SKYTRAK®

Service and Maintenance Manual

Model
3606

8990300
OCTOBER 1999

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REGISTERED COMPANY
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Foreword

SKY TRAK Model 3606

Service Manual

This manual is designed to provide the service technician with complete information on the maintenance and repair of the Sky Trak International SKY TRAK Model 3606 rough-terrain material handler.

Particular effort has been made to produce a manual to serve as a reference handbook for the experienced service technician, but also provide essential step-by-step procedures for the professional development of the less experienced person. Remember that even the best manual in the world is no substitute for an appropriate education, skill development that comes through experience alone, safety, wise and judicious discernment, and, ultimately, proper performance of service procedures.

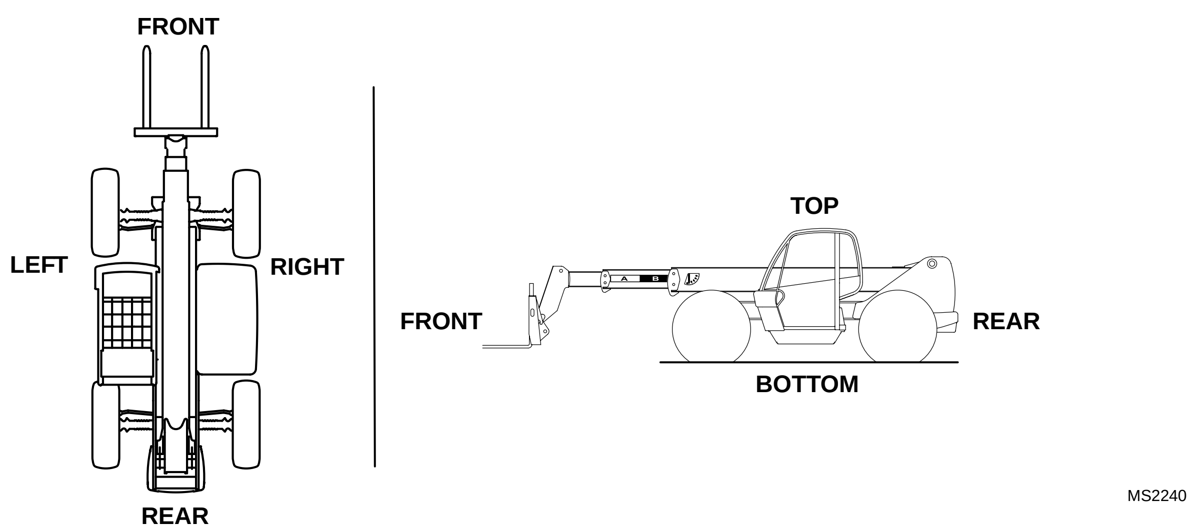
There are many variations in service environments and skill levels of repair technicians, as well as procedures, techniques, tools, and service parts. A service manual cannot possibly anticipate all such variations and provide advice or cautions for each one. Accordingly, any departure from the instructions in this manual must take into consideration both personal safety as well as vehicle integrity.

This service manual provides general directions for accomplishing service and repair procedures with tested, effective techniques. Following the procedures in this manual will help assure safety and equipment reliability. Appropriate service methods and proper repair procedures are essential for the safety of the individual doing the work, for the safety of the operator, and for the safe, reliable operation of the vehicle. All references to the right side, left side, front, and rear are given from the perspective of the operator's position, facing forward (see figure below).

The *Section Contents* allows the user to quickly locate any desired section. Each section begins with its own table of contents, and, where applicable, an informative introduction and exploded-view illustration appears, to show the location of major section components.

Provision for supplementary information is made by Trak International in the form of Service Bulletins, Service Campaigns, Service Training Schools, the OmniQuip web site, other literature, and through updates to the manual itself. Comments and suggestions for improvement are welcomed and encouraged.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication approval. Trak reserves the right to make changes and improvements to its products, and to discontinue the manufacture of any product, at its discretion at any time without public notice or obligation. When additional information is desired to satisfy a situation not covered sufficiently, consult the nearest Sky Trak International distributor, or the Sky Trak International Service Department at 1-414-268-8959.



All references to direction are as viewed from the operator's position, facing forward.

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Section 1
Safety

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1.1 INTRODUCTION

Sky Trak International (hereafter, Sky Trak) products meet all applicable industry safety standards. Sky Trak actively promotes safe practices in the use and maintenance of its products through training programs, instructional manuals, and the pro-active efforts of all employees involved in engineering, design, manufacture, marketing and service.

Many factors contribute to unsafe conditions: carelessness, fatigue, overload, inattentiveness, unfamiliarity, even drugs and alcohol, among others. Although equipment damage can usually be repaired in a brief period of time, death and irreparable injury are permanent. For optimal safety, encourage everyone to think, and to act, safely.

Read, understand and follow the information in this manual, and obey all locally-approved safety practices, procedures, rules, codes, regulations and laws. Prior to performing any maintenance on the vehicle, consider all factors, circumstances and conditions which can have an effect upon the safety of personnel and equipment, and take appropriate action to ensure the safety of all involved.

These instructions cannot cover all details or variations in the equipment, procedures, or processes described, nor provide directions for meeting every possible contingency during operation, maintenance, or testing. When additional information is desired to satisfy a situation not covered sufficiently, consult the local Sky Trak distributor or the Sky Trak Service Department at 1-800-439-8959.

1.2 OWNERS/OPERATORS MANUAL

The vehicle must be driven and operated as a consequence of, or when performing, service, maintenance and test procedures. The service technician must, therefore, thoroughly read, understand, and follow the *Sky Trak 3606 Owners/Operators Manual*.

An owners/operators manual is supplied with each vehicle and must be kept in the holder or storage compartment located to the left and below the operators seat (for vehicles without the closed cab option, see Fig. 1–1; for vehicles with the closed cab option, see Fig. 1–2).

In the event that the owners/operators manual is missing, consult the local Sky Trak distributor or the Sky Trak Service Department before proceeding.

WITHOUT CLOSED CAB

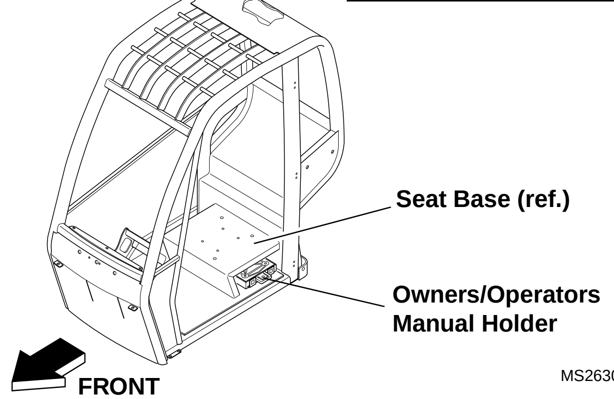


Figure 1–1. The Owners/Operators Manual holder is located beneath the seat (*without* closed cab option).

WITH CLOSED CAB

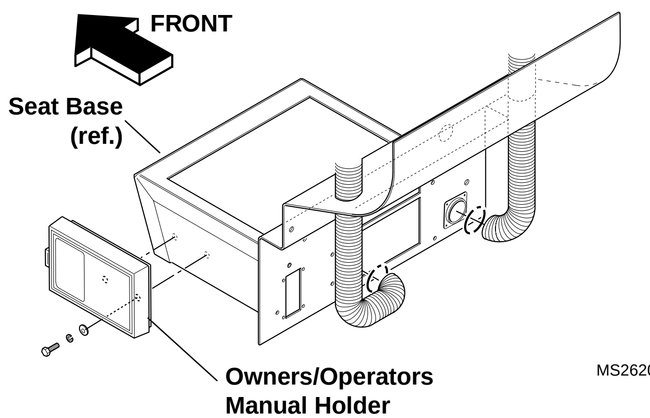


Figure 1–2. The Owners/Operators Manual holder is located at the left side of the seat base (*closed cab option*).

1.3 SAFETY INFORMATION

The following information provides general safety instructions, including signal words, hazard statement definitions, notification of hazards, methods to help avoid hazards, and the consequences of failing to follow the safety information. For safe maintenance of the vehicle, read, understand and follow all DANGER, WARNING, and CAUTION information.

The information in this manual does not replace any other safety rules or proper judgment. Governmental authorities and employers also have their own sets of rules, codes, regulations and laws. Before starting work at a site, check with the supervisor or safety coordinator and ask about the safety policy. Learn the safety requirements in effect before operating, maintaining, servicing or testing the vehicle. Safety depends on following safety requirements.

1.3.1 Safety Alert Symbol

The exclamation mark within a triangle is the Safety Alert Symbol.

The Safety Alert Symbol means ATTENTION! BECOME ALERT! YOUR SAFETY IS INVOLVED! The symbol is used to attract attention to safety hazards found on vehicle safety decals and throughout this manual.

The message that follows the symbol contains important information about Safety. To avoid possible death or injury, carefully read and follow all safety messages. Fully understand the potential causes of death or injury.

Also, know where to obtain medical assistance, how to use a first-aid kit and fire extinguisher/fire suppression system. Keep emergency telephone numbers (fire and police departments, ambulance, rescue squad or paramedics, etc.) nearby. If working alone, routinely check with another person to help assure personal safety.

1.3.2 Signal Words

Three types of hazard statements are used in this manual. Each signal word indicates the existence and degree of relative risk of the hazard described within the statement that follows the signal word. The three types of hazard statements use the following signal words:

DANGER

⚠	**DANGER:**

The signal word **DANGER** denotes an extremely hazardous situation exists on or near the vehicle which would result in a high probability of death or irreparable injury if proper precautions are not taken.

WARNING

⚠	**WARNING:**

The signal word **WARNING** denotes a hazard exists on or near the vehicle which can result in injury or death if the proper precautions are not taken.

CAUTION

⚠	**CAUTION:**

The signal word **CAUTION** denotes a reminder of safety practices or directs attention to unsafe practices on or near the vehicle which could result in personal injury if the proper precautions are not taken.

1.4 ACCIDENT PREVENTION TAGS

Figure 1–3. Accident Prevention Tag.

Before beginning any maintenance or service, place an Accident Prevention Tag on both the ignition switch and the steering wheel (Fig. 1–4), stating that the vehicle should not be operated. Copies of Accident Prevention Tags are provided on pages 1-9 and 1-10.

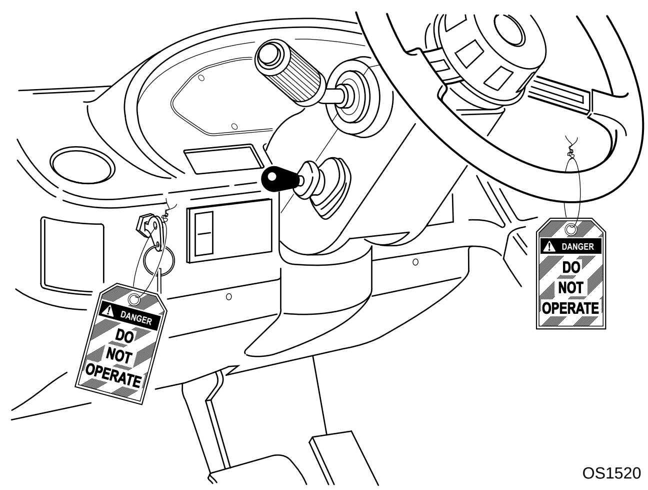


Figure 1–4. Place Accident Prevention Tags on both the ignition switch and the steering wheel.

1.5 SAFETY INSTRUCTIONS

Following are general safety statements to consider ***before*** performing maintenance procedures on the vehicle. Additional statements related to specific tasks and procedures are located throughout this manual and are listed prior to any work instructions to provide safety information before the hazard occurs.

For all safety messages, carefully read, understand and follow the instructions ***before*** proceeding.

1.5.1 Personal Hazards

HAIR and CLOTHING: **DO NOT** wear loose clothing or jewelry. Tie up or restrain hair. Wear the correct safety equipment for the job (including but not limited to: hard hat; safety shoes; safety glasses, goggles, or face shield; heavy gloves; hearing protection; reflective clothing; wet-weather gear; respirator or filter mask).

EYE PROTECTION: Always wear appropriate eye protection when chiseling, grinding, sanding, welding, painting, repairing hydraulic systems, or checking, testing or charging the battery.

BREATHING PROTECTION: Wear respiratory protection when grinding or painting.

HEARING PROTECTION: Always wear hearing protection in a high-noise area.

FOOT PROTECTION: Wear protective footwear with reinforced toe caps and slip-resistant soles.

LIFTING: **NEVER** lift a heavy object without the help of at least one assistant or a suitable sling and hoist.

1.5.2 Equipment Hazards

OWNERS/OPERATORS MANUAL: Before operating the vehicle, carefully read, understand and follow the Owners/Operators manual.

OPERATIONAL PROTECTION: Before operating the vehicle or returning it for operational use, check that the cab and all roll-over protection systems and falling-object protection systems (ROPS/FOPS) are intact, undamaged and secure. Replace any component as required.

LIFTING OF EQUIPMENT: Before using any lifting equipment (chains, slings, brackets, hooks, etc.), verify that it is of the proper capacity, in good working condition, and **properly attached.**

NEVER stand or otherwise become positioned under a suspended load or under raised equipment. The load or equipment could fall or tip.

DO NOT use a hoist, jack, or jack stands only to support equipment. Always support equipment with proper-capacity blocks or approved stands. Hoist or jack failure can allow the equipment to tip or to fall.

COMPRESSED AIR: Before and during the use of compressed air, wear eye protection and advise other personnel in the work area that compressed air is about to be used.

HAND TOOLS: Always use the proper tool for the job; keep tools clean and in good working order, and use special service tools only as recommended.

1.5.3 General Hazards

SOLVENTS: Only use approved solvents, and solvents that are known to be safe for use.

HOUSEKEEPING: Keep the work area and operator’s cab clean and remove all hazards (debris, oil, tools, etc.).

FIRST AID: Immediately clean, dress, and report all injuries resulting in bleeding or opened skin (cuts, abrasions, burns, etc.), no matter how minor. Know where the First Aid Kit is, and how to use it.

CLEANLINESS: Wear eye protection, and clean all components with a high-pressure or steam cleaner before attempting service.

When removing hydraulic components, plug hose ends and connections to prevent excess leakage and contamination. Place a suitable catch basin beneath the vehicle to capture fluid run-off.

1.5.4 Operational Hazards

OPERATIONAL CONSIDERATIONS: Before operating the vehicle, carefully read, understand and follow the owners/operators manual.

ENGINE: Stop the engine before performing any service.

DANGEROUS START: Place a warning sign on vehicles that are dangerous to start. Disconnect battery leads if leaving the vehicle unattended. Place Accident Prevention Tags on the steering wheel and ignition key switch before attempting to perform any service or maintenance.

VENTILATION: Avoid prolonged engine operation in enclosed areas with inadequate ventilation.

RADIATOR CAP: Always wear steam-resistant, heat-protective gloves when opening the radiator cap. Cover cap with a clean, thick cloth and turn slowly to the first stop to relieve pressure.

SOFT SURFACES AND SLOPES: **NEVER** work on a vehicle parked on soft surfaces or slopes (inclined ground or hills). Vehicle must be on hard, level surface with wheels blocked when necessary before performing any service. Obtain assistance, block all wheels, and add supports if necessary before beginning any work.

SUPPORTS AND STRAPS: Install safe, stable supports, slings or straps beneath or around a component or structural member before beginning any work.

FLUID PRESSURE: Before loosening any hydraulic or diesel component, hoses or tubes, turn engine OFF. Wear heavy, protective gloves and eye protection. **NEVER** check for leaks using any part of your body; use a piece of cardboard or wood instead. If injured, see a doctor immediately. Diesel fuel leaking under pressure can explode. Hydraulic fluid and diesel fuel leaking under pressure can penetrate the skin, cause infection, gangrene, and other serious personal injury. Relieve all pressure before disconnecting any component, part, line or hose. Slowly loosen parts and allow release of residual pressure before removing any part or component. Before starting engine or applying pressure, use components, parts, hoses and pipes that are in good condition, connected and tightened to the proper torque. Capture fluid in an appropriate container and dispose of in accordance with prevailing environmental regulations.

PRESSURE TESTING: When conducting any test, only use test equipment that is correctly calibrated and in good condition. Use the correct equipment in the proper manner, and make changes or repairs as indicated by the test procedures to achieve the desired results.

LEAVING VEHICLE: Lower the attachment to the ground before leaving the vehicle.

TIRE PRESSURE: Always keep tires inflated to the proper pressure to help prevent dangerous travel and load-handling situations. **DO NOT** over-inflate tires.

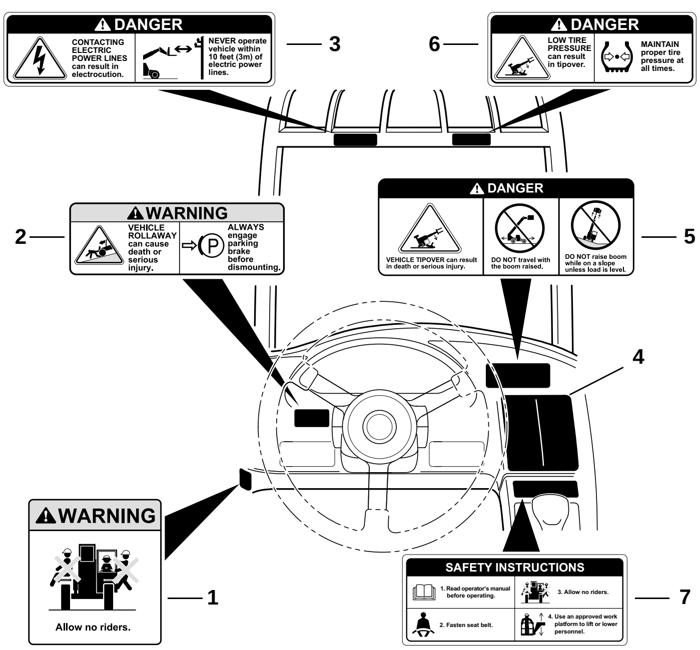
1.6 SAFETY DECALS

Locations of vehicle safety and other decals are shown on the following pages. As part of routine maintenance, check that ALL safety and informational decals on the vehicle are present and readable. Keep the safety decals clean. If a replacement decal is needed, refer to the owners/operators manual and parts catalog for the latest parts numbers and ordering information. Or, contact OmniQuip Parts Worldwide directly at:

1-888-872-5123

Safety Decal List – *Earlier* Models

1. No Riders WARNING
2. Vehicle Rollaway WARNING
3. Electrocution DANGER
4. Load Chart Booklet
5. Tipover DANGER – Operating
6. Tipover DANGER – Tire Pressure
7. Safety Instructions
8. Moving Parts WARNING
9. Explosive Gases WARNING
10. Carrying Personnel WARNING
11. Boom Extend Stripes
12. Boom Angle Indicator



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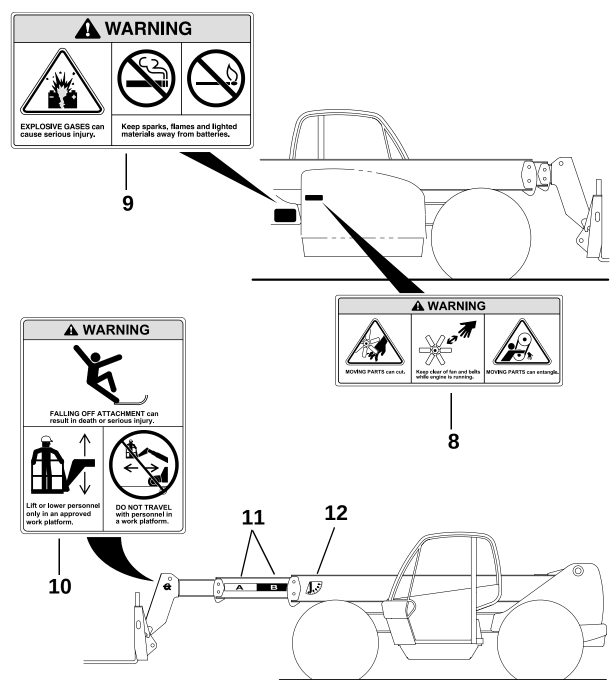

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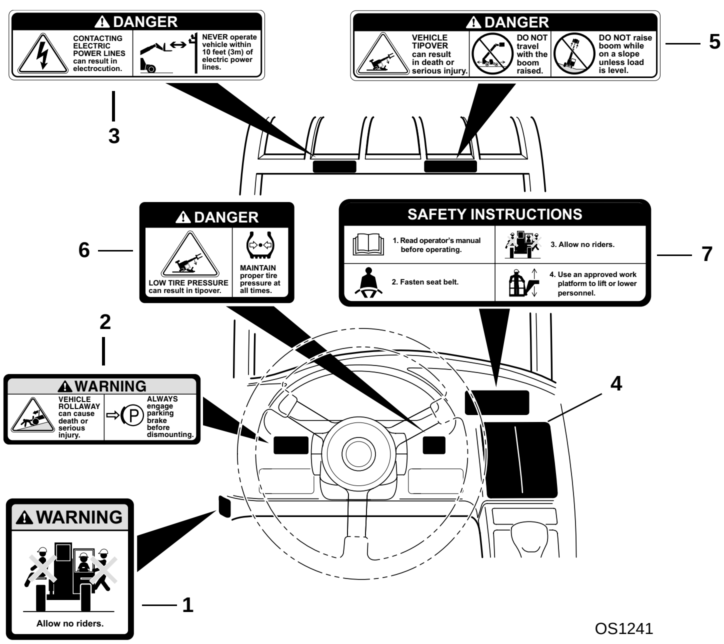
Note: Many of these hazard related decals are available free of charge by calling OmniQuip Parts Worldwide at 1-888-872-5123.

Safety Decal List – *Later* Models

1. No Riders WARNING
2. Vehicle Rollaway WARNING
3. Electrocution DANGER
4. Load Chart Booklet
5. Tipover DANGER – Operating
6. Tipover DANGER – Tire Pressure
7. Safety Instructions
8. Moving Parts WARNING
9. Explosive Gases WARNING
10. Carrying Personnel WARNING
11. Boom Extend Stripes
12. Boom Angle Indicator



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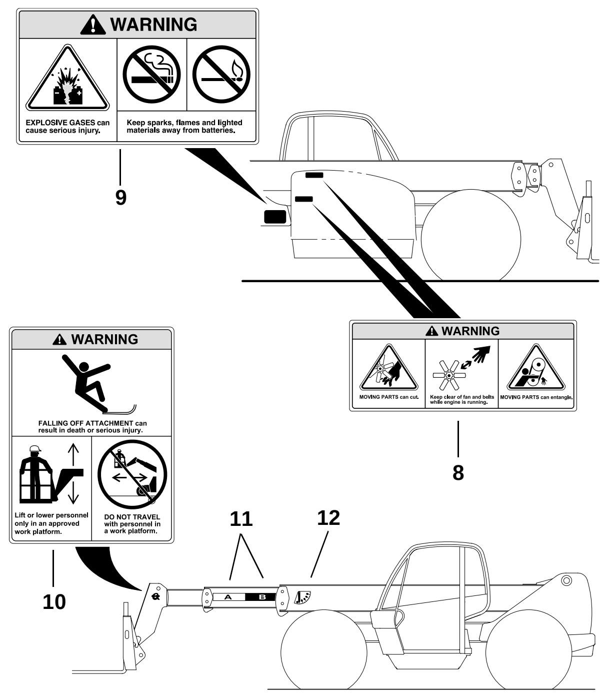

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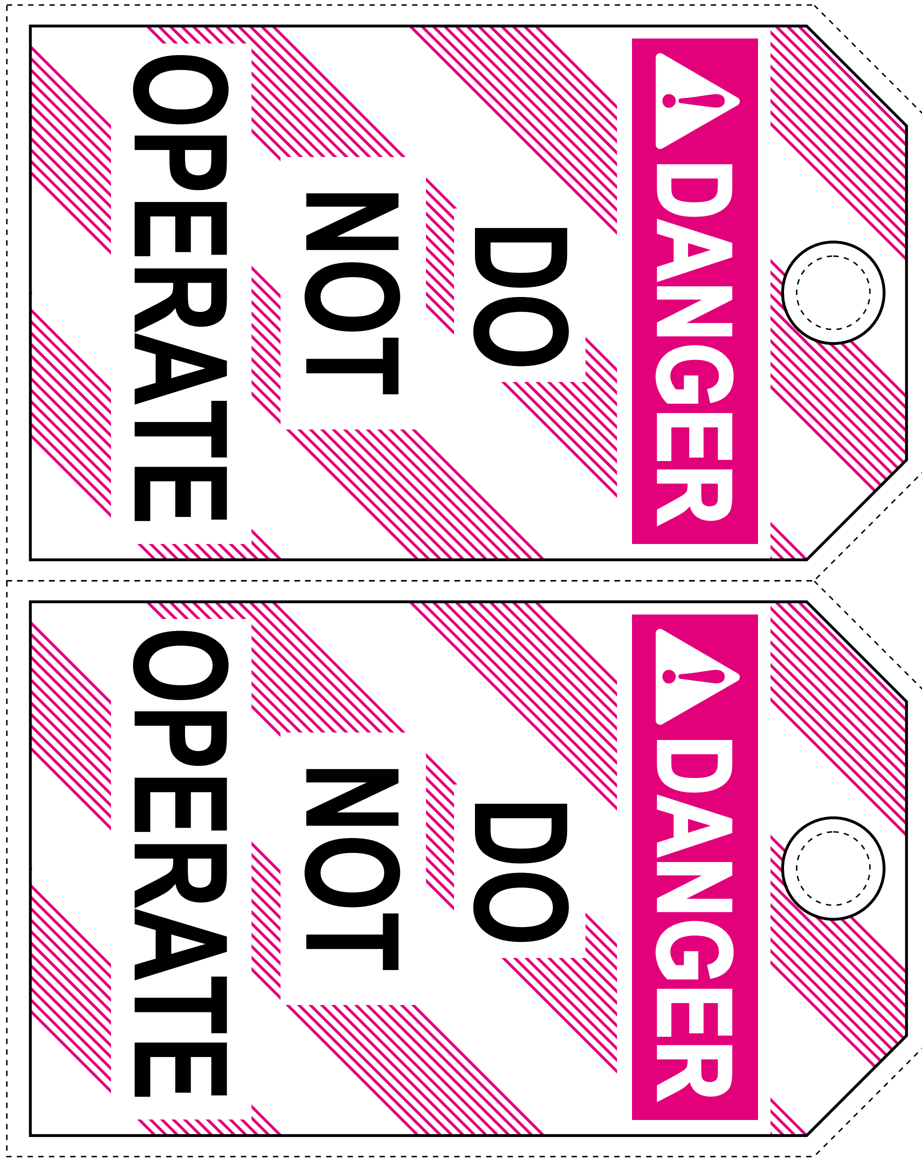
Note: Many of these hazard related decals are available free of charge by calling OmniQuip Parts Worldwide at 1-888-872-5123.

Copies of Accident Prevention Tags are provided on pages 1-9 and 1-10.



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Section 2
General Information, Specifications, and Maintenance

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2.1 REPLACEMENT PARTS AND WARRANTY INFORMATION

The replacement of any part with any other than a Sky Trak authorized replacement part can adversely affect the safety, performance, or durability of the vehicle, and may void the warranty. Sky Trak International assumes no liability whatsoever for unauthorized replacement parts.

A warranty registration form must be filled out by the Sky Trak distributor, signed by the purchaser, and returned to Sky Trak when the vehicle is sold and/or put into use. Registration activates the warranty period and helps to assure that warranty claims are promptly processed. To guarantee full warranty service, verify that the distributor has returned the business reply card of the warranty registration form to Sky Trak.

2.2 SERIAL NUMBER LOCATIONS

When ordering replacement parts or making service inquiries about the vehicle, various serial numbers are required to help assure the provision of correct parts and information. Before ordering parts or initiating service inquiries, make note of the pertinent serial numbers.

2.3 TORQUE VALUES

2.3.1 Fastener Rating

All fasteners (nuts, bolts, washers, etc.) are equal to SAE Grade 5 (PC8.8) and are plated, unless otherwise specified.

Unless otherwise specified, the following values apply for Grade 5 (PC8.8) nuts and bolts:

Size	Torque		Size	Torque	
Inch	lb/ft	Nm	mm	Nm	lb/ft
1/4	9	12	6.0	10	7
5/16	18	24	8.0	25	18
3/8	31	42	10.0	50	37
7/16	50	68	--	--	--
1/2	75	102	12.0	80	59
9/16	110	150	14.0	130	95
5/8	150	203	16.0	200	146
3/4	250	340	20.0	360	263
7/8	380	515	22.0	510	372
1.0	585	793	24.0	650	475

2.3.2 Straight Thread O-ring Fitting (non-adjustable)

When the vehicle leaves the factory, it is equipped only with straight thread O-ring fittings. Customer-added accessories may differ; therefore, consult the manufacturer's product literature for information.

1. Verify that both threads and sealing surfaces are free of burrs, nicks, scratches, and any foreign material.
2. Lubricate the new O-ring with a light coating of hydraulic oil.
3. Tighten fitting to the proper torque according to the following chart:

SAE Size	Torque	
	lb/ft	Nm
4	22-26	30-35
6	46-54	62-73
8	95-105	129-142
10	125-135	170-183
12	165-175	224-237
16	245-255	332-346
20	270-290	366-393
24	365-385	495-522

2.3.3 Straight Thread O-ring Fitting (adjustable)

When the vehicle leaves the factory, it is equipped only with straight thread O-ring fittings. Customer-added accessories may differ; therefore, consult the manufacturer's product literature for information.

1. Verify that both mating parts are free of burrs, nicks, scratches, and any foreign material.
2. Lubricate the new O-ring with a light coat of hydraulic oil.
3. Back off the locknut as far as possible.
4. Screw the fitting into the port by hand until the backup washer contacts the face of the port and is pushed all the way towards the locknut.
5. To position the fitting, unscrew by the required amount, but not more than one full turn.

6. Hold the fitting in the desired position and tighten to the proper torque according to the following chart:

Adjustable Straight-thread O-ring Fitting Torque Chart

SAE Size	Torque	
	lb/ft	Nm
4	14.5-17.5	20-24
6	37-43	50-58
8	75-85	102-115
10	115-125	156-170
12	155-165	210-224
16	225-235	305-319
20	260-280	353-380
24	340-360	461-488

2.3.4 Metric Conversion Factors

A. Approximate American to Metric Conversions

When this is known	*Multiply by*	*To Find*
TORQUE (moment of force)		
Pound/feet (lb/ft)	1.356	Newton meters (Nm)
Pound/inches (lb/in)	0.113	Newton meters (Nm)
POWER		
Horsepower (hp)	745.7	Watts
SPEED (velocity)		
Miles per hour (mph)	1.609	Kilometers per hour (km/hr; kph)
FUEL CONSUMPTION		
Miles per gallon, US (mpg)	0.425	Kilometers per liter (km/l)

[Miles per gallon values are commonly converted to liters/100 kilometers; mpg (Imperial x l/100 km = 282; US mpg x l/100 m = 235)]

LENGTH (distance)		
Inches (in)	25.4	Millimeters (mm)
Inches (in)	2.5	Centimeters (cm)
Feet (ft)	30.5	Centimeters (cm)
Feet (ft)	0.305	Meters (m)
Yards (yd)	0.9	Meters (m)
Miles (mi)	1.6	Kilometers (km)
AREA		
Square inches (in^2)	6.5	Square centimeters (cm^2)
Square feet (ft^2)	0.09	Square meters (m^2)
Square yards (yd^2)	0.8	Square meters (m^2)
Square miles (mi^2)	2.6	Square kilometers (km^2)
Acres	0.4	Hectares (ha)
MASS (weight)		
Ounces (oz)	28	Grams (g)
Pounds (lb)	0.4536	Kilograms (kg)
Short tons (2000 lb)	0.9	Metric ton (t)
VOLUME		
Teaspoons (tsp)	5	Milliliters (ml)
Tablespoons (Tbsp)	15	Milliliters (ml)
Cubic inches (in^3)	16	Milliliters (ml)
Fluid ounces (fl oz)	30	Milliliters (ml)
Cups (c)	0.24	Liters (l)
Pints (pt)	0.47	Liters (l)
Quarts (qt)	0.95	Liters (l)
Gallons (gal)	3.8	Liters (l)
Cubic feet (ft^3)	0.03	Cubic meters (m^3)
Cubic yards (yd^3)	0.76	Cubic meters (m^3)
AIR PRESSURE		
Pounds per square inch (psi)	6.895	Kilopascals (kPa)
HYDRAULIC PRESSURE		
Pounds per square inch (psi)	0.069	Bars

TEMPERATURE (exact)

To determine degrees Celsius (°C), subtract 32, then multiply by 0.56; (°F - 32) x 0.56 = °C.

B. Approximate Metric to American Conversions

When this is known	*Multiply by*	*To Find*
TORQUE (moment of force)		
Newton meters (Nm)	0,738	Pounds/feet (lb/ft)
Newton meters (Nm)	8,85	Pounds/inches (lb/in)
POWER		
Watts	0,0013	Horsepower (hp)
SPEED (velocity)		
Kilometers per hour (km/hr; kph)	0,621	Miles per hour (mph)
FUEL CONSUMPTION		
Kilometers per liter (km/l)	2,352	Miles per gallon, US (mpg)

[Miles per gallon values are commonly converted to liters/100 kilometers; mpg (Imperial x l/100 km = 282; US mpg z l/100 km = 235)]

LENGTH (distance)

Millimeters (mm)	0,0394	Inches (in)
Centimeters (cm)	0,394	Inches (in)
Meters (m)	3,281	Feet (ft)
Meters (m)	1,1	Yards (yd)
Kilometers (km)	0,621	Miles (mi)

AREA

Square centimeters (cm^2)	0,4	Square inches (in^2)
Square meters (m^2)	1,1	Square yards (yd^2)
Square kilometers (km^2)	0,6	Square miles (mi^2)
Hectares (10000 m^2)	2,5	Acres

MASS (weight)

Grams (g)	0,035	Ounces (oz)
Kilograms (kg)	2,2	Pounds (lb)
Metric ton (1000 kg) (t)	1,1	Short tons

VOLUME

Milliliters (ml)	0,03	Fluid ounces (fl oz)
Milliliters (ml)	0,06	Cubic inches (in^3)
Liters (l)	2,1	Pints (pt)
Liters (l)	1,06	Quarts (qt)
Liters (l)	0,26	Gallons (gal)
Cubic meters (m^3)	35	Cubic feet (ft^3)
Cubic meters (m^3)	1,3	Cubic yards (yd^3)

AIR PRESSURE

Kilopascals (kPa)	0,145	Pounds per square inch (psi)

HYDRAULIC PRESSURE

Bars	14,5	Pounds per square inch (psi)

TEMPERATURE (exact)

To determine degrees Fahrenheit (°F), multiply degrees Celsius (°C) by 1.8, then add 32; (°C x 1.8) + 32 = °F.

