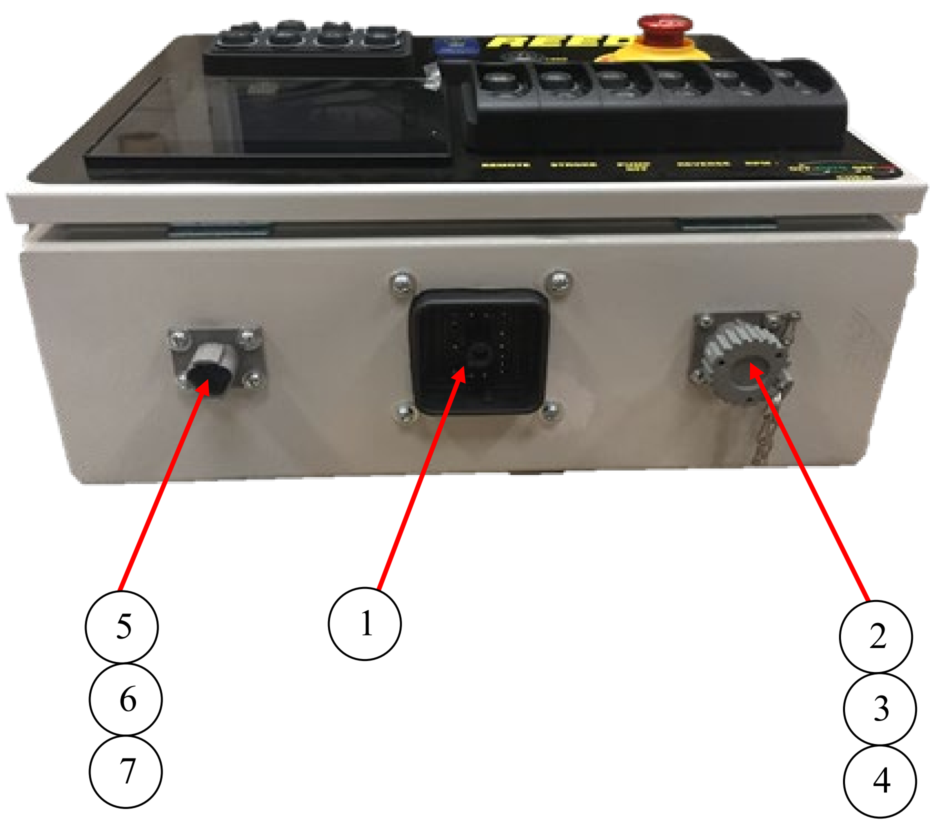
CONNECTORS



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	89652	PLUG 48 PIN	REF	
2	89223	DEUTSCH HD10 PLUG, FLANGED 6 PIN	1	EA
3	89402	CHAIN SASH LANYARD	1	EA
4	89223-C	CAP FOR 89223	1	EA
5	88932	3 WAY RECEPTACLE FLANGE MOUNT DT SER.	1	EA
6	88938	KEYED WEDGE LOCK FOR 3 WAY RECEPTACLE	1	EA
7	88958	CONTACT PIN SOLID SIZE 16	3	EA

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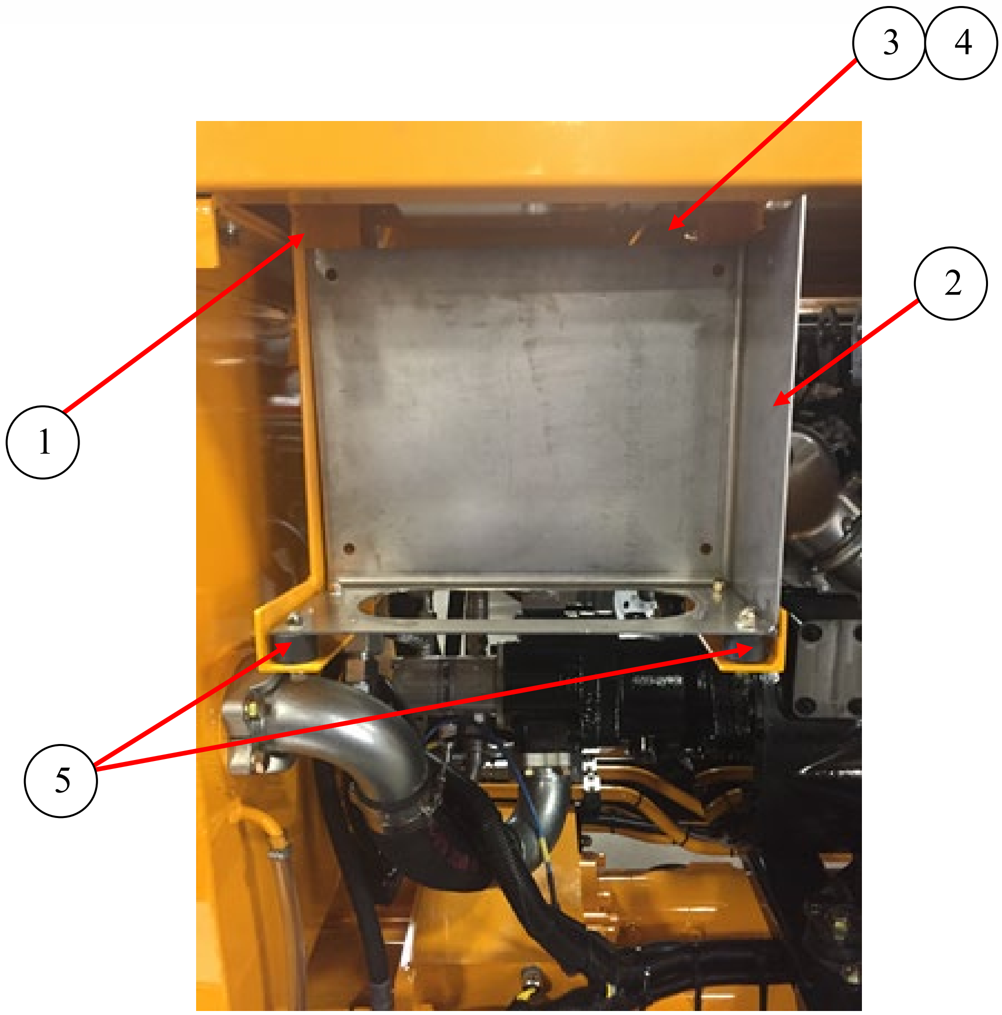
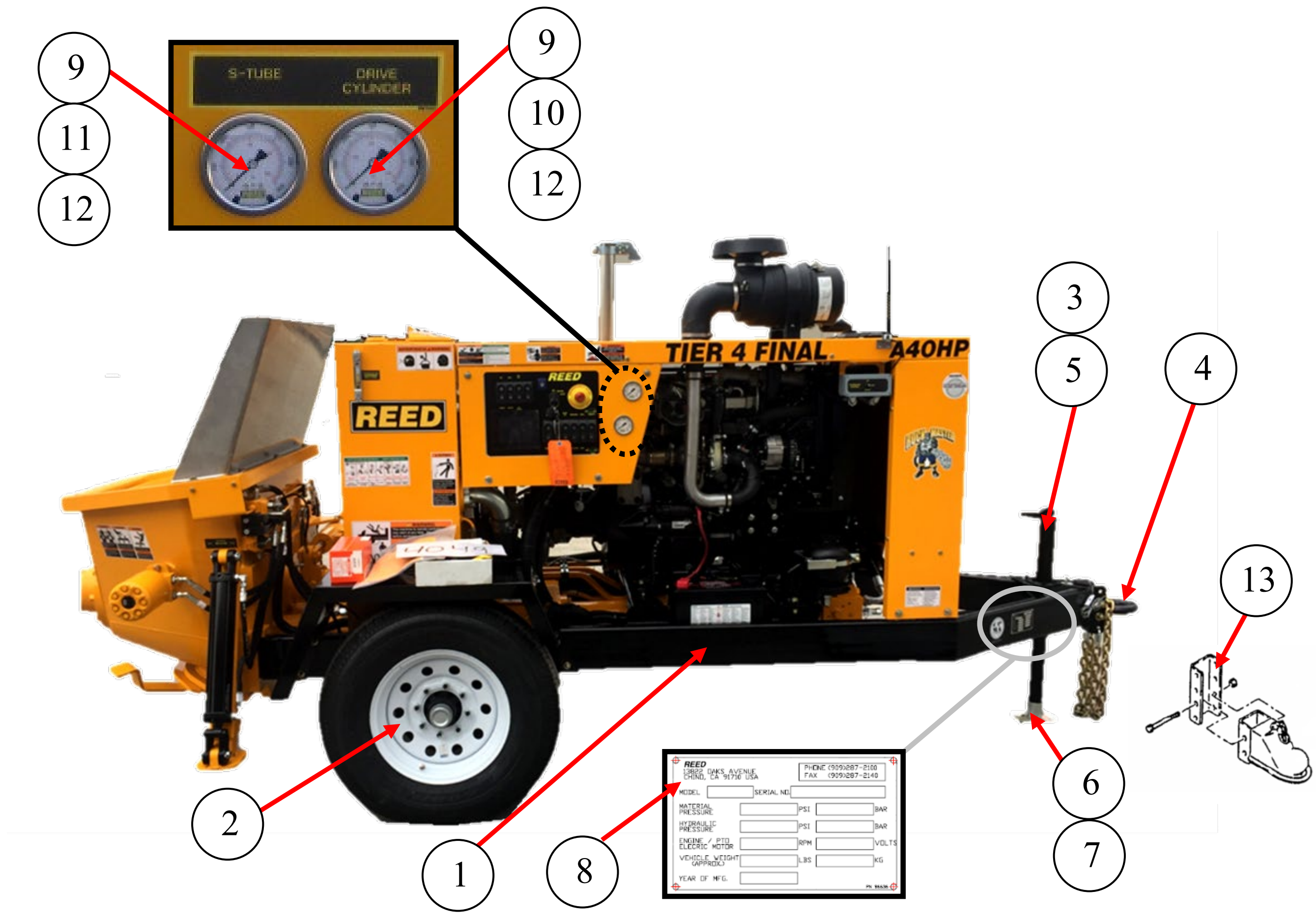
PANEL MOUNT, BRACKET



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	BW10548	CONTROL BOX ASSY SUPPORT BRACKET	1	EA
2	BW10549	CONTROL BOX COVER A SER TIER-4	1	EA
3	BW10560	POLYETHYLEN BAR 2X2"	0.33	EA
4	80347	HORN,12 V	1	EA
5	73748	BUMPER, MOUNT	4	EA

FRAME INSTALLATION
FRAME, GAUGES, TIRES, JACK, AND TOW EYE



ID #	PART #	PART DESCRIPTION	QUANTITY	
	BW10516	FRAME ASSY A-SERIES TIER-4 PERKINS	1	EA
1	BW10513	FRAME WELDMENT A SER TIER-4 PERKINS	1	EA
2	BW10096	TIRE & WHEEL ASSY	2	EA
3	BW10098	JACK FRAME	1	EA
4	71051	EYE-LUNETTE 3”	1	EA
5	BW10169	JACK, FOOT	1	EA
6	86242	CHAIN-3/8 PROOF COIL GR 30 ZINC	6	FT
7	86243	CONNECTOR – 3/8 CHAIN TREADED	2	EA
8	86636	SERIAL NUMBER PLATE (BLANK)	1	EA
9	78594	MINICHECK GAUGE ADAPTER, ¼” NPT	2	EA
10	74562	PRESSURE GAUGE, 6000 PSI/BAR	1	EA
11	70366	PRESSURE GAUGE, 3000 PSI/BAR	1	EA
12	BW10318	MINICHECK HOSE, 90° 48”	2	EA
13	71099	ASSEMBLY, ADJUSTABLE BALL COUPLER 2-5/16”	1	EA

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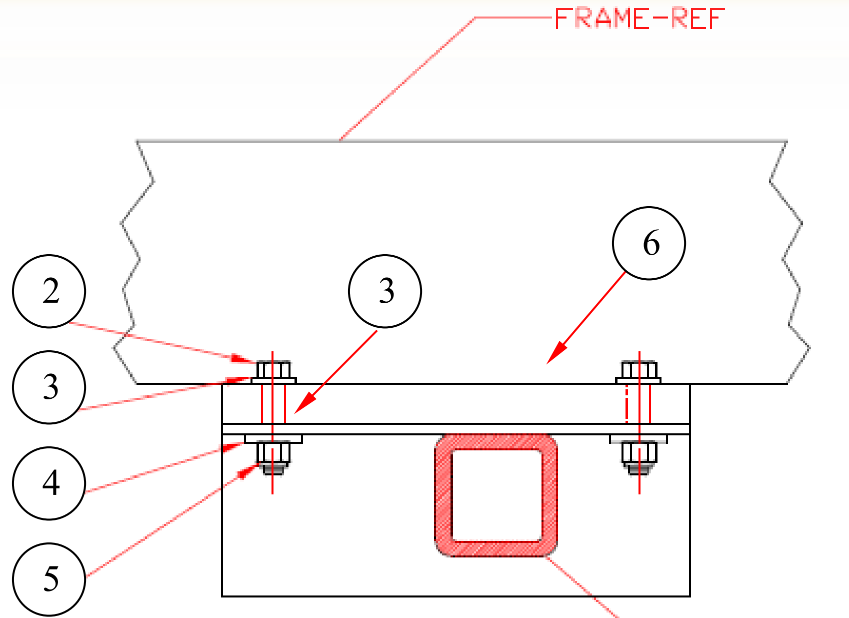
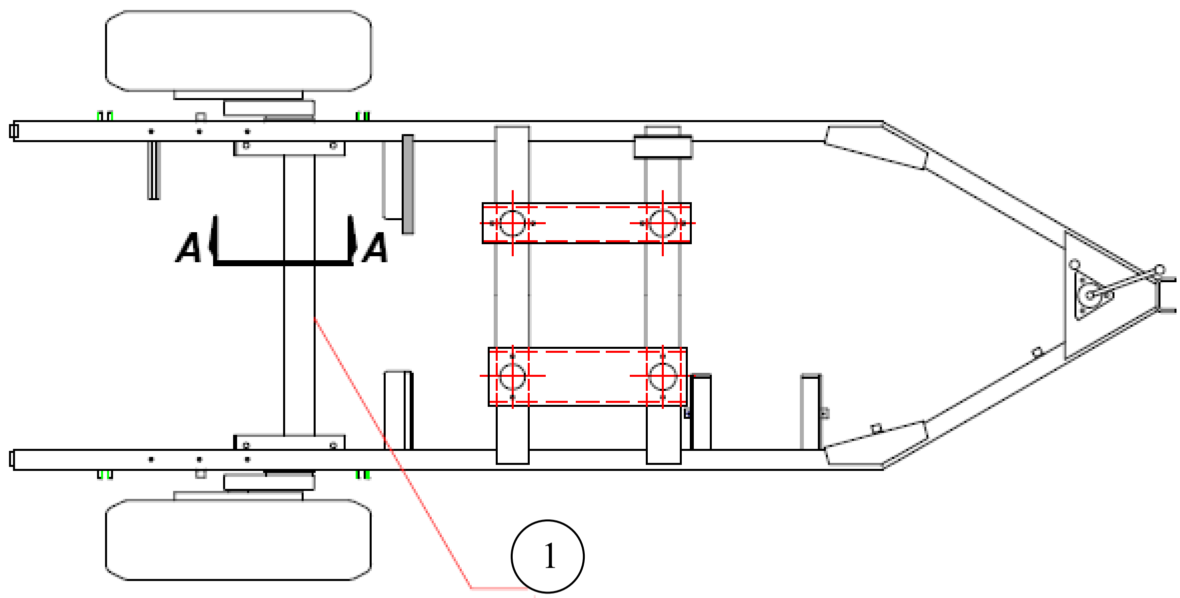
5200LB AXLE MOUNTING ASSEMBLY





ID #	PART #	PART DESCRIPTION	QUANTITY	
1	BW10095	AXLE, TORSTION, 5200 LB, 6 ON 5.5 BC (BRAKE 71056)	1	EA
2		BOLT, ½"-20X3" ,GRADE 8	4	EA
3	80054	WASHER -SAE ½"	8	EA
4	80044	WASHER, ½" USS HARDENED EXTRA THICK	4	EA
5	80075	NUT NYLOCK ½"-13 COARSE	4	EA
6	BW10450	FLAT AXLE MOUNT SPACER	2	EA

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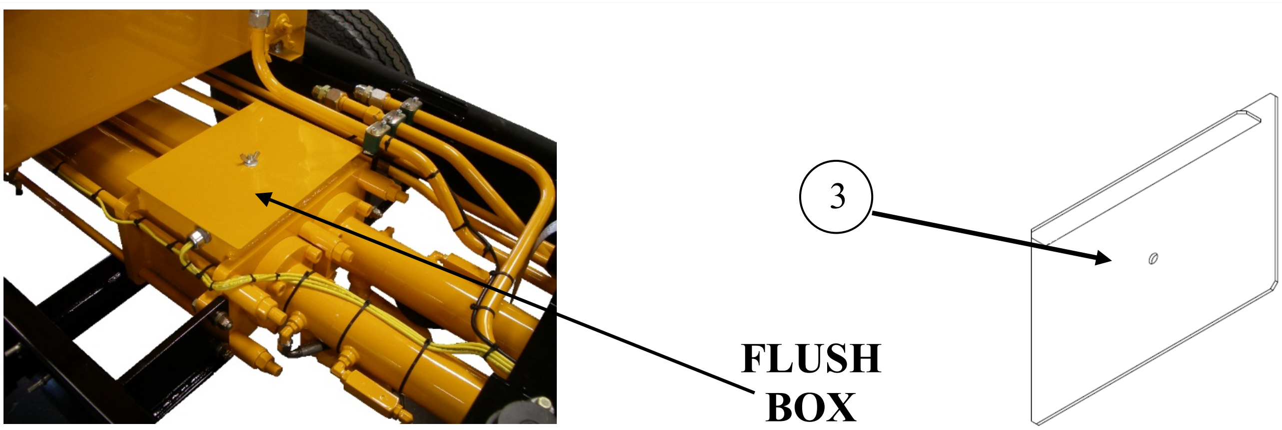
HOOD AND COVERS



ID #	PART #	PART DESCRIPTION	QUANTITY	
1	BW10557	COVER TOP, A SERIES, T4F, PAINTED	1	EA
2	BW10556	COVER FRONT WELD, A SERIES, T4F, PAINTED	1	EA
3	BW10387	COVER, FLUSHBOX, A40 SER.	1	EA
4	85714-1	SPLASH GUARD, WITH HOPPER SAFETY	1	EA

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FENDERS AND OUTRIGGERS

ID #	PART #	PART DESCRIPTION	QUANTITY	
1	BW10350	FENDER, LH, A SERIES PAINTED	1	EA
2	BW10349	FENDER, RH, A SERIES PAINTED	1	EA
3	BW10110	OUTRIGGER INNER LEG-PAINTED	2	EA
4	BW10114	OUTER TUBE, OUTRIGGER-PAINTED	2	EA
5	85595	PIN, Q/R, 5/8 DIA X 3 1/2 L	2	EA
6	800418	LANYARD, Q/R PIN	2	EA
7	BW10267	¾ ID FENDER WASHER	4	EA
	BW10348	MANUAL OUTRIGGER (OPTION)		

A40HP TIER 4
PARTS

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AVAILABLE OPTIONS

OUTRIGGER GROUP
- HYD OUTRIGGER
- OUTRIGGER/AGITATOR
- ELECTRIC OUTRIGGER

AGITATOR GROUP
- STD/PADDLE
- OPTION/PADDLE
- HYD/AGITATOR/SINGLE
- HYD/AGITATOR/TRIPLE

RADIO REMOTE

AARCOMM
Advancing Remote Control Technologies

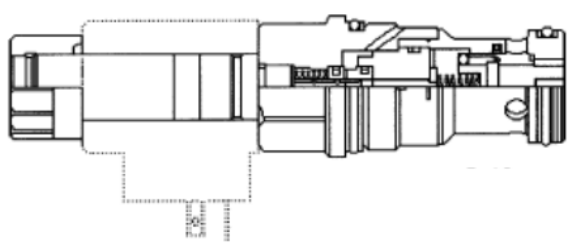
AARCOMM 2-WAY RADIO W/STROKE COUNTER AND VOLUME INDICATOR (IF EQUIPPED)

50' CABLE REMOTE, 100'CABLE REMOTE AVALAIBLE

OMNEX
CONTROL SYSTEMS INC

ELECTRIC VOLUME CONTROL

RADIO CONROL OF VOLUME (IF EQUIPPED)



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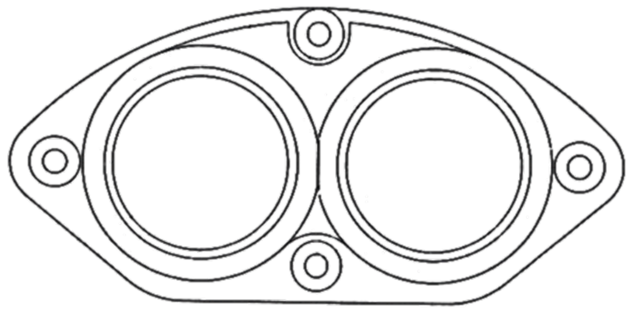
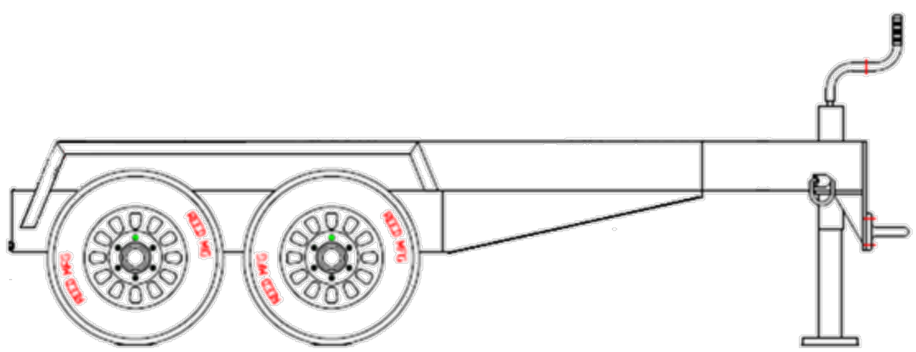
AVAILABLE OPTIONS

CARBIDE WEAR PARTS
- WEAR RING/CARBIDE
- WEAR PLATE/CARBIDE



VIBRATOR KIT
- OL

DUAL AXLE



AUTO LUBE
- STEEL TUBING 12 PORT
- PLASTIC TUBING 12 PORT

MANUAL LUBE BLOCK

LINE PUMP SAFETY MANUAL 7

VERSION 7.0.1

A guide for the prevention of accidents when driving, operating, cleaning, and maintaining small line concrete pumps and related equipment.

AMERICAN CONCRETE PUMPING ASSOCIATION
606 Enterprise Drive | Lewis Center, OH 43035
P: 614.431.5618 | F: 614.431.6944
WWW.CONCRETPUMPERS.COM

CALIFORNIA

Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

SAFETY MANUAL

A GUIDE FOR THE PREVENTION OF ACCIDENTS WHEN DRIVING, OPERATING, CLEANING, AND MAINTAINING CONCRETE LINE PUMPS AND RELATED EQUIPMENT

Introduction

Safety is one of the major concerns of every person involved in the concrete pumping industry. Although much of the responsibility for everyday safety rests upon the pump operator, it is vital that everyone involved makes safety the top priority. This includes the owners, the mechanics, the ready mix drivers, the placing crew, the concrete contractors, and the machine manufacturers.

Although this *Safety Manual* covers a great deal of information regarding the prevention of accidents while operating a concrete pump, it is unlikely that every conceivable circumstance has been covered. Regardless of how thorough a manual like this may be, there is always the unexpected. Please understand that there is no substitute for **common sense** and dedication to the idea that **you are responsible for your own safety,** and affect the safety of those around you. You have to know the rules first, but you must keep your mind on the job if knowledge of the rules is going to keep you and your coworkers alive and well. No attempt has been made in this *Safety Manual* to provide the highly specialized knowledge of the workings of the individual machines that is also critical for safe and proper operation. For that, you must **read and understand the operation manual for the machine(s) that you operate!**

This *Safety Manual* is a guide for the prevention of accidents and is to be used in conjunction with **professional training.** The ACPA now has an Operator Training Program. Additional information and materials are available through the American Concrete Pumping Association, including, specifically, an Operator Certification Program. Make the commitment to be professional - get your certification!

Version 7.0.1
February 2015

SAFETY MANUAL

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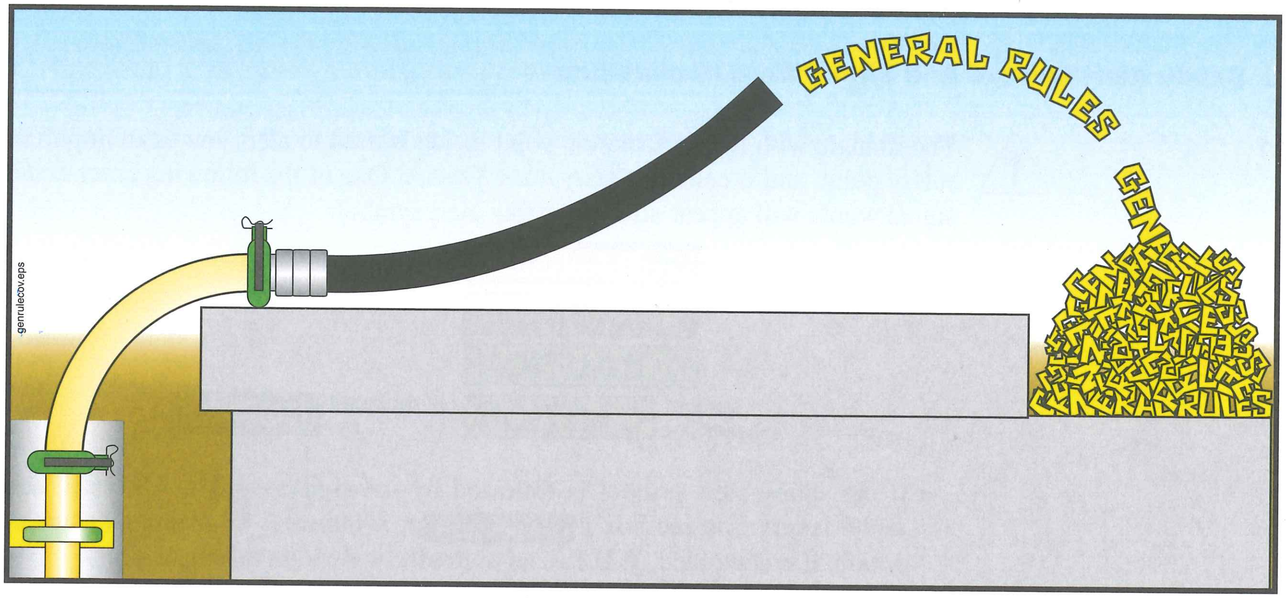

General Rules
Table of Contents

I. Before You Leave The Yard

1. Safety Alert Symbol And Signal Word Explanation

1.1 The triangle with the exclamation point inside is used to alert you to an important safety point, and is called a *Safety Alert Symbol*. One of the following color-coded signal words will appear after the safety alert symbol:

DANGER

WARNING

CAUTION

or - without the symbol: CAUTION is replaced by: NOTICE

- If the safety alert symbol is followed by the signal word **DANGER** with white letters in a red box (DANGER), it indicates a hazardous situation which, if not avoided, **WILL** lead to **death or serious injury.**
- If the safety alert symbol is followed by the signal word **WARNING** with black letters in an orange box (WARNING), it indicates a potentially hazardous situation which, if not avoided, **COULD** result in **death or serious injury.**
- If the safety alert symbol is followed by the signal word **CAUTION** with black letters in a yellow box (CAUTION), it indicates a potentially hazardous situation which, if not avoided, **COULD** result in **minor to moderate injury.**
- The signal word **CAUTION,** used in a yellow box, but **without the safety alert symbol** (CAUTION), means the point addresses a hazard which, if not avoided, **COULD** cause **damage to equipment or property.**
- The signal word **NOTICE** (NOTICE), now replaces the signal word caution (without the safety alert symbol), above.

2. What To Do Before You Arrive At Work

2.1 Get enough sleep to be ready for the day's work. Accidents can happen when the body is on the job, but the mind is not.

2.2 Dress in appropriate apparel and Personal Protective Equipment (P.P.E. or just PPE.) See Figure1. You should always wear these items when pumping concrete:

- hard hat;
- safety glasses or goggles (plus a full face shield, when shotcreting);
- snug-fitting clothes;
- gloves;
- steel-toed shoes;

In addition, you should wear:

- hearing protection if you stand near the pump or any other source of noise;

†† Illustration © British Concrete Pumping Association. Used by permission.

- breathing mask whenever there is cement dust in the air;
- rubber gloves during cleanout or if you'll be touching wet concrete;
- rubber boots anytime you have to stand in concrete;
- full face-shield when shotcreting, or any time material is rebounding.

* Full face shield should be used in addition to safety glasses when shotcreting, or any time material is rebounding.

** Breathing mask needed when cement dust (or other toxic dust) is present in the air.

Figure 1
Personal Protective Equipment (PPE)

2.3 Jewelry, athletic shoes, sandals, and shorts are examples of clothing that should NOT be worn when pumping.

2.4 **⚠WARNING** Be sure that any clothing you wear does not have strings, fringes, or other external tightening means that could be caught in moving parts (Figure 2).

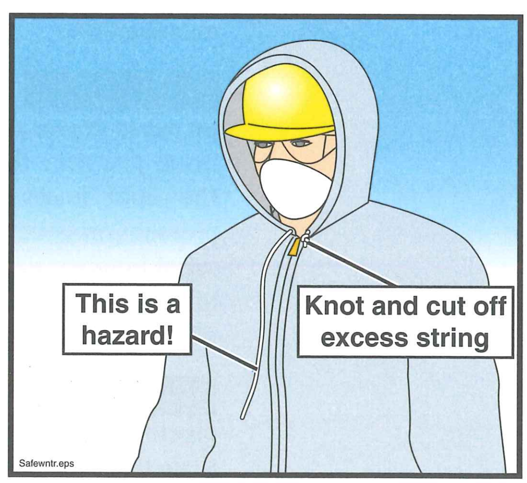

Figure 2
No strings attached

SAFETY MANUAL

2.5 Arrive to work on time. Accidents can be caused by hurrying through procedures.

2.6 ⚠WARNING **Never** go to work on a construction site or work on, around or near a piece of machinery when under the influence of drugs or alcohol. Beware of prescription medications or over the counter drugs, many of which have specific warnings about operating machinery after taking the medication (Figure 3).

Figure 3
Your coworkers depend upon you for their safety

2.7 ⚠WARNING Don't bring your personal problems to work with you. In an office setting this may be annoying to coworkers, but on a construction site it can be deadly. The workers around you depend on you for their safety.

3. What To Check Before You Leave The Yard

3.1 ⚠WARNING Do not operate the machine until you read and understand the unit's operation manual. Lack of understanding of proper operating procedures could result in unsafe operation. Operation manuals are issued with each new unit. If you haven't seen it, ask your supervisor. Replacements are available from the manufacturer.

3.2 ⚠WARNING Inspect delivery pipes, concrete delivery hoses, and end hoses for wear. Never use a hose or pipe that is dented or worn out. **Know the maximum pressure that your machine can exert on the concrete, and be sure that the pipes, hoses and clamps are capable of handling the pressure.** Maximum pressure on concrete is stated in operation manuals, service manuals, and on the serial number plate of the machine. A chart showing the minimum wall thickness of pipeline versus maximum pressure is found on page 47 in the Appendix section of this *Safety Manual*.

3.3 ⚠WARNING If you will need to use compressed air to clean out the system pipeline, BE SURE that you have the proper training, equipment, and attachments to do this procedure safely! Proper attachments include:

- A blowout head with properly sized air discharge regulator valve and separate water/air inlet. The two openings should be spaced apart far enough that a blowout ball could not cover both openings at once.
- A *go-devil*, or a hard sponge ball. Regardless of which is used, it **must** fit into the pipeline tight enough that air cannot escape ahead of it.
- A ball or go-devil catcher that will catch the go-devil or ball when the line has been purged of all concrete, unless another method of controlling the outlet is used. There are two types of catchers (see paragraph 5.24 on page 13).
- A hose that is rated for the pressure of the air compressor you will use and that is able to connect with both the air compressor and the blowout head. The hose must be in good working condition and must be free of cracks, frays, tears or other damage. Do **NOT** improvise on this. **Make sure** you have the right part (Figure 4).

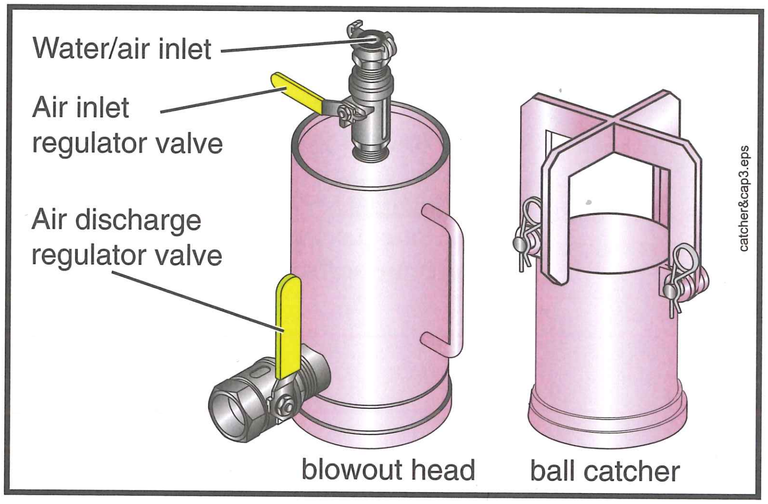

Figure 4
Compressed air accessories

3.4 **⚠WARNING** Be sure that the unit is equipped with all the pipes, clamps, gaskets and hoses, blowout adapters, ball catchers, and other accessories that you will need for the day's work. Making do with inappropriate equipment could cause accidents.

3.5 On trailer-mounted units, check the oil and cooling system of the pump drive engine. Accidents could occur when lack of maintenance is causing a distraction while operating the equipment.

3.6 Be sure the battery has enough charge to start the pump drive engine. You will be rushed on the job if you have to do repair work before you can begin operation.

3.7 **⚠WARNING** The operator is responsible for checking to see that the concrete pump, and delivery system are in safe and proper working condition. If an unsafe condition exists, **work must not begin** until necessary repairs have been completed, or until the machine can be operated safely.

SAFETY MANUAL

3.8

⚠WARNING The operator is responsible for checking that all safety equipment and guards are in place and in good condition. If found to be missing, incomplete, or damaged, **work must not begin** until the situation has been made safe.

3.9

⚠WARNING The operator is responsible for checking that all safety decals are in place and are in readable condition. If found to be missing or unreadable for any reason, steps should be taken to obtain replacements.

3.10

⚠WARNING Inspect the tires and brakes on the truck. Never drive a truck with bald or cracked tires, or with weak or worn brakes. If you have air brakes, be sure that the air system is free from leaks and will maintain pressure when driving. Loss of air pressure will cause the brakes to be applied while driving. If driving continues after the brakes are applied, the resulting friction could cause enough heat to start a fire.

3.11

Drain moisture from the air tanks that supply the unit's brakes (if so equipped). This is especially important if weather conditions could cause the moisture to freeze. If you lose air pressure because of frozen moisture, the brakes will apply themselves, and you will have to stop driving until the unit is repaired.

3.12

⚠WARNING (See Figure 5.) Mount or dismount the pump or truck using the *3-point Rule* (i.e. keep two hands and one foot or one hand and two feet in contact with a secure surface at ALL times).

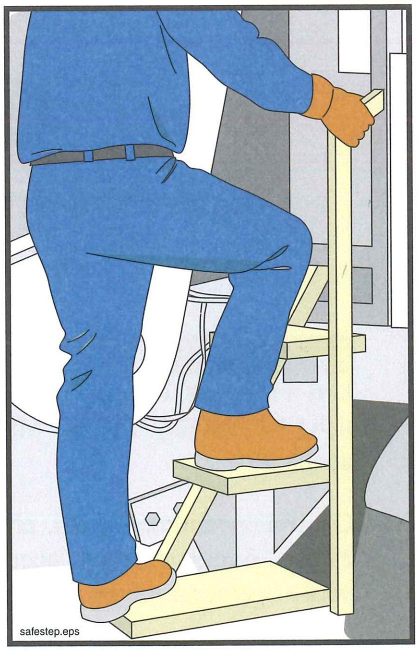

Figure 5
The 3-point Rule

3.13

⚠WARNING Never mount or dismount the truck or pump while carrying objects that prevent you from using the3-point Rule. Move the objects separately, if needed.

3.14 **⚠WARNING** If applicable, be sure that outriggers are pinned and locked before traveling. If the locking device is damaged or worn, it should be repaired immediately and the unit **must not be driven until the outriggers can be positively locked** against accidental opening.

3.15 **⚠WARNING** Be sure there is nothing in the cab of the truck (such as empty soda cans, loose tools, etc.) that could interfere with the operation of the vehicle.

3.16 Be sure that all road-related safety devices (warning signs, flares, fire extinguisher, etc.) are present and secured for travel.

3.17 Be sure all personal protective equipment (hard hat, safety goggles, rubber gloves, etc.) are secured for travel.

3.18 **⚠WARNING** Be sure the windshield and mirrors are clean and free of frost or ice, and that the mirrors are properly adjusted.

3.19 **⚠WARNING** Verify that head lights, tail lights, turn signals, brake lights, backup warning horn, and backup lights are operational.

3.20 In some cases you may be asked to operate a machine other than the one with which you are familiar. In these cases, be sure to:

- Know the weight, height, and width of the machine.
- Have a copy of the operation manual with you.
- Ask the machine's normal operator, the dispatcher, or your supervisor questions regarding any unusual or unique operational characteristics of the machine.
- Familiarize yourself with the machine by setting it up in the yard and running the functions, and by familiarizing yourself with the operation manual. This is especially important if the new machine is significantly different than the one you normally operate. Your coworkers depend on you to know the machine.

3.21 **⚠WARNING** Be certain that all loose items on the unit are secured for travel before driving.

3.22 **⚠WARNING** Emergency stop switches (E-stops) should be periodically checked by activating the switch in the yard and confirming that none of the pump functions operate electrically or manually.

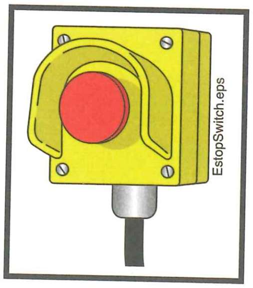

Figure 6
Periodically check your emergency stop switches (E-stops) for proper function

4. Safety Rules For Towing Trailer-Mounted Concrete Pumps

4.1 **⚠WARNING** Be sure the towing vehicle is sized appropriately for the trailer. It must be heavy enough and have enough braking ability to maintain control at highway speeds and to stop—even on hills. If the trailer is heavier than the towing vehicle, braking distances will be greatly increased (Figure 7).

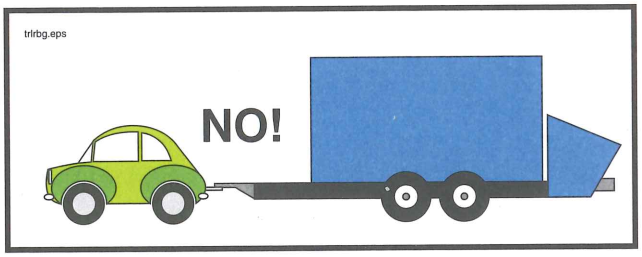

Figure 7
Do not under size the towing vehicle

4.2 **⚠WARNING** Never tow a trailer that has concrete in the hopper. The extra weight in the back of the machine will remove weight from the tongue and cause the trailer to fishtail.

4.3 **⚠WARNING** Check the tires, tire pressure, and brakes on the trailer before towing. Never tow a vehicle with cracked or bald tires. A trailer tire blowout can cause loss of control in the towing vehicle.

4.4 **⚠WARNING** Be especially careful on ice or slippery roads when towing a trailer. A skid that would normally be easily correctable can be multiplied by the trailer, causing loss of control.

4.5 **⚠WARNING** Be sure the electrical connections between the towing vehicle and the trailer are sturdy and reliable, and that the lights on the towing vehicle and trailer are working.

4.6 **⚠WARNING** Always use safety chains and break-away protection when towing a trailer.

4.7 **⚠CAUTION** Be aware of local or state regulations regarding mirrors, lights and maximum speed when towing a trailer.

4.8 **⚠WARNING** When towing a trailer, your stopping distance and turning radius are greatly increased. Be aware of this **at all times.**

4.9 **⚠WARNING** When towing a trailer long distances, it is important to frequently check the hitch, hitch pins, couplers, safety clips, towing eyes, wiring, emergency breakaway switch, safety chains, and other accessories, as equipped.

4.10 **⚠WARNING** Be aware of your length when towing a trailer. A common cause of trailer accidents is turning too close to curbs or objects.

4.11 **⚠WARNING** Never back up a trailer without a guide.

4.12 **⚠WARNING** Frequently observe the trailer and watch for unusual swerving or indications of problems, such as a flat tire.

II. On The Job Site - Safety Rules For Job Setup

5. Setting Up A Trailer-Mounted Pump and/or A Separate Pipeline

5.1 **The job setup phase sets the stage for most accidents.** Taking a few extra moments to correctly set up the job will improve your chances of having a safe, trouble free day.

5.2 **The operator is responsible for the safe operation of the machine.** Notify your employer, the job superintendent, and/or O.S.H.A. if you are being asked to set up in an unsafe manner. **You are never required to take a chance with safety.** You are the **only** person who can determine that the job circumstances under your control are safe.

5.3 **⚠WARNING** **Any power connections above 28 volts must be made by a licensed electrician.** The supply power and appropriate disconnect boxes are the responsibility of the contractor.

5.4 **⚠WARNING** **Electrical power on the job site may be taken only from a fused, grounded disconnect box with a disconnect switch that can be locked against activation.** If you will be making repairs to the concrete pump or separate placing boom, first lock out the power at the disconnect box.

5.5 **⚠WARNING** On units equipped with electric motors, **check the power cables every day.** If they are frayed or have open spots in the insulation, replace the wire. If the connectors are worn or loose, have repairs made by a licensed electrician.

5.6 **⚠WARNING** **Consider the safe approach and departure of the ready-mix trucks and adjust your setup accordingly.** Adjusting your setup position by a few degrees one way or another could mean the difference between a safe approach and an unsafe approach. Some examples of unsafe approaches are: too near an excavation or sticking out into traffic.

5.7 **⚠WARNING** **Avoid collisions!** Secure the immediate area of the machine from public traffic in accordance with all applicable regulations (warning lights, safety cones, barricades with flashers, etc.).

5.8 **⚠WARNING** Pipelines, end hoses, couplings, and all other **material delivery components must be able to withstand the maximum concrete pressure of the pump. Be sure** of it! Read and understand the minimum wall thickness chart found in the *Appendix* of this manual. If you don't understand the chart, contact the pipe manufacturer for assistance.

5.9 A *concrete delivery hose* is a flexible concrete hose that has two end couplings. An *end hose* is a flexible concrete hose that has one end coupling. See Figure 8.

Figure 8
End hose vs delivery hose

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5.10 **⚠WARNING** Do not use a piece of pipeline, end hose, coupling, or any other material delivery component that is not in good condition. **Replace, do not repair damaged pipes and hoses.** Concrete pipeline system is subject to wear, and the rate of wear is affected by pumping pressure, concrete composition, pipeline material, and other factors. Read and understand the minimum wall thickness chart in the *Appendix* of this manual. **Bursting pipes and concrete escaping under pressure is a serious safety hazard (Figure 9)!**

Figure 9
Delivery system components must be able to withstand maximum pump pressure

5.11 When laying out a pipeline, it is preferable to use an elbow instead of a hose to make direction changes. Elbows have less resistance to flow than hoses, and will therefore reduce the overall pressure required to push the concrete.

5.12 Always use the largest diameter pipeline that is practical, and use steel pipe instead of rubber hose. This will keep the pressure required to push the concrete to a minimum.

5.13 Support the delivery pipeline. Either an "S' transition pipe should be used to bring the pipe to ground level, or **each** section of the pipeline should be supported at the pump outlet level.

5.14 **⚠WARNING** The sections of pipe nearest the pump are subjected to the highest pressure and the greatest wear. Because of this increase of pressure near the pump, you should install only thick-walled pipe, in like-new condition there. Read and understand the minimum wall thickness chart in the *Appendix* of this manual.

5.15 **⚠WARNING** **The maximum concrete pressure of the pump must be the only factor used to determine what thickness of pipe and what type of ends are needed.** In the case of a rock jam or any other type of blockage, **the maximum pressure of the pump will be exerted.**

5.16 Grooved (Victaulic) ends are **not recommended** for concrete pumping. Read and understand the comparison between heavy duty raised, metric, and grooved ends in the *Appendix* of this manual.

5.17 **⚠WARNING** If the pipeline remains on the job (as is the case when pumping a high-rise building), **the operator is responsible for checking the pipeline for**

dents, cracks, wear, and continuous connection each day before the pour begins.

5.18 **⚠WARNING** In vertical runs, the weight of the vertical sections of pipe must be supported by a thrust block (often called a *deadman,* Figure 10) or other load-bearing device. **Each section of pipeline in a vertical run must be secured from lateral and horizontal movement.**

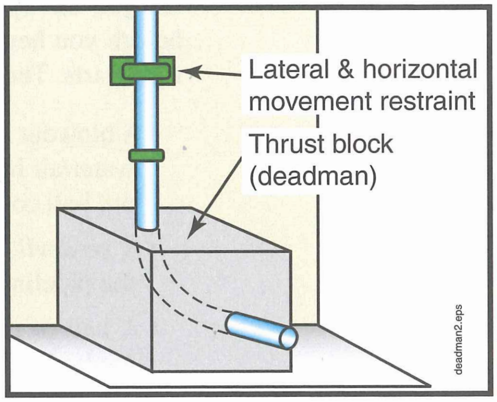

Figure 10
A thrust block (deadman)

5.19 **⚠WARNING** If you will be unable to see the point of placement, establish a system of communications with the workmen who will be there. Arrange for radio communications, a system of visual or auditory signals (lights or bells), or a signalperson (Figure 11). If a signalperson is used, **agree on hand signals before beginning the pour!**

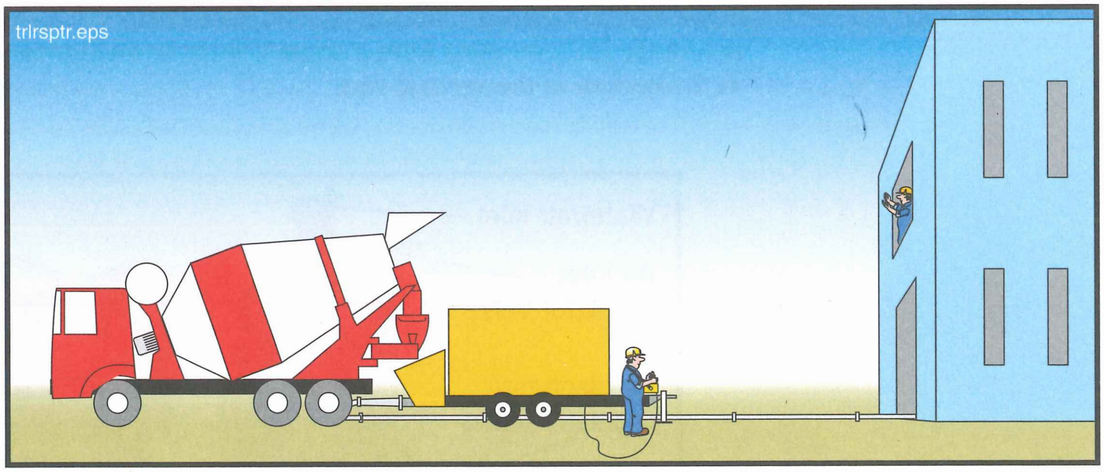

Figure 11
Arrange communications before starting

5.20 **⚠WARNING** Never leave the machine unattended when it is running or ready to run. If you must leave the area, you must leave someone to monitor the unit. This is especially critical if there are children in the vicinity.

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5.21 **⚠WARNING** Watch for children! It is possible for children to access the machine, but it is not safe for them to do so.

5.22 **⚠WARNING** If spectators will be near the job, cordon off an area where they will be safe.

5.23 **⚠WARNING** If you will be cleaning the pipeline with compressed air at the completion of the job, **be sure that you have all the necessary accessories to do the job safely.** If you don't have all of them, make arrangements to get them before you begin to pump. **Do not improvise on this. Make sure** you have the right parts. The minimum accessories include:

- A blowout head with properly sized air discharge regulator valve, and separate water/air inlet. The two openings must be spaced apart far enough that a blowout ball could not cover both openings at once.
- A *go-devil*, or a hard sponge ball. Regardless of which is used, it **must** fit into the pipeline tight enough that air cannot escape ahead of it.
- A ball or go-devil catcher that will catch the go-devil or ball, or some other method of controlling the discharge while the line is being purged of material. There are two types of catchers (see paragraph 5.24).
- A hose that is rated for the pressure of the air compressor you will use and that is able to connect with both the air compressor and the blowout head. The hose must be in good working condition and must be free of cracks, frays, tears or other damage.
- If you will be cleaning the pipeline with compressed air at the completion of the job, be sure an adequate air compressor is available before starting the job.
- If you will be cleaning a vertical pipeline with compressed air at the completion of the job, you **must have a shutoff valve or switching valve installed at the bottom of the vertical run!**

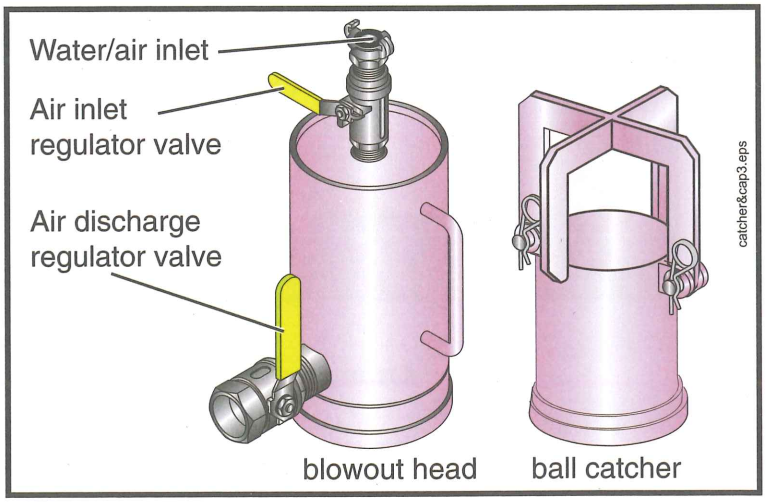


Figure 12
Ball catcher and blowout head

5.24 **⚠WARNING** There are two types of ball catchers. Know which type of catcher you are using. You may need to adjust your cleanout procedure according to which type you have. The two types are as follows:

1. Catchers that stop the ball or go-devil before air can escape, and
2. Catchers that allow the air out of the pipeline after the ball or go-devil has reached the end.

Each type of catcher has advantages and disadvantages (Figure 13).

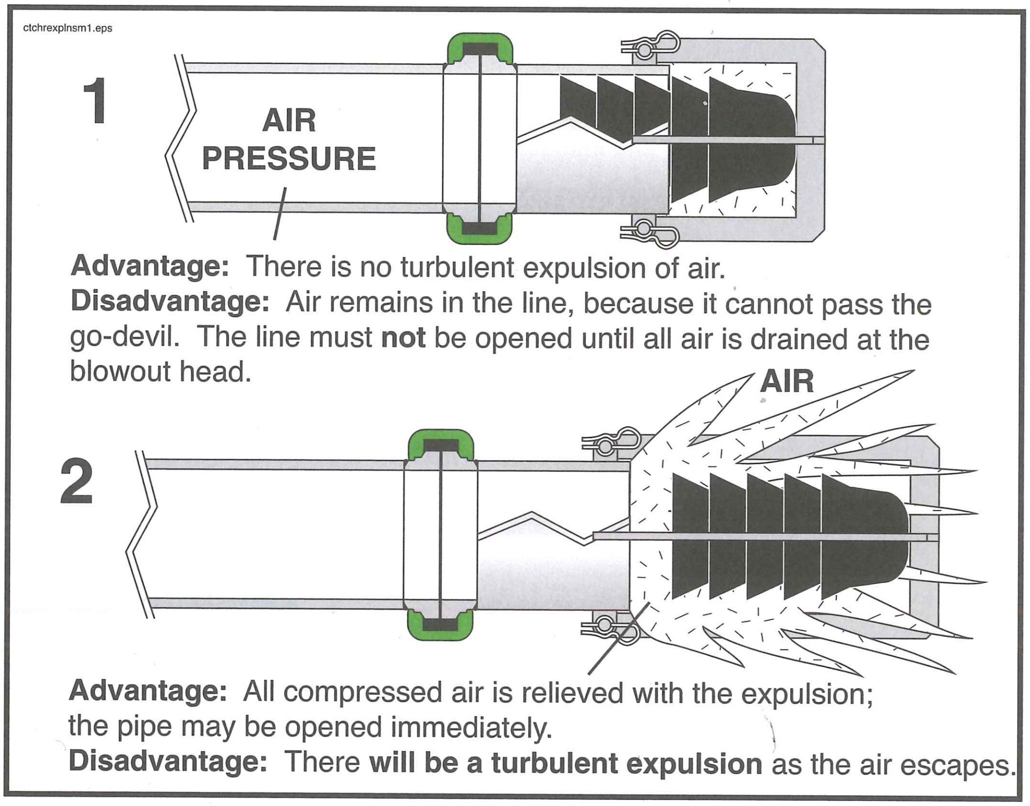


Figure 13
Types of catchers

With catcher type 1, the go-devil stops, but air is still trapped behind it. The advantage is prevention of the sometimes violent expulsion of air at the end of the pipe. The disadvantage is that the air must be drained from the blowout head before the pipe line is safe to open. The pipeline must be controlled; allow no one to open it until all compressed air is relieved.