2.4 SPECIFICATIONS

2.4.1 Vehicle Dimensions (Fig. 2-1)

With Standard 12-ply 13.00-24 Tires

Ref. Description

A.	Length (without attachment)	221.0" (5613 mm)
B.	Width	98.0" (2489 mm)
C.	Height (boom lowered)	91.75" (2330 mm)
D.	Wheelbase	122.0" (3099 mm)
E.	Tread	84.0" (2134 mm)
F.	Ground Clearance	17.0" (432 mm)
G.	Turning radius, curb to curb	138.0" (3505,2 mm)
H.	Turning radius, clearance	180.5" (4584,7 mm)
I.	Maximum lift height, boom extended	36' 2" (11023,6 mm)
J.	Maximum lift height, boom retracted	18' 6" (5638,8 mm)
K.	Maximum below grade depth, boom extended	2' 5" (736,6 mm)
L.	Maximum reach, from front of front tires	24' 8" (7518,4 mm)
M.	Maximum reach at maximum lift angle, boom extended	67.2" (1707 mm)
N.	Maximum reach at maximum lift angle, boom retracted	-26.2" (-665,48 mm)
O.	Maximum reach at minimum lift angle, boom extended	24' 2" (7366 mm)
P.	Maximum boom lift angle	68°
Q.	Minimum boom lift angle	-3.8°
R.	Angle of approach	N/A
S.	Angle of departure	33°

Fork tilt angle:

T.	At minimum boom angle up	8.1°
U.	At minimum boom angle down	-108.3°
V.	At maximum boom angle up	80.8°
W.	At maximum boom angle down	-21.8°

Frame tilt angle *(not shown)*:

Right	10.0°
Left	10.0°

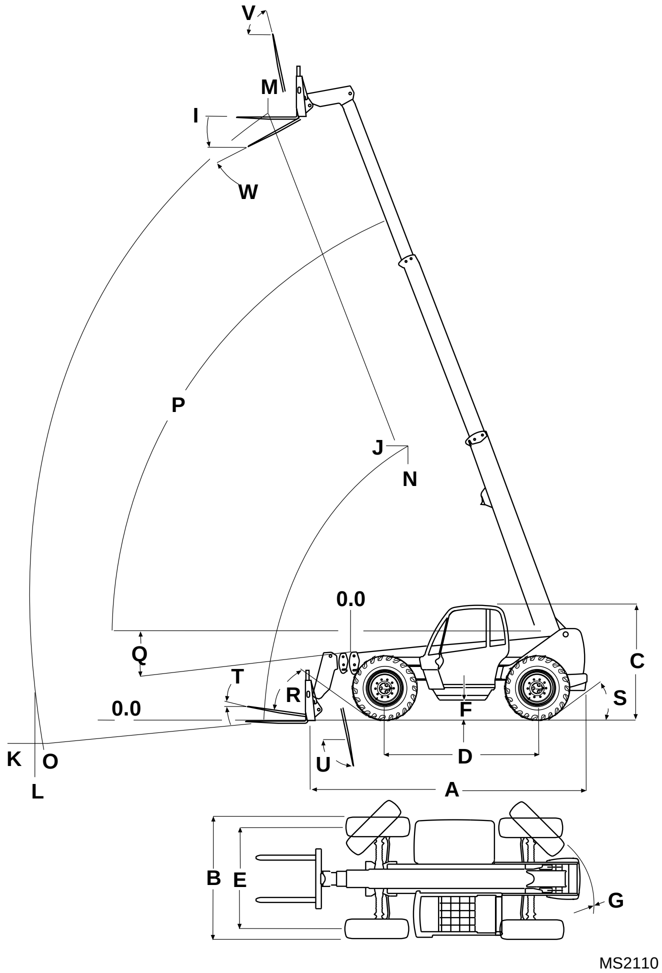


Figure 2–1. Vehicle dimensions with standard tires.

2.4.2 Performance Specifications

Performance criteria is based on full throttle engine speed unless otherwise specified or not applicable:

A. Travel Speed (standard tires, no load)

	4-SPEED	3-SPEED
First gear	4.3 mph (6,9 km/hr)	4.2 mph (6,8 km/hr)
Second gear	9.1 mph (14,6 km/hr)	9.2 mph (14,8 km/hr)
Third gear	15.3 mph (24,6 km/hr)	17.7 mph (28,5 km/hr)
Fourth gear	20.8 mph (33,5 km/hr)	N/A

B. Braking Distance (standard tires, no load)

	4-SPEED	3-SPEED
From road speed to stop	29.0 ft (8,8 m)	21.4 ft (6,5 m)

C. Cylinder Times (with no load, at full throttle)

Function	Approximate Times, in seconds
Boom extend	12.00
Boom retract	7.00
Boom lift retracted	12.75
Boom lower retracted	10.75
Fork tilt up	4.20
Fork tilt down	3.75
Frame tilt left to right with boom down	8.50
Frame tilt left to right with boom above 40° and emergency brake engaged	24.0 to 30.0
Frame tilt right to left with boom down	13.50
Frame tilt right to left with boom above 40° and emergency brake engaged	24.0 to 30.0

D. Draw Bar Pull
Per SAE drawbar test, 200 ft (61 m) track

	4-SPEED	3-SPEED
Peak drawbar in 1st gear at converter stall (no load)	15,000 lb (6.810,0 kg), slip	13,250 lb (6.015,5 kg), no slip
Peak drawbar in 1st gear at converter stall (rated load)	16,750 lb (7.604,5 kg), no slip	13,250 lb (6.015,5 kg), no slip

E. Engine Performance

Low idle setting for all engines = 1050 +/- 50 RPM

Engine	Model	Displace-ment	High Idle	Horse-power	Peak Torque
Perkins Turbo	1004.4T	243 CID	2600 +/- 100	108 HP @ 2400 rpm	277 lb/ft @ 1600 rpm
Perkins Natural/ EPA	1004.42	258 CID	2600 +/- 100	86 HP @ 2400 rpm	221 lb/ft @ 1600 rpm
Cummins Turbo	4BT3.9	239 CID	2700 +/- 100	110 HP @ 2500 rpm	293 lb/ft @ 1500 rpm

Note: Engine manufacturer's maximum "high idle" setting is lockwired and sealed. **DO NOT** disturb this setting.

F. Fuel Consumption

Average, depending on load/duty:
2 gal/hr (1,67 Imp gal/hr, or 7,57 l/hr)

G. Steering Wheel

Maximum number of turns, lock to lock
3.80 turns

Minimum number of turns, lock to lock
3.20 turns

H. Breakout Force

Utility bucket (calculated at -24° lip angle, max moment)
15,100 lb (6.855,4 kg).

2.4.3 Weights

A. Basic Vehicle

Curb Weight	20,195 lbs (9.160 kg)
Operating Load	6,600 lbs (3.000 kg)

B. Working Weight

Machine working weight is figured with 48" carriage, two 48" pallet forks, 25%-full fuel tank, and standard bias ply tires (no hydrofill):

	Front Axle	Rear Axle	TOTAL
Open Cab	8,390 lb (3,8 kg)	12,540 lb (5,6 kg)	20,930 lb (950 kg)
Closed Cab	N/A	N/A	N/A

C. Attachments

Std 48" carriage with shaft .... 456 lb (205 kg)

Std 60" carriage with shaft .... 526 lb (236,7 kg)

Std 72" carriage with shaft .... 677 lb (304,6 kg)

48" side tilt carriage
with shaft and cylinder.............................. 640 lb (288 kg)

60" side tilt carriage
with shaft and cylinder.............................. 700 lb (315 kg)

72" side tilt carriage
with shaft & cylinder .... 770 lb (346,5 kg)

52" swing carriage
with shaft & cylinders .... 950 lb (427,5 kg)

72" swing carriage
with shaft and cylinder...................... 1,135 lb (510,75 kg)

Bucket, 1.125 yd^3 (0,855 m^3)................... 760 lb (342 kg)

Broom, 8 foot (2,44 m) .... 1,100 lb (495 kg)

Pallet forks, 2.25 x 4 x 48 (5,7 x 10 x 122 cm),
quantity: 2 .... 312 lb (140,4 kg)

Block forks, 2 x 2 x 48 (5 x 5 x 122 cm)
quantity: 6.. 480 lb (216 kg)

Lumber forks, 1.75 x 7 x 60 (4 x 17,8 152,4 cm)
quantity: 2... 466 lb (209,7 kg)

Auger drive unit .... 285 lb (128,2 kg)

Auger mounting frame................................ 180 lb (81 kg)

Auger (various sizes available)............................... Varies

Auger extension (various sizes available) .... Varies

2.4.4 Miscellaneous Specifications

A. Wheels and Tires

Wheel lug nut torque ....370 lb/ft (500 Nm)

Air Pressure

13.00-24, 12-ply (minimum) tires .... 65 psi (448 kPa)

Tire Footprint Area

(area is established under max tip load)

13.00-24, 12-ply tires @ 65 psi (448 kPa),
Vehicle with no load: .... 140 in^2 (910 cm^2)

13.00-24, 12-ply tires @ 65 psi (448 kPa),
Vehicle with rated load: .... 165 in^2 (1072,5 cm^2)

Maximum Ground Pressure

Vehicle with no load,
13.00-24 12-ply tires @ 65 psi (448 kPa):
.... 75 psi (516,6 kPa)

Vehicle with 6,600 lb (2.994 kg) load,
13.00-24 12-ply tires @ 65 psi (448 kPa):
.... 85 psi (585,4 kPa)

Note: Maximum ground pressure at tip = (machine weight + load) / (foot print area x 2)

B. Valve Relief Settings

Main system relief ....3,500 +/- 100 psi (241,5 Bars)

Port relief boom hoist ....3,700 +/- 100 psi (255,3 Bars)

Port relief boom extend ....3,175 +/- 75 psi (219 Bars)

Port relief boom retract......3,750 +/- 100 psi (258,8 Bars)

Port relief fork tilt
(both sides) ....3,700 +/- 100 psi (255,3 Bars)

Pressure-reducing/relieving valve,
stabilizer cylinder........................100 +/- 25 psi (6,9 Bars)

Power steering relief..........2,500 +/- 100 psi (172,5 Bars)

Park brake relief .... 550 +/- 50 psi (38 Bars)

C. Tamper Proofing

A tamper-proof means is in place on the following adjustable components prior to machine shipment. This can either be tamper-proof paint, or a steel tamper-proof cap. **DO NOT** attempt to defeat, by-pass or alter any tamper-proof device.

- Hoist cylinder counterbalance valves (1)
- Main valve port relief valves (5)
- Extend cylinder counterbalance valves (2)
- Steering relief valve (1)
- Fork cylinder counterbalance valves (2)
- Pilot relief valve (1)
- Main system relief valve (1)
- Park brake relief (1)

D. Fork Ratings

All approved forks for this vehicle are marked with a maximum load capacity rating. This rating is stamped on the left edge of the fork, just below the fork pivot shaft (Fig. 2–2). The rating is listed in U.S. pounds and based upon a 24" (610 mm) load center.

This rating specifies the maximum load capacity that the individual fork can safely carry at a maximum load center of 24" (610 mm).

Since forks are always used in multiples, the total rating of any combination of forks is the sum of their rated capacity.

Other than block forks, use all forks in matched pairs. Use block forks in matched sets.

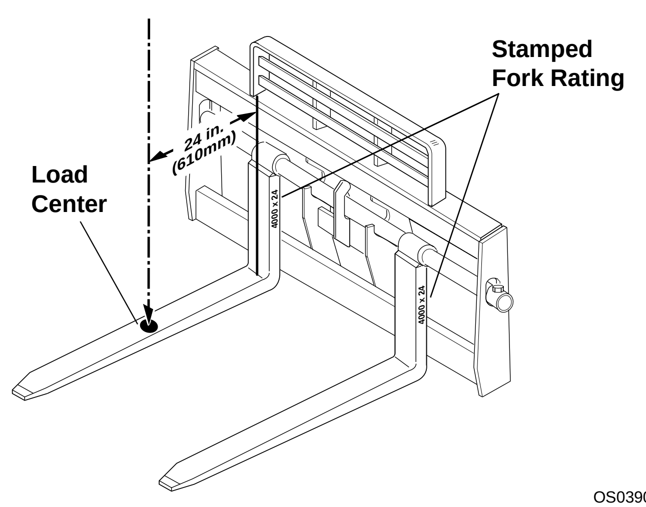


Figure 2–2. The stamped fork rating specifies the maximum load capacity that the individual fork can safely carry at a maximum load center of 24" (610 mm).

2.5 FLUIDS, LUBRICANTS AND CAPACITIES

2.5.1 Axles (Differential Housings) and Transfer Case

A. Axle and Transfer Case Lubricants

In general, use gear oil that meets the requirements of U.S. ordinance specification MIL-L-2105C with an API classification of GL-5. The oil should be a multi-grade 80W90 with EP properties.

Products known to meet these requirements include:

- AMOCO GEAR LUBE 80W90
- ARCO HD 90W GEAR LUBE
- BP TRANS GEAR 80W90
- CATERPILLAR 80W90 EP GL-5
- CHEVRON ULTRA GEAR LUBE 80W90
- CITGO PREMIUM GEAR LUBE 80W90
- CONOCO UGL 80W90
- EXXON GEAR OIL GX80W90
- FRANKLIN GEAREX AGMA 5 EP GEAR OIL
- KENDALL NS-MP 80W90
- MOBIL MOBILUBE HD 80W90
- MP GEAR LUBE GL-5 80W90
- PENNZOIL 409L 80W90
- QUAKER STATE HIGH PERFORMANCE 80W90
- QUAKER STATE SYNTHETIC 80W90
- SHELL SPIRAX HD 80W90
- STUART M2C-105A 80W90
- SUNOCO DURO GEAR GL-5, SYNTHETIC
- SUNOCO MULTI-PURPOSE GL-5
- TEXACO DIFFERENTIAL GEAR LUBE 80W90
- TEXACO MULTIGEAR EP 80W90
- UNICAL 76 MP GEAR LUBE-LS
- VALVOLINE
  HIGH PERFORMANCE GEAR LUBE 80W90

Note: Use of a premium grade 80W140 gear oil is recommended for operation where the ambient (outside air) temperature is consistently above 80°F (27°C).

B. Axle and Transfer Case Capacities

Axles (differential housings) .... 18 qt (17 l)

Transfer case .... 1.5 qt (1,4 l)

2.5.2 Wheel Ends

A. Wheel-end Lubricants

In general, use gear oil with an API classification of GL-5 that meets the requirements of U.S. ordinance specification MIL-L-2105 and MIL-L-2105D, respectively. The oil should be a 90W, a multi-grade 80W-90, or 80W-140 with EP properties (80W-90 EP). Products known to meet these requirements include:

- BP TRANS GEAR 80W90
- CHEVRON ULTRA GEAR LUBE 80W90
- CITGO PREMIUM GEAR LUBE 80W90
- MOBIL MOBILUBE HD 80W90

DO NOT add additional friction modifier to factory-filled wheel ends. All wheel ends are factory-filled by the manufacturer with oil. If a wheel end is drained for service, it should be refilled with the gear oils listed above.

Note: DO NOT use synthetic oil without the express written consent of the manufacturer.

B. Wheel-end Capacity

Wheel end capacity.............. 1.4 qt (44.8 oz, or 1,324 ml)

2.5.3 Lubrication Points (grease fittings)

Lubricants

When lubricating any component via the grease fittings, use multi-purpose lithium-based grease with EP additives that meets NLGI Grade-2 specifications. Products known to meet these requirements include:

- AMOCO AMOLITH EP2
- ARCO LITHOLINE EP2
- BENZ MOLY-SERVICE EP2
- CHEVRON DUROLITH EP2
- CITGO H EP2
- GULF GULFCROWN EP2
- MOBILE MOBILUX EP2
- SHELL ALVANIA EP2
- SUN PRESTIGE 742EP
- TEXACO MULTIFAX EP2

Note: Refer to section *2.12.2 Maintenance Schedule and Checklist* for lubrication intervals and grease fitting locations.

2.5.4 Hydraulic System

A. Hydraulic Fluids

The hydraulic system is factory filled with ISO Grade 46 anti-wear hydraulic oil. When filling the hydraulic system, use an anti-wear hydraulic oil meeting ISO Grade 46 with -40°F (-40°C) pour point/ASTM viscosity SUS 215 at 100°F (38°C), or a 10W motor oil that meets the requirements of U.S. ordinance specification MIL-L-2104C. Products known to meet these requirements include:

- AMOCO RYKON 46
- ARCO DURO AW S-215
- BENZ PETRAULIC 46-7C
- CASTROL AGRICASTROL HDD
- CASTROL/DEUSOL CRD
- CHEVRON AW HYDRAULIC OIL 46
- CITGO PACEMAKER XD-46
- ESSO ESSOLUBE D-3HP
- ESSO ESSOLUBE XD-3
- GULF HARMONY 46 AW
- ISO-46 HYDRAULIC OIL
- MOBIL DTE-25
- SAE 10W MOTOR OIL
- SHELL RIMULA CT
- SHELL RIMULA TX
- SHELL RIMULA X
- SHELL TULLUS 46
- SUN SUNVIS 821 WR
- TEXACO RANDO HD 46

Note: For -30°F to +70°F (-34°C to 21°C), 5W20 motor oil with -50°F (-45°C) pour point can be substituted. However, above 70°F (21°C), hydraulic system oil must be changed to ISO-46 hydraulic oil or SAE 10W motor oil.

B. Hydraulic System Capacity

System capacity .... 59.5 gal (225,2 l)

Reservoir capacity .... 32.2 gal (121,9 l)

2.5.5 Engine

A. Engine Fluids and Lubricants

1. Engine oil:

Diesel Engine Oil, SAE 10W-30, or 15W40

In general, use a premium-quality 10W-30 diesel engine (motor) oil. Additives are not necessary. For most climates, use 15W40 motor oil that meets API, CD or CE (severe duty diesel engine) specifications. In cold climates where ambient (outside air) temperatures are consistently below 32°F (0°C), 10W30 motor oil can be used; however, continuous use of low viscosity oil may cause premature engine wear.

2. Cooling system (engine coolant):

In general, use a 50/50-mix of premium-quality ethylene glycol (commonly referred to as “anti-freeze/anti-boilover”) and water. Additives are not necessary.

3. Fuel:

In general, use No. 2 diesel fuel. From November 15 to March 15 when operating in cooler climates where ambient (outside air) temperatures are consistently at or below 32°F (0°C), use a 50/50 mix of #1 and #2 diesel fuels. Use good quality diesel fuel and change the fuel filter regularly. Additives are not necessary.

B. Engine Capacities

1. Engine oil capacity:

	TOTAL CAPACITY WITH FILTER CHANGE	FILTER CAPACITY
Cummins Turbo	11.6 qt (11,0 l)	1.3 qt (1,2 l)
Perkins Turbo	9.0 qt (8,5 l)	1.5 qt (1,5 l)
Perkins Natural	9.0 qt (8,5 l)	1.5 qt (1,5 l)

2. Cooling system capacity (w/o heater):

Cummins Turbo .... 5.0 gal (18,9 l)

Perkins Turbo .... 5.0 gal (18,9 l)

Perkins Natural.......... 5.0 gal (18,9 l)

Coolant system overflow bottle capacity:

	CAPACITY W/O HEATER	CAPACITY W/ HEATER
Overflow bottle	3.0 qt (2,8 l)	3.0 qt (2,8 l)

3. Fuel tank capacity:

Total capacity .... 35.1 gal (132,8 l)

Usable capacity......... 33.6 gal (127,2 l)

2.5.6 Transmission

A. Transmission Fluid

Vehicle transmissions are factory filled with 10W motor oil. Any suitable 10W motor oil, which meets the requirements of U.S. ordinance specification MIL-L-2104C, can be used. Products known to meet these requirements include:

- ARCO TRACTOR FLUID or equivalent
- CASTROL AGRICASTROL HDD
- CASTROL/DEUSOL CRD
- ESSO ESSOLUBE D-3HP
- ESSO ESSOLUBE XD-3
- SAE 10W MOTOR OIL
- SHELL RIMULA CT
- SHELL RIMULA TX
- SHELL RIMULA X

In general, use any approved 10W or 5W20 motor oil (depending on ambient temperatures; see information below), Dexron* or Dexron II D*, or an anti-wear hydraulic oil meeting ISO Grade 46 specifications with a -40°F (-40°C) pour point/ASTM viscosity SUS 215 at 100°F (38°C).

For -30°F to +120°F (-34°C to 49°C), Dexron* II transmission fluid with a -50°F pour point may be substituted. 5W20 motor oil may be substituted for use with temperature conditions of -30°F to 70°F (-34°C to 21°C) only.

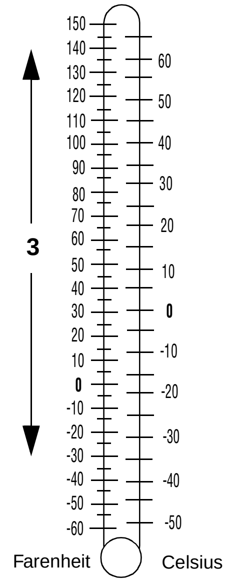
Products known to meet these requirements include:

- AMOCO RYKON 46
- ARCO DURO AW S-215
- BENZ PETRAULIC 46-7C
- CHEVRON AW HYDRAULIC OIL 46
- CITGO PACEMAKER XD-46 or equivalent
- GULF HARMONY 46
- ISO-46 HYDRAULIC OIL
- MOBIL DTE-25
- SHELL TULLUS 46
- SUN SUNVIS 821 WR
- TEXACO RANDO HD 46

If anti-wear hydraulic oil as specified above is not available, a suitable tractor fluid may be substituted which meets the requirements of any of the following specifications:

- ARCO TRACTOR FLUID or equivalent
- DETROIT DIESEL C-3
- FORD TRACTOR M2C134B
- JOHN DEERE J20A
- TEXACO TDH OIL
- WHITE FARM Q1826

RECOMMENDED LUBRICANTS FOR CLARK-HURTH T12000 POWER SHIFTED TRANSMISSION



Temperature Range "3"
If using Dexron*,
Use ONLY Dexron*
or Dexron II D*
See NOTE Below

Chart 2-1. Transmission fluid temperature range.

PREFERRED OIL VISCOSITY: Select the highest viscosity compatible with prevailing ambient temperatures and the oil application information listed under *Section 2.5.6 A. Transmission Fluid*.

The Clark Hurth T12000 modulated shift transmission used in this vehicle should use ONLY C-3 or Temperature Range 3 transmission fluids, Dexron* or Dexron II D*.

Note: Dexron II D* is not compatible with graphitic clutch plate friction material UNLESS IT MEETS THE APPROVED C-3 SPECIFICATIONS.

*Dexron and Dexron II D are registered trademarks of General Motors Corporation.

B. Transmission Capacity

Capacity w/ filter change .... 3.4 gal (12,9 l)

Filter .... 1.5 qt (1,4 l)

2.5.7 Drive Shaft Splines

IMPORTANT: DO NOT disassemble any of the drive shafts (see *Section 6 Transfer Case* of this manual for information covering drive shafts and U-joints). To help ensure optimum performance, the drive shaft assemblies are specially balanced as a unit at the factory. When servicing any flange yoke, slip yoke or drive shaft tube, order a complete assembly. Refer to the parts manual for ordering information.

Respective of the above statement, should it become necessary to coat the transmission input drive shaft splines, use molybdenum disulfide grease. Molybdenum disulfide grease specifically formulated for this purpose is marketed by several manufacturers under various names, including:

Aldrich Chemical Co., Inc.
Product name: *Aldrich MOLYBDENUM (IV) SULFIDE,*
Catalog Number 23,484-2
Package Size: 5 g (0.175 oz)
100 g (3.5 oz)
500 g (17.5 oz)
Contact:
Aldrich Chemical Co., Inc.
P.O. Box 335
Milwaukee, Wisconsin 53201 USA
Telephone: (414) 273-3850

DOW CORNING INC.
Product name: *MOLYKOTE® 77 Paste*
Contact:
Dow Corning Corporate Center
P.O. Box 994
Midland, MI 48686-0994
Telephone: (517) 496-4400

2.5.8 General Anti-corrosion

A. Anti-corrosion Compound

For general anti-corrosion protection, use a wax film rust inhibitor that provides a protective film two ten-thousandths of an inch (0.0002", or 0,00005 mm) thick. One such rust inhibitor that is specifically formulated for this purpose is *LPS 3*. It is marketed by:

LPS Laboratories, Inc.
4647 Hugh Howell Rd.
Tucker GA 30085-5052
Phone: 1-800-241-8334
Fax: (770) 493-9206

Note: Anti-corrosion protection is especially important in frame and stabilizer cylinder pin support bores for protection from fretting corrosion wear.

B. Anti-corrosion Need Areas

Coat all unplated pins and all bores for cylinder pins, attachment pivot pins, chain sheave pins, the quick-attach lock pin, and all quick-attach lock pin bores. On the boom, coat the fork shaft and unpainted boom slide pathways.

2.5.9 Electrical

A. Basic Ratings

Battery Type .... 12Vdc, Negative (-) ground/earth, Maintenance Free

Battery Rating ....1,000 cold cranking amps @ 0°F (-18°C)

Number of Batteries .... One (1)

Alternator Rating ....65 amps

B. Fuse Ratings, amps

- Main (S/N 8249 and Before) 40
  (S/N 8250 and After) 30
- Cold Start (Optional) 15
- Logic Panel 7.5
- Display Panel 7.5
- Fuel Shutoff 7.5
- Neutral Sense 7.5
- Neutral Relay/Starter 7.5
- Hourmeter 7.5
- Horn 7.5
- Stabil-TRAK 7.5
- Stabilizer Lock Relay 7.5
- Steering Solenoids 7.5
- Park Brake Sense Relay 7.5
- Transmission Solenoids 7.5
- Transmission Relay (without Closed Cab Option)..... 7.5
- Transmission Relay (with Closed Cab Option)........... 15
- Switch Lamps (Optional) 7.5
- Closed Cab Option - Front Wiper Motor 7.5
- Closed Cab Option - Skylight Wiper Motor 7.5
- Closed Cab Option - Rear Wiper Motor 7.5
- Closed Cab Option - Blower Motor 25
- Closed Cab Option - Power WIndow Motor 30
- Closed Cab Option - Power Accessories Relay 40
- Closed Cab Option - Power Window Motor Relay 40
- Light Package Option - Circuit A 20
- Light Package Option - Circuit B 20

2.5.10 Paint

Unless otherwise specified, paint components as indicated in the following sections.

A. Orange Paint

Durable, premium Sky Trak orange paint is available in both a convenient 16-ounce (480 ml) spray can for touch-ups, and in a production-sized one gallon (3,8 l) container for extensive repainting. Consult the current *Sky Trak Model 3606 PARTS MANUAL* for the applicable part number and ordering information. Use orange paint on all vehicle components except as specified in paragraphs 2.5.10 *A, B, C* and *D*.

B. Black Paint

Durable, premium black paint is available in both a convenient 16-ounce (480 ml) spray can for touch-ups, and in a production-sized one gallon (3,8 l) container for extensive repainting. Consult the current *Sky Trak Model 3606 PARTS MANUAL* for the applicable part number and ordering information.

- Boom Angle Indicator Pointer
- Wheels (some models)
- Brake Pedal
- Radiator
- Seat Adapter Plate
- Radiator Shroud
- Transmission Oil Cooler
- Axles
- Drive Shafts
- Drop Box
- Forks
- Mirrors and Mirror Brackets
- Air Cleaner
- Steering Column

C. White Paint

Durable, premium white paint is available in both a convenient 16-ounce (480 ml) spray can for touch-ups, and in a production-sized one gallon (3,8 l) container for extensive repainting. Consult the current *Sky Trak Model 3606 PARTS MANUAL* for the applicable part number and ordering information.

- Boom Extend Cylinder
- Extend Cylinder Mount Bracket (some models)

D. Gray Paint

The following parts must be painted dark gray (Ref.: Sky Trak Color Chip 8528102):

- Wheels
- Engine mount/Hyd. tank
- Counterweight
- Cab Mount

Durable, premium gray paint is available in both a convenient 16-ounce (480 ml) spray can for touch-ups, and in a production-sized one gallon (3,8 l) container for extensive repainting. Consult the current *Sky Trak Model 3606 PARTS MANUAL* for the applicable part number and ordering information.

- Wheels (some models)
- Fuel Tank Cradle
- Hydraulic Fluid Reservoir
- Battery Cover Panel

2.5.11 Thread Locking Compound

For general thread-locking purposes, Loctite® products, manufactured by Loctite Corporation, are recommended.

Contact:

Loctite Corporation
1001 Trout Brook Crossing
Rocky Hill, CT 06067 USA
Phone: 1-800-LOCTITE (1-800-562-8483)
FAX: (860) 571-2460
Internet: http://www.loctite.com

Loctite® is a registered trademark of Loctite Corporation.

2.6 CLEANING

Dirt and abrasive dust reduce the efficient working life of parts and systems, and lead to the costly replacement of components. To help increase the service life of parts, clean the exterior of all parts before beginning any repairs.

Use cleaning fluids and solvents suitable for cleaning parts that do not create safety hazards. Certain types of cleaning fluids can cause skin irritation and damage to components (such as rubber, electrical parts, etc.).

Servicing the hydraulic system in particular requires cleanliness.

Follow these precautions before attempting to service any hydraulic component:

1. Flush hose and tube assemblies with a solvent compatible with hose materials. Blow excess solvent away with shop air.
2. Cap hydraulic fittings, hoses and tube assemblies, and protect threads until time of installation. Clean up any hydraulic fluid spillage immediately.
3. Flush hydraulic reservoir, fuel tank, and gear housing with a suitable solvent to remove paint, metal chips, etc.
4. Protect hydraulic system components from airborne contaminants. Plug all cylinder, valve, reservoir, tank and pump openings until time of installation.
5. Use clean, filtered oil when filling the system. Maintain the hydraulic system at a minimum cleanliness level of ISO code 18/15-particle ration count.

2.7 REPLACEMENT

ALWAYS use the correct tool when removing or replacing any part or performing any service.

Replace O-rings, seals, and gaskets whenever they are disturbed. **NEVER** mix new and old seals or O-rings, regardless of apparent visual condition. Always lubricate new seals and O-rings with hydraulic oil before installation.

2.8 HOSES AND TUBES

2.8.1 Hose and Tube Inspection

1. Damaged, dented, crushed, or leaking hose and tube fittings restrict oil flow and the operation of the system being served. Fittings showing signs of movement from their original position have failed and must be replaced. **ALWAYS** replace the entire hose or tube assembly if the fittings are damaged.
2. Hoses must remain in good condition. Obvious signs of external hose wear or hydraulic fluid leaking or weeping indicates the need to replace the hose assembly. If in doubt, replace the hose.
3. Replace if any of the following conditions exist:
   - Ballooning (replace hose immediately!)
   - Kinking, crushing, stretching or deforming
   - Concealed corrosion of wire reinforcement
   - Chafed outer cover

2.8.2 Hose and Tube Installation

1. When installing a new hose, loosely connect each end and verify that the hose takes up the designed position before tightening the connection completely. Tighten clamps sufficiently to hold the hose without crushing it, and to prevent movement and chafing.
2. If a hose is replaced on a moving part, move the part through its entire range of motion to verify that the hose will not incur damage. Adjust as necessary.
3. When installing any hose, verify that it does not become kinked or twisted.
4. **NEVER** allow freely-moving or unsupported hoses to contact each other or a related work surface. Such contact causes chafing and reduces hose life.

2.9 BEARINGS

2.9.1 Bearing Removal

1. **NEVER** remove bearings unless absolutely necessary! Always use the recommended puller to reduce the risk of bearing or related component damage.
2. When bearings or bushings are removed, verify that the bearing or bushing is free from discoloration, nicks, scuffing, and signs of overheating. If in doubt, replace the bearing or bushing.

2.9.2 Bearing Cleaning

Wear safety glasses. Clean bearings acceptable for service in a suitable solvent. **NEVER** spin-dry a bearing with compressed air; this can cause metal-to-metal contact and bearing damage. Compressed air can also cause a bearing to come apart. After cleaning a bearing, immerse it in clean lubricating oil until needed.

2.9.3 Bearing Installation

1. Always install bearings carefully to help avoid damaging their delicate surfaces.
2. Install bearings using one of the following methods:
   - PRESS FIT for installation on rotating parts such as shafts and gears;
   - PUSH FIT into static locations such as reduction gear housings.
3. Always install the bearing into the rotating part first whenever possible.
4. Use a press or the proper installation tools when installing a bearing or bushing.
5. In the absence of a press or proper installation tools, carefully heat the casing and/or bearing in hot oil to assist in the installation.

2.10 PRESSURE TESTING AND ADJUSTMENT

Prior to pressure testing or adjustment, verify that all hoses and tubes are in good condition and that all fittings are tight.

Use pressure gauges with the proper ranges and ratings to measure the specified pressures.

Use correct test procedures to help prevent personal injury, damage to the system or test equipment.

Verify that the hydraulic oil is at proper operating temperature, 80°-120°F (27°-49°C), before adjusting the pressure reducing valve, or relief valves. If necessary, operate the vehicle to raise the oil temperature. In the absence of a temperature gauge, the oil temperature can be checked by placing a hand against the side or the bottom of the reservoir; if the tank is too hot to keep the hand in contact with it, the oil temperature should be within the proper range.

2.11 AFTER SERVICE STARTUP AND CHECKS

2.11.1 After Service Startup

Note: Refer to the owners/operators manual for engine cold-start procedures.

1. Check fluid levels.
2. Connect the negative (-) battery cable to the battery if it is disconnected.
3. Start and idle engine. Check for leaks from hydraulic components, engine, axles, transmission, brakes and reservoirs or tanks. Check the levels of all fluids and lubricants.
4. Purge the hydraulic system of air by operating all vehicle functions through their entire range of motion several times.
5. Check for proper operation of all components.
6. Retract all cylinders fully. Turn the engine OFF and check the hydraulic reservoir level. Recheck the level when the hydraulic oil is cold.
7. Replace the hydraulic filter if required.

2.11.2 After Electrical/Electronic Component Service

1. Check the torque of all fasteners securing replaced electrical/electronic components.
2. Check wiring connections to components.
3. Verify that wiring components are dry and free of moisture.
4. Check connectors for broken, frayed, or loose wires.
5. Check for brittle or frayed wire shielding.
6. Connect the negative (-) battery cable terminal to the battery; if it is disconnected.
7. Start the engine and bleed the hydraulic system of air.
8. Recalibrate sensors as required.
9. Check the operation of the replaced component(s).

2.11.3 After Hydraulic Component Service

1. Check torque of fasteners on replaced components.
2. Check that hoses and tubes are properly attached, positioned, and tightly connected.
3. If a hydraulic component failed and contaminated the system, flush the system, clean the hydraulic oil reservoir (tank), and replace the hydraulic oil filter.
4. After normal hydraulic component maintenance, check the hydraulic fluid level and add fluid as required.
5. Start engine and bleed hydraulic system of air. Operate all boom functions through their full range of motion several times. Cycle the hoist and extend cylinders to bleed air from the system. Visually check for leaks.
6. Recalibrate sensors as required.
7. Check operation of all systems in the hydraulic circuit by operating the controls through all functions several times.

2.11.4 After Brake System Service

1. Check the oil level in the axle and replenish with SAE 80W90 or SAE 80W140 oil as required.
2. Bleed the brakes.
3. Check brake pressure.
4. Check brake operation.

2.11.5 After Fuel System Service

1. Drain and flush fuel tank; if it was contaminated.
2. Bleed fuel system.
3. Fill fuel tank with fresh, clean fuel, as required.

2.11.6 After Transmission Service or Replacement

1. Check transmission oil level and add 10W motor oil as required. In general, use an anti-wear hydraulic oil meeting ISO Grade 46 with -40°F (-40°C) pour point/ ASTM viscosity SUS 215 at 100°F (38°C) or other lubricant that meets these specifications (refer to *Section 2.5.6 Transmission* for information on transmission lubricants).
2. Replace transmission filter.
3. Check torque on drive shaft yoke retaining bolts. Tighten these M12 bolts to 156 lb/ft (212 Nm).
4. Refer to the Clark-Hurth 12000 transmission maintenance manual for servicing the transmission after overhaul or repair.
5. Wear suitable eye protection. When an overhauled or repaired transmission is installed, thoroughly clean the oil cooler lines to and from the transmission.
6. Drain and flush the entire system.
7. Disconnect and clean all transmission lines. When possible, remove transmissions lines from the vehicle for cleaning.
8. Thoroughly clean transmission filter screens and cases, and replace transmission filter elements.
9. “Back flush” the transmission oil cooler with oil and compressed air until all foreign material is removed. Flushing in direction of normal oil flow does not adequately clean the cooler. If needed, remove the transmission oil cooler assembly from the vehicle. **DO NOT** use flushing compounds for cleaning purposes.
10. Reassemble all components and fill the transmission with clean, fresh anti-wear ISO Grade 46 or 10W motor oil through the filler opening until oil comes up to the FULL port on the transmission housing.
11. Remove UPPER check plug, fill until oil runs from UPPER oil hole. Replace filler and level plug.
12. Run engine for two minutes at idle to help prime the torque converter and transmission lines.
13. Recheck the level of fluid in the transmission with the engine running at idle.
14. Add ISO 46 10W motor oil as necessary to bring the fluid level up until it begins to run freely from the UPPER oil level check plug hole. Install the oil level plug. Recheck the oil level when it reaches operating temperature (180-200°F, or 83-94°C).
15. Recheck all drain plugs, lines, connections, etc., for leaks and tighten where necessary.