Catcher type 2 is long enough that the compressed air escapes behind the go-devil. **Note!** This would happen with either catcher when used with a ball instead of a go-devil. The advantage of this is that once you hear the turbulent expulsion, there is no pressurized air remaining in the line, and the line may be opened immediately. The disadvantage is the expulsion itself. In this case, the end of the line must be controlled because flying concrete and aggregate pose a hazard.

Both catchers can be safely used if care is given to the hazards involved.

III. Concrete Pump Operation

6. Safety Rules For Pump Operators

6.1 **⚠WARNING** Only qualified operators are allowed to operate the pump. A Qualified Operator is defined as someone who:

- has reached the age of 18 years (21 for interstate travel);
- is physically and mentally capable;
- has been trained in the operation and maintenance of the pump and the placing boom (if applicable);
- has demonstrated their capabilities to the employer in respect to the operation and maintenance of the pump and placing boom (if applicable); and
- can be expected to perform these duties, as assigned, in a reliable manner.

6.2 **⚠WARNING** Because operators are responsible for the safe operation of the machine, it is crucial that they understand the proper operation of the machine and the safety rules that apply to the job at hand, so the course of action taken in unforeseen circumstances will be a safe one. Only thorough training and supervised job experience can supply the necessary understanding.

6.3 **⚠WARNING** When operating the machine, **wear Personal Protective Equipment** (P.P.E., or just PPE). (Including *full face shield and/or ** breathing mask, when necessary, as shown in Figure 14.)

* Full face shield should be used in addition to safety glasses when shotcreting, or any time material is rebounding.

** Breathing mask needed when cement dust (or other toxic dust) is present in the air.

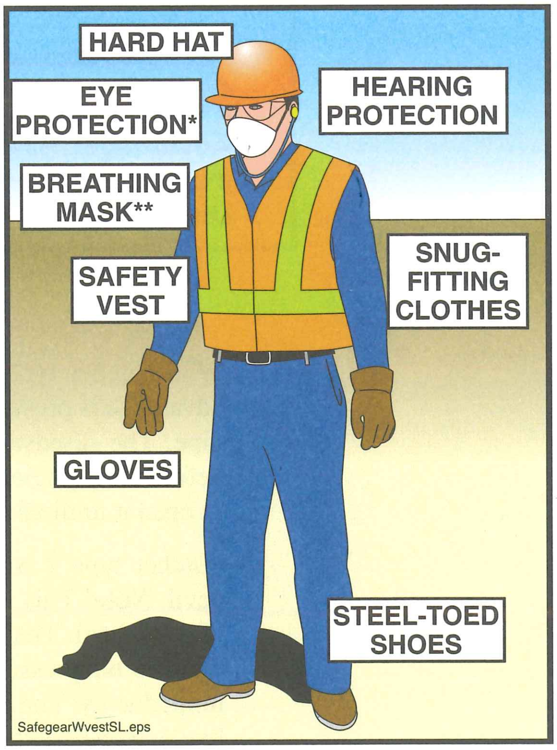


Figure 14
Wear Personal Protective Equipment (PPE)

6.4 **⚠WARNING** All guards, covers, and service flaps must be secured in place during operation.

6.5 **⚠WARNING** **Electrocution hazard!** If you are operating and lightning moves into the area, seek shelter until the lightning is gone.

6.6 **⚠WARNING** **Crushing hazard! Never, ever** position yourself between a ready mix truck and the pump! Stand off to the side, so the ready mix driver can see you at all times (Figure 15).

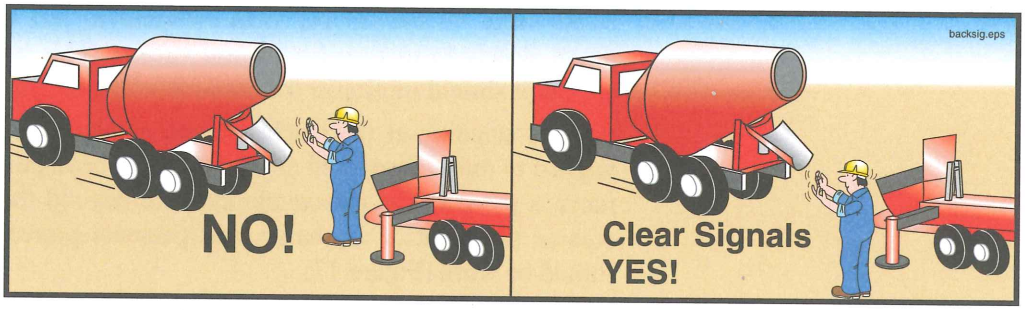


Figure 15
Never stand between the ready mix truck and the pump
Use clear and concise hand signals

6.7 **⚠WARNING** When backing in ready mix trucks, use clear and concise hand signals (Figure 15).

6.8 **⚠WARNING** If the job requires that you work above ground to operate your machine, an approved fall protection plan must be implemented.

6.9 **⚠CAUTION** **Loss of hearing!** While standing near a working concrete pump, sound pressure levels may exceed O.S.H.A. standards for constant exposure (Figure 16).

PERMISSIBLE NOISE EXPOSURES*
*Under part 1910.95 Occupational Noise Exposure, (Dept. of Labor) of the Code of Federal Regulations, Chap. XVII of Title 29 (39 F.R. 7006).

DURATION per DAY in HOURS	Sound level in dB (A) Slow response
8	90
6	92
4	95
3	97
2	100
1 1/2	102
1	105
1/2	110
1/4 or LESS	115

WEAR HEARING PROTECTION!

Figure 16
Noise level and exposure time limits

SAFETY MANUAL

6.10

⚠WARNING **Do not let the concrete level in the hopper become low!** If air is sucked into the material cylinders, the pump will compress the air. Compressed air always poses a hazard as it is expelled from the hopper or the delivery pipeline (Figure 17). If air is taken into the material cylinders, take the following steps to minimize the hazard:

1. Stop the pump immediately. Hit the emergency stop switch (E-Stop) if that is the quickest way to stop the pump. There will be an expulsion of compressed air the next time the concrete valve shifts, which can be safely absorbed by filling the hopper with concrete.
2. If possible, fill the hopper with concrete to just below the grate, then pump slowly in reverse for several strokes. This will not remove all the air, but it should minimize the amount left in the pipeline.
3. Persons standing at the discharge end or near the delivery line must be warned to move away until all of the air has been purged. Personnel should move a prudent and reasonable distance beyond the end-hose movement area or the point of discharge, and personal protective equipment (PPE) should be worn (Figure 17).
4. When the pump is restarted, pump forward slowly until **all** air is removed from the pipeline. Don't assume that the first little air bubble is the end of the compressed air.
5. Do not allow anyone near the discharge until concrete runs steadily from the end and there is no movement of the delivery system.

If workers are positioned in high or precarious places, warn them to expect a loud sound as the air escapes the pipeline. (Warn them even if they are well away from the discharge.) That way, we can prevent the worker from falling as a result of being startled by the noise.

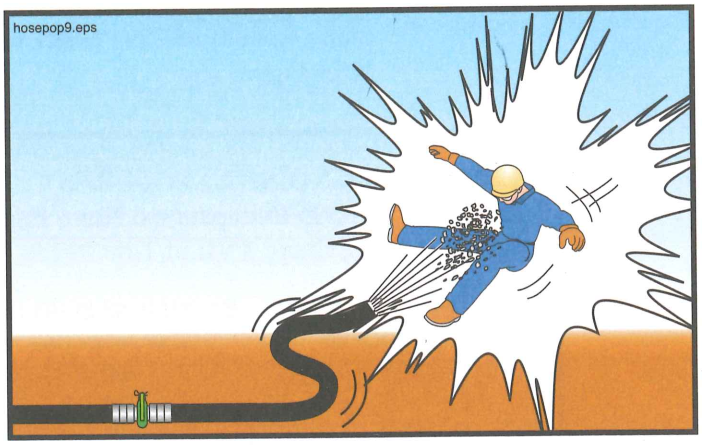


Figure 17
Remove everyone from the discharge area whenever air is in the line

6.11

⚠WARNING Air can be introduced into the delivery system in several ways besides being sucked in through the hopper.
For example:

- when initially priming the delivery system;
- when restarting after moving;

- when restarting after adding or removing delivery system;
- when attempting to remove a blockage by rocking the concrete;
- when opening the system to remove a blockage;
- when pumping is stopped and the pipeline is at a downward angle.

6.12 ⚠WARNING When initially priming the delivery system, when restarting after moving, when restarting after adding or removing hoses, when attempting to remove a blockage by rocking the concrete, or whenever air has been introduced into the line, warn everyone to stay away from the discharge until material runs steadily. Personnel should move a prudent and reasonable distance beyond the end-hose movement area or the point of discharge, and personal protective equipment (PPE) should be worn (Figure 17).

6.13 ⚠WARNING **Blockages in the pump or delivery pipeline can create an unsafe condition.** Blockages are caused by many different factors, as outlined below.

CAUSES OF BLOCKAGES

- **Faulty concrete mix design.** The concrete being supplied may not be a pumpable mix; for example there may be too much sand or too little cement. There may be bleeding or segregation. Some admixtures adversely affect pumpability (e.g., too much air entrainment). If the mix is not pumpable, no amount of operator expertise will make it so.
- **The line size may be inadequate.** The line size should always be at least 3 times larger than the largest aggregate being pumped, or blockages could occur.
- **Worn concrete valve parts.** Worn parts allow the finest material and water to escape back into the hopper when pressure is applied.
- **Pipeline and joint deficiencies.** This would include: dirty pipes (pipes that have not been cleaned properly); worn and leaking pipe joints that allow loss of concrete fines and water; pipes that haven't been properly primed before starting; and too many sections of rubber hose, which increases friction. These are all causes of blockages that can be controlled by the operator.
- **Pump inadequate for the application.** The pump selected for the job may not have enough pressure or horsepower available for the required duty.
- **Concrete setting up in the pipeline.** This may be caused by delays on site (e.g., repairing a broken form), or by attempting to pump old concrete (concrete that was batched hours before pumping and is being kept alive only by adding water and constant agitation). Weather conditions can also affect how quickly the concrete becomes hard. Companies should establish procedures for these situations. A good rule of thumb is: **If in doubt...wash out.**
- **Foreign matter in the concrete.** Pieces of old concrete that break away from mixer fins, unmixed clumps of cement, mixer fins, hammers, and furry mammals are examples of foreign matter that have caused blockages.
- **An inexperienced operator can cause blockages by setting up the job improperly.** For example, if the placing crew is forced to add hose or pipe to reach a far point after the pour is already in progress, there is a great chance of

creating a blockage due to the dry conditions inside the pipe or hose. It is for this reason that the job should be set up so pipe or hose need only be removed (never added) as the day progresses. If dry pipe or hose must be added, it must be lubricated just like the rest of the pipe was lubricated when you first started.

- **An inexperienced or improperly trained placing crew can cause blockages by kinking the end hose.** This type of blockage can lead to serious accidents because the hose may unkink by the force of the pump.
- **The concrete becomes segregated in the hopper.**
  - a. If the concrete is too wet, the cement and fine material get washed from the stone and course sand. This mix will not pump. It is for this reason that you should cover the hopper as you wait out a passing storm, never allow a truck mixer to wash out in your hopper, and never add water to the mix.
  - b. If concrete is over vibrated, it will separate. Turn off the hopper vibrator when not actively pumping.

6.14 ⚠WARNING Never try to remove a pipeline blockage by applying high pressure to it, because that will cause the blockage to become a plug. If you have a blockage, immediately stop the pump. Stroke the pump several times in reverse. Slowly stroke the pump in forward, and try to dislodge the blockage. If you are moving the blockage, continue to do so slowly and gently. While attempting to clear the blockage, remove all personnel from the discharge area, as air may be introduced into the placing line during this process. If you are unable to move the blockage after a couple of attempts, stop the pump. Continuing to apply high pressure could create a hazardous condition.

6.15 ⚠WARNING If the pump or associated equipment develops a problem that creates an unsafe condition, you must stop pumping immediately! Do not restart until the unsafe condition has been remedied.

6.16 ⚠WARNING The following points must be observed when locating a blockage.

- Pump in **reverse** for **at least two strokes,** then stop the pump. In the case of a mechanical pump (which cannot be reversed), it is important to carefully follow the manufacturer's instructions for relieving line pressure before any clamp is opened. **Do not allow anyone to open the pipeline** until the pressure is relieved (Figure 18).
- Wear personal protective equipment (PPE) when opening a blocked pipeline.
- Clear the area of nonessential personnel before opening the line.
- In all cases, the blockage must be removed before pumping again. Remember that air will be introduced when the system is taken apart, and keep personnel away from the discharge when restarting.
- Plugs will be found (in the order of likelihood): reducers, hoses, elbows, and pipe.
- If you are tapping the pipe to find the plug, the sound will be a dull thud (tik-tik) rather than a ringing sound (tong-tong) at the spot of the plug, because the

jammed material will keep the pipeline from vibrating. (This method won't find a plug in a hose.)

- To find a plug in a hose: with the pressure relieved, tap or step on the hose to locate the hard spot where the hose is plugged.

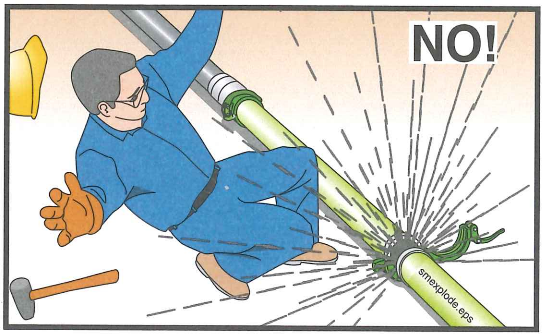
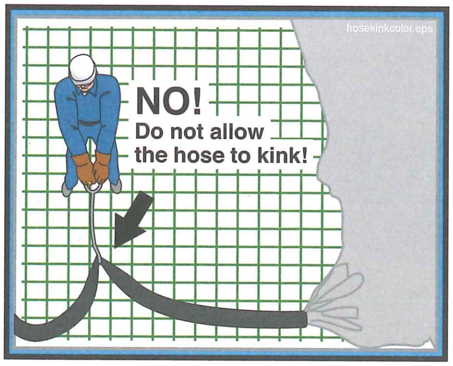


Figure 18
Never open a pressurized pipeline

6.17 **⚠WARNING** It is possible that some pressure will remain in the pipeline after reversing the pump. Use a shovel or pry bar to open the clamps on a blocked pipeline. Wear face protection, and turn away from the pipeline when opening the clamp.

6.18 **⚠WARNING** It would be better to let the pipe be ruined by setting concrete than to risk injury by ignoring safe procedures. Always use safe practices when cleaning pipe. Remember, pipeline is replaceable, you are not.

6.19 **⚠WARNING** **Do not kink hoses.** Kinking will cause the pump to create maximum concrete pressure. **The pump may unkink the hose with force!** (See Figure 19.)



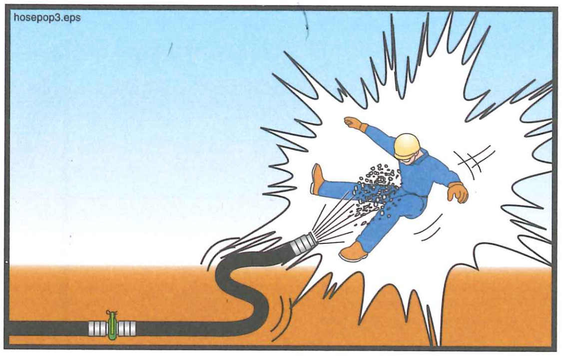


Figure 19
Kinking the hose creates a hazard

6.20 **⚠WARNING** Never use compressed air to clear a blockage! It is unsafe and unnecessary. The pump can develop much more pressure than an air compressor. If the pump pressure cannot move it, air pressure won't either.

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6.21

⚠WARNING Never stand on, sit on, or straddle a pipeline while it's in use, or whenever it is pressurized. Pipeline wears out with each stroke of the pump. If the pipe bursts, you want to be to the side of it, not on top of it (Figure 20).

Figure 20
Never straddle or sit on a pressurized pipeline

6.22

⚠WARNING Crushing/amputation hazard. Do not remove the water box covers or grates when the machine is stroking (Figure 21). If you must remove the water box cover (to add water, for example), and there is not a bolt-down grate over the water box, then stop the pump and activate the emergency stop (E-stop) so the pump cannot be restarted until you are finished and the covers are back in place. If a bolt-down grate is installed, you may simply stop the pump from stroking before removing the water box covers. Replace the covers before restarting the pump.

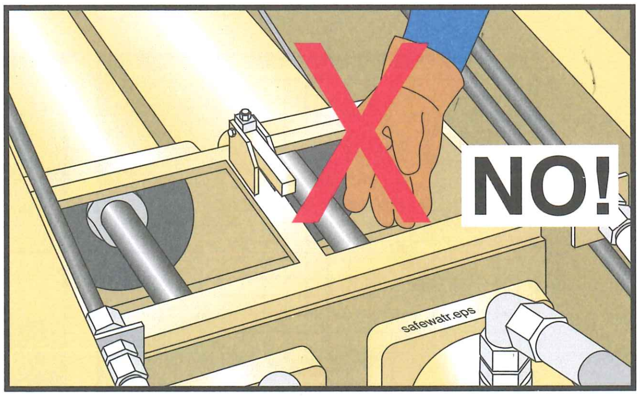

Figure 21
Keep your body out of the water box

6.23

⚠WARNING **Never leave the pump unattended!** Before you leave a laborer, ready mix driver, or any other worker alone with the pump for any reason, make sure the worker who you leave with the pump knows:

- the safety rules for a person stationed at the pump (the rules are listed in this *Safety Manual*, beginning on page 35),

- how to stop the pump,
- the location of the emergency stop switches (E-stops),
- how to signal you.

6.24 **⚠WARNING** To prevent any unintentional movements of the machine, **all** control devices on the operator's panel and the remote control box must be switched off before changing from remote control to local control, or vice-versa. Whenever you are connecting or disconnecting the remote cable, push in the emergency stop switch (E-stop).

6.25 **⚠WARNING** Crushing/amputation hazard. Never put your hands, feet, or any other body part into the water box, concrete valve, or hopper when the hydraulic system is operational or ready to operate! (See Figure 22.)

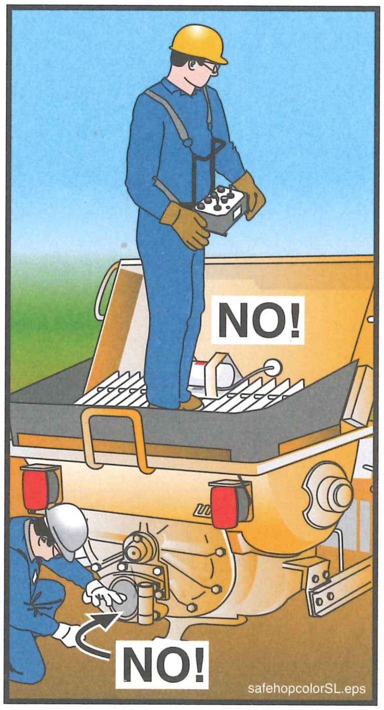

Figure 22
Don't put your body in the machine

6.26 **⚠WARNING** Do not work on the hopper, water box, concrete valve, or the hydraulic system unless the drive engine is turned off and the accumulator pressure (if so equipped) has been released! On units with internal combustion engines, the key must be removed. If there is more than one key, you should tag the ignition. On units driven by electric motors, the main disconnect must be locked out according to applicable standards.

6.27 **⚠WARNING** Never operate the pump blind. If you can't see the point of placement, you must establish a system of communications with the workmen who can see the point of placement. Arrange for radio communications, a system of visual or auditory signals (lights or bells), or a signalperson. If a signalperson is used, **agree on hand signals before beginning the pour!** (Use of the ACPA standardized hand signals is highly recommended.)

7. Safety Rules For Shotcreting

7.1 Keep the pump clean. A clean machine runs more efficiently. To enhance the cleaning of your pump, it will help to spray some type of bond breaker on the entire unit before each use (form oil or equivalent). Do not put oil on surfaces that will become hot, such as exhaust manifolds.

7.2 ⚠WARNING The nozzle person and nearby personnel should protect themselves by wearing appropriate safety gear, including a full face shield to prevent rebounding concrete from injuring their face and eyes (Figure 23).

Figure 23
Wear a full face shield for rebound protection

7.3 ⚠WARNING Direct the reducers away from the operator and the concrete mixer driver. The line pressures can be quite high during the shotcrete process (Figure 24).

Figure 24
Point reducers away from the operator and driver

7.4 ⚠WARNING When practical, the nozzle man and the pump operator should use radios to communicate to facilitate a fast shut-down in the event of a line plug.

7.5 ⚠WARNING If setting up on a city street or some other obstacle prevents you from directing the reducers away from your work station, it can be helpful to use rubber matting and bungee cords to cover the reducers and act as a protective cover to protect you and the mixer driver in the event of a line rupture (Figure 25).

Figure 25
Cover reducers and use containment boxes for cleanout

7.6 **⚠WARNING** Crushing/amputation hazard! Always keep the hopper grate in place (Figure 26). Never put your hands, feet, or any other body part into the concrete valve, hopper, or water box when the hydraulic system is operational or ready to operate! Never stand on the hopper grate! In addition, the grate can keep many items from entering the hopper that would become blockages in the line.

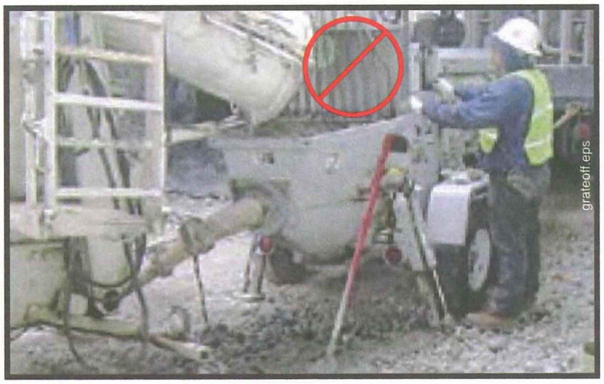

Figure 26
Never remove the hopper grate while the pump is operating

7.7 **⚠CAUTION** Overspray always presents a problem during the shotcrete process. Protect personnel and equipment in the area by providing overspray protection, even when you are shooting on the inside. The most commonly used protection is plastic sheeting. It is easy to work with and can be nailed or fastened to almost any surface. Canvas tarps can be used in the same manner, but need to be cleaned frequently. Masonite and plywood also work well in some instances. It can help to over-form the area where shotcrete is to be applied. For example, if a wall is to be six feet high, you can form it to eight feet creating a two-foot area of protection. The same would apply to the end of a wall.

7.8 **⚠WARNING** Check forms and rebar for stability—both backward and forward—before shotcreting. The rebar cage needs to be tied to something—usually the back form. When the shotcrete wall is being built up, the placed shotcrete wants to sag forward, bringing the rebar with it. If the rebar moves, the form may also move.

IV. Cleaning The Pump And System

8. Safety Rules For Cleaning The Concrete Valve And Hopper

8.1 ⚠WARNING Wear protective clothing and equipment when cleaning the concrete pump because the lime in concrete can burn your skin. Protect against concrete burns and concrete poisoning by wearing rubber boots and gloves during cleanout or any other time that you will be **in** contact with the concrete.

8.2 ⚠WARNING Crushing and amputation hazard! **Never put your hands or any other body part into the concrete valve.** Instead, use water jets and the supplied rake (Figure 27).

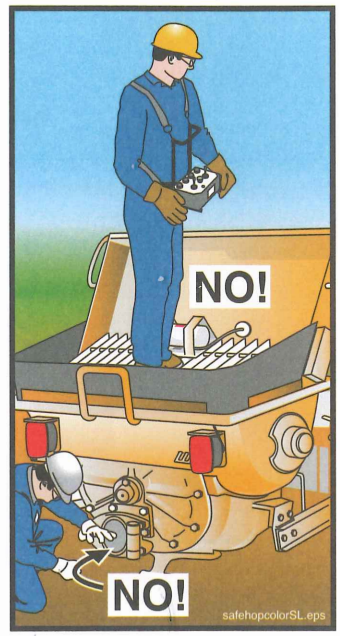

Figure 27
Keep your body parts out of the machine

8.3 ⚠WARNING **Never put your hands or any other body part into the machine when the hydraulic system is operational.** If you must remove the grate to chip at hardened concrete, you must first disable the system by taking the transmission out of gear and locking the cab door, or stopping the engine, relieving pressure in the accumulator circuit (if so equipped) and securing the controls against unintended operation. Reinstall the grate before restarting the engine (Figure 27).

8.4 ⚠WARNING Never put a bar or other solid tool into the hopper, water box, or other working system while the hydraulics are operational (Figure 28).

9. Safety Rules For Cleaning The Water Box

9.1 ⚠WARNING Crushing and amputation hazard! Stop the concrete pump before removing the water box covers. If your unit has bolt-down guards, do not remove them for cleaning. If there is not a bolt-down guard over the water box, then stop the pump and activate the emergency stop (E-stop) so the pump cannot

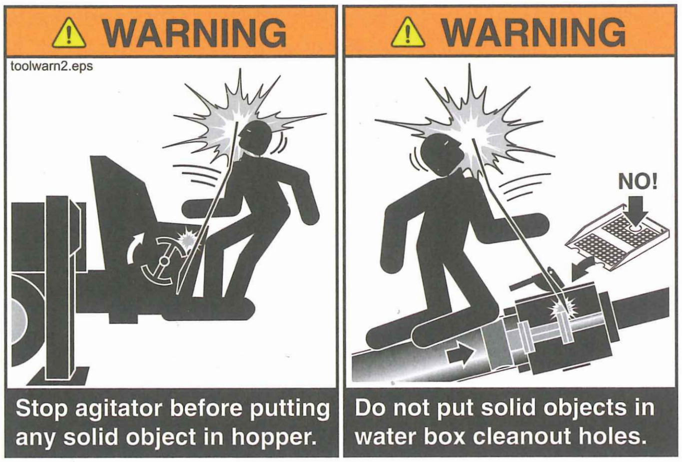

Figure 28
Don't put solid objects into working systems

be restarted until you are finished cleaning and the covers are back in place. If a bolt-down grate is installed, you may simply stop the pump from stroking before removing the water box covers. Replace the covers before restarting the pump.

9.2 **WARNING** Falling hazard! Be sure of your footing when cleaning the water box.

9.3 **WARNING** Crushing and amputation hazard! Do not remove the water box guards for cleaning. Clean the water box with water jets only. **Do not put your hands or any other body part into the water box for cleaning or at any other time when the hydraulic system is operational (Figure 29).**

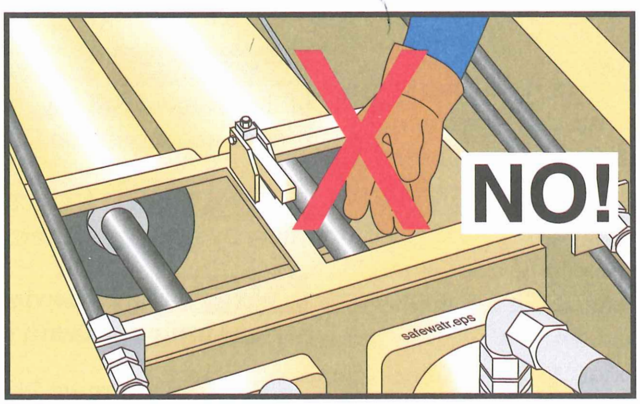

Figure 29
Keep your hands out of the water box

10. Safety Rules For Cleaning A Separately Laid Pipeline

10.1 **WARNING** Flying particle hazard! Clear the discharge area of personnel and equipment before forcing a ball or go-devil through the pipeline, even if you are cleaning with water. Some air will be trapped in the pipeline, and the trapped air will become compressed before discharge.

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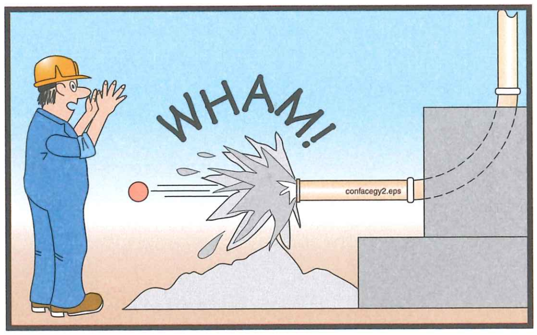
10.2 **⚠WARNING** Using compressed air to clean the delivery system should only be done when no other method is practical, or as recommended by the manufacturer.

10.3 **⚠WARNING** The point of discharge must be controlled. Use a ball catcher or some other containment device at the point of discharge, even when cleaning with water.

Figure 30
Cleaning with compressed air can be extremely hazardous if you don't follow the safety rules



10.4 **⚠WARNING** If you have to use compressed air for cleaning the line you **must** have all of the necessary accessories. Read and understand the complete safety rules regarding cleaning out with compressed air in this section of this *Safety Manual* starting at paragraph 10.8 on page 26. Cleaning with compressed air should only be done by qualified people. See Figure 30.

10.5 **⚠WARNING** If the ball or go-devil doesn't come out of the delivery system after applying compressed air, **you must relieve the pipe of air pressure before opening it.** If the bleed-off valve plugs when you are draining the air, the only safe way to proceed is to drill small holes into the pipeline, which will then allow the air to escape. Wear a full face shield when drilling the holes. Pipe you have drilled into is ruined and must be replaced. Drill the holes to relieve the air pressure even if the concrete has set up in the pipe. The pipe is hazardous until the pressure is relieved.

10.6 **⚠WARNING** Exercise care when tapping on the pipeline to find the location of the cleanout ball. Applying too much force will dent a single wall pipe (making it weak and unsafe) and could break the carbide insert of double wall pipe.

10.7 **⚠WARNING** It is better to let the pipe be ruined by setting concrete than to risk injury by ignoring safe procedures. Remember, pipeline is replaceable, you are not.

10.8 **⚠WARNING** **Blowing out with compressed air creates potential hazards! Serious injury or death could result** if you do not adhere to these safety points.

- **Blowing out must be performed under the supervision of a qualified person.** (See the glossary for the definition of *qualified person.*)
- **Blowing out requires two people!** One trained person must be at the inlet end to operate the air insertion, and the other trained person must be near (but safely back from) the discharge point to monitor the discharge and to make sure that no one enters the hazard area.
- **No pipe bends or flexible delivery hoses may be connected to the end of the pipeline during the blowing out process,** unless there is a pre-planned

cleanout station erected to route the discharge into the ready mix truck.

- **The point of discharge must be controlled. Clear the discharge area of personnel and equipment** before beginning the blowing out process. Do not allow anyone to enter the area during the blowout process. If a ball catcher is used, be aware of which type you have, and adjust your procedure accordingly. Ball catcher types are described in paragraph 5.24 on page 13.
- **The concrete outlet must be positioned high enough to permit easy discharge of the material.**
- If you are going to divert the discharge into a discharge pipe system, you must lubricate the discharge line with slurry, or a plug could occur.
- **The pipe cleaning blowout head must be equipped with a properly sized air discharge regulator valve and a separate water/air inlet.** The two openings should be spaced apart far enough that a blowout ball could not cover both openings at once (Figure 31).

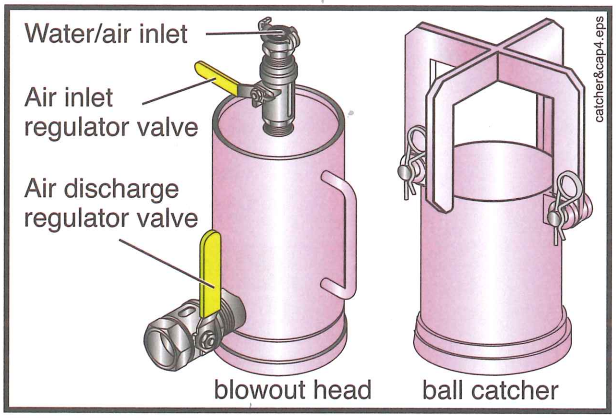


Figure 31
Ball catcher and blowout head

- The ball or go-devil must be large enough to prevent compressed air flow around and into the concrete.
- **The pipeline must not be disassembled until it has been completely relieved of air.** Be **sure** of this! (See Figure 32.)

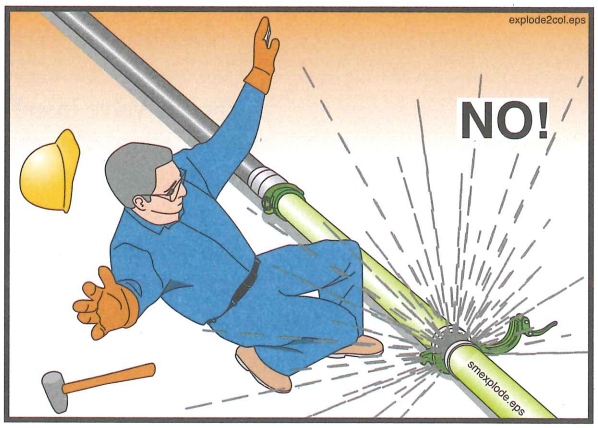


Figure 32
Never open a pressurized pipeline

- **Do not use compressed air to blow out concrete delivery hose, single pipe sections and short pipelines up to a length of 40 feet.** Hoses will jump and move unpredictably; short pipelines don't have enough concrete to resist the force of the air, causing it to discharge too quickly, like a cannon (Figure 33).

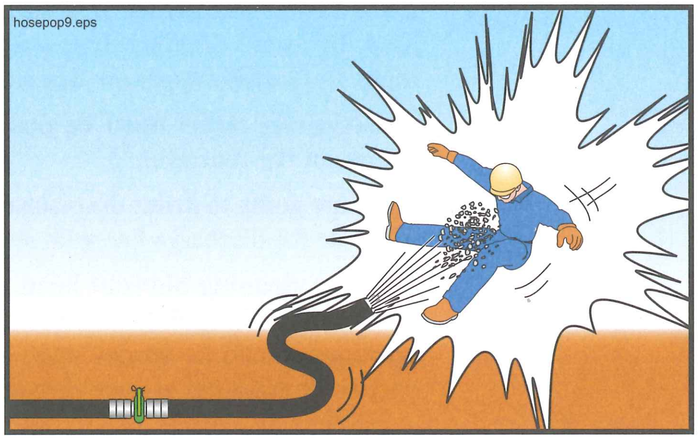


Figure 33
Never use air to blow out hoses or short pipelines

- **When air pressure begins to drop rapidly, shut off the air supply from the compressor, and immediately begin bleeding air out of the pipeline.** (The drop in pressure signifies that the pipeline is almost empty of concrete.)

10.9 ⚠WARNING When blowing out a vertical line, a shutoff valve is required to prevent the following scenario.

1. (See diagram A in Figure 34.) Without a shutoff valve installed, the pipeline is disconnected from the pump. Immediately, the concrete drains out of the vertical sections of pipe, leaving concrete in both horizontal sections, and air trapped in between.
2. (See diagram B in Figure 34.) The ball is inserted, and pushed with compressed air. This also compresses the air that is trapped in the vertical sections of pipe. The trapped air will be violently expelled when it reaches the end of the pipe, but the pipe will not yet be empty.

A shutoff valve installed at the bottom of the vertical run will prevent this hazardous situation. The shutoff valve must be capable of handling the maximum concrete pressure of the pump and, of course, must be installed before the pour begins. Several different styles are available, ranging from a manually operated flat gate that is put into place with a hammer to fully hydraulic types that will also divert the concrete to a different pipeline. With a shutoff valve installed, you can proceed as indicated below.

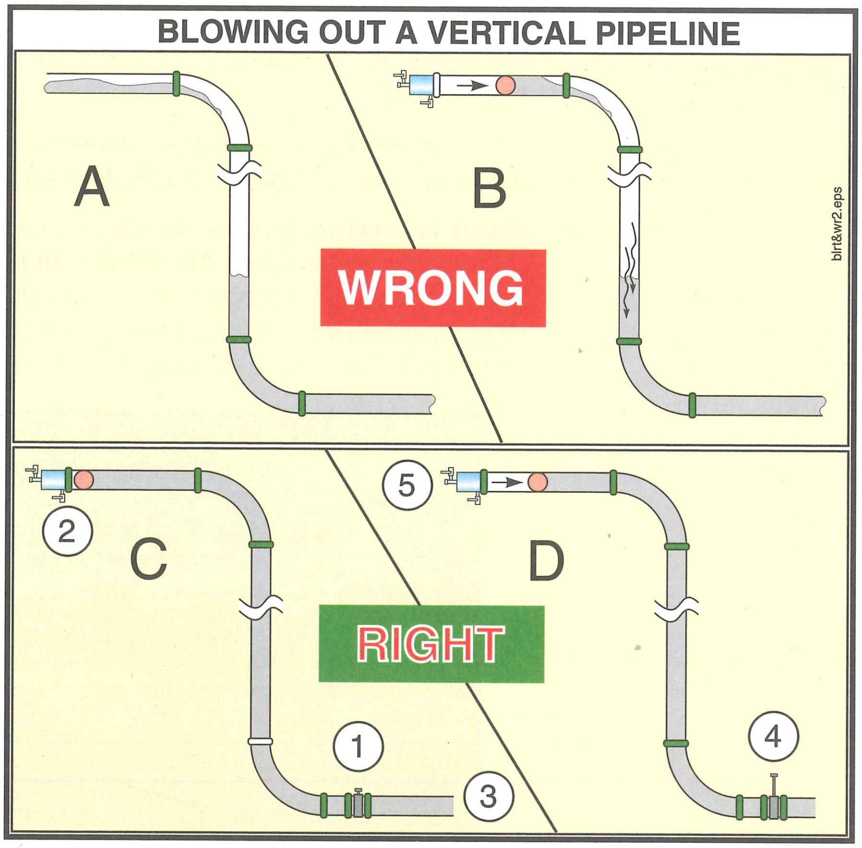


Figure 34
Blowout of a vertical line

10.10

⚠WARNING **Blowing out vertical sections of pipe** (for example on a high-rise building) **requires additional safety precautions.**

1. **Know where the discharge area for blowing out will be before the pour begins.** Ready the area and accessories before the pour begins so you will not waste time when pumping is completed.
2. **Blowing out with compressed air requires two qualified persons.**
3. **The persons at both ends of the pipeline must be able to communicate without delays,** which means you must establish communications (for example, with a radio).
4. **When pumping is complete, close the shutoff valve before disconnecting the pipeline from the pump** (Item 1, Figure 34). Failure to do this will cause the concrete to fall out of the vertical sections of pipe, leaving concrete in the horizontal sections of pipe and an air pocket in the vertical sections. This does not apply if you are using a switching (diversion) valve.
5. Install the ball(s) in the pipeline, secure the blowout head and hook up the air compressor. **Do not apply the air yet!** (Item 2, Figure 34.)

6. If you will be diverting the discharge to a cleanout area, lubricate the discharge line with slurry, or a plug could occur.
7. **Position the ready mix truck at the cleanout standpipe,** or install the ball catcher or other containment device at the end of the discharge line. (Item 3, Figure 34.)
8. **Clear the discharge area of personnel.** You must allow no one to enter the discharge area until the pipeline is depressurized.
9. **Divert the vertical pipe line to the cleanout area and secure the discharge (Figure 35), or open the shutoff valve in the delivery pipe line now.** Allow gravity to start the concrete moving through the discharge line. As the concrete falls from the vertical sections, it will take the ball with it, making it impossible to trap air in the line. (Item 4, Figure 34.)

Figure 35
Divert vertical pipeline to the cleanout area and be sure to secure the discharge before continuing

10. **Apply the compressed air to the pipeline.** Close communications must be maintained at this time. Add only enough air to keep the concrete moving. Do not allow the concrete to accelerate. (Item 5, Figure 34.)
11. **When concrete starts to accelerate, shut off the air supply from the compressor, and open the air regulator to bleed air from the line.** Rapidly accelerating concrete indicates that the pipeline is almost empty. After the ball has been expelled from the pipeline, leave the air regulator open to be sure that all air is removed from the system.
12. All the rules for blowing out found in Point 10.8 on page 26 also apply to blowing out a vertical pipe line. These rules are in addition to the general cleaning a pipeline with compressed air rules.

10.11

⚠WARNING **Never use compressed air to attempt to clear a blockage!** It is unsafe and unnecessary. If the pump pressure can't move it, air pressure won't either.

V. Maintenance Of The Machinery

11. Safety Rules Regarding Inspection

11.1 **⚠WARNING** Visually inspect your unit each day before it is put into operation. If any problem is found that will affect the safe operation of the pump, don't use the pump until it is repaired!

11.2 **⚠WARNING** If safety decals are faded, missing, damaged, or otherwise unreadable, they must be replaced immediately. Contact the manufacturer of your unit to obtain replacements.

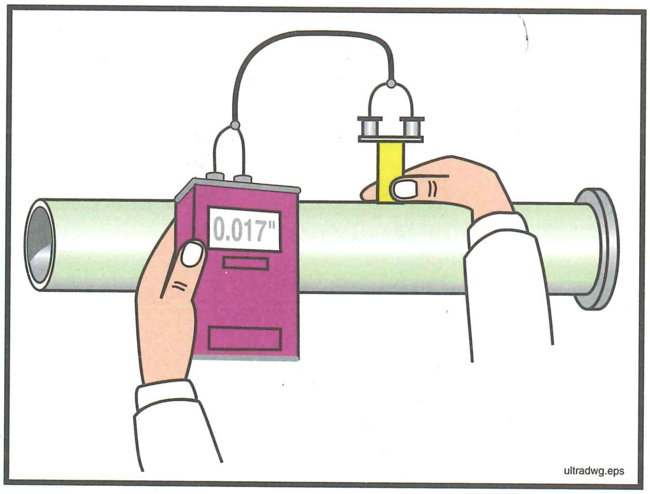
11.3 **⚠WARNING** If safety devices or guards are removed for inspection purposes, they must be replaced before someone uses the machine.

11.4 **⚠WARNING** Pay attention to the operation manual and manufacturers service bulletins regarding maintenance and inspection procedures and intervals.

11.5 **⚠WARNING** If inspection reveals something that looks wrong, or even suspicious, report it to the manufacturer for consideration. Don't just assume that it's okay.

11.6 **⚠WARNING** Visual inspection of the concrete pump circuits and safety devices should be done daily. Hands-on inspection and documentation of results should be done weekly, or at least when preventive maintenance is scheduled.

11.7 **⚠WARNING** Do not neglect the delivery pipeline, clamps, or hoses. Check them often for wear, dents, and frays. Never send a unit to a job with a worn or damaged delivery system. For single wall pipes, ultrasonic thickness testers are more accurate than the tap method.



††

Figure 36
Check delivery system wall thickness with an ultrasonic thickness tester

12. Safety Rules Regarding Scheduled Maintenance

12.1 ⚠WARNING Proper and timely maintenance is important to the safe operation of a concrete pump. The proper procedures are outlined in the operation manual supplied with the pump. Do not put it off. Do not treat it lightly. Do not fudge results. The lives of the operator, oiler, and workers on the job are depending on it.

12.2 ⚠WARNING Keep the machine clean! Oil spills, grease, loose tools, and displaced accessories are hazards.

12.3 ⚠WARNING Pins should be used on all delivery system clamps. Clamps that will hang over workers, and clamps used on system that will be dragged shall be pinned (Figure 37).

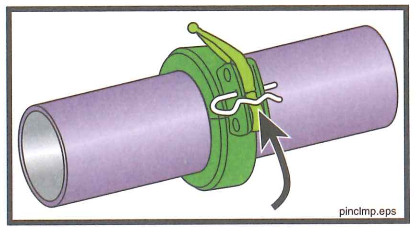


Figure 37
Pin the clamps

12.4 ⚠WARNING Be sure that you are installing the correct clamps for the types of pipe ends used. Never try to mate dissimilar pipe ends unless using a clamp specifically made for this purpose. See the comparison regarding weld-on ends on page 46 in the *Appendix* of this manual.

12.5 ⚠WARNING When using new pipe and/or hose on the machine, be sure that it is capable of handling the maximum concrete pressure of the pump.

12.6 ⚠WARNING If safety devices or guards are removed for servicing, they must be replaced before the machine is put back in service.

12.7 ⚠WARNING Do not change the maximum relief valve setting on any hydraulic circuit without permission from the manufacturer. **Never** change an accumulator circuit pressure setting without specific instructions from the manufacturer.

12.8 ⚠WARNING Never make unauthorized modifications to structural members or pressure circuits.

12.9 ⚠WARNING You must **replace, not repair** damaged hydraulic or concrete hoses or pipes.

12.10 ⚠WARNING Never try to repair a machine using worn, damaged, or defective components.

12.11 NOTICE **Never allow welding current to travel through bearings or hydraulic cylinders.** Keep the ground cable on the component that is being welded.

12.12 NOTICE **Electronic components can be destroyed by welding current.** Before welding on the unit, you must disconnect the battery cables, and unplug all radio remote control power wires. If in doubt, contact the Service Department of the manufacturer for instructions **before** proceeding.

13. Safety Rules When Servicing The Machinery

13.1 ⚠WARNING **Repairs should be carried out by qualified workshop personnel.** (See the glossary for the definition of *qualified personnel.*)

13.2 ⚠WARNING **Read and understand the maintenance procedures in the** operation manual **of the machine before attempting any repairs.** If in doubt, call the manufacturer. Incorrectly done repairs affect the safe use of the machine.

13.3 ⚠WARNING Burn hazard! **Never work on a hot hydraulic system.**

13.4 ⚠WARNING Falling hazard! If you cannot work at ground level, you must find and use a suitable work platform, a tie-off harness system, or otherwise secure yourself from falling.

13.5 ⚠WARNING If maintenance work requires that you use a crane, hoist, fork truck, or similar machine, read and understand the safety regulations for that equipment.

13.6 ⚠WARNING **Only operators should operate the unit.** If work on the machine requires that it be operated and you are not qualified as an operator, you must get someone who is qualified to assist you.

13.7 ⚠ DANGER Electrocution hazard! **Repair work on electrical systems over 28 volts must be done by qualified electricians.**

13.8 ⚠WARNING Explosion hazard! **Be sure that you understand the potential danger of spring-loaded or compressed-gas components before you service them.** (Examples: nitrogen accumulators, gas springs for toolbox doors, tires, brake chambers.) If you don't know the dangers, call the manufacturer **before** beginning work!

13.9 ⚠WARNING If you will be working in a hidden area inside the machine, lock it out as follows.

- With a gas or diesel engine, remove the ignition key and place a *Do Not Operate* sign on the controls. Carry the key with you.
- With an electrically driven pump, lock out the main breaker and tag the controls.

The above rules are one simple Lock Out-Tag Out procedure. A procedure may also be provided in the operation manual for the unit and there may be state or local regulations that require a more advanced or stringent Lock Out-Tag Out program. Be aware of the regulations in your area.

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13.10 **⚠WARNING** **Never activate the system hydraulics without checking if another workman is in a hidden position.** Always yell "clear" before starting the engine or electric motor, and allow time for response.

13.11 **⚠WARNING** **Never work on a pressurized hydraulic system.** Stop the engine or electric motor, relieve the accumulator circuit and verify zero pressure on the gauge (if so equipped), and be sure that no hydraulic components are loaded, (i.e., outrigger supporting the unit) before you open the hydraulic system.

13.12 **⚠WARNING** **Never use gasoline or diesel fuel as a cleaning solvent.** This is critical to remember when cleaning hydraulic oil reservoirs, because gas and diesel fuels are highly explosive and **traces left in the oil may ignite when compressed!**

13.13 **⚠WARNING** Remember to mount and dismount the unit using the 3-point Rule. One hand and two feet or two hands and one foot are to be in contact with a secure surface at all times (Figure 38).

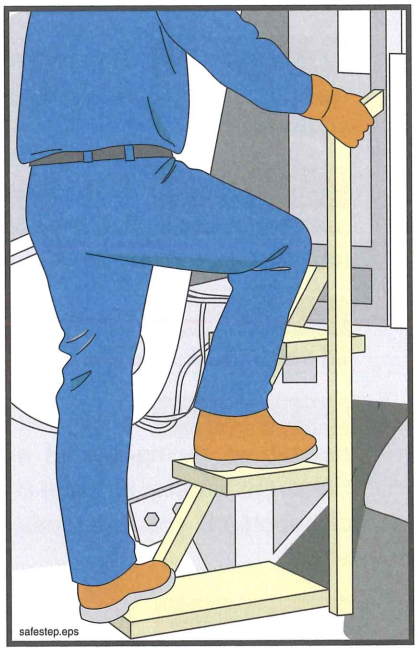

Figure 38
The 3-point Rule

13.14 **⚠WARNING** **Always use the correct tools for the job.** Tools should be kept clean and in good condition.

13.15 **⚠WARNING** If you see a coworker engaging in an unsafe practice, warn him about the dangers. Safety is always in the hands of those on the job!

13.16 **⚠WARNING** After any repair is completed, test the function of the repaired part to be sure that repairs were done correctly.

VI. Coworker Safety

14. Safety Rules For Workers Assigned To The Pump.

14.1 ⚠WARNING **You must know how to stop the pump.** Have the operator show you the locations of the emergency stop switches (E-stops) (Figure 39).

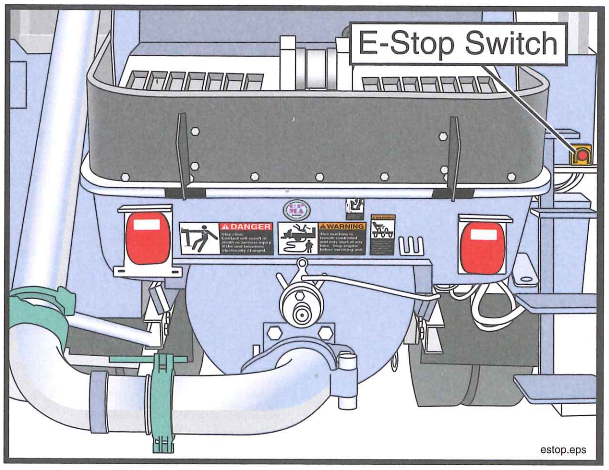

Figure 39
Know how to stop the unit in an emergency

14.2 ⚠ DANGER **You should wear the same personal protective equipment as the operator.** Goggles, hard hat, ear protection, and rubber gloves are especially important when working near the hopper, (including *full face shield and/or ** breathing mask, when necessary, as shown in Figure 40).

* Full face shield should be used in addition to safety glasses when shotcreting, or any time material is rebounding. ** Breathing mask needed when cement dust (or other toxic dust) is present in the air.

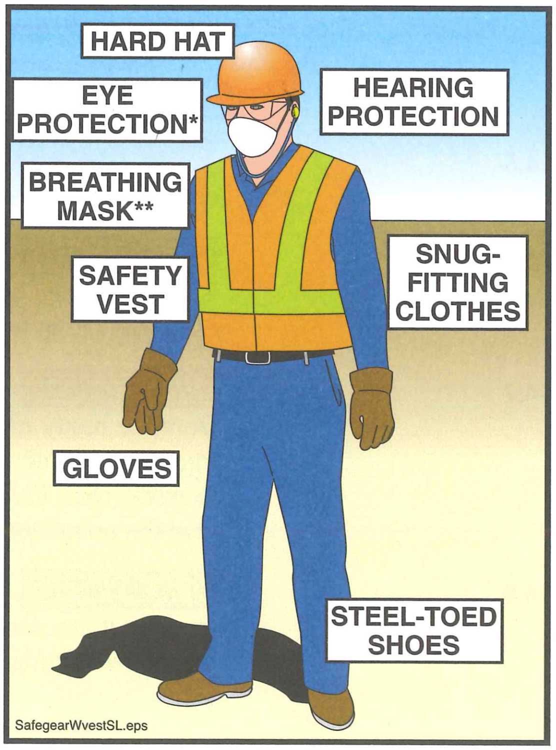

Figure 40
Wear the same personal protective equipment as the operator

14.3 **WARNING** **Crushing hazard. Never, ever position yourself between the ready mix truck and the pump!** Stand to the side, where the driver can see you (Figure 41).

Figure 41
Never stand between the ready mix truck and the pump

14.4 **WARNING** When backing in ready mix trucks, use clear and concise hand signals (Figure 42).

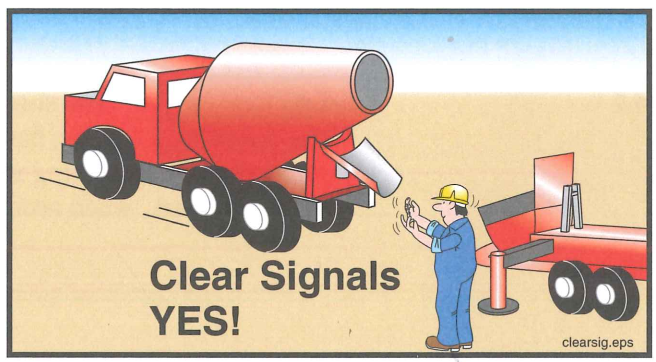

Figure 42
Use clear, concise hand signals

14.5 **WARNING** If handling the chutes of a ready mix truck, keep your hands clear of the hinged areas.

14.6 **WARNING** Do not allow the ready mix driver to put concrete in the pump hopper until the pump operator gives him the ‘okay.’ Filling the hopper early can cause the pump to plug.

14.7 **WARNING** If you see foreign material that could create a blockage coming from the ready mix truck, alert the operator to stop the pump. Do not attempt to remove the material from the hopper or grate while the hydraulic system is ready to work. (See Point 14.16 on page 39.) If necessary, depress the E-stop button to stop the pump and alert the operator.

14.8 **WARNING** **Never allow the ready mix driver to clean out in the hopper,** because it can create a blockage. (Water will wash the cement and fine sand from the course aggregate causing segregation.)

14.9 **⚠WARNING** Do not operate the pump unless you are also a trained operator and the regular operator has released the controls to you. **There must not be more than one operator at a time.** This does not apply to stopping the pump or boom if there is a need to do so.

14.10 **⚠WARNING** Do not let the concrete level in the hopper become low! If air is sucked into the material cylinders, the pump will compress the air. Compressed air always poses a hazard as it is expelled from the hopper or the delivery pipeline (Figure 43). If air is taken into the material cylinders, take the following steps to minimize the hazard:

1. Stop the pump immediately. Hit the emergency stop switch (E-stop) if that is the quickest way to stop the pump. There will be an expulsion of compressed air the next time the concrete valve shifts. If possible, fill the hopper with concrete to help contain the expulsion. Do not put your face directly over the hopper.
2. Alert the operator of the problem. It is the operator's job to know the procedures for safe removal of air from the pump and delivery system. These procedures include pumping in reverse for a couple of strokes.
3. Persons standing at the discharge end or near the delivery line must be warned to move away until all of the air has been purged. Warn them to stay a reasonable and prudent distance beyond the reach of the end hose or point of discharge (Figure 43).
4. When the pump is restarted, don't assume that the first little air bubble is the end of the compressed air.
5. Do not allow anyone near the discharge until concrete runs steadily from the end and there is no movement of the delivery system.

- If workers are positioned in high or precarious places, warn them to expect a loud sound as the air escapes the pipeline. (Warn them even if they are well away from the discharge.) That way, we can prevent the worker from falling as a result of being startled by the noise.

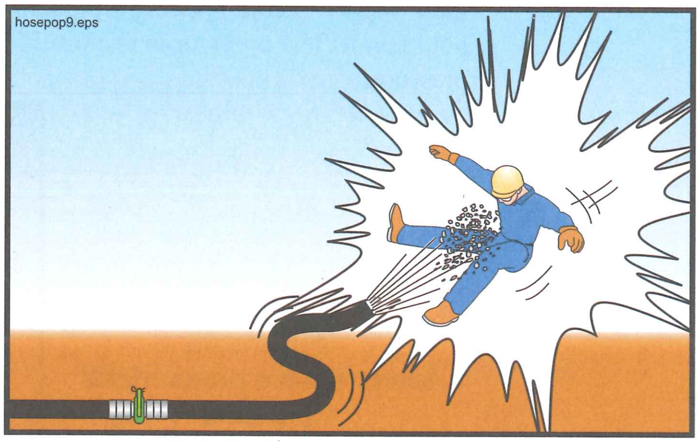

Figure 43
Remove everyone from the discharge area whenever air has been introduced into the line

14.11 **⚠WARNING** When initially priming the delivery system, when restarting after moving, when restarting after adding or removing hoses, or whenever air has been introduced into the line, warn everyone to stay away from the discharge until concrete runs steadily and there is no movement of the delivery system. Personnel should stay back a reasonable and prudent distance beyond the reach of the end hose or point of discharge (Figure 43). Air will be in the line when first starting, when restarting after moving, when a blockage has been successfully removed by rocking the concrete, and after the line has been taken apart or opened for any reason.

14.12 **⚠WARNING** **Never use compressed air to clear a blockage!** The operator is responsible for knowing the safe blockage removal procedures. It is unsafe and unnecessary to use compressed air. If the pump pressure cannot move it, air pressure won't either.

14.13 **⚠WARNING** Never stand on, sit on, or straddle a pipeline while it's in use, or whenever it is pressurized. Pipeline wears out with each stroke of the pump. If the pipe bursts, you want to be to the side of it, not on top of it (Figure 44).

Figure 44
Never straddle or sit on a pressurized pipeline

14.14 **⚠WARNING** Expulsion hazard! **Never open a pipeline that is under pressure** (Figure 45). The pump must be run in reverse for at least two strokes and then stopped before opening a pipeline. If the pipeline is pressurized with air, do not open it. The operator is responsible for knowing how to safely release the air pressure.

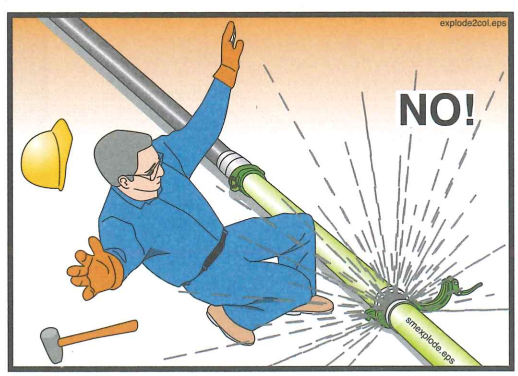

Figure 45
Never open a pressurized pipeline

14.15 **⚠WARNING** Be careful when handling pipeline or any other heavy object. Learn how to lift without using your back. Get assistance if needed.

14.16 **⚠WARNING** Crushing/amputation hazard! Never put your hands, feet, or any other body part into the water box, concrete valve, or hopper when the hydraulic system is operational or ready to operate! Never stand on the hopper grate! (See Figure 46.)

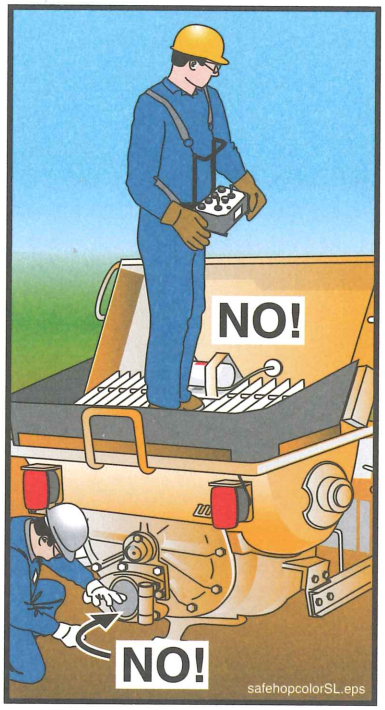

Figure 46
Never put your body in the machine!

14.17 **⚠WARNING** Never lift or remove the hopper grate for any reason (Figure 47).

Figure 47
Lifting hopper grate exposes the agitator and the concrete valve

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14.18

⚠WARNING Do not remove the water box covers or grates when the machine is stroking (Figure 48). Do not remove the water box cover (to add water, for example), until the operator has disabled the machine. Replace the covers before the operator restarts the pump.

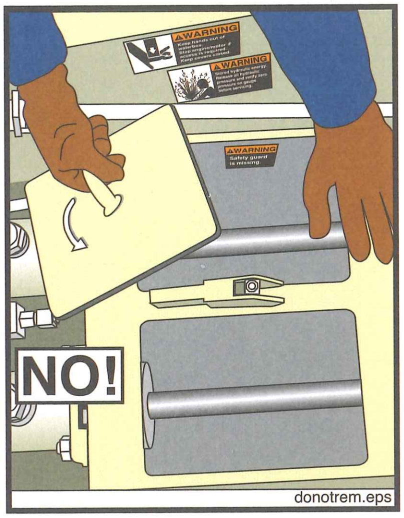


Figure 48
Do not remove the water box covers when the machine is stroking

14.19

⚠WARNING Mount or dismount the pump or truck using the *3-point Rule.* One hand and two feet or two hands and one foot are to be in contact with a secure surface at all times (Figure 49).

Figure 49
The 3-point Rule

14.20

⚠WARNING Keep unauthorized personnel off of the pump.

15. Safety Rules For The Placing Crew

15.1 **⚠WARNING** Wear Personal Protective Equipment (P.P.E., or just PPE) when working around a concrete pump (Figure 50). The gloves should resist concrete lime burns. If you will be working **in** the concrete, protect your feet and hands with rubber boots and gloves (including *full face shield and/or ** breathing mask, when necessary, as shown below).

* Full face shield should be used in addition to safety glasses when shotcreting, or any time material is rebounding.

** Breathing mask needed when cement dust (or other toxic dust) is present in the air.

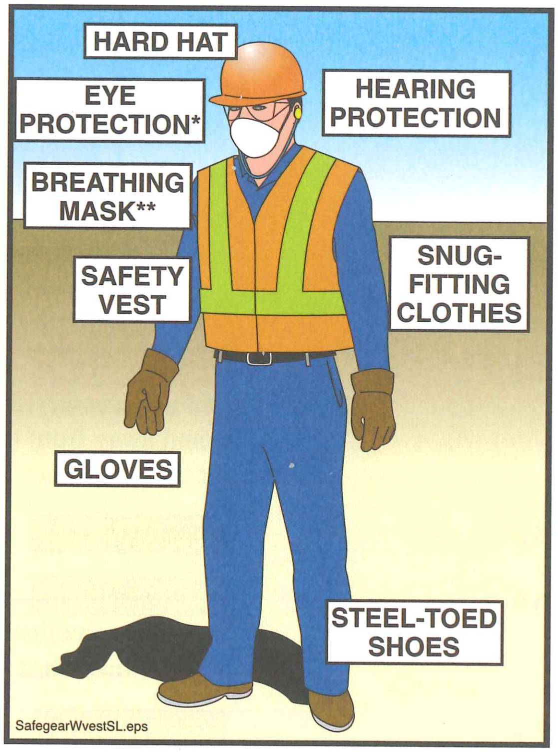


Figure 50
Wear Personal Protective Equipment (PPE)

15.2 **⚠WARNING** When the operator is initially priming the delivery system, restarting after moving, restarting after adding or removing pipes or hoses, or any time that air has been introduced into the delivery system, stand a reasonable and prudent distance away from the tip hose or point of discharge. Do not get near the discharge until material runs steadily and there is no movement of the delivery system. (Figure 51). Compressed air in the line can cause rubber hose to move violently. If the operator tells you that air is coming in the delivery system, proceed as follows:

- Get to ground level (if in a high place) and remain well away from the discharge or at least take cover.
- Stay away from the discharge. Be sure that **all** the air is gone before getting near the point of discharge again. It is the operator's job to know when it's safe to go back to normal pumping.

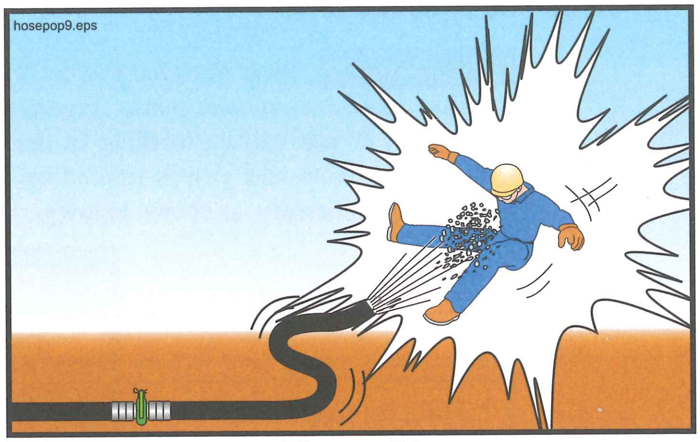


Figure 51
Stay away from the point of discharge when starting or restarting, and when there's air in the pipeline

15.3 ⚠WARNING **Never use compressed air to clear a blockage!** It is unsafe and unnecessary. If the pump pressure cannot move it, air pressure won't either. Stand away from the discharge and the line if anyone attempts to use compressed air in this manner.

15.4 ⚠WARNING **Do not look into the end of a plugged hose or pipe!**

15.5 ⚠WARNING When the pump crew is using compressed air to clean the boom or system pipeline, stay away from the discharge area. **Never try to hold down a pipe or hose that is being cleaned with air.**

15.6 ⚠WARNING Never open a pressurized pipeline (Figure 52). The pump operator must release the pressure before you open the line. If the line is pressurized with compressed air, let the operator release the pressure and verify that the air has escaped before you proceed.

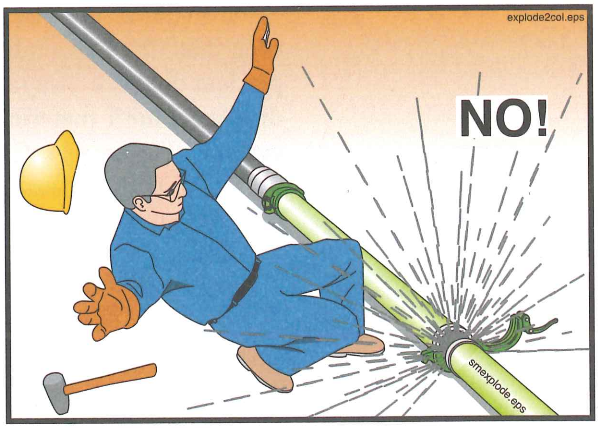


Figure 52
Never open a pressurized pipeline

15.7 ⚠WARNING After removing pipe sections you must **reassemble using gaskets and clamps.** Pipelines assembled without gaskets will leak cement and water, which can cause a blockage.

15.8 **⚠WARNING** Concrete is being moved through the delivery system by pressure. Failure of a pipe, clamp, hose, or elbow is possible. For this reason, spend as little time as possible standing near the pipeline, and wear protective clothing.

15.9 **⚠WARNING** Do not kink the end hose. Kinking will cause the pump to create maximum concrete pressure. The pump may unkink the hose by force! (See Figure 53.)

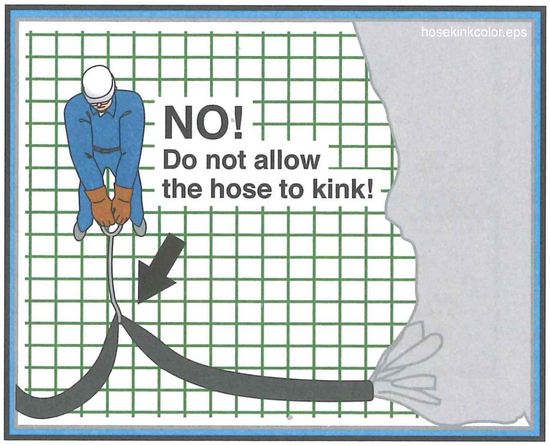


Figure 53
Never kink the hose;
Never hold the hose with your shoulder

15.10 **⚠CAUTION** Be careful when handling pipeline or any other heavy object. Learn how to lift without using your back. Get assistance if needed.

15.11 **⚠WARNING** Falling hazard! When pouring columns, slabs, or walls above ground, secure yourself from falling.

15.12 **⚠WARNING** Never stand on, sit on, or straddle a pipeline while it's in use, or whenever it is pressurized (Figure 54). Pipeline wears out with each stroke of the pump. If the pipe bursts, you want to be to the side of it, not on top of it.

Figure 54
Never straddle or sit on a pressurized pipeline

15.13 **⚠WARNING** To avoid confusion and conflicting signals, only one person should act as a signalperson (give operational signals to the pump operator). However, the operator is trained to obey a stop signal from anyone and everyone.

15.14 **⚠WARNING** Before the pour begins, the hose person, the signalperson, and the operator should agree on the hand signals (Figure 55).

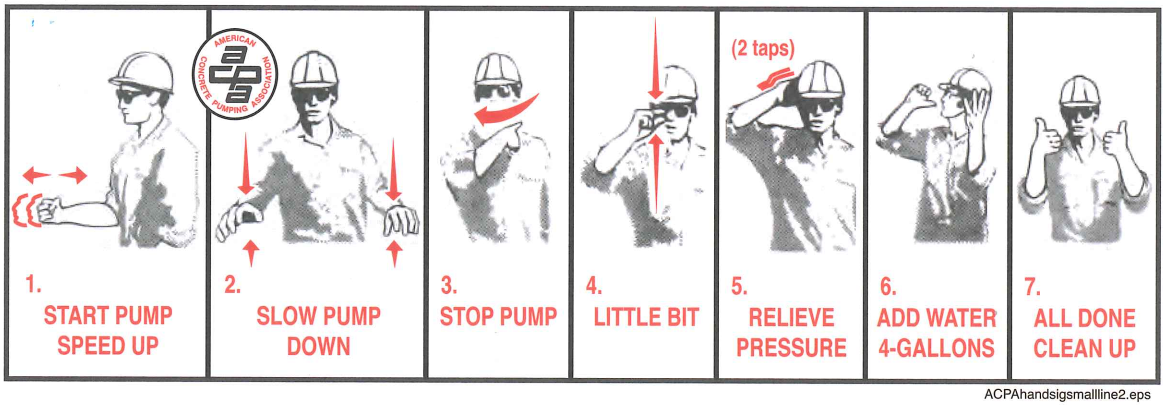
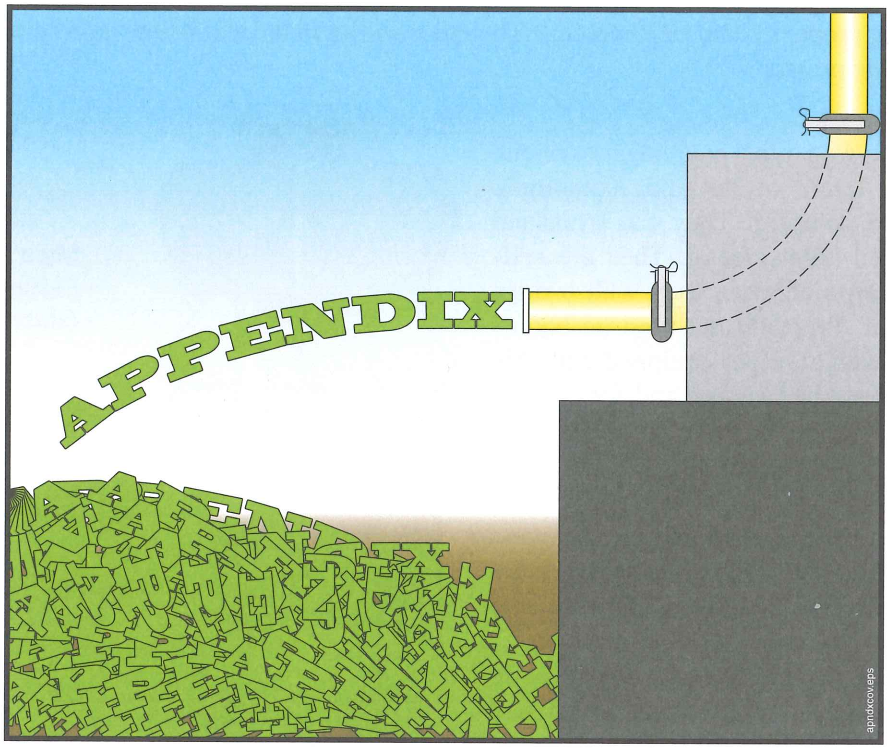


Figure 55
Recommended ACPA hand signals



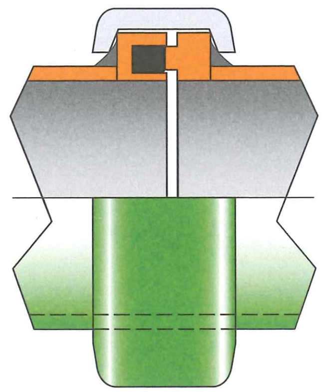
Appendix

VII. Weld-On Ends/Coupling Comparison

Shown is a comparison among commonly used ends/couplings. No two ends shown can be joined without the use of an adapter pipe or a special adapter clamp. Clamps and pipe strength must also be considered when determining proper system requirements. The ratios shown in the text below represent the safety factor from burst:working pressures.

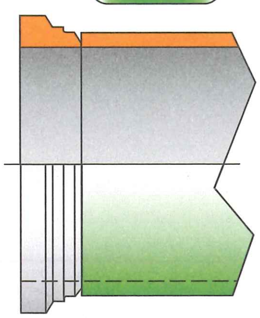
weldends7.eps

1. Male/female o-ring type couplings have the highest pressure rating of the ends commonly used for concrete pumping. They can withstand 4350 PSI @ a 2:1 safety factor. They are self-aligning and waterproof when used with o-rings in good condition. Typically not used on booms because of their weight. Pipes equipped with this style coupling cannot be swapped end-for-end.



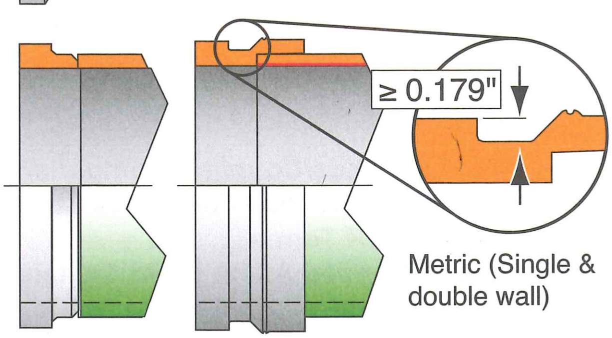
Male / Female
O-Ring
(shown with clamp)

2. Heavy-Duty couplings are designed for pressures up to 2250 PSI @ 2:1. They have 20% more contact area than metric couplings, and a tapered face that draws the pipe sections together during assembly. Both the ends and clamps weigh more than metric style, and therefore should not be used on booms without consulting the manufacturer.



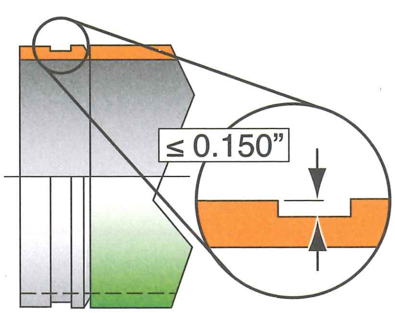
Heavy-Duty

3. Metric couplings are designed for pressures up to 1400 PSI @ 2:1. They have 85% more contact area than grooved couplings. The face is flat and will not draw pipe together. Although they have a raised edge, they are not compatible with Heavy-Duty couplings unless a special clamp or an adapter pipe is used to change from one style to the other. Metric connections are standard equipment on booms because of the weight savings compared with other styles.



Metric (Single & double wall)

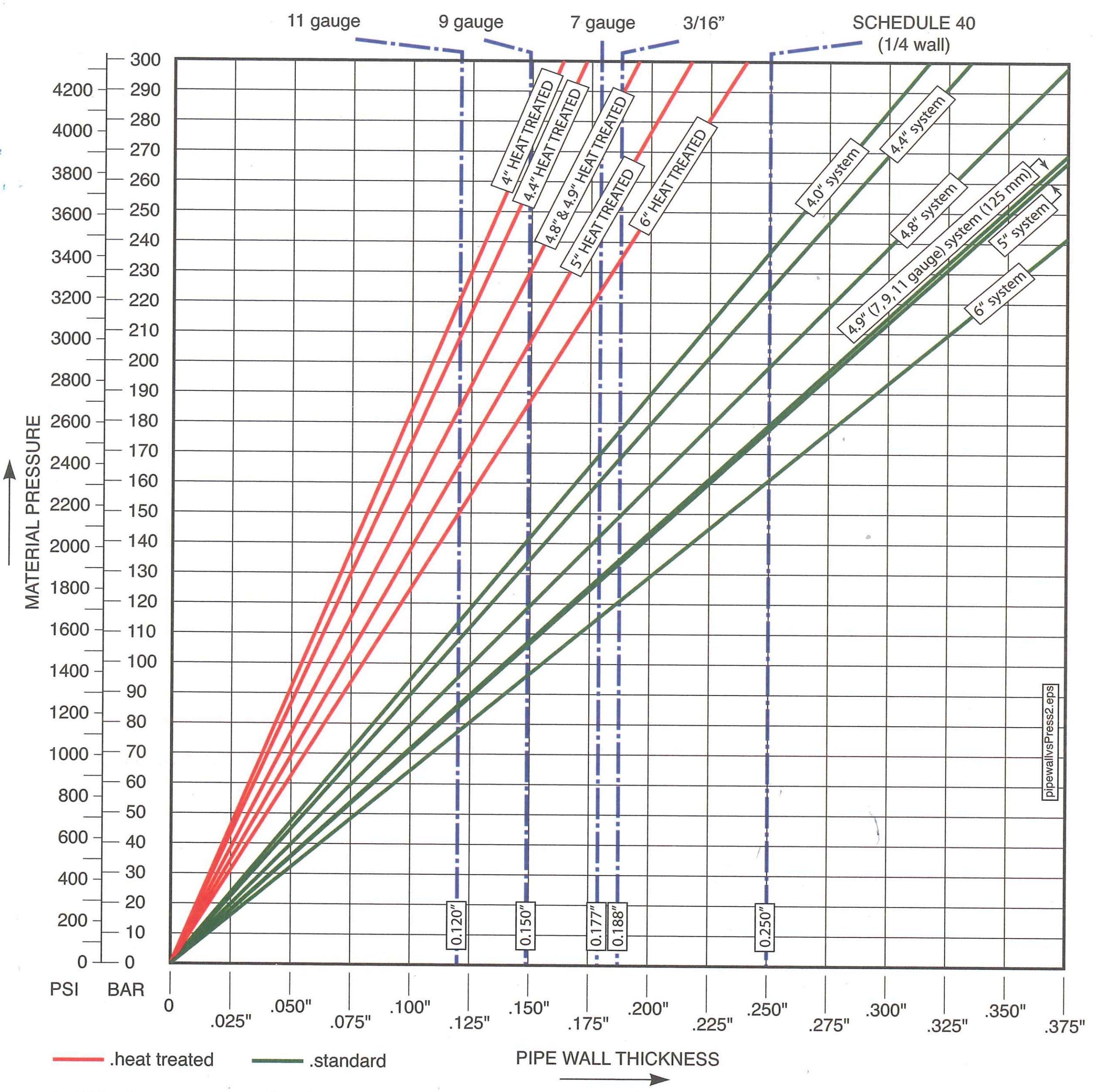
4. Grooved (Victaulic) couplings (lip height of 0.15" or less) are designed for pressures only up to 750 PSI @ 2:1. The recessed groove is hard to clean when changing pipe on a job. The weld-on end fails before the pipe because the groove is cut into the pipe thickness, making it the weakest spot. Grooved couplings are not recommended for concrete pumping applications.



Grooved; flange height equal to or less than 0.150", cut directly into pipe wall. NOT ALLOWED for concrete pumping per ASME B30.27

NOTE: All pressure ratings listed refer to 5-inch (125mm) diameters in like-new condition. Other pressures would apply to other diameters.

VIII. Minimum Pipe Wall Thickness Chart



1. This chart assumes a safety factor of 2:1. Higher safety factors may be required in some circumstances.
2. Wear reduces wall thickness. Thickness must be checked on a regular basis.
3. Pressures may be limited even more by clamp style or pipe end used.
4. The chart is based on 62,000 PSI tensile strength. Heat-treated calculations are based on 120,000 PSI tensile strength.
5. The chart is for pressure calculations ONLY. There is no allowance for mechanical forces other than pressure, and thicker walls may be needed for mechanical strength because of support or restraint considerations.
6. The chart does not take into account metal fatigue caused by pressure cycles.

Note! This chart is intended as a guide for concrete pumping applications and is subject to the notes, assumptions, and conditions listed above. Any other use of this chart is not recommended.

This chart does not apply to double-wall pipe. Double-wall pipe can be checked by inspecting the inside of the pipe. If the insert is intact, the pipe is okay. If the insert is worn through, the pipe must be replaced. Contact your pipe supplier for the pressure capacity of your double-wall pipe.

IX. Glossary Of Terms

Accumulator

A hydraulic device that stores fluid power energy in much the same way that a battery stores electrical energy. Because an accumulator will store energy, it MUST be drained and depressurized before work begins on an accumulator-equipped actuator or hydraulic system.

Agitator

A device that sits in the concrete hopper to keep concrete moving, preventing it from setting. It is typically a rotating shaft to which several paddles have been mounted. *See Also:* Hopper Grate

ASME B30.27

A safety standard for material placement systems (concrete pumps and material placement conveyors) that has been accepted by ANSI as an Ameirican National Standard.

Blanking Plate

Also known as a blanking plug or end cap. Its purpose is to prevent material from falling out of the delivery system when moving a boom with a full pipeline over personnel or property.

Blockage

Simply put, if the pump is pushing and concrete fails to come out at the point of discharge, it is called a blockage. Blockages can be removed with pump pressure, by rocking the pump between forward and reverse, or some other remedial measure. If the blockage cannot be removed in such a manner, it's called a plug. *See Also:* Plug, Rock Jam. The causes of blockages are detailed in Section 6.12 of this manual. In all cases, blockages create a hazard by causing high concrete pressure, combined with the sometimes uncoordinated efforts of untrained workmen to remedy the problem.

Bulk Density

The mass of a substance per volume. For example, one cubic foot of air weighs much less than one cubic foot of water. One cubic foot of lightweight concrete weighs less than one cubic foot of steel-entrained concrete. We could say that steel-entrained concrete has a higher bulk density than lightweight concrete. All calculations for the operation manuals and specifications of concrete pumps are based upon 150 pounds per cubic foot, which is the approximate mass of hard rock (normal) concrete.

Certified Operator

An operator that has been issued a certification card by the American Concrete Pumping Association. There are several classes of certification, each relating to a different category of pump. For an operator to become certified, he (she) must: pass the written tests regarding operation, setup, and cleanout for each category of pump; pass the safety rules test which is common to all certification categories; meet the experience requirements set forth for each category; and maintain a safe and clean driving record. The certification card only certifies that the operator has passed a written test administered by an ACPA certification proctor and does not attest to their ability to operate a concrete pump. *See Also:* Qualified Person, Qualified Operator.

Concrete Delivery Hose

A flexible concrete hose that has two end couplings.

Concrete Pressure

The force per square area that is exerted on the concrete. The concrete pressure will always be a ratio in direct proportion to the hydraulic oil pressure on the concrete pump circuit. *See Also*: Maximum Pressure

Decibels

One tenth of a bel. Abbreviated dB. It is a measurement of sound volume. As it applies to concrete pumps, it is a measurement of the sound pressure level one meter away from a noise source. O.S.H.A. has developed guidelines for time limits on exposure to sound at different volume levels. The chart can be found on page 15 of this manual.

Drive Engine

The primary source of power for a hydraulic system. Typically, the word "engine" denotes an internal combustion device, whereas the word "motor" denotes an electrical device.

End Hose

A flexible concrete hose that has one end coupling.

Foreign Material

Material that was never intended to be pumped, which ends up in the concrete hopper. Examples of foreign material include: small animals; hammers; ready mix truck fins; unmixed clumps of cement; hardened concrete that breaks away from ready mix truck fins; and soda pop cans. These items could create a blockage if pumped.

Go-devil

A plug made from a rubber composite, usually with several fins that expand to seal when pressure is applied. They are intended to be inserted in a steel delivery pipeline and pushed with water or compressed air for the purpose of cleaning the pipe. *See Also:* Sponge Ball

Guide

An assistant brought in to help in backing up a truck or trailer, or to help in other circumstances where the driver cannot see enough to assure safety. *See Also:* Signalperson

High Voltage

For the purposes of this manual, anything over 28 volts is to be considered high voltage. In the U.S., electrically driven concrete pumps normally operate the motors at 480 volts AC (high voltage) and the controls at 24 volt DC (low voltage).

Hopper Grate

A meshwork placed over the concrete hopper, typically made from steel bars. It serves the functions of keeping human body parts away from the agitator (when left in its proper position) and keeping large foreign objects from falling into the hopper, which could cause blockages if they were pumped.

Jacking the Outriggers

Adjustment of the outriggers in the vertical direction.

Licensed Electrician

A qualified electrician licensed by the state, county or municipality where the connections are to be made. In some locations electricians are not required to be licensed, and in these cases the work should still be carried out by competent professionals. Under no circumstances should high-voltage connections be made by a concrete pump operator or related personnel.

Maintenance

All procedures for service, inspection, and repair of concrete pumps and related equipment and devices. Maintenance and inspection are methods of ***maintaining*** the desired state of the equipment. Repair is the method of ***restoring*** the desired state of the equipment.

Maximum Pressure

When talking about a hydraulic system, maximum pressure refers to the highest pressure that can be achieved with the settings of the circuit relief valves. When discussing concrete output, maximum pressure refers to the pressure that will be developed if the hydraulic system pressure reaches the relief valve setting. Concrete pressure is the force at which the differential cylinders are moving, divided by the cross sectional area of the concrete cylinder. Maximum concrete pressure, then, is developed when the differential cylinders are moving with maximum force, which is determined by the hydraulic system relief valve setting. *See Also:* Concrete Pressure.

Minimum Safety Distance

In this manual, the term "minimum safety distance" refers to the closest distance that you are allowed to approach an object, electrical wires, etc. and still leave room for errors in human judgement or machine malfunction. With electrical wires in the U.S., this distance is 20 feet from the wires (50 feet above 350 Kv), as recommended by the American Concrete Pumping Association. This distance may have other values in different locations. It is up to the operator to know the value for the place of operation.

Operational Area

The area around a working piece of equipment or point of discharge where hazards can be encountered due to the nature of the machinery or process in use.

O.S.H.A.

Occupational Safety and Health Administration. A branch of the United States federal government that deals with job safety. It establishes and enforces safety regulations for industry and business. Among the areas over which it has authority are construction job sites and work shops.

Personal Protective Equipment (P.P.E. or just PPE)

Things you can wear to protect yourself from potential dangers in a concrete placing environment. Examples are:

- Snug-fitting work clothes
- Steel-toed work boots
- Lime-resistant gloves
- Safety glasses
- Ear muffs or ear plugs
- Rubber boots when you have to stand in concrete
- Hard hat
- Breathing mask when working with cement dust

Plug

A plug is a blockage that cannot be removed with the pump pressure, or by other remedial measures. A plug must be removed manually. *See Also:* Blockage.

Point of Discharge

Also known as the point of placement. The location of concrete expulsion from a delivery system. This can be the point of placement (the actual form that is being filled with concrete) or the cleanout area after completion of the job.

Pour

Used by the concrete pumping industry and in this manual as a noun. It is the specific job for the pump during any given time period. (e.g. "We'll grab lunch right after the pour.")

Qualified Person

As used in this *Safety Manual*, a *qualified person* is defined as: a person who, by possession of a recognized degree of certificate of professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter and work. Other qualified persons may include master mechanics and after-sales service technicians of the manufacturer. *See Also:* Certified Operator

Qualified Operator

Operators shall be considered qualified when they have completed a program of training and supervised operation of concrete pumps and have passed a practical operating examination of their ability to operate a specific model and type of equipment as well as their understanding of the controls and operating procedures. Furthermore, the operator must meet the knowledge and physical requirement sections of the concrete pumping safety standard.

Qualified Personnel

A generic term used to describe a person who is qualified in the area of application. For example, having your boom repairs inspected by "qualified personnel" before use would refer to inspection by a certified welder or certified welding inspector. Having repairs to your hydraulic system done by "qualified personnel" would refer to repairs made by qualified workshop personnel.

Qualified Workshop Personnel

An individual who:

- has reached the age of 18 years,
- is physically and mentally capable,
- has been trained in proper repair, maintenance, and inspection procedures plus the pertinent safety rules for concrete pumps and related equipment,
- has demonstrated their capabilities to their company in regards to the above mentioned procedures and rules, and
- can be expected to perform these duties, as assigned, in a reliable manner.

Rock Jam

A specific type of blockage caused when the cement and fines of the concrete are not present in sufficient quantity to fully coat the larger aggregates and the walls of the delivery system. In these cases, the rock (larger aggregates of the mix) will form a wedge inside of the pipe. Resistance to movement then becomes overpowering and the concrete stops. *See Also:* Blockage.

Separate Pipeline

A pipeline that is laid between the concrete pump and the point of discharge, other than the placing boom pipeline.

Shutoff Valve

In hydraulics: a valve with the ability to stop the flow or pressure of hydraulic oil. It must be able to withstand the maximum pressure of the hydraulic circuit that it controls.

In concrete: A manually or hydraulically operated valve that will prevent the flow of concrete in either direction. The shutoff valve must be able to withstand the maximum pressure on the concrete of which the pump is capable of exerting.

Signalperson

A person positioned at a vantage point where both the point of discharge and the pump operator can be seen and who relays operational signals to the operator.

Soil Pressure

The force per square area that is exerted on the ground by the outrigger legs. The amount of pressure that the soil will support varies with the composition and compaction of the soil. To make a determination on the stability of the soil.

Sponge Ball

A medium to hard sponge formed into a sphere and used to clean the inside of delivery pipelines. *See Also:* Go-devil

SAFETY MANUAL

Spotter

A person positioned at a vantage point where the distance between a hazard and the pump can be clearly seen and evaluated and the pump operator can be alerted if a predetermined safety distance is compromised. *See Also:* Guide

Sucking Back

The act of putting the concrete pump into the reverse mode for any of several reasons.

Thrust Block

Also known as a “dead man”. This is a large block of poured concrete, usually with one or more sweep elbows cast inside, placed at the bottom of a vertical run for the purpose of supporting the weight of the vertical run and for lateral stabilization of the pipeline. It stabilizes and supports the vertical run by virtue of its enormous mass (normally one cubic yard or larger).

Towing Vehicle

In this manual, *Towing Vehicle* applies only to vehicles that tow trailer-mounted concrete pumps. It is the vehicle that you will use to tow the trailer on the road, on the job site, or in the yard. See the safety rules regarding this subject on page 8 of this *Safety Manual*.

Transport Position

This relates to the position of the machinery when you will be driving or towing the unit. For example, the travel position of the engine hood is the position of the hood when it is completely lowered and latched into place.

Unauthorized

Without authority, without permission. Examples: Unauthorized operation of the boom could be operation by a passer-by, unauthorized repairs to the boom could be repairs designed without the manufacturer’s knowledge.

Unintentional Movement

Movement of the pump, boom or related equipment without a specific intentional command by the operator. An example of an unintentional movement would be if an operator fell while walking with the remote control box and accidentally hit a joystick, causing a boom movement.

Vertical Run

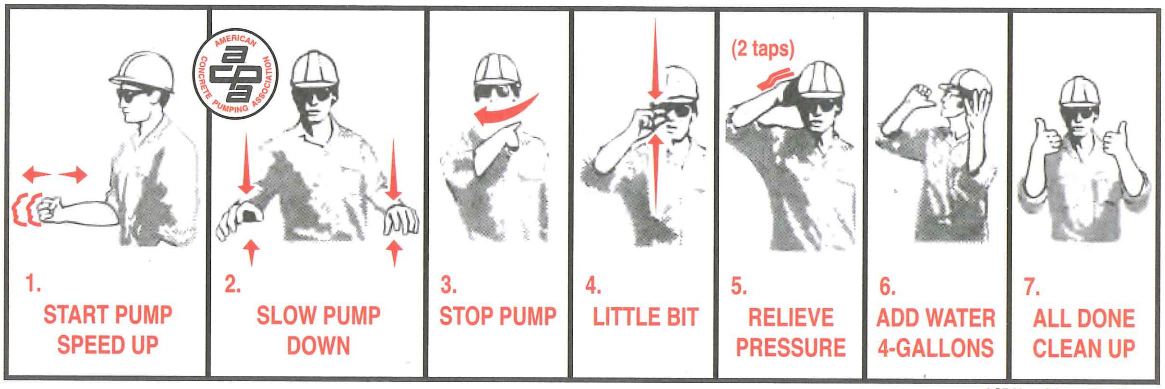
Sections of concrete delivery pipeline that are running in an up (or down) direction. Vertical runs have very specific procedures and rules for installation, support, cleaning, and inspection. Concrete pumping personnel should, therefore, have specific training in these procedures and rules before attempting to use them in a job setting.

Water Jet

The actual stream of water that comes out of the end of a water hose or pressure washer. This is the only part of the water system that needs to go into the hopper, concrete valve, or water box for cleaning.

X. Recommended ACPA Hand Signals

The American Concrete Pumping Association (ACPA) recommends using the following hand signals as standard procedure.



ACPAhandsigsmallline2.eps

XI. Bibliography

Further information regarding concrete pumping is available from the sources listed below. Information for this book was gathered from several different sources, including the following books:

PUMPING CONCRETE AND CONCRETE PUMPS © F. W. Schwing, GmbH

CONCRETE PUMP OPERATOR'S GUIDE TO SAFETY © British Concrete Pumping Association

The MANUAL and ADVISORY SAFETY CODE of PRACTICE for CONCRETE PUMPING © British Concrete Pumping Association

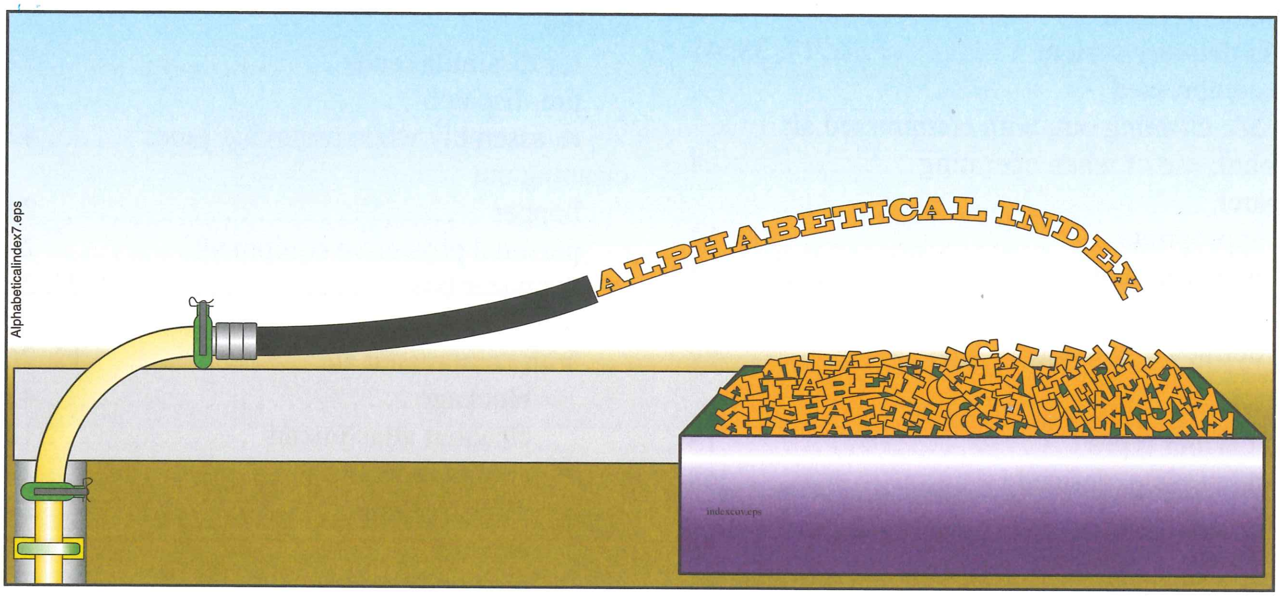
SAFETY STANDARD FOR CONCRETE PUMPS, PLACING BOOMS, AND DELIVERY SYSTEM by the Concrete Pump Manufacturers Bureau

Additional technical information and/or graphic were supplied by:

Construction Forms, Inc.

The American Concrete Pumping Association

Some cartoons were scanned from the book CONCRETE PUMP OPERATOR'S GUIDE TO SAFETY © British Concrete Pumping Association. Used by Permission.



Alphabetical Index

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R

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T

U

V

Information contained in this Safety Manual is not intended to supercede the manufacturer's recommendations or company policies.

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Perkins®

THE HEART OF EVERY GREAT MACHINE

SEBU8726-02
July 2013

Operation and Maintenance Manual

854E-E34TA and 854F-E34T Industrial Engines

JR (Engine)
JS (Engine)
JT (Engine)

Important Safety Information

Most accidents that involve product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or to other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "DANGER", "WARNING" or "CAUTION". The Safety Alert "WARNING" label is shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning explains the hazard and can be either written or pictorially presented.

Operations that may cause product damage are identified by "NOTICE" labels on the product and in this publication.

Perkins cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all inclusive. If a tool, procedure, work method or operating technique that is not specifically recommended by Perkins is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that the product will not be damaged or be made unsafe by the operation, lubrication, maintenance or repair procedures that you choose.

The information, specifications, and illustrations in this publication are on the basis of information that was available at the time that the publication was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service that is given to the product. Obtain the complete and most current information before you start any job. Perkins dealers or Perkins distributors have the most current information available.

⚠ WARNING

When replacement parts are required for this product Perkins recommends using Perkins replacement parts.

Failure to heed this warning can lead to premature failures, product damage, personal injury or death.

Table of Contents

Foreword

Literature Information

This manual contains safety, operation instructions, lubrication and maintenance information. This manual should be stored in or near the engine area in a literature holder or literature storage area. Read, study and keep it with the literature and engine information.

English is the primary language for all Perkins publications. The English used facilitates translation and consistency.

Some photographs or illustrations in this manual show details or attachments that may be different from your engine. Guards and covers may have been removed for illustrative purposes. Continuing improvement and advancement of product design may have caused changes to your engine which are not included in this manual. Whenever a question arises regarding your engine, or this manual, please consult with your Perkins dealer or your Perkins distributor for the latest available information.

Safety

This safety section lists basic safety precautions. In addition, this section identifies hazardous, warning situations. Read and understand the basic precautions listed in the safety section before operating or performing lubrication, maintenance and repair on this product.

Operation

Operating techniques outlined in this manual are basic. They assist with developing the skills and techniques required to operate the engine more efficiently and economically. Skill and techniques develop as the operator gains knowledge of the engine and its capabilities.

The operation section is a reference for operators. Photographs and illustrations guide the operator through procedures of inspecting, starting, operating and stopping the engine. This section also includes a discussion of electronic diagnostic information.

Maintenance

The maintenance section is a guide to engine care. The illustrated, step-by-step instructions are grouped by service hours and/or calendar time maintenance intervals. Items in the maintenance schedule are referenced to detailed instructions that follow.

Recommended service should be performed at the appropriate intervals as indicated in the Maintenance Interval Schedule. The actual operating environment of the engine also governs the Maintenance Interval Schedule. Therefore, under extremely severe, dusty, wet or freezing cold operating conditions, more frequent lubrication and maintenance than is specified in the Maintenance Interval Schedule may be necessary.

The maintenance schedule items are organized for a preventive maintenance management program. If the preventive maintenance program is followed, a periodic tune-up is not required. The implementation of a preventive maintenance management program should minimize operating costs through cost avoidances resulting from reductions in unscheduled downtime and failures.

Maintenance Intervals

Perform maintenance on items at multiples of the original requirement. We recommend that the maintenance schedules be reproduced and displayed near the engine as a convenient reminder. We also recommend that a maintenance record be maintained as part of the engine's permanent record.

Your authorized Perkins dealer or your Perkins distributor can assist you in adjusting your maintenance schedule to meet the needs of your operating environment.

Overhaul

Major engine overhaul details are not covered in the Operation and Maintenance Manual except for the interval and the maintenance items in that interval. Major repairs should only be carried out by Perkins authorized personnel. Your Perkins dealer or your Perkins distributor offers a variety of options regarding overhaul programs. If you experience a major engine failure, there are also numerous after failure overhaul options available. Consult with your Perkins dealer or your Perkins distributor for information regarding these options.

California Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm. Battery posts, terminals and related accessories contain lead and lead compounds. **Wash hands after handling**.

Safety Section

i04112132

Safety Messages

There may be several specific warning signs on your engine. The exact location and a description of the warning signs are reviewed in this section. Please become familiar with all warning signs.

Ensure that all of the warning signs are legible. Clean the warning signs or replace the warning signs if the words cannot be read or if the illustrations are not visible. Use a cloth, water, and soap to clean the warning signs. Do not use solvents, gasoline, or other harsh chemicals. Solvents, gasoline, or harsh chemicals could loosen the adhesive that secures the warning signs. The warning signs that are loosened could drop off the engine.

Replace any warning sign that is damaged or missing. If a warning sign is attached to a part of the engine that is replaced, install a new warning sign on the replacement part. Your Perkins distributor can provide new warning signs.

Universal Warning

WARNING

Do not operate or work on this equipment unless you have read and understand the instructions and warnings in the Operation and Maintenance Manuals. Failure to follow the instructions or heed the warnings could result in serious injury or death.

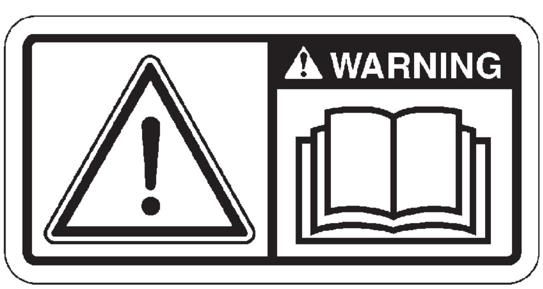

Illustration 1 g01154807

Typical example

The Universal Warning label (1) is located on the top of the engine, on the engine interface connector cover.

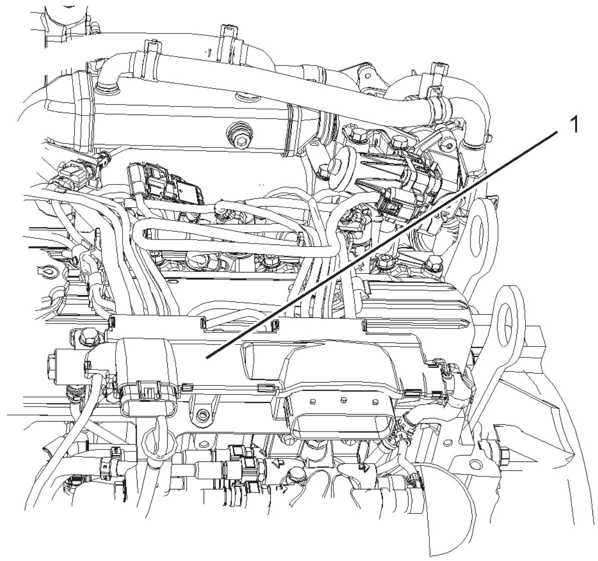

Illustration 2 g02582556

Typical example

i03566024

General Hazard Information

Illustration 3 g00104545

Attach a "Do Not Operate" warning tag or a similar warning tag to the start switch or to the controls before the engine is serviced or before the engine is repaired. Attach the warning tags to the engine and to each operator control station. When it is appropriate, disconnect the starting controls.

Do not allow unauthorized personnel on the engine, or around the engine when the engine is being serviced.

- Tampering with the engine installation or tampering with the OEM supplied wiring can be dangerous. Personal injury, death and/or engine damage could result.
- Vent the engine exhaust to the outside when the engine is operated in an enclosed area.
- If the engine is not running, do not release the secondary brake or the parking brake systems unless the vehicle is blocked or unless the vehicle is restrained.
- Wear a hard hat, protective glasses, and other protective equipment, as required.
- When work is performed around an engine that is operating, wear protective devices for ears in order to help prevent damage to hearing.
- Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.
- Ensure that all protective guards and all covers are secured in place on the engine.
- Never put maintenance fluids into glass containers. Glass containers can break.
- Use all cleaning solutions with care.
- Report all necessary repairs.

Unless other instructions are provided, perform the maintenance under the following conditions:

- The engine is stopped. Ensure that the engine can not be started.
- The protective locks or the controls are in the applied position.
- Engage the secondary brakes or parking brakes.
- Block the vehicle or restrain the vehicle before maintenance or repairs are performed.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help prevent sparks.
- Disconnect the connector for the unit injector that is located on the valve cover base. This will help prevent personal injury from the high voltage to the unit injectors. Do not come in contact with the unit injector terminals while the engine is operating.
- Do not attempt any repairs or any adjustments to the engine while the engine is operating.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.
- For initial start-up of a new engine or for starting an engine that has been serviced, make provisions to stop the engine if an overspeed occurs. This may be accomplished by shutting off the fuel supply and/or the air supply to the engine.
- Start the engine from the operator's station (cab). Never short across the starting motor terminals or the batteries. This could bypass the engine neutral start system and/or the electrical system could be damaged.

Engine exhaust contains products of combustion which may be harmful to your health. Always start the engine and operate the engine in a well ventilated area. If the engine is in an enclosed area, vent the engine exhaust to the outside.

Cautiously remove the following parts. To help prevent spraying or splashing of pressurized fluids, hold a rag over the part that is being removed.

- Filler caps
- Grease fittings
- Pressure taps
- Breathers
- Drain plugs

Use caution when cover plates are removed. Gradually loosen, but do not remove the last two bolts or nuts that are located at opposite ends of the cover plate or the device. Before removing the last two bolts or nuts, pry the cover loose in order to relieve any spring pressure or other pressure.

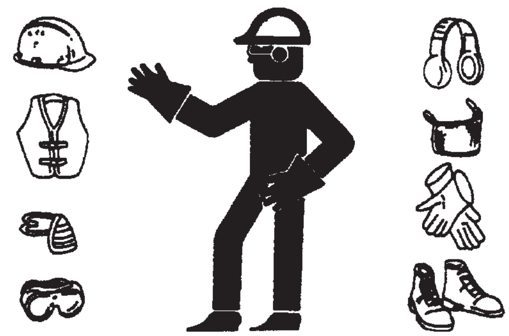

Illustration 4 g00702020

- Wear a hard hat, protective glasses, and other protective equipment, as required.
- When work is performed around an engine that is operating, wear protective devices for ears in order to help prevent damage to hearing.
- Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.
- Ensure that all protective guards and all covers are secured in place on the engine.
- Never put maintenance fluids into glass containers. Glass containers can break.
- Use all cleaning solutions with care.
- Report all necessary repairs.

Unless other instructions are provided, perform the maintenance under the following conditions:

- The engine is stopped. Ensure that the engine cannot be started.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help prevent sparks.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.

Pressurized Air and Water

Pressurized air and/or water can cause debris and/or hot water to be blown out. This could result in personal injury.

When pressurized air and/or pressurized water is used for cleaning, wear protective clothing, protective shoes, and eye protection. Eye protection includes goggles or a protective face shield.

The maximum air pressure for cleaning purposes must be below 205 kPa (30 psi). The maximum water pressure for cleaning purposes must be below 275 kPa (40 psi).

Fluid Penetration

Pressure can be trapped in the hydraulic circuit long after the engine has been stopped. The pressure can cause hydraulic fluid or items such as pipe plugs to escape rapidly if the pressure is not relieved correctly.

Do not remove any hydraulic components or parts until pressure has been relieved or personal injury may occur. Do not disassemble any hydraulic components or parts until pressure has been relieved or personal injury may occur. Refer to the OEM information for any procedures that are required to relieve the hydraulic pressure.