2.11.7 After Tire and Wheel Service

1. Check air pressure.
2. Check wheel nut torque. Tighten to 370 lb/ft (500 Nm).

2.11.8 After Engine Service

Consult the qualified service agent (manufacturer’s representative and/or service manual) for proper procedures before engine startup.

2.11.9 After Boom Service

1. Check wear pads.
2. Check chain tension adjustment.
3. Apply grease at all lubrication points (grease fittings).
4. Check for proper operation by operating all boom functions through their full range of motion several times.

2.11.10 After Axle Service

1. Check fluid levels.
2. Check torque on drive shaft flange yoke retaining bolts. Tighten these M12 bolts to 156 lb/ft (212 Nm).
3. Check wheel nut torque. Tighten to 370 lb/ft (500 Nm).
4. Check toe-in if required.
5. Apply grease at all lubrication points (grease fittings).
6. Refer to the axle manufacturer’s maintenance manual for further information.

2.12 MAINTENANCE INSTRUCTIONS

Maintenance Introduction

WARNING: DO NOT perform service or maintenance on the vehicle with the engine running. Contact with moving parts can cause serious injury or death.

This section contains a routine equipment checklist and a maintenance schedule and checklist with references to pertinent procedures and instructions. To help prevent problems before they occur, follow the maintenance schedule.

Note: Lubrication and Maintenance Chart decals are located inside the engine compartment cover (Fig. 2–3). These decals contain a general maintenance schedule that should be followed to maintain the vehicle in good operating condition. The same schedule information is presented in this manual, except that it contains a more detailed account of how to perform these specific maintenance operations.

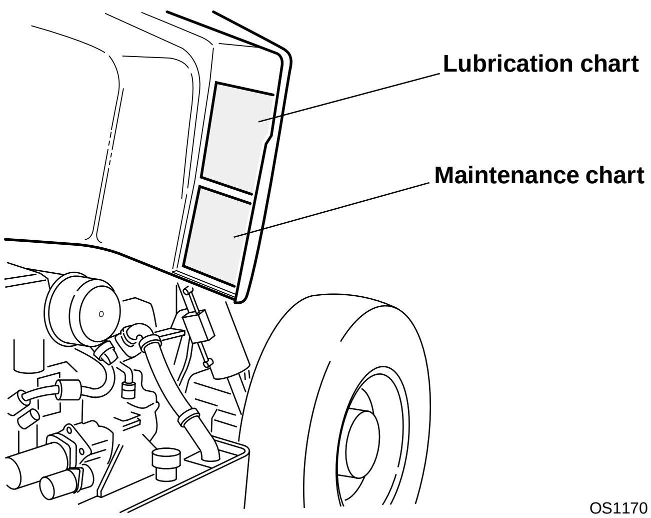


Figure 2–3. Lubrication and maintenance charts are located inside the engine cover.

2.12.1 Maintenance Schedule and Checklist

A. 10 Hour Intervals

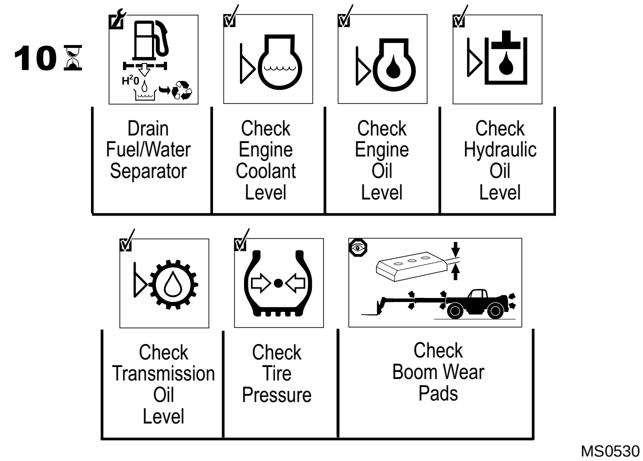


Figure 2–4. Ten-hour interval maintenance schedule and checklist.

At ten hour intervals, perform the following:

- Drain the fuel/water separator (see 2.12.7).
- Check the engine coolant level (see 2.12.5).
- Check the engine oil level (see 2.12.6).
- Check the hydraulic reservoir oil level (see 2.12.9).
- Check the transmission oil level (see 2.12.10).
- Check the air pressure in the tires (see 2.12.14).
- Check boom wear pad thickness (see 2.12.2).

B. At First 50 Hours of Use

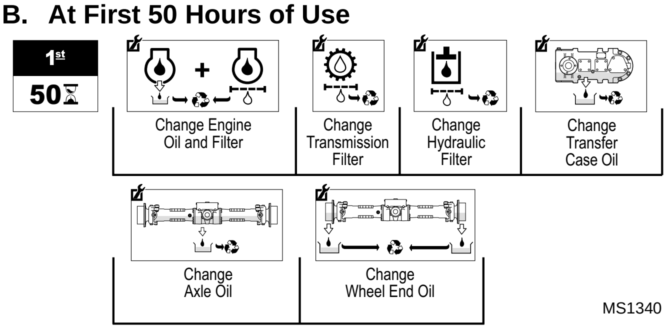


Figure 2–5. First 50 hour interval maintenance schedule and checklist.

When the vehicle completes its first 50 hours of use, perform the following:

- Change the engine oil and filter (see 2.12.6 C).
- Change the transmission filter (see 2.12.10).
- Change the hydraulic filter (see 2.12.9).
- Change the transfer case oil (see 2.12.13).
- Change the axle oil (see 2.12.11).
- Change the wheel end oil (see 2.12.12).

C. 250 Hour Intervals

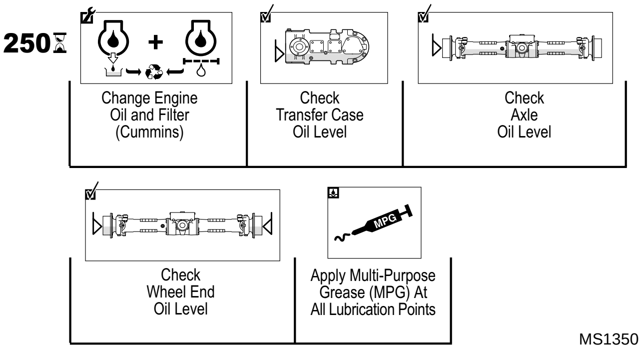


Figure 2–6. Two-hundred-fifty hour interval maintenance schedule and checklist.

At 250 hour intervals, perform the following:

- On a unit equipped with a Cummins engine, change the engine oil and filter (see 2.12.6).
- Check the transfer case oil level (see 2.12.13).
- Check the axle oil level (see 2.12.11).
- Check the wheel end oil level (see 2.12.12).
- Apply multi-purpose grease at all lubrication points (Fig. 2–7). Lubricate the following components via the grease fittings with a multi-purpose, lithium-based grease every 250 hours (remove all excess grease):

A. Hydraulic cylinder pins ....7 points
B. Drive shaft slip joints and universal joints......9 points
C. Boom pivot pin ....2 points
D. Carriage Quick Attach pivot pin....................2 points
E. Axle trunnion pivot pins................................4 points
F. Boom attachments......................................All points
G. Axle steering knuckles.................................8 points
H. Tilt cylinder pivot pins...................................2 points

Note: Shorten the lubrication interval on all lubrication points when operating under severe conditions.

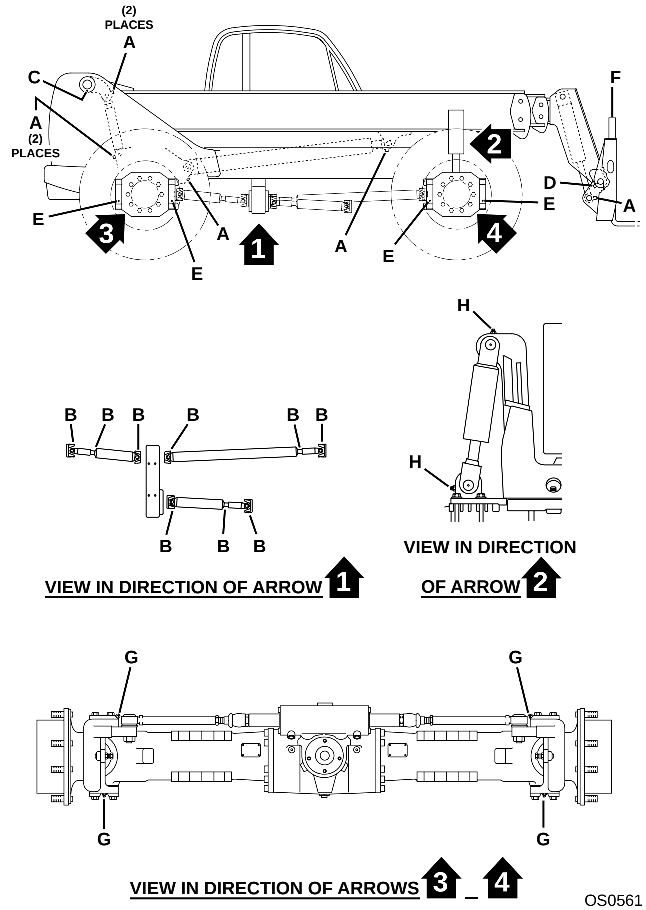


Figure 2–7. Sky Trak Model 3606 lubrication points.

D. 500 Hour Intervals

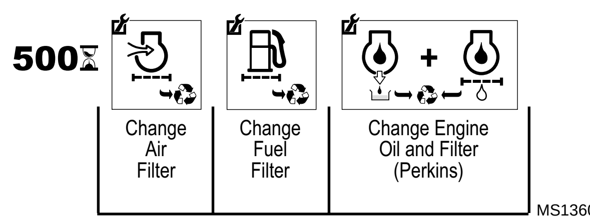


Figure 2–8. Five-hundred hour interval maintenance schedule and checklist.

At 500 hour intervals, perform the following:

- Change the air filter (see 2.12.3).
- Change the fuel filter (see 2.12.7).
- On a unit equipped with a Perkins engine, change the engine oil and filter (see 2.12.6).

E. 1,000 Hour Intervals

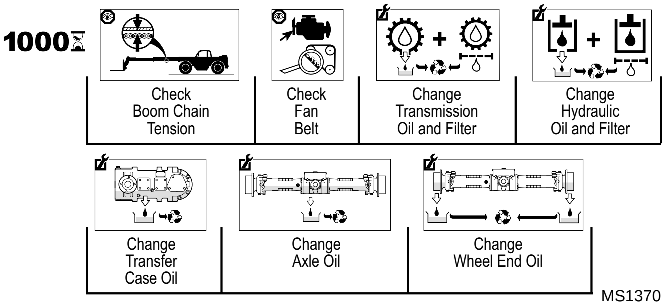


Figure 2–9. One-thousand-hour interval maintenance schedule and checklist.

At 1,000 hour intervals, perform the following:

- Check boom chain tension (see 2.12.17).
- Check the fan belt (see 2.12.8).
- Change the transmission oil and filter (see 2.12.10).
- Change the hydraulic oil and filter (see 2.12.9).
- Change the transfer case oil (see 2.12.13).
- Change the axle oil (see 2.12.11).
- Change the wheel end oil (see 2.12.12).

F. 2,000 Hour Intervals

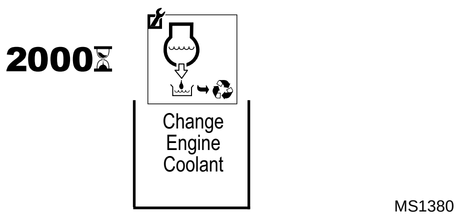


Figure 2–10. Two-thousand hour interval maintenance schedule and checklist.

At 2,000 hour intervals, perform the following:

- Change the engine coolant (see 2.12.5).

2.12.2 Boom Wear Pad Maintenance

A. Boom Wear Pad Check

Daily, and every 10 hours of engine operation, visually inspect the boom wear pads between the boom sections at the rear and front of the boom for excessive wear (Fig. 2–11).

The average expected service life of boom wear pads varies depending on the particular location of each wear pad within the boom, vehicle use, operating conditions, and the load weight.

If load weights are at or near maximum capacity, or if the vehicle is operating in very dirty or dusty conditions, the boom wear pads will wear at a much faster rate.

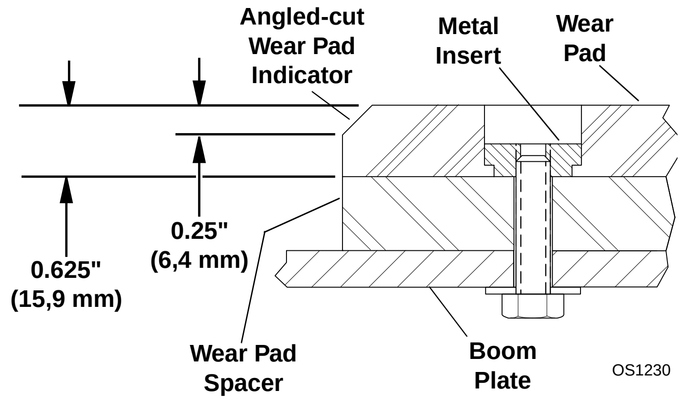


Figure 2–11. Inspect boom wear pads for excessive wear.

The boom wear pads that are under the most stress from weight of the load will also wear faster than other pads. For example, the lower pads at the front of the boom are under much more stress than the pads attached at the top front or sides of the boom. Consequently, the lower pads will require service more often.

B. Boom Wear Pad Replacement

Each boom wear pad is manufactured with a convenient wear pad indicator. This is the angled cut at each end of all boom wear pads (Fig. 2–11). The total thickness of a new boom wear pad is 0.625 inch (15,9 mm). The angled cut will provide a total wear thickness of 0.25 inch (6,4 mm). This will leave approximately 0.375 inch (9,5 mm) of total unused base material.

The pads must **NEVER** be worn past the angled cut indicator, or the metal pad insert that holds the pads in place will begin to wear into the boom pad sliding surfaces. Pads worn past this point will gouge the boom surfaces, resulting in premature wear of any new boom wear pads installed, and requiring eventual, expensive replacement of the boom. Replacement of boom wear pads must be performed when the boom wear pads indicate.

C. Boom Wear Pad Lubrication

IMPORTANT: The boom has been factory lubricated for proper wear pad break-in and will normally not require further lubrication. However, after replacing any wear pad(s), or after prolonged periods of inoperation, light lubrication of the boom wear surfaces with a rust inhibitor/ lubricant such as *LPS 3* or equivalent is recommended to keep the boom wear surfaces lubricated properly. Light lubrication of the boom wear surfaces is also recommended in salt air climates, and when the vehicle is stored, to help prevent rusting. *LPS 3* is marketed by:

LPS Laboratories, Inc.
4647 Hugh Howell Rd.
Tucker GA 30085-5052
Phone: 1-800-241-8334
Fax: (770) 493-9206

2.12.3 Air Cleaner

A. Engine Air Filter Restriction Warning Indicator

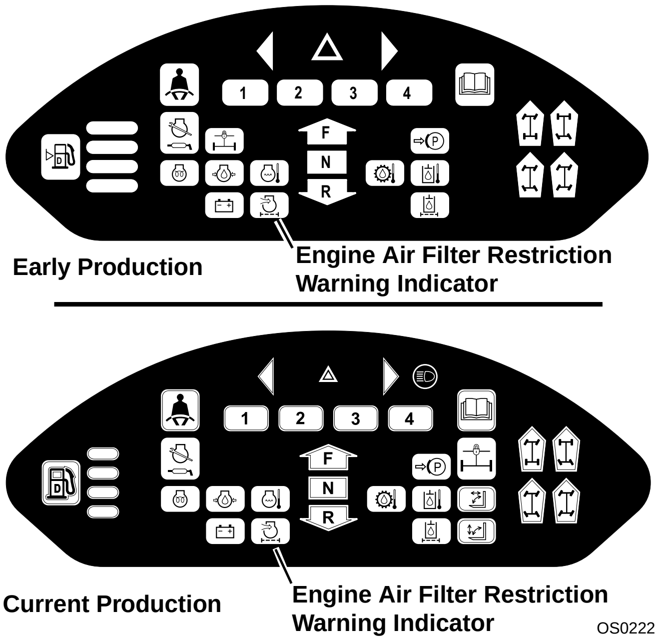


Figure 2–12. Engine air filter restriction warning indicator.

The operator's display panel includes an indicator light (Fig. 2–13) that illuminates to alert the operator when restricted air flow to the engine is sensed. This indicates that the air filter needs servicing. **NEVER** operate the vehicle without the air cleaner assembly and both filters in place.

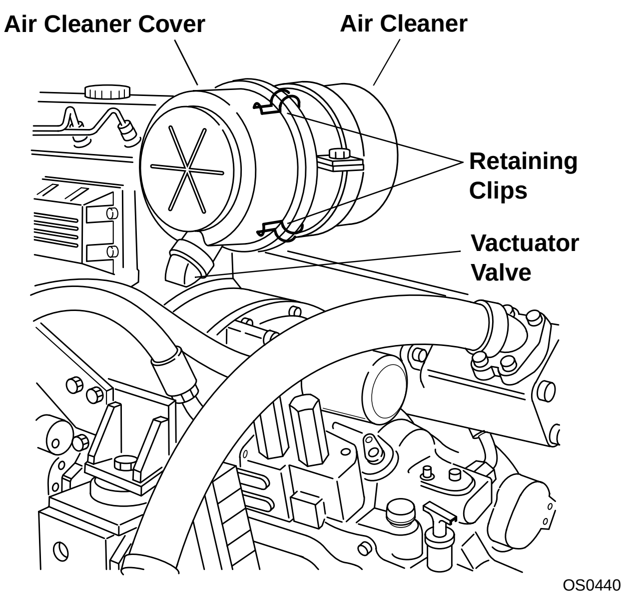


Figure 2–13. Location of engine air cleaner components.

B. Air Cleaner Element: Change or Clean

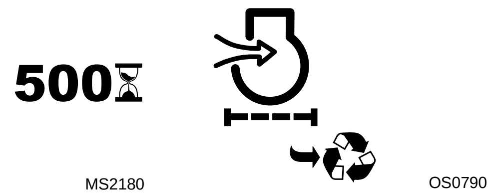


Figure 2–14. Change or clean the air filter element.

As indicated by the air cleaner restriction indicator, and/or every 500 hours, change or clean the air cleaner element.

Outer Primary Element

All air cleaner manufacturers agree that attempting to clean or wash an element increases the chance for element damage. Consider the value of cleaning an element against the risks that could lead to engine damage. Adopt the policy that all elements should be replaced with new and not cleaned.

Careful cleaning or washing, if done correctly, can extend the life of an element. Each time an element is cleaned, the dirt-holding capacity is reduced and the risk of dirt reaching the clean side of the filter is increased. Filters should **NEVER** be washed more than six times or retained for more than one year's service, whichever comes first.

If an element is washed, use a non-sudsing detergent that dissolves combustion residues without damaging the filter media. One such detergent that is specifically formulated for this purpose is *FM 1400*. This cleaner contains biodegradable synthetic detergents and is environmentally safe. *FM 1400* is marketed by:

Filter Service Corp.
2105 W. Apache
Farmington, New Mexico 87401
Telephone: (505) 326-1127

Inner Safety Element

An inner safety element (Fig. 2–15) should **NEVER** be washed or reused. **ALWAYS** install a new element.

Replace safety elements after every third primary element change. **DO NOT** remove a safety element until the inside of the air cleaner canister is thoroughly cleaned. This will help prevent dirt that could damage the engine from entering the induction manifold.

IMPORTANT: NEVER run the engine with only the safety element installed.

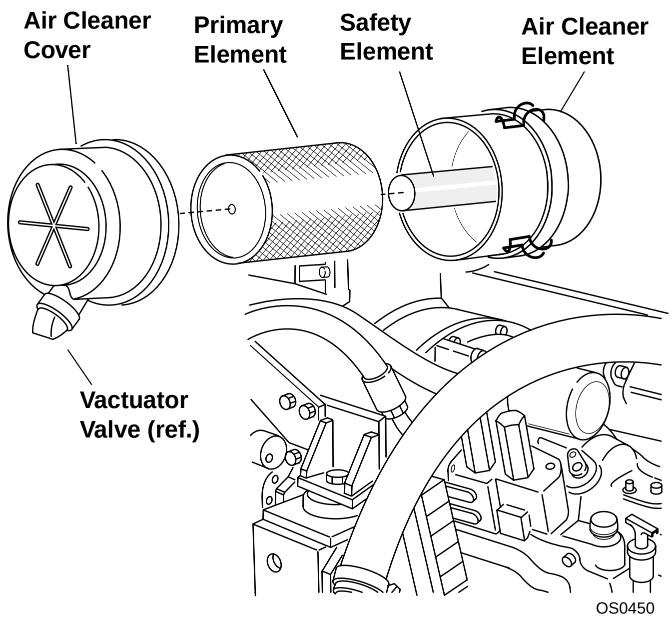


Figure 2–15. Engine air cleaner components.

To change elements:

1. Unlatch the three retaining clips (Fig. 2–13) and remove the air cleaner cover (Fig. 2–15).
2. Remove the wing nut and the primary element. Inspect the element for damage. **DO NOT** clean or reuse a damaged element.
3. Thoroughly clean the interior of the air filter canister and vactuator valve.
4. If replacing the safety element, carefully slide it out. Always discard this element and replace it with a new element.
5. Slide the new primary element over the safety element, making sure the sealing edge is flush with the base of the air cleaner. Install and tighten the wing nut securely.
6. Position the canister cover in place and secure it by latching the three retaining clips.

Sky Trak recommends changing filters. If a replacement filter is not available, carefully follow these procedures to clean a primary element:

1. Remove loose particles from the filter with compressed air [maximum 30 psi (2,1 kPa)] or water hose [maximum 40 psi (2,8 kPa) without nozzle]. Rotate and apply pressure from the inside of the element.
2. Soak the filter in non-sudsing detergent (such as *FM 1400*) for at least 15 minutes. **NEVER** soak longer than 24 hours.
3. Swish the filter around in the solution to remove loosened dirt particles.
4. Rinse the filter from the inside out with a gentle stream of water [less than 40 psi (2,8 kPa), without nozzle] to remove all dirt and suds. If the inside of the element has been contaminated with dirty water from the soaking, rinse both sides.
5. Dry the filter before re-using. Circulate warm air at less than 160°F (57°C). **DO NOT** use a light bulb to dry the filter.
6. Inspect for holes or tears by looking through the filter toward a bright light. Check for damaged gaskets or metal parts. **DO NOT** re-use a damaged filter.

C. Air Intake System-Inspection

Inspect the intake piping for cracked hoses, loose clamps, or punctures that can allow dirt or debris to enter the combustion chamber. If dirt or debris is allowed to enter the combustion chamber, it can severely damage the engine. If necessary, tighten or replace parts to help prevent air intake system leakage.

2.12.4 Optional Closed Cab Air Filters

The optional closed cab has two air filters, the recirculation air filter (Fig. 2–16) and the fresh air intake filter (Fig. 2–17). Both of these filters require periodic inspection and maintenance.

Recirculation Air Filter

Periodically remove and inspect the recirculation air filter (Fig. 2–16) located directly below the seat. Gently hand wash with water, a mild detergent may also be used if the filter is saturated with dirt.

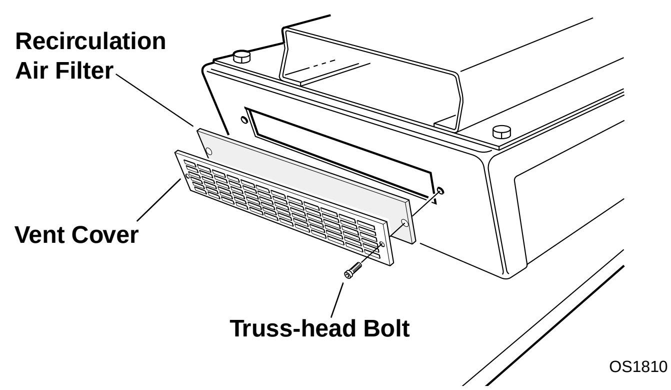


Figure 2–16. Periodically remove and inspect the recirculation air filter.

Fresh Air Intake Filter

Periodically remove the cab rear panel and inspect the fresh air intake filter (Fig. 2–17). The filter must be cleaned sometimes as often as twice a day, depending on the operating environment. This is done by removing the filter and shaking it. Pressurized air can also be used to blow out dust. The filter will clean outside air when pressurizing the cab. The filter should be replaced when required.

Note: Correctly position the filter so the air flow is directed into the cab.

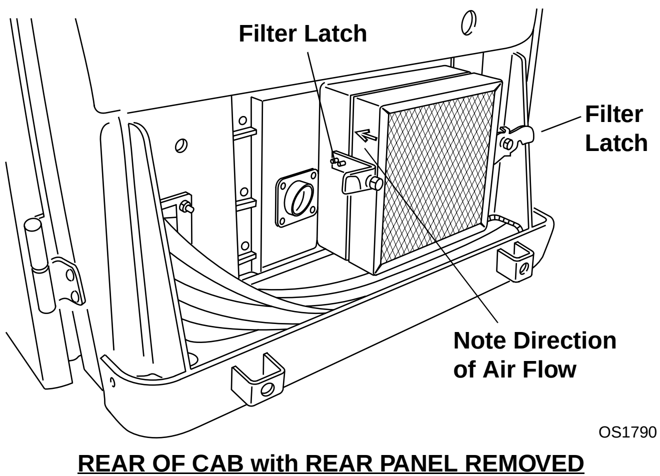


Figure 2–17. Periodically remove and inspect the recirculation air filter.

2.12.5 Engine Cooling System

A. Engine Coolant Level Check (10 Hour Intervals)

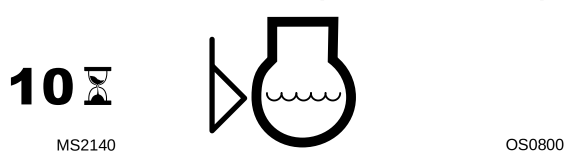


Figure 2–18. Check the engine coolant level every 10 hours of engine operation.

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut off the engine.
2. Unlatch, unlock and open the engine cover.
3. Check the coolant level in the overflow bottle (Fig. 2–19). When the coolant is hot, the bottle should be half to three-quarters full. When the coolant is cool, the bottle should be one-quarter to half full. Add coolant (use a 50/50 mixture of ethylene glycol and water) as required through the overflow bottle.

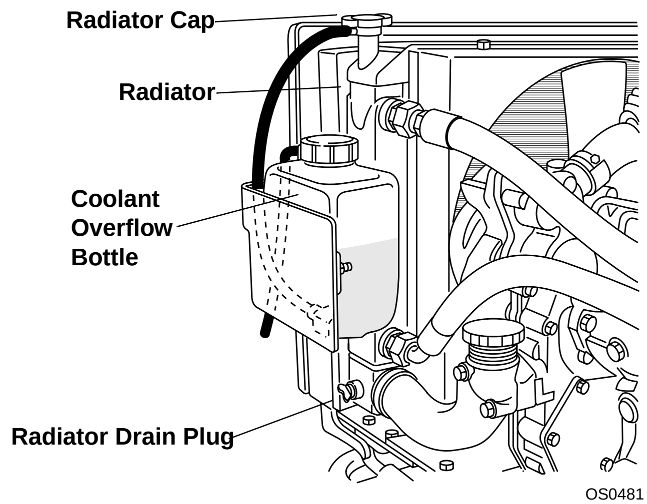


Figure 2–19. Check the coolant level in the overflow bottle.

B. Drain and Flush the Radiator

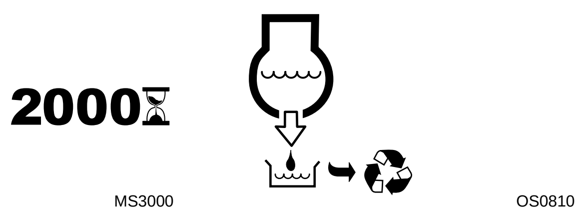


Figure 2–20. Drain and flush the radiator every 2,000 hours of engine operation.

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut off the engine.

> **WARNING: DO NOT** attempt this procedure when the engine is hot. Wait for the engine, muffler, and tailpipes to cool down before proceeding. Failure to do so could result in severe burns.

2. Unlatch, unlock and open the engine cover. Allow the engine to cool before proceeding. Draining and flushing the cooling system while the engine is hot can cause cracks in the engine block.

> **WARNING: NEVER** remove the radiator cap while the engine is hot. The cooling system is under pressure. Hot coolant can cause severe burns or eye injury. Wear protective clothing and safety glasses.

3. Slowly turn the radiator cap to the first stop and allow any pressure to escape. Remove the radiator cap.

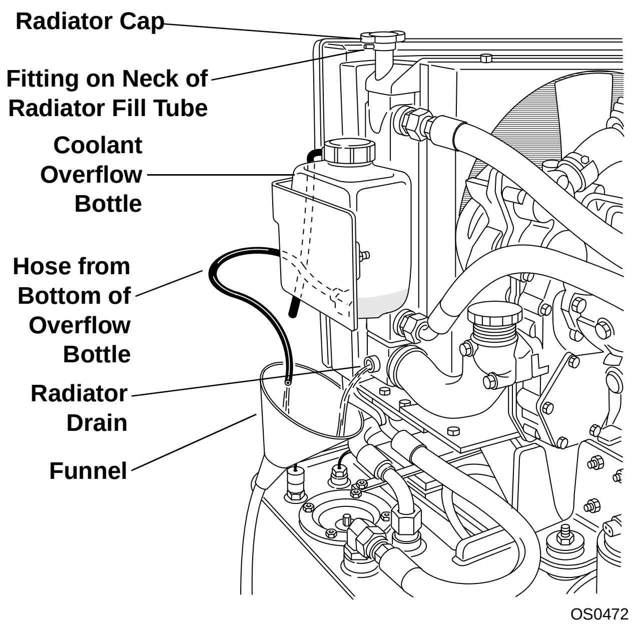


Figure 2–21. Drain coolant from the overflow bottle.

4. Place a funnel at the base of the radiator (Fig. 2–22) to channel the drained coolant into a container. Unscrew the radiator drain plug and allow the coolant to drain into the funnel.
5. Detach the hose from the fitting on the neck of the radiator fill tube and drain any coolant from the overflow bottle into the funnel.
6. Flush the radiator with clean water, and drain again.
7. Remove the engine block drain plug (Fig. 2–23) and drain any coolant from the engine block. Replace the engine block plug.

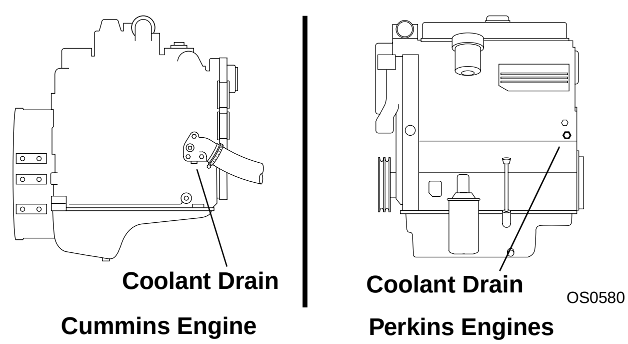


Figure 2–22. Remove the engine block coolant drain plug.

8. Transfer the coolant into a properly labeled container. Dispose of properly.
9. Reconnect the hose to the fitting on the neck of the radiator fill tube. Close the radiator drain plug or petcock.
10. Fill the radiator completely with a 50/50 mixture of ethylene glycol and water. Replace the radiator cap. Add coolant to the overflow bottle until the bottle is half to three-quarters full. This “overfilling” will compensate for any air in the cooling system.
11. Clean dirt and debris from the radiator core.
12. Start and run the engine until normal engine operating temperature is reached, then turn the engine OFF. Check for leaks while the engine is cooling.
13. Allow the engine to cool. Check the radiator coolant level again and top off as needed with a 50/50 mixture of ethylene glycol and water. Replace the radiator cap.
14. The overflow bottle should be one-quarter to half full. If not, fill as necessary with a 50/50 mixture of ethylene glycol and water.

2.12.6 Engine Oil and Filter

A. Engine Oil Recommendations

The use of quality engine oil combined with the appropriate oil and filter change intervals are critical factors in maintaining engine performance and durability. Refer to the engine manufacturer’s manual for recommended oil types for various operating conditions).

Engine oil capacity, with filter change, is:

Perkins Engines............................ 9.0 quarts (8,5 liters)

Cummins Engine .... 11.6 quarts (11,0 liters)

For most climates, use a premium-quality 15W40 motor oil that meets API, CD or CE (severe duty diesel engine) specifications. In cold climates where ambient (outside air) temperatures are consistently below 32° F (0° C), 10W30 motor oil can be used; however, continuous use of low viscosity oil may cause premature engine wear.

B. Oil Level Check

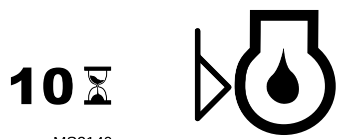


Figure 2–23. Check the oil level every 10 hours of engine operation.

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut off the engine.
2. Unlock and open the engine cover.
3. Remove the engine dipstick (Fig. 2–24). Check the oil mark on the dipstick. The oil should be between the full and add marks. On Cummins engines, the oil mark should be within the crosshatched area of the dipstick.

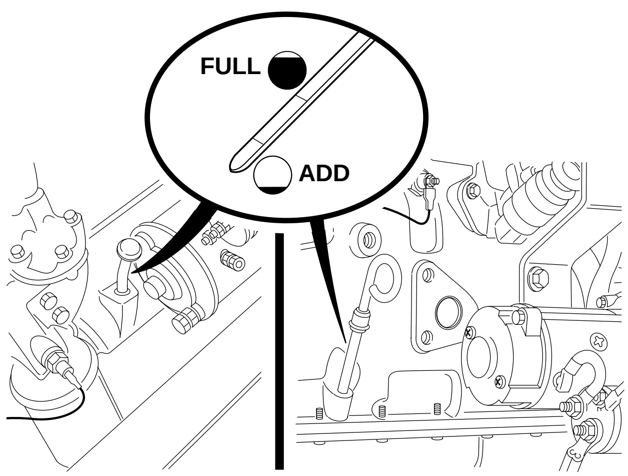


Figure 2–24. Check the oil level mark on the dipstick.

4. Add oil as required. Replace the dipstick.

C. Oil and Filter Change

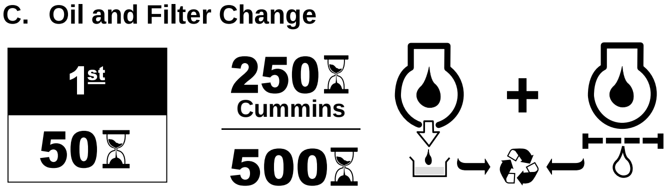


Figure 2–25. Change the engine oil and engine oil filter.

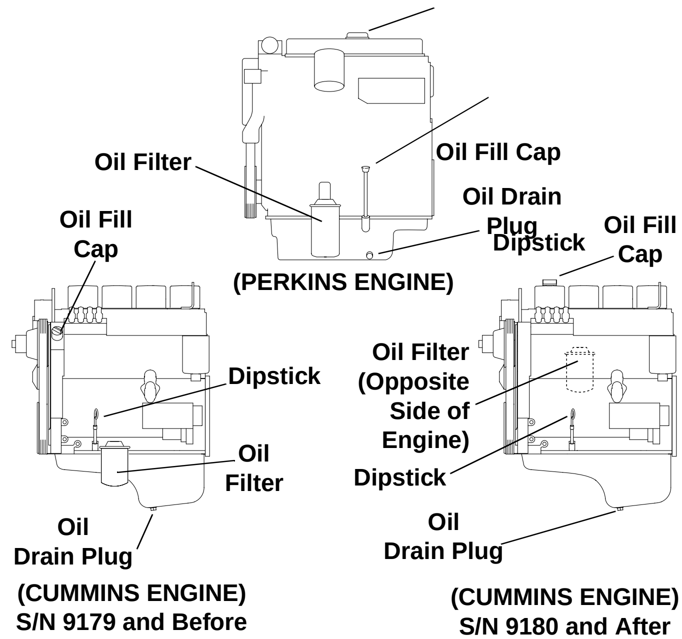


Figure 2–26. Location of items relevant to checking the engine oil level and changing the oil and filter.

Change the oil and filter after the first 50 hours of vehicle operation, at 250-hour intervals for Cummins engines, and 500-hour intervals for Perkins engines. To change the oil and filter:

1. Operate the engine until it reaches operating temperature (approximately five minutes).
2. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut off the engine.
3. Unlock and open the engine cover.
4. Place an oil drain pan under the engine's oil drain plug. For Cummins engines, fabricate a V-shaped piece of cardboard to serve as a funnel trough for draining oil from the oil pan to the oil drain pan.
5. Remove the drain plug from the engine oil pan.
6. Allow the oil to drain completely into the receptacle. Transfer the oil to a container with a cover and label the container as used motor oil. Dispose of properly.
7. Remove the oil filter and clean the filter sealing surface.
8. Apply a thin coat of clean engine oil to the new filter mating surface.
9. Install the new oil filter and hand tighten. Use an oil filter wrench or strap to tighten the filter down an additional one-quarter to half turn. **DO NOT** overtighten.
10. Clean and reinstall the oil drain plug into the engine oil pan.

11. Remove the engine oil fill cap and add oil (refer to the engine manufacturer's manual for recommended oil types for various operating conditions). Engine oil capacity with filter change is:
    Perkins Engine . . . . 9.0 quarts (8,5 liters)
    Cummins Engine . . . . 11.6 quarts (11,0 liters)
12. Reinstall the oil fill cap. Start the engine and allow it to run for several minutes.
13. Shut off the engine. Wait several minutes, then check the oil level again on the dipstick. Add oil as required. **DO NOT** overfill.
14. Look for oil leaks at the filter and drain plug. Tighten as required.

2.12.7 Engine Fuel System

A. Drain Water from Fuel Water Separator/Filter

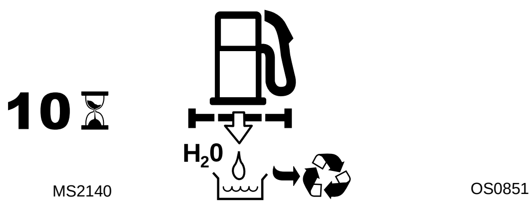


Figure 2–27. Drain water from the fuel-water separator/filter every 10 hours of engine operation.

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut off the engine. Allow the engine to cool.
2. Unlock and open the engine compartment cover.
3. Position a suitable glass container beneath the fuel filter drain cock (Fig. 2–28), located on the underside of the fuel filter.

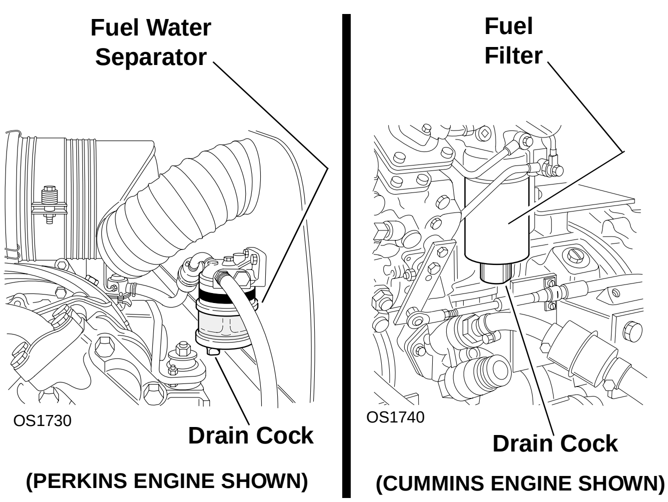


Figure 2–28. Position a suitable glass container beneath the fuel filter drain cock.

4. Loosen the fuel filter drain cock. Allow the water to drain into the glass container until clear fuel is visible. After draining is complete, tighten the drain cock. Dispose of drainage properly.
5. Close and lock the engine compartment cover.

B. Change Fuel Filter

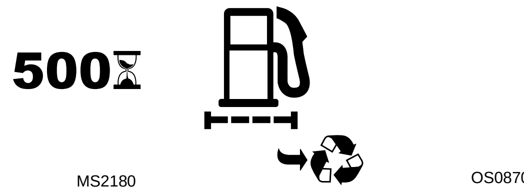


Figure 2–29. Change the fuel filter every 500 hours of engine operation.

Change the fuel filter every 500 hours of engine operation, or at shorter intervals with water evidence of contaminated fuel.

PERKINS ENGINE

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut off the engine. Allow engine to cool.
2. Unlock and open the engine cover. Clean the outside surfaces of the filter assembly.
3. Loosen the drain cock at the bottom of the canister (Fig. 2–30) to remove it and allow the fuel-water to drain into a suitable container. Dispose of properly.

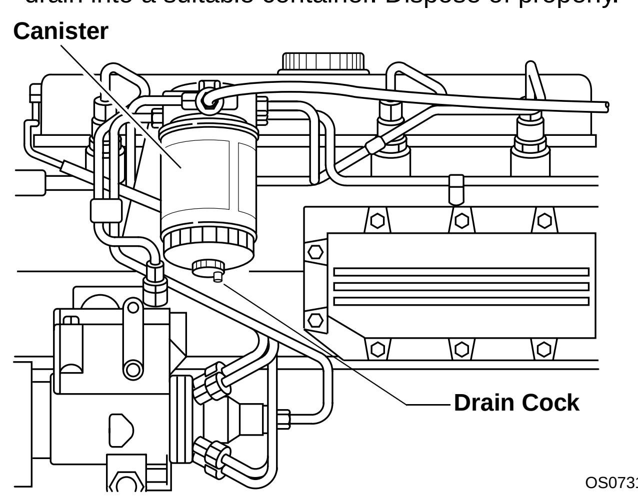


Figure 2–30. Perkins drain cock location.

4. Unscrew the canister to remove it from the base. Clean the base. Properly dispose of the canister.
5. Lightly lubricate the new fuel filter gasket with clean No. 2 diesel fuel. If the engine has been completely run out of fuel, prefill the canister with clean fuel.

6. Screw the new canister onto the base. Hand tighten only.
7. Remove air from the fuel system. See *Venting Air from the Fuel System*. (see 2.12.7 D)
8. Close, latch and lock the engine cover.

CUMMINS ENGINE

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut off the engine. Allow engine to cool.
2. Unlock and open the engine cover. Clean around the fuel-filter head (Fig. 2–31).

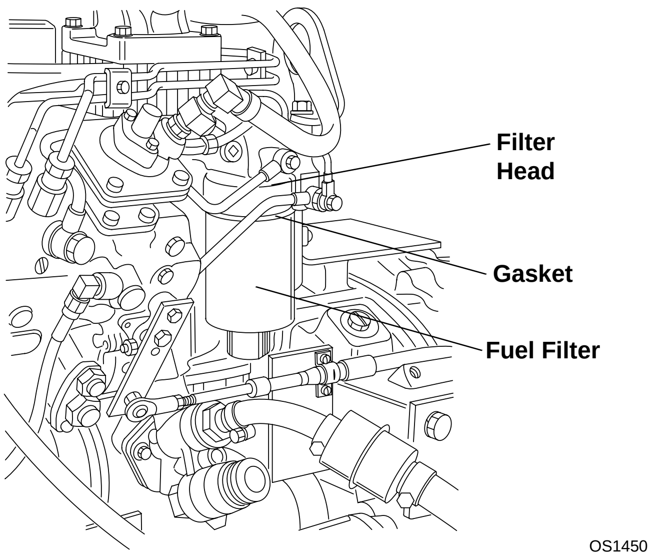


Figure 2–31. Cummins fuel filter location.

3. Clean the filter head gasket surface and replace the O-ring.
4. Fill the new fuel filter with clean No. 2 diesel fuel.
5. Lubricate the O-ring seal with clean lubricating oil.
6. Install the fuel-filled filter and tighten by hand. **DO NOT** over tighten.

Note: DO NOT overtighten. **DO NOT** tighten with mechanical means (tools, etc.). Mechanical over-tightening may distort the threads or damage the O-ring seal.

Controlled venting is provided at the injection pump through the fuel drain manifold. Small amounts of air introduced by changing the fuel filter element will be vented automatically as long as the element was filled with fuel prior to installation.

C. In-line Fuel Strainer

(Every 500 hours of engine operation)

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut off the engine. Allow engine to cool.
2. Unlock and open the engine cover.
3. On both Perkins and Cummins engines, the in-line fuel strainer is located down line from the engine lift pump (Fig. 2–32). Loosen the two hose clamps securing the strainer in place.

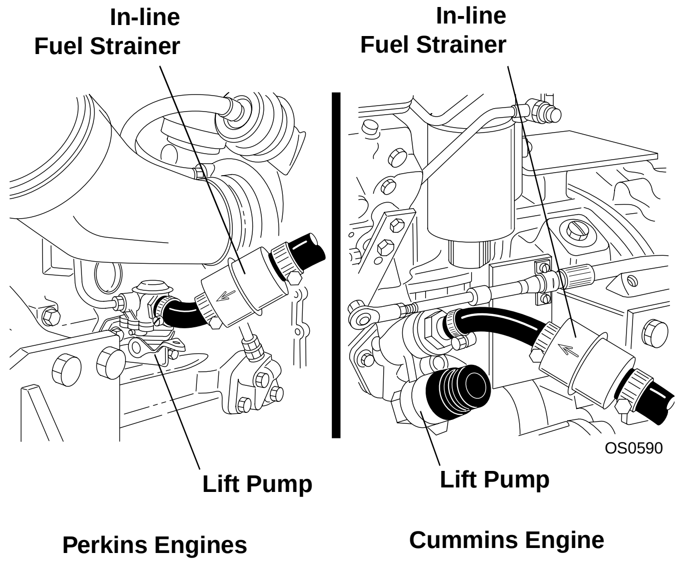


Figure 2–32. In-line fuel strainer and lift pump locations.

4. Remove and properly dispose of the old strainer.
5. Install the new strainer with the arrow pointing toward the lift pump.
6. Assemble the hoses to the strainer and tighten the hose clamps.
7. Remove air from the fuel system. See *Venting Air from the Fuel System*. (see 2.12.7 D)
8. Close and lock the engine cover.

D. Venting Air from the Fuel System

WARNING: DO NOT vent air from the fuel system of a hot engine. Allow the engine to cool before attempting to purge air from the fuel system. Failure to do so could create a fire hazard.

Air must be vented from the fuel system whenever any component between the fuel tank and the injection pump has been disconnected, or when the system has been emptied, or has run out of fuel.

IMPORTANT: DO NOT attempt to start the engine until the injection pump has been filled and primed with fuel. Serious damage to the lift pump will result due to lack of proper lubrication.

PERKINS ENGINE

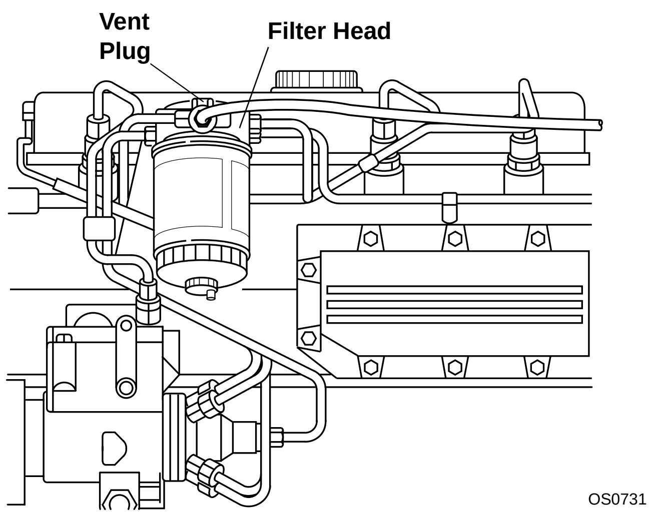


Figure 2–33. Perkins vent plug and filter head locations.

1. To vent air from the low pressure fuel lines, loosen the vent plug until fuel, free of air, comes out of the vent plug. Tighten the vent plug.

Note: If the lift pump drive cam is at the point of maximum lift, it will not be possible to operate the priming lever. In this situation, the crankshaft must be turned one revolution.

2. Loosen the high pressure connections at the injectors. Verify that the manual stop control is in the RUN position. Operate the starter motor until fuel, free of air, comes out of the pipe connections. Tighten the connections to 16 lb/ft (22 Nm).

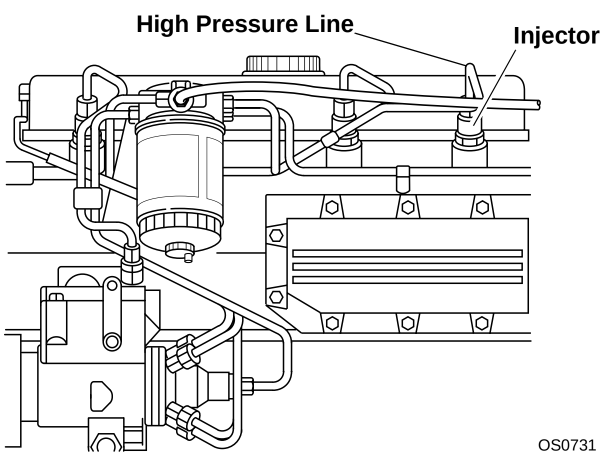


Figure 2–34. Perkins high pressure line and injector locations.

CUMMINS ENGINE

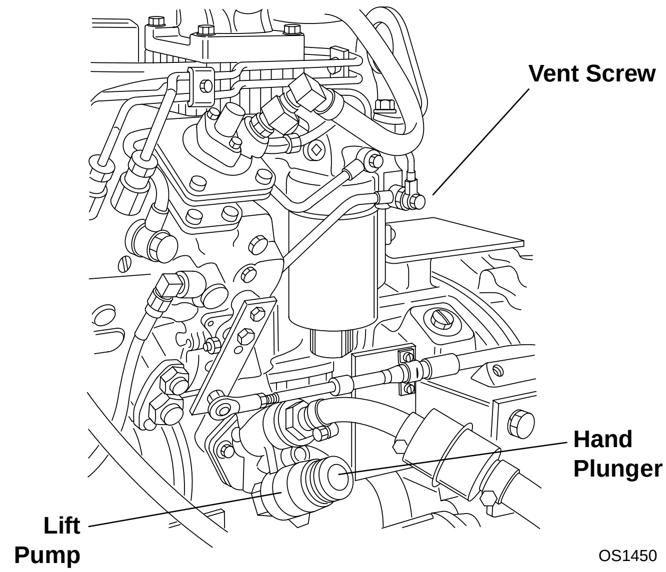


Figure 2–35. Cummins vent screw, hand plunger and lift pump locations.

1. To vent the low pressure lines and fuel filter, open the vent screw located on the filter head. Operate the hand plunger on the lift pump until fuel flowing from the fitting is free of air. Tighten the vent screw and torque to 7 lb/ft (9 Nm).

IMPORTANT: When cranking the engine with the starter motor to vent air from the fuel system, **DO NOT** energize the starter solenoid or crank the engine for more than 15 seconds at a time. Wait two minutes between each 15-second cranking interval.

2. Operate the starter motor for no more than 15 seconds. The process of venting the high pressure fuel lines involves energizing the starter motor, which rotates the crankshaft, which, in turn, operates the fuel pump to purge air from the high pressure fuel lines.

!	**WARNING: KEEP CLEAR** of spraying fuel. Diesel fuel will spray when venting high pressure lines. The fuel pressure is sufficient to penetrate the skin and cause serious bodily injury. Wear protective clothing and safety glasses.

3. Loosen one fitting at the injector (Fig. 2–36). Operate the starter motor for 15 seconds. Wait two minutes. Operate the starter motor again for 15 seconds. Repeat this process until fuel, free of air, comes out of the injector fitting.

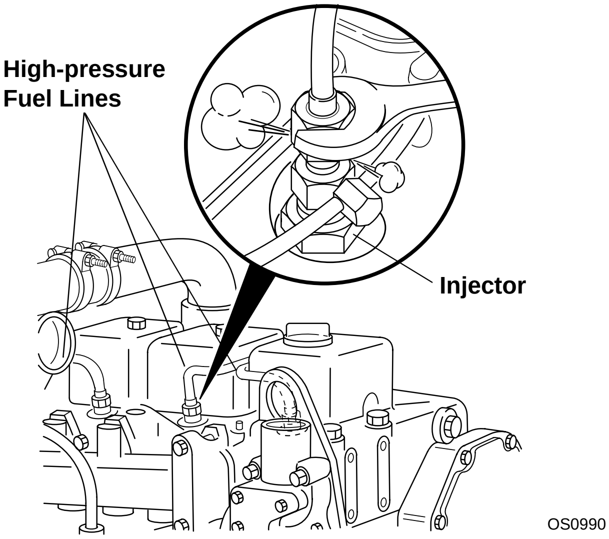


Figure 2–36. Cummins injector and high-pressure fuel line locations.

4. Tighten the fitting to 22 lb/ft (30 Nm). Repeat this procedure for each fitting until the engine runs smoothly. With the engine running, visually check for leaks. Turn the ignition switch OFF.

2.12.8 Engine Fan Belt

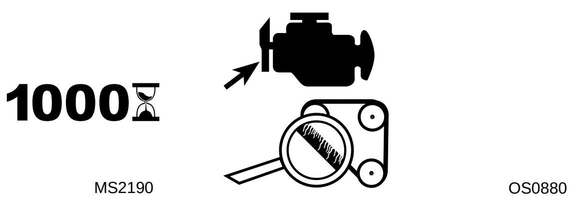


Figure 2–37. Inspect the engine fan belt every 1,000 hours of engine operation.

PERKINS ENGINE

1. Ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut off the engine. Allow engine to cool.
2. Unlock and open the engine cover.
3. Inspect the fan belt. Replace if cracked or frayed.
4. Check fan belt tension midway between the crankshaft and alternator pulleys (Fig. 2–38). Deflection should be 1/4" to 3/8" (6,4 to 9,4 mm) with an applied force of 13 to 15 pounds (6 to 7 kg).

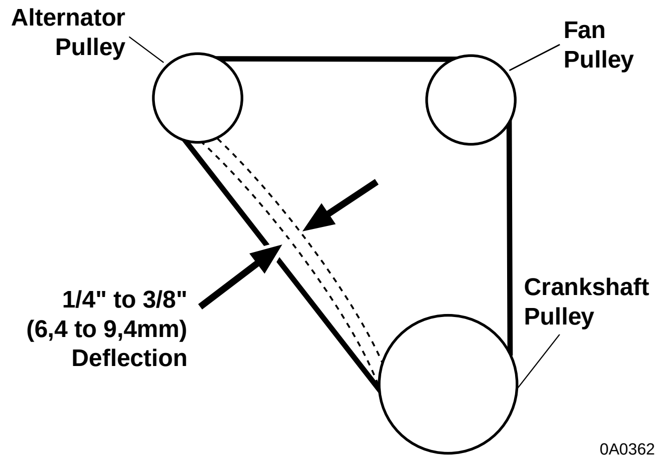


Figure 2–38. Perkins engine fan belt adjustment points.

5. If the fan belt needs adjustment, loosen both alternator mounting bolts and use a fan-belt tensioner to carefully pry the alternator to tighten the belt. **DO NOT** overtighten. Retighten the alternator mounting bolts.
6. Recheck fan belt deflection. Adjust as necessary.
7. Close and lock the engine compartment cover.

CUMMINS ENGINE

1. Ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut off the engine. Allow engine to cool.
2. Unlock and open the engine cover.
3. The Cummins engine is equipped with an automatic belt tensioner (Fig. 2–39). Rotate the tensioner up and remove the fan belt. Inspect the fan belt and tensioner bearing. Inspect the fan belt. Replace if cracked or frayed. Spin the bearing, and check for resistance or rough spots in bearing travel.
4. Spin the fan and check for wobble or excessive play. Maximum play should be 0.006 inch (0,15 mm).
5. To install the fan belt, position the belt over the grooved pulleys. While holding the tensioner up, slide the belt over the water pump pulley.

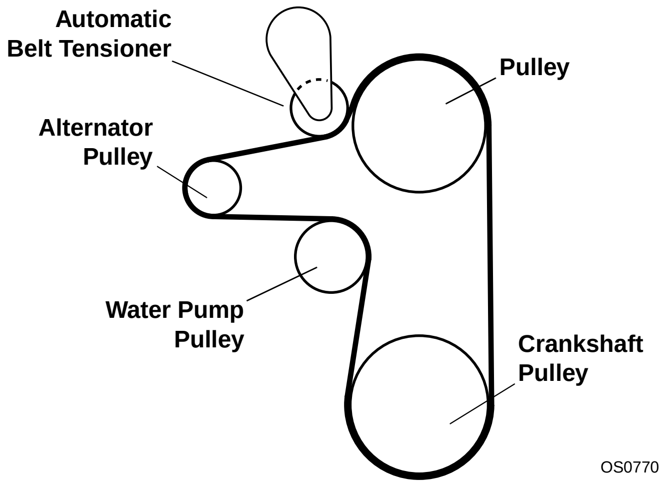


Figure 2–39. Cummins engine fan belt adjustment points.

6. Close and lock the engine compartment cover.

2.12.9 Hydraulic System Oil And Filter

A. Hydraulic Oil Level Check

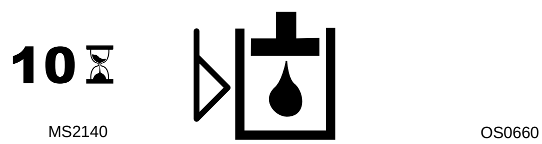


Figure 2–40. Check the hydraulic oil level every 10 hours of engine operation.

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), and engage the parking brake switch.
2. Fully retract all hydraulic cylinders and shut off the engine.
3. Allow the hydraulic oil to cool.
4. Unlock and open the engine cover. Locate the hydraulic oil sight glass along the vertical wall of the hydraulic oil tank (Fig. 2–41). Check the level of the hydraulic oil in the tank. The hydraulic oil level should be visible at the lower end of the sight glass. If hydraulic oil is not visible, remove the hydraulic oil fill cap and add ISO Grade 46 hydraulic oil until the hydraulic oil level is visible at the lower end of the sight glass. **DO NOT** overfill.

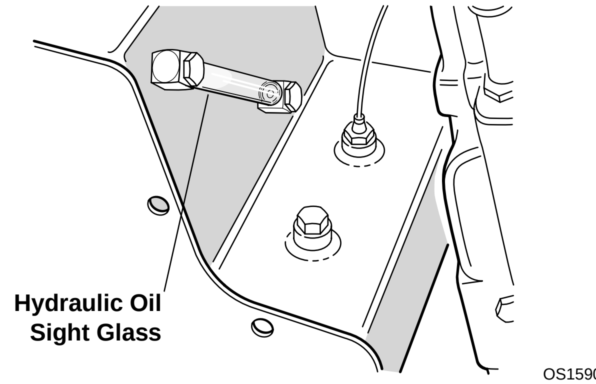


Figure 2–41. Check the hydraulic oil level via the sight glass.

5. Reinstall the hydraulic oil fill cap. Close and lock the engine cover.

B. Hydraulic Oil and Hydraulic Oil Filter Change

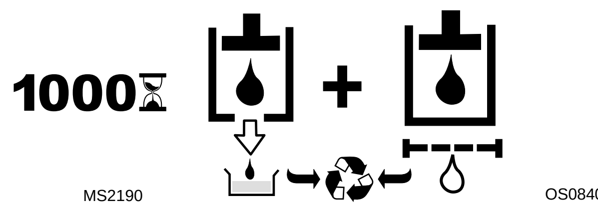


Figure 2–42. Change the hydraulic oil filter after the first 50 hours of engine, and every 1,000 hours thereafter.

Change the hydraulic oil filter after the first 50 hours of engine operation, and every 1,000 hours of operation thereafter.

Also, the hydraulic oil filter must be changed anytime the hydraulic oil filter restriction warning indicator light on the operator's instrument panel begins to flicker ON and OFF at high idle (Fig. 2–43).

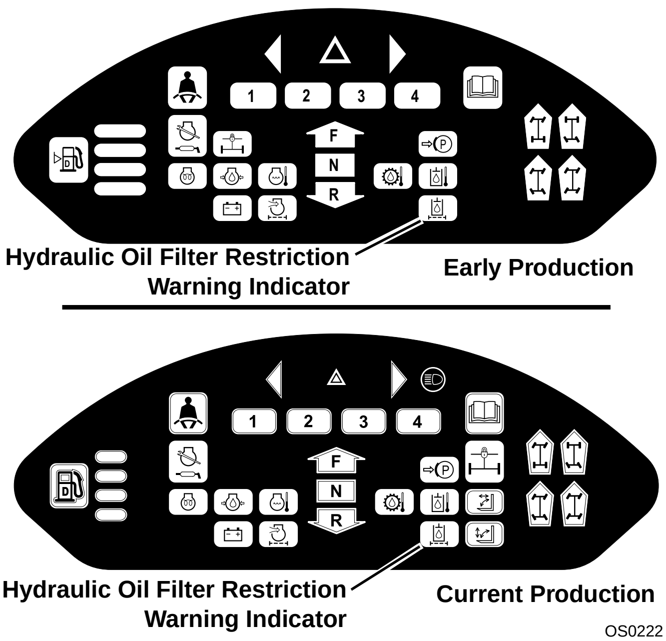


Figure 2–43. Hydraulic oil filter restriction warning indicator for early production (top) and current production (bottom) vehicles.

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), and engage the parking brake switch.

> **WARNING: DO NOT** change the hydraulic oil or the hydraulic oil filter with the engine running. Contact with moving parts can cause serious injury or death.

2. Fully retract all hydraulic cylinders and shut off the engine.
3. Unlock and open the engine cover. Allow the hydraulic oil to cool.
4. Clean around the hydraulic oil filter head (Fig. 2–44). Loosen, but **DO NOT** remove, the nuts that secure the hydraulic oil filter head to the hydraulic oil tank.
5. Place a suitable container under the hydraulic reservoir drain plug. The container must be large enough to hold 32 gallons (121,9 liters) of hydraulic oil.
6. To facilitate removal of the hydraulic oil filter head and filter, the hydraulic oil return line may need to be swiveled out of the way, and the indicator wiring unplugged. **DO NOT** crimp the hydraulic oil return line or indicator wiring. Rotate and remove the hydraulic oil filter head; be prepared for a large amount of oil to be displaced.

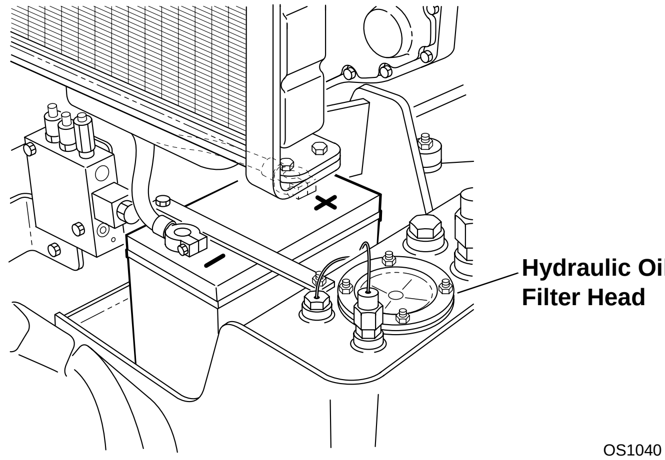


Figure 2–44. Clean around the hydraulic oil filter head.

7. Remove the hydraulic oil filter element (Fig. 2–45) from the hydraulic oil filter head. Dispose of properly.
8. Clean the filter head sealing surface.

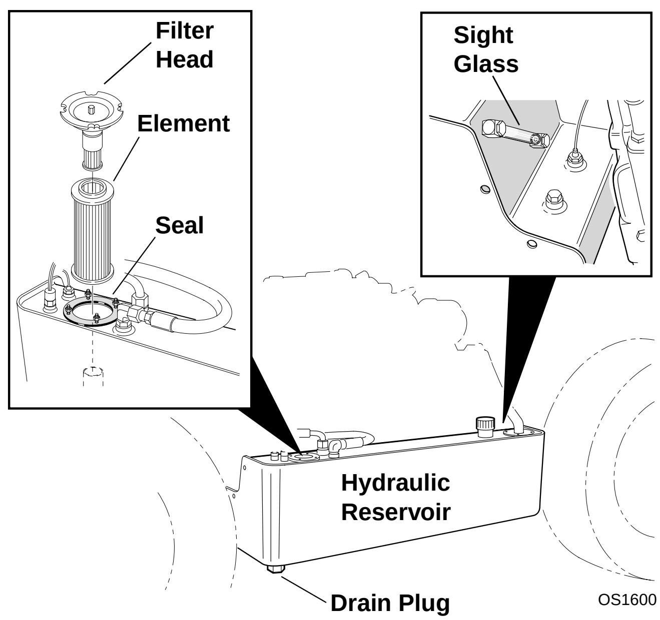


Figure 2–45. Replace the hydraulic filter element and add hydraulic oil as required.

9. Remove the magnetic drain plug and allow the hydraulic oil to drain into the container. Clean loose particles from the magnetic drain plug. Transfer the used hydraulic oil to a container with a cover and label the container as used hydraulic oil. Dispose of properly.
10. Reinstall the magnetic drain plug into the hydraulic oil reservoir.

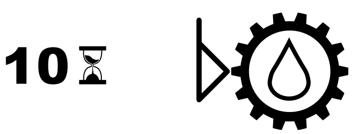
11. Fully install a new hydraulic oil filter element onto the hydraulic oil filter head until the filter seats. Slide the filter assembly into the reservoir. Secure the filter head by tightening the nuts loosened earlier.
12. If the hydraulic oil return line was swiveled out of the way, reposition the line. If the indicator wiring was unplugged, reconnect it.
13. Remove the fill cap and fill with ISO Grade 46 hydraulic oil until the oil level is visible within the lower end of the sight glass. Reservoir capacity is 32 gallons (121,9 liters). Reinstall the fill cap. Thoroughly clean or wipe up any spilled hydraulic oil.
14. Close and lock the engine compartment cover.
15. Operate all hydraulic functions through their full range of motion several times. Cycle all control modes to help purge air from the hydraulic system.

WARNING: DO NOT use your hand or any part of your body to check for hydraulic leaks. Hydraulic oil leaking under pressure can penetrate the skin and cause severe personal injury. When checking for hydraulic leaks, wear safety glasses and gloves to help provide protection from spraying hydraulic oil. Use a piece of cardboard or paper to search for leaks.

16. Check for leaks.

2.12.10 Transmission Oil And Filter

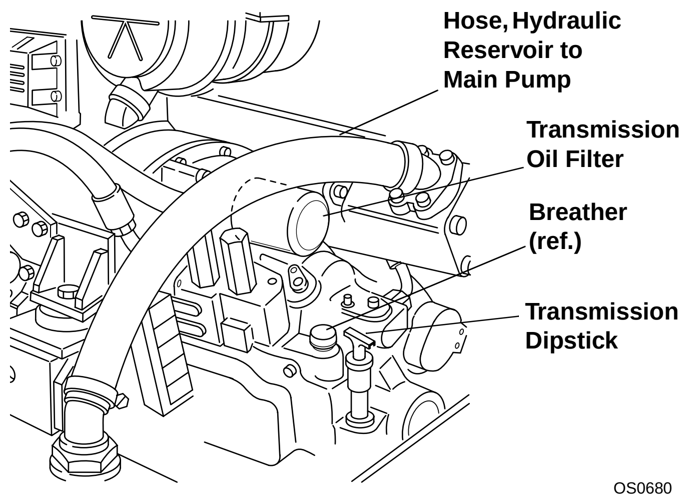
A. Transmission Oil Level Check



MS2140 OS0890

Figure 2–46. Every 10 hours of engine operation, check the transmission oil level.

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), and engage the parking brake switch.
2. Check the transmission oil level with the engine at idle and the oil at normal operating temperature.
3. Remove the transmission dipstick (Fig. 2–46). Check the transmission oil level.

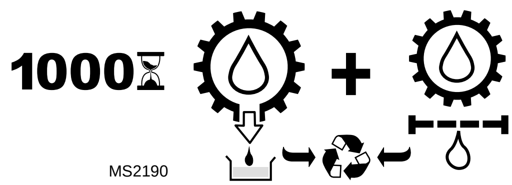


OS0680

Figure 2–47. Transmission oil level dipstick location.

4. As required, add a premium grade of transmission fluid (see *Section 2.5.6 A. Transmission* for a list of approved fluids) to the transmission to bring the level up to the full mark.

B. Transmission Oil and Filter Change



MS2190 OS0950

Figure 2–48. Every 1,000 hours of engine operation, change the transmission oil and transmission oil filter.

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), and engage the parking brake switch.
2. Unlock and open the engine compartment cover. Allow the engine and transmission to cool.
3. Place a suitable receptacle under the transmission drain plug (Fig. 2–49). Remove the drain plug and allow the transmission oil to drain into the receptacle. Transfer the used transmission oil into a suitable covered container and label the container as used oil. Dispose of properly.

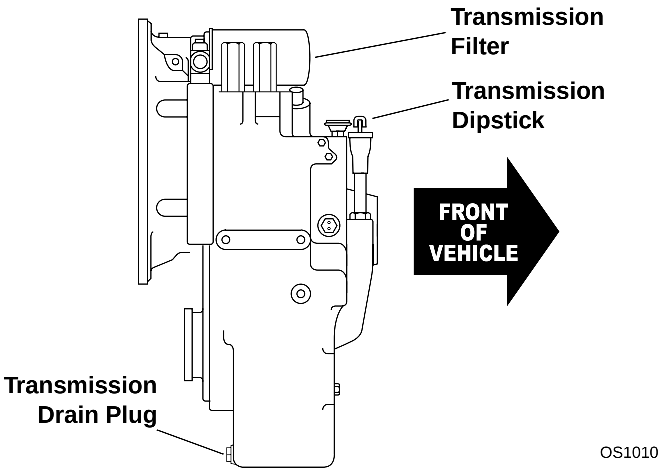


Figure 2–49. Location of transmission maintenance items.

4. Clean and reinstall the transmission drain plug into the transmission housing.
5. Remove the transmission oil filter and dispose of properly. Clean the mating surface where the filter mounts.

Note: 10W motor oil is recommended in most climates; however, 5W20 motor oil may be substituted for use under temperature conditions of -30°F to 70°F (-34°C to 21°C) only. Refer to *Section 2.5.6. A. Transmission Fluid*.

6. Apply a thin film of clean 10W motor oil (that meets ISO 46 standards) to the new filter gasket. Install the new filter and torque 20-25 lb/ft (27-34 Nm).
7. Transmission oil may be added through either the fill plug (Fig. 2–50) or dipstick. Remove the fill plug or dipstick and fill with approximately 3.4 gallons (12,9 liters) of 10W motor oil. Check the level by taking intermittent dipstick readings as outlined in *Transmission Oil Level Check*. **DO NOT** overfill. Reinstall the fill plug or dipstick when finished.