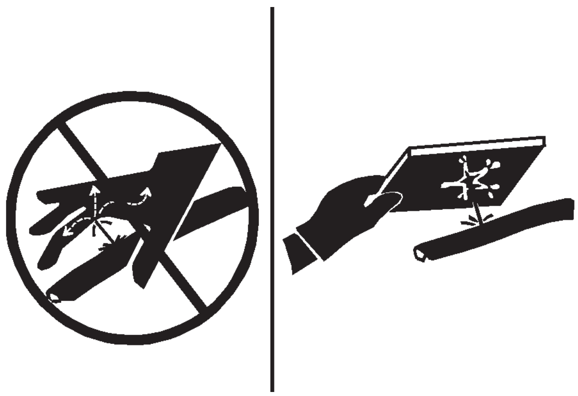

Illustration 5 g00687600

Always use a board or cardboard when you check for a leak. Leaking fluid that is under pressure can penetrate body tissue. Fluid penetration can cause serious injury and possible death. A pin hole leak can cause severe injury. If fluid is injected into your skin, you must get treatment immediately. Seek treatment from a doctor that is familiar with this type of injury.

Containing Fluid Spillage

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Asbestos Information

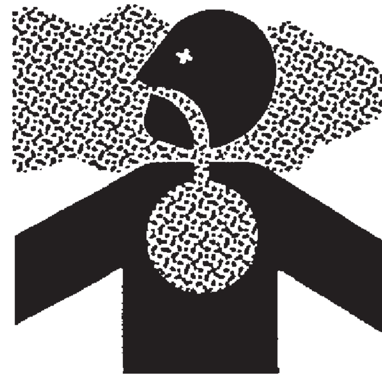

Illustration 6 g00702022

Perkins replacement parts that are shipped from Perkins are asbestos free. Perkins recommends the use of only genuine Perkins replacement parts. Use the following guidelines when you handle any replacement parts that contain asbestos or when you handle asbestos debris.

Use caution. Avoid inhaling dust that might be generated when you handle components that contain asbestos fibers. Inhaling this dust can be hazardous to your health. The components that may contain asbestos fibers are brake pads, brake bands, lining material, clutch plates, and some gaskets. The asbestos that is used in these components is usually bound in a resin or sealed in some way. Normal handling is not hazardous unless airborne dust that contains asbestos is generated.

If dust that may contain asbestos is present, there are several guidelines that should be followed:

- Never use compressed air for cleaning.
- Avoid brushing materials that contain asbestos.
- Avoid grinding materials that contain asbestos.
- Use a wet method in order to clean up asbestos materials.
- A vacuum cleaner that is equipped with a high efficiency particulate air filter (HEPA) can also be used.
- Use exhaust ventilation on permanent machining jobs.
- Wear an approved respirator if there is no other way to control the dust.
- Comply with applicable rules and regulations for the work place. In the United States , use Occupational Safety and Health Administration (OSHA) requirements. These OSHA requirements can be found in 29 CFR 1910.1001.
- Obey environmental regulations for the disposal of asbestos.
- Stay away from areas that might have asbestos particles in the air.

Dispose of Waste Properly

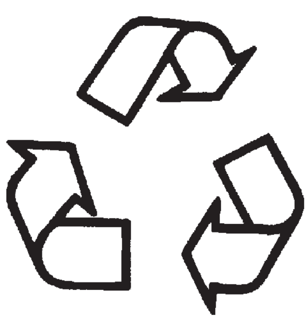

Illustration 7 g00706404

Improperly disposing of waste can threaten the environment. Potentially harmful fluids should be disposed of according to local regulations.

Always use leakproof containers when you drain fluids. Do not pour waste onto the ground, down a drain, or into any source of water.

i04289958

Burn Prevention

Do not touch any part of an operating engine system. The engine, the exhaust, and the engine aftertreatment system can reach temperatures as high as 650 °C (1202 °F) under normal operating conditions.

At idle engine speed and/or zero vehicle speed, an operator can request a manual regeneration. Under this condition, the exhaust gas temperature can reach 650 °C (1202 °F). Otherwise automatic regeneration can produce exhaust gas temperatures as high as 650 °C (1202 °F).

Allow the engine system to cool before any maintenance is performed. Relieve all pressure in the following systems, hydraulic system, lubrication system, fuel system, and the cooling system before related items are disconnected.

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

After the engine has stopped, you must wait for 10 minutes in order to allow the fuel pressure to be purged from the high-pressure fuel lines before any service or repair is performed on the engine fuel lines.

Induction System

⚠ WARNING

Sulfuric Acid Burn Hazard may cause serious personal injury or death.

The exhaust gas cooler may contain a small amount of sulfuric acid. The use of fuel with sulfur levels greater than 15 ppm may increase the amount of sulfuric acid formed. The sulfuric acid may spill from the cooler during service of the engine. The sulfuric acid will burn the eyes, skin and clothing on contact. Always wear the appropriate personal protective equipment (PPE) that is noted on a material safety data sheet (MSDS) for sulfuric acid. Always follow the directions for first aid that are noted on a material safety data sheet (MSDS) for sulfuric acid.

Coolant

When the engine is at operating temperature, the engine coolant is hot. The coolant is also under pressure. The radiator and all lines to the heaters or to the engine contain hot coolant.

Any contact with hot coolant or with steam can cause severe burns. Allow cooling system components to cool before the cooling system is drained.

Check the coolant level after the engine has stopped and the engine has been allowed to cool.

Ensure that the filler cap is cool before removing the filler cap. The filler cap must be cool enough to touch with a bare hand. Remove the filler cap slowly in order to relieve pressure.

Cooling system conditioner contains alkali. Alkali can cause personal injury. Do not allow alkali to contact the skin, the eyes, or the mouth.

Oils

Hot oil and hot lubricating components can cause personal injury. Do not allow hot oil to contact the skin. Also, do not allow hot components to contact the skin.

Batteries

Electrolyte is an acid. Electrolyte can cause personal injury. Do not allow electrolyte to contact the skin or the eyes. Always wear protective glasses for servicing batteries. Wash hands after touching the batteries and connectors. Use of gloves is recommended.

i04303237

Fire Prevention and Explosion Prevention

Illustration 8 g00704000

All fuels, most lubricants, and some coolant mixtures are flammable.

Flammable fluids that are leaking or spilled onto hot surfaces or onto electrical components can cause a fire. Fire may cause personal injury and property damage.

After the emergency stop button is operated, ensure that you allow 15 minutes, before the engine covers are removed.

Determine whether the engine will be operated in an environment that allows combustible gases to be drawn into the air inlet system. These gases could cause the engine to overspeed. Personal injury, property damage, or engine damage could result.

If the application involves the presence of combustible gases, consult your Perkins dealer and/ or your Perkins distributor for additional information about suitable protection devices.

Remove all flammable combustible materials or conductive materials such as fuel, oil, and debris from the engine. Do not allow any flammable combustible materials or conductive materials to accumulate on the engine.

Store fuels and lubricants in correctly marked containers away from unauthorized persons. Store oily rags and any flammable materials in protective containers. Do not smoke in areas that are used for storing flammable materials.

Do not expose the engine to any flame.

Exhaust shields (if equipped) protect hot exhaust components from oil or fuel spray in a line, a tube, or a seal failure. Exhaust shields must be installed correctly.

Do not weld on lines or tanks that contain flammable fluids. Do not flame cut lines or tanks that contain flammable fluid. Clean any such lines or tanks thoroughly with a nonflammable solvent prior to welding or flame cutting.

Wiring must be kept in good condition. All electrical wires must be correctly routed and securely attached. Check all electrical wires daily. Repair any wires that are loose or frayed before you operate the engine. Clean all electrical connections and tighten all electrical connections.

Eliminate all wiring that is unattached or unnecessary. Do not use any wires or cables that are smaller than the recommended gauge. Do not bypass any fuses and/or circuit breakers.

Arcing or sparking could cause a fire. Secure connections, recommended wiring, and correctly maintained battery cables will help to prevent arcing or sparking.

WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

After the engine has stopped, you must wait for 10 minutes in order to allow the fuel pressure to be purged from the high-pressure fuel lines before any service or repair is performed on the engine fuel lines.

Ensure that the engine is stopped. Inspect all lines and hoses for wear or for deterioration. The hoses must be correctly routed. The lines and hoses must have adequate support and secure clamps.

Ensure that Oil filters and fuel filters are correctly installed. The filter housings must be tightened to the correct torque. Refer to the Disassembly and Assembly manual for more information.

Illustration 9 g00704059

Use caution when you are refueling an engine. Do not smoke while you are refueling an engine. Do not refuel an engine near open flames or sparks. Always stop the engine before refueling.

Illustration 10 g00704135

Gases from a battery can explode. Keep any open flames or sparks away from the top of a battery. Do not smoke in battery charging areas.

Never check the battery charge by placing a metal object across the terminal posts. Use a voltmeter or a hydrometer.

Incorrect jumper cable connections can cause an explosion that can result in injury. Refer to the Operation Section of this manual for specific instructions.

Do not charge a frozen battery. Charging a frozen battery may cause an explosion.

The batteries must be kept clean. The covers (if equipped) must be kept on the cells. Use the recommended cables, connections, and battery box covers when the engine is operated.

Fire Extinguisher

Make sure that a fire extinguisher is available. Be familiar with the operation of the fire extinguisher. Inspect the fire extinguisher and service the fire extinguisher regularly. Obey the recommendations on the instruction plate.

Lines, Tubes, and Hoses

Do not bend high-pressure lines. Do not strike high-pressure lines. Do not install any lines that are damaged.

Leaks can cause fires. Consult your Perkins dealer or your Perkins distributor for replacement parts.

Replace the parts if any of the following conditions are present:

- High-pressure fuel line or lines are removed.
- End fittings are damaged or leaking.
- Outer coverings are chafed or cut.
- Wires are exposed.
- Outer coverings are ballooning.
- Flexible parts of the hoses are kinked.
- Outer covers have embedded armoring.
- End fittings are displaced.

Make sure that all clamps, guards, and heat shields are installed correctly. During engine operation, this check will help to prevent vibration, rubbing against other parts, and excessive heat.

Regeneration

The exhaust gas temperature during regeneration will be elevated. Follow proper fire prevention instructions and use the disable switch function when appropriate.

i02143194

Crushing Prevention and Cutting Prevention

Support the component correctly when work beneath the component is performed.

Unless other maintenance instructions are provided, never attempt adjustments while the engine is running.

Stay clear of all rotating parts and of all moving parts. Leave the guards in place until maintenance is performed. After the maintenance is performed, reinstall the guards.

Keep objects away from moving fan blades. The fan blades will throw objects or cut objects.

When objects are struck, wear protective glasses in order to avoid injury to the eyes.

Chips or other debris may fly off objects when objects are struck. Before objects are struck, ensure that no one will be injured by flying debris.

i04016709

Mounting and Dismounting

Do not climb on the engine or the engine aftertreatment. The engine and aftertreatment have not been designed with mounting or dismounting locations.

Refer to the OEM for the location of foot and hand holds for your specific application.

i04112191

High Pressure Fuel Lines

WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

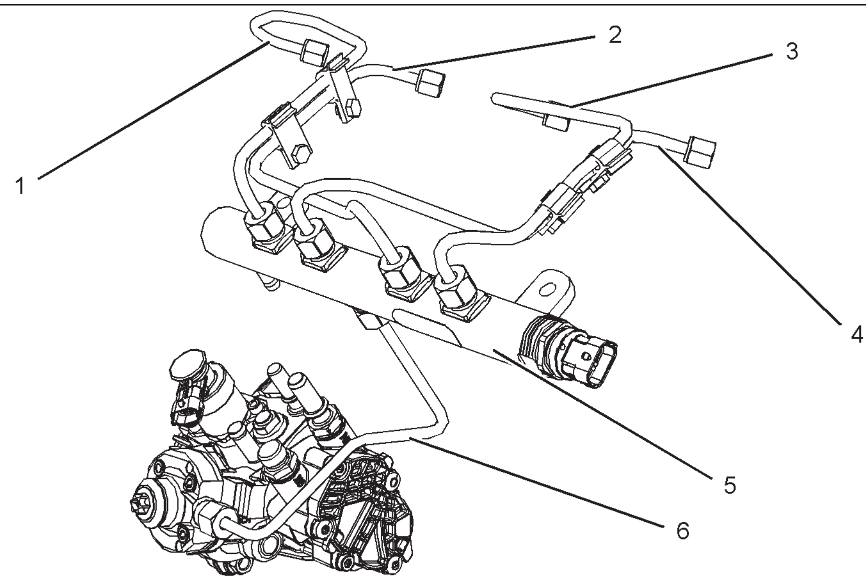

Illustration 11 g02315653

(1) High-pressure line
(2) High-pressure line
(3) High-pressure line
(4) High-pressure line
(5) High-pressure fuel manifold (rail)
(6) Fuel transfer line that is high pressure

The high-pressure fuel lines are the fuel lines that are between the high-pressure fuel pump and the high-pressure fuel manifold and the fuel lines that are between the fuel manifold and cylinder head. These fuel lines are different from fuel lines on other fuel systems.

These differences are because of the following items:

- The high-pressure fuel lines are constantly charged with high pressure.
- The internal pressures of the high-pressure fuel lines are higher than other types of fuel system.
- The high-pressure fuel lines are formed to shape and then strengthened by a special process.

Do not step on the high-pressure fuel lines. Do not deflect the high-pressure fuel lines. Do not bend or strike the high-pressure fuel lines. Deformation or damage of the high-pressure fuel lines may cause a point of weakness and potential failure.

Do not check the high-pressure fuel lines with the engine or the starting motor in operation. After the engine has stopped wait for 10 minutes in order to allow the fuel pressure to be purged from the high-pressure fuel lines before any service or repair is performed.

Do not loosen the high-pressure fuel lines in order to remove air from the fuel system. This procedure is not required.

Visually inspect the high-pressure fuel lines before the engine is started. This inspection should be each day.

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, “General hazard Information”.

- Inspect the high-pressure fuel lines for damage, deformation, a nick, a cut, a crease, or a dent.
- Do not operate the engine with a fuel leak. If there is a leak, do not tighten the connection in order to stop the leak. The connection must only be tightened to the recommended torque. Refer to Disassembly and Assembly, “Fuel injection lines - Remove and Fuel injection lines - Install”.
- If the high-pressure fuel lines are torqued correctly, and the high-pressure fuel lines are leaking the high-pressure fuel lines must be replaced.
- Ensure that all clips on the high-pressure fuel lines are in place. Do not operate the engine with clips that are damaged, missing, or loose.
- Do not attach any other item to the high-pressure fuel lines.
- Loosened high-pressure fuel lines must be replaced. Also removed high-pressure fuel lines must be replaced. Refer to Disassembly and Assembly, “Fuel Injection Lines - Install”.

i02813489

Before Starting Engine

Before the initial start-up of an engine that is new, serviced or repaired, make provision to shut the engine off, in order to stop an overspeed. This may be accomplished by shutting off the air and/or fuel supply to the engine.

Overspeed shutdown should occur automatically for engines that are controlled electronically. If automatic shutdown does not occur, press the emergency stop button in order to cut the fuel and/or air to the engine.

Inspect the engine for potential hazards.

Before starting the engine, ensure that no one is on, underneath, or close to the engine. Ensure that the area is free of personnel.

If equipped, ensure that the lighting system for the engine is suitable for the conditions. Ensure that all lights work correctly, if equipped.

All protective guards and all protective covers must be installed if the engine must be started in order to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Do not bypass the automatic shutoff circuits. Do not disable the automatic shutoff circuits. The circuits are provided in order to help prevent personal injury. The circuits are also provided in order to help prevent engine damage.

See the Service Manual for repairs and for adjustments.

i04478934

Engine Starting

WARNING

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

If a warning tag is attached to the engine start switch, or to the controls DO NOT start the engine or move the controls. Consult with the person that attached the warning tag before the engine is started.

All protective guards and all protective covers must be installed if the engine must be started in order to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Start the engine from the operators compartment or from the engine start switch.

Always start the engine according to the procedure that is described in the Operation and Maintenance Manual, “Engine Starting” topic in the Operation Section. Knowing that the correct procedure will help to prevent major damage to the engine components. Knowing that the procedure will also help to prevent personal injury.

To ensure that the jacket water heater (if equipped) and/or the lube oil heater (if equipped) is working correctly, check the water temperature gauge. Also, check the oil temperature gauge during the heater operation.

Engine exhaust contains products of combustion which can be harmful to your health. Always start the engine and operate the engine in a well ventilated area. If the engine is started in an enclosed area, vent the engine exhaust to the outside.

Note: These engines are equipped with a glow plug starting aid in each cylinder that heats the intake air in order to improve starting.

i02234873

Engine Stopping

Stop the engine according to the procedure in the Operation and Maintenance Manual, “Engine Stopping (Operation Section)” in order to avoid overheating of the engine and accelerated wear of the engine components.

Use the Emergency Stop Button (if equipped) ONLY in an emergency situation. Do not use the Emergency Stop Button for normal engine stopping. After an emergency stop, DO NOT start the engine until the problem that caused the emergency stop has been corrected.

Stop the engine if an overspeed condition occurs during the initial start-up of a new engine or an engine that has been overhauled.

To stop an electronically controlled engine, cut the power to the engine and/or shutting off the air supply to the engine.

i04112409

Electrical System

Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operating. A spark can cause the combustible gases that are produced by some batteries to ignite.

To help prevent sparks from igniting combustible gases that are produced by some batteries, the negative “−” cable should be connected last from the external power source to the negative “−” terminal of the starting motor. If the starting motor is not equipped with a negative “−” terminal, connect the cable to the engine block.

Check the electrical wires daily for wires that are loose or frayed. Tighten all loose electrical connections before the engine is started. Repair all frayed electrical wires before the engine is started. See the Operation and Maintenance Manual for specific starting instructions.

Grounding Practices

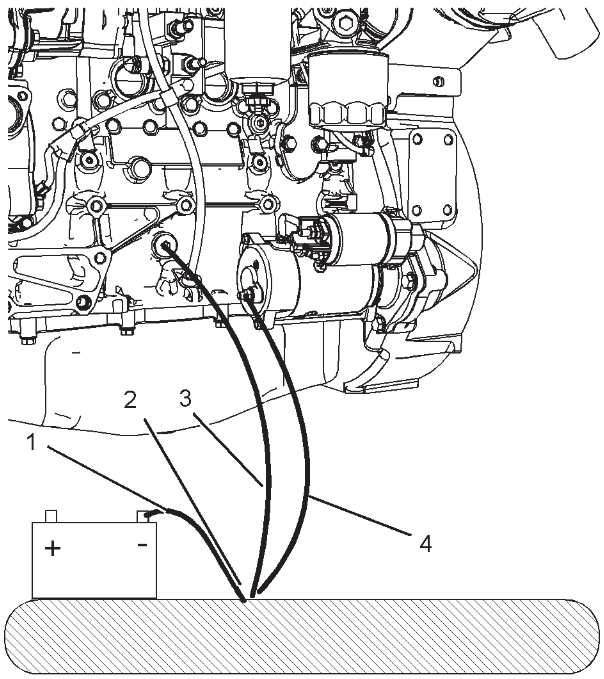

Illustration 12 g02315896

Typical example

(1) Ground to battery
(2) Primary position for grounding
(3) Ground to engine block
(4) Ground to starting motor

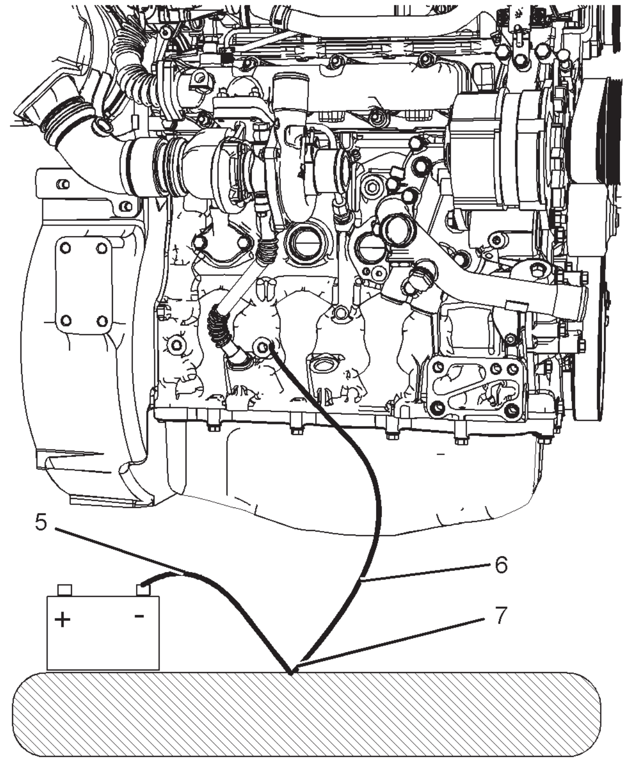

Illustration 13 g02315900

Typical example

(5) Ground to battery
(6) Ground to engine block
(7) Primary position for grounding

Correct grounding for the engine electrical system is necessary for optimum engine performance and reliability. Incorrect grounding will result in uncontrolled electrical circuit paths and in unreliable electrical circuit paths.

Uncontrolled electrical circuit paths can result in damage to engine components.

Engines that are installed without engine-to-frame ground straps can be damaged by electrical discharge.

To ensure the engine and the engine electrical systems function correctly, an engine-to-frame ground strap with a direct path to the battery must be used. This path may be provided by way of a direct engine ground to the frame.

The connections for the grounds should be tight and free of corrosion. The engine alternator must be grounded to the negative “-” battery terminal with a wire adequate to handle the full charging current of the alternator.

The power supply connections and the ground connections for the engine electronics should always be from the isolator to the battery.

i04346349

Engine Electronics

⚠ WARNING

Tampering with the electronic system installation or the OEM wiring installation can be dangerous and could result in personal injury or death and/or engine damage.

⚠ WARNING

Electrical Shock Hazard. The electronic unit injectors use DC voltage. The ECM sends this voltage to the electronic unit injectors. Do not come in contact with the harness connector for the electronic unit injectors while the engine is operating. Failure to follow this instruction could result in personal injury or death.

This engine has a comprehensive, programmable Engine Monitoring System. The Electronic Control Module (ECM) has the ability to monitor the engine operating conditions. If any of the engine parameters extend outside an allowable range, the ECM will initiate an immediate action.

The following actions are available for engine monitoring control:

- Warning
- Derate
- Shutdown

The following monitored engine operating conditions and components have the ability to limit engine speed and/or the engine power :

- Engine Coolant Temperature
- Engine Oil Pressure
- Engine Speed
- Intake Manifold Air Temperature
- Engine Intake Throttle Valve Fault
- Wastegate Regulator
- Supply Voltage to Sensors
- Fuel Pressure in Manifold (Rail)
- NOxReduction System
- Engine Aftertreatment System

The Engine Monitoring package can vary for different engine models and different engine applications. However, the monitoring system and the engine monitoring control will be similar for all engines.

Product Information Section

General Information

i05297867

Model View Illustrations

The following model views show typical features of the engine. Due to individual applications, your engine may appear different from the illustrations.

Engine and Aftertreatment

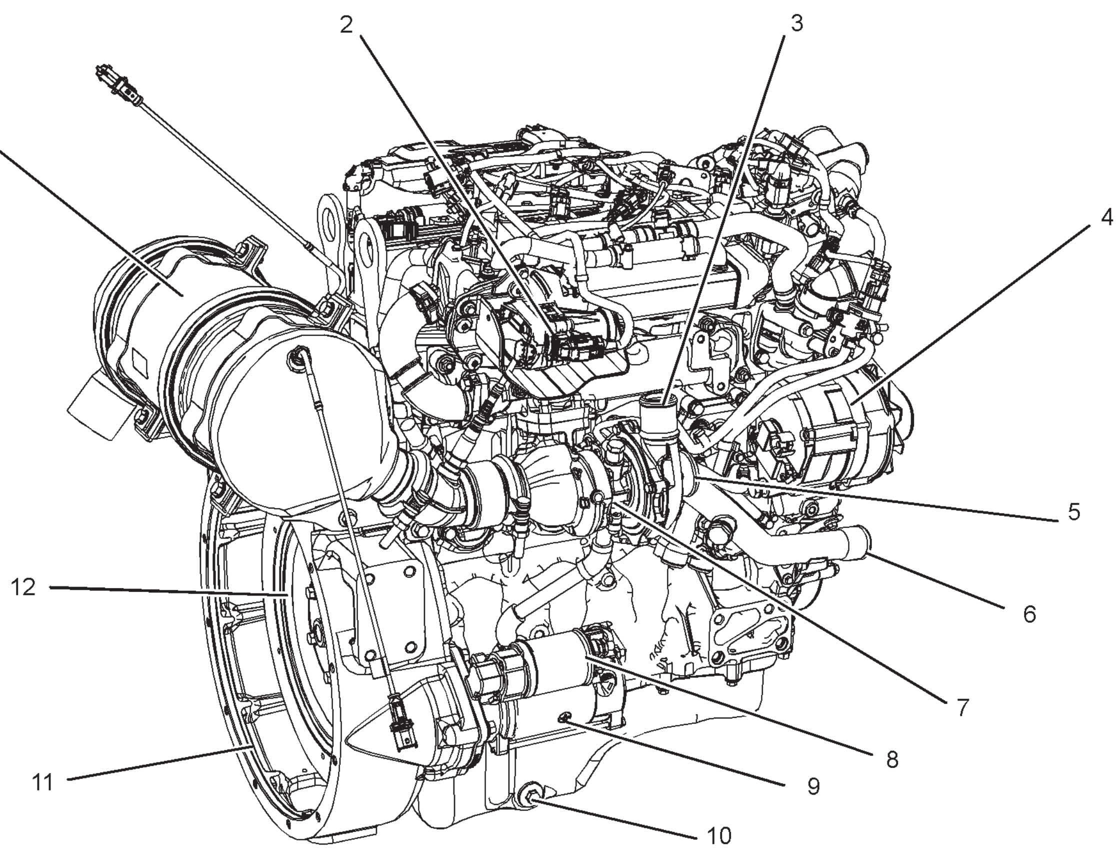

Illustration 14 g03367500

Typical example

(1) Engine aftertreatment system
(2) NOx control valve
(3) Air outlet connection from turbocharger
(4) Alternator
(5) Air intake from air filter
(6) Coolant intake connection
(7) Turbocharger
(8) Solenoid for stating motor
(9) Starting motor
(10) Oil drain plug
(11) Flywheel housing
(12) Flywheel

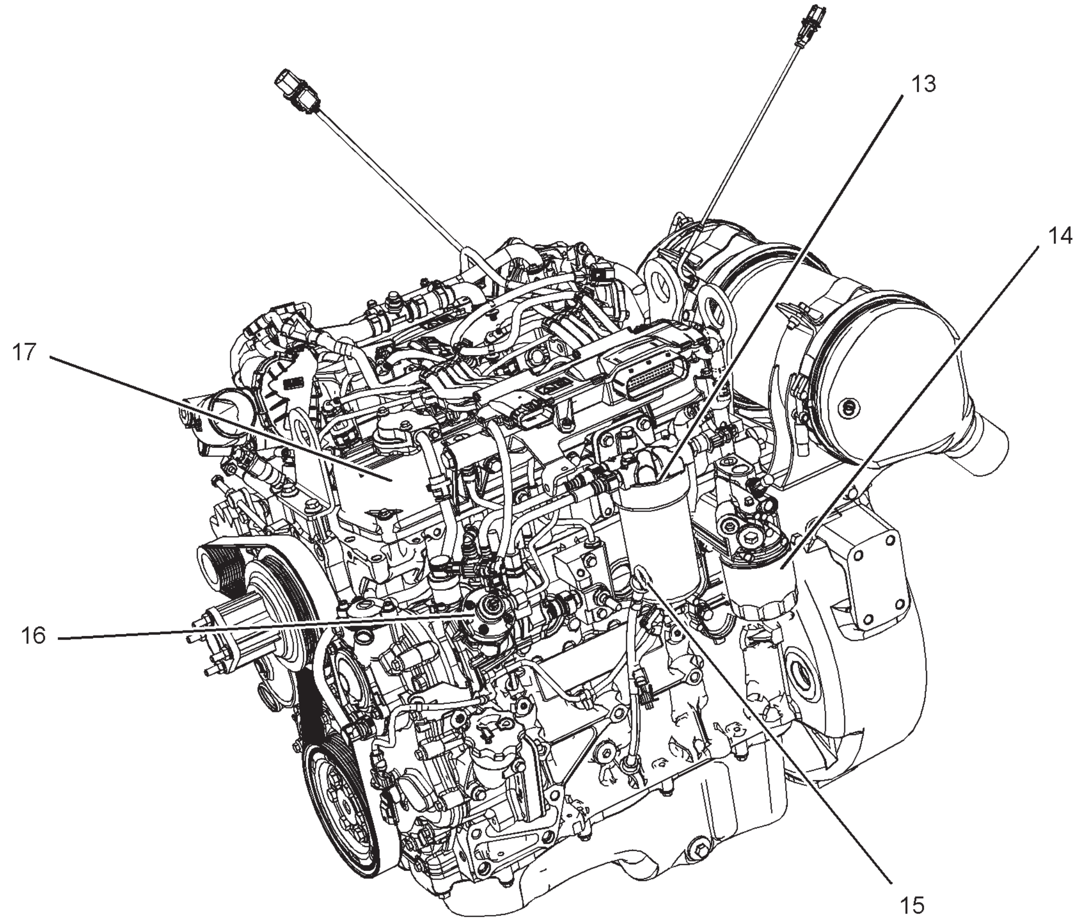

Illustration 15 g03367502

Typical example

(13) Secondary fuel filter
(14) Oil filter
(15) Oil level gauge (Dipstick)
(16) High-pressure fuel pump
(17) Valve mechanism cover

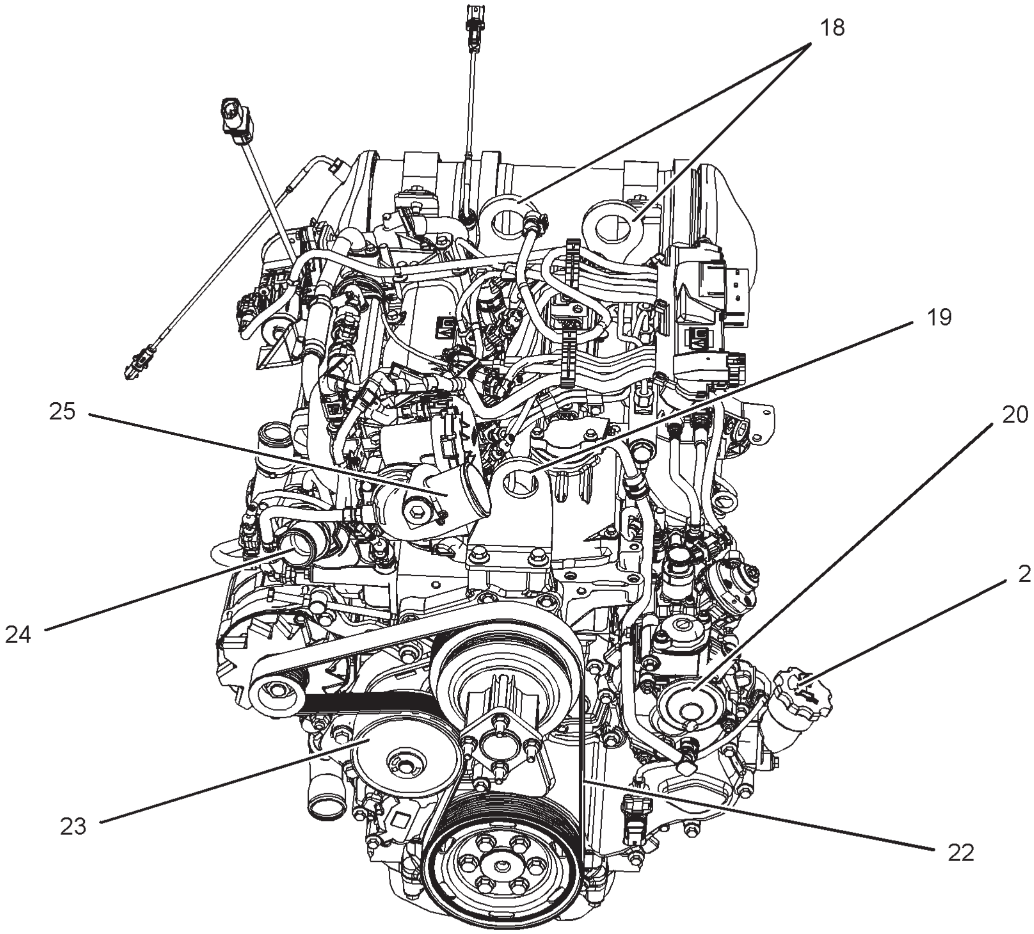

Illustration 16 g03367547

(18) Rear lifting eyes
(19) Front lifting eye
(20) Crankcase breather
(21) Oil filler cap
(22) Belt
(23) Coolant pump
(24) Coolant outlet connection
(25) Air inlet connection

The oil filler cap (21) can be located on the valve mechanism cover.

Off Engine Parts

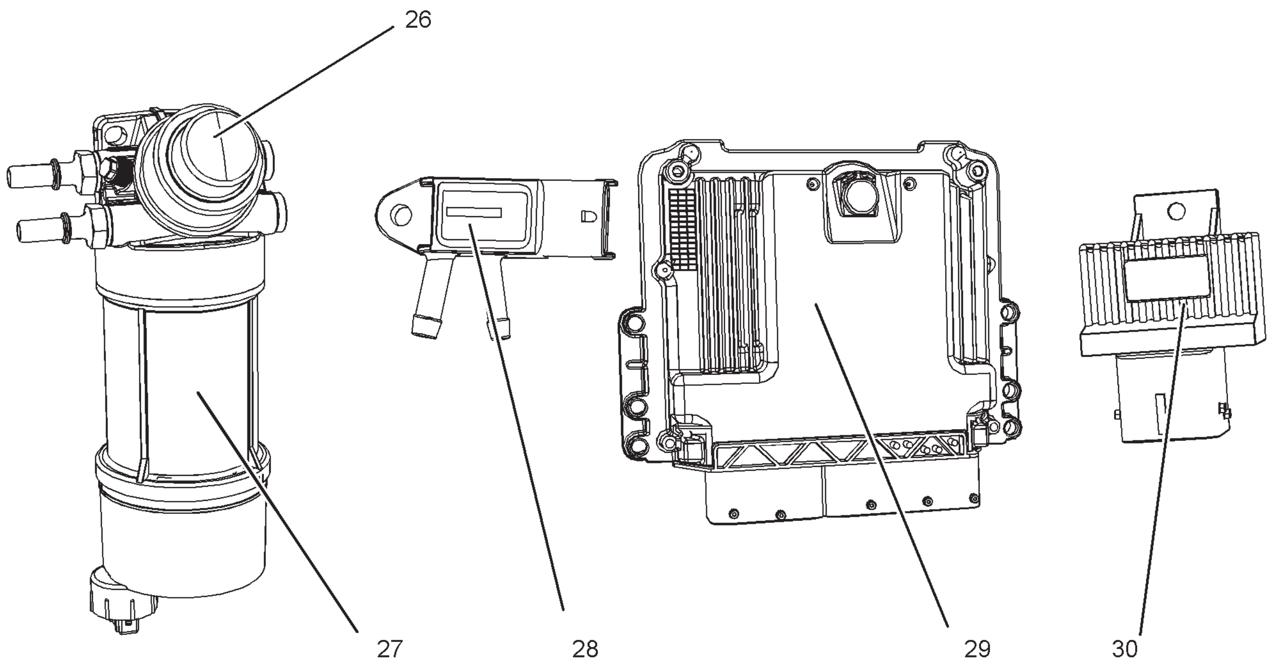

Illustration 17 g03367521

(26) Fuel priming pump
(27) Primary fuel filter
(28) Differential pressure sensor
(29) Electronic control module
(30) Relay for glow plugs

Engine View with Wall Flow Diesel Particulate Filter

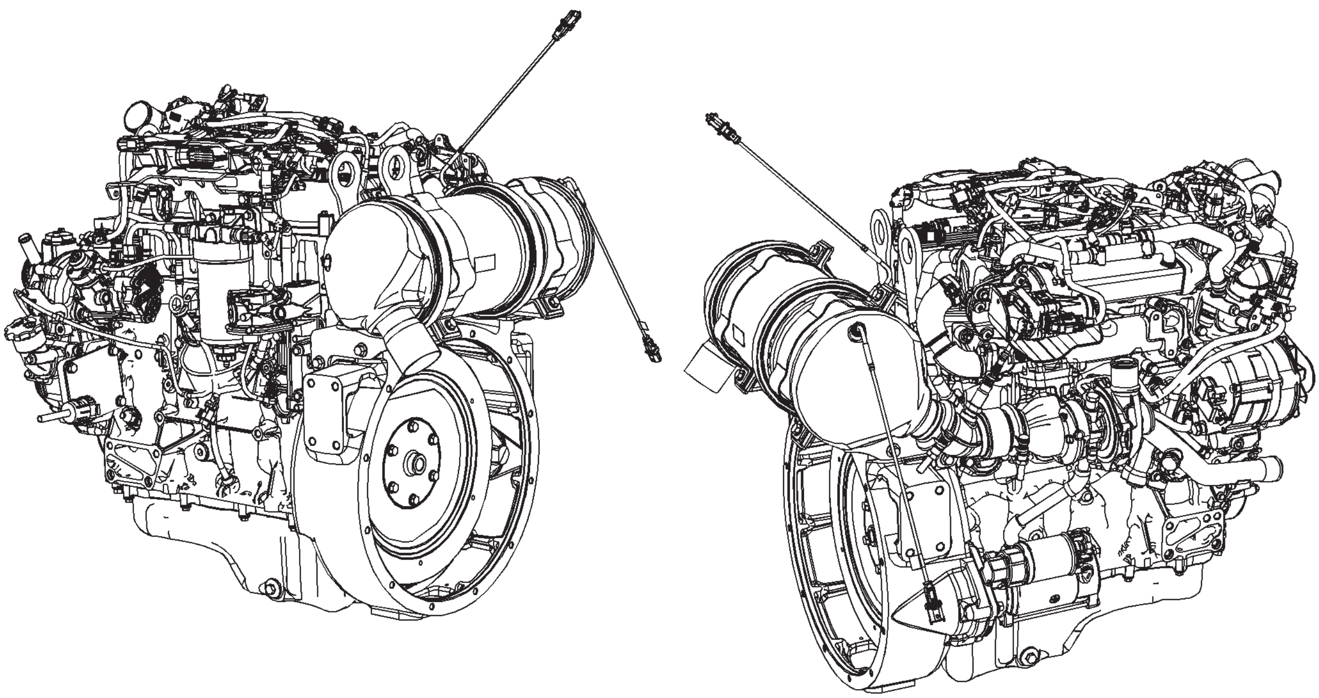

Illustration 18 g03367096

Typical example

The wall flow Diesel Particulate Filter (DPF) will require a service, refer to this Operation and Maintenance Manual, “Maintenance Interval Schedule” for the service period.

Engine View with Through Flow Diesel Particulate Filter

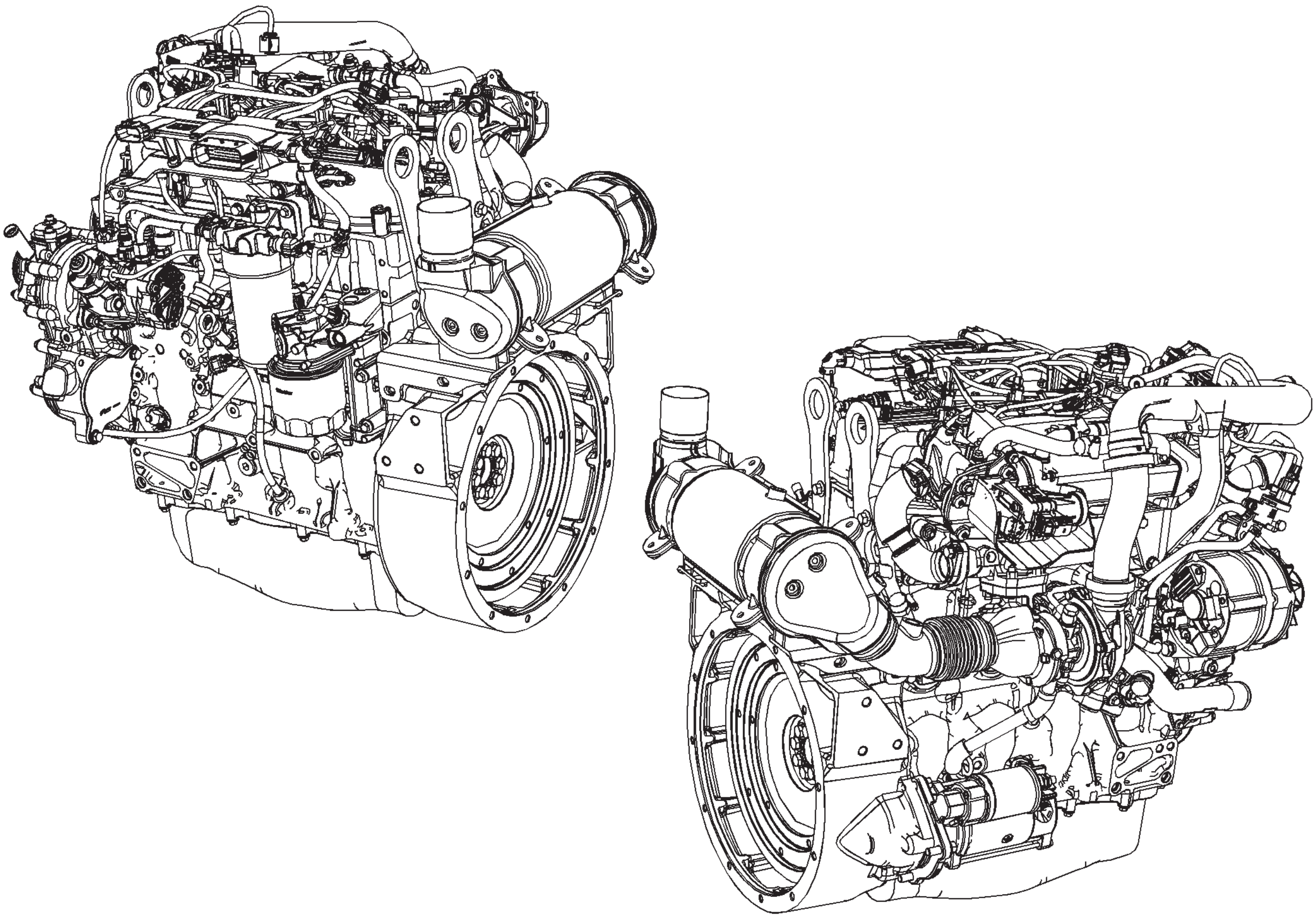

Illustration 19 g03367094

Typical example

The through-flow type of DPF will not require a service interval.

i05326347

Product Description

The Perkins 854F-E34T and the 854E-E34TA industrial engines has the following characteristics.

- In-line 4 cylinder
- Two valves in each cylinder
- Four stroke cycle
- Turbocharged
- Turbocharged charge cooled
- Wall Flow Diesel Particulate Filter or Through-Flow Diesel Particulate Filter

Engine Specifications

Note: The front end of the engine is opposite the flywheel end of the engine. The left and the right sides of the engine are determined from the flywheel end. The number 1 cylinder is the front cylinder.

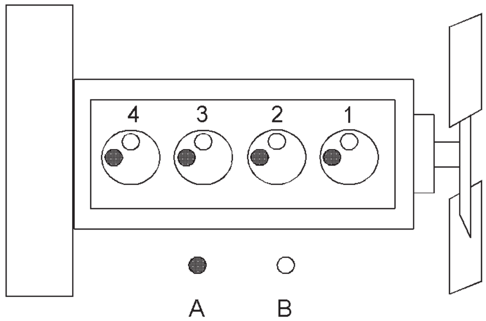

Illustration 20 g02317934

Cylinder and valve location

(A) Exhaust valves
(B) Inlet valves

Table 1

854F-E34T and 854E-E34TA Engine Specifications	
Operating Range (rpm)	800 to 2500(1)
Number of Cylinders	4 In-Line
Bore	99 mm (3.89763 inch)
Stroke	110 mm (4.33070 inch)
Power	854F 45 to 55.4 kW (60.345 to 74.3 hp) 854E 62 to 86 kW (83.142 to 115.326 hp)
Aspiration	854F Turbocharged 854E Turbocharged charge cooled
Compression Ratio	17: 1
Displacement	3.4 L (207.48 cubic inch)
Firing Order	1-3-4-2
Rotation (flywheel end)	Counterclockwise

(1) The operating rpm is dependent on the engine rating, the application, and the configuration of the throttle.

Engine Type and Aftertreatment Type

There are three different engine types and two different types of aftertreatment. The 854E-E34TA is turbocharged, charge cooled engine, with a wall flow Diesel Particulate Filter (DPF). The letters JR will be on the identification plate.

The 854F-E34T is divided into two different engine types. The engine with JS on the identification plate will have a wall flow DPF. The engine with the letters JT on the identification plate will have a through-flow DPF.

The through-flow DPF will not require a service period.

Electronic Engine Features

The engine operating conditions are monitored. The Electronic Control Module (ECM) controls the response of the engine to these conditions and to the demands of the operator. These conditions and operator demands determine the precise control of fuel injection by the ECM. The electronic engine control system provides the following features:

- Engine monitoring
- Engine speed governing
- Control of the injection pressure
- Cold start strategy
- Automatic air/fuel ratio control
- Torque rise shaping
- Injection timing control
- System diagnostics
- Aftertreatment Regeneration

For more information on electronic engine features, refer to the Operation and Maintenance Manual, “Features and Controls” topic (Operation Section).

Engine Diagnostics

The engine has built-in diagnostics in order to ensure that the engine systems are functioning correctly. The operator will be alerted to the condition by a “Stop or Warning” lamp. Under certain conditions, the engine horsepower and the vehicle speed may be limited. The electronic service tool may be used to display the diagnostic codes.

There are three types of diagnostic codes: active, logged and event.

Most of the diagnostic codes are logged and stored in the ECM. For additional information, refer to the Operation and Maintenance Manual, “Engine Diagnostics” topic (Operation Section).

The ECM provides an electronic governor that controls the injector output in order to maintain the desired engine rpm.

Engine Cooling and Lubrication

The cooling system and lubrication system consists of the following components:

- Belt driven centrifugal water pump
- Water temperature regulator which regulates the engine coolant temperature
- Gear-driven rotor type oil pump
- Multi plate oil cooler

The engine lubricating oil is cooled and the engine lubricating oil is filtered.

Engine Service Life

Engine efficiency and maximum utilization of engine performance depend on the adherence to proper operation and maintenance recommendations. In addition, use recommended fuels, coolants, and lubricants. Use the Operation and Maintenance Manual as a guide for required engine maintenance.

Aftermarket Products and Perkins Engines

Perkins does not warrant the quality or performance of non-Perkins fluids and filters.

When auxiliary devices, accessories, or consumables (filters, additives, catalysts,) which are made by other manufacturers are used on Perkins products, the Perkins warranty is not affected simply because of such use.

However, failures that result from the installation or use of other manufacturers devices, accessories, or consumables are NOT Perkins defects. Therefore, the defects are NOT covered under the Perkins warranty.

Aftertreatment System

The aftertreatment system is approved for use by Perkins . In order to be emission-compliant only the approved Perkins aftertreatment system must be used on a Perkins engine.

Product Identification Information

i04725109

Plate Locations and Film Locations
(Engine)

Perkins engines are identified by an engine serial number.

An example of an engine number is JR*****L000001V.

*****________________The list number for the engine

JR__________________________The type of engine

L_______________________________Built in the Italy

000001____________________Engine Serial Number

V__________________________Year of Manufacture

Perkins dealers or Perkins distributors need all of these numbers in order to determine the components that were included with the engine. This information permits accurate identification of replacement part numbers.

The numbers for fuel setting information for electronic engines are stored within the flash file. These numbers can be read by using the electronic service tool.

Serial Number location

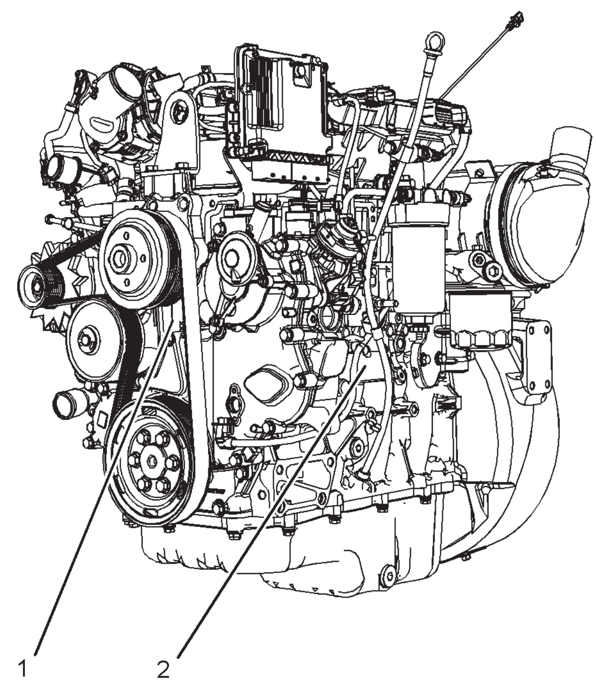

Illustration 21 g02474416

Typical example of a non-stressed cylinder block

The engine serial number can be installed in three different positions.

All engines will have the serial number install in location (1) on the front face of the engine.

On a non-stressed cylinder block the serial number is located in position (2). On the left-hand side on the cylinder block.

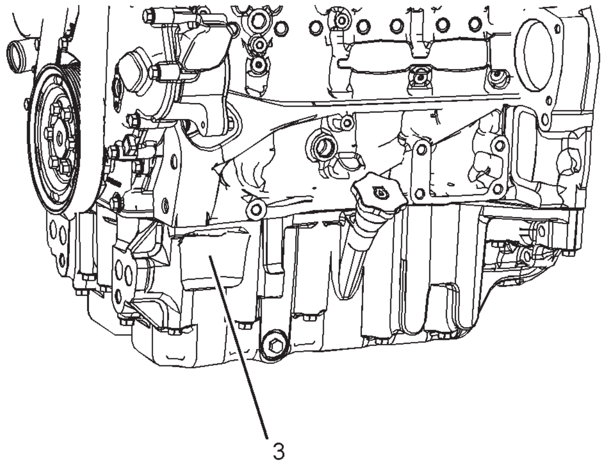

Illustration 22 g02826736

Typical example

On a stressed cylinder block the serial number is located in position (3).

The engine serial number is stamped on the emissions plate.

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Plate Locations and Film Locations
(Aftertreatment)

Wall Flow Diesel Particulate Filter (DPF)

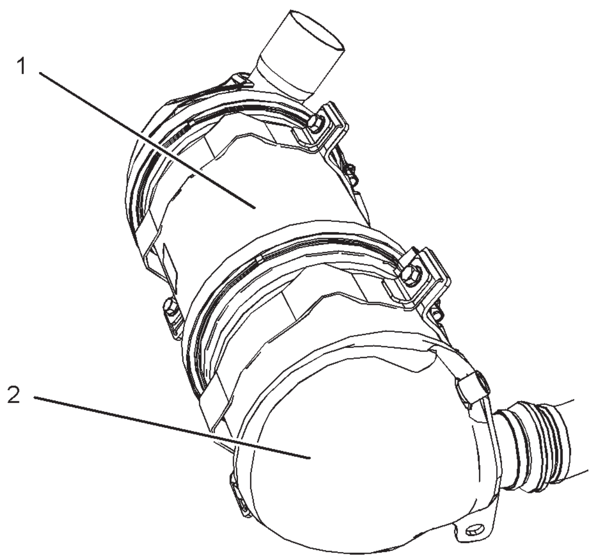

Illustration 23 g02475495

Typical example

The serial number for identifying the aftertreatment will be in two locations. On the DPF in position (1) and in position (2). On the end cover of the inlet to the DPF.

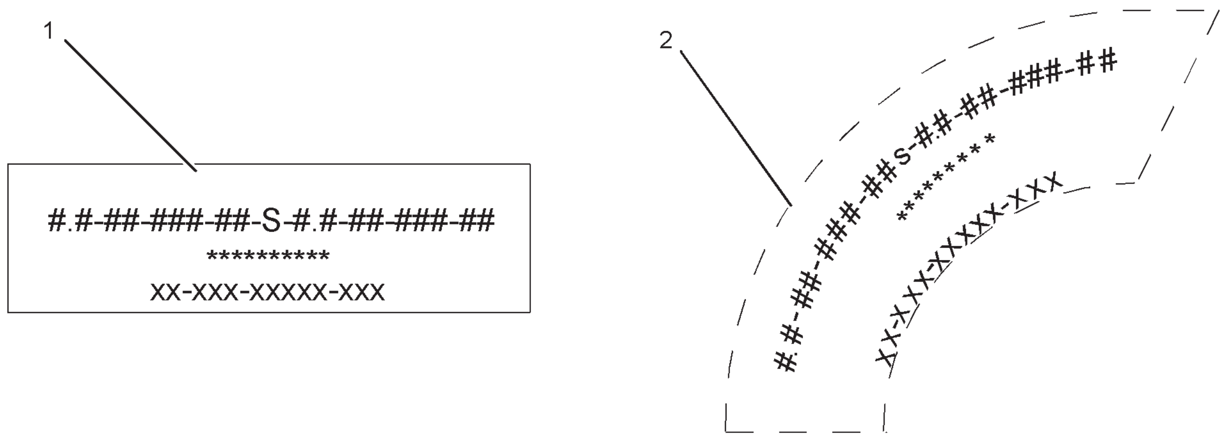

Illustration 24 g02723697

(1) Serial numbers on main body

(2) Serial numbers on inlet end cover

Ensure that all numbers on the aftertreatment are recorded.

Your Perkins distributor or your dealer will require all the numbers in order to identify the components for your aftertreatment.

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Plate Locations and Film Locations
(Aftertreatment)

Through-Flow Diesel Particulate Filter (DPF)

A serial number label for identifying the through-flow DPF will be located on the main body of the DPF.

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Emissions Certification Film

The emission label will be installed on the left side of the non-stressed cylinder block.