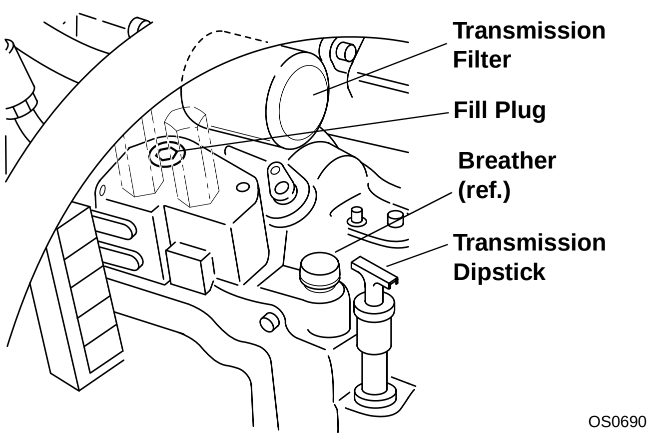


Figure 2–50. Fill the transmission through the fill plug or dipstick opening.

8. Close and lock the engine compartment cover.

2.12.11 Axle Oil

A. Axle Oil Level Check

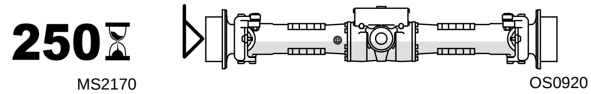


Figure 2–51. Every 250 hours of engine operation, check the axle oil level in both the front and rear axles.

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut the engine off.

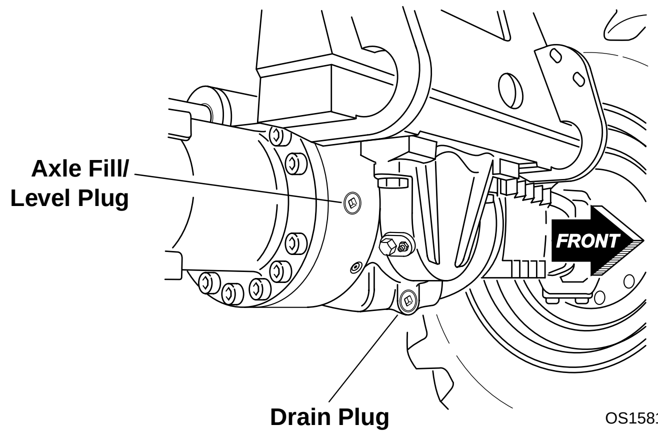


Figure 2–52. Axle fill/level plug (front axle shown; rear axle similar).

2. Clean the area around the axle fill/level plug (Fig. 2–52), then remove the plug from the axle housing.
3. Add a premium grade of SAE 80W90 or SAE 80W140 axle oil to bring the oil level up, even with the bottom of the plug hole.
4. Reinstall the axle fill/level plug.

B. Axle Oil Change

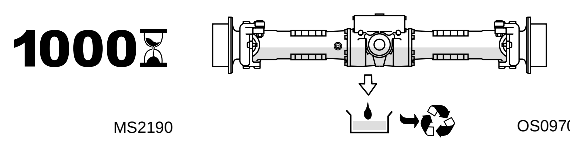


Figure 2–53. Every 1,000 hours of engine operation, change the axle oil.

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut the engine off.
2. Clean the area around both the axle fill/level plug (Fig. 2–52) and the axle drain plug.
3. Place a suitable receptacle under the axle drain plug. Remove the plug from the axle housing and allow the axle oil to drain completely.
4. Transfer the oil to a container with a cover and label the container as used axle oil. Dispose of properly.

5. Clean and reinstall the drain plug. Remove the axle fill/level plug from the axle housing.
6. Fill the axle with a premium grade of SAE 80W90 or SAE 80W140 axle oil. Filling is accomplished through the axle fill/level hole. Fill until the axle oil level is even with the plug hole. The axle capacity is three gallons (11,5 liters).
7. Reinstall the axle fill/level plug into the axle housing.

2.12.12 Wheel End Oil

> **WARNING: DO NOT** perform service or maintenance on this vehicle with the engine running. Contact with moving parts can cause serious injury or death.

A. Wheel End Oil Level Check

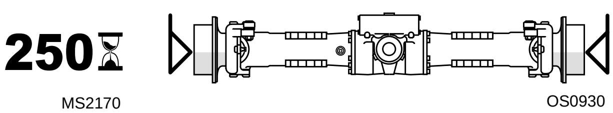


Figure 2–54. Every 250 hours of engine operation, check the wheel-end oil level for all four wheel-ends.

1. With the vehicle on level ground, move forward or backward enough to align the oil level line (Fig. 2–55) horizontally.
2. Ground the carriage, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut the engine off.
3. Clean the area around the wheel end fill/drain plug. Slowly remove the plug; pressure may be present. Check the oil level. It should be even with the bottom edge of the hole.

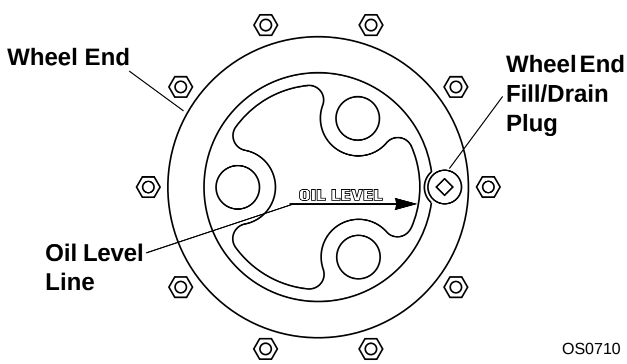


Figure 2–55. Wheel-end oil should be even with the bottom edge of the fill/drain plug hole.

4. As required, add a premium grade of SAE 80W90 or SAE 80W140 axle oil to bring the level up and even with the plug hole.
5. Clean and reinstall the wheel end fill/drain plug.

B. Wheel End Oil Change

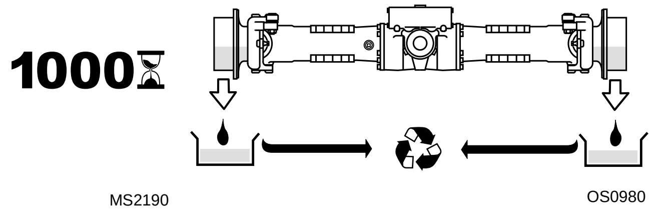


Figure 2–56. Every 1,000 hours of engine operation, change the wheel-end oil level at all four wheel-ends.

1. Position the vehicle on level ground and move the vehicle forward or backward to place the wheel end fill/drain plug in the six o'clock position (Fig. 2–57).

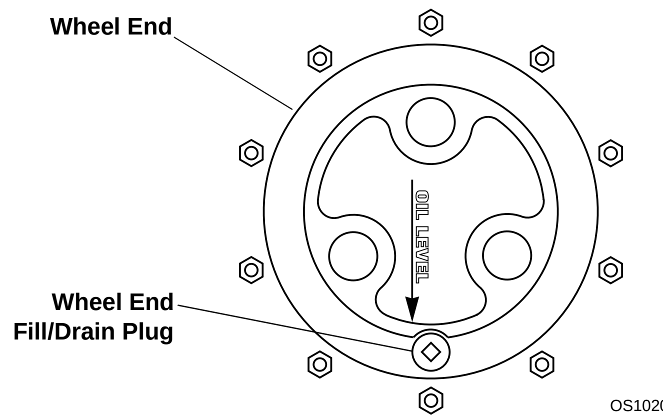


Figure 2–57. Drain each wheel-end every 1,000 hours of engine operation.

2. Ground the carriage, place the travel select lever in the NEUTRAL (N) position, engage the parking brake switch and shut the engine off.
3. Clean the area around the wheel end fill/drain plug. Slowly loosen the plug. Hold a receptacle under the wheel end and remove the plug from the wheel end.
4. Allow the axle oil to drain completely into the receptacle. Transfer the axle oil to a container with a cover and label the container as used oil. Dispose of properly.
5. Reposition the vehicle so the oil level line is placed horizontally.
6. Fill the wheel end with a premium grade of SAE 80W90 or SAE 80W140 axle oil. The wheel end is full when the oil is level with the bottom of the plug hole. Wheel end oil capacity is approximately 1.4 quarts (1,3 liters).
7. Clean and reinstall the wheel end fill/drain plug.

2.12.13 Transfer Case Oil

A. Transfer Case Oil Level Check

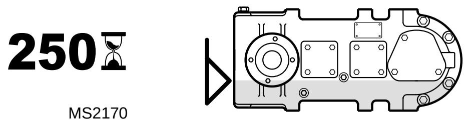


Figure 2–58. Every 250 hours of engine operation, check the transfer case oil level.

1. Level the vehicle, ground the carriage, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut the engine OFF.
2. Clean the area around the transfer case oil level plug and oil fill/vent cap (Fig. 2–59).

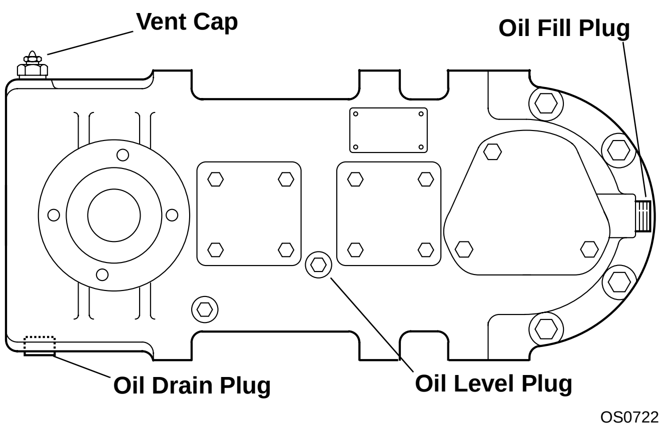


Figure 2–59. Clean the area around the transfer case oil level plug.

3. Remove the oil level plug from the transfer case and check the oil level.
4. Add a premium grade of SAE 80W90 or SAE 80W140 gear oil as required through the oil level hole or oil fill/vent cap. Bring the oil level up and even with the oil level plug hole.
5. Clean and reinstall the oil level plug and oil fill/vent plug.

B. Transfer Case Oil Change

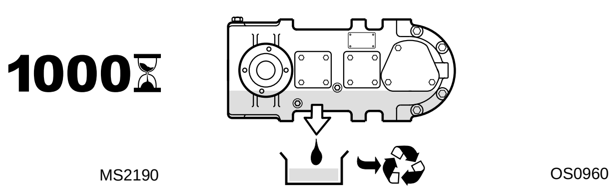


Figure 2–60. Every 1,000 hours of engine operation, change the transfer case oil.

1. Level the vehicle, ground the carriage, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut the engine OFF.
2. Clean the area around the transfer case oil level plug, oil drain plugs and the oil fill/vent cap (Fig. 2–61).

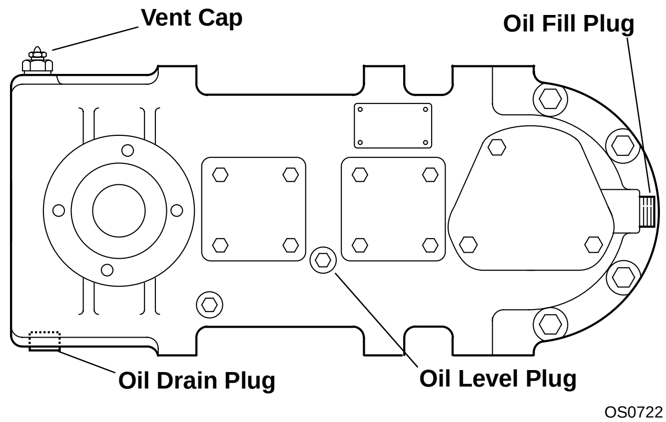


Figure 2–61. Remove the oil drain plug from the transfer case to drain the oil.

3. Place a receptacle beneath the transfer case drain plugs.
4. Remove the drain plugs from the transfer case.
5. Allow the oil to drain completely into the receptacle. Transfer the oil into a container with a cover and label as used oil. Dispose of properly.
6. Clean and reinstall the transfer case drain plugs.
7. Remove the oil fill/vent cap and oil level plug.
8. Fill the transfer case with SAE 80W90 or SAE 80W140 gear oil. The transfer case is full when oil is level with the bottom of the oil level plug hole. Total transfer case gear oil capacity is 1.5 qt (1,4 l).
9. Replace the oil fill/vent cap and oil level plug. Wipe up any spilled gear oil.

2.12.14 Wheels and Tires

A. Tire Pressure Check

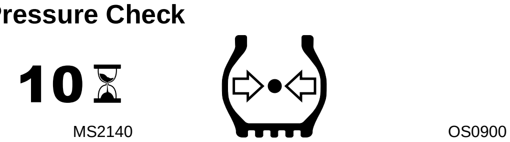


Figure 2–62. Every ten hours of engine operation, check the air pressure in all four tires.

DANGER: LOW TIRE PRESSURE can result in vehicle tipover.
MAINTAIN proper tire pressure at all times.

Check all four tires:

1. Remove the valve stem cap.
2. Check tire pressure using a premium-quality gauge. Proper inflation pressure cannot be determined visually. Pressure should be 65 psi (448 kPa)

minimum for 13.00 - 24, 12-ply tires. Maximum ground pressure with a full load is 93 psi (641 kPa).

3. Add air as required. **DO NOT** overinflate.
4. Replace the valve stem cap.

B. Wheel Lug Nut Check

Every ten hours of engine operation, check the torque on all lug nuts. Tighten as required.

1. Wire brush the area around the lugs if necessary. Foreign material such as dirt, concrete, mud, etc. can prevent an accurate torque reading.
2. Use the torque sequence diagram below (Fig. 2–63), to alternately check the torque of each of the ten lug nuts. The recommended torque is 370 lb/ft (500 Nm).

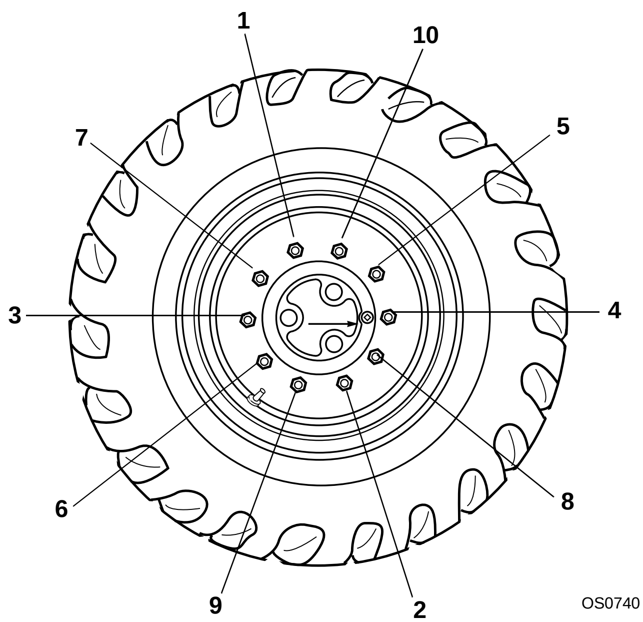


Figure 2–63. Lug nut torque sequence.

2.12.15 BATTERY

A. Battery Inspection, Testing and Service

> **WARNING:** A lead-acid battery produces flammable and potentially explosive gases. To help avoid personal injury when checking, testing or charging the battery:
> • **DO NOT** use smoking materials near a battery.
> • Keep arcs, sparks and open flames away from the battery.
> **WARNING:** • Provide adequate ventilation and wear safety glasses

The battery is of maintenance-free design. The battery is filled with electrolyte and charged when shipped with the vehicle. A warning indicator light on the operator's display panel (Fig. 2–64) illuminates when the alternator is no longer able to charge the battery.

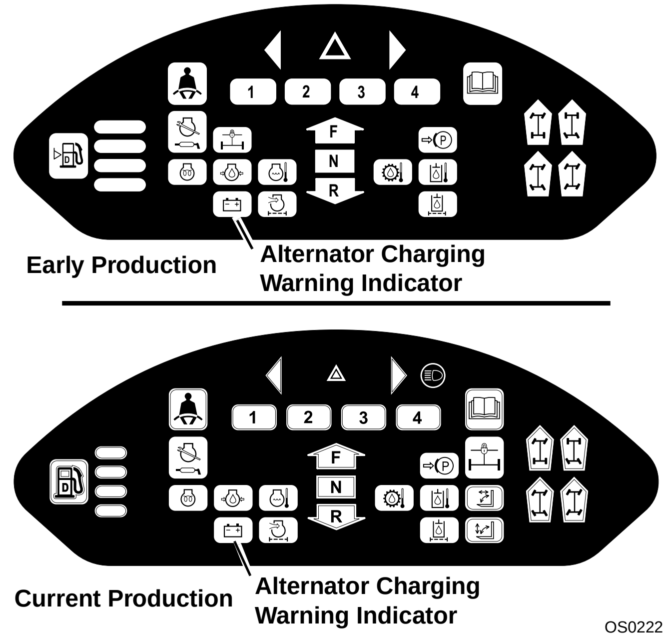


Figure 2–64. Typical alternator charging warning indicator.

To service the battery:

1. Level the vehicle, ground the carriage, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut the engine off.
2. Unlock and open the engine cover. The battery is located directly underneath the radiator assembly (Fig. 2–65).

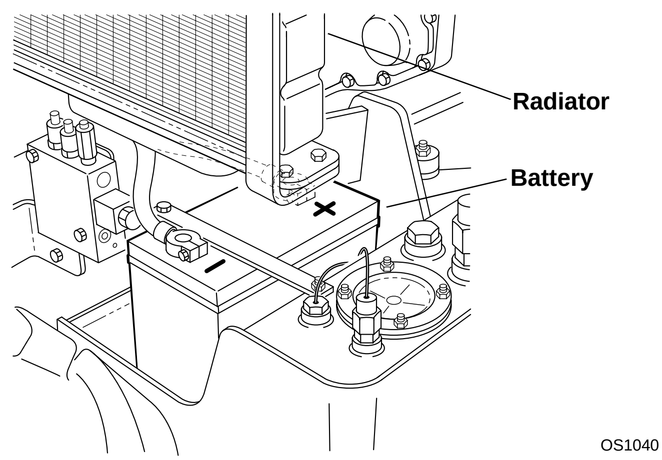


Figure 2–65. The battery is located beneath the radiator.

3. Wear safety glasses and visually inspect the battery. Check terminals for corrosion. Replace the battery if it has a cracked, melted or damaged case.

WARNING: Fluid (electrolyte) in electric storage batteries contains sulfuric acid, a **POISON** that can cause **SEVERE CHEMICAL BURNS**. Avoid all contact of fluid with eyes, skin or clothing. Use proper protective gear when handling batteries. **DO NOT** tip a battery beyond a 45° angle in any direction. If contact with battery fluid does occur, follow the First Aid suggestions in the "Battery Fluid (electrolyte) First Aid" box below.

Battery Fluid (electrolyte) First Aid

- External Contact: Flush with water.
- Eyes: Flush with water for at least 15 minutes and get medical attention immediately.
- Internal Contact: Drink large quantities of water. Follow with Milk of Magnesia, a beaten egg or vegetable oil and get medical attention immediately. **DO NOT** take fluids that induce vomiting.

IMPORTANT: In case of internal contact **DO NOT** take fluids that induce vomiting!

B. Battery Charging

WARNING: **DO NOT** charge a frozen battery. A frozen battery could explode and cause serious personal injury. Allow the battery to thaw before "jump starting" the vehicle or connecting a battery charger.

Under normal operating conditions, the alternator will keep the battery charged. The alternator may not be able to charge a battery that has been completely discharged for an extended period of time. Under this condition, a battery charger or a "jump start" is required to recharge the battery.

An attempt to "jump start" the vehicle and let the engine run so the alternator charges the battery can be made before using a battery charger.

C. Jump Starting

WARNING: **NEVER** jump start the vehicle directly at the starter motor or starter solenoid. Serious personal injury or death could result from the vehicle lurching forward or backward and running over personnel attempting to jump start the vehicle.

WARNING: To help avoid personal injury when jump starting with another vehicle, **DO NOT** allow the vehicles to contact each other. **NEVER** jump start a frozen battery. A frozen battery could explode and cause serious personal injury. Keep arcs, sparks, lighted smoking materials and open flames away from the battery. A lead-acid battery produces flammable and potentially explosive gases. Wear safety glasses when working near a battery.

The jumper or booster battery must be a 12-volt type. A vehicle used for jump starting must also have a negative ground electrical system. When handling and connecting jumper cables, **DO NOT** allow premature or unintended contact with any part of the vehicle.

<u>To jump start the vehicle:</u>

1. Connect the positive (+) jumper cable to the positive (+) post of the discharged battery.
2. Connect the other end of the positive (+) jumper cable to the positive (+) post of the booster battery.
3. Connect one end of the negative (-) jumper cable to the negative (-) post of the booster battery.
4. Make the final cable connection to the engine block ground or to the ground point furthest away from the battery.
5. From the operator's seat with the seat belt fastened, check that the parking brake switch is engaged. Place the travel select lever in NEUTRAL (N). Turn the ignition switch to the START position (fully clockwise) to crank the engine. Release the key when the engine starts. **DO NOT** energize the starter solenoid or crank the engine for more than 15 seconds at a time. Wait two minutes between each 15-second cranking interval. If the engine fails to start on the first try, wait until the engine and starter come to a complete stop before engaging the starter again.
6. After the engine starts, remove the jumper cables in reverse order of their connection. First, remove the final cable connection that was made at the engine block ground or at the ground point furthest away from the battery.

7. Next, remove the negative (-) jumper cable connected to the negative (-) post of the booster battery.
8. Remove the other end of the positive (+) jumper cable connected to the positive (+) post of the booster battery.
9. Remove the positive (+) jumper cable connected to the positive (+) post of the discharged, but now charging, battery.
10. Run the engine at partial throttle for 30 to 60 seconds before attempting to operate the vehicle. Allow the engine to return to idle RPM before engaging the travel- or range-select levers.

2.12.16 Fuse and Relay Replacement

Note: There are *three* (3) types of fuse and relay panels currently in use on the Sky Trak Model 3606. Vehicles with serial number *8249 and before* use the fuse and relay panel shown in Fig. 2–68. Mid-production vehicles with serial number *8250 through 9398* use the fuse and relay panel shown in Fig. 2–69. Current production vehicles with serial numbers 9399 *and after* use the fuse and relay panel shown in Fig. 2–70.

IMPORTANT: Shut off the engine and disconnect the negative battery cable before checking the electrical system. Use an ohmmeter to check the resistance of wires and components.

Fuses and relays help to protect the electrical system. In general, a blown fuse is symptomatic of another electrical problem. Simply replacing the fuse often will not solve the problem. Blown fuses usually are due to simple causes, including loose or corroded connections, or a defective relay. The main causes of blown fuses include a shorted or grounded wire in the applicable circuit, or a defective electrical component. Visually check the condition of the fuse, wires, connections and components in the involved circuit before replacing a fuse. Check the circuit for shorts, grounding or defective electrical components.

To gain access to the fuses and relays, remove the three screws securing the lower dash panel to the cab (Fig. 2–66). The fuses and relays are conveniently mounted under the lower left side of the operator's console (Fig. 2–66). Remove the four screws securing the panel to gain access to the fuses.

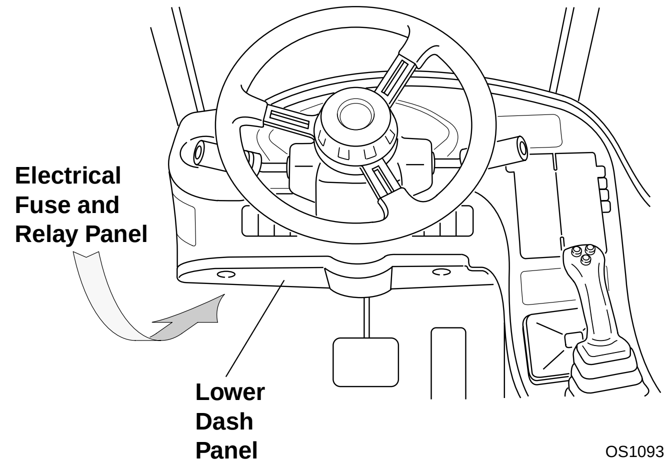


Figure 2–66. Remove the lower dash panel to gain access to the fuses and relays.

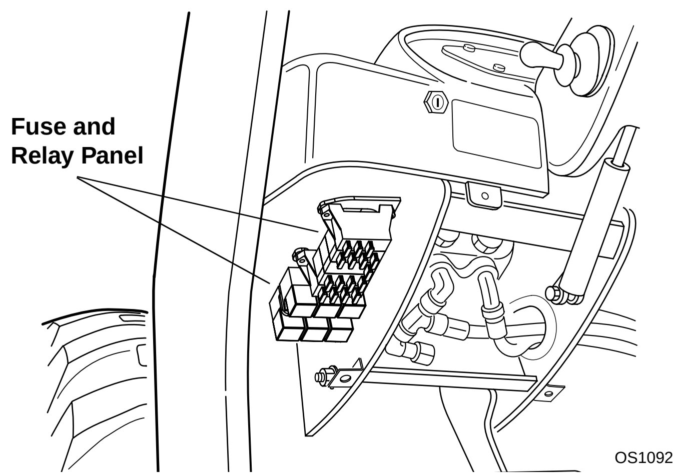


Figure 2–67. Location of fuses and relays.

Before checking a malfunctioning electrical circuit, examine the applicable wiring diagram (see *Section 10: Electrical System*) to help identify the components involved. Problems can often be identified by noting whether other components related to the circuit are functioning properly. When several components or circuits fail at one time, the problem is probably related to a poor ground connection, because several circuits share that same connection.

See *Section 10 Electrical System* for further information.

<u>Vehicles Stamped with S/N 8249 *and Before*</u>

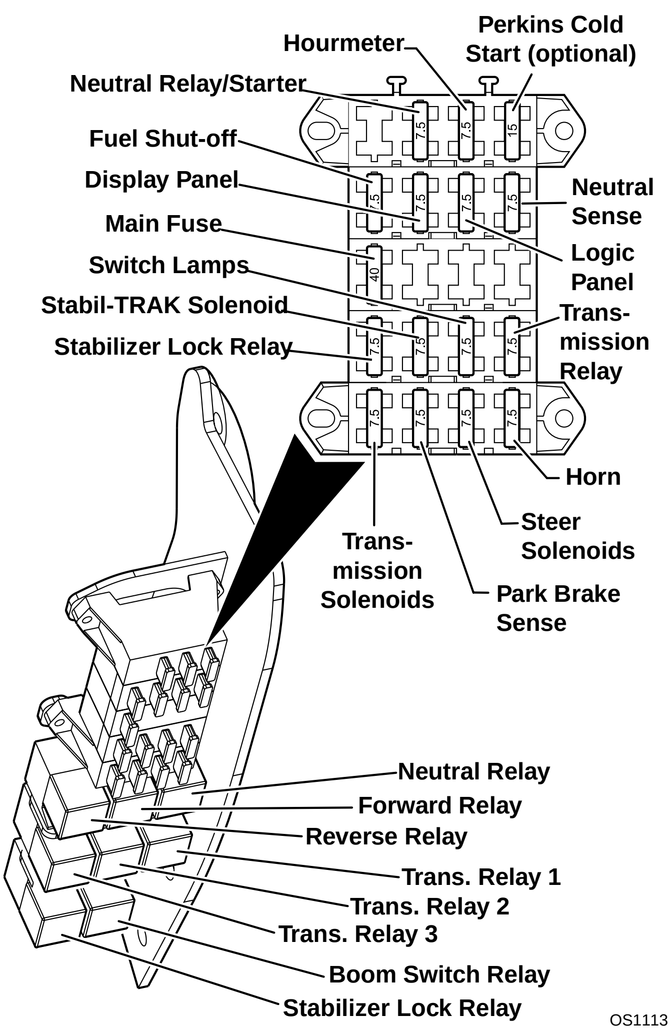


Figure 2–68. Vehicles with serial number *8249 and before* use the fuse and relay panel shown here.

<u>Vehicles Stamped with S/N 8250 *through 9398*</u>

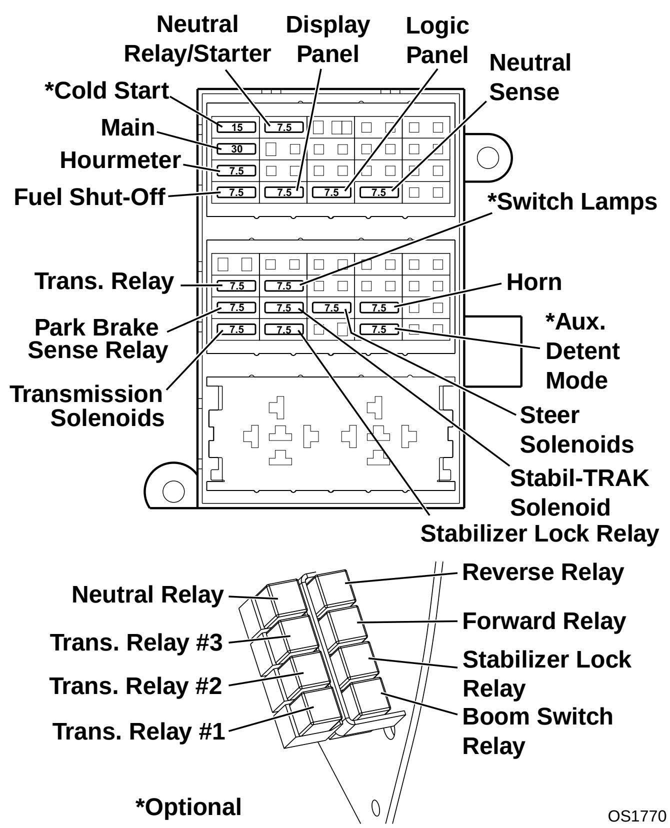


Figure 2–69. Vehicles stamped with serial number *8250 through 9398* use the fuse and relay panel shown here.

Vehicles Stamped with S/N 9399 *and After*

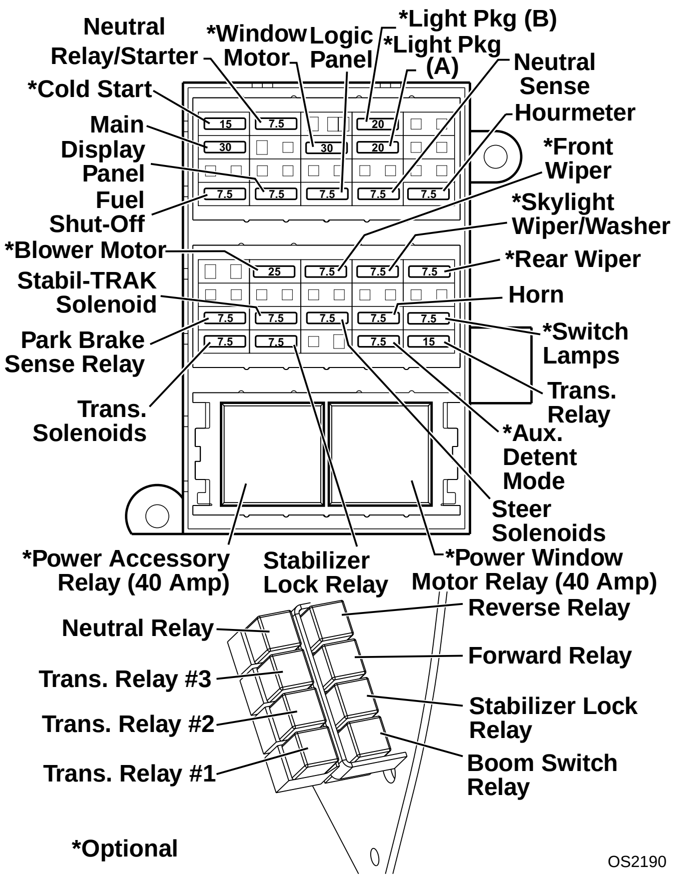


Figure 2–70. Vehicles stamped with serial number *9399 and after* use the fuse and relay panel shown here.

2.12.17 Boom Chains

A. Boom Chain Tension Check

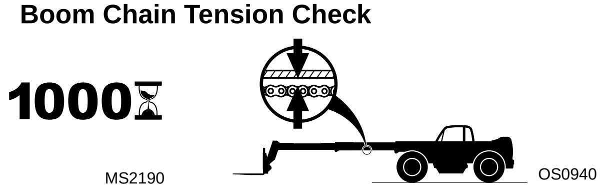


Figure 2–71. Every 1,000 hours of engine operation, check both boom chains for proper tension.

1. Park the vehicle on level ground. Place the travel select lever in NEUTRAL (N), engage the parking brake switch and raise the boom to a horizontal boom. Retract the boom completely and shut the engine off.
2. Measure the distance between the inner boom and the intermediate boom (Fig. 2–72). The inner boom should extend 2.25 inches (57 mm) to 2.75 inches (70 mm) beyond the end of the intermediate boom. If the measurement is less than 2.25 inches (57 mm), the chains require adjustment.

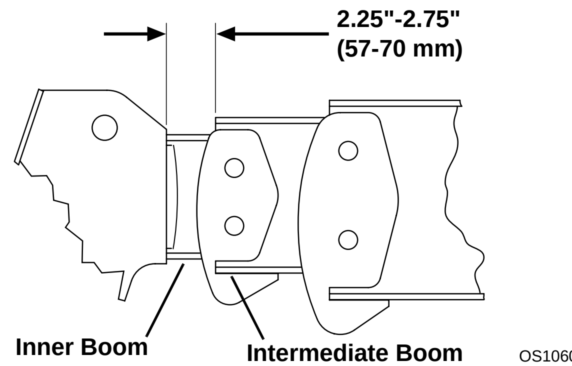


Figure 2–72. Measure the distance between the inner boom and the intermediate boom.

B. Boom Chain Adjustment

1. Park the vehicle on level ground. Place the travel select lever in NEUTRAL (N), engage the parking brake switch and raise the boom to a horizontal boom. Retract the boom completely and shut the engine off.
2. Loosen the retract chain locknut (Fig. 2–73) located on the bottom at the front of the outer boom.

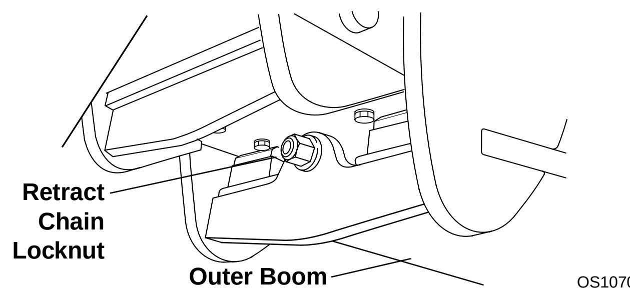


Figure 2–73. Turn the retract chain locknut at the front of the outer boom.

3. Unlock and open the rear cover.
4. While preventing the clevis end from turning, tighten the extend chain locknut (Fig. 2–74) located at the rear of the outer boom.

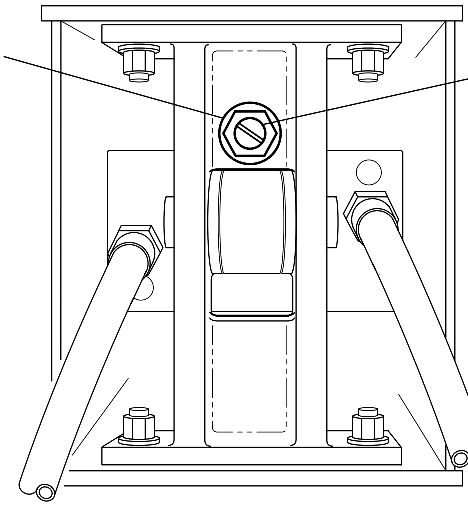


Figure 2–74. Prevent the clevis end from turning, and tighten the extend chain locknut at the rear of the outer boom.

5. Periodically measure the distance between the inner boom and the intermediate boom. Repeat Step 4 until a distance of 2.5 inches (63,5 mm) is obtained between the inner boom and the intermediate boom (Fig. 2–72).
6. Tighten the retract chain locknut (Fig. 2–73) to 35-40 lb/ft (47,5-54,2 Nm).
7. Close and lock the rear cover.

2.12.18 Storage

A. Before Storing a Vehicle

Perform the following steps prior to placing the vehicle in storage:

1. Clean the entire vehicle.
2. Lubricate all grease fittings.
3. Prepare the engine for storage (refer to the engine manual).
4. Apply *LPS 3* (or equivalent) to all exposed hydraulic cylinder rods.
5. Disconnect the battery cables. Remove the battery from the vehicle and store it in a dry place not subject to temperatures near or below freezing.
6. Preferably, store the vehicle inside where it will remain dry. If it must be stored outside, park it on lumber laid on flat, level ground, or on a concrete slap. Cover the vehicle with a tarp.

B. Removing Vehicle From Storage

After removing the vehicle from storage and before operating it, perform the following steps:

1. Install a properly charged battery. Secure the hold-down strip and attach the cables.
2. Change the engine oil and filter to remove condensation or other residuals.
3. If the vehicle has been stored for two years or more, drain the coolant from the engine block and radiator and refill with a 50/50 mixture of fresh anti-freeze and water.
4. Wipe off any *LPS 3* (or equivalent) applied to exposed cylinder rods prior to storage.
5. Perform all recommended 10 hour maintenance procedures.

2.12.19 Transport

When transporting the vehicle, make use of all four tiedowns (Fig. 2–75).

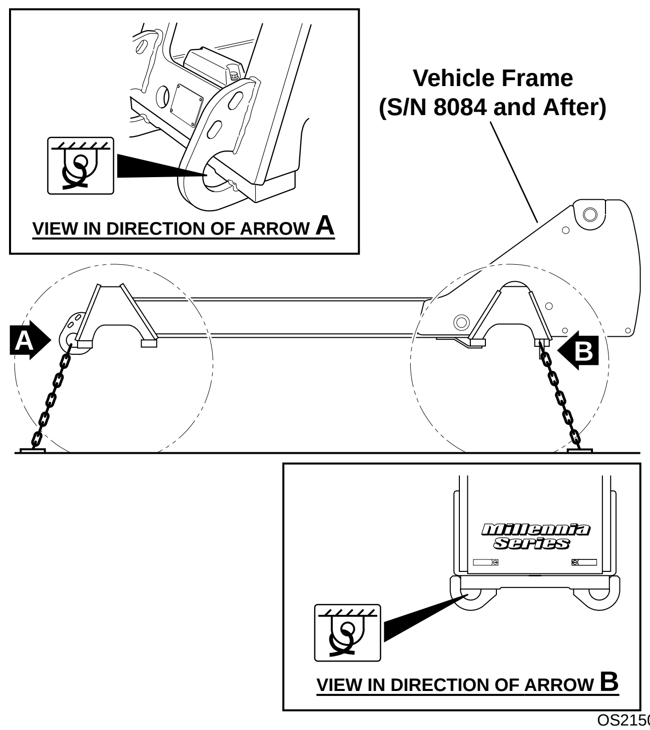


Figure 2–75. When transporting the vehicle, make use of all four tiedowns.

2.13 EMERGENCY OPERATIONS

2.13.1 Towing a Disabled Vehicle

IMPORTANT: After the vehicle has been towed to a secure location, reactivate the parking brake. Carefully follow these procedures from start to finish. Consult your local Sky Trak Distributor or the Sky Trak Service Department if you are unsure about any part of this procedure, or for specific instructions for your particular situation.

Towing a disabled vehicle should only be attempted as a last resort, after exhausting all other options. Make every effort to repair the vehicle, and move it under its own power, _before_ using the following emergency towing procedures.

To prepare the vehicle for towing, the parking brake mechanisms at the front axle must be disabled. This will allow the front wheels to rotate freely during emergency towing.

2.13.2 Disabling the Parking Brakes

⚠	**WARNING: BLOCK ALL FOUR WHEELS.** Failure to do so could result in death or serious injury from vehicle roll away.

1. Place an Accident Prevention Tag on both the ignition key and the steering wheel (Fig. 2–76) stating that the vehicle should not be operated. If a tag is not available, tape over the ignition switch.

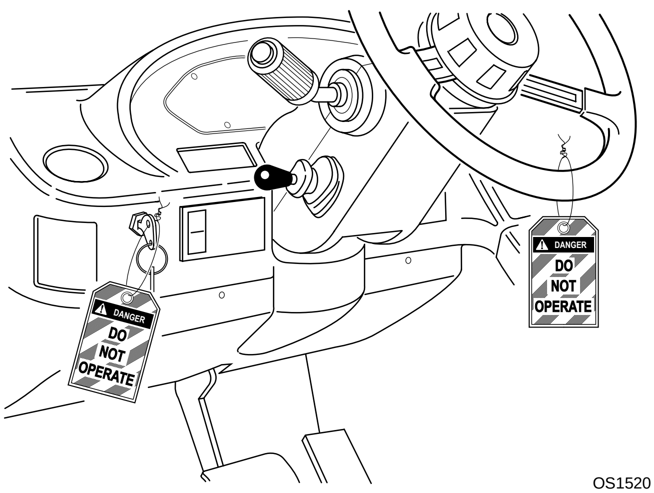


Figure 2–76. Place an Accident Prevention Tag on both the ignition switch and the steering wheel.

2. **Block all four wheels** to help prevent the vehicle from moving after the parking brake is disabled.
3. Position the towing vehicle in place. Attach any chains needed to secure the disabled vehicle.
4. An 8 mm Allen®-head socket and torque wrench are needed to properly disable the parking brakes. Scribe a line on the socket to aid in accurately counting the number of turns each bolt makes during the procedure.
5. At the base of the front axle, locate the six parking brake release bolts (three bolts per side; for early production vehicles, see Fig. 2–77; for current production vehicles, see Fig. 2–78). Thoroughly clean all dirt and debris from the six bolt recesses.

EARLY PRODUCTION

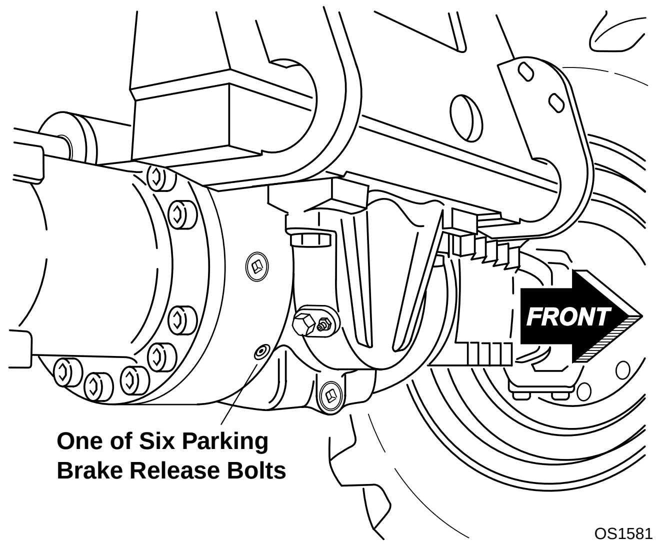


Figure 2–77. Clean all dirt and debris from the six parking brake release bolt recesses (*early production vehicles*).

CURRENT PRODUCTION

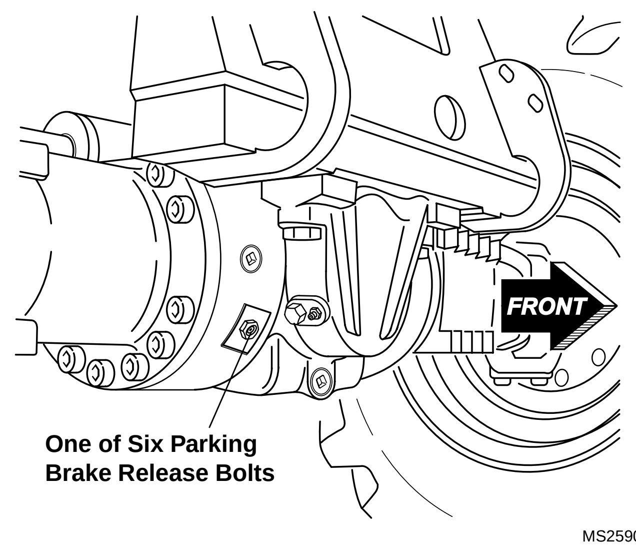


Figure 2–78. Clean all dirt and debris from the six parking brake release bolt recesses (*current production vehicles*).

6. For early production vehicles, see Fig. 2–79; for current production vehicles, see Fig. 2–80. Alternately turn the parking brake release bolts A, B and C inward (clockwise) two to three complete turns until resistance is felt.

EARLY PRODUCTION

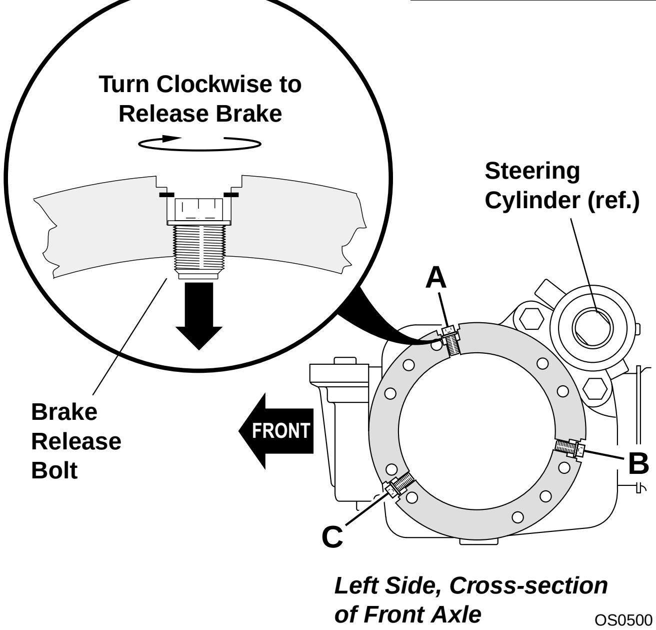


Figure 2–79. Alternately turn parking brake release bolts A, B and C inward until resistance is felt (*early production vehicles*).

CURRENT PRODUCTION

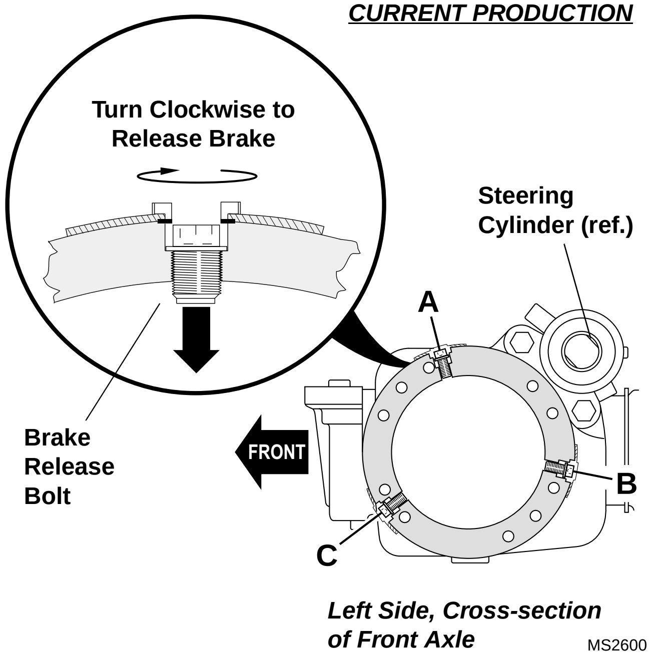


Figure 2–80. Alternately turn parking brake release bolts A, B and C inward until resistance is felt (*current production vehicles*).

7. Use a torque wrench to alternately turn parking brake release bolts A, B and C (Fig. 2–79 or Fig. 2–80) inward (clockwise) until a torque of 22 lb/ft (30 Nm) is reached. This will take approximately a half-turn. **DO NOT** exceed 50 lb/ft (68 Nm).
8. Continue using a torque wrench to alternately turn parking brake release bolts A, B and C inward (clockwise) until a minimum torque of 30 lb/ft (41 Nm) is reached. This will take approximately a half-turn. **DO NOT** exceed 50 lb/ft (68 Nm).
9. Clear the area of any unnecessary personnel.
10. Carefully remove the wheel blocks from each of the four tires. Tow the vehicle to a secure location.

2.13.3 Reactivating the Parking Brakes

WARNING: BLOCK ALL FOUR WHEELS.
Failure to do so could result in death or serious injury from vehicle roll away.

Upon arriving at a secure location with the towed vehicle, block all four wheels and continue following these procedures.

1. Block all four wheels to help prevent the vehicle from moving. Clear the area of any unnecessary personnel.
2. For early production vehicles, see Fig. 2–81; for current production vehicles, see Fig. 2–82. Use a torque wrench to alternately turn parking brake release bolts A, B and C outward (counter-clockwise) a half-turn until the torque drops to 22 lb/ft (30 Nm).

EARLY PRODUCTION

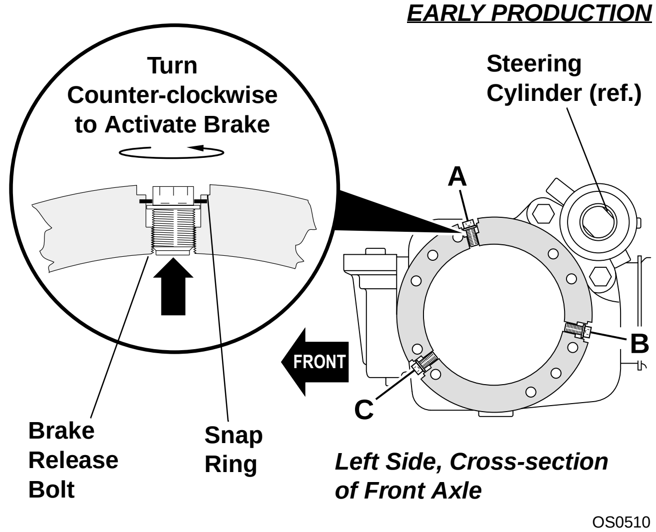


Figure 2–81. Alternately turn parking brake release bolts A, B and C outward until torque decreases (*early production vehicles*).

CURRENT PRODUCTION

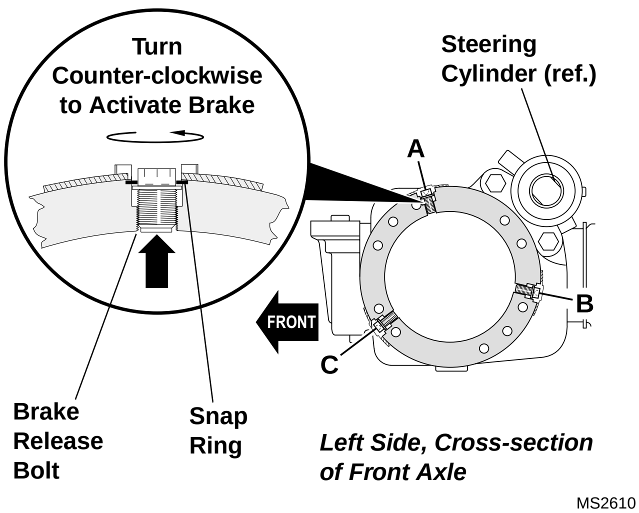


Figure 2–82. Alternately turn parking brake release bolts A, B and C outward until torque decreases (*current production vehicles*).

3. Use a torque wrench to alternately turn parking brake release bolts A, B and C outward (counter-clockwise) until the torque decreases sharply.
4. For early production vehicles, see Fig. 2–81; for current production vehicles, see Fig. 2–82. Alternately turn parking brake release bolts A, B and C outward (counter-clockwise) until the bolt flanges begin to press against the snap ring. Then, turn each bolt inward (clockwise) one-quarter turn.
5. The parking brakes should now be re-activated and the front wheels locked. Carefully remove the blocking from the four tires.
6. Verify that the parking brake works.
7. Remove the Accident Prevention Tags from the ignition switch and steering wheel.

Section 3
Boom

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Introduction

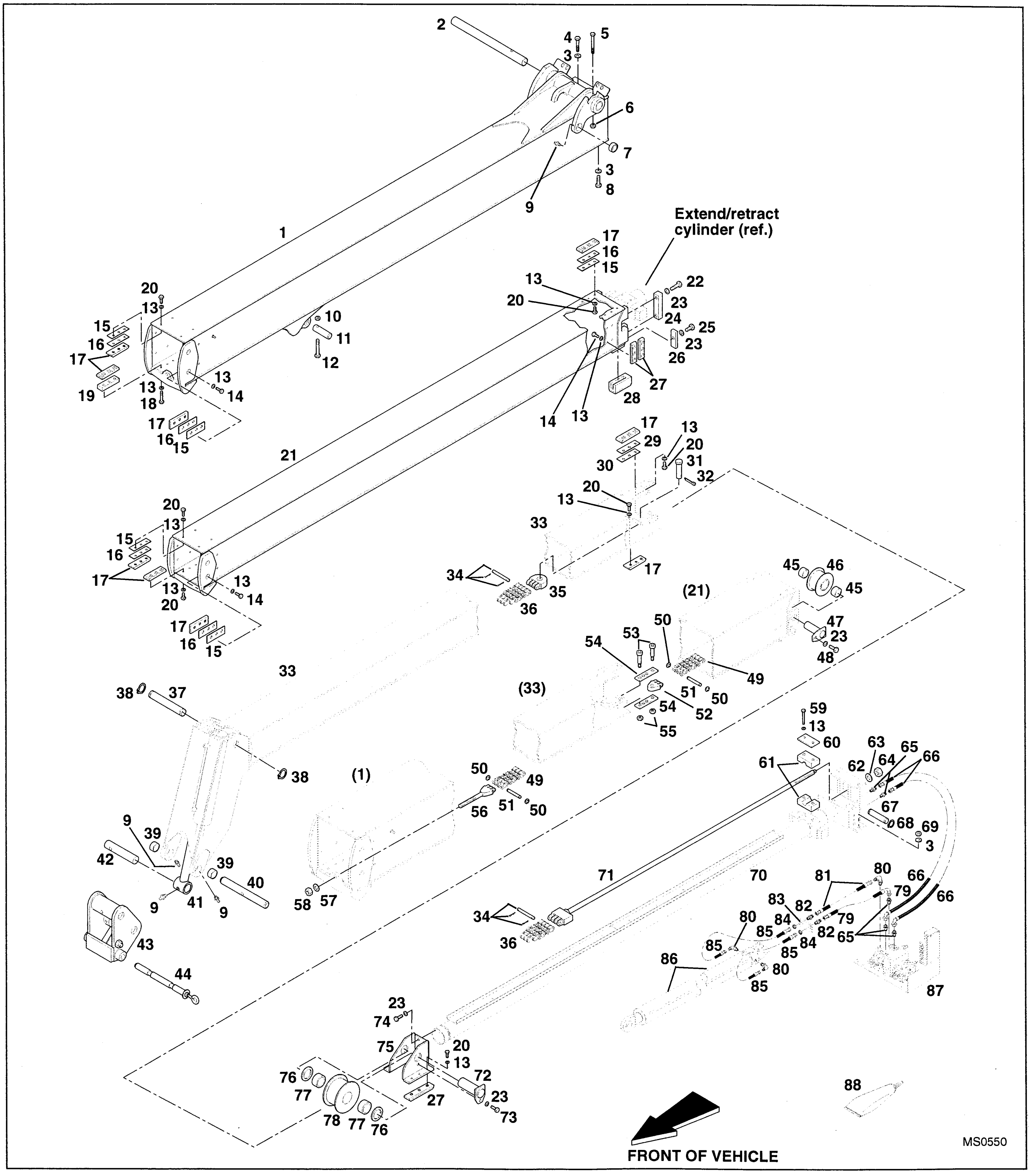
The boom operates via an interchange among the electrical, hydraulic and mechanical systems. Components involved include the joystick, attachment tilt cylinder, extend/retract cylinder, hoist/lower cylinder, slave cylinders, electronic sensors, extend and retract chains, various pivots, supporting hardware and other components.

The boom assembly consists of inner, intermediate and outer booms. Boom extension and retraction is accomplished via hydraulic power and chain movement. As the extend/retract cylinder, anchored at the rear of the outer boom, begins to extend, it forces the inner boom out of the intermediate boom. The intermediate boom slides within the outer boom, while the inner boom slides within the intermediate boom via movement of the extend/retract cylinder and chains. By design, due to the mechanical links formed by the chains and supporting hardware, the intermediate boom extends and retracts at the same rate as the inner boom. The outer boom does not extend or retract, but lifts and lowers via action of the hoist/lower cylinder.

Legend

1. Outer Boom
2. Boom Pivot Pin
3. Hardened Washer, 3/4"
4. Grade 8 HHCS, 3/4-10 x 3-1/2"
5. Grade 5 HHCS, 5/8-11 x 6-1/2"
6. Hex Lock Elastic Nut, 5/8-11
7. Self-aligning Bearing
8. Grade 8 HHCS, 3/4-10 x 2-1/2"
9. Self-tapping Lube Fitting, 1/8 NPT
10. Hex Lock Nut, 1/2-13
11. Pin, 2" diameter
12. HHCS, 1/2-13 x 4"
13. Lock Washer, 3/8"
14. Grade 5 HHCS, 3/8-16 x 3/4"
15. Wear Pad Shim, 0.13" thick
16. Wear Pad Shim, 0.07" thick
17. Wear Pad, w/inserts
18. Grade 5 HHCS, 3/8-16 x 2"
19. Wear Pad Spacer
20. Grade 5 HHCS, 3/8-16 x 1"
21. Intermediate Boom
22. Grade 5 HHCS, 1/2-13 x 2-1/4"
23. Lock Washer, 1/2"
24. Extend Cylinder Trunion Clamp
25. HHCS, 1/2-13 x 1-1/4"
26. Wear Pad Retainer
27. Wear Pad w/inserts
28. Channel Wear Pad
29. Wear Pad Shim, 0.07" thick
30. Wear Pad Shim, 0.13" thick
31. Extend Chain Anchor Clevis Pin
32. Cotter Pin, 3/16 x 1-1/2"
33. Inner Boom
34. Clevis Pin and Cotter Pins
35. Extend Chain Anchor Clevis
36. Extend Chain, 8 x 8 Leaf Lacing
37. Attachment Tilt Cylinder Base Pin
38. External Retaining Ring, 2"
39. Quick-Attach Pivot Bushing
40. Carriage Pivot Pin
41. Attachment Tilt Cylinder
42. Attachment Tilt Cylinder Pin
43. Quick-Attach
44. Lock Pin
45. Retract Chain Sheave Bushing
46. Retract Chain Sheave
47. Retract Chain Sheave Pin
48. Grade 5 HHCS, 1/2-13 x 1"
49. Retract Chain, 6 x 6 Leaf Lacing
50. Retaining E-ring
51. Retract Chain Clevis Pin
52. Retract Chain Clevis
53. Hex Socket-Head Shoulder Bolt, 1/2 x 1-1/2" x 3/8-16
54. Retract Chain Anchor Link
55. Hex Lock Elastic Nut, 3/8-16
56. Retract Chain Clevis
57. Flat 3/4" Narrow Washer
58. Hex Lock Elastic Nut, 3/4-16 NF
59. Grade 5 HHCS, 3/8-16 x 2-1/4"
60. Cover Plate
61. Extend Chain Adjustment Rod Guide Half
62. Cylinder Mount Bracket Assembly
63. Flat 1" Narrow Washer
64. Hex Lock Elastic Nut, 1-14 NF
65. Connector, SAE 12, O-ring Face Seal
66. Hose, 3/4" I.D. x 36"
67. Extend Cylinder Rod Pin
68. External Retaining Ring, 1-3/4"
69. Hex Lock Elastic Nut, 3/4-10
70. Extend/Retract Cylinder
71. Extend Chain Clevis Rod
72. Extend Chain Sheave Pin
73. Grade 5 HHCS, 1/2-13 x 3/4"
74. HHCS, 1/2-13 x 1-1/4"
75. Extend Cylinder Bracket
76. Thrust Pack Washer
77. Chain Sheave Bushing
78. Extend Chain Sheave
79. Hose, 3/4" I.D. x 27"
80. 90° Elbow, SAE 12, O-ring Face Seal
81. Hose, 3/4" I.D. x 21-1/2"
82. Connector, SAE 12, O-ring Face Seal
83. Bulkhead (reference only)
84. Bulkhead Nut, O-ring Face Seal
85. Hose, 3/4" I.D. x 45"
86. Hoist/Lower Cylinder
87. Main Control Valve Plate Ass'y
88. Loctite® #242 (blue)

General Overview



3.1 SPECIFICATIONS

Refer to *Section 2.4 Specifications.*

3.2 BOOM ASSEMBLY

The boom assembly consists of the inner, intermediate, and outer booms and supporting hardware.

IMPORTANT: Boom replacement must be completed in sequence, one boom section at a time, as described in these instructions. Replacement of two or more boom sections as a unit requires special considerations that are not covered in these instructions.

The inner, intermediate and outer boom removal instructions must be completed in sequence. The inner boom must be removed before removing the intermediate boom. The inner boom and intermediate boom must be removed *one at a time* before removing the outer boom.

Before beginning, conduct a visual inspection of the vehicle, work area and task about to be undertaken. Read, understand and follow these instructions.

After servicing the boom, perform the following:

1. Check wear pads.
2. Check chain tension adjustment.
3. Apply grease at all lubrication points (grease fittings).

Check for proper operation by operating all boom functions through their full range of motion several times.

3.2.1 Inner Boom Replacement

WARNING: Wear protective footwear with reinforced toe caps and slip-resistant soles. Failure to comply can result in foot injury from falling objects or other bodily injury from slipping or falling.

WARNING: NEVER lift a heavy object without the help of at least one assistant or a suitable sling and hoist. Failure to comply can result in serious personal injury.

A. Inner Boom Removal

1. Remove any attachment from the quick-attach assembly.

Note: If attachment removal instructions are required, see *Section 3.3 QUICK-ATTACH ASSEMBLY.*

2. Park the vehicle on a hard, level surface. Engage the park lock and fully retract the boom. Shut off the engine and allow the hydraulic fluid to cool before proceeding.
3. Remove all wear pads attached to the front of the intermediate and outer booms. Tape and mark each pad and fastener for return to its original position upon reinstallation.

WARNING: Before loosening any hydraulic or diesel component, hoses or tubes:

- Turn off the engine. Allow the engine and the hydraulic fluid to cool completely before proceeding.
- Wear heavy, protective gloves and eye protection. **NEVER** check for leaks using any part of the human body; use a piece of cardboard or wood instead.
- If injured, see a doctor immediately.
- Relieve all pressure before disconnecting any component, part, line or hose. Slowly loosen parts and allow release of residual pressure before removing any part or component.
- Before starting engine or applying pressure, use components, parts, hoses and pipes that are in good condition, properly connected and tightened to the correct torque value.

  NOTE: Hydraulic fluid and diesel fuel leaking under pressure can explode and penetrate the skin, cause infection, gangrene, and other serious personal injury.

4. Label the attachment tilt hoses at the attachment tilt cylinder (Fig. 3-1). Position a suitable container beneath the gooseneck. Disconnect the attachment hoses at the cylinder and cap the ends to help avoid excess spillage of hydraulic oil.

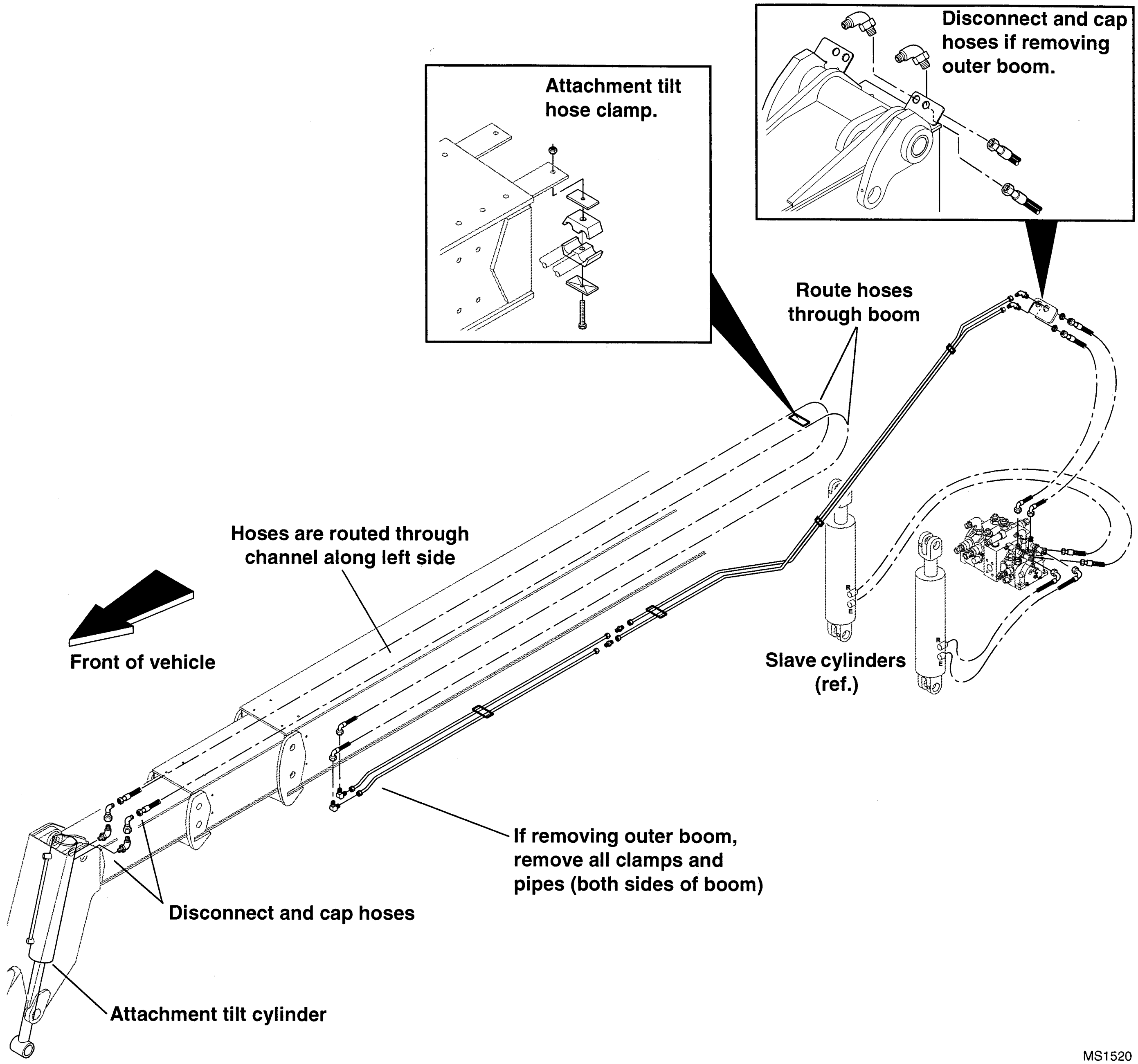


Figure 3–1. Disconnect the attachment tilt hoses.

5. Open the rear cover to begin removing the extend/retract cylinder (Fig. 3–2).

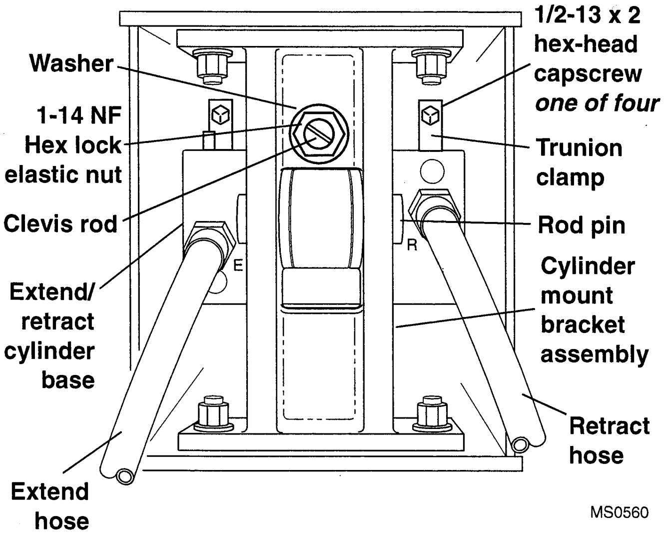


Figure 3–2. Open the rear cover to begin removing the extend/retract cylinder.

6. Remove the four bolts (two upper, two lower) and related hardware securing the cylinder mount bracket assembly to the outer boom. Note the position and number of washers at each location for proper reinstallation.
7. Remove the 1-14 NF hex lock elastic nut (Fig. 3–2) securing the clevis rod to the extend/retract cylinder mount bracket assembly. Dispose of the 1-14 NF hex lock elastic nut.

Note: Always replace elastic-lined nuts with new elastic-lined nuts to help ensure proper fastening.

WARNING: Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

8. Use a large pry bar to begin working the cylinder mount bracket assembly out of its position within the rear of the outer boom. As needed, start the vehicle and use the joystick to operate the boom extend and retract functions _momentarily only_ to help free the cylinder mount bracket assembly. Allow the base end of the extend/retract cylinder to move back, out of the rear of the outer boom, only until the mount bracket assembly clears the outer boom.

Note: DO NOT allow the base end of the extend/retract cylinder to move back, out of the rear of the outer boom, any further than is absolutely necessary for the mount bracket assembly (Fig. 3–2) to clear the edge of the outer boom. Damage to the extend and retract hoses can occur.

9. Disconnect and cap the extend and retract hoses (Fig. 3–2) and the extend/retract cylinder.
10. Position a suitable container beneath the counterweight at the rear of the vehicle. Inside the top left rear of the boom, loosen the attachment tilt hose clamp (Fig. 3–1). Carefully route the attachment tilt hoses through the boom and secure them safely out of the way. It is not necessary to completely remove the attachment tilt hoses.
11. Use a socket wrench and long extension to remove the four 1/2-13 x 2" hex-head capscrews (Fig. 3–2) and 1/2" lock washers securing the extend cylinder trunion clamps (Fig. 3-2 and Fig. 3-6) to the intermediate boom. Pull the cylinder mount bracket assembly rearward as needed to allow working room within the boom.
12. Remove the two 3/8-16 x 2-1/4" hex-head capscrews (Fig. 3–5) and 3/8" lock washers securing the cover plate and extend chain adjustment rod guide halves to the extend/retract cylinder.
13. Use a hoist or overhead crane and sling attached to the extend/retract cylinder to carefully withdraw the cylinder from the inner boom. Readjust the position of the sling as needed to help balance the cylinder during withdrawal. Carefully extract the attachment tilt hoses as the extend/retract cylinder is withdrawn. When the cylinder is clear of the vehicle, carefully lower it to the ground.
14. At the rear of the inner boom, remove the 3/16 x 1-1/2" cotter pin (Fig. 3–3) securing the extend chain anchor clevis pin to its anchor. Remove the extend chain anchor clevis pin. Remove the retract chain from its anchor.
15. Detach both the extend chain (Fig. 3–3) and the retract chain from their anchors. It is not necessary to remove the chains from the clevis.

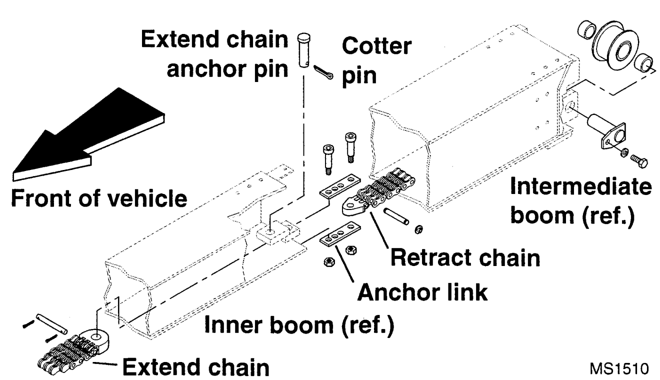


Figure 3–3. Chains, anchors and clevis mounting.

16. At the front of the vehicle, use a hoist and sling attached to the inner boom just behind the gooseneck weldment. Begin withdrawing the inner boom. Readjust the position of the sling as needed to help balance the boom during withdrawal. When the boom is clear of the vehicle, carefully lower it to the ground.
17. Use a hoist and sling attached to the inner boom; remove slack from the hoist cable, and begin withdrawing the inner boom a few feet (decimeters) at a time. Reposition the sling at the approximate center of the inner boom, then continue withdrawing the boom until it clears the vehicle. Carefully lower the inner boom onto suitable supports, or to the ground.