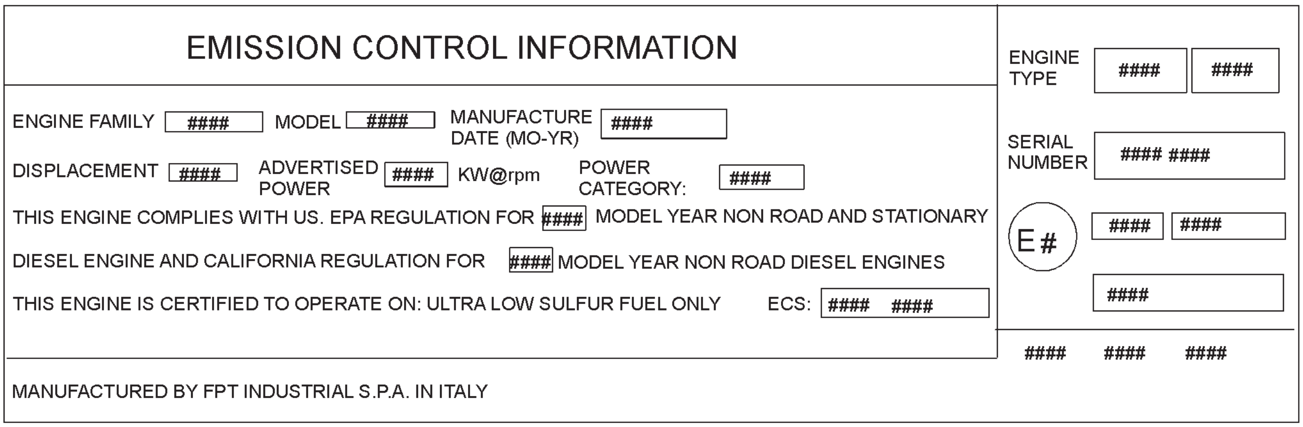

Illustration 25 g02646428

Typical example

i05324886

Reference Information

Information for the following items may be needed to order parts. Locate the information for your engine. Record the information in the appropriate space. Make a copy of this list for a record. Keep the information for future reference.

Record for Reference

Engine Model____________________

Engine Serial Number____________________

Engine Low Idle Revolutions Per Minute (RPM)____________________

Engine Full Load RPM ____________________

Primary Fuel Filter____________________

Secondary Fuel Filter Element____________________

Lubrication Oil Filter Element____________________

Auxiliary Oil Filter Element____________________

Total Lubrication System Capacity____________________

Total Cooling System Capacity____________________

Air Cleaner Element____________________

Drive Belt____________________

Engine Aftertreatment System

Part Number____________________

Serial Number____________________

Operation Section

Lifting and Storage

i04315227

Product Lifting

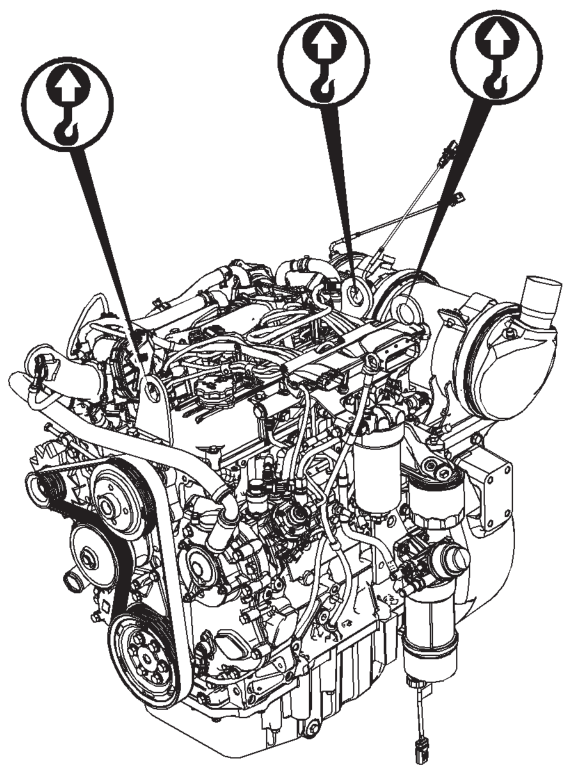

Illustration 26 g02475658

Typical example

NOTICE
Never bend the eyebolts and the brackets. Only load the eyebolts and the brackets under tension. Remember that the capacity of an eyebolt is less as the angle between the supporting members and the object becomes less than 90 degrees.

When it is necessary to remove a component at an angle, only use a link bracket that is properly rated for the weight.

Use a hoist to remove heavy components. Use an adjustable lifting beam to lift the engine. All supporting members (chains and cables) should be parallel to each other. The chains and cables should be perpendicular to the top of the object that is being lifted.

Some removals require lifting the fixtures in order to obtain correct balance and safety.

To remove the engine ONLY, use the lifting eyes that are on the engine.

Lifting eyes are designed and installed for specific engine arrangements. Alterations to the lifting eyes and/or the engine make the lifting eyes and the lifting fixtures obsolete. If alterations are made, ensure that correct lifting devices are provided. Consult your Perkins dealer or your Perkins distributor for information regarding fixtures for correct engine lifting.

Note: The engine is equipped with three lifting eyes. All the lifting eyes must be used in order to lift the engine.

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Product Storage
(Engine and Aftertreatment)

Perkins are not responsible for damage which may occur when an engine is in storage after a period in service.

Your Perkins dealer or your Perkins distributor can assist in preparing the engine for extended storage periods.

Condition for Storage

The engine must be stored in a water proof building. The building must be kept at a constant temperature. Engines that are filled with Perkins ELC will have coolant protection to an ambient temperature of −36° C (−32.8° F). The engine must not be subjected to extreme variations in temperature and humidity.

Storage Period

An engine can be stored for up to 6 months provided all the recommendation are adhered to.

Storage Procedure

Keep a record of the procedure that has been completed on the engine.

Note: Do not store an engine that has biodiesel in the fuel system.

1. Ensure that the engine is clean and dry.

a. If the engine has been operated using biodiesel, the system must be drained and new filters installed. The fuel tank will require flushing.

b. Fill the fuel system with an ultra low sulfur fuel. For more information on acceptable fuels refer to this Operation and Maintenance Manual, “Fluid recommendations”. Operate the engine for 15 minutes in order to remove all biodiesel from the system.

2. Drain any water from the primary filter water separator. Ensure that the fuel tank is full.

3. The engine oil will not need to be drained in order to store the engine. Provided the correct specification of engine oil is used the engine can be stored for up to 6 months. For the correct specification of engine oil refer to this Operation and Maintenance Manual, “Fluid recommendations”.

4. Remove the drive belt from the engine.

Sealed Coolant System

Ensure that the cooling system is filled with Perkins ELC, or an antifreeze that meets ASTM D6210 specification.

Open Cooling System

Ensure that all cooling drain plugs have been opened. Allow the coolant to drain. Install the drain plugs. Place a vapor phase inhibitor into the system. The coolant system must be sealed once the vapor phase inhibitor has been introduced. The effect of the vapor phase inhibitor will be lost if the cooling system is open to the atmosphere.

For maintenance procedures ref to this Operation and Maintenance Manual.

Aftertreatment

No special procedures are required. The exhaust outlet of the aftertreatment should be capped. Before storing, the engine and the aftertreatment must be enclosed in a cover.

Monthly Checks

The crankshaft must be rotated in order to change the spring loading on the valve train. Rotate the crankshaft more than 180 degrees. Visibly check for damage or corrosion to the engine and aftertreatment.

Ensure that the engine and aftertreatment are covered completely before storage. Log the procedure in the record for the engine.

Features and Controls

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Alarms and Shutoffs

The alarm is a warning to the operator that an abnormal operating condition has occurred. The shutoffs are set in order to protect the engine from damage. A shutoff can be triggered by pressure, temperature, engine speed, and electronic fault.

The operator should become familiar with the warning lamps and shutdown lamps on the installed control panel before operating the application. For more information refer to this Operation and Maintenance Manual, “Monitoring System (Table for the Indicator lamps)”.

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Gauges and Indicators

Your engine may not have the same gauges or all of the gauges that are described. For more information about the gauge package, see the OEM information.

Gauges provide indications of engine performance. Ensure that the gauges are in good working order. Determine the normal operating range by observing the gauges over a period.

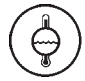
Noticeable changes in gauge readings indicate potential gauge or engine problems. Problems may also be indicated by gauge readings that change even if the readings are within specifications. Determine and correct the cause of any significant change in the readings. Consult your Perkins distributor for assistance.

Some engine applications are equipped with Indicator Lamps. Indicator lamps can be used as a diagnostic aid. There are two lamps. One lamp has an orange lens and the other lamp has a red lens.

These indicator lamps can be used in two ways:

- The indicator lamps can be used to identify the current operational status of the engine. The indicator lamps can also indicate that the engine has a fault. This system is automatically operated via the ignition switch.
- The indicator lamps can be used to identify active diagnostic codes. This system is activated by pressing the Flash Code button.

Refer to the Troubleshooting Guide, “Indicator Lamps” for further information.



Jacket Water Coolant Temperature – Typical temperature range is 79° to 94°C (174° to 201 °F). This temperature range will vary according to engine load and the ambient temperature.

A 100 kPa (14.5 psi) radiator cap must be installed on the cooling system. The maximum temperature for the cooling system will depend on engine power. For engines that are 75kW and lower the maximin cooling temperature is 110° C (230° F). For engines that are above 75kW the maximin temperature is 108° C (226.4° F). The engine coolant temperature is regulated by the engine sensors and the engine ECM. This programming cannot be altered. An engine derate can occur if the maximum engine coolant temperature is exceeded.

If the engine is operating above the normal range, reduce the engine load. If high coolant temperatures are a frequent event, perform the following procedures:

1. Reduce the load and the engine rpm.

2. Determine if the engine must be shut down immediately or if the engine can be cooled by reducing the load.

3. Inspect the cooling system for leaks. If necessary, consult your Perkins distributor for assistance.

Tachometer – This gauge indicates engine speed (rpm). When the throttle control lever is moved to the full throttle position without load, the engine is running at high idle. The engine is running at the full load rpm when the throttle control lever is at the full throttle position with maximum rated load.

NOTICE

To help prevent engine damage, never exceed the high idle rpm. Overspeeding can result in serious damage to the engine. Operation at speeds exceeding high idle rpm should be kept to a minimum.

Ammeter – This gauge indicates the amount of charge or discharge in the battery charging circuit. Operation of the indicator should be to the “+” side of “0” (zero).

Fuel Level – This gauge indicates the fuel level in the fuel tank. The fuel level gauge operates when the “START/ STOP” switch is in the “on” position.

Service Hour Meter – The gauge indicates total operating hours of the engine.

Indicator Lamps

- Shutdown lamp
- Warning lamp
- Wait to start lamp
- Low oil pressure lamp (On solid) and engine oil reset lamp (Flashing)

For information, refer to this manual, “Monitoring System (Table for the Indicator Lamps)” for the sequence of operation of the shutdown lamp and the warning lamp.

The function of the wait to start lamp is automatically controlled at engine start-up.

The low oil pressure lamp has two functions.

- The low oil pressure lamp is controlled by the engine ECM. If low oil pressure is detected, the lamp will be illuminated on solid. The reason for the illumination of the low-pressure lamp should be investigated immediately.
- Low oil pressure lamp flashing, an engine oil change is required. The lamp must be reset, refer to this Operation and Maintenance Manual, “Engine Oil and Filter - Change” for more information.

All lamps will illuminate for 2 seconds in order to check that the lamps are functioning when the keyswitch is turned to the ON position. If any of the lamps stay illuminated, the reason for illumination should be investigated immediately.

Aftertreatment Lamps

For information on the aftertreatment lamp, refer to this Operation and Maintenance Manual, “Diesel Particulate Filter Regeneration”.

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Monitoring System
(Table for the Indicator lamps)

When in operation the amber warning indicator has three states, on solid, flashing and fast flashing. The sequence is to give a visual indication of the importance of the warning. Some application can have an audible warning installed.

Table 2

Warning Indicator	Shutdown Indicator	Lamp State	Description of the Indication	Engine Status	Operator Action
On	On	Indicator Check	When the keyswitch is moved to the ON position, the lamps will illuminate for 2 seconds and the lamps will then go off. **During indicator check, the after-treatment indicators will also be checked.**	The keyswitch is in the ON position but the engine has not yet been cranked.	If any of the indicators will not illuminate during indicator check, the fault must be investigated immediately. If any Indicators stay illuminated or flash, the fault must be investigated immediately.
Off	Off	No Faults	With the engine in operation, there are no active warnings, diagnostic codes, or event codes.	The engine is operating with no detected faults.	None
Level 1					
On Solid	Off	Warning	Level 1 warning	The engine is operating normally but there is one or more faults with the electronic management system for the engine.	As soon as possible the fault should be investigated.
Level 2					
Flashing	Off	Warning	Level 2 warning	The engine continues to be operated, but there are active diagnostic, or event codes active. Derate to engine power may be applied.	Stop the engine. Investigate the code.
Level 3					
Flashing	On solid	Warning	Level 3 warning If both the warning lamp and the shutdown lamp are in operation, this issue indicates one of the following conditions. 1. One or more of the shutdown values for the engine protection strategy has been exceeded. 2. A serious active diagnostic code has been detected. 3. After a short time period, the engine may shut down.	The engine continues to be operated, but the level of importance of the warning has increased. The engine will automatically shut down. If shut down is not enabled, the engine could be damaged if continued to be operated.	Stop the engine immediately. Investigate the fault

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Monitoring System

WARNING

If the Shutdown mode has been selected and the warning indicator activates, engine shutdown may take as little as 20 seconds from the time the warning indicator is activated. Depending on the application, special precautions should be taken to avoid personal injury. The engine can be restarted following shutdown for emergency maneuvers, if necessary.

NOTICE

The Engine Monitoring System is not a guarantee against catastrophic failures. Programmed delays and derate schedules are designed to minimize false alarms and provide time for the operator to stop the engine.

The following parameters are monitored:

- Coolant temperature
- Intake manifold air temperature
- Intake manifold air pressure
- Oil pressure
- Pressure in the fuel rail
- Engine speed/timing
- Fuel temperature
- Atmospheric pressure (Barometric pressure)
- Water in fuel switch
- Inlet temperature of the diesel oxidation catalyst
- Inlet temperature of the diesel particulate filter
- Differential pressure in the diesel particulate filter
- The amount of soot in the diesel particulate filter

Programmable Options and Systems Operation

WARNING

If the Warning/Derate/Shutdown mode has been selected and the warning indicator activates, bring the engine to a stop whenever possible. Depending on the application, special precautions should be taken to avoid personal injury.

The engine can be programmed to the following modes:

"Warning"

The orange "Warning" lamp will turn "ON" and the warning signal is activated continuously in order to alert the operator that one or more of the engine parameters is not within normal operating range.

"Derate"

The orange "Warning" lamp will turn "ON" and the red shutdown lamp will be flashing. After the warning, the engine power will be derated. The warning lamp will begin to flash when the derating occurs.

The engine will be derated if the engine exceeds preset operational limits. The engine derate is achieved by restricting the amount of fuel that is available for each injection. The amount of this reduction of fuel is dependent on the severity of the fault that has caused the engine derate, typically up to a limit of 50%. This reduction in fuel results in a predetermined reduction in engine power.

"Shutdown"

The orange warning will turn "ON" and the red shutdown lamp will also turn "ON" . After the warning, the engine power will be derated. The engine will continue at the rpm of the set derate until a shutdown of the engine occurs. The engine can be restarted after a shutdown for use in an emergency.

A shutdown of the engine may occur in as little as 20 seconds. The engine can be restarted after a shutdown for use in an emergency. However, the cause of the initial shutdown may still exist. The engine may shut down again in as little as 20 seconds.

If there is a signal for high coolant temperature, there will be a 2 second delay in order to verify the condition.

If there is a signal for low oil pressure, there will be a 2 second delay in order to verify the condition.

For information on the operation of the warning lamps and the shutdown lamp, refer to this Operation and Maintenance Manual, “Monitoring System (Table for Indicator Lamps)”. For each of the programmed modes, refer to Troubleshooting Guide, “Indicator Lamps” for more information on Indicator Lamps.

For more information or assistance for repairs, consult your Perkins distributor or your Perkins dealer.

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Overspeed

- ECM ________________ Electronic Control Module
- RPM _________________ Revolutions Per Minute

An overspeed is detected by the speed/timing sensors.

The default overspeed is set at 2800. The ECM will cut the power to the electronic unit injectors, until the rpm drops below the overspeed setting. A diagnostic fault code will be logged into the ECM memory and a warning lamp will indicate a diagnostic fault code. Some application may have a display panel in order to alert the operator.

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Sensors and Electrical Components

Full Engine Views

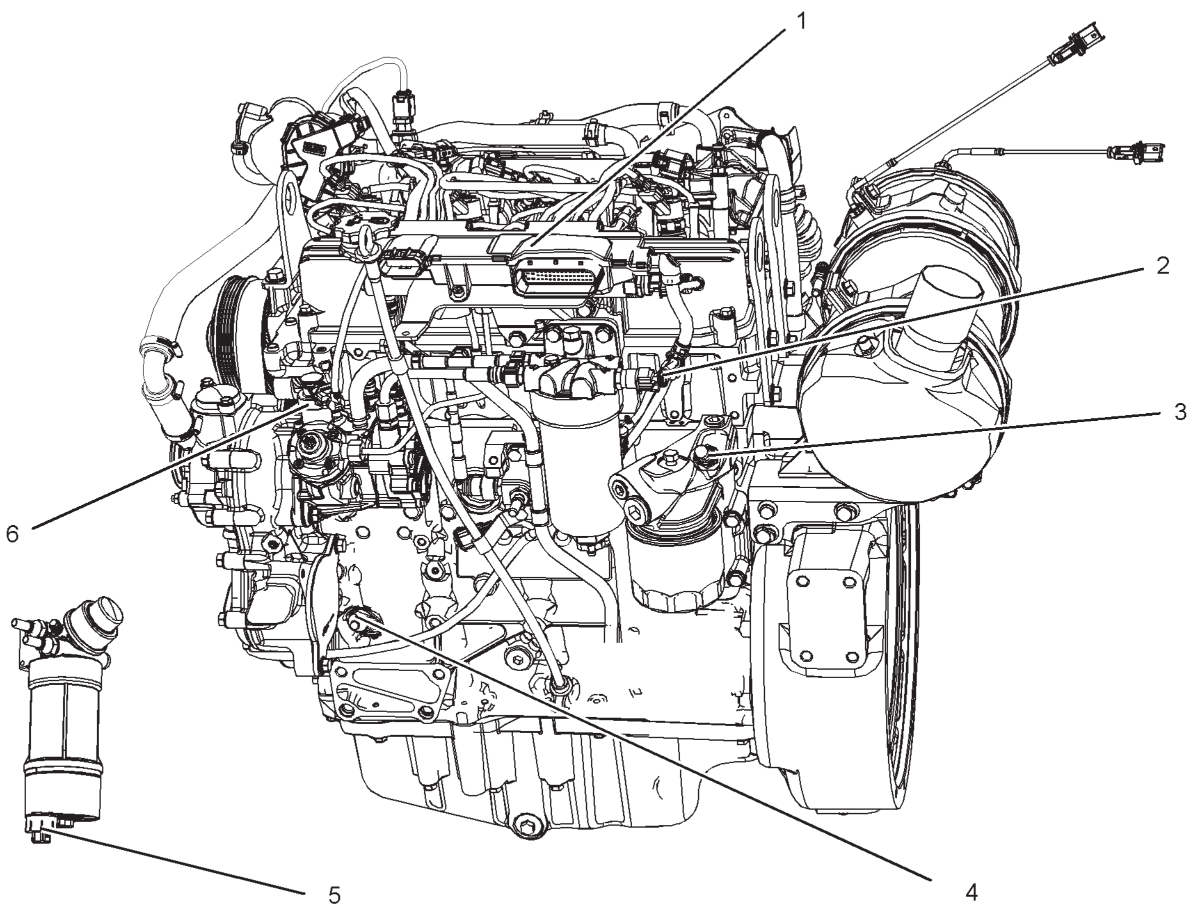

Illustration 27 g03373765

Typical example

(1) 10 Pin and 62 pin connector
(2) Fuel temperature sensor
(3) Oil pressure switch
(4) Primary speed/timing sensor (crankshaft position sensor)
(5) Water in fuel switch
(6) Fuel metering valve

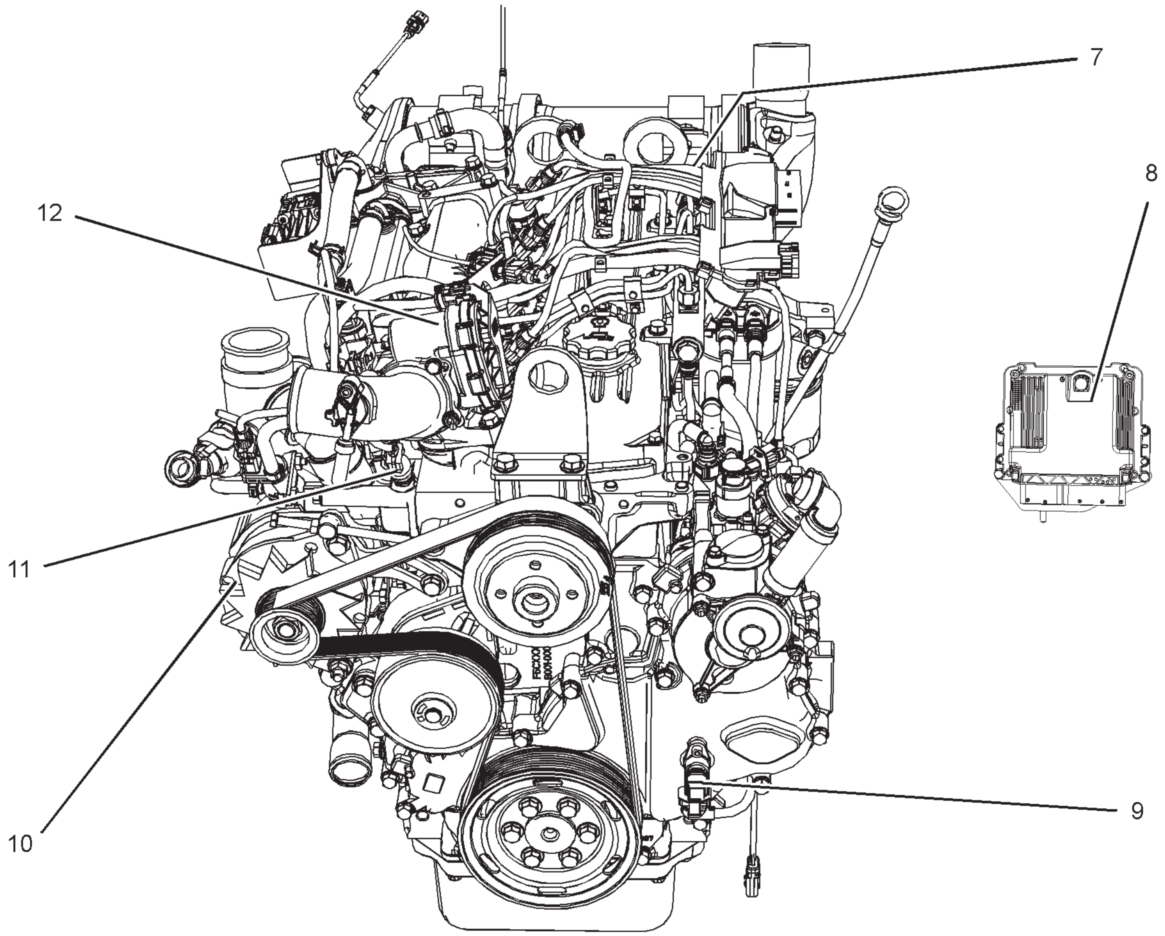

Illustration 28 g02477200

Typical example

(7) Fuel manifold (rail) pressure sensor
(8) Electronic control module
(9) Secondary speed/timing sensor (camshaft position sensor)
(10) Alternator
(11) Coolant temperature sensor
(12) Intake throttle valve

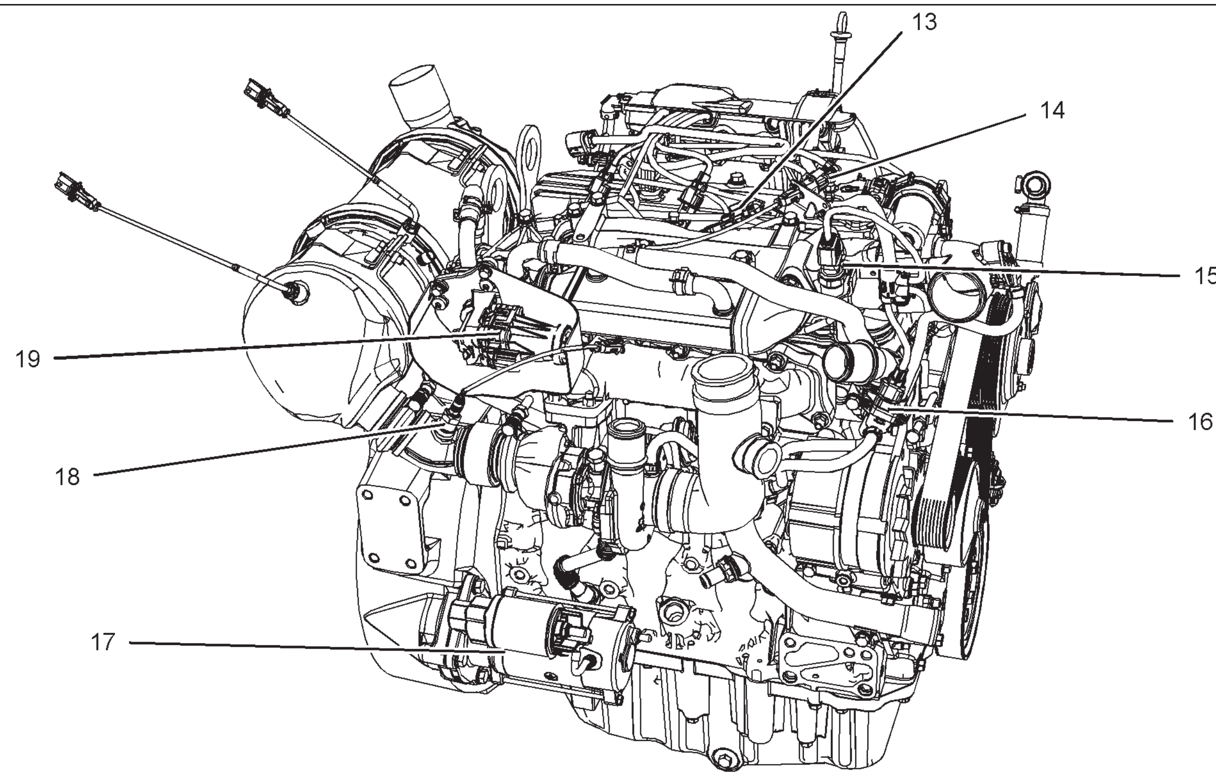

Illustration 29 g02529496

Typical example

(13) Inlet manifold pressure and temperature sensor.
(14) Exhaust temperature sensor connection
(15) Exhaust pressure sensor
(16) Waste gate regulator
(17) Starting motor
(18) Oxygen sensor
(19) Control valve for the NOx reduction system

Note: Item (13), lower powered engines have separate inlet manifold pressure sensors and inlet manifold temperature sensors.

Engine View Low Power with Separate Inlet Pressure and Inlet Temperature

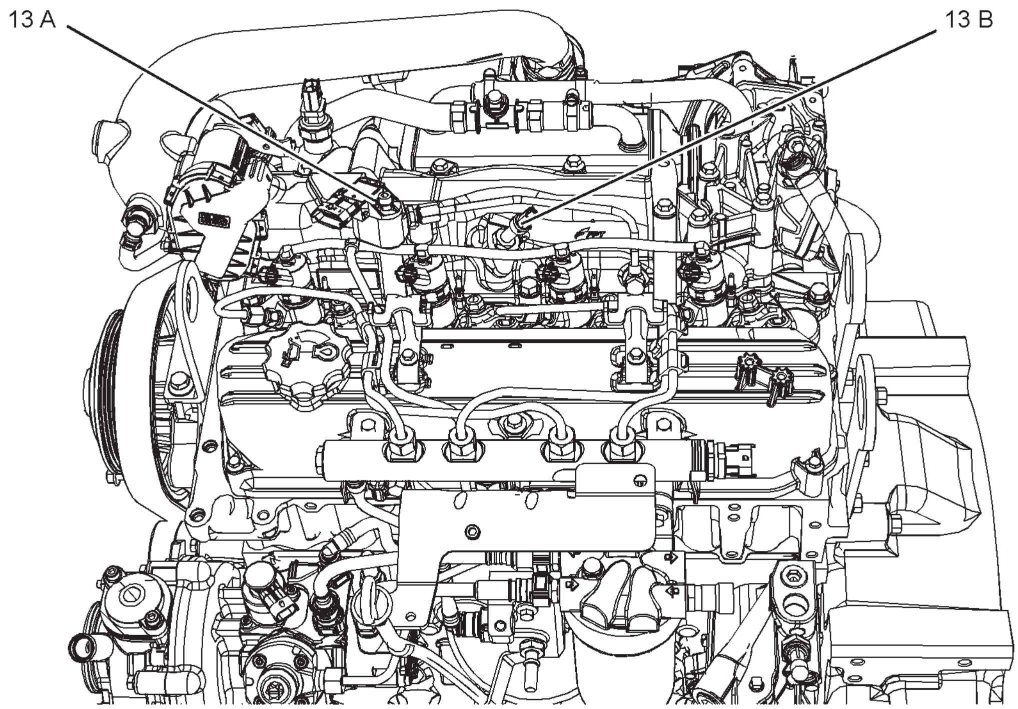

Illustration 30 g03373789

Typical example

(13 A) Inlet pressure sensor

(13 B) Inlet temperature sensor

Location Views

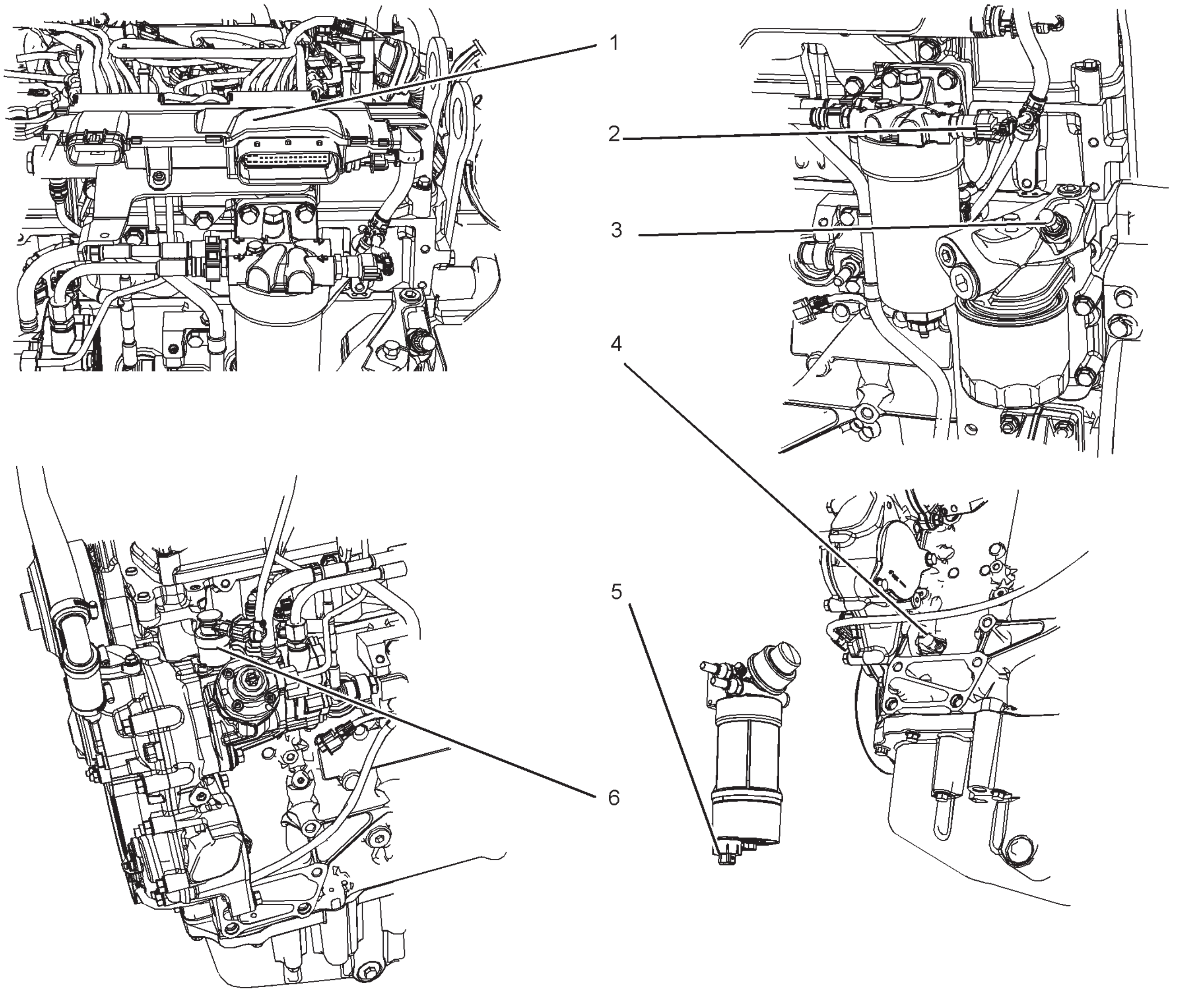

Illustration 31 g03373767

Typical example

(1) 10 Pin and 62 pin connector
(2) Fuel temperature sensor
(3) Oil pressure switch
(4) Primary speed/timing sensor (crankshaft position sensor)
(5) Water in fuel switch
(6) Fuel metering valve

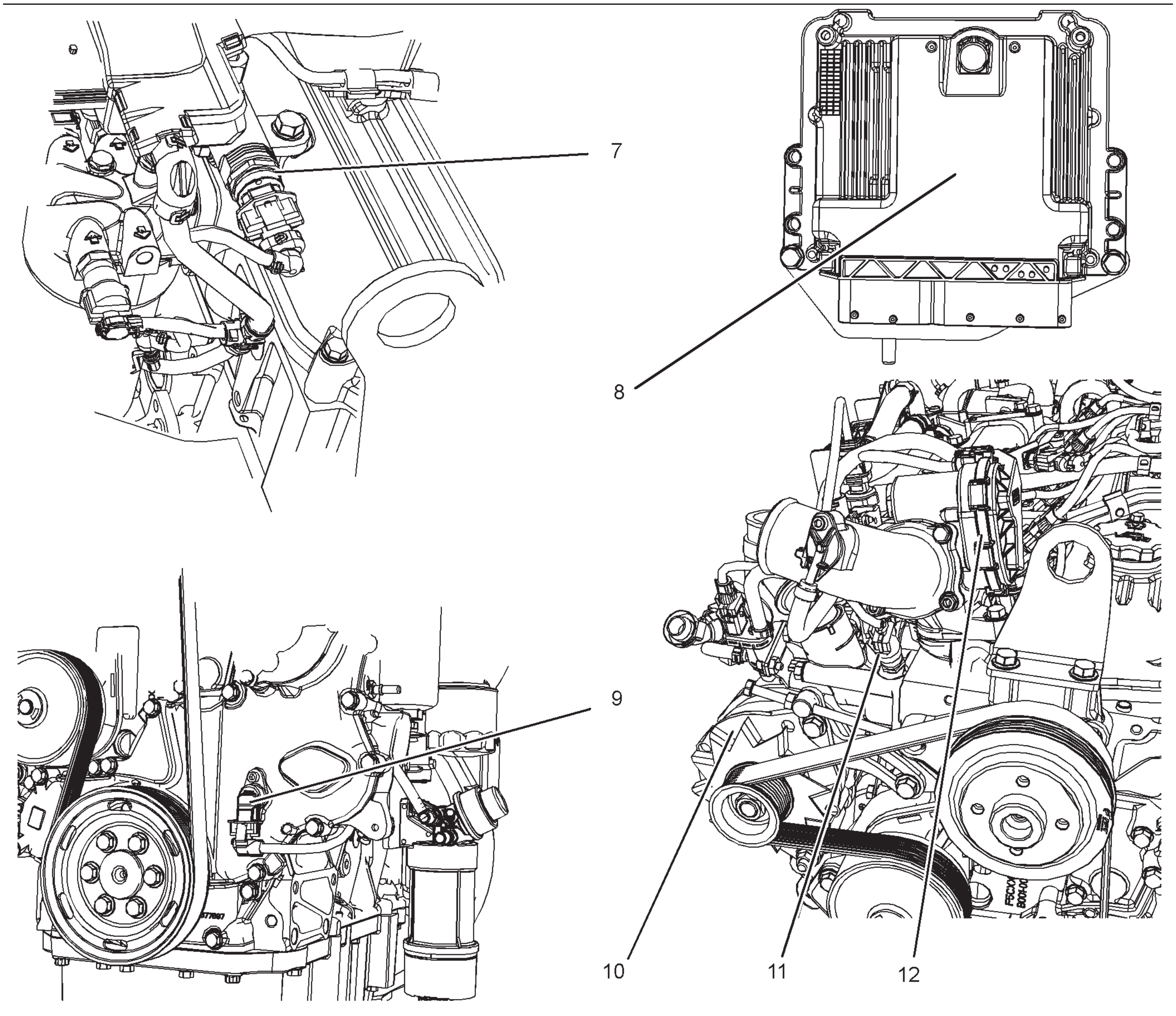

Illustration 32 g02529820

Typical example

(7) Fuel manifold (rail) pressure sensor
(8) Electronic control module
(9) Secondary speed/timing sensor (camshaft position sensor)
(10) Alternator
(11) Coolant temperature sensor
(12) Intake throttle valve

Note: The location of item (8) the engine electronic control module will depend on the application.

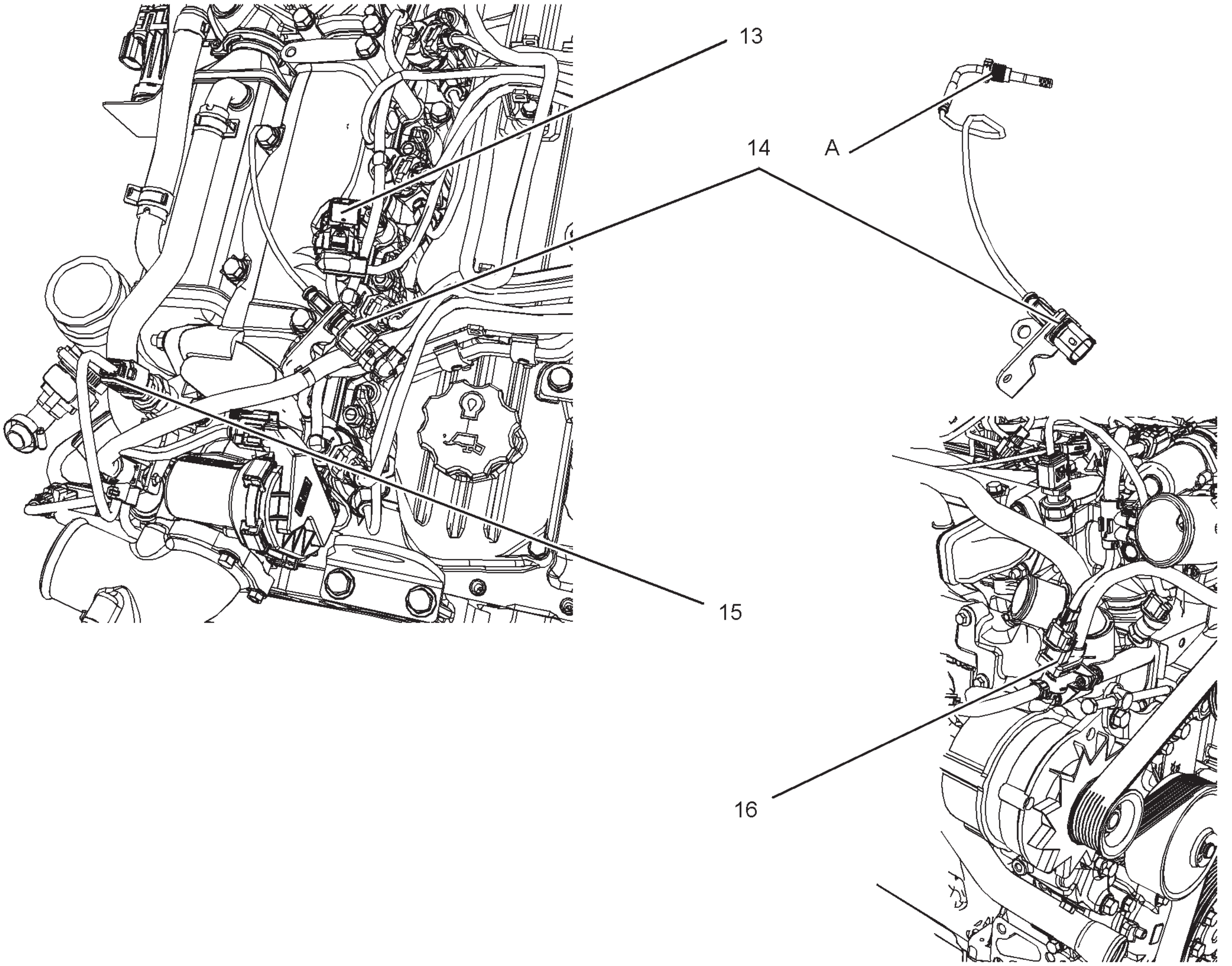

Illustration 33 g02529821

Typical example

(13) Inlet manifold pressure and temperature sensor.

(14) Exhaust temperature sensor connection

(A) Exhaust temperature sensor

(15) Exhaust pressure sensor

(16) Waste gate regulator

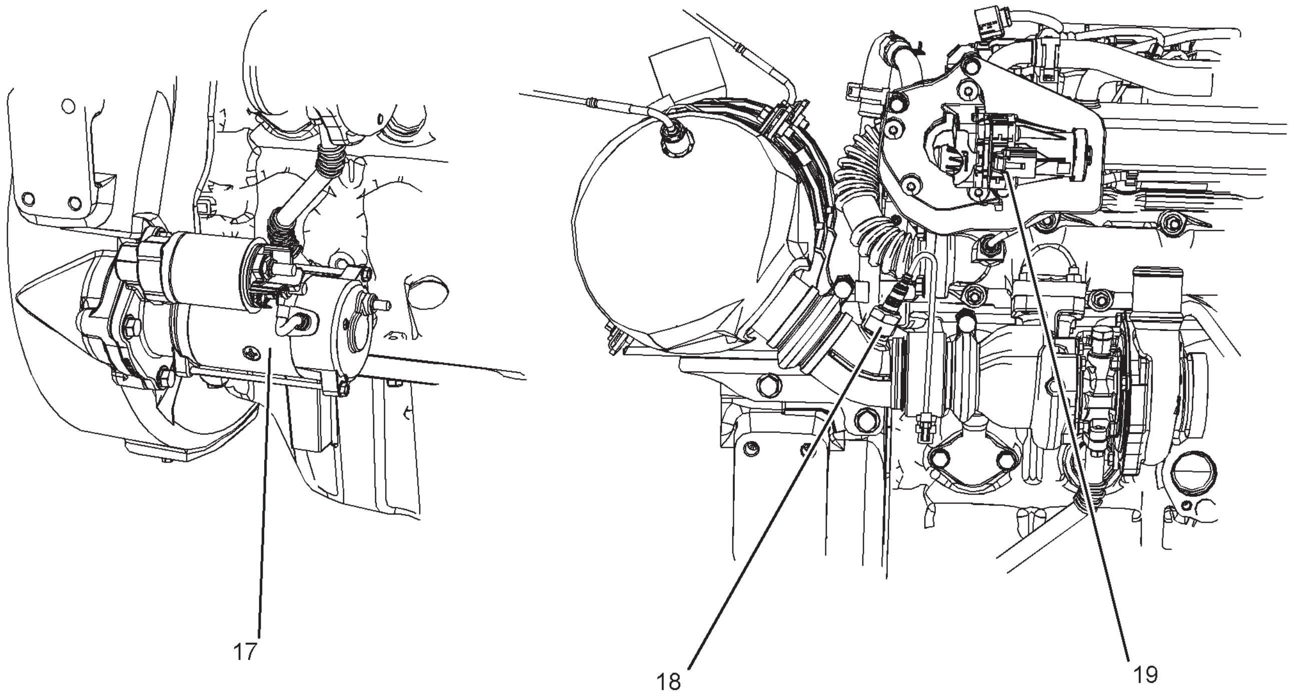

Illustration 34 g02530397

Typical example

(17) Starting motor

(18) Position for oxygen sensor

(19) NOx reduction control valve

Note: Some engines can have the air intake temperature sensor and the glow plug control unit supplied loose.

Separate Inlet Pressure and Inlet Temperature Views

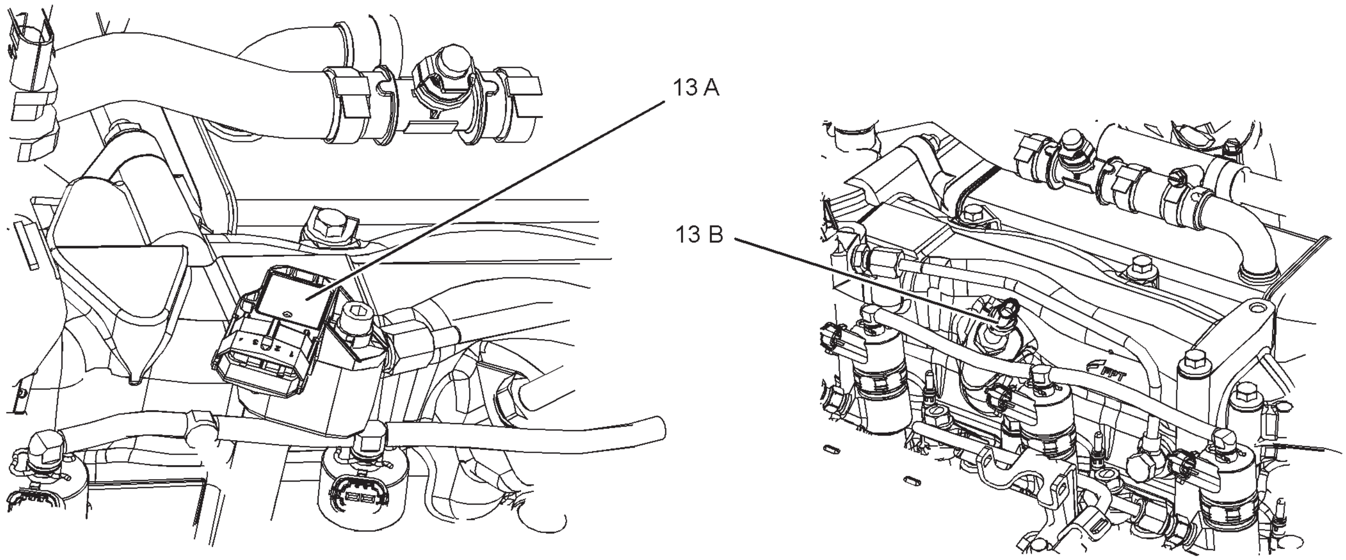

Illustration 35 g03373791

Typical example

(13 A) Intake manifold pressure sensor

(13 B) Intake manifold temperature sensor

Engine Option or Parts that are Supplied Loose

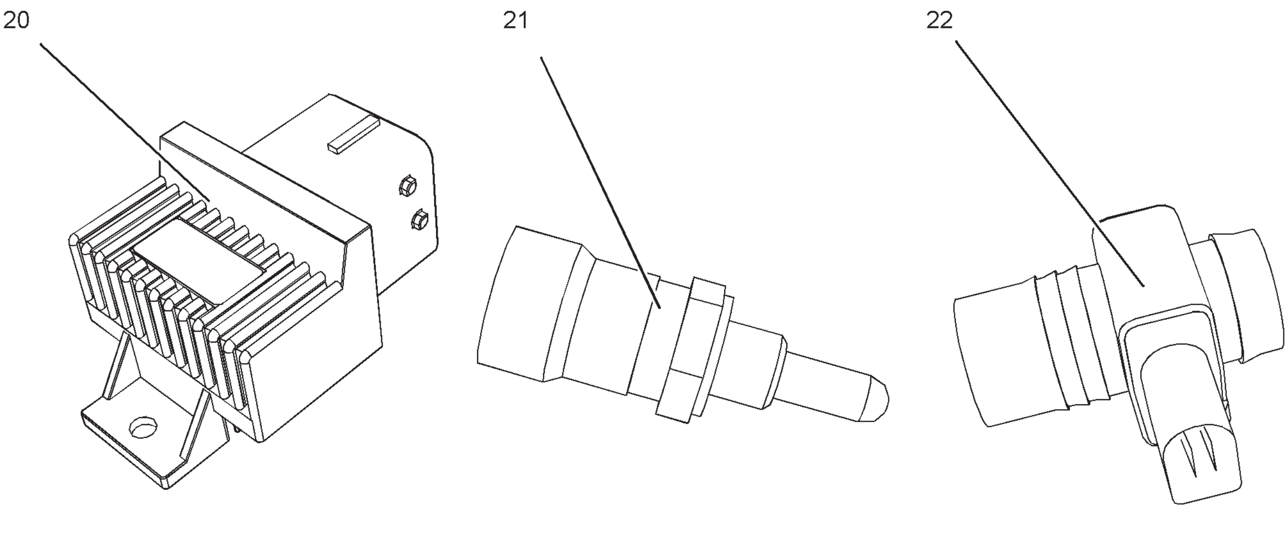

Illustration 36 g02821639

Typical example

(20) Glow plug control unit (21) Inlet air temperature sensor (22) Breather heater

Some engines can have a breather heater (22) for the crankcase breather installed.

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Sensors and Electrical Components (Aftertreatment)

There are two types of aftertreatment that can be installed. The engine power will determine the type of aftertreatment that is installed.

Wall Flow Aftertreatment

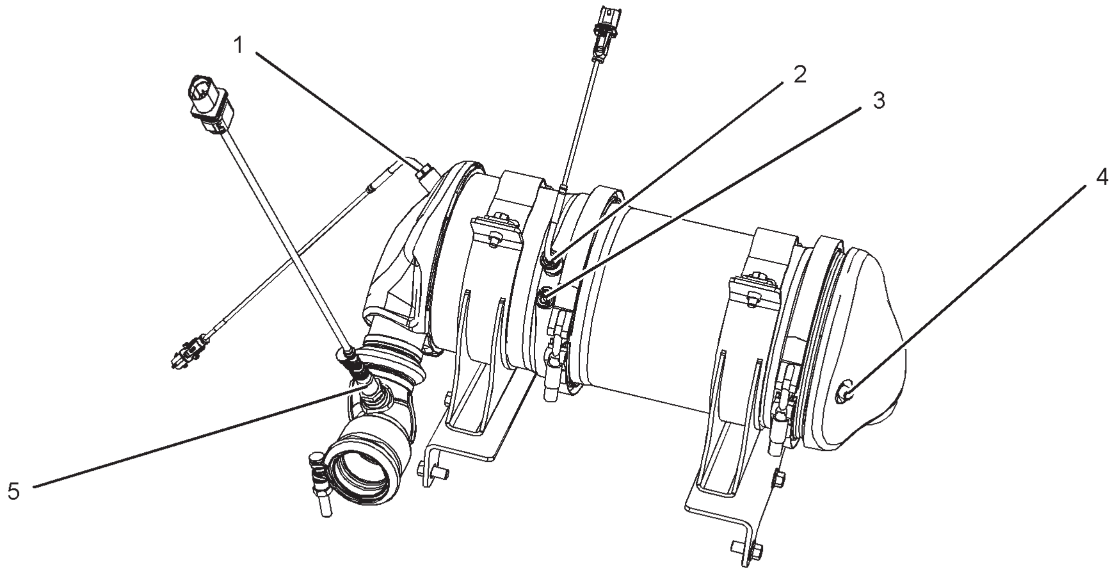

Illustration 37 g03373851

Typical example

(1) Diesel oxidation catalyst temperature sensor
(2) Diesel particulate filter (DPF) temperature sensor
(3) Inlet connection for the differential pressure sensor
(4) Outlet connection for the differential pressure sensor
(5) Oxygen sensor

Through Flow Aftertreatment

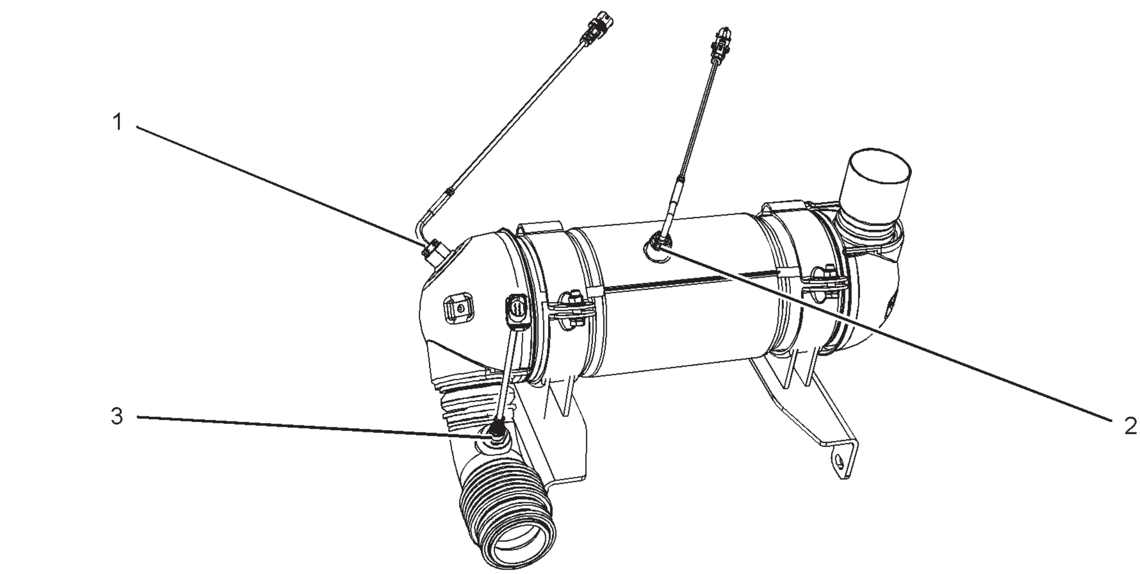

Illustration 38 g03373872

Typical example

(1) Diesel oxidation catalyst (DOC) temperature sensor
(2) Temperature sensor after DOC
(3) Oxygen sensor

Differential Pressure sensor

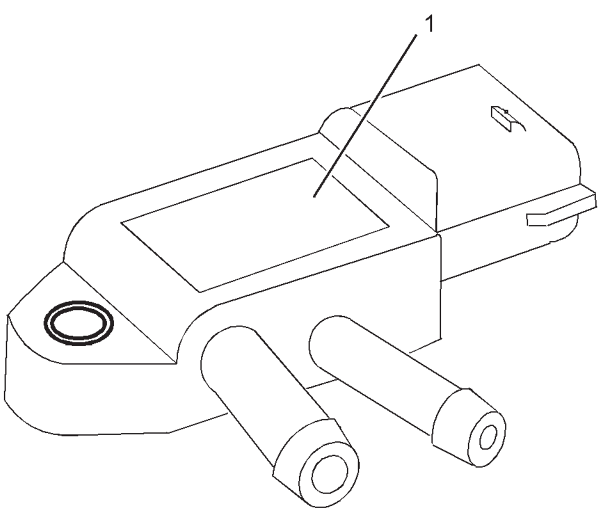

Illustration 39 g02477086

Typical example

(1) Differential pressure sensor

The location of the differential pressure sensor will depend on the application. The differential pressure is installed on the wall flow DPF. The through-flow DPF does not always require the sensor to be installed.

Engine Diagnostics

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Self-Diagnostics

Perkins electronic engines have the capability to perform a self-diagnostics test. When the system detects an active problem, a diagnostic lamp is activated. Diagnostic codes will be stored in permanent memory in the Electronic Control Module (ECM). The diagnostic codes can be retrieved by using the electronic service tool. Refer to Troubleshooting, “Electronic Service Tools” for further information.

Some installations have electronic displays that provide direct readouts of the engine diagnostic codes. Refer to the manual that is provided by the OEM for more information on retrieving engine diagnostic codes. Alternatively refer to Troubleshooting, “Indicator Lamps” for further information.

Active codes represent problems that currently exist. These problems should be investigated first.

Logged codes represent the following items:

- Intermittent problems
- Recorded events
- Performance history

The problems may have been repaired since the logging of the code. These codes do not indicate that a repair is needed. The codes are guides or signals when a situation exists. Codes may be helpful to troubleshoot problems.

When the problems have been corrected, the corresponding logged fault codes should be cleared.

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Diagnostic Lamp

A diagnostic lamp is used to indicate the existence of an active fault. Refer to Troubleshooting, “Indicator Lamps” for more information. A fault diagnostic code will remain active until the problem is repaired. The diagnostic code may be retrieved by using the electronic service tool. Refer to Troubleshooting, “Electronic Service Tools” for more information.

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Fault Logging

The system provides the capability of Fault Logging. When the Electronic Control Module (ECM) generates an active diagnostic code, the code will be logged in the memory of the ECM. The codes that have been logged by the ECM can be identified by the electronic service tool. The active codes that have been logged will be cleared when the fault has been rectified or the fault is no longer active.

i03554534

Engine Operation with Active Diagnostic Codes

If a diagnostic lamp illuminates during normal engine operation, the system has identified a situation that is not within the specification. Use electronic service tools to check the active diagnostic codes.

Note: If the customer has selected “DERATE” and if there is a low oil pressure condition, the Electronic Control Module (ECM) will limit the engine power until the problem is corrected. If the oil pressure is within the normal range, the engine may be operated at the rated speed and load. However, maintenance should be performed as soon as possible.

The active diagnostic code should be investigated. The cause of the problem should be corrected as soon as possible. If the cause of the active diagnostic code is repaired and there is only one active diagnostic code, the diagnostic lamp will turn off.

Operation of the engine and performance of the engine can be limited as a result of the active diagnostic code that is generated. Acceleration rates may be significantly slower. Refer to the Troubleshooting Guide for more information on the relationship between these active diagnostic codes and engine performance.

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Engine Operation with Intermittent Diagnostic Codes

If a diagnostic lamp illuminates during normal engine operation and the diagnostic lamp shuts off, an intermittent fault may have occurred. If a fault has occurred, the fault will be logged into the memory of the Electronic Control Module (ECM).

In most cases, it is not necessary to stop the engine because of an intermittent code. However, the operator should retrieve the logged fault codes and the operator should reference the appropriate information in order to identify the nature of the event. The operator should log any observation that could have caused the lamp to light.

- Low power
- Limits of the engine speed
- Excessive smoke, etc

This information can be useful to help troubleshoot the situation. The information can also be used for future reference. For more information on diagnostic codes, refer to the Troubleshooting Guide for this engine.

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Configuration Parameters

The engine electronic control module (ECM) has two types of configuration parameters. The system configuration parameters and the customer specified parameters.

The electronic service tool is required in order to alter the configuration parameters.

System Configuration Parameters

System configuration parameters affect the emissions of the engine or the power of the engine. System configuration parameters are programmed at the factory. Normally, system configuration parameters would never require changing through the life of the engine. System configuration parameters must be reprogrammed if an ECM is replaced.

Customer Specified Parameters

Customer specified parameters allow the engine to be configured to the exact needs of the application.

The electronic service tool is required in order to alter the customer configuration parameters.

Customer parameters may be changed repeatedly as operational requirements change.

Table 3

Customer Specified Parameters	
Specified Parameters	**Record**
Low Idle Speed	
Throttle Position 1 Engine Speed	

(continued)

(Table 3, contd)

Throttle Position 2 Engine Speed	
Throttle Position 3 Engine Speed	
Throttle Position 4 Engine Speed	
Engine Idle Shutdown Enable Status	
Engine Idle Shutdown Delay Status	
Throttle Lock Feature Installation Status	
Multi State Input Switch Enable Status	
Multi State Input Switch Control Purpose	
Multi Position Throttle Switch Initialization Enable Status	
Throttle Lock Engine Set Speed #1	
Throttle Lock Increment Speed Ramp Rate	
Throttle Lock Decrement Speed Ramp Rate	
Throttle Lock Engine Set Speed Increment	
Monitoring Mode Shutdowns	
Limp Home Desired Engine Speed	
Engine Acceleration Rate	
Engine Location	
High Exhaust System Temperature Indicator Installation Status	
DPF Regeneration Inhibit Indicator Installation Status	
DPF Soot Loading Indicator Installation Status	
Oil Pressure Lamp Installation Status	
Wait to Start Lamp Installation Status	
Warning Lamp Installation Status	
Shutdown Lamp Installation Status	
Starter Relay Installation Status	
Low Pressure Fuel Pump Installation Status	
Remote Torque Speed Control Enable Status	
Throttle Arbitration Method	
Manual Throttle Arbitration Precondition Check	
Throttle Enable Status	
Throttle #1 Initial Lower Position	
Throttle #1 Initial Upper Position	
Throttle #1Idle Validation Switch Enable Status	
Throttle #1Idle Validation Minimum Off Threshold	
Throttle #1 Idle Validation Maximum On Threshold	
Throttle #1 Lower Diagnostic Limit	
Throttle #1 Upper Diagnostic Limit	

(continued)

(Table 3, contd)

Throttle #2 Initial Lower Position	
Throttle #2 Initial Upper Position	
Throttle #2 Idle Validation Switch Enable Status	
Throttle #2 Idle Validation Minimum Off Threshold	
Throttle #2 Idle Validation Maximum On Threshold	
Throttle #2 Lower Diagnostic Limit	
Throttle #2 Upper Diagnostic Limit	
Engine Operation Mode #1 High Idle Speed	
Engine Operation Mode #1 High Idle Droop Percentage	
Engine Operation Mode #1 Throttle #1 Droop Percentage	
Engine Operation Mode #2 Throttle #1 Droop Percentage	
Engine Operation Mode #1 TSC1 Droop Percentage	
Engine Operation Mode #2 High Idle Speed	
Engine Operation Mode #2 High Idle Droop Percentage	
Engine Operation Mode #2 Throttle #1 Droop Percentage	
Engine Operation Mode #2 Throttle #2 Droop Percentage	
Engine Operation Mode #2 TSC1 Droop Percentage	
Engine Operation Mode #3 High Idle Droop Percentage	
Engine Operation Mode #3 High Idle Droop Percentage	
Engine Operation Mode #3 Throttle #1 Droop Percentage	
Engine Operation Mode #3 Throttle #2 Droop Percentage	
Engine Operation Mode #3 TSC1 Droop Percentage	
Engine Operation Mode #4 High Idle Speed	
Engine Operation Mode #4 High Idle Droop Percentage	
Engine Operation Mode #4 Throttle #1 Droop Percentage	
Engine Operation Mode #4 Throttle #2 Droop Percentage	
Engine Operation Mode #4 TSC1 Droop Percentage	

Engine Starting

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Before Starting Engine

ce and other
periodic maintenance before the engine is started. Inspect the engine compartment. This inspection can help prevent major repairs at a later date. Refer to the Operation and Maintenance Manual, “Maintenance Interval Schedule” for more information.

- Ensure that the engine has an adequate fuel supply.
- Open the fuel supply valve (if equipped).

NOTICE
All valves in the fuel return line must be open and fuel supply lines must be open. Damage to the fuel system can occure if fuel lines are closed with the engine in operation.

If the engine has not been started for several weeks, fuel may have drained from the fuel system. Air may have entered the filter housing. Also, when fuel filters have been changed, some air pockets will be trapped in the engine. In these instances, prime the fuel system. Refer to the Operation and Maintenance Manual, “Fuel System - Prime” for more information on priming the fuel system. Also, check that the fuel specification is correct and that the fuel condition is correct. Refer to the Operation and Maintenance Manual, “Fuel Recommendations”.

WARNING

Engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.

- Do not start the engine or move any of the controls if there is a “DO NOT OPERATE” warning tag or similar warning tag attached to the start switch or to the controls.
- Reset all of the shutoffs or alarm components.
- Ensure that any driven equipment has been disengaged. Minimize electrical loads or remove any electrical loads.

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Cold Weather Starting

WARNING

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

The ability to start the engine will be improved at temperatures below −18 °C (0 °F) from the use of a jacket water heater or extra battery capacity.

When Group 2 diesel fuel is used, the following items provide a means of minimizing starting problems and fuel problems in cold weather: Engine oil pan heaters, jacket water heaters, fuel heaters and fuel line insulation.

Use the procedure that follows for cold weather starting.

Note: Do not adjust the engine speed control during start-up. The electronic control module (ECM) will control the engine speed during start-up.

1. Disengage any driven equipment.

Note: During key ON, the indicator lamps will be illuminated for 2 seconds in order to check the lamp operation. If any of the indicator lamps do not illuminate check the bulb. If any indicator lamps stay illuminated or flash, refer to Troubleshooting, “Indicator Lamp Circuit - Test”.

2. Turn the keyswitch to the RUN position. Leave the keyswitch in the RUN position until the warning light for the glow plugs is extinguished.

3. When the warning light for the glow plugs is extinguished, turn the keyswitch to the START position in order to engage the electric starting motor and crank the engine.

Note: The operating period of the warning light for the glow plugs will change due to the ambient air temperature.

NOTICE
Do not engage the starting motor when flywheel is turning. Do not start the engine under load.

If the engine fails to start within 30 seconds, release the starter switch or button and wait two minutes to allow the starting motor to cool before attempting to start the engine again.

4. Allow the keyswitch to return to the RUN position after the engine starts.

5. Repeat step 2 through step 4 if the engine fails to start.

Note: After starting, the engine will be held at low speed. The time held at low speed will depend on ambient temperature and time since last run. The procedure is in order to allow the engine systems to stabilize. The engine should not be "raced" in order to speed up the warm-up process.

6. Allow the engine to idle for 3 to 5 minutes, or allow the engine to idle until the water temperature indicator begins to rise. When idling after the engine has started in cold weather, increase the engine rpm from 1000 to 1200 rpm. This operation will warm up the engine more quickly. Maintaining an elevated low idle speed for extended periods will be easier with the installation of a hand throttle. Allow the white smoke to disperse before proceeding with normal operation.

7. Operate the engine at low load until all systems reach operating temperature. Check the gauges during the warm-up period.

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Starting the Engine

Note: Do not adjust the engine speed control during start-up. The electronic control module (ECM) will control the engine speed during start-up.

Starting the Engine

1. Disengage any equipment that is driven by the engine.

2. Turn the keyswitch to the first position power on. Check that the low oil pressure lamp is on solid. If the lamp is on solid, the engine start sequence can continue. If the lamp is flashing, and engine oil change is required. Refer to this Operation and Maintenance Manual, "Engine Oil and Filter - Change" for more information.

3. Turn the keyswitch to the RUN position. Leave the keyswitch in the RUN position until the warning light for the glow plugs is extinguished.

Note: During the key on, the indicator lamps will be illuminated for 2 seconds in order to check lamp operation. If any of the lamps do not illuminate, check the bulb. If the fault remains refer to Troubleshooting, "Indicator Lamp Circuit - Test".

4. When the warning light for the glow plugs is extinguished, turn the keyswitch to the START position in order to engage the electric starting motor and crank the engine.

Note: The operating period of the warning light for the glow plugs will change due to the temperature of the engine.

NOTICE

Do not engage the starting motor when flywheel is turning. Do not start the engine under load.

If the engine fails to start within 30 seconds, release the starter switch or button and wait two minutes to allow the starting motor to cool before attempting to start the engine again.

5. Allow the keyswitch to return to the RUN position after the engine starts. Ensure that all warning lamps are off.

6. Repeat step 2 through step 5 if the engine fails to start.

7. After starting, the engine will be held at low speed. The time held at low speed will depend on ambient temperature and time since last run. The procedure is in order to allow the engine systems to stabilize.

8. If the engine will not start, refer to Troubleshooting, "Engine Cranks but Does Not Start"

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Starting with Jump Start Cables

WARNING

Improper jump start cable connections can cause an explosion resulting in personal injury.

Prevent sparks near the batteries. Sparks could cause vapors to explode. Do not allow jump start cable ends to contact each other or the engine.

Note: If it is possible, first diagnose the reason for the starting failure. Refer to Troubleshooting, “Engine Will Not Crank and Engine Cranks But Will Not Start” for further information. Make any necessary repairs. If the engine will not start only due to the condition of the battery, either charge the battery, or start the engine by using another battery with jump start cables.
The condition of the battery can be rechecked after the engine has been switched OFF.

NOTICE

Using a battery source with the same voltage as the electric starting motor. Use ONLY equal voltage for jump starting. The use of higher voltage will damage the electrical system.

Do not reverse the battery cables. The alternator can be damaged. Attach ground cable last and remove first.

Turn all electrical accessories OFF before attaching the jump start cables.

Ensure that the main power switch is in the OFF position before attaching the jump start cables to the engine being started.

1. Turn the start switch on the stalled engine to the OFF position. Turn off all the engine's accessories.

2. Connect one positive end of the jump start cable to the positive cable terminal of the discharged battery. Connect the other positive end of the jump start cable to the positive cable terminal of the electrical source.

3. Connect one negative end of the jump start cable to the negative cable terminal of the electrical source. Connect the other negative end of the jump start cable to the engine block or to the chassis ground. This procedure helps to prevent potential sparks from igniting the combustible gases that are produced by some batteries.

Note: The engine ECM must be powered before the starting motor is operated or damage can occur.

4. Start the engine in the normal operating procedure. Refer to this Operation and Maintenance Manual, “Starting the Engine”.

5. Immediately after the engine is started, disconnect the jump start cables in reverse order.

After jump starting, the alternator may not be able to fully recharge batteries that are severely discharged. The batteries must be replaced or charged to the proper voltage with a battery charger after the engine is stopped. Many batteries which are considered unusable are still rechargeable. Refer to Operation and Maintenance Manual, “Battery - Replace” and Testing and Adjusting Manual, “Battery - Test”.

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After Starting Engine

After starting, the engine will be held at low speed. The time held at low speed will depend on ambient temperature and time since last run. The procedure is in order to allow the engine systems to stabilize.

Note: In ambient temperatures from 0 to 60°C (32 to 140°F), the warm-up time is approximately 3 minutes. In temperatures below 0°C (32°F), additional warm-up time may be required.

When the engine idles during warm-up, observe the following conditions:

Do not check the high-pressure fuel lines with the engine or the starting motor in operation. If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, “General hazard Information”.

- Check for any fluid or for any air leaks at idle rpm and at one-half full rpm (no load on the engine) before operating the engine under load.
- Allow the engine to idle for 3 to 5 minutes, or allow the engine to idle until the water temperature indicator begins to rise. Check all gauges during the warm-up period.

Note: Gauge readings should be observed and the data should be recorded frequently while the engine is operating. Comparing the data over time will help to determine normal readings for each gauge. Comparing data over time will also help detect abnormal operating developments. Significant changes in the readings should be investigated.

Engine Operation

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Engine Operation

Proper operation and maintenance are key factors in obtaining the maximum life and economy of the engine. If the directions in the Operation and Maintenance Manual are followed, costs can be minimized and engine service life can be maximized.

The time that is needed for the engine to reach normal operating temperature can be less than the time taken for a walk-around inspection.

The engine can be operated at the rated rpm after the engine is started and after the engine reaches operating temperature. The engine will reach normal operating temperature sooner during a low engine speed (rpm) and during a low-power demand. This procedure is more effective than idling the engine at no load. The engine should reach operating temperature in a few minutes.

Avoid excess idling. Excessive idling causes carbon buildup, engine slobber and soot loading of the Diesel Particulate Filter (DPF). Excess idling can be harmful to the engine.

Gauge readings should be observed and the data should be recorded frequently while the engine is operating. Comparing the data over time will help to determine normal readings for each gauge. Comparing data over time will also help detect abnormal operating developments. Significant changes in the readings should be investigated.

System Check

During normal engine operation the Electronic Control Module (ECM) will elevate the fuel pressure to the injectors. This check will be at scheduled intervals of approximately 100 hours depending on the duty cycle of the engine. The check will be carried out automatically without the need of any input from the operator.

During the time of elevated fuel pressure, the operator may notice a change in the tone of the engine. The ECM will operate the check at low idle for approximately 5 minutes.

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Diesel Particulate Filter Regeneration

Regeneration

Regeneration is the removal of soot from the Diesel Particulate Filter (DPF). There are two different types of DPF that can be installed The through flow DPF and the wall flow DPF. Engines with a power output of 56kW and above will have the wall flow DPF installed. Engines with a power output below 56kW have the option to use both types of DPF.

In table 4 titled **Indicator Operation** the operator will find information on the regeneration indicators. The table informs the operator why an indicator is illuminated and what action should be taken.

Through Flow DPF

The through flow DPF uses passive regeneration in order to remove the soot from the DPF. Passive regeneration is a chemical reaction within the system. Normal operation of the engine creates enough heat for a chemical reaction in order to regenerate the DPF. The regeneration occurs automatically during normal engine operation.

This system uses an amount of active regeneration in order to ensure that soot cannot exit the DPF. The through flow DPF will not require manual cleaning.

For a typical view of the through flow DPF, refer to this Operation and Maintenance Manual, “Sensors and Electrical Components (Aftertreatment)”

Wall Flow DPF

The wall flow DPF uses passive regeneration and active regeneration in order to remove the soot from the DPF. The ash is trapped within the DPF and must be removed by a manual cleaning process. Refer to Operation and Maintenance Manual, “Diesel Particulate Filter- Clean”.

For a typical view of the wall flow DPF, refer to this Operation and Maintenance Manual, “Sensors and Electrical Components (Aftertreatment)”

Regeneration Indicators

Five indicators can be affected by the DPF regeneration. these indicators are, Regeneration Active, DPF, Disable Regeneration, Amber, or Yellow Warning Indicator and Red Stop Indicator.

Regeneration Active – This indicator will illuminate during active regeneration. The indicator shows that elevated exhaust temperatures are possible. The indicator will be turned off when regeneration is complete.

DPF – This indicator provides a general indication of the soot load. The indicator is off when the soot load is normal.

Disable Regeneration – This indicator is illuminated whenever the disable switch is activated.

Modes of Regeneration

- Automatic regeneration
- Manual regeneration

Automatic regeneration – Automatic regeneration will occur when the level of soot reaches the trigger point that is set in the ECM. The engine can operate normally during an automatic regeneration.

Manual – A manual regeneration is initiated by pressing the regeneration switch. A forced regeneration can only be performed after the soot load has illuminated the DPF indicator . A forced regeneration will only be required if the automatic regeneration has not been completed. This situation can be due to either the disable switch being operated or the duty cycle of the engine.

Note: In some applications the engine safety interlocks will need to be in place before a forced regeneration can occur.

Regeneration Switch

Note: The regeneration switch is a three position switch. Some OEMs may use other means of activating a forced regeneration such as touch screen interfaces.

Force Regeneration – Press in the top of the switch for 2 seconds in order to begin regeneration.

Disable Regeneration – Press in the bottom of the switch for 2 seconds in order to disable regeneration.

Note: The MIDDLE position of the regeneration switch is the default position for automatic regeneration.

Note: You may return to normal operation at any point during a regeneration.

Regeneration System Warning Indicators

Some applications may also have an audible warning installed.

Table 4

Indicator Operation					
During passive regeneration no indicator will be illuminated					
Aftertreatment Indicator	**Aftertreatment Indicator State**	**Warning Indicator**	**Warning Indicator State**	**Description**	**Action Required**
Regeneration Active indicator	On Solid	None	None	Regeneration is activated. The indicator will stay illuminated during regeneration.	None
-					
DPF Indicator	On Solid	None	None	The indicator provides a general indication of the soot load. The indicator is off when the soot load is normal.	A regeneration is required. In automatic mode the ECM will decide when to allow the active regeneration. If the DPF indicator stays illuminated allow a manual regeneration without interruption. An uninterrupted active regeneration will reset the DPF indicator.
-					
DPF Indicator	On Solid	Amber indicator	Flashing	The indicator indicates that the soot load has increased. The engine will derate.	A manual regeneration is required. Perform a manual regeneration, or a service regeneration will be required.
-					
DPF Indicator	On Solid	Amber indicator	Flashing	The flashing warning indicator and red stop indicator indicates that the engine has continued to be operated while a regeneration is required. The engine will be derated and the engine should be shut down immediately.	**Once the engine enters into shutdown mode, you must contact your Perkins distributor or your Perkins dealer.** Your dealer or distributor will need to perform a service level regeneration. **The DFP may need to be replaced.**
-	-	Red indicator (STOP)	On Solid		

Note: Amber or yellow warning indicator can be used as a diagnostic lamp. For more information refer to this Operation and Maintenance Manual, "Diagnostic Lamp".

Regeneration Operation

Regeneration will require the following conditions:

Automatic Regeneration

In order for an automatic regeneration to take place the engine must be at operating temperature.

Turning the keyswitch to the OFF position during a regeneration will stop the regeneration. An interrupted regeneration will not remove the soot from the DPF and will waste fuel.

Wall Flow DPF Only

The engine Revs Per Minute (RPM) must be above 1200 RPM for the regeneration to start. Normal operation can continue. During an automatic regeneration the minimum idle speed will be controlled to 950 RPM.

Manual Regeneration

The DPF indicator must be illuminated. Where applicable, safety interlock for your application must be engaged before a manual regeneration can occur, refer to your OEM for more information. No throttle inputs are required, the ECM will control the engine RPM. Press the force regeneration switch for 2 seconds. Do not operate the application during the manual regeneration.

Service Regeneration

The electronic service tool will be required in order to perform a force regeneration. Contact your Perkins distributor or your Perkins dealer.

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Fuel Conservation Practices

The efficiency of the engine can affect the fuel economy. Perkins design and technology in manufacturing provides maximum fuel efficiency in all applications. Follow the recommended procedures in order to attain optimum performance for the life of the engine.

- Avoid spilling fuel.

Fuel expands when the fuel is warmed up. The fuel may overflow from the fuel tank. Inspect fuel lines for leaks. Repair the fuel lines, as needed.

- Be aware of the properties of the different fuels. Use only the recommended fuels. Refer to the Operations and Maintenance Manual, “Fuel Recommendations”for further information.

- Avoid unnecessary idling.

Shut off the engine rather than idle for long periods of time.

- Observe the service indicator frequently. Keep the air cleaner elements clean.

- Ensure that the turbocharger is operating correctly. For more information refer to this Operation and Maintenance Manual, “Turbocharger - Inspect”

- Maintain a good electrical system.

One faulty battery cell will overwork the alternator. This fault will consume excess power and excess fuel.

- The belt should be in good condition. Refer to the Systems Operation, Testing and Adjusting, “V-Belt Test” for further information.

- Ensure that all of the connections of the hoses are tight. The connections should not leak.

- Ensure that the driven equipment is in good working order.

- Cold engines consume excess fuel. Utilize heat from the jacket water system and the exhaust system, when possible. Keep cooling system components clean and keep cooling system components in good repair. Never operate the engine without water temperature regulators. All of these items will help maintain operating temperatures.

Cold Weather Operation

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Cold Weather Operation

Perkins Diesel Engines can operate effectively in cold weather. During cold weather, the starting and the operation of the diesel engine is dependent on the following items:

- The type of fuel that is used
- The viscosity of the engine oil
- The operation of the glow plugs
- Optional Cold starting aid
- Battery condition

This section will cover the following information:

- Potential problems that are caused by cold-weather operation
- Suggest steps which can be taken in order to minimize starting problems and operating problems when the ambient air temperature is between 0° to−40 °C (32° to 40 °F).

The operation and maintenance of an engine in freezing temperatures is complex . This complexity is because of the following conditions:

- Weather conditions
- Engine applications

Recommendations from your Perkins dealer or your Perkins distributor are based on past proven practices. The information that is contained in this section provides guidelines for cold-weather operation.

Hints for Cold Weather Operation

- If the engine will start, operate the engine until a minimum operating temperature of 80° C (176° F) is achieved. Achieving operating temperature will help prevent the intake valves and exhaust valves from sticking.
- The cooling system and the lubrication system for the engine do not lose heat immediately upon shutdown. This means that an engine can be shut down for a period and the engine can still have the ability to start readily.
- Install the correct specification of engine lubricant before the beginning of cold weather.
- Check all rubber parts (hoses, fan drive belts,) weekly.
- Check all electrical wiring and connections for any fraying or damaged insulation.
- Keep all batteries fully charged and warm.
- Fill the fuel tank at the end of each shift.
- Check the air cleaners and the air intake daily. Check the air intake more often when you operate in snow.
- Ensure that the glow plugs are in working order. Refer to Troubleshooting, “Glow Plug Starting Aid-Test”.

WARNING

Personal injury or property damage can result from alcohol or starting fluids.

Alcohol or starting fluids are highly flammable and toxic and if improperly stored could result in injury or property damage.

WARNING

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

- For jump starting with cables in cold weather, refer to the Operation and Maintenance Manual, “Starting with Jump Start Cables.” for instructions.

Cold Weather Operation

Viscosity of the Engine Lubrication Oil

Correct engine oil viscosity is essential. Oil viscosity affects the amount of torque that is needed to crank the engine. Refer to this Operation and Maintenance Manual, “Fluid Recommendations” for the recommended viscosity of oil.

Recommendations for the Coolant

Provide cooling system protection for the lowest expected outside temperature. Refer to this Operation and Maintenance Manual, “Fluid Recommendations” for the recommended coolant mixture.

In cold weather, check the coolant often for the correct glycol concentration in order to ensure adequate freeze protection.

Engine Block Heaters

Engine block heaters (if equipped) heat the engine jacket water that surrounds the combustion chambers. This heat provides the following functions:

- Startability is improved.
- Warm up time is reduced.

An electric block heater can be activated once the engine is stopped. A block heater can be 110 V dc or 240 V dc. The output can be 750/1000W. Consult your Perkins dealer or your Perkins distributor for more information.

Idling the Engine

After starting the engine, the engine speed will be held at low speed. The time held at low speed will depend on ambient temperature and time since last run. The procedure is in order to allow the engine system to stabilize. When idling after the engine is started in cold weather, increase the engine rpm from 1000 to 1200 rpm. This idling will warm up the engine more quickly. Maintaining an elevated low idle speed for extended periods will be easier with the installation of a hand throttle. The engine should not be “raced” in order to speed up the warm-up process.

While the engine is idling, the application of a light load (parasitic load) will assist in achieving the minimum operating temperature. The minimum operating temperature is 80° C (176° F).

Recommendations for Coolant Warm Up

Warm up an engine that has cooled below normal operating temperatures due to inactivity. This warm -up should be performed before the engine is returned to full operation. During operation in very cold temperature conditions, damage to engine valve mechanisms can result from engine operation for short intervals. This damage can happen if the engine is started and the engine is stopped many times without being operated in order to warm up completely.

When the engine is operated below normal operating temperatures, fuel and oil are not completely burned in the combustion chamber. This fuel and oil causes soft carbon deposits to form on the valve stems. Generally, the deposits do not cause problems and the deposits are burned off during operation at normal engine operating temperatures.

When starting and stopping an engine many times without being operated in order to warm up completely, the carbon deposits become thicker. This starting and stopping can cause the following problems:

- Free operation of the valves is prevented.
- Valves become stuck.
- Pushrods may become bent.
- Other damage to valve train components can result.

For this reason, when the engine is started, the engine must be operated until the coolant temperature is 80° C (176° F) minimum. Carbon deposits on the valve stems will be kept at a minimum and the free operation of the valves and the valve components will be maintained.

The engine must be thoroughly warmed in order to keep other engine parts in better condition. The service life of the engine will be generally extended. Lubrication will be improved. There will be less acid and less sludge in the oil. This condition will provide longer service life for the engine bearings, the piston rings, and other parts. However, limit unnecessary idle time to 10 minutes in order to reduce wear and unnecessary fuel consumption.

The Water Temperature Regulator and Insulated Heater Lines

The engine is equipped with a water temperature regulator. When the engine coolant is below the correct operating temperature, jacket water circulates through the engine cylinder block and into the engine cylinder head. The coolant then returns to the cylinder block via an internal passage that bypasses the valve of the coolant temperature regulator. This return ensures that coolant flows around the engine under cold operating conditions. The water temperature regulator begins to open when the engine jacket water has reached the correct minimum operating temperature. As the jacket water coolant temperature rises above the minimum operating temperature, the water temperature regulator opens further allowing more coolant through the radiator to dissipate excess heat.

The progressive opening of the water temperature regulator operates the progressive closing of the bypass passage between the cylinder block and head. This action ensures maximum coolant flow to the radiator in order to achieve maximum heat dissipation.

Note: Do not restrict the air flow. Restriction of the air flow can damage the fuel system. Perkins discourages the use of all air flow restriction devices such as radiator shutters. Restriction of the air flow can result in the following: high exhaust temperatures, power loss, excessive fan usage and reduction in fuel economy.

A cab heater is beneficial in very cold weather. The feed from the engine and the return lines from the cab should be insulated in order to reduce heat loss to the outside air.

Recommendation for Crankcase Breather Protection

Crankcase ventilation gases contain a large quantity of water vapor. This water vapor can freeze in cold ambient conditions and can plug or damage the crankcase ventilation system. If the engine is operated in temperatures below -15 °C (5 °F), measures must be taken to prevent freezing and plugging of the breather system. Insulated hoses and a heated assembly should be installed.

Consult with your Perkins dealer or your Perkins distributer for the recommended breather components for operation from −15° to -40°C (5 ° to -72.°F).

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Fuel and the Effect from Cold Weather

Note: Only use grades of fuel that are recommended by Perkins . Refer to this Operation and Maintenance Manual, “Fluid Recommendations”.

The following components provide a means of minimizing problems in cold weather:

- Glow plugs (if equipped)
- Engine coolant heaters, which may be an OEM option
- Fuel heaters, which may be an OEM option
- Fuel line insulation, which may be an OEM option

The cloud point is a temperature that allows wax crystals to form in the fuel. These crystals can cause the fuel filters to plug.

The pour point is the temperature when diesel fuel will thicken. The diesel fuel becomes more resistant to flow through fuel lines, fuel filters,and fuel pumps.

Be aware of these facts when diesel fuel is purchased. Consider the average ambient air temperature for the engine's application. Engines that are fueled in one climate may not operate well if the engines are moved to another climate. Problems can result due to changes in temperature.

Before troubleshooting for low power or for poor performance in the winter, check the fuel for waxing.

Low temperature fuels may be available for engine operation at temperatures below 0 °C (32 °F). These fuels limit the formation of wax in the fuel at low temperatures.

For more information on cold weather operation, refer to the Operation and Maintenance Manual, “Cold Weather Operation and Fuel Related Components in Cold Weather”.

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Fuel Related Components in Cold Weather

Fuel Tanks

Condensation can form in partially filled fuel tanks. Top off the fuel tanks after you operate the engine.

Fuel tanks should contain some provision for draining water and sediment from the bottom of the tanks.

Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe.

Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

Drain the water and sediment from any fuel storage tank at the following intervals: weekly, service intervals and refueling of the fuel tank. This will help prevent water and/or sediment from being pumped from the fuel storage tank and into the engine fuel tank.

Fuel Filters

A primary fuel filter is installed between the fuel tank and the engine fuel inlet. After you change the fuel filter, always prime the fuel system in order to remove air bubbles from the fuel system. Refer to the Operation and Maintenance Manual in the Maintenance Section for more information on priming the fuel system.

The location of a primary fuel filter is important in cold weather operation. The primary fuel filter and the fuel supply line are the most common components that are affected by cold fuel.

Fuel Heaters

Note: The OEM may equip the application with fuel heaters. If this is the case, the temperature of the fuel must not exceed 73 °C (163 °F) at the fuel transfer pump.

For more information about fuel heaters (if equipped), refer to the OEM information.

Engine Stopping

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Stopping the Engine

NOTICE
Stopping the engine immediately after it has been working under load, can result in overheating and accelerated wear of the engine components.

Avoid accelerating the engine prior to shutting it down.

Avoiding hot engine shutdowns will maximize turbocharger shaft and bearing life.

Note: Individual applications will have different control systems. Ensure that the shutoff procedures are understood. Use the following general guidelines in order to stop the engine.

1. Remove the load from the engine. Reduce the engine speed (rpm) to low idle. Allow the engine to idle for 5 minutes in order to cool the engine.

2. Stop the engine after the cool down period according to the shutoff system on the engine and turn the ignition key switch to the OFF position. If necessary, refer to the instructions that are provided by the OEM.

3. Wait 60 seconds before the battery disconnect switch is turned off. The engine ECM required power after the keyswitch is turned off.

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Emergency Stopping

NOTICE
Emergency shutoff controls are for EMERGENCY use ONLY. DO NOT use emergency shutoff devices or controls for normal stopping procedure.

The OEM may have equipped the application with an emergency stop button. For more information about the emergency stop button, refer to the OEM information.

Ensure that any components for the external system that support the engine operation are secured after the engine is stopped.

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After Stopping Engine

Note: Before you check the engine oil, do not operate the engine for at least 10 minutes in order to allow the engine oil to return to the oil pan.

WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

- After the engine has stopped, you must wait for 10 minutes in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and assembly Manual, “Fuel Injection Lines - Install”.
- Check the crankcase oil level. Maintain the oil level between the “MIN” mark and the “MAX” mark on the engine oil level gauge.
- If the engine is equipped with a service hour meter, note the reading. Perform the maintenance that is in the Operation and Maintenance Manual, “Maintenance Interval Schedule”.
- Fill the fuel tank in order to help prevent accumulation of moisture in the fuel. Do not overfill the fuel tank.

NOTICE
Only use antifreeze/coolant mixtures recommended in the Refill Capacities and Recommendations topic that is in this Operation and Maintenance Manual. Failure to do so can cause engine damage.

WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

- Allow the engine to cool. Check the coolant level.
- Check the coolant for correct antifreeze protection and the correct corrosion protection. Add the correct coolant/water mixture, if necessary.
- Perform all required periodic maintenance on all driven equipment. This maintenance is outlined in the instructions from the OEM.

Maintenance Section

Refill Capacities

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Refill Capacities

Lubrication System

The refill capacities for the engine crankcase reflect the approximate capacity of the crankcase or sump plus standard oil filters. Auxiliary oil filter systems will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter. Refer to the Operation and Maintenance Manual, "Maintenance Section" for more information on Lubricant Specifications.

Table 5

Engine Refill Capacities		
Compartment or System	**Minimum**	**Maximum**
Crankcase Oil Sump(1)	6 L (1.6 US gal)	8.5 L (2.2 US gal)

(1) These values are the approximate capacities for the crankcase oil sump (aluminum) which includes the standard factory installed oil filters. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter. The design of the oil pan can change the oil capacity of the oil pan.

Cooling System

Refer to the OEM specifications for the External System capacity. This capacity information will be needed in order to determine the amount of coolant/ antifreeze that is required for the Total Cooling System.

Table 6

Engine Refill Capacities	
Compartment or System	**Liters**
Engine Only	6 L (1.6 US gal)
External System Per OEM(1)	

(1) The External System includes a radiator or an expansion tank with the following components: heat exchanger and piping. Refer to the OEM specifications. Enter the value for the capacity of the External System in this row.

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Fluid Recommendations
(Fuel Specification)

- **Glossary**
- ISO International Standards Organization
- ASTM American Society for Testing and Materials
- HFRR High Frequency Reciprocating Rig for Lubricity testing of diesel fuels
- FAME Fatty Acid Methyl Esters
- CFR Co-ordinating Fuel Research
- ULSD Ultra Low Sulfur Diesel
- RME Rape Methyl Ester
- SME Soy Methyl Ester
- EPA Environmental Protection Agency of the United States
- PPM Parts Per Million
- DPF Diesel Particulate Filter

General Information

NOTICE
Every attempt is made to provide accurate, up-to-date information. By use of this document you agree that Perkins Engines Company Limited is not responsible for errors or omissions.

NOTICE
These recommendations are subject to change without notice. Contact your local Perkins distributor for the most up-to-date recommendations.

Diesel Fuel Requirements

Perkins is not in a position to continuously evaluate and monitor all worldwide distillate diesel fuel specifications that are published by governments and technological societies.

The Perkins Specification for Distillate Diesel Fuel provides a known reliable baseline in order to judge the expected performance of distillate diesel fuels that are derived from conventional sources.

Satisfactory engine performance is dependent on the use of a good quality fuel. The use of a good quality fuel will give the following results: long engine life and acceptable exhaust emissions levels . The fuel must meet the minimum requirements that are stated in the table 7 .

NOTICE

The footnotes are of the key part Perkins Specification for Distillate Diesel Fuel Table. Read ALL of the footnotes.

Table 7

Perkins Specification for Distillate Diesel Fuel[1]				
Property	**UNITS**	**Requirements**	**ASTMTest**	**ISOTest**
Aromatics	%Volume	35% maximum	D1319	ISO3837
Ash	%Weight	0.01% maximum	D482	ISO6245
Carbon Residue on 10% Bottoms	%Weight	0.35% maximum	D524	ISO4262
Cetane Number [2]	-	40 minimum	D613/D6890	ISO5165
Cloud Point	°C	The cloud point must not exceed the lowest expected ambient temperature.	D2500	ISO3015
Copper Strip Corrosion	-	No. 3 maximum	D130	ISO2160
Density at 15 °C (59 °F)[3]	Kg / M ^{3}	801 minimum and 876 maximum	No equivalent test	ISO 3675ISO 12185
Distillation	°C	10% at 282 °C (539.6 °F) maximum 90% at 360 °C (680 °F) maximum	D86	ISO3405
Flash Point	°C	legal limit	D93	ISO2719
Thermal Stability	-	Minimum of 80% reflectance after aging for 180 minutes at 150 °C (302 °F)	D6468	No equivalent test
Pour Point	°C	6 °C (42.8 °F) minimum below ambient temperature	D97	ISO3016
Sulfur [1]	%mass	0.0015	D5453/D26222	ISO 20846ISO 20884
Kinematic Viscosity [4]	mm^2/s (cSt)	The viscosity of the fuel that is delivered to the fuel injection pump. “1.4 minimum/ 4.5 maximum”	D445	ISO3405
Water and sediment	% weight	0.1% maximum	D1796	ISO3734
Water	% weight	0.1% maximum	D1744	No equivalent test
Sediment	% weight	0.05% maximum	D473	ISO3735
Gums and Resins [5]	mg/100mL	10 mg per 100 mL maximum	D381	ISO6246
Lubricity corrected wear scar diameter at 60 °C (140 °F). [6]	mm	0.52 maximum	D6079	ISO12156-1

(1) This specification includes the requirements for Ultra Low Sulfur Diesel (ULSD). ULSD fuel will have ≤ 15 ppm (0.0015%) sulfur. Refer to ASTM D5453, ASTM D2622, or ISO 20846, ISO 20884 test methods.

(2) A fuel with a higher cetane number is recommended in order to operate at a higher altitude or in cold weather.

(3) “Via standards tables, the equivalent API gravity for the minimum density of 801 kg / m^3 (kilograms per cubic meter) is 45 and for the maximum density of 876 kg / m^3 is 30”.

(continued)

(Table 7, contd)

(4) The values of the fuel viscosity are the values as the fuel is delivered to the fuel injection pumps. Fuel should also meet the minimum viscosity requirement and the fuel should meet the maximum viscosity requirements at 40 °C (104 °F) of either the ASTM D445 test method or the ISO 3104 test method. If a fuel with a low viscosity is used, cooling of the fuel may be required to maintain "1.4 cSt"or greater viscosity at the fuel injection pump. Fuels with a high viscosity might require fuel heaters in order to lower the viscosity to "1.4 cSt" at the fuel injection pump.
(5) Follow the test conditions and procedures for gasoline (motor).
(6) The lubricity of a fuel is a concern with ultra low sulfur fuel. To determine the lubricity of the fuel, use the ISO 12156-1 or ASTM D6079 High Frequency Reciprocating Rig (HFRR) test. If the lubricity of a fuel does not meet the minimum requirements, consult your fuel supplier. Do not treat the fuel without consulting the fuel supplier. Some additives are not compatible. These additives can cause problems in the fuel system.

Engines that are manufactured by Perkins are certified with the fuel that is prescribed by the United States Environmental Protection Agency . Engines that are manufactured by Perkins are certified with the fuel that is prescribed by the European Certification. Perkins does not certify diesel engines on any other fuel.

Note: The owner and the operator of the engine has the responsibility of using the fuel that is prescribed by the EPA and other appropriate regulatory agencies.

NOTICE

Operating with fuels that do not meet the Perkins recommendations can cause the following effects: Starting difficulty, reduced fuel filter service life, poor combustion, deposits in the fuel injectors, significantly reduce service life of the fuel system, deposits in the combustion chamber and reduced service life of the engine.

NOTICE

The Perkins 854 diesel engine must be operated using Ultra Low Sulfur Diesel. The sulphur content of this fuel must be lower than 15 PPM. This fuel complies with the emissions regulations that are prescribed by the Environmental Protection Agency of the United States.

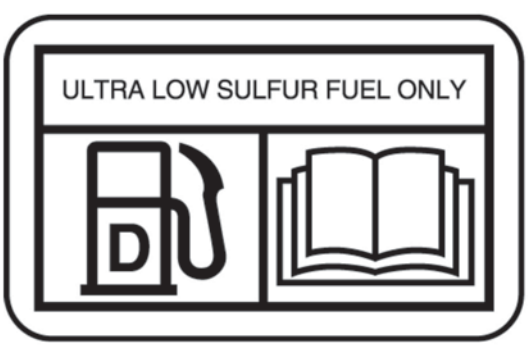

Illustration 40 g02157153

Illustration 40 is a representation of the label that will be installed next to the fuel filler cap on the fuel tank of the application.

The fuel specifications that are listed in the table 8 are released as acceptable to use on 854 engine.

Table 8

Acceptable Fuel Specification for the 854 Engines(1)	
Fuel Specification	Comments
EN590	European Automotive Diesel Fuel (DERV)
ASTM D975 GRADE 1D S15	“North American Light Distillate Diesel fuel with less than 15 PPM sulfur level”
ASTM D975 GRADE 2D S15	“North American Middle Distillate general purpose Diesel fuel with less than 15 PPM sulfur level”
JIS K2204	“Japanese Diesel Fuel” Must meet the requirements that are stated in the section “Lubricity”.
BS 2869: 2010 CLASS A2 or EU equivalent	“EU Off Road Diesel fuel. Acceptable from 2011 MUST have less than 10 PPM sulfur level”

(1) **All the fuels must comply with the specification in the table for the Perkins Specification Distillate Diesel Fuel .**

Diesel Fuel Characteristics

Cetane Number

Fuel that has a high cetane number will give a shorter ignition delay. A high cetane number will produce a better ignition quality. Cetane numbers are derived for fuels against proportions of cetane and heptamethylnonane in the standard CFR engine. Refer to ISO 5165 for the test method.

Cetane numbers in excess of 45 are normally expected from current diesel fuel. However, a cetane number of 40 may be experienced in some territories. The United States of America is one of the territories that can have a low cetane value. A minimum cetane value of 40 is required during average starting conditions. A fuel with higher cetane number is recommended for operations at high altitudes or in cold-weather operations.

Fuel with a low cetane number can be the root cause of problems during a cold start.

Viscosity

Viscosity is the property of a liquid of offering resistance to shear or flow. Viscosity decreases with increasing temperature. This decrease in viscosity follows a logarithmic relationship for normal fossil fuel. The common reference is to kinematic viscosity. Kinematic viscosity is the quotient of the dynamic viscosity that is divided by the density. The determination of kinematic viscosity is normally by readings from gravity flow viscometers at standard temperatures. Refer to ISO 3104 for the test method.

The viscosity of the fuel is significant because fuel serves as a lubricant for the fuel system components. Fuel must have sufficient viscosity in order to lubricate the fuel system in both extremely cold temperatures and extremely hot temperatures . If the kinematic viscosity of the fuel is lower than “1.4 cSt” at the fuel injection pump, damage to the fuel injection pump can occur. This damage can be excessive scuffing and seizure. Low viscosity may lead to difficult hot restarting, stalling, and loss of performance. High viscosity may result in seizure of the pump.

Perkins recommends kinematic viscosities of 1.4 and 4.5 mm2/sec that is delivered to the fuel injection pump. If a fuel with a low viscosity is used, cooling of the fuel may be required to maintain 1.4 cSt or greater viscosity at the fuel injection pump. Fuels with a high viscosity might require fuel heaters in order to lower the viscosity to 4.5 cSt at the fuel injection pump.

Density

Density is the mass of the fuel per unit volume at a specific temperature. This parameter has a direct influence on engine performance and a direct influence on emissions. This influence determines from a heat output given injected volume of fuel. This parameter is quoted in the following kg/m^3 at 15 °C (59 °F).

Perkins recommends a density of 841 kg/m^3 in order to obtain the correct power output. Lighter fuels are acceptable but these fuels will not produce the rated power.

Sulfur

The level of sulfur is governed by emissions legislations . Regional regulation, national regulations, or international regulations can require a fuel with a specific sulfur limit. The sulfur content of the fuel and the fuel quality must comply with all existing local regulations for emissions.

Perkins 854 diesel engines have been designed to operate only with ULSD. By using the test methods ASTM D5453, ASTM D2622, or ISO 20846 ISO 20884, the content of sulfur in ULSD fuel must be below 15 PPM (mg/kg) or 0.0015% mass.

NOTICE

Use of diesel fuel with higher than 15 PPM sulphur limit in these engines will harm or permanently damage emissions control systems and/or shorten their service interval.

Lubricity

Lubricity is the capability of the fuel to prevent pump wear. The fluids lubricity describes the ability of the fluid to reduce the friction between surfaces that are under load. This ability reduces the damage that is caused by friction. Fuel injection systems rely on the lubricating properties of the fuel. Until fuel sulfur limits were mandated, the fuels lubricity was generally believed to be a function of fuel viscosity.

The lubricity has particular significance to the current ultra low sulfur fuel, and low aromatic fossil fuels. These fuels are made in order to meet stringent exhaust emissions.

The lubricity of these fuels must not exceed wear scar diameter of 0.52 mm (0.0205 inch). The fuel lubricity test must be performed on an HFRR, operated at 60 °C (140 °F). Refer to ISO 12156-1.

NOTICE

The fuels system has been qualified with fuel having lubricity up to 0.52 mm (0.0205 inch) wear scar diameter as tested by ISO 12156-1. Fuel with higher wear scar diameter than 0.52 mm (0.0205 inch) will lead to reduced service life and premature failure of the fuel system.

Fuel additives can enhance the lubricity of a fuel. Contact your fuel supplier for those circumstances when fuel additives are required. Your fuel supplier can make recommendations for additives to use, and for the proper level of treatment.

Distillation

Distillation is an indication of the mixture of different hydrocarbons in the fuel. A high ratio of light weight hydrocarbons can affect the characteristics of combustion.

Recommendation for Biodiesel

Biodiesel is a fuel that can be defined as mono-alkyl esters of fatty acids . Biodiesel is a fuel that can be made from various feedstock. The most commonly available biodiesel in Europe is Rape Methyl Ester (REM) . This biodiesel is derived from rapeseed oil . Soy Methyl Ester (SME) is the most common biodiesel in the United States. This biodiesel is derived from soybean oil . Soybean oil or rapeseed oil are the primary feedstocks. These fuels are together known as Fatty Acid Methyl Esters (FAME) .

Raw pressed vegetable oils are NOT acceptable for use as a fuel in any concentration in compression engines . Without esterification, these oils solidify in the crankcase and the fuel tank. These fuels may not be compatible with many of the elastomers that are used in engines that are manufactured today. In original forms, these oils are not suitable for use as a fuel in compression engines . Alternate base stocks for biodiesel may include animal tallow , waste cooking oils , or various other feedstocks. In order to use any of the products that are listed as fuel, the oil must be esterified .

Fuel made of 100 percent FAME is generally referred to as B100 biodiesel or neat biodiesel.

Biodiesel can be blended with distillate diesel fuel. The blends can be used as fuel. The most commonly available biodiesel blends are B5, which is 5 percent biodiesel and 95 percent distillate diesel fuel. B20, which is 20 percent biodiesel and 80 percent distillate diesel fuel.

Note: The percentages given are volume-based.

The U.S. distillate diesel fuel specification ASTM D975-09a includes up to B5 (5 percent) biodiesel.

European distillate diesel fuel specification EN590: 2010 includes up B7 (7 percent) biodiesel.

Note: Engines that are manufactured by Perkins are certified by use of the prescribed Environmental Protection Agency (EPA) and European Certification fuels. Perkins does not certify engines on any other fuel. The user of the engine has the responsibility of using the correct fuel that is recommended by the manufacturer and allowed by the EPA and other appropriate regulatory agencies.

Specification Requirements

The neat biodiesel must conform to the latest EN14214 or ASTM D6751 (in the USA). The biodiesel can only be blended in mixture of up to 20% by volume in acceptable mineral diesel fuel meeting latest edition of EN590 or ASTM D975 S15 designation.

In United States Biodiesel blends of B6 to B20 must meet the requirements listed in the latest edition of ASTM D7467 (B6 to B20) and must be of an API gravity of 30-45.

In North America biodiesel and biodiesel blends must be purchased from the BQ-9000 accredited producers and BQ-9000 certified distributors.

In other areas of the world, the use of biodiesel that is BQ-9000 accredited and certified, or that is accredited and certified by a comparable biodiesel quality body to meet similar biodiesel quality standards is required.

Engine Service Requirements

Aggressive properties of biodiesel fuel may cause debris in the fuel tank and fuel lines. The aggressive properties of biodiesel will clean the fuel tank and fuel lines. This cleaning of the fuel system can prematurely block of the fuel filters. Perkins recommend that after the initial usage of B20 biodiesel blended fuel the fuel filters must be replaced at 50 hours.

Glycerides present in biodiesel fuel will also cause fuel filters to become blocked more quickly. Therefore the regular service interval should be reduced to 250 hours.

When biodiesel fuel is used, crank case oil and aftertreatment systems may be influenced. This influence is due to the chemical composition and characteristics of biodiesel fuel, such as density and volatility, and to chemical contaminants that can be present in this fuel, such as alkali and alkaline metals (sodium, potassium, calcium, and magnesium).

- Crankcase oil fuel dilution can be higher when biodiesel or biodiesel blends are used. This increased level of fuel dilution when using biodiesel or biodiesel blends is related to the typically lower volatility of biodiesel. In-cylinder emissions control strategies utilized in many of the industrial latest engine designs may lead to a higher level of biodiesel concentration in the sump. The long-term effect of biodiesel concentration in crankcase oil is currently unknown.
- Perkins recommend the use of oil analysis in order to check the quality of the engine oil if biodiesel fuel is used. Ensure that the level of biodiesel in the fuel is noted when the oil sample is taken.

Performance Related Issues

Due to the lower energy content than the standard distillate fuel B20 will cause a power loss in order of 2 to 4 percent. In addition, over time the power may deteriorate further due to deposits in the fuel injectors.

Biodiesel and biodiesel blends are known to cause an increase in fuel system deposits, most significant of which are deposits within the fuel injector. These deposits can cause a loss in power due to restricted or modified fuel injection or cause other functional issues associated with these deposits.

Note: Perkins T400012 Fuel Cleaner is most effective in cleaning and preventing the formation of deposits. Perkins Diesel Fuel Conditioner helps to limit deposit issues by improving the stability of biodiesel and biodiesel blends. For more information refer to "Perkins Diesel Fuel System Cleaner".