> **WARNING:** Never weld or drill the boom or frame. Failure to comply can result in death or severe personal injury.

18. Inspect the boom and welds. Contact Sky Trak International or the local Sky Trak International distributor if structural damage is detected.
19. Inspect hoses, hardware, wear pads, mounting points, chains, and other components visible with the inner boom removed. Replace if damaged.

B. Inner Boom Installation

> **WARNING:** Wear protective footwear with reinforced toe caps and slip-resistant soles. Failure to comply can result in foot injury from falling objects or other bodily injury from slipping or falling.

> **WARNING:** Never lift a heavy object without the help of at least one assistant or a suitable sling and hoist. Failure to comply can result in serious personal injury

IMPORTANT: Light lubrication of the boom wear surfaces with a rust inhibitor/lubricant such as *LPS 3* or equivalent is recommended to keep the boom wear surfaces lubricated properly. Light lubrication of the boom wear surfaces is also recommended in salt air climates, and when the vehicle is stored, to help prevent rusting.

1. Use a hoist or overhead crane and sling attached to the inner boom. Remove slack from the hoist cable. Raise the inner boom and begin inserting it into the intermediate boom at the front of the vehicle.
2. Readjust the position of the sling as needed to help balance the boom during installation. When the inner boom is almost fully inserted into the intermediate boom, carefully remove the sling and hoist. Slide the inner boom into the intermediate boom until the rear of the gooseneck weldment on the inner boom contacts the front of the intermediate boom (Fig. 3–4).

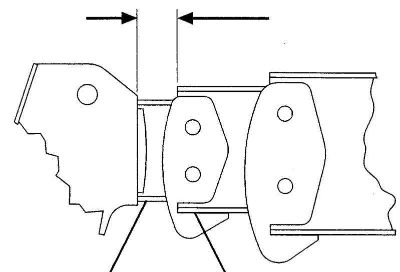


Figure 3–4. Slide the inner boom into the intermediate boom until the rear of the gooseneck weldment on the inner boom contacts the front of the intermediate boom.

3. At the rear of the inner boom, place the extend chain and extend chain clevis rod, as an assembly, into the inner boom. **DO NOT** allow the chain to twist or kink.
4. At the rear of the inner boom, install the extend chain anchor clevis pin (refer to Fig. 3–3, or to item 31 in the *General Overview* illustration) at its anchor. Secure the clevis pin with a 3/16 x 1-1/2" cotter pin (32).
5. Install the retract chain anchor link (refer to Fig. 3–3 or to item 54 in the *General Overview* illustration) at the retract chain anchor. Secure the anchor link to the anchor with a 1/2 x 1-1/2" x 3/8-16 hex-head shoulder bolt and a new 3/8-16 hex-lock elastic nut.
6. Use a hoist or overhead crane and sling attached to the extend/retract cylinder to carefully raise and position the cylinder near the rear of the inner boom.
7. Position the extend chain (Fig. 3–5) over the extend chain sheave mounted on the extend/retract cylinder. Route the extend chain and clevis rod through the channel on top of the extend/retract cylinder.

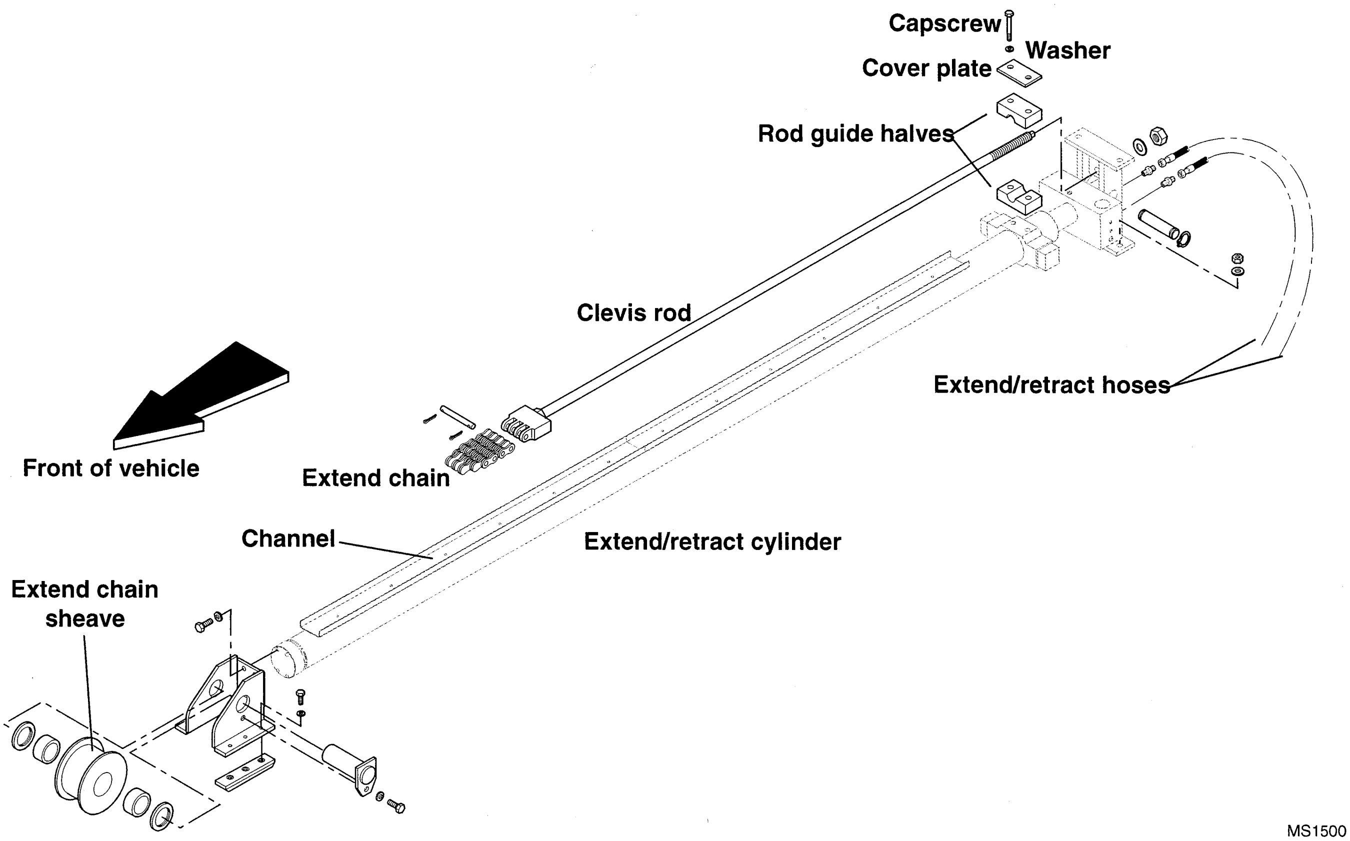


Figure 3–5. Extend/retract cylinder mounting detail.

8. Attach the clevis rod (Fig. 3–5) to the extend/retract cylinder with the cover plate and extend chain adjustment rod guide halves. Secure with two 3/8" lockwashers and 3/8-16 x 2-1/4" hex-head capscrews coated with Loctite® 242 (blue). Torque to 31 lb/ft (42 Nm).
9. Insert the extend/retract cylinder fully into the inner boom while observing that the extend chain remains properly aligned and does not kink, fold or otherwise distort.
10. Readjust the sling as needed to help balance the cylinder in the sling during installation. When the cylinder and extend chain are properly inserted within the inner boom, carefully lower the cylinder and remove the sling and hoist.
11. Position one of the two extend cylinder trunion clamps (Fig. 3–6) against its mounting boss within the intermediate boom. Use a long extension and socket wrench to install two 1/2-13 x 2-1/4" hex-head capscrews and 1/2" lockwashers to secure the extend cylinder trunion clamps to the intermediate boom. Install the other extend cylinder trunion clamp. Torque all four of the capscrews to 75 lb/ft (102 Nm).

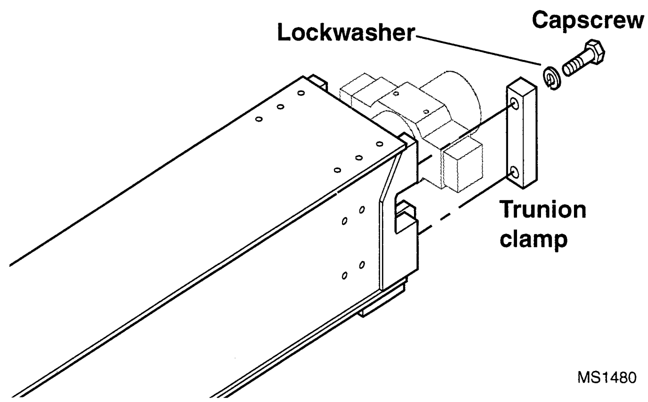


Figure 3–6. Extend/retract cylinder trunion clamp.

12. Route the attachment tilt cylinder hoses forward along the inside left inner boom channel. Connect the hoses to the attachment tilt cylinder at the front of the boom within the gooseneck.
13. Reconnect the attachment tilt hose clamps to the bracket on the inner boom (see Fig. 3-1).
14. Connect the extend and retract hoses to the extend/retract cylinder (Fig. 3-5). Always use new flat-faced O-rings when connecting hydraulic fittings.

15. Coat the intermediate boom wear pad ***bolts*** with Loctite® 242 (blue). DO NOT coat the pads with Loctite®. Use the bolts and 3/8" washers to secure the wear pads and shims to the front of the intermediate boom.
16. Measure all wear-pad gaps (refer to *Section 3.2.5 Boom Wear Pads* for wear pad gap dimensions and wear pad thickness requirements). Add or remove shims as required. Replace the wear pads with new ones, if needed.
17. Check and adjust the boom chain (refer to *Section 3.2.4 Boom Chains* for measurement and adjustment procedures).
18. Clean up all debris, hydraulic fluid, etc., in, on, near, and around the vehicle.

WARNING: Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

19. Start the engine and operate all boom functions several times. Check the chain tension again and adjust as necessary. Check for leaks, and check the hydraulic fluid level in the tank; add fluid if required.
20. Apply grease at all lubrication points (grease fittings).

3.2.2 Intermediate Boom Replacement

WARNING: Wear protective footwear with reinforced toe caps and slip-resistant soles. Failure to comply can result in foot injury from falling objects or other bodily injury from slipping or falling.

WARNING: NEVER lift a heavy object without the help of at least one assistant or a suitable sling and hoist. Failure to comply can result in serious personal injury.

A. Intermediate Boom Removal

1. Remove the inner boom as described in *Section 3.2.1 Inner Boom Replacement.* Remove the boom wear pads from the front of the outer boom.
2. Move the retract chain out of the way. The retract chain sheave and attaching hardware can remain attached at the rear of the intermediate boom during removal.
3. Working from the front of the vehicle, use a hoist and sling attached to the intermediate boom; remove slack from the hoist cable, and begin withdrawing the intermediate boom a few feet (decimeters) at a time. Reposition the sling at the approximate center of the intermediate boom, then continue withdrawing the boom until it clears the vehicle. Carefully lower the intermediate boom onto suitable supports, or to the ground.

WARNING: NEVER weld or drill the boom or frame. Failure to comply can result in death or severe personal injury.

4. Inspect the boom and welds. Contact Sky Trak International or the local Sky Trak International distributor if structural damage is detected.
5. Inspect hoses, hardware, wear pads, mounting points, chains, and other components visible with the intermediate boom removed. Replace if damaged.

B. Intermediate Boom Installation

WARNING: Wear protective footwear with reinforced toe caps and slip-resistant soles. Failure to comply can result in foot injury from falling objects or other bodily injury from slipping or falling.

WARNING: NEVER lift a heavy object without the help of at least one assistant or a suitable sling and hoist. Failure to comply can result in serious personal injury.

IMPORTANT: Light lubrication of the boom wear surfaces with a rust inhibitor/lubricant such as *LPS 3* or equivalent is recommended to keep the boom wear surfaces lubricated properly. Light lubrication of the boom wear surfaces is also recommended in salt air climates, and when the vehicle is stored, to help prevent rusting.

1. If the retract chain sheave and its attaching hardware at the rear of the intermediate boom are not installed, install these items before proceeding.
2. If needed, install wear pads (refer to *Section 3.2.5 Boom Wear Pads*) on the outer rear of the intermediate boom before inserting the intermediate boom into the outer boom. Coat boom wear pad bolts with Loctite® 242 (blue). Use the bolts and 3/8" washers to secure the wear pads and shims to the boom.
3. Use a hoist or overhead crane and sling attached to the intermediate boom; remove slack from the hoist cable. Working from the front of the vehicle, raise the intermediate boom and begin inserting it into the outer boom. Insert the boom a few feet (decimeters) at a time, then reposition the sling. Continue inserting the intermediate boom until it is completely installed. Remove the sling and hoist.

4. Working from the rear of the vehicle, route the retract chain (Fig. 3–7) properly over the retract chain sheave mounted to the intermediate boom.

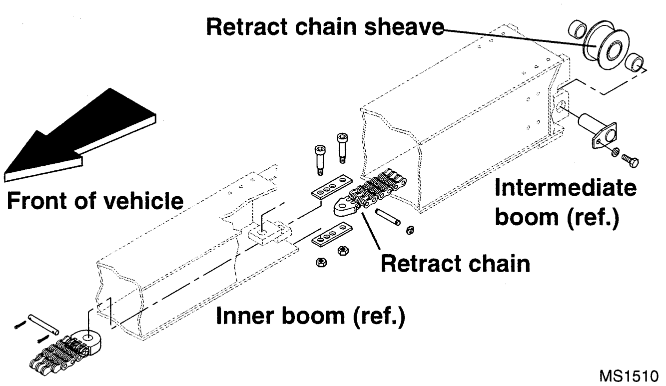


Figure 3–7. Route the retract chain over the sheave.

5. Install the inner boom, extend/retract cylinder and extend chain and attaching hardware (refer to *Section 3.2.1 Inner Boom Replacement*, part B).
6. Clean up all debris, hydraulic fluid, etc., in, on, near, and around the vehicle.

> **WARNING:** Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

7. Start the engine and operate all boom functions several times. Check the chain tension again and adjust as necessary. Check for leaks, and check the hydraulic fluid level in the tank; add fluid if required. Apply grease at all lubrication points (grease fittings).

3.2.3 Outer Boom Replacement

> **WARNING:** Wear protective footwear with reinforced toe caps and slip-resistant soles. Failure to comply can result in foot injury from falling objects or other bodily injury from slipping or falling.

> **WARNING: NEVER** lift a heavy object without the help of at least one assistant or a suitable sling and hoist. Failure to comply can result in serious personal injury.

A. Outer Boom Removal

1. Remove both the inner boom and intermediate boom as described in *Section 3.2.1 Inner Boom Replacement* and *Section 3.2.2 Intermediate Boom Replacement*.
2. Remove all clamps securing hydraulic pipes to the outer boom and frame (Fig. 3–1). Label and remove the pipes.
3. Use a hoist or overhead crane and sling attached to the outer boom; raise and support the outer boom at a slight angle. Allow room to remove the hoist/lower cylinder attaching hardware.
4. Place blocks or supports beneath the outer boom and lower the outer boom onto the blocks or supports. Remove the sling from around the outer boom.
5. Use a hoist or overhead crane and sling attached to the hoist/lower cylinder; remove slack from the sling.
6. Remove the 1/2-13 x 4" hex-head capscrew (Fig. 3–8) and 1/2-13 nut securing the hoist/lower cylinder pin at the outer boom hoist/lower cylinder mount boss on the underside of the outer boom (Fig. 3–9).

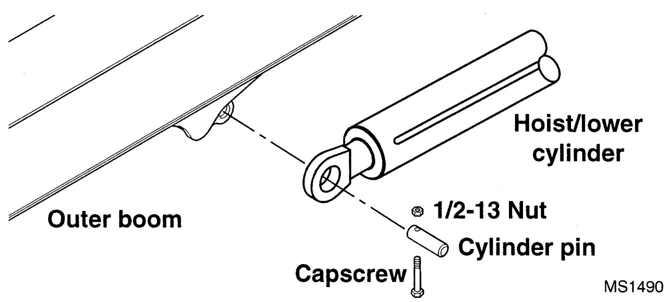


Figure 3–8. Hoist/lower cylinder mounting detail.

7. Carefully extract the hoist/lower cylinder pin (Fig. 3–8).

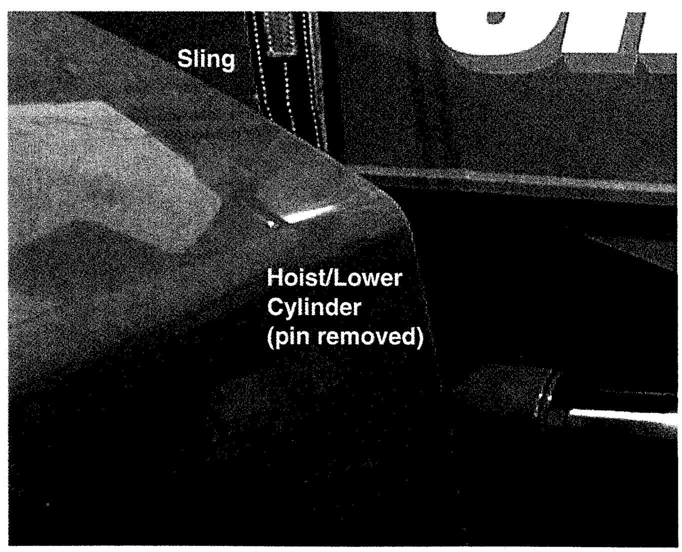


Figure 3–9. Raise *and support* the outer boom, then remove the hoist/lower cylinder pin and lower the cylinder onto a suitable support within the chassis cavity.

8. Lower the hoist/lower cylinder into the chassis cavity, onto a suitable support placed at the front of the cylinder.
9. Working from the top of each slave cylinder (Fig. 3–10), remove the 5/16-18 x 3-1/2" hex-head capscrew and 5/16-18 hex lock nut at the cylinder mount pin.

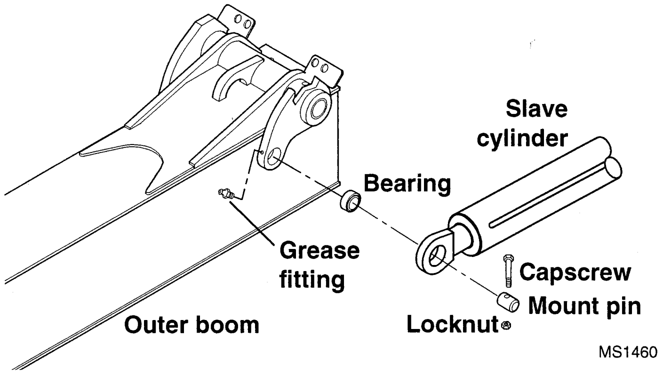


Figure 3–10. Slave cylinder mounting detail (top).

10. Extract the cylinder mount pin (Fig. 3–10) through the circular opening in the chassis weldment. A long bolt of the same thread size as the tapped hole in the cross pin may be threaded into the cross pin to aid in removal. Carefully lower each slave cylinder down between the chassis and the outer boom. **DO NOT** stretch or damage the slave cylinder hydraulic hoses.
11. Disconnect the metal hydraulic pipes (Fig. 3–1) at the left rear of the vehicle to gain access to the 5/8-11 x 6-1/2" hex-head capscrew securing the boom pivot pin to the outer boom (Fig. 3–11). Cap the hydraulic pipes and remove the capscrew and nut.

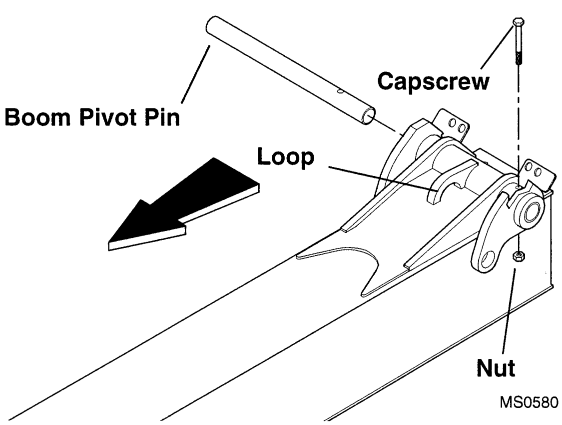


Figure 3–11. Remove the capscrew and nut securing the boom pivot pin to the outer boom.

12. Use a hoist or overhead crane and sling attached to the loop (Fig. 3–11) on top of the outer boom. Attach another sling around the outer boom near the center point and secure it to the hoist. Remove slack from the slings.
13. Remove the boom pivot pin.
14. Withdraw the outer boom from the vehicle. Carefully lower the outer boom onto suitable supports, or to the ground.

> **WARNING: NEVER** weld or drill the boom or frame. Failure to comply can result in death or severe personal injury.

15. Inspect the boom and welds. Contact Sky Trak International or the local Sky Trak International distributor if structural damage is detected.
16. Inspect hoses, hardware, wear pads, mounting points, chains, and other components visible with the outer boom removed. Replace if damaged.

B. Outer Boom Installation

> **WARNING:** Wear protective footwear with reinforced toe caps and slip-resistant soles. Failure to comply can result in foot injury from falling objects or other bodily injury from slipping or falling.

> **WARNING: NEVER** lift a heavy object without the help of at least one assistant or a suitable sling and hoist. Failure to comply can result in serious personal injury.

IMPORTANT: Light lubrication of the boom wear surfaces with a rust inhibitor/lubricant such as *LPS 3* or equivalent is recommended to keep the boom wear surfaces lubricated properly. Light lubrication of the boom wear surfaces is also recommended in salt air climates, and when the vehicle is stored, to help prevent rusting.

1. Use a hoist or overhead crane and sling attached to the loop (Fig. 3–11) on top of the outer boom. Attach another sling around the outer boom near the center point and secure it to the hoist. Remove slack from the slings.
2. Carefully raise the outer boom into position on the vehicle chassis. Install the boom pivot pin and secure it with a Grade 5, 5/8-11 x 6-1/2" hex-head capscrew and a new 5/8-11 hex-lock elastic nut. Torque to 150 lb/ft (203 Nm).

Note: Always use new elastic-lined nuts to help ensure proper fastening.

3. Place a block or support within the chassis near the front of the outer boom.
4. Lower the outer boom onto the block or support and remove the slings and hoist or overhead crane.
5. Raise each slave cylinder into position at the outer boom slave-cylinder mounting bosses. **DO NOT** stretch or damage the slave cylinder hydraulic hoses.

6. Coat each slave cylinder mount pin (Fig. 3–11) with anti-seize compound. Insert each mount pin through its circular opening in the chassis weldment and through the outer boom and slave cylinder mount eye. A long bolt of the same thread size as the tapped hole in the cross pin may be threaded into the cross pin to aid in installation.
7. Working from above, insert a 5/16-18 x 3-1/2" hex-head capscrew through each slave cylinder mount pin. Secure the capscrew with a new 5/16-18 hex lock nut. Torque to 18 lb/ft (24 Nm).
8. Use a hoist or overhead crane and sling attached to the hoist/lower cylinder; remove slack from the hoist cable, and raise the hoist/lower cylinder into its mount boss on the underside of the outer boom.
9. Coat the hoist/lower cylinder pivot pin with anti-seize compound. Install the pin through the lower boom mounting boss and hoist/lower cylinder eye (Fig. 3–12) and secure with a 1/2-13 x 4" hex-head capscrew and 1/2-13 nut. Torque to 75 lb/ft (102 Nm).

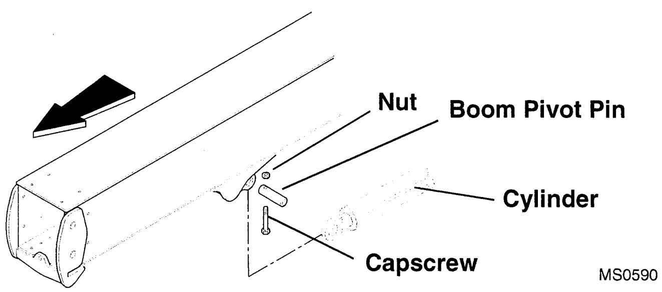


Figure 3–12. Install the hoist/lower cylinder and secure with the boom pivot pin, capscrew and nut.

10. Remove the sling and hoist or overhead crane from the hoist/lower cylinder, and remove the blocks or supports from beneath the cylinder.
11. Use a hoist or overhead crane and sling attached to the outer boom; raise the outer boom slightly, and remove the blocks or supports from beneath the outer boom. Lower the outer boom and remove the sling and hoist or overhead crane.

Note: Always use new flat-faced O-rings when connecting hydraulic fittings.

12. Install the intermediate boom, retract chain and attaching hardware (refer to *Section 3.2.2 Intermediate Boom Replacement*).
13. Install the inner boom, extend/retract cylinder and extend chain and attaching hardware (refer to *Section 3.2.1 Inner Boom Replacement*).
14. As required, install the hydraulic pipe clamps (Fig. 3–1) on the outer boom and secure the hydraulic pipes within the clamps on the boom and frame. Connect the metal hydraulic pipes at the left rear bulkhead on the outer boom. Reconnect all hydraulic pipes and fittings.
15. Clean up all debris, hydraulic fluid, etc., in, on, near, and around the vehicle.

> **WARNING:** Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

16. Start the engine and operate all boom functions several times. Check the chain tension again and adjust as necessary. Check for leaks, and check the hydraulic fluid level in the tank; add fluid if required.
17. Install wear pads (refer to *Section 3.2.5 Boom Wear Pads*). Coat boom wear pad bolts with Loctite® 242 (blue). Use the bolts and 3/8" washers to secure the wear pads and shims to the boom.
18. Apply grease at all lubrication points (grease fittings).

3.2.4 Boom Chains

This vehicle uses a single extend chain to extend the boom and a single retract chain to retract the boom. The extend chain is constructed of one-inch pitch links with 8 x 8 leaf lacing. The retract chain is constructed of 3/4" pitch links with 6 x 6 leaf lacing.

IMPORTANT: DO NOT attempt to service or repair a chain. Replace a stretched or damaged chain with a new one. When replacing a chain, also replace both clevises and both chain-to-clevis attaching pins with new ones.

A. Boom Chain Tension Check

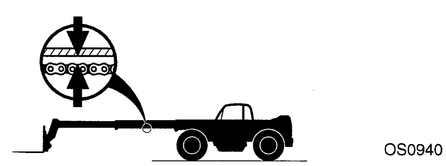


Figure 3–13. Every 1,000 hours of engine operation, check both boom chains for proper tension.

1. Park the vehicle on level ground. Place the travel select lever in NEUTRAL (N), engage the parking brake switch and raise the boom to a horizontal boom. Retract the boom completely and shut the engine off.
2. Measure the distance between the inner boom and the intermediate boom (Fig. 3–14). The inner boom should extend 2.25" (57 mm) to 2.75" (70 mm) beyond the end of the intermediate boom. If the measurement is less than 2.25" (57 mm) or more than 2.75" (70mm), the boom chain requires adjustment. See *Section 3.2.4 B Boom Chain Adjustment*.

Note: If the boom measurement cannot be adjusted within the 2.25" and 2.75" range, the boom may require extensive adjustment and/or repair. Contact Sky Trak International or the nearest Sky Trak distributor.

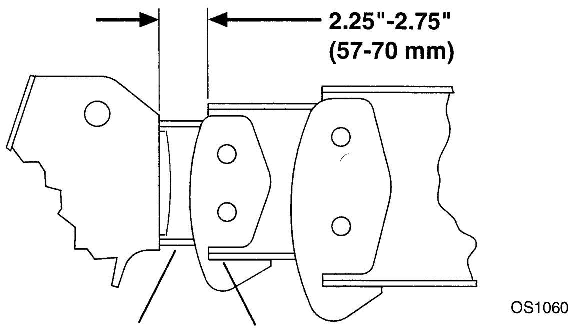


Figure 3–14. Measure the distance between the inner boom and the intermediate boom.

B. Boom Chain Adjustment (as required)

1. Park the vehicle on level ground. Place the travel select lever in NEUTRAL (N), engage the parking brake switch and raise the boom to a horizontal boom. Retract the boom completely and shut the engine off.
2. Loosen the retract chain locknut (Fig. 3–15) located on the bottom at the front of the outer boom.

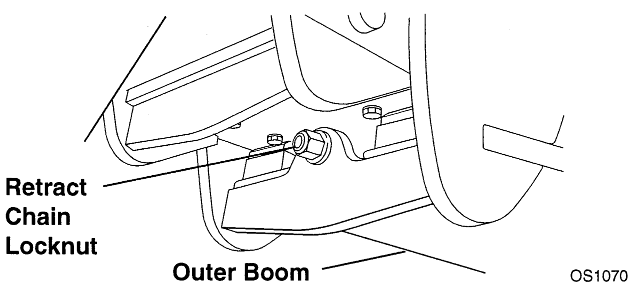


Figure 3–15. Turn the retract chain locknut at the front of the outer boom.

3. Unlock and open the rear cover.
4. While holding the clevis end to keep it from turning (Fig. 3–16), tighten the extend chain locknut located at the rear of the outer boom.

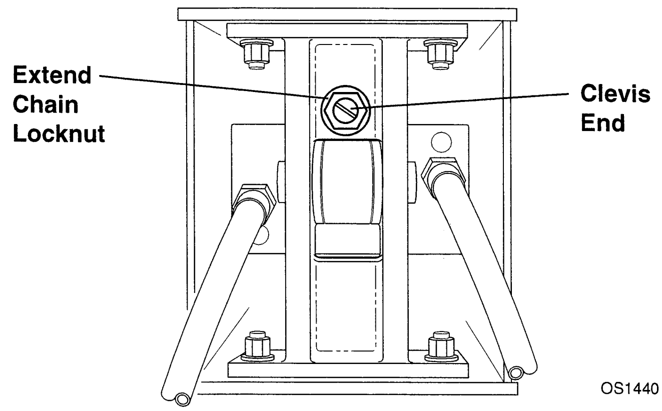


Figure 3–16. Prevent the clevis end from turning, and tighten the extend chain locknut at the rear of the outer boom.

5. Periodically measure the distance between the inner boom and the intermediate boom. Repeat Step 4 until a distance of 2.5" (63,5 mm) is obtained between the inner boom and the intermediate boom (Fig. 3–14).

IMPORTANT: The boom has been factory lubricated for proper wear pad break in and will normally not require lubrication. However, after replacing any wear pad(s), or after prolonged periods of inoperation, light lubricating (with *LPS 3* or equivalent) of the boom wear surfaces is recommended to keep the wear pads in the boom wear surfaces lubricated properly. Light lubricating of the boom wear surfaces is also recommended in salt air climates or when the vehicle is to be put in storage to help prevent rusting.

6. Tighten the retract chain locknut (Fig. 3–15) to 35-40 lb/ft (47,5 to 54,2 Nm).
7. Close and lock the rear cover.

C. Chain Replacement

IMPORTANT: Chains and clevises are wear items and experience the same stress. **DO NOT** attempt to service or repair a chain. Always replace a stretched or damaged chain with a new one, and replace both clevises and both chain-to-clevis attaching pins with new ones.

Extend Chain Removal

1. Removal of the extend/retract cylinder is required to remove the extend chain. Refer to *Section 3.2.1 A. Inner Boom Removal.* Follow steps 1-15.
2. Inspect wear and condition of the booms, chains, clevises, chain sheaves, extend/retract cylinder, chain rods, clevis anchors and all mounting hardware. Replace any worn or damaged parts. **DO NOT** attempt to make any repairs to the chain.

Note: Chains and clevises are wear items and experience the same stress. **DO NOT** attempt to service or repair a chain. Always replace a stretched or damaged chain with a new one, and replace both clevises and both chain-to-clevis attaching pins with new ones.

Extend Chain Installation

Follow the procedure detailed in *Section 3.2.1 B. Inner Boom Installation*, Steps 3 through 17.

Retract Chain Removal

1. Removal of the inner boom is required to remove the retract chain. Refer to *Section 3.2.1 A. Inner Boom Removal.* Follow steps 1-15.
2. Remove the retract chain clevis locknut and washer at the front of the outer boom (Fig. 3–17).

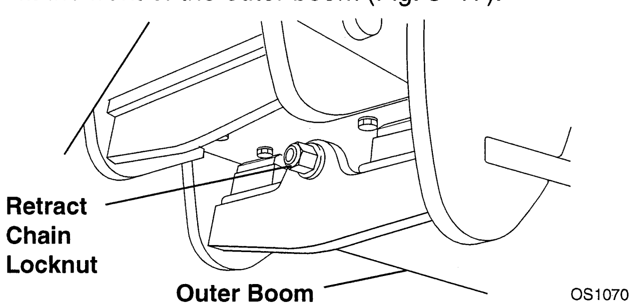


Figure 3–17. The retract chain locknut and washer secure the retract chain clevis at the front of the outer boom.

3. Remove the complete retract chain and clevis (Fig. 3–18) as an assembly from the front of the boom. If the vehicle is equipped with auxiliary hydraulics, remove the retract chain from the rear of the boom. Adjust the position of the intermediate and inner booms and remove wear pads and shims as necessary.

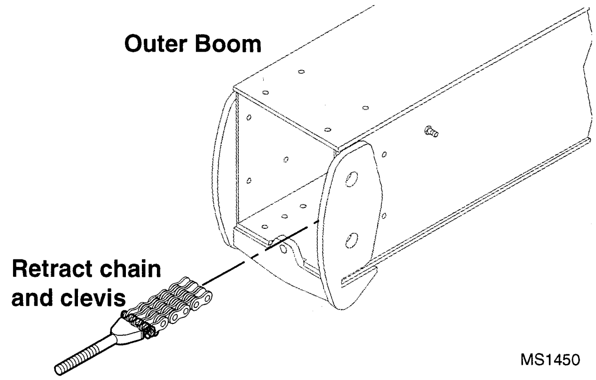


Figure 3–18. Remove the retract chain and clevis.

4. Inspect wear and condition of the booms, chains, clevises, chain sheaves, extend/retract cylinder, chain rods, clevis anchors and all mounting hardware. Replace any worn or damaged parts. **DO NOT** attempt to make any repairs to the chain.

Note: Chains and clevises are wear items and experience the same stress. **DO NOT** attempt to service or repair a chain. Always replace a stretched or damaged chain with a new one, and replace both clevises and both chain-to-clevis attaching pins with new ones.

Retract Chain Installation

1. Assemble the retract chain, clevises and hardware. Attach a length of stiff wire or small-diameter rod to the front clevis; the wire or rod must be long enough to pull the clevis and chain through to the front of the outer boom.
2. At the rear of the intermediate boom, route the wire or rod, retract chain clevis and retract chain underneath the retract chain sheave. Work the wire or rod forward to the front of the outer boom.

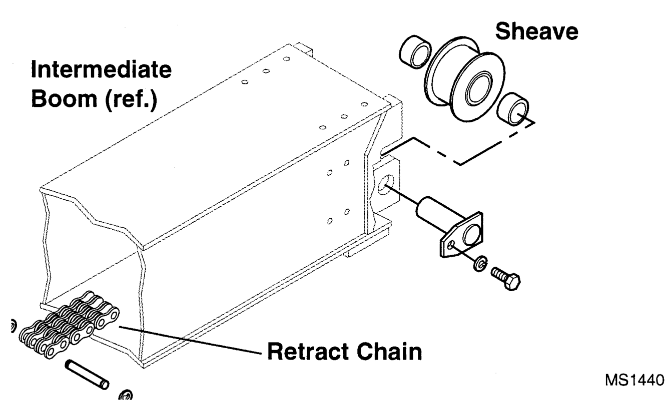


Figure 3–19. Route the retract chain under the sheave.