Biodiesel fuel contains metal contaminants (sodium, potassium, calcium, and/or magnesium) that form ash products upon combustion in the diesel engine. The ash can have an impact on the life and performance of aftertreatment emissions control devices and can accumulate in DPF. The ash accumulation may cause the need for more frequent ash service intervals and cause loss of performance

General Requirements

Biodiesel has poor oxidation stability, which can result in long-term problems in the storage of biodiesel. Biodiesel fuel should be used within 6 months of manufacture. Equipment should not be stored with the B20 biodiesel blends in the fuel system for longer than 3 months.

Due to poor oxidation stability and other potential issues, it is strongly recommended that engines with limited operational time either not use B20 biodiesel blends or, while accepting some risk, limit biodiesel blend to a maximum of B5. Examples of applications that should limit the use of biodiesel are the following: Standby Generator sets and certain emergency vehicles.

Perkins strongly recommended that seasonally operated engines have the fuel systems, including fuel tanks, flashed with conventional diesel fuel before prolonged shutdown periods. An example of an application that should seasonally flush the fuel system is a combine harvester.

Microbial contamination and growth can cause corrosion in the fuel system and premature plugging of the fuel filter. Consult your supplier of fuel for assistance in selecting appropriate anti-microbial additive.

Water accelerates microbial contamination and growth. When biodiesel is compared to distillate fuels, water is naturally more likely to exist in the biodiesel. It is therefore essential to check frequently and if necessary, drain the water separator.

Materials such as brass, bronze, copper, lead, tin, and zinc accelerate the oxidation process of the biodiesel fuel. The oxidation process can cause deposits formation therefore these materials must not be used for fuel tanks and fuel lines.

Fuel for Cold Weather Operation

The European standard EN590 contains climate dependant requirements and a range of options. The options can be applied differently in each country. There are five classes that are given to arctic climates and severe winter climates . 0, 1, 2, 3 and 4.

Fuel that complies with EN590 CLASS 4 can be used at temperatures as low as −44 °C (−47.2 °F). Refer to EN590 for a detailed discretion of the physical properties of the fuel.

The diesel fuel ASTM D975 1-D used in the United States of America may be used in very cold temperatures that are below −18 °C (−0.4 °F).

Aftermarket Fuel Additives

Supplemental diesel fuel additives are not generally recommended . This recommendation is due to potential damage to the fuel system or the engine. Your fuel supplier or the fuel manufacturer will add the appropriate supplemental diesel fuel additives.

Perkins recognizes the fact that additives may be required in some special circumstances. Contact your fuel supplier for those circumstances when fuel additives are required. Your fuel supplier can recommend the appropriate fuel additive and the correct level of treatment.

Note: For the best results, your fuel supplier should treat the fuel when additives are required. The treated fuel must meet the requirements that are stated in table 7 .

Perkins Diesel Fuel System Cleaner

Perkins T400012 Fuel Cleaner is the only fuel cleaner that is recommended by Perkins .

If biodiesel or biodiesel blends of fuel are to be used, Perkins require the use of Perkins fuel cleaner. The use of the fuel is in order to remove deposits within the fuel system that is created with the use of biodiesel. For more information on the use of biodiesel and biodiesel blends refer to “Recommendation for Biodiesel”.

Perkins fuel cleaner will remove deposits that can form in the fuel system with the use of biodiesel and biodiesel blends. These deposits can create a loss of power and engine performance.

Once the fuel cleaner has been added to the fuel, the deposits within the fuel system are removed after 30 hours of engine operation. For maximum results, continue to use the fuel cleaner for up to 80 hours. Perkins fuel cleaner can be used on an on-going basis with no adverse impact on engine or fuel system durability.

Details instruction on the rate of which the fuel cleaner must be use are on the container.

Note: Perkins fuel cleaner is compatible with existing and U.S. EPA Tier 4 nonroad certified diesel engine emission control catalysts and particulate filters. Perkins fuel system cleaner contains less than 15 ppm of sulfur and is acceptable for use with ULSD fuel.

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Fluid Recommendations

General Lubricant Information

Because of government regulations regarding the certification of exhaust emissions from the engine, the lubricant recommendations must be followed.

- API_______________American Petroleum Institute
- SAE________Society Of Automotive Engineers Inc.
- ACEA_____________Association des Constructers European Automobiles .
- ECF-3_________________Engine Crankcase Fluid

Licensing

The Engine Oil Licensing and Certification System by the American Petroleum Institute (API) and the Association des Constructers European Automobilesand (ACRA) is recognized by Perkins . For detailed information about this system, see the latest edition of the API publication No. 1509. Engine oils that bear the API symbol are authorized by API.

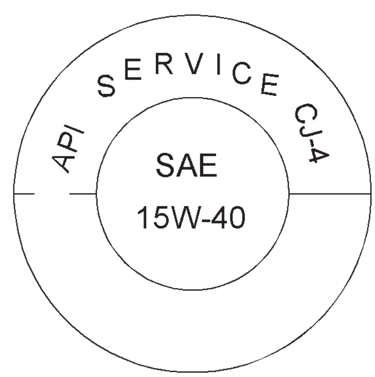

Illustration 41 g01987816

Typical API symbol

Terminology

Certain abbreviations follow the nomenclature of SAE J754. Some classifications follow SAE J183 abbreviations, and some classifications follow the EMA Recommended Guideline on Diesel Engine Oil. In addition to Perkins definitions, there are other definitions that will be of assistance in purchasing lubricants. Recommended oil viscosities can be found in this publication, "Fluid Recommendations/ Engine Oil" topic (Maintenance Section).

Engine Oil

Commercial Oils

NOTICE
Perkins require the use of the following specification of engine oil. Failure to use the appropriate specification of engine oil will reduce the life of your engine. Failure to use the appropriate specification of engine oil will also reduce the life of your aftertreatment system.

Table 9

Classifications for the 854 Industrial Engine
Oil Specification
API CJ-4 ACEA E9 ECF-3

API CJ-4 and ACEA E9 oil categories have the following chemical limits:

- 0.1 percent maximum sulfated ash
- 0.12 percent maximum phosphorous
- 0. 4 percent maximum sulfur

The chemical limits were developed in order to maintain the expected life of the engine aftertreatment system. The performance of the engine aftertreatment system can be adversely affected if oil that is not specified in table 9 is used.

The life of your Aftertreatment system is defined by the accumulation of ash on the surface of the filter. Ash is the inert part of the particulate matter. The system is designed in order to collect this particulate matter. There is a small percentage of particulate matter that is left behind as the soot is burnt. This matter will eventually block the filter, causing loss of performance and increased fuel consumption. Most of the ash comes from the engine oil which is gradually consumed during normal operation. This ash is passes through the exhaust. To meet the designed life of the product, the use of the appropriate engine oil is essential. The oil specification that is listed in table 9 has low ash content.

Maintenance intervals for engines that use biodiesel – The oil change interval can be adversely affected by the use of biodiesel. Use oil analysis in order to monitor the condition of the engine oil. Use oil analysis also in order to determine the oil change interval that is optimum.

Note: These engine oils are not approved by Perkins and these engine oils must not be used: CC, CD, CD-2, CF-4, CG-4, CH-4 and CI-4.

Lubricant Viscosity Recommendations for Direct Injection (DI) Diesel Engines

The correct SAE viscosity grade of oil is determined by the minimum ambient temperature during cold engine start-up, and the maximum ambient temperature during engine operation.

Refer to illustration 42 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to illustration 42 (maximum temperature) in order to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

Generally, use the highest oil viscosity that is available to meet the requirement for the temperature at start-up.

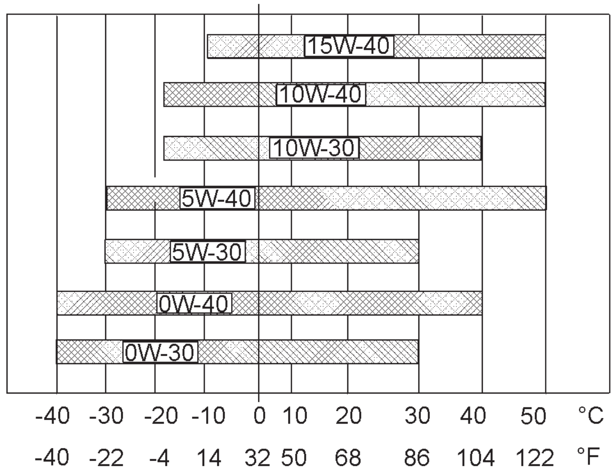

Illustration 42 g03363756

Lubricant Viscosities

Supplemental heat is recommended for cold soaked starts below the minimum ambient temperature. Supplemental heat may be required for cold soaked starts that are above the minimum temperature that is stated, depending on the parasitic load and other factors. Cold soaked starts occur when the engine has not been operated for a period of time. This interval will allow the oil to become more viscous due to cooler ambient temperatures.

Aftermarket Oil Additives

Perkins does not recommend the use of aftermarket additives in oil. It is not necessary to use aftermarket additives in order to achieve the engines maximum service life or rated performance. Fully formulated, finished oils consist of base oils and of commercial additive packages. These additive packages are blended into the base oils at precise percentages in order to help provide finished oils with performance characteristics that meet industry standards.

There are no industry standard tests that evaluate the performance or the compatibility of aftermarket additives in finished oil. Aftermarket additives may not be compatible with the finished oils additive package, which could lower the performance of the finished oil. The aftermarket additive could fail to mix with the finished oil. This failure could produce sludge in the crankcase. Perkins discourages the use of aftermarket additives in finished oils.

To achieve the best performance from a Perkins engine, conform to the following guidelines:

- See the appropriate “Lubricant Viscosities”. Refer to the illustration 42 in order to find the correct oil viscosity grade for your engine.
- At the specified interval, service the engine. Use new oil and install a new oil filter.
- Perform maintenance at the intervals that are specified in the Operation and Maintenance Manual, “Maintenance Interval Schedule”.

Oil analysis

Some engines may be equipped with an oil sampling valve. If oil analysis is required, the oil sampling valve is used to obtain samples of the engine oil. The oil analysis will complement the preventive maintenance program.

The oil analysis is a diagnostic tool that is used to determine oil performance and component wear rates. Contamination can be identified and measured by using oil analysis. The oil analysis includes the following tests:

- The Wear Rate Analysis monitors the wear of the engines metals. The amount of wear metal and type of wear metal that is in the oil is analyzed. The increase in the rate of engine wear metal in the oil is as important as the quantity of engine wear metal in the oil.
- Tests are conducted in order to detect contamination of the oil by water, glycol, or fuel.
- The Oil Condition Analysis determines the loss of the oils lubricating properties. An infrared analysis is used to compare the properties of new oil to the properties of the used oil sample. This analysis allows technicians to determine the amount of deterioration of the oil during use. This analysis also allows technicians to verify the performance of the oil according to the specification during the entire oil change interval.

i04358959

Fluid Recommendations

General Coolant Information

NOTICE

Never add coolant to an overheated engine. Engine damage could result. Allow the engine to cool first.

NOTICE

If the engine is to be stored in, or shipped to an area with below freezing temperatures, the cooling system must be either protected to the lowest outside temperature or drained completely to prevent damage.

NOTICE

Frequently check the specific gravity of the coolant for proper freeze protection or for anti-boil protection.

Clean the cooling system for the following reasons:

- Contamination of the cooling system
- Overheating of the engine
- Foaming of the coolant

NOTICE

Never operate an engine without water temperature regulators in the cooling system. Water temperature regulators help to maintain the engine coolant at the proper operating temperature. Cooling system problems can develop without water temperature regulators.

Many engine failures are related to the cooling system. The following problems are related to cooling system failures: Overheating, leakage of the water pump and plugged radiators or heat exchangers.

These failures can be avoided with correct cooling system maintenance. Cooling system maintenance is as important as maintenance of the fuel system and the lubrication system. Quality of the coolant is as important as the quality of the fuel and the lubricating oil.

Coolant is normally composed of three elements: Water, additives and glycol.

Water

Water is used in the cooling system in order to transfer heat.

Distilled water or deionized water is recommended for use in engine cooling systems.

DO NOT use the following types of water in cooling systems: Hard water, softened water that has been conditioned with salt and sea water.

If distilled water or deionized water is not available, use water with the properties that are listed in Table 10 .

Table 10

Acceptable Water	
Property	**Maximum Limit**
Chloride (Cl)	40 mg/L
Sulfate (SO_4)	100 mg/L
Total Hardness	170 mg/L
Total Solids	340 mg/L
Acidity	pH of 5.5 to 9.0

For a water analysis, consult one of the following sources:

- Local water utility company
- Agricultural agent
- Independent laboratory

Additives

Additives help to protect the metal surfaces of the cooling system. A lack of coolant additives or insufficient amounts of additives enable the following conditions to occur:

- Corrosion
- Formation of mineral deposits
- Rust
- Scale
- Foaming of the coolant

Many additives are depleted during engine operation. These additives must be replaced periodically.

Additives must be added at the correct concentration. Over concentration of additives can cause the inhibitors to drop out-of-solution. The deposits can enable the following problems to occur:

- Formation of gel compounds
- Reduction of heat transfer
- Leakage of the water pump seal
- Plugging of radiators, coolers, and small passages

Glycol

Glycol in the coolant helps to provide protection against the following conditions:

- Boiling
- Freezing
- Cavitation of the water pump

For optimum performance, Perkins recommends a 1:1 mixture of a water/glycol solution.

Note: Use a mixture that will provide protection against the lowest ambient temperature.

Note: 100 percent pure glycol will freeze at a temperature of −13 °C (8.6 °F).

Most conventional antifreezes use ethylene glycol. Propylene glycol may also be used. In a 1:1 mixture with water, ethylene and propylene glycol provide similar protection against freezing and boiling. Refer to Table 11 and refer to table 12 .

Table 11

Ethylene Glycol	
Concentration	**Freeze Protection**
50 Percent	−36 °C (−33 °F)
60 Percent	−51 °C (−60 °F)

NOTICE

Do not use propylene glycol in concentrations that exceed 50 percent glycol because of the reduced heat transfer capability of propylene glycol. Use ethylene glycol in conditions that require additional protection against boiling or freezing.

Table 12

Propylene Glycol	
Concentration	**Freeze Protection**
50 Percent	−29 °C (−20 °F)

To check the concentration of glycol in the coolant, measure the specific gravity of the coolant.

Coolant Recommendations

- ELC__________Extended Life Coolant
- SCA__________Supplement Coolant Additive
- ASTM__________American Society for Testing and Materials

The following two coolants are used in Perkins diesel engines:

Preferred – Perkins ELC

Acceptable – A commercial heavy-duty antifreeze that meets ASTM D6210 specifications

NOTICE

The 854 industrial engines must be operated with a 1:1 mixture of water and glycol. This concentration allows the NOx reduction system to operate correctly at high ambient temperatures.

NOTICE

Do not use a commercial coolant/antifreeze that only meets the ASTM D3306 specification. This type of coolant/antifreeze is made for light automotive applications.

Perkins recommends a 1:1 mixture of water and glycol. This mixture of water and glycol will provide optimum heavy-duty performance as an antifreeze. This ratio may be increased to 1:2 water to glycol if extra freezing protection is required.

A mixture of SCA inhibitor and water is acceptable but will not give the same level of corrosion, boiling and, freezing protection as ELC. Perkins recommends a 6 percent to 8 percent concentration of SCA in those cooling systems. Distilled water or deionized water is preferred. Water which has the recommended properties may be used.

Table 13

Coolant Service Life	
Coolant Type	**Service Life (1)**
Perkins ELC	6,000 Service Hours or Three Years
Commercial Heavy-Duty Antifreeze that meets ASTM D6210	3000 Service Hours or Two Year
Commercial SCA inhibitor and Water	3000 Service Hours or One Year

(1) Use the interval that occurs first. The cooling system must also be flushed out at this time.

ELC

Perkins provides ELC for use in the following applications:

- Heavy-duty spark ignited gas engines
- Heavy-duty diesel engines
- Automotive applications

The anti-corrosion package for ELC is different from the anti-corrosion package for other coolants. ELC is an ethylene glycol base coolant. However, ELC contains organic corrosion inhibitors and antifoam agents with low amounts of nitrite. Perkins ELC has been formulated with the correct amount of these additives in order to provide superior corrosion protection for all metals in engine cooling systems.

ELC is available in a premixed cooling solution with distilled water. ELC is a 1:1 mixture. The Premixed ELC provides freeze protection to −36 °C (−33 °F). The Premixed ELC is recommended for the initial fill of the cooling system. The Premixed ELC is also recommended for topping off the cooling system.

Containers of several sizes are available. Consult your Perkins distributor for the part numbers.

ELC Cooling System Maintenance

Correct additions to the Extended Life Coolant

NOTICE
Use only Perkins products for pre-mixed or concentrated coolants.

Mixing Extended Life Coolant with other products reduces the Extended Life Coolant service life. Failure to follow the recommendations can reduce cooling system components life unless appropriate corrective action is performed.

In order to maintain the correct balance between the antifreeze and the additives, you must maintain the recommended concentration of ELC. Lowering the proportion of antifreeze lowers the proportion of additive. This will lower the ability of the coolant to protect the system from pitting, from cavitation, from erosion, and from deposits.

NOTICE
Do not use a conventional coolant to top-off a cooling system that is filled with Extended Life Coolant (ELC).

Do not use standard supplemental coolant additive (SCA).

When using Perkins ELC, do not use standard SCA's or SCA filters.

ELC Cooling System Cleaning

Note: If the cooling system is already using ELC, cleaning agents are not required to be used at the specified coolant change interval. Cleaning agents are only required if the system has been contaminated by the addition of some other type of coolant or by cooling system damage.

Clean water is the only cleaning agent that is required when ELC is drained from the cooling system.

Before the cooling system is filled, the heater control (if equipped) must be set to the HOT position. Refer to the OEM in order to set the heater control. After the cooling system is drained and the cooling system is refilled, operate the engine until the coolant level reaches the normal operating temperature and until the coolant level stabilizes. As needed, add the coolant mixture in order to fill the system to the specified level.

Changing to Perkins ELC

To change from heavy-duty antifreeze to the Perkins ELC, perform the following steps:

NOTICE
Care must be taken to ensure that all fluids are contained during performance of inspection, maintenance, testing, adjusting and the repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant into a suitable container.

2. Dispose of the coolant according to local regulations.

3. Flush the system with clean water in order to remove any debris.

4. Use an appropriate cleaner to clean the system. Follow the instruction on the label.

5. Drain the cleaner into a suitable container. Flush the cooling system with clean water.

6. Fill the cooling system with clean water and operate the engine until the engine is warmed to 49° to 66°C (120° to 150°F).

NOTICE
Incorrect or incomplete flushing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all the signs of the cleaning agent are gone.

7. Drain the cooling system into a suitable container and flush the cooling system with clean water.

Note: The cooling system cleaner must be thoroughly flushed from the cooling system. Cooling system cleaner that is left in the system will contaminate the coolant. The cleaner may also corrode the cooling system.

8. Repeat Steps 6 and repeat steps 7 until the system is completely clean.

9. Fill the cooling system with the Perkins Premixed ELC.

ELC Cooling System Contamination

NOTICE
Mixing ELC with other products reduces the effectiveness of the ELC and shortens the ELC service life. Use only Perkins Products for premixed or concentrate coolants. Failure to follow these recommendations can result in shortened cooling system component life.

ELC cooling systems can withstand contamination to a maximum of 10 percent of conventional heavy-duty antifreeze or SCA. If the contamination exceeds 10 percent of the total system capacity, perform ONE of the following procedures:

- Drain the cooling system into a suitable container. Dispose of the coolant according to local regulations. Flush the system with clean water. Fill the system with the Perkins ELC.
- Drain a portion of the cooling system into a suitable container according to local regulations. Then, fill the cooling system with premixed ELC. This procedure should lower the contamination to less than 10 percent.
- Maintain the system as a conventional Heavy-Duty Coolant. Treat the system with an SCA. Change the coolant at the interval that is recommended for the conventional Heavy-Duty Coolant.

Commercial Heavy-Duty Antifreeze and SCA

NOTICE
Commercial Heavy-Duty Coolant which contains Amine as part of the corrosion protection system must not be used.

NOTICE
Never operate an engine without water temperature regulators in the cooling system. Water temperature regulators help to maintain the engine coolant at the correct operating temperature. Cooling system problems can develop without water temperature regulators.

Check the antifreeze (glycol concentration) in order to ensure adequate protection against boiling or freezing. Perkins recommends the use of a refractometer for checking the glycol concentration. A hydrometer should not be used.

Perkins engine cooling systems should be tested at 500 hour intervals for the concentration of SCA.

Additions of SCA are based on the results of the test. An SCA that is liquid may be needed at 500 hour intervals.

Adding the SCA to Heavy-Duty Coolant at the Initial Fill

Use the equation that is in Table 14 to determine the amount of SCA that is required when the cooling system is initially filled.

Table 14

Equation For Adding The SCA To The Heavy-Duty Coolant At The Initial Fill
$V \times 0.045 = X$
V is the total volume of the cooling system.
X is the amount of SCA that is required.

Table 15 is an example for using the equation that is in Table 14 .

Table 15

Example Of The Equation For Adding The SCA To The Heavy-Duty Coolant At The Initial Fill		
Total Volume of the Cooling System (V)	**Multiplication Factor**	**Amount of SCA that is Required (X)**
15 L (4 US gal)	× 0.045	0.7 L (24 oz)

Adding The SCA to The Heavy-Duty Coolant For Maintenance

Heavy-duty antifreeze of all types REQUIRE periodic additions of an SCA.

Test the antifreeze periodically for the concentration of SCA. For the interval, refer to the Operation and Maintenance Manual, “Maintenance Interval Schedule” (Maintenance Section). Cooling System Supplemental Coolant Additive (SCA) Test/Add.

Additions of SCA are based on the results of the test. The size of the cooling system determines the amount of SCA that is needed.

Use the equation that is in Table 16 to determine the amount of SCA that is required, if necessary:

Table 16

Equation For Adding The SCA To The Heavy-Duty Coolant For Maintenance
V × 0.014 = X
V is the total volume of the cooling system.
X is the amount of SCA that is required.

Table 17 is an example for using the equation that is in Table 16 .

Table 17

Example Of The Equation For Adding The SCA To The Heavy-Duty Coolant For Maintenance		
Total Volume of the Cooling System (V)	**Multiplication Factor**	**Amount of SCA that is Required (X)**
15 L (4 US gal)	× 0.014	0.2 L (7 oz)

Cleaning the System of Heavy-Duty Antifreeze

- Clean the cooling system after used coolant is drained or before the cooling system is filled with new coolant.
- Clean the cooling system whenever the coolant is contaminated or whenever the coolant is foaming.

Maintenance Recommendations

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System Pressure Release

Coolant System

WARNING

Pressurized system: Hot coolant can cause serious burn. To open cap, stop engine, wait until radiator is cool. Then loosen cap slowly to relieve the pressure.

The engine can have the ability to auto start. Ensure that the power supply is isolated before any service or repair is performed.

To relieve the pressure from the coolant system, turn off the engine. Allow the cooling system pressure cap to cool. Remove the cooling system pressure cap slowly in order to relieve pressure.

Fuel System

To relieve the pressure from the fuel system, turn off the engine.

High Pressure Fuel Lines

WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

The high pressure fuel lines are the fuel lines that are between the high pressure fuel pump and the high pressure fuel manifold and the fuel lines that are between the fuel manifold and cylinder head. These fuel lines are different from fuel lines on other fuel systems.

This is because of the following differences:

- The high pressure fuel lines are constantly charged with high pressure.
- The internal pressures of the high pressure fuel lines are higher than other types of fuel system.

Before any service or repair is performed on the engine fuel lines, perform the following tasks:

1. Stop the engine.

2. Wait for 10 minutes.

Do not loosen the high pressure fuel lines in order to remove air from the fuel system.

Engine Oil

To relieve pressure from the lubricating system, turn off the engine.

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Welding on Engines with Electronic Controls

NOTICE

Because the strength of the frame may decrease, some manufacturers do not recommend welding onto a chassis frame or rail. Consult the OEM of the equipment or your Perkins dealer regarding welding on a chassis frame or rail.

Proper welding procedures are necessary in order to avoid damage to the engines ECM, sensors, and associated components. When possible, remove the component from the unit and then weld the component. If removal of the component is not possible, the following procedure must be followed when you weld on a unit equipped with an Electronic Engine. The following procedure is considered to be the safest procedure to weld on a component. This procedure should provide a minimum risk of damage to electronic components.

NOTICE

Do not ground the welder to electrical components such as the ECM or sensors. Improper grounding can cause damage to the drive train bearings, hydraulic components, electrical components, and other components.

Clamp the ground cable from the welder to the component that will be welded. Place the clamp as close as possible to the weld. This will help reduce the possibility of damage.

Note: Perform the welding in areas that are free from explosive hazards.

1. Stop the engine. Turn the switched power to the OFF position.

2. Ensure that the fuel supply to the engine is turned off.

3. Disconnect the negative battery cable from the battery. If a battery disconnect switch is provided, open the switch.

4. Disconnect all electronic components from the wiring harnesses. Include the following components:

- Electronic components for the driven equipment
- ECM
- Sensors
- Electronically controlled valves
- Relays
- Aftertreatment ID module

NOTICE
Do not use electrical components (ECM or ECM sensors) or electronic component grounding points for grounding the welder.

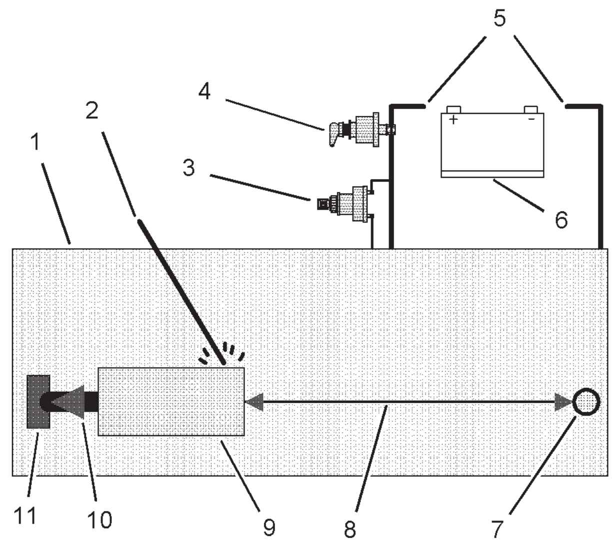

Illustration 43 g01075639

Use the example above. The current flow from the welder to the ground clamp of the welder will not damage any associated components.

(1) Engine
(2) Welding electrode
(3) Keyswitch in the OFF position
(4) Battery disconnect switch in the open position
(5) Disconnected battery cables
(6) Battery
(7) Electrical/Electronic component
(8) Minimum distance between the component that is being welded and any electrical/electronic component
(9) The component that is being welded
(10) Current path of the welder
(11) Ground clamp for the welder

5. Connect the welding ground cable directly to the part that will be welded. Place the ground cable as close as possible to the weld in order to reduce the possibility of welding current damage to the following components. Bearings, hydraulic components, electrical components, and ground straps.

Note: If electrical/electronic components are used as a ground for the welder, or electrical/electronic components are located between the welder ground and the weld, current flow from the welder could severely damage the component.

6. Protect the wiring harness from welding debris and spatter.

7. Use standard welding practices to weld the materials.

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Severe Service Application

Severe service is the application of an engine that exceeds the current published standards for that engine. Perkins maintains standards for the following engine parameters:

- Performance such as power range, speed range, and fuel consumption
- Fuel quality
- Operational Altitude
- Maintenance intervals
- Oil selection and maintenance
- Coolant type and maintenance
- Environmental qualities
- Installation
- The temperature of the fluid in the engine

Refer to the standards for the engine or consult your Perkins dealer or your Perkins distributor in order to determine if the engine is operating within the defined parameters.

Severe service operation can accelerate component wear. Engines that operate under severe conditions may need more frequent maintenance intervals in order to ensure maximum reliability and retention of full service life.

Due to individual applications, it is not possible to identify all of the factors which can contribute to severe service operation. Consult your Perkins dealer or your Perkins distributor for the unique maintenance that is necessary for the engine.

The operating environment, incorrect operating procedures, and incorrect maintenance procedures can be factors which contribute to a severe service application.

Environmental Factors

Ambient temperatures – The engine may be exposed to extended operation in cold environments or hot environments. Valve components can be damaged by carbon buildup if the engine is frequently started and stopped in cold temperatures. Hot intake air reduces engine performance.

Quality of the air – The engine may be exposed to extended operation in an environment that is dirty or dusty, unless the equipment is cleaned regularly. Mud, dirt, and dust can encase components. Maintenance can be difficult. The buildup can contain corrosive chemicals.

Buildup – Compounds, elements, corrosive chemicals, and salt can damage some components.

Altitude – Problems can arise when the engine is operated at altitudes that are higher than the intended settings for that application. Necessary adjustments should be made.

Incorrect Operating Procedures

- Extended operation at low idle
- Frequent hot shutdowns
- Operating at excessive loads
- Operating at excessive speeds
- Operating outside the intended application

Incorrect Maintenance Procedures

- Extending the maintenance intervals
- Failure to use recommended fuel, lubricants, and coolant/antifreeze

i05325425

Maintenance Interval Schedule

When Required

Daily

Every Week

Every 50 Service Hours or Weekly

Every 50 Service Hours or Monthly

Every 500 Service Hours

Every 500 Service Hours or 1 Year

Every 1000 Service Hours

Every 1500 Service Hours

Every 2000 Service Hours

Every 3000 Service Hours

Every 3000 Service Hours or 2 Years

Every 4000 Service Hours

Every 6000 Service Hours or 3 Years

Every 12 000 Service Hours or 6 Years

Commissioning

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Aftercooler Core - Clean/Test (Air-To-Air Aftercooler)

The air-to-air aftercooler is OEM installed in many applications. Please refer to the OEM specifications for information that is related to the aftercooler.

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Aftercooler Core - Inspect

Note: Adjust the frequency of cleaning according to the effects of the operating environment.

Inspect the aftercooler for these items: damaged fins, corrosion, dirt, grease, insects, leaves, oil and other debris. Clean the aftercooler, if necessary.

For air-to-air aftercoolers, use the same methods that are used for cleaning radiators.

WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.

After cleaning, start the engine and accelerate the engine to high idle rpm. This will help in the removal of debris and drying of the core. Stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning, if necessary.

Inspect the fins for damage. Bent fins may be opened with a “comb”.

Note: If parts of the aftercooler system are repaired or replaced, a leak test is highly recommended.

Inspect these items for good condition: Welds, mounting brackets, air lines, connections, clamps and seals. Make repairs, if necessary.

i02322311

Alternator - Inspect

Perkins recommends a scheduled inspection of the alternator. Inspect the alternator for loose connections and correct battery charging. Check the ammeter (if equipped) during engine operation in order to ensure correct battery performance and/or correct performance of the electrical system. Make repairs, as required.

Check the alternator and the battery charger for correct operation. If the batteries are correctly charged, the ammeter reading should be very near zero. All batteries should be kept charged. The batteries should be kept warm because temperature affects the cranking power. If the battery is too cold, the battery will not crank the engine. When the engine is not run for long periods of time or if the engine is run for short periods, the batteries may not fully charge. A battery with a low charge will freeze more easily than a battery with a full charge.

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Alternator and Fan Belts - Replace

1. Remove the guard that covers the alternator. Refer to the Original Equipment Manufacture (OEM) for the correct procedure.

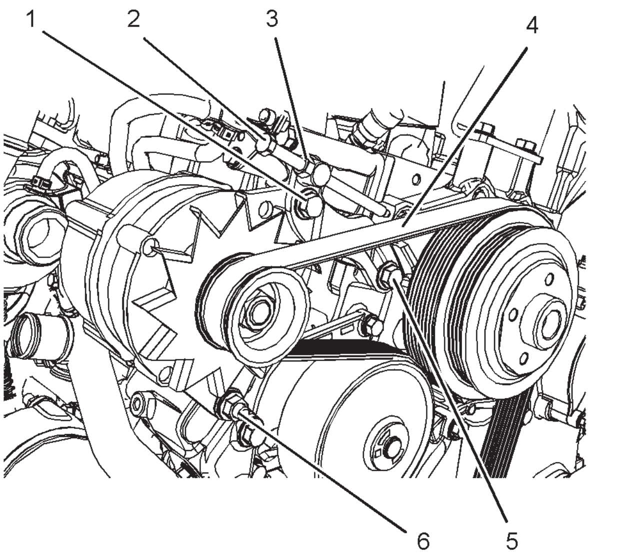

Illustration 44 g02729648

2. Loosen bolt (5) and loosen nut and bolt 6. Also, loosen nut and bolt (1).

3. Loosen nut (3) and turn screw (2) counter clockwise. Turn the screw (2) in order to give clearance to remove the belt (4).

4. Remove belt (4) and visually check all pulleys that the belt operates. Ensure that all pulleys are clean and free from damage. Ensure that the pulleys rotate freely. Replace any component that is damaged.

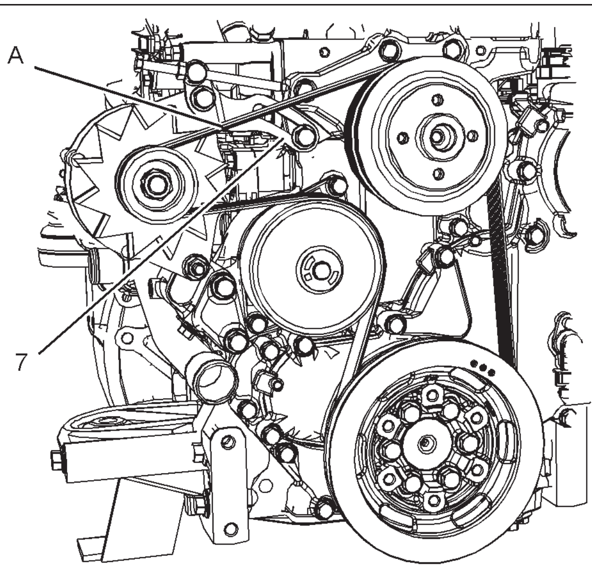

Illustration 45 g02603591

(A) Belt configuration

5. Install the new belt, use belt configuration (A). Visually check that the belt is correctly aligned.

6. Turn the screw (2) clockwise in order to tension the belt. Ensure that the link adjuster (7) is at the maximum extension, refer to illustration 45 .

7. Tighten bolt (5), nut, and bolt (6) and tighten nut and bolt (1). Tighten these nuts and bolts to 50 N·m (37 lb ft).

8. Rotate bolt (2) counter clockwise two complete revolutions and tighten nut (3) to 30 N·m (22 lb ft).

9. Install the guard, refer to OEM for more information.

i03559623

Battery - Replace

WARNING

Batteries give off combustible gases which can explode. A spark can cause the combustible gases to ignite. This can result in severe personal injury or death.

Ensure proper ventilation for batteries that are in an enclosure. Follow the proper procedures in order to help prevent electrical arcs and/or sparks near batteries. Do not smoke when batteries are serviced.

WARNING

The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

1. Switch the engine to the OFF position. Remove all electrical loads.

2. Turn off any battery chargers. Disconnect any battery chargers.

3. Ensure that the battery disconnect switch is in the OFF position.

4. Disconnect the NEGATIVE “-” cable from the NEGATIVE “-” battery terminal.

5. Disconnect the POSITIVE "+" cable from the POSITIVE "+" battery terminal.

Note: Always recycle a battery. Never discard a battery. Dispose of used batteries to an appropriate recycling facility.

6. Remove the used battery.

7. Install the new battery.

Note: Before the cables are connected, ensure that the battery disconnect switch is in the OFF position.

8. Connect the POSITIVE "+" cable to the POSITIVE "+" battery terminal.

9. Connect the NEGATIVE "-" cable to the NEGATIVE "-" battery terminal.

10. Turn the battery disconnect switch to the ON position.

i02747977

Battery Electrolyte Level - Check

When the engine is not run for long periods of time or when the engine is run for short periods, the batteries may not fully recharge. Ensure a full charge in order to help prevent the battery from freezing. If batteries are correctly charged, the ammeter reading should be very near zero, when the engine is in operation.

⚠ WARNING

All lead-acid batteries contain sulfuric acid which can burn the skin and clothing. Always wear a face shield and protective clothing when working on or near batteries.

1. Remove the filler caps. Maintain the electrolyte level to the "FULL" mark on the battery.

   If the addition of water is necessary, use distilled water. If distilled water is not available use clean water that is low in minerals. Do not use artificially softened water.

2. Check the condition of the electrolyte with a suitable battery tester.

3. Install the caps.

4. Keep the batteries clean.

   Clean the battery case with one of the following cleaning solutions:

   - Use a solution of 0.1 kg (0.2 lb) baking soda and 1 L (1 qt) of clean water.
   - Use a solution of ammonium hydroxide .

   Thoroughly rinse the battery case with clean water.

i02323088

Battery or Battery Cable - Disconnect

⚠ WARNING

The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

1. Turn the start switch to the OFF position. Turn the ignition switch (if equipped) to the OFF position and remove the key and all electrical loads.

2. Disconnect the negative battery terminal. Ensure that the cable cannot contact the terminal. When four 12 volt batteries are involved, two negative connection must be disconnected.

3. Remove the positive connection.

4. Clean all disconnected connection and battery terminals.

5. Use a fine grade of sandpaper to clean the terminals and the cable clamps. Clean the items until the surfaces are bright or shiny. DO NOT remove material excessively. Excessive removal of material can cause the clamps to not fit correctly. Coat the clamps and the terminals with a suitable silicone lubricant or petroleum jelly.

6. Tape the cable connections in order to help prevent accidental starting.

7. Proceed with necessary system repairs.

8. In order to connect the battery, connect the positive connection before the negative connector.

i05326349

Coolant (Commercial Heavy-Duty) - Change

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to Local regulations and mandates.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Clean the cooling system and flush the cooling system before the recommended maintenance interval if the following conditions exist:

- The engine overheats frequently.
- Foaming of the coolant is observed.
- The oil has entered the cooling system and the coolant is contaminated.
- The fuel has entered the cooling system and the coolant is contaminated.

Note: When the cooling system is cleaned, only clean water is needed.

NOTICE
When any servicing or repair of the engine cooling system is performed, the procedure must be performed with the engine on level ground. This action will allow you to check accurately the coolant level. This action will also help in avoiding the risk of introducing an air lock into the coolant system.

Drain

WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

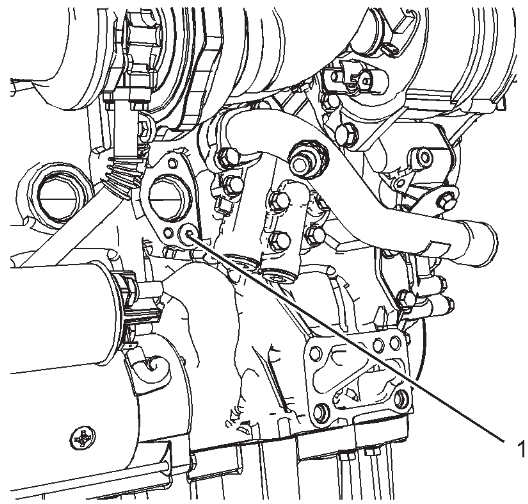

Illustration 46 g02513896

Typical example

2. Remove the drain plug (1) on the engine. Also, open drain cock or remove the drain plug on the radiator.

Allow the coolant to drain.

NOTICE
Dispose of used engine coolant or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Perkins to reclaim the coolant.

For information regarding the disposal and the recycling of used coolant, consult your Perkins dealer or your Perkins distributor.

Flush

1. Flush the cooling system with clean water in order to remove any debris.

2. Install the drain plug on the engine. Close the drain cock or install the drain plug on the radiator.

NOTICE
Do not fill the cooling system faster than 5 L (1.3 US gal) per minute, in order to avoid air locks.

Cooling system air locks may result in engine damage.

3. Fill the cooling system with clean water. Install the cooling system filler cap.

4. Start and run the engine at low idle until the temperature reaches 49 to 66 °C (120 to 150 °F).

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Remove the drain plug on the engine. Open the drain cock or remove the drain plug on the radiator. Allow the water to drain. Flush the cooling system with clean water.

Fill

1. Install the drain plug on the engine. Close the drain cock or install the drain plug on the radiator.

NOTICE
Do not fill the cooling system faster than 5 L (1.3 US gal) per minute, in order to avoid air locks.

Cooling system air locks may result in engine damage.

2. Fill the cooling system with Commercial Heavy-Duty Coolant. Add Supplemental Coolant Additive to the coolant. For the correct amount, refer to the Operation and Maintenance Manual, “Fluid Recommendations” topic (Maintenance Section) for more information on cooling system specifications. Do not install the cooling system filler cap.

3. Start and run the engine at low idle. Increase the engine rpm to high idle. Operate the engine in order to open the engine thermostat. This operation will allow any air in the system to be purged. Decrease the engine speed to low idle. Stop the engine.

4. Maintain the coolant level at the maximum mark that is correct for your application.

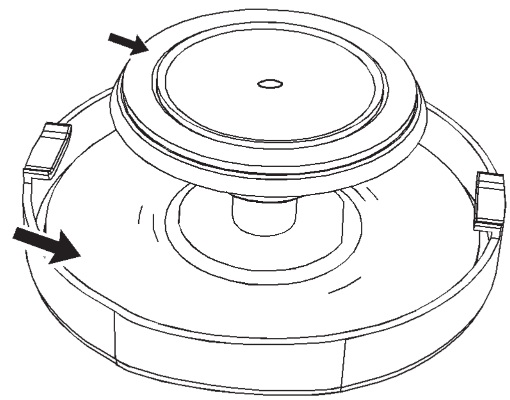

Illustration 47 g02590196

Filler cap

5. Clean the cooling system filler cap and inspect the gasket. If the gasket is damaged, discard the old filler cap and install a new filler cap. If the gasket is not damaged, use a suitable pressurizing pump in order to pressure test the filler cap. The correct pressure is stamped on the face of the filler cap. If the filler cap does not retain the correct pressure, install a new filler cap.

6. Start the engine. Inspect the cooling system for leaks and for correct operating temperature.

i05326371

Coolant (ELC) - Change

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to Local regulations and mandates.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Clean the cooling system and flush the cooling system before the recommended maintenance interval if the following conditions exist:

- The engine overheats frequently.
- Foaming of the coolant is observed.
- The oil has entered the cooling system and the coolant is contaminated.
- The fuel has entered the cooling system and the coolant is contaminated.

Note: When the cooling system is cleaned, only clean water is needed when the ELC is drained and replaced.

Note: Inspect the water pump and the water temperature regulator after the cooling system has been drained. This inspection can be a good opportunity to replace the water pump, the water temperature regulator, and the hoses, if necessary.

NOTICE
When any servicing or repair of the engine cooling system is performed, the procedure must be performed with the engine on level ground. Level ground will allow you to check accurately the coolant level. This check will also help in avoiding the risk of introducing an air lock into the coolant system.

Drain

WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

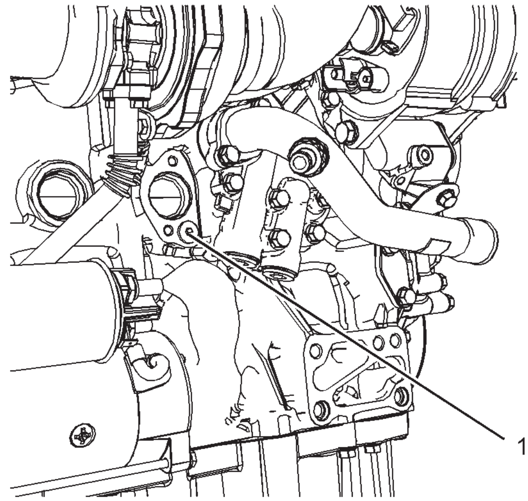

Illustration 48 g02513896

Typical example

2. Remove the drain plug (1) on the engine. Also, open the drain cock or remove the drain plug on the radiator.

Allow the coolant to drain.

NOTICE
Dispose of used engine coolant or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Perkins to reclaim the coolant.

For information regarding the disposal and the recycling of used coolant, consult your Perkins dealer or your Perkins distributor.

Flush

1. Flush the cooling system with clean water in order to remove any debris.

2. Install the drain plug in the engine. Close the drain cock or install the drain plug on the radiator.

NOTICE
Do not fill the cooling system faster than 5 L (1.3 US gal) per minute, in order to avoid air locks.

Cooling system air locks may result in engine damage.

3. Fill the cooling system with clean water. Install the cooling system filler cap.

4. Start and run the engine at low idle until the temperature reaches 49 to 66 °C (120 to 150 °F).

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Remove the drain plug on the engine. Open the drain cock or remove the drain plug on the radiator. Allow the water to drain. Flush the cooling system with clean water.

Fill

1. Install the drain plug on the engine. Close the drain cock or install the drain plug on the radiator.

NOTICE

Do not fill the cooling system faster than 5 L (1.3 US gal) per minute, in order to avoid air locks.

Cooling system air locks may result in engine damage.

2. Fill the cooling system with Extended Life Coolant (ELC). Refer to the Operation and Maintenance Manual, “Fluid Recommendations” topic (Maintenance Section) for more information on cooling system specifications. Do not install the cooling system filler cap.

3. Start and run the engine at low idle. Increase the engine rpm to high idle. Operate the engine in order to open the engine thermostat. This procedure will allow any air in the system to be purged. Decrease the engine speed to low idle. Stop the engine.

4. Maintain the coolant level at the maximum mark that is correct for your application.

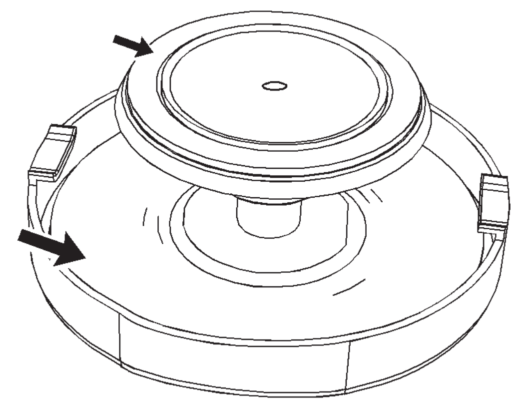

Illustration 49 g02590196

Filler cap

5. Clean the cooling system filler cap and inspect the gasket. If the gasket is damaged, discard the old filler cap and install a new filler cap. If the gasket is not damaged, use a suitable pressurizing pump in order to pressure test the filler cap. The correct pressure is stamped on the face of the filler cap. If the filler cap does not retain the correct pressure, install a new filler cap.

6. Start the engine. Inspect the cooling system for leaks and for correct operating temperature.

i05197396

Coolant Extender (ELC) - Add

In order for Perkins ELC to achieve 12000 hours an extender must be added at 6000 hours. For a suitable extender, contact your Perkins dealer or Perkins distributor.

i05149389

Coolant Level - Check

Engines With a Coolant Recovery Tank

Note: The cooling system may not have been provided by Perkins . The procedure that follows is for typical cooling systems. Refer to the OEM information for the correct procedures.

Check the coolant level when the engine is stopped and cool.

NOTICE
When any servicing or repair of the engine cooling system is performed, the procedure must be performed with the engine on level ground. Level ground will allow you to check accurately the coolant level. This checking will also help in avoiding the risk of introducing an air lock into the coolant system.

1. Observe the coolant level in the coolant recovery tank. Maintain the coolant level to “COLD FULL” mark on the coolant recovery tank.

WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

2. Loosen filler cap slowly in order to relieve any pressure. Remove the filler cap.

3. Pour the correct coolant mixture into the tank. Refer to the Operation and Maintenance Manual, “Refill Capacities and Recommendations” for information on the correct mixture and type of coolant. Refer to the Operation and Maintenance Manual, “Refill Capacities and Recommendations” for the engine cooling system capacity. Do not fill the coolant recovery tank above “COLD FULL” mark.

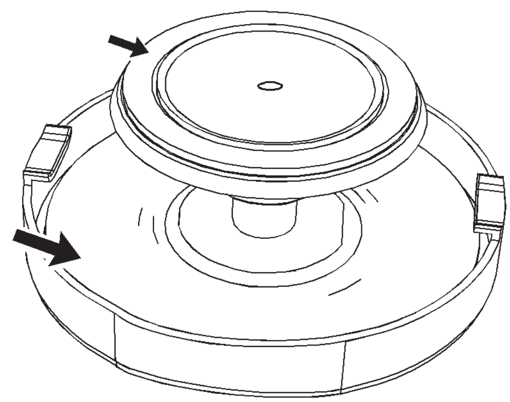

Illustration 50 g02590196
Filler cap

4. Clean the filler cap and the receptacle. Reinstall the filler cap and inspect the cooling system for leaks.

Note: The coolant will expand as the coolant heats up during normal engine operation. The additional volume will be forced into the coolant recovery tank during engine operation. When the engine is stopped and cool, the coolant will return to the engine.

Engines Without a Coolant Recovery Tank

Check the coolant level when the engine is stopped and cool.

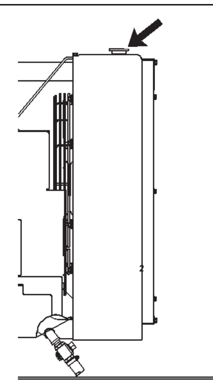

Illustration 51 g00285520
Cooling system filler cap

WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Remove the cooling system filler cap slowly in order to relieve pressure.
2. Maintain the coolant level at the maximum mark that is correct for your application. If the engine is equipped with a sight glass, maintain the coolant level to the correct level in the sight glass.
3. Clean the cooling system filler cap and inspect the gasket. If the gasket is damaged, discard the old filler cap and install a new filler cap. If the gasket is not damaged, use a suitable pressurizing pump in order to pressure test the filler cap. The correct pressure is stamped on the face of the filler cap. If the filler cap does not retain the correct pressure, install a new filler cap.
4. Inspect the cooling system for leaks.

i03644948

Cooling System Supplemental Coolant Additive (SCA) - Test/Add

WARNING

Cooling system coolant additive contains alkali. To help prevent personal injury, avoid contact with the skin and the eyes. Do not drink cooling system coolant additive.

Test for SCA Concentration

Heavy-Duty Coolant/Antifreeze and SCA

NOTICE

Do not exceed the recommended six percent supplemental coolant additive concentration.

Use a Coolant Conditioner Test Kit in order to check the concentration of the SCA.

Add the SCA, If Necessary

NOTICE

Do not exceed the recommended amount of supplemental coolant additive concentration. Excessive supplemental coolant additive concentration can form deposits on the higher temperature surfaces of the cooling system, reducing the engine's heat transfer characteristics. Reduced heat transfer could cause cracking of the cylinder head and other high temperature components. Excessive supplemental coolant additive concentration could also result in radiator tube blockage, overheating, and/or accelerated water pump seal wear. Never use both liquid supplemental coolant additive and the spin-on element (if equipped) at the same time. The use of those additives together could result in supplemental coolant additive concentration exceeding the recommended maximum.

WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

NOTICE

When any servicing or repair of the engine cooling system is performed the procedure must be performed with the engine on level ground. This will allow you to accurately check the coolant level. This will also help in avoiding the risk of introducing an air lock into the coolant system.

1. Slowly loosen the cooling system filler cap in order to relieve the pressure. Remove the cooling system filler cap.

Note: Always discard drained fluids according to local regulations.

2. If necessary, drain some coolant from the cooling system into a suitable container in order to allow space for the extra SCA.
3. Add the correct amount of SCA. Refer to the Operation and Maintenance Manual, “Refill Capacities and Recommendations” for more information on SCA requirements.

4. Clean the cooling system filler cap and inspect the gasket. If the gasket is damaged, discard the old filler cap and install a new filler cap. If the gasket is not damaged, use a suitable pressurizing pump in order to pressure test the filler cap. The correct pressure is stamped on the face of the filler cap. If the filler cap does not retain the correct pressure, install a new filler cap.

i04650530

Diesel Particulate Filter - Clean

WARNING

Wear goggles, gloves, protective clothing, and a National Institute for Occupational Safety and Health (NIOSH) approved P95 or N95 half-face respirator when handling a used Diesel Particulate Filter or Catalytic Converter Muffler. Failure to do so could result in personal injury.

WARNING

The muffler, catalytic converter/muffler, and diesel particulate filter will become extremely hot during engine operation. A hot muffler, catalytic converter/muffler and diesel particulate filter can cause serious burns. Allow adequate cooling time before working on or near the muffler, catalytic converter/muffler and diesel particulate filter.

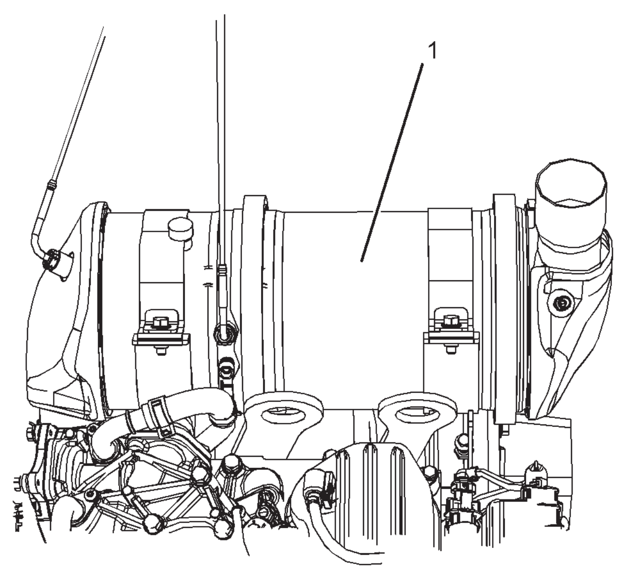

Illustration 52 g02524596

Typical example

Note: Only the wall flow type of aftertreatment requires a service period, in order to remove the ash. The wall flow aftertreatment uses active regeneration in order to remove soot.

For information on removal of the (1) diesel particulate filter, refer to Disassembly and Assembly, "DPF - Remove". Also, refer to System Operation Testing and Adjusting, "Diesel Particulate Filter - Clean".

i02151646

Driven Equipment - Check

Refer to the OEM specifications for more information on the following maintenance recommendations for the driven equipment:

- Inspection
- Adjustment
- Lubrication
- Other maintenance recommendations

Perform any maintenance for the driven equipment which is recommended by the OEM.

i03991933

Engine - Clean

WARNING

Personal injury or death can result from high voltage.

Moisture can create paths of electrical conductivity.

Make sure that the electrical system is OFF. Lock out the starting controls and tag the controls "DO NOT OPERATE" .

NOTICE

Accumulated grease and oil on an engine is a fire hazard. Keep the engine clean. Remove debris and fluid spills whenever a significant quantity accumulates on the engine.

Periodic cleaning of the engine is recommended. Steam cleaning the engine will remove accumulated oil and grease. A clean engine provides the following benefits:

- Easy detection of fluid leaks
- Maximum heat transfer characteristics
- Ease of maintenance

Note: Caution must be used in order to prevent electrical components from being damaged by excessive water when the engine is cleaned. Pressure washers and steam cleaners should not be directed at any electrical connectors or the junction of cables into the rear of the connectors. Avoid electrical components such as the alternator, the starter, and the ECM. Protect the fuel injection pump from fluids in order to wash the engine.

Aftertreatment

During the engine cleaning process, ensure that water or cleaning fluids cannot enter the aftertreatment system. If cleaning fluids enters the aftertreatment system, damage could occur.

i04150591

Engine Air Cleaner Element (Single Element) - Inspect/Clean/Replace

Refer to Operation and Maintenance Manual, "Engine Air Cleaner Service Indicator-Inspect".

NOTICE
Never run the engine without an air cleaner element installed. Never run the engine with a damaged air cleaner element. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaner elements help to prevent airborne debris from entering the air inlet.

NOTICE
Never service the air cleaner element with the engine running since this will allow dirt to enter the engine.

A wide variety of air cleaners may be installed for use with this engine. Consult the OEM information for the correct procedure to replace the air cleaner.

i02335405

Engine Air Cleaner Service Indicator - Inspect

Some engines may be equipped with a different service indicator.

Some engines are equipped with a differential gauge for inlet air pressure. The differential gauge for inlet air pressure displays the difference in the pressure that is measured before the air cleaner element and the pressure that is measured after the air cleaner element. As the air cleaner element becomes dirty, the pressure differential rises. If your engine is equipped with a different type of service indicator, follow the OEM recommendations in order to service the air cleaner service indicator.

The service indicator may be mounted on the air cleaner element or in a remote location.

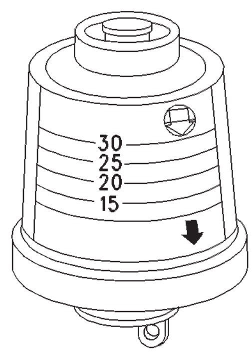

Illustration 53 g00103777
Typical service indicator

Observe the service indicator. The air cleaner element should be cleaned or the air cleaner element should be replaced when one of the following conditions occur:

- The yellow diaphragm enters the red zone.
- The red piston locks in the visible position.

Test the Service Indicator

Service indicators are important instruments.

- Check for ease of resetting. The service indicator should reset in less than three pushes.
- Check the movement of the yellow core when the engine is accelerated to the engine rated speed. The yellow core should latch at the greatest vacuum that is attained.

If the service indicator does not reset easily, or if the yellow core does not latch at the greatest vacuum, the service indicator should be replaced. If the new service indicator will not reset, the hole for the service indicator may be restricted.

The service indicator may need to be replaced frequently in environments that are severely dusty.

i02343354

Engine Air Precleaner - Check/ Clean

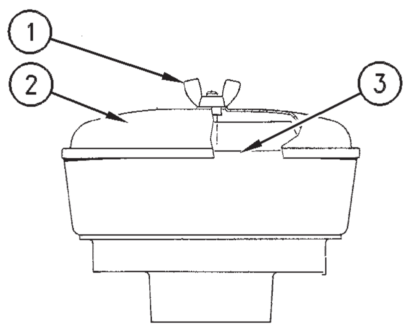

Illustration 54 g00287039

Typical example

(1) Wing nut
(2) Cover
(3) Body

Remove wing nut (1) and cover (2). Check for an accumulation of dirt and debris in body (3). Clean the body, if necessary.

After cleaning the precleaner, install cover (2) and wing nut (1).

Note: When the engine is operated in dusty applications, more frequent cleaning is required.

i04725716

Engine Crankcase Breather Element - Replace

⚠ WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Engine Breather

NOTICE

Ensure that the engine is stopped before any servicing or repair is performed.

The crankcase breather is a very important component in order to keep your engine emissions compliant .

- The filter element within the crankcase breather must be serviced at the prescribed service interval.
- The correct filter element must be installed before the engine is operated.
- The installation of the filter element is very important .
- The quality of the filter element that is installed is very important.
- The filter element protects the engine from excessive quantities of oil from entering the induction system. The filter element also protects the engine aftertreatment system.

Note: Excessive quantities of oil that enter the induction system of the engine can rapidly increase the engine speed without control.

Remove the Breather Element

1. Remove the guard that covers the engine breather, refer to the Original Equipment Manufacture (OEM) for more information.

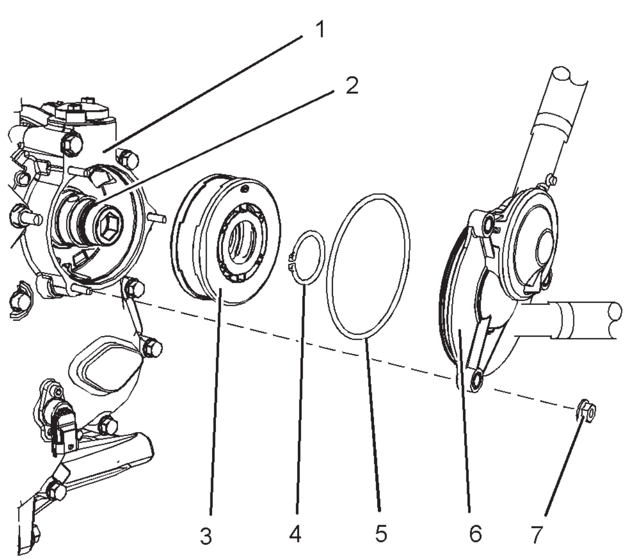

Illustration 55 g02827199

Typical example

2. If necessary, remove breather pipes on cover (6). Remove nuts (7) and remove cover (6) from housing (1).

3. Remove circlip (4) and remove the breather element (3) and discard.

4. Remove the O ring seal (5) from the cover.

Install the Breather Element

Ensure that all the components are clean and free from damage.

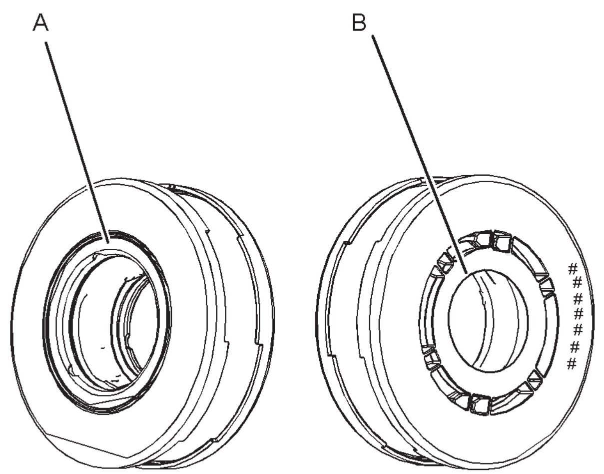

Illustration 56 g02827300

Typical example

(A) Diameter
(B) Diameter

1. Install a new O ring seal (5) onto the cover (6).

Note: The breather element must have the correct orientation before installation. Diameter (A) is visibly larger than diameter (B).

2. Install diameter (A) of the breather element (3) onto the shaft (2). When correctly installed the part number of the breather element will be visible.

3. Install circlip (4) and cover (6). Install nuts (7) and tighten to 25 N·m (18 lb ft). If necessary, install breather pipes to cover.

4. Install the guard, refer to OEM.

i02323089

Engine Mounts - Inspect

Note: The engine mounts may not have been supplied by Perkins . Refer to the OEM information for further information on the engine mounts and the correct bolt torque.

Inspect the engine mounts for deterioration and for correct bolt torque. Engine vibration can be caused by the following conditions:

- Incorrect mounting of the engine
- Deterioration of the engine mounts
- Loose engine mounts

Any engine mount that shows deterioration should be replaced. Refer to the OEM information for the recommended torques.

i04728471

Engine Oil Level - Check

WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Illustration 57 g02829378

Typical example

NOTICE
Perform this maintenance with the engine stopped.

Note: Ensure that the engine is either level or that the engine is in the normal operating position in order to obtain a true level indication.

Note: After the engine has been switched OFF, wait for 10 minutes in order to allow the engine oil to drain to the oil pan before checking the oil level.

1. Maintain the oil level between the MIN mark and the mark MAX on the engine oil dipstick. Do not fill the crankcase above the MAX mark.

NOTICE

Operating your engine when the oil level is above the MAX mark could cause your crankshaft to dip into the oil. The air bubbles created from the crankshaft dipping into the oil reduces the oils lubricating characteristics and could result in the loss of power.

2. Remove the oil filler cap and add oil, if necessary. Clean the oil filler cap. Install the oil filler cap.

If an increase in the oil level is noticed, refer to Troubleshooting, “Oil Contains Fuel”.

i01907674

Engine Oil Sample - Obtain

The condition of the engine lubricating oil may be checked at regular intervals as part of a preventive maintenance program. Perkins include an oil sampling valve as an option. The oil sampling valve (if equipped) is included in order to regularly sample the engine lubricating oil. The oil sampling valve is positioned on the oil filter head or the oil sampling valve is positioned on the cylinder block.

Perkins recommends using a sampling valve in order to obtain oil samples. The quality and the consistency of the samples are better when a sampling valve is used. The location of the sampling valve allows oil that is flowing under pressure to be obtained during normal engine operation.

Obtain the Sample and the Analysis

WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

In order to help obtain the most accurate analysis, record the following information before an oil sample is taken:

- The date of the sample
- Engine model
- Engine number
- Service hours on the engine
- The number of hours that have accumulated since the last oil change
- The amount of oil that has been added since the last oil change

Ensure that the container for the sample is clean and dry. Also ensure that the container for the sample is clearly labelled.

To ensure that the sample is representative of the oil in the crankcase, obtain a warm, well mixed oil sample.

To avoid contamination of the oil samples, the tools and the supplies that are used for obtaining oil samples must be clean.

The sample can be checked for the following: the quality of the oil, the existence of any coolant in the oil, the existence of any ferrous metal particles in the oil and the existence of any nonferrous metal particles in the oil.

i05327085

Engine Oil and Filter - Change

WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

The engine oil service reset procedure must be completed after the engine oil, and filter have been changed. Refer to “Engine Oil Service Reset” for more information.

Do not drain the engine lubricating oil when the engine is cold. As the engine lubricating oil cools, suspended waste particles settle on the bottom of the oil pan. The waste particles are not removed with draining cold oil. Drain the oil pan with the engine stopped. Drain the oil pan with the oil warm. This draining method allows the waste particles that are suspended in the oil to be drained properly.

Failure to follow this recommended procedure will cause the waste particles to be recirculated through the engine lubrication system with the new oil.

Drain the Engine Lubricating Oil

Ensure that the vessel that will be used is large enough to collect the waste oil. After the engine has been run at the normal operating temperature, stop the engine. Ensure that the application that the engine is installed is on level ground. Use one of the following methods to drain the engine oil pan:

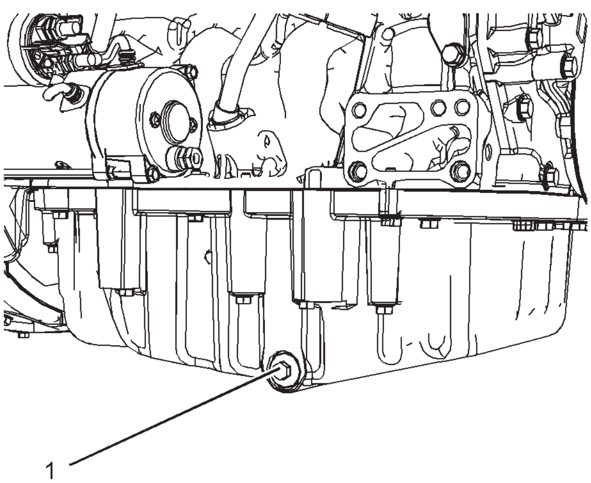

Illustration 58 g02519103

Typical example

- If the engine is equipped with a drain valve, turn the drain valve knob counterclockwise in order to drain the oil. After the oil has drained, turn the drain valve knob clockwise in order to close the drain valve.
- If the engine is not equipped with a drain valve, remove the oil drain plug (1) in order to allow the oil to drain. If the engine is equipped with a shallow oil pan, remove the bottom oil drain plugs from both ends of the oil pan.

After the oil has drained, replace the drain plug. If necessary replace the seal on the drain plug. Install drain plug and tighten to 34 N·m (25 lb ft).

Replace the Oil Filter

NOTICE

Perkins oil filters are manufactured to Perkins specifications. Use of an oil filter that is not recommended by Perkins could result in severe damage to the engine bearings, crankshaft, as a result of the larger waste particles from unfiltered oil entering the engine lubricating system. Only use oil filters recommended by Perkins .

1. Using a suitable tool remove the engine oil filter.

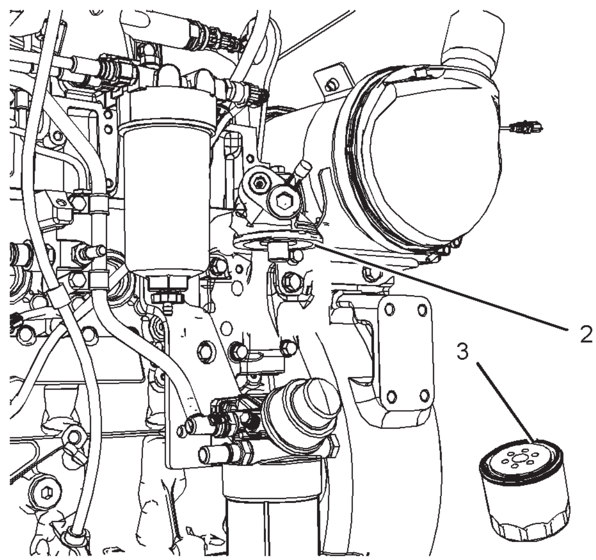

Illustration 59 g02516777

Typical example

2. Clean sealing surface (2).

3. Apply clean engine oil to O ring seal (3) on the new oil filter.

NOTICE

Do not fill the oil filters with oil before installing them. This oil would not be filtered and could be contaminated. Contaminated oil can cause accelerated wear to engine components.

4. Install the engine oil filter, spin on the oil filter until the O ring seal contacts the oil filter base. Then, rotate the oil filter ¾ of a full turn, by hand only.

Vertically Up Oil Filter

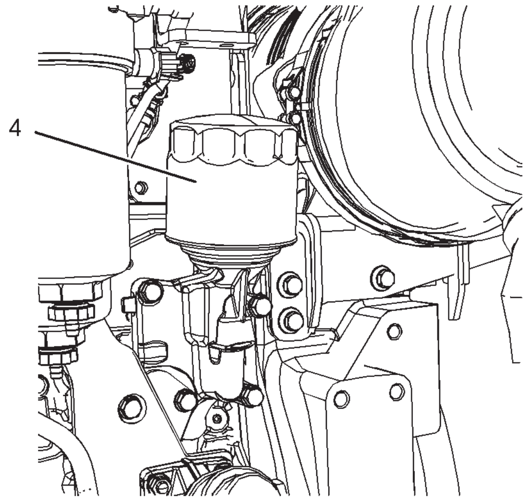

Illustration 60 g02596778

(4) Vertically up oil filter

Some oil filters may be installed vertically up. Use the same procedure in order to replace the oil filter. Ensure that all the oil has drained from the filter before removal.

Fill the Oil Pan

1. Remove the oil filler cap. Refer to this Operation and Maintenance Manual, “Fluid Recommendations” for more information on suitable oils. Fill the oil pan with the correct amount of new engine lubricating oil. Refer to this Operation and Maintenance Manual, “Refill Capacities” for more information on refill capacities.

NOTICE

If equipped with an auxiliary oil filter system or a remote filter system, follow the OEM or the filter manufactures recommendations. Under filling or over filling the crankcase with oil can cause engine damage.

2. Start the engine and run the engine at “LOW IDLE” for 2 minutes. Perform this procedure in order to ensure that the lubrication system has oil and that the oil filters are filled. Inspect the oil filter for oil leaks.

3. Stop the engine and allow the oil to drain back to the oil pan for a minimum of 10 minutes.

Illustration 61 g02829378

4. Remove the engine oil level gauge in order to check the oil level. Maintain the oil level between the MIN mark and MAX mark on the engine oil level gauge. Do not fill the crankcase above the MAX mark.

Engine Oil Service Reset

NOTICE

Failure to perform a schedule oil and filter service with an engine oil service reset will trigger an engine derate.

The low oil warning lamp has two functions. The lamp on solid will indicate that the engine has low oil pressure. The lamp flashing will indicate the engine oil and filter **MUST** be changed and the engine oil service reset **MUST** be completed. The lamp will only flash with the key in the ON position, with the engine in operation the lamp will be extinguished.

Note: If the engine oil and filter have been changed before the warning lamp has started to flash, the engine oil service reset procedure **MUST** still be completed. Upon completion of the reset procedure, the lamp will flash three times.

Some applications may have other methods in order to perform an engine oil service reset. For assistance with the engine oil service reset contact your Perkins distributor, or your OEM.

Use one of the following procedures after the engine oil and filter has been changed in order to complete an engine oil service reset:

Throttle Control Option

Note: Some application the maximum throttle position can before the throttle peddle has reached the stop. The actual maximum position of the throttle must be known before starting the procedure. With the known maximum position the middle position of the throttle can be calculated. The throttle must be positioned in the required positions for the prescribed period in order to perform an engine oil service reset.

1. Turn the keyswitch to the ON position, and wait 15 seconds, but not more than 30 seconds. Go to step 2.

2. Move the throttle to the maximum position for more than 15 seconds, but less than 30 seconds.

3. Return throttle to zero position for more than 15 seconds, but less than 30 seconds.

4. Move the throttle to the maximum position for more than 15 seconds, but less than 30 seconds.

5. Return throttle to zero position for more than 15 seconds, but less than 30 seconds.

6. Move the throttle to the middle position for more than 15 seconds, but less than 30 seconds. Return the throttle to zero position. The engine oil service reset procedure is complete. Turn the keyswitch to the OFF position.

7. On completion of the sequence, the low oil warning lamp will flash three times. Each flash will be for 1 second with a 1 second interval. This sequence of flashes indicates that the warning lamp has been reset and the engine can be started and operated normally.

8. If the procedure has been interrupted before completion, turn the power off for 20 seconds before starting again.

Multi-State Switch Option

1. Turn the keyswitch to the ON position, and wait 15 seconds, but not more than 30 seconds. Go to step 2.

2. Turn the multi-state switch to position 1 for more than 15 seconds, but less than 30 seconds.

3. Return the multi-state switch to position 0 for more than 15 seconds, but less than 30 seconds.

4. Turn the multi-state switch to position 1 for more than 15 seconds, but less than 30 seconds.

5. Return the multi-state switch to position 0 for more than 15 seconds, but less than 30 seconds

6. Turn the multi-state switch to position 1 for more than 15 seconds, but less than 30 seconds. Return the multi-state switch to position 0. The engine oil service reset procedure is complete. Turn the keyswitch to the OFF position.

7. On completion of the sequence, the low oil warning lamp will flash three times. Each flash will be for 1 second with a 1 second interval. This sequence of flashes indicates that the warning lamp has been reset and the engine can be started and operated normally.

8. If the procedure has been interrupted before completion, turn the power off for 20 seconds before starting again.

i04401341

Fan Clearance - Check

There are different types of cooling systems. Refer to the OEM for information on clearance for the fan.

Ensure that the engine is stopped. Ensure that the battery disconnect switch is in the OFF position. Ensure that the cooling system is full. The clearance between the cover (1) and the fan (2) will require checking. The gap (A) between the edge of the cover and the tip of the fan blade must be checked in four equally spaced positions.

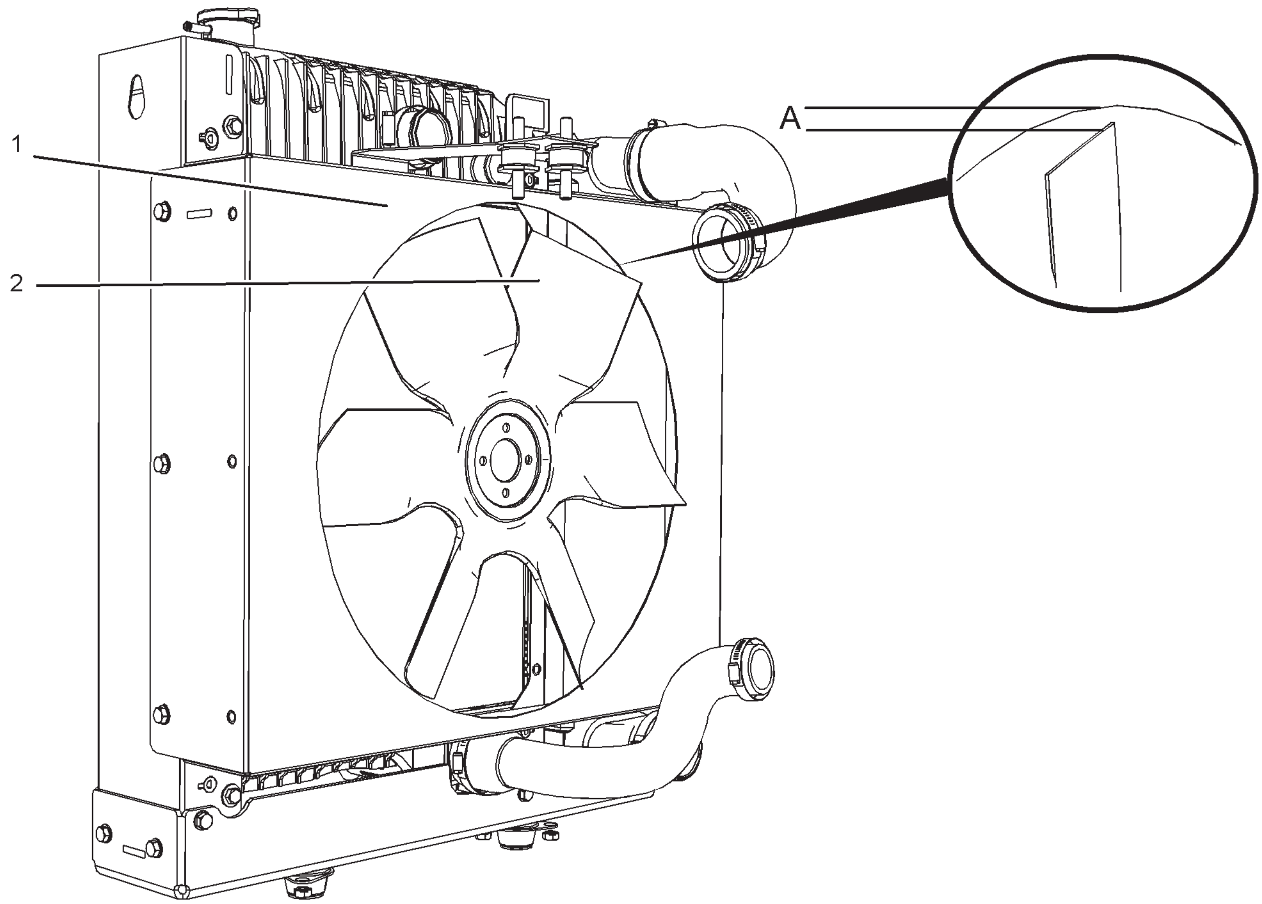

Illustration 62 g02585058

Typical example

Adjustment of the cover will change the clearance (gap) between the edge of the cover and the tip of the fan blade. Ensure that the cover is centralized to the fan.

The clearance (A) must be set to 10 ± 1 mm (0.39370 ± 0.03937 inch).

i04366913

Fuel System - Prime

Note: Refer to Systems Operation, Testing, and Adjusting, “Cleanliness of Fuel System Components” for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

Ensure that all adjustments and repairs are performed by authorized personnel that have had the correct training.

NOTICE

Do not crank the engine continuously for more than 30 seconds. Allow the starting motor to cool for two minutes before cranking the engine again.

If air enters the fuel system, the air must be purged from the fuel system before the engine can be started. Air can enter the fuel system when the following events occur:

- The fuel tank is empty or the fuel tank has been partially drained.
- The low-pressure fuel lines are disconnected.
- A leak exists in the low-pressure fuel system.
- The fuel filter has been replaced.

Use the following procedures in order to remove air from the fuel system:

1. Ensure that the fuel system is in working order. Check that the fuel supply valve (if equipped) is in the "ON" position.

2. Operate the hand priming pump. Count the number of operations of the pump. After approximately 80 depression of the pump stop.

Note: As the fuel system is primed, the pressure will increase within the fuel system and this increase in pressure can be felt during priming.

3. The fuel system should now be primed and the engine should be able to start.

4. Operate the engine starter and crank the engine. After the engine has started, operate the engine at low idle for a minimum of 5 minutes. Ensure that the fuel system is free from leaks.

Note: Operating the engine for this period will help ensure that the fuel system is free of air. **DO NOT loosen the high-pressure fuel lines in order to purge air from the fuel system. This procedure is not required.**

After the engine has stopped, you must wait for 10 minutes in order to allow the fuel pressure to be purged from the high-pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low-pressure fuel system and from the cooling, lubrication, or air systems. Replace any high-pressure fuel line that has leaked. Refer to Disassembly and Assembly Manual, "Fuel Injection Lines - Install".

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard . Refer to Operation and Maintenance Manual, "General hazard Information".

If the engine will not start, refer to Troubleshooting, "Engine Cranks but will not Start".

i05326388

Fuel System Primary Filter (Water Separator) Element - Replace

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

Note: Refer to Systems Operation, Testing, and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

NOTICE

Ensure that the engine is stopped before any servicing or repair is performed.

Remove the Element

1. Turn the fuel supply valve (if equipped) to the OFF position before performing this maintenance.

2. Place a suitable container under the water separator in order to catch any fuel that might spill. Clean up any spilled fuel. Clean the outside body of the filter assembly.

3. Make a temporary Mark (A) across the filter before the assembly is removed.

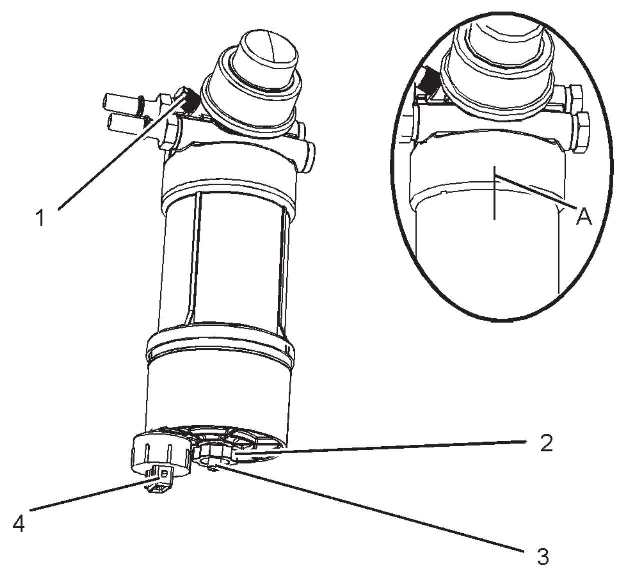

Illustration 63 g03374220

Typical example

4. Install a suitable tube onto drain (3). Open the drain valve (2). Rotate the drain valve counterclockwise. Two full turns are required. Loosen vent screw (1).

Note: Two complete rotations of the valve will release the valve from the filter element.

5. Allow the fuel to drain into the container. Remove the tube and install the valve into the filter element. Engage the threads of the valve into the filter element. Do not secure the valve.

6. Tighten the vent screw (1) securely . Remove the wiring harness from connection (4).

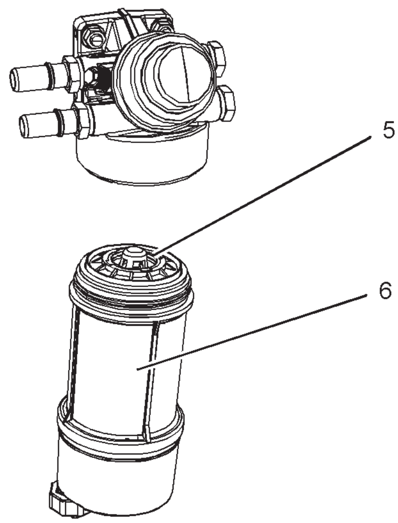

Illustration 64 g03374223

Typical example

7. Using a suitable tool, remove the filter bowl (6). Rotate the filter assembly counterclockwise in order to remove the filter assembly. Use a suitable tool in order to remove the filter assembly.

8. Rotate the filter element counterclockwise and remove the filter element (5). Clean the filter bowl.

Install the Element

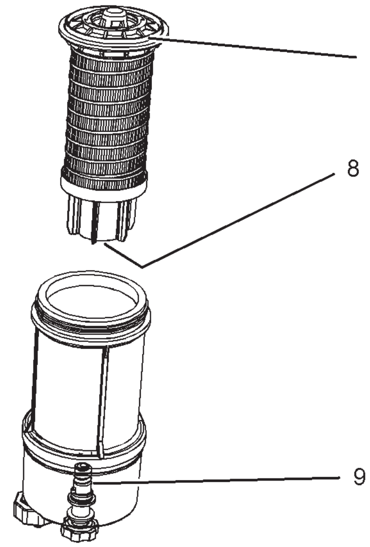

Illustration 65 g03374224

Typical example

1. Locate the thread in the filter element (8) onto the threads (9). Spin on the element. Do not tighten.

2. Lubricate the O ring seal (7) with clean engine oil. Do NOT fill the bowl with fuel before the assembly is installed.

3. Do NOT use a tool in order to install the filter assembly. Tighten the filter bowl (6) by hand. Install the filter bowl (6) and align with your temporary marks (A).

4. Tighten the valve (2) securely. Remove the container and dispose of the fuel in a safe place.

5. The secondary filter element must be replaced at the same time as the primary filter element. Refer to the Operation and Maintenance Manual, “Fuel System Filter - Replace”.

i05326334

Fuel System Primary Filter/ Water Separator - Drain

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

NOTICE

Ensure that the engine is stopped before any servicing or repair is performed.

NOTICE

The water separator can be under suction during normal engine operation. Ensure that the drain valve is tightened securely to help prevent air from entering the fuel system.

1. Place a suitable container under the water separator in order to catch any fluid that might spill. Clean up any spilled fluid.

2. Ensure that the outer body of the filter assembly is clean and free from dirt.

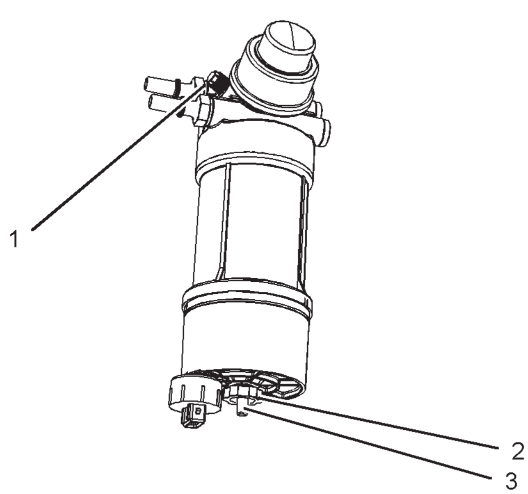

Illustration 66 g03374226

Typical example

3. Install a suitable tube onto drain (3). Open the drain valve (2). Rotate the drain valve counterclockwise. Two full turns are required. Loosen vent screw (1).

Note: Two complete rotations of the valve will release the valve from the filter element.

4. Allow the fluid to drain into the container.

5. Engage the threads of the valve into the filter element and tighten the drain valve by hand pressure only. Tighten vent screw securely.

6. Remove the tube and remove the container.

i04367528

Fuel System Secondary Filter - Replace

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

NOTICE

Ensure that the engine is stopped before any servicing or repair is performed.

Refer to Systems Operation, Testing, and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

Remove the Element

1. Turn the fuel supply valve (if equipped) to the OFF position before performing this maintenance.

2. Place a suitable container under the fuel filter in order to catch any fuel that might spill. Clean up any spilled fuel. Clean the outside body of the filter assembly.

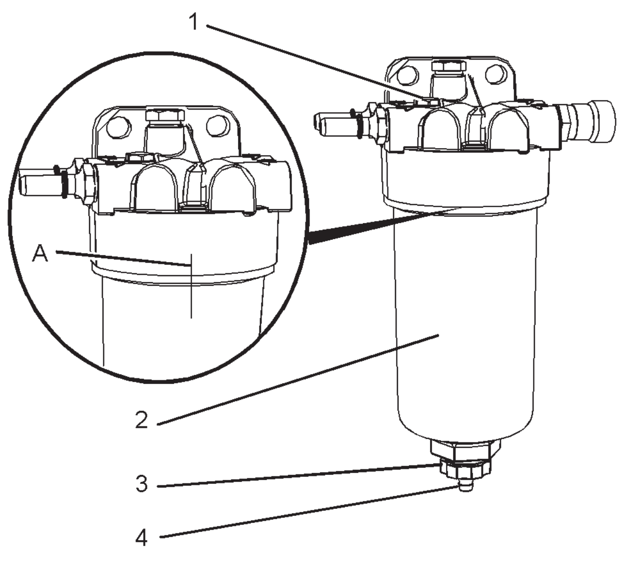

Illustration 67 g02522536

Typical example

3. Make a temporary Mark (A) across the filter before the assembly is removed. Install a suitable tube onto drain (4). Open the drain valve (3). Rotate the drain valve counterclockwise. Two full turns are required. Loosen vent screw (1).

Note: Two complete rotations of the valve will release the valve from the filter element.

4. Allow the fuel to drain into the container. Remove the tube and install the valve into the filter element. Engage the threads of the valve into the filter element. Do not secure the valve.

5. Tighten the vent screw (1) securely.

6. Remove the filter bowl (2). Rotate the filter assembly counterclockwise in order to remove the assembly. Use a suitable tool in order to remove the filter bowl.

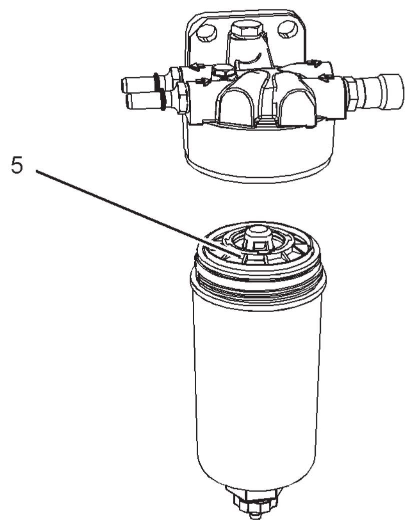

Illustration 68 g02522538

Typical example

7. Rotate the filter element counterclockwise and remove the filter element (5). Clean the filter bowl.

Install the Element

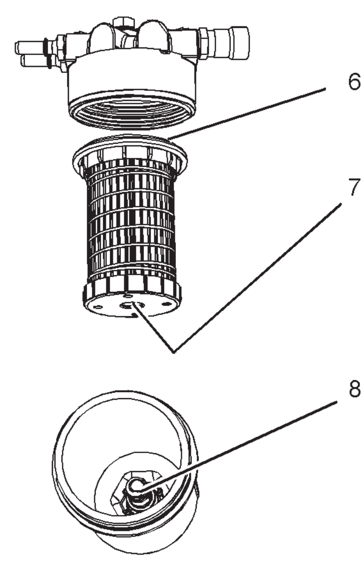

Illustration 69 g02522540

Typical example

1. Locate the thread in the filter element (7) onto the threads (8). Spin on the element. Do not tighten.

2. Lubricate the O ring seal (6) with clean engine oil. Do NOT fill the filter bowl (2) with fuel before the filter assembly is installed.

3. Do not use a tool in order to install the filter assembly. Tighten the assembly by hand. Install the filter bowl (2) and align with your temporary Marks.

4. Tighten the drain valve (3). Turn the fuel supply valve to the ON position.

5. The Primary filter element must be replaced at the same time as the secondary filter element. Refer to the Operation and Maintenance Manual, “Fuel System Primary Filter (Water Separator) Element - Replace”.

6. Prime the fuel system. Refer to the Operation and Maintenance Manual, “Fuel System - Prime” for more information.

i02348492

Fuel Tank Water and Sediment - Drain

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Fuel Tank

Fuel quality is critical to the performance and to the service life of the engine. Water in the fuel can cause excessive wear to the fuel system.

Water can be introduced into the fuel tank when the fuel tank is being filled.

Condensation occurs during the heating and cooling of fuel. The condensation occurs as the fuel passes through the fuel system and the fuel returns to the fuel tank. This causes water to accumulate in fuel tanks. Draining the fuel tank regularly and obtaining fuel from reliable sources can help to eliminate water in the fuel.

Drain the Water and the Sediment

Fuel tanks should contain some provision for draining water and draining sediment from the bottom of the fuel tanks.

Open the drain valve on the bottom of the fuel tank in order to drain the water and the sediment. Close the drain valve.

Check the fuel daily. Allow five minutes after the fuel tank has been filled before draining water and sediment from the fuel tank.

Fill the fuel tank after operating the engine in order to drive out moist air. This will help prevent condensation. Do not fill the tank to the top. The fuel expands as the fuel gets warm. The tank may overflow.

Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe. Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

Fuel Storage Tanks

Drain the water and the sediment from the fuel storage tank at the following intervals:

- Weekly
- Service intervals
- Refill of the tank

This will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank.

If a bulk storage tank has been refilled or moved recently, allow adequate time for the sediment to settle before filling the engine fuel tank. Internal baffles in the bulk storage tank will also help trap sediment. Filtering fuel that is pumped from the storage tank helps to ensure the quality of the fuel. When possible, water separators should be used.

i02518232

Hoses and Clamps - Inspect/ Replace

WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, “General hazard Information”.

Inspect all hoses for leaks that are caused by the following conditions:

- Cracking
- Softness
- Loose clamps

Replace hoses that are cracked or soft. Tighten any loose clamps.

Check for the following conditions:

- End fittings that are damaged or leaking
- Outer covering that is chafed or cut
- Exposed wire that is used for reinforcement
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering

A constant torque hose clamp can be used in place of any standard hose clamp. Ensure that the constant torque hose clamp is the same size as the standard clamp.

Due to extreme temperature changes, the hose will harden. Hardening of the hoses will cause hose clamps to loosen. This can result in leaks. A constant torque hose clamp will help to prevent loose hose clamps.

Each installation application can be different. The differences depend on the following factors:

- Type of hose
- Type of fitting material
- Anticipated expansion and contraction of the hose
- Anticipated expansion and contraction of the fittings

Replace the Hoses and the Clamps

Refer to the OEM information for further information on removing and replacing fuel hoses (if equipped).

The following text describes a typical method of replacing coolant hoses. Refer to the OEM information for further information on the coolant system and the hoses for the coolant system.

WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Stop the engine. Allow the engine to cool.

2. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

Note: Drain the coolant into a suitable, clean container. The coolant can be reused.

3. Drain the coolant from the cooling system to a level that is below the hose that is being replaced.

4. Remove the hose clamps.

5. Disconnect the old hose.

6. Replace the old hose with a new hose.

7. Install the hose clamps with a torque wrench.

Note: For the correct coolant, see this Operation and Maintenance Manual, “Fluid Recommendations”.

8. Refill the cooling system. Refer to the OEM information for further information on refilling the cooling system.

9. Clean the cooling system filler cap. Inspect the cooling system filler cap's seals. Replace the cooling system filler cap if the seals are damaged. Install the cooling system filler cap.

10. Start the engine. Inspect the cooling system for leaks.

i05324852

Oxygen Sensor - Replace

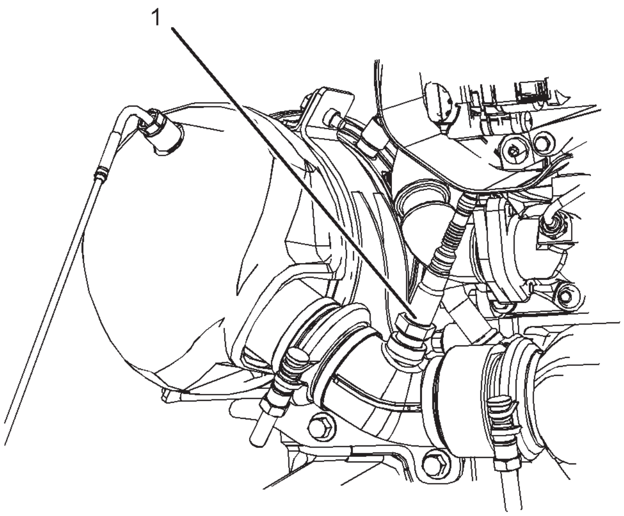

Illustration 70 g03373217

Typical example

The oxygen sensor (1) must be replaced at 3000 hours. Refer to the Disassembly and Assembly, "Oxygen Sensor - Remove and Install" for the procedure.

The electronic service tool will be required in order to perform a reset after a new oxygen sensor is installed.

i04245214

Radiator - Clean

The radiator is not usually supplied by Perkins . The following text describes a typical cleaning procedure for the radiator. Refer to the OEM information for further information on cleaning the radiator.

Note: Some application will require a fuel cooler to be installed. The fuel cooler is a type of radiator that uses air to cool the fuel and the fuel cooler will require cleaning.

Note: Adjust the frequency of cleaning according to the effects of the operating environment.

Inspect the radiator for these items: Damaged fins, corrosion, dirt, grease, insects, leaves, oil and other debris. Clean the radiator, if necessary.

WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.

Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction to the fans air flow. Hold the nozzle approximately 6 mm (0.25 inch) away from the radiator fins. Slowly move the air nozzle in a direction that is parallel with the radiator tube assembly. The pressurized air will remove debris that is between the tubes.

Pressurized water may also be used for cleaning. The maximum water pressure for cleaning purposes must be less than 275 kPa (40 psi). Use pressurized water in order to soften mud. Clean the core from both sides.

Use a degreaser and steam for removal of oil and grease. Clean both sides of the core. Wash the core with detergent and hot water. Thoroughly rinse the core with clean water.

If the radiator is blocked internally, refer to the OEM Manual for information regarding flushing the cooling system.

After cleaning the radiator, start the engine. Allow the engine to operate at low idle speed for 3 to 5 minutes. Accelerate the engine to high idle. The high idle speed will help in the removal of debris and the drying of the core. Slowly reduce the engine speed to low idle and then stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning, if necessary.

Inspect the fins for damage. Bent fins may be opened with a "comb". Inspect these items for good condition: Welds, mounting brackets, air lines, connections, clamps and seals. Make repairs, if necessary.

i03639888

Radiator Pressure Cap - Clean/ Replace

WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

NOTICE

When any servicing or repair of the engine cooling system is performed the procedure must be performed with the engine on level ground. This will allow you to accurately check the coolant level. This will also help in avoiding the risk of introducing an air lock into the coolant system.

1. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the radiator pressure cap.

2. Check coolant level. Refer to Operation and Maintenance Manual, "Cooling System Coolant Level - Check".

3. Install new radiator pressure cap.

i02177969

Starting Motor - Inspect

Perkins recommends a scheduled inspection of the starting motor. If the starting motor fails, the engine may not start in an emergency situation.

Check the starting motor for correct operation. Check the electrical connections and clean the electrical connections. Refer to the Systems Operation, Testing and Adjusting Manual, "Electric Starting System - Test" for more information on the checking procedure and for specifications or consult your Perkins dealer or your Perkins distributor for assistance.

i04407666

Turbocharger - Inspect

WARNING

Hot engine components can cause injury from burns. Before performing maintenance on the engine, allow the engine and the components to cool.

NOTICE

Turbocharger bearing failures can cause large quantities of oil to enter the air intake and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of oil into a turbocharger under extended low idle operation should not cause problems as long as a turbocharger bearing failure has not occurred.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine rpm up at no load), do not continue engine operation until the turbocharger is renewed.

A visual inspection of the turbocharger can minimize unscheduled downtime. A visual inspection of the turbocharger can also reduce the chance for potential damage to other engine parts. Do not inspect the engine with the engine in operation.

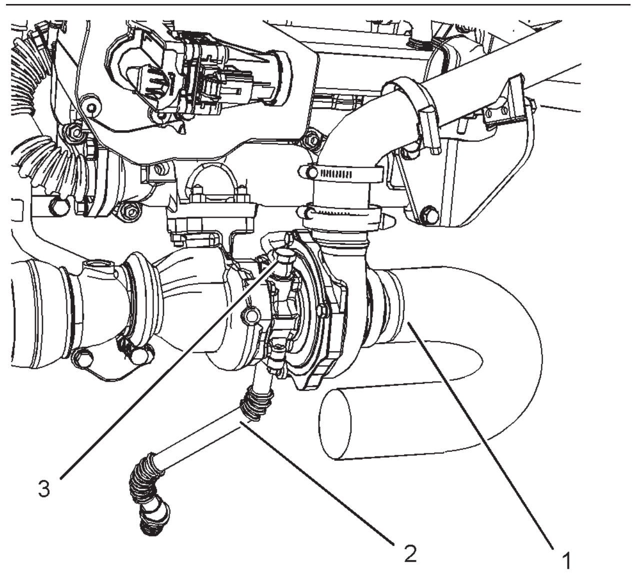

Illustration 71 g02603804

Typical example

1. Ensure that the turbocharger is clean and free from dirt before removing components for inspection.

2. Remove the air intake pipe (1). Visually inspect the piping for the presence of oil. A small amount oil will be expected, this oil is due to the breather system design. Clean the interior of the pipe in order to prevent dirt from entering during reassembly.

3. Check for obvious heat discoloration of the turbocharger. Check for any loose bolts or any missing bolts. Check for damage to the oil supply line (3) and the oil drain line (2). Check for cracks in the housing of the turbocharger. Ensure that the compressor wheel can rotate freely. Check that there are no visual signs of damage to the compressor wheel.

4. Check for the presence of oil. If oil is leaking from the back side of the compressor wheel, there is a possibility of a failed turbocharger oil seal.

   The presence of oil may be the result of extended engine operation at low idle. The presence of oil may also be the result of a restriction of the line for the intake air (clogged air filters). A restriction can cause the turbocharger to slobber.

5. Install the air intake pipe to the turbocharger housing. Ensure that all clamps are installed correctly and that all clamps are tightened securely. For more information, refer to Systems Operation, Testing, and Adjusting, “Turbocharger - Inspect”.

i04367583

Walk-Around Inspection

Inspect the Engine for Leaks and for Loose Connections

A walk-around inspection should only take a few minutes. When the time is taken to perform these checks, costly repairs and accidents can be avoided.

For maximum engine service life, make a thorough inspection of the engine compartment before starting the engine. Look for items such as oil leaks or coolant leaks, loose bolts, worn belts, loose connections, and trash buildup. Make repairs, as needed:

- The guards must be in the correct place. Repair damaged guards or replace missing guards.

- Wipe all caps and plugs before the engine is serviced in order to reduce the chance of system contamination.

NOTICE

For any type of leak (coolant, lube, or fuel) clean up the fluid. If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more often than recommended until the leak is found or fixed, or until the suspicion of a leak is proved to be unwarranted.

NOTICE

Accumulated grease and/or oil on an engine is a fire hazard. Remove the accumulated grease and oil. Refer to this Operation and Maintenance Manual, “Engine - Clean” for more information.

- Ensure that the cooling system hoses are correctly clamped and that the cooling system hoses are tight. Check for leaks. Check the condition of all pipes.

- Inspect the water pump for coolant leaks.

Note: The water pump seal is lubricated by the coolant in the cooling system. It is normal for a small amount of leakage to occur as the engine cools down and the parts contract.

Excessive coolant leakage may indicate the need to replace the water pump. Remove the water pump. Refer to Disassembly and Assembly, “Water Pump - Remove and Install”. For more information, consult your Perkins dealer or your Perkins distributor.

- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the oil pan, the oil filters, and the rocker cover.

- Inspect the piping for the air intake system and the elbows for cracks and for loose clamps. Ensure that hoses and tubes are not contacting other hoses, tubes, wiring harnesses, etc.

- Ensure that the areas around the rotating parts are clear.

- Inspect the alternator belts and any accessory drive belts for cracks, breaks, or other damage.

- Inspect the wiring harness for damage.

Belts for multiple groove pulleys must be replaced as matched sets. If only one belt is replaced, the belt will carry more load than the belts that are not replaced. The older belts are stretched. The additional load on the new belt could cause the belt to break.

High Pressure Fuel Lines

WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

After the engine has stopped, you must wait for 10 minutes in order to allow the fuel pressure to be purged from the high-pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low-pressure fuel system and from the cooling, lubrication, or air systems. Replace any high-pressure fuel line that has leaked. Refer to Disassembly and Assembly Manual, "Fuel Injection Lines - Install".

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, "General hazard Information".

Visually inspect the high-pressure fuel lines for damage or signs of fuel leakage. Replace any damaged high-pressure fuel lines or high-pressure fuel lines that have leaked.

Ensure that all clips on the high-pressure fuel lines are in place and that the clips are not loose.

- Inspect the rest of the fuel system for leaks. Look for loose fuel line clamps.
- Drain the water and the sediment from the fuel tank on a daily basis in order to ensure that only clean fuel enters the fuel system.
- Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires. Check for any loose tie-wraps or missing tie-wraps.
- Inspect the ground strap for a good connection and for good condition.
- Disconnect any battery chargers that are not protected against the current drain of the starting motor. Check the condition and the electrolyte level of the batteries, unless the engine is equipped with a maintenance free battery.
- Check the condition of the gauges. Replace any gauges that are cracked. Replace any gauge that cannot be calibrated.

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Water Pump - Inspect

A failed water pump may cause severe engine overheating problems that could result in the following conditions:

- Cracks in the cylinder head
- A piston seizure
- Other potential damage to the engine

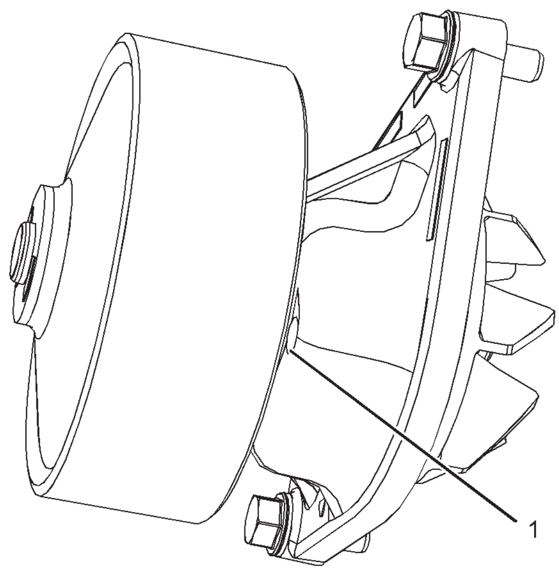

Illustration 72 g02601196

Typical example

(1) Weep hole

Note: The water pump seals are lubricated by the coolant in the cooling system.

Visually inspect the water pump for leaks.

Note: If engine coolant enters the engine lubricating system, the lubricating oil and the engine oil filter must be replaced. Draining will remove any contaminate and will prevent any irregular oil samples.

In order to install a new water pump, refer to the Disassembly and Assembly Manual, "Water Pump - Remove and Install".

Warranty Section

Warranty Information

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Emissions Warranty Information

- EPA _______________ United States Environmental Protection Agency
- CARB ___________ California Air Resources Board

Note: The warranty of the engine applies to engines that are operated within the areas of the world where the following regulations apply: US EPA Tier 4 Interim, EU Stage IIIB or Japanese MLIT Step 4. If an engine is operated in regions of the world where these regulations do not apply the warranty will be void. Contact your Perkins dealer or your Perkins distributor for more information.

For a full warranty statement contact your Perkins dealer or your Perkins distributor. For customers that have a valid user name and password, for perkins.com. Login then go to TIPSS, and the warranty information can be accessed.

Maintenance Recommendations

Efficiency of the emission control and the engine performance depends on adherence to proper operation and maintenance recommendations and use of recommended fuels and lubricating oils. According to recommendations, major adjustments and repairs should be made by your authorized Perkins distributor or your authorized Perkins dealer.

Various chemical fuel additives which claim to reduce visible smoke are available commercially. Although additives have been used to solve some isolated smoke problems in the field, additives are not recommended for general use. The engines should be certified without smoke depressants according to federal smoke regulations.

The aftertreatment system can be expected to function properly for the life-time of the engine (emissions durability period) subject to prescribed maintenance requirements being followed.

Reference Information Section

Reference Materials

i04224089

Engine Protection Plans
(Extended Service Contract)

Extended Service Contracts-purchased in minutes, protected for years.

Extended Service Contracts (ESC) protect you from the stress that unexpected repair work brings to your life by covering the cost of getting your engine up and running again. Unlike other extended warranties, Perkins Platinum ESC protects you against all component part failures.

Purchase peace of mind from only £0.03 / $0.05 / euro 0.04 a day and let an ESC make your dreams a reality.

Why buy an Extended Service Contract?

1. No surprises - total protection from unexpected repair cost (parts, labor, and travel).

2. Enjoy longer lasting product support from Perkins global network.

3. Genuine Perkins parts ensure continued engine performance.

4. Highly trained technicians carry out all repairs.

5. Transferable coverage should you sell your machine.

Flexible coverage provides the right level of protection for your Perkins Engine. Coverage can be extended to 2 years/ 1,000 hours right up to 10 year/ 40,000

You can buy an ESC at any time during standard warranty - even the last day!

Each Perkins Distributor has highly trained and experienced Perkins Product Support Service Technicians. The Support Service are equipped, and available around the clock to get your engine running again with the minimum of downtime. Buying an ESC means that you get all this for free.

To purchase an Extended Service Contract, is quick and simple! Contact your local Perkins Distributor now and the distributor can provide you with a quote in minutes. You can locate your nearest Perkins Distributor by visiting:

www.perkins.com

NOTICE
Dependant upon engine type and application.

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