3. From the front of the outer boom, pull the wire or rod, retract chain clevis and retract chain forward.

4. Insert the retract chain clevis into its mounting hole at the bottom front of the outer boom. Secure the clevis with a 3/4" narrow flat washer and a new 3/4-16 NF hex-lock elastic nut but **DO NOT** tighten at this time.

Note: Always use new elastic-lined nuts to help ensure proper fastening.

5. At the rear of the inner boom, position the retract chain clevis between two retract chain anchor links. Coat a 1/2 x 1-1/2" x 3/8-16 shoulder bolt with anti-seize compound and secure the links with the shoulder bolt and a new 3/8-16 hex-lock elastic nut. Torque to 31 lb/ft (42 Nm).

Note: Always use new elastic-lined nuts to help ensure proper fastening.

6. Route the retract chain and anchor links over the retract chain sheave. Coat a 1/2 x 1-1/2" x 3/8-16 shoulder bolt with anti-seize compound and secure the links with the shoulder bolt and a new 3/8-16 hex-lock elastic nut. Torque to 31 lb/ft (42 Nm).

Note: Always use new elastic-lined nuts to help ensure proper fastening.

7. If the boom wear pads are not installed, install the outer boom lower right side wear pad first, then install the outer boom upper wear pads.
8. Follow the procedure detailed in *Section 3.2.1 B. Inner Boom Installation*, steps 3-17, to install the extend/ retract cylinder.
9. Check and adjust the boom chain tension by following the procedures in *Section 3.2.4 Boom Chains*.

3.2.5 Boom Wear Pads

Three types of wear pads are used (Fig. 3–20): flat wear pads with metal inserts and shims, flat wear pads with metal inserts, and channel wear pads.

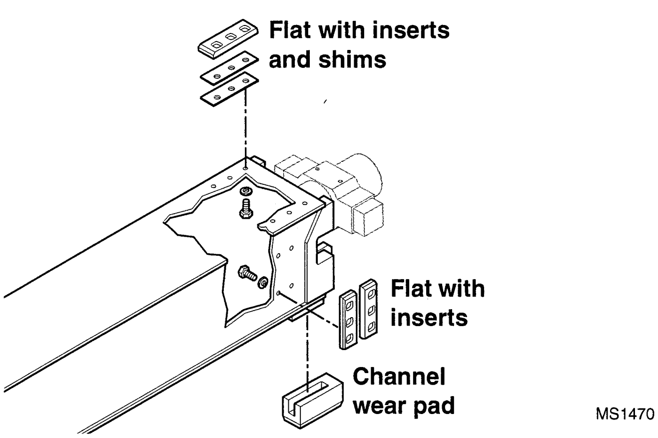


Figure 3–20. Wear pad types.

The inserts are special metal hardware that will scratch the boom if the wear pads are worn beyond usable limits (see *Section 3.2.5 A. Boom Wear Pad Check*).

A total of 32 wear pads are installed on the outer, intermediate and inner booms. Eight wear pads are attached to the inner boom, 16 to the intermediate boom (including two channel wear pads at the lower rear), and eight to the outer boom.

At the front of the boom, shims are used to maintain a minimum gap of 0.07-0.13" (1,8 to 3,3 mm) between the wear pads and the booms.

Wear Pad Gaps:

***FRONT**, outer boom to intermediate boom and intermediate boom to inner boom:*

TOP: 0.07"-0.130" (1,8mm-3,3mm), minimum

SIDE: 0.07"-0.130" (1,8mm-3,3mm), minimum

Note: Shim front upper and side wear pads to maintain minimum gap in both vertical and horizontal directions.

***REAR**, intermediate boom to outer boom and inner boom to intermediate boom:*

UPPER PADS: Shim upper rear wear pads to maintain a *maximum* gap of 0.06" (1,7mm) at the rear edge of the upper pads **AND** to maintain a total *minimum* gap of 0.07-0.13" (1,8-3,3mm) in the *vertical* direction.

A. Boom Wear Pad Check

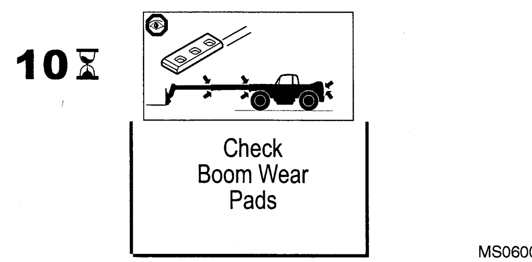


Figure 3–21. At ten hour intervals, check boom wear pad thickness.

At ten hour intervals, check boom wear pad thickness (Fig. 3–21). Replace wear pads that are less than 3/8" thick (0.375", or 9,5 mm). The angled cut at each end of the flat wear pads serves as a wear pad indicator (Fig. 3–22).

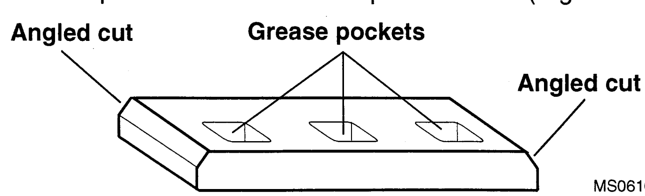


Figure 3–22. The angled cut at each end of the flat wear pads serves as a wear pad indicator.

The total thickness of a new flat wear pad is 0.625" (15,9 mm). The angled cut provides a total wear thickness of 0.25" (6,4 mm). This leaves approximately 3/8" (0.375", or 9,5 mm) of total unused material. **DO NOT** allow wear pads to wear past the angled cut indicator or the metal inserts (Fig. 3–23) will damage the boom and begin to wear into the boom pad sliding surfaces. Pads worn past this point will gouge the boom surfaces, resulting in premature wear of any new boom wear pads installed, and requiring eventual, expensive replacement of the boom. Replacement of boom wear pads must be performed when the boom wear pads indicate.

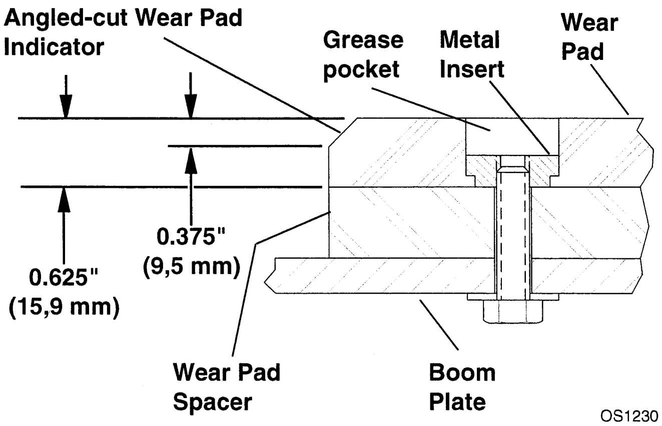


Figure 3–23. Inspect the boom wear pads for excessive wear, gouging or other damage.

When conducting the daily or 10-hour inspection, visually check the boom wear pads between the boom sections at the rear and front of the boom for excessive wear, gouging or other damage.

The average expected service life of boom wear pads varies depending on the particular location of each wear pad within the boom, vehicle use, load weight and operating conditions.

If load weights are at or near maximum capacity, or if the vehicle is operating in very dirty or dusty conditions, the boom wear pads will wear at a much faster rate.

The boom wear pads that are under the most stress from the weight of the load will also wear faster than other pads. For example, the lower pads at the front and top pads at the rear of the boom are under much more stress than the pads attached at the lower rear (channel wear pads), top front or sides of the boom. Consequently, the lower pads will require service more often.

B. Boom Wear Pad Replacement

When installing a wear pad on one surface of a boom, replace the wear pad on the opposite surface. Usually, shimming will remain the same when installing new wear pads. When installing new wear pads, apply Loctite® #242 (blue) to all wear pad mounting capscrews and torque to 31 lb/ft (42 Nm).

Inner Boom

All inner boom pads are mounted on the rear outside of the inner boom (Fig. 3–24). The inner boom must be removed from the vehicle in order to replace the wear pads. Refer to *Section 3.2.1 Inner Boom Replacement* for information on removing the inner boom.

When replacing inner boom wear pads, fill the pockets of the *top rear* boom wear pads with multi-purpose grease. Use Loctite® 242 (blue) on all wear pad capscrews.

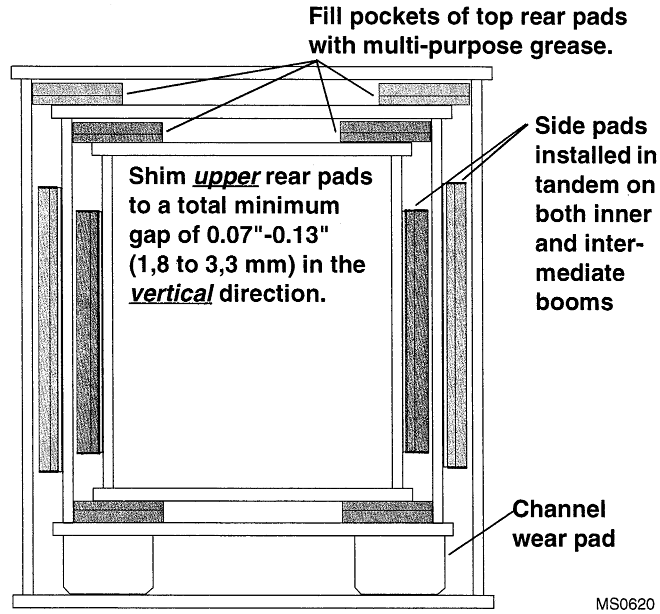


Figure 3–24. *Rear* boom wear pad locations.

Shim the *upper rear* wear pads as required to maintain a ***maximum*** gap of 0.06" (1,7 mm) at the rear edge of the pads and maintain a total *minimum* gap of 0.7"-0.13" (1,8 to 3,3 mm) in the vertical direction (Fig. 3–25).

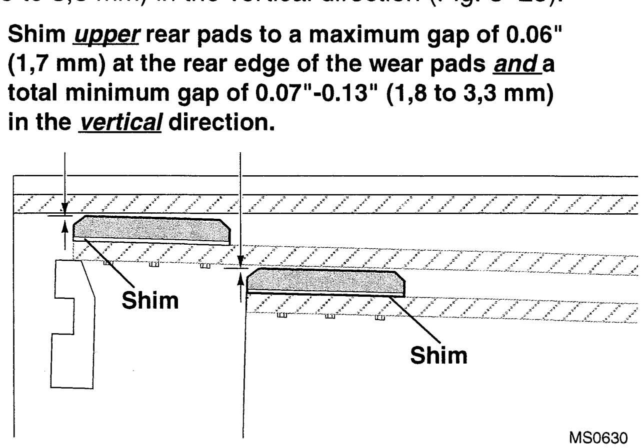


Figure 3–25. *Rear* boom wear pad gap dimensions.

Intermediate Boom

The inner boom and extend/retract cylinder must be removed from the vehicle to allow removal of the ***rear*** wear pads on the rear top and rear sides of the *intermediate* boom, and the channel wear pads on the rear bottom of the intermediate boom. Refer to *Section 3.2.1 Inner Boom Replacement* for information on removing the inner boom and extend/retract cylinder. Coat all wear pad capscrews with Loctite 242® (blue) before installation.

The wear pads on the ***front*** of the intermediate boom can be replaced by removing the fasteners securing them to the top, sides and bottom of the boom. When removing pads, move the boom sections as needed to gain access for removal and installation of wear pads. Mark or otherwise label each pad, spacer/shim and hardware set for ease of installation later. Top wear pads are secured to the boom with 3/8" washers and 3/8-16 x 1" capscrews; side wear pads are secured with 3/8" washers and 3/8-16 x 3/4" capscrews. Use Loctite® 242 (blue) on all wear pad capscrews.

Use shims as required to achieve a total minimum gap of 0.7"-0.013" (1,8 to 3,3 mm) between top and side wear pads and boom surfaces (Fig. 3–26).

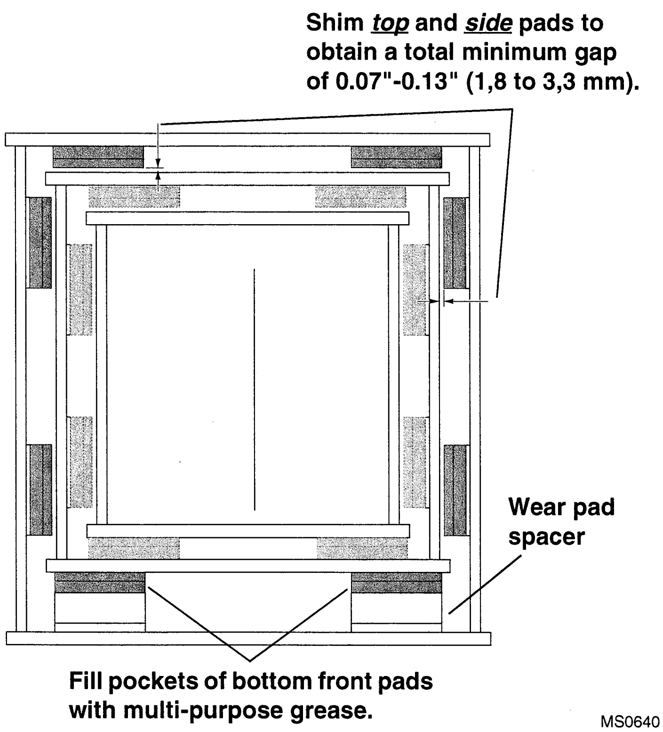


Figure 3–26. *Front* boom wear pad locations.

Outer Boom

All outer boom pads are mounted on the front of the outer boom. Remove the top wear pads before removing the bottom wear pads. Lower the gooseneck to the ground until the intermediate boom raises up, providing clearance for removing the bottom pads. Fill the pockets of the top rear boom wear pads with multi-purpose grease (Fig. 3–22 and Fig. 3–23). Use Loctite® 242 (blue) on all wear pad capscrews.

Use shims as required to achieve a total minimum gap of 0.7"-0.013" (1,8 to 3,3 mm) between top and side wear pads and boom surfaces (Fig. 3–26).

C. Boom Wear Pad Lubrication

The boom has been factory lubricated for proper wear pad break-in and will normally not require further lubrication. However, after replacing any wear pad(s), or after prolonged periods of inoperation, light lubrication of the boom wear surfaces with a rust inhibitor/lubricant such as *LPS 3* or equivalent is recommended to keep the boom wear surfaces lubricated properly. Light lubrication of the boom wear surfaces is also recommended in salt air climates, and when the vehicle is stored, to help prevent rusting.

3.2.6 Boom Lubrication Points

In general, lubricate the boom with multi-purpose grease every 250 hours (Fig. 3–27), more often as required by operating conditions, and after servicing the boom.

Figure 3–27. Lubricate the boom with multi-purpose grease via the grease fittings every 250 hours, more often under severe operating conditions, and after boom service.

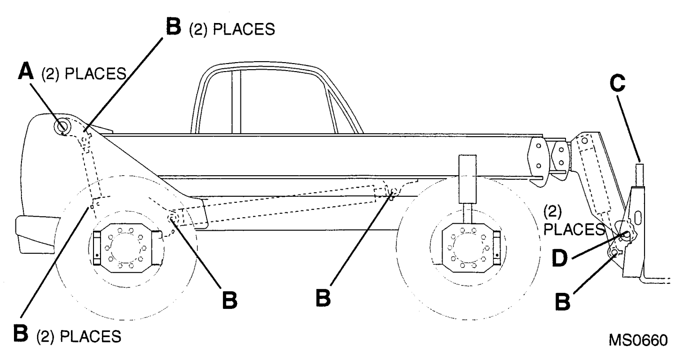


Figure 3–28. Sky Trak International Model 3606 lubrication points.

Apply a premium grade of lithium-based multi-purpose grease (MPG) via the grease fittings (Fig. 3–28) at these locations:

A. Boom pivot pins	2 points
B. Hydraulic cylinder pins	7 points
C. Boom attachments	All points
D. Carriage ("quick-attach") pivot pin	2 points

Shorten the lubrication interval when operating under severe conditions.

3.2.7 Emergency Boom Lowering and Retracting

This section covers emergency boom lowering procedures. Two types of conditions requiring emergency boom lowering are addressed; (a) Engine or Hydraulic Pump Failure, and (b) Hydraulic Line Failure.

A. Engine or Hydraulic Pump Failure

IMPORTANT: In the event of total loss of engine power or hydraulic pump failure with an elevated load, properly evaluate and deal with each situation on an individual basis. Contact the nearest Sky Trak International distributor, or the Sky Trak International Service Department at 1-414-268-8959 for specific instructions.

Secure the vehicle until the situation has been properly evaluated by following the procedures below:

1. Clear the area of any unnecessary personnel.
2. Block all four wheels.

> **WARNING: DO NOT** get under a raised boom unless the boom is blocked up. Always block the boom before doing any servicing that requires the boom to be up.

3. Section off a large area under the boom with string or tape to restrict any personnel from entering this potentially dangerous area.
4. Temporarily block up or support the outer boom so it cannot be lowered.
5. If the load can be removed safely, completely remove the load from the carriage and/or attachment. If the load cannot be removed, leave the load in place.
6. Place an Accident Prevention tag on both the ignition key and the steering wheel (Fig. 3–29) stating that the vehicle should not be operated. If a tag is not available, tape over the ignition switch.

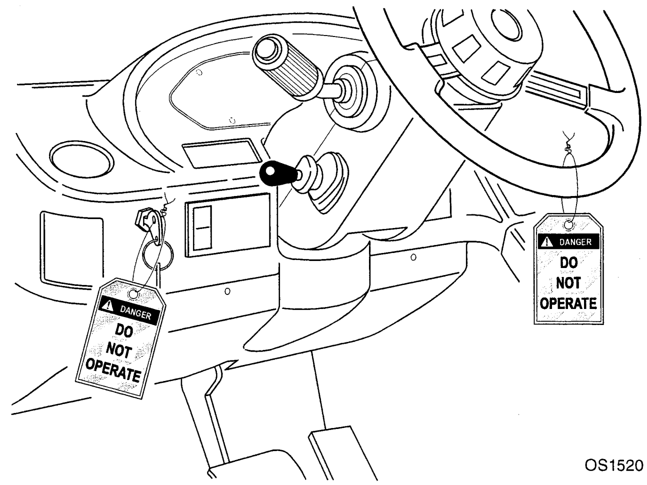


Figure 3–29. Place an Accident Prevention tag on both the ignition switch and the steering wheel.

B. Hydraulic Line Failure

In the event of hydraulic line failure, follow these step-by-step procedures to assist in safely retracting and then lowering the boom. Read this information from start to finish before performing any of these procedures to fully understand the process and the danger involved. If unsure about any part of these procedures, contact the nearest Sky Trak International distributor, or the Sky Trak International Service Department.

Every attempt should be made to repair a hydraulic line failure, and to retract and then lower the boom in its normal fashion. However, this is not always possible. Step-by-step procedures are listed here (Steps 3 and 4) for when the boom must be retracted and lowered immediately and replacement hydraulic lines or other parts are not available. Resort to these procedures (Steps 3 and 4) only when absolutely necessary.

IMPORTANT: The boom must first be retracted, and then lowered, to help avoid vehicle tipover.

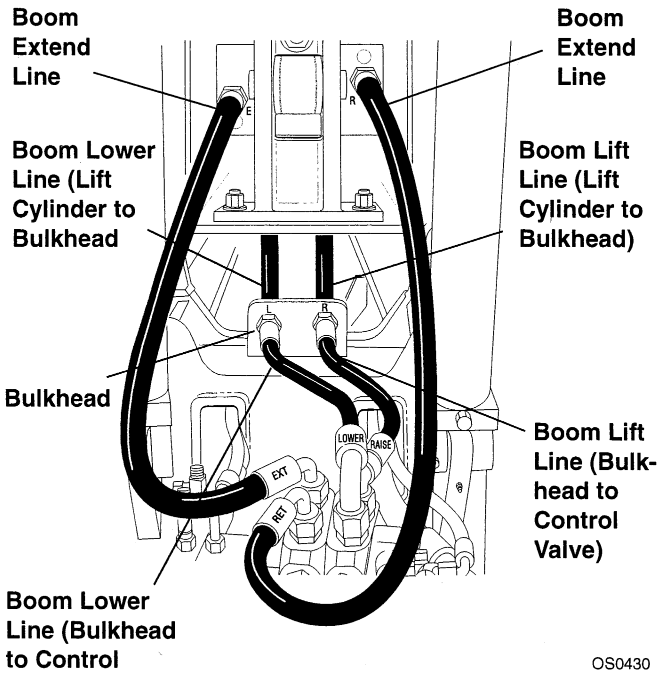


Figure 3–30. Correctly identify which hydraulic line has failed.

Whenever there is hydraulic line failure, it is critical to correctly identify which hydraulic line has failed. Identify the hydraulic line that has failed (Fig. 3–30) and use the following table to help determine which Step to follow to retract and lower the boom.

Boom Troubleshooting Steps to Follow for Hydraulic Line Failure and for EMERGENCY OPERATIONS

		Normal Steps	**EMERGENCY STEPS**
Failed Hydraulic Line	Step to follow if parts are available	Step to follow if parts are not available	**FOLLOW THIS STEP AS A LAST RESORT!**
Boom **Lift** Line (lift cylinder to bulkhead)	Step 1	Step 2	
Boom **Lift** Line (bulkhead to control valve)	Step 1	Step 2	
Boom **Lower** Line (lift cylinder to bulkhead)	Step 1		Step 3
Boom **Lower** Line (bulkhead to control valve)	Step 1		Step 3
Boom **Extend** Line	Step 1	Step 2	
Boom **Retract** Line	Step 1		Step 4

Hydraulic Line Failure

STEP 1

1. Clear the area of any unnecessary personnel.
2. Block all four wheels.

WARNING: DO NOT get under a raised boom unless the boom is blocked up. Always block the boom before doing any servicing that requires the boom to be up.

3. If the load can be removed safely, completely remove the load from the carriage and/or attachment. If the load cannot be removed, leave the load in place.
4. Temporarily block up or support the outer boom so it cannot be lowered.
5. Wear protective clothing and proper eye protection when working with or around hydraulic oil. Wait for hydraulic oil to cool before attempting to repair the failure. Hot hydraulic oil can cause severe burns and other serious injury.

6. Replace the failed hydraulic line with a new hydraulic line (Fig. 3–31).

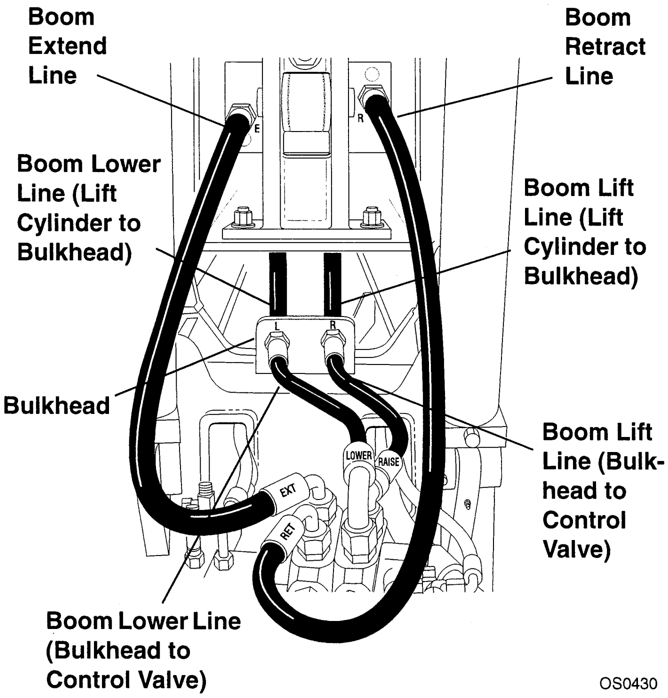


Figure 3–31. Replace the failed hydraulic line with a new hydraulic line.

7. Check the hydraulic oil level. Add hydraulic oil as required.
8. Remove the blocking or support from the outer boom.
9. From the operator's seat with the seat belt fastened, start the engine.
10. Tilt the carriage and/or attachment upward if necessary for clearance before retracting the boom.
11. Slowly retract the boom.
12. Slowly lower the boom and ground the carriage and/or attachment.
13. Shut off the engine.
14. If the load was not removed earlier, completely remove the load from the carriage and/or attachment.
15. From the operator's seat with the seat belt fastened, start the engine.
16. Operate all boom functions through their full range of motion several times. Cycle the hoist and extend cylinders to bleed air from the system. Visually check for leaks.
17. Check the hydraulic oil level again. Add hydraulic oil as required.

Hydraulic Line Failure

STEP 2

USE IN CASE OF:

- **Boom Raise Line Failure (lift cylinder to bulkhead)**
- **Boom Raise Line Failure (bulkhead to control valve)**
- **Boom Extend Line Failure**

1. Clear the area of any unnecessary personnel.
2. Block all four wheels.

> **WARNING:** Wear protective clothing and proper eye protection when working with or around hydraulic oil. Wait for hydraulic oil to cool before attempting to repair the failure. Hot hydraulic oil can cause severe burns and other serious injury

3. Place a suitable container under the failed hydraulic hose to catch hydraulic oil that may escape during this procedure.
4. From the operator's seat with the seat belt fastened, start the engine.
5. Slowly retract the boom.
6. Slowly lower the boom and ground the carriage and/or attachment.
7. Shut off the engine.
8. Completely remove the load from the carriage and/or attachment.
9. Place an Accident Prevention tag on both the ignition key and the steering wheel (Fig. 3–32) stating that the vehicle should not be operated. If a tag is not available, tape over the ignition switch.

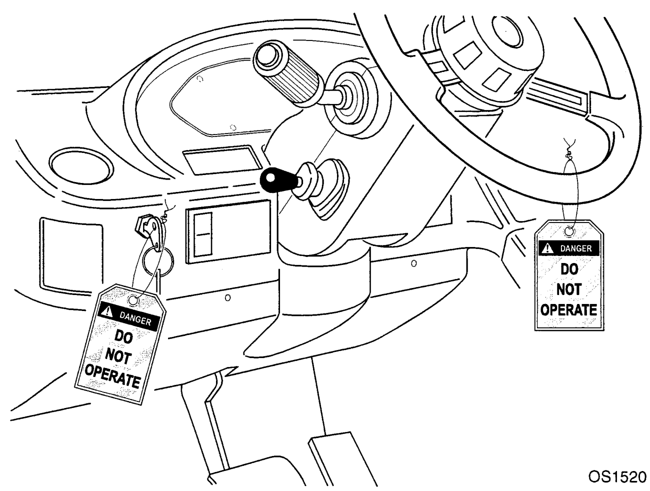


Figure 3–32. Place an Accident Prevention tag on both the ignition switch and the steering wheel.

10. Replace any failed hydraulic lines with new hydraulic lines (Fig. 3–31).
11. From the operator's seat with the seat belt fastened, start the engine.
12. Operate all boom functions through their full range of motion several times. Cycle the hoist and extend cylinders to bleed air from the system. Visually check for leaks.
13. Check the hydraulic oil level. Add hydraulic oil as required.
14. Transfer any wasted hydraulic oil to a covered container and label as used oil. Dispose of properly.

Hydraulic Line Failure

STEP 3

Use in case of boom lower line failure (EMERGENCY ONLY!)

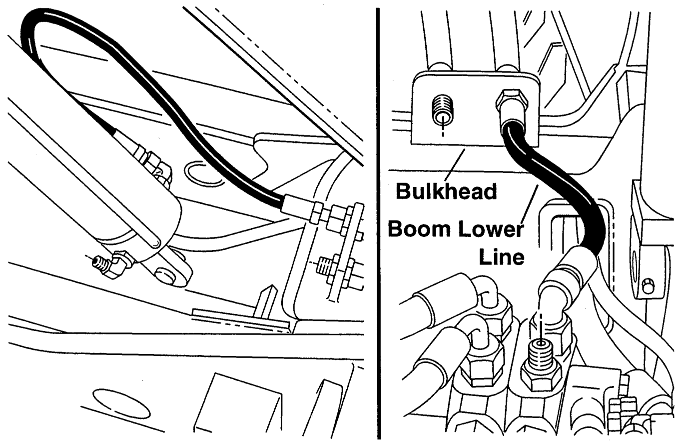
1. Clear the area of any unnecessary personnel.
2. Block all four wheels.

> **WARNING: DO NOT** get under a raised boom unless the boom is blocked up. Always block the boom before doing any servicing that requires the boom to be up.

3. Temporarily block up or support the outer boom so it cannot be lowered.
4. If the load can be removed safely, completely remove the load from the carriage and/or attachment. If the load cannot be removed, leave the load in place.

> **WARNING:** Wear protective clothing and proper eye protection when working with or around hydraulic oil. Wait for hydraulic oil to cool before attempting to repair the failure. Hot hydraulic oil can cause severe burns and other serious injury.

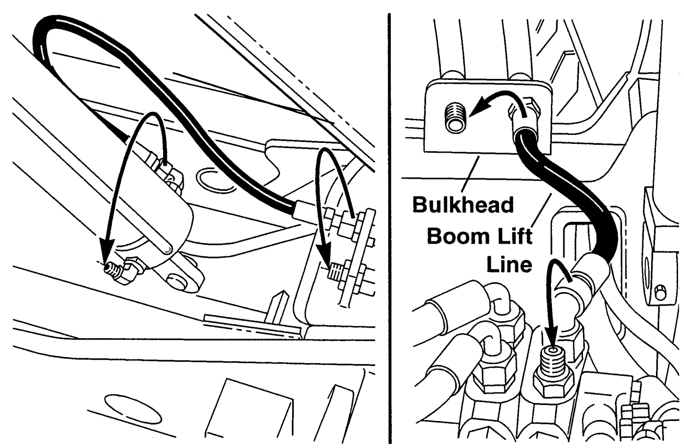
5. Place a suitable (ten-gallon capacity or larger) container under the failed hydraulic hose to catch hydraulic oil that may escape during this procedure.
6. Remove the failed boom lower line (Fig. 3–33).



OS2160

Figure 3–33. Replace the failed boom lower line.

7. Temporarily, remove the adjacent boom lift line on the opposite side of the bulkhead. In an emergency situation, this line can be used to lower the boom.
8. Attach the boom lift line where the failed boom lower line was previously connected (Fig. 3–34).



OS2170

Figure 3–34. Attach the boom lift line where the failed boom lower line was previously.

9. Service the vehicle and replace the hoses as soon as the boom is lowered and the vehicle is in a secure location.
10. Attach the failed hydraulic hose where the adjacent boom lift line was located. Direct the failed hose so the container will catch escaping oil.
11. Close the rear cover.

12. Check the hydraulic oil level. Add hydraulic oil as required.
13. Remove the blocking or support from the outer boom.
14. From the operator's seat with the seat belt fastened, start the engine.
15. Tilt the carriage and/or attachment upward, if necessary, for clearance before retracting the boom.
16. Slowly retract the boom.
17. Slowly lower the boom and ground the carriage and/or attachment.
18. Shut off the engine.
19. If the load was not removed earlier, completely remove the load from the carriage and/or attachment.
20. Service the vehicle immediately. Replace any failed hydraulic lines.
21. From the operator's seat with the seat belt fastened, start the engine.
22. Operate all boom functions through their full range of motion several times. Cycle the hoist and extend cylinders to bleed air from the system. Visually check for leaks.
23. Transfer any wasted hydraulic oil to a covered container and label as used oil. Dispose of properly.
24. Check the hydraulic oil level again. Add hydraulic oil as required.

Hydraulic Line Failure

STEP 4

Use in case of boom retract line failure (EMERGENCY ONLY!)

1. Clear the area of any unnecessary personnel.
2. Block all four wheels.

WARNING: DO NOT get under a raised boom unless the boom is blocked up. Always block the boom before doing any servicing that requires the boom to be up.

3. If the load can be removed safely, completely remove the load from the carriage and/or attachment. If the load cannot be removed, leave the load in place.

WARNING: Wear protective clothing and proper eye protection when working with or around hydraulic oil. Wait for hydraulic oil to cool before attempting to repair the failure. Hot hydraulic oil can cause severe burns and other serious injury.

4. Place a suitable (ten-gallon capacity or larger) container under the failed hydraulic hose to catch hydraulic oil that may escape during this procedure.
5. Remove the failed boom retract line (Fig. 3–35).

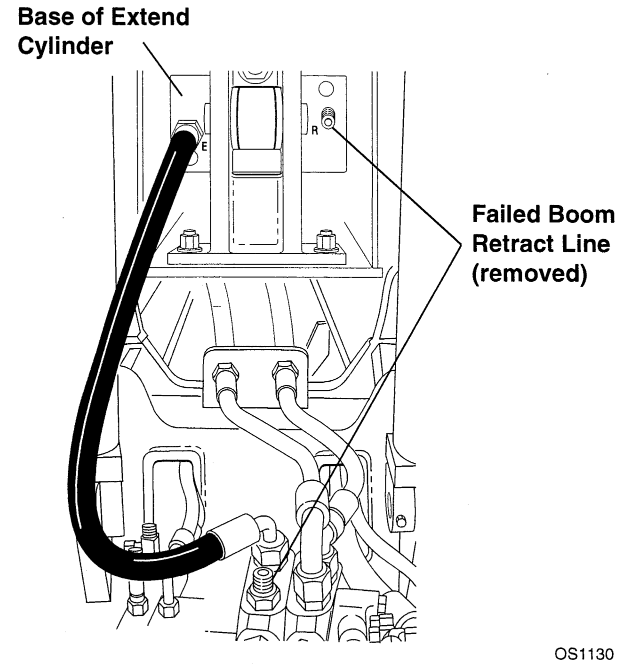


Figure 3–35. Remove the failed boom retract line.

6. Temporarily, remove the adjacent boom extend line on the opposite side of the bulkhead. In an emergency situation, this line can be used to retract the boom.
7. Attach the boom extend line where the failed boom retract line was previously connected (Fig. 3–36).

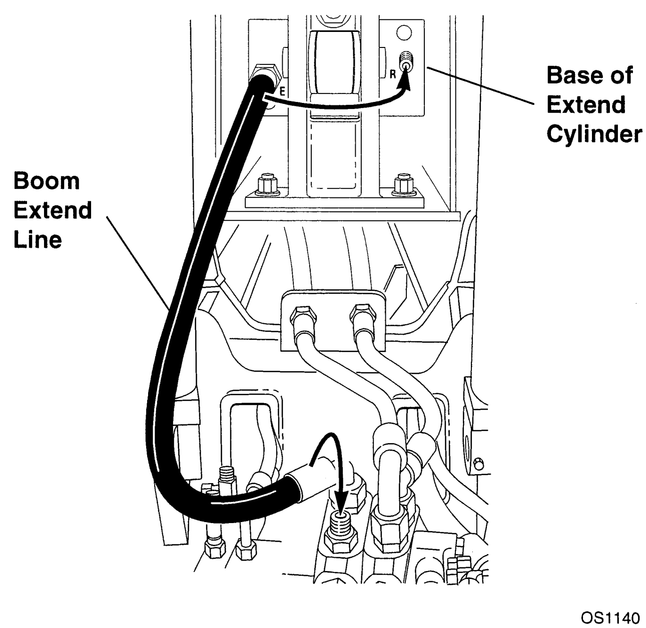


Figure 3–36. Attach the boom extend line where the failed boom retract line was previously connected.

8. Service the vehicle and replace the hoses as soon as the boom is retracted and the vehicle is in a secure location.
9. Attach the failed hydraulic hose where the adjacent boom extend line was located. Direct the failed hose so the container will catch escaping oil.
10. Close the rear cover.
11. Check the hydraulic oil level. Add hydraulic oil as required.
12. From the operator's seat with the seat belt fastened, start the engine.
13. Tilt the carriage and/or attachment upward, if necessary, for clearance before retracting the boom.
14. **Slowly** retract the boom.
15. **Slowly** lower the boom and ground the carriage and/or attachment.
16. Shut off the engine.
17. If the load was not removed earlier, completely remove the load from the carriage and/or attachment.
18. Service the vehicle immediately. Replace any failed hydraulic lines.
19. From the operator's seat with the seat belt fastened, start the engine.
20. Operate all boom functions through their full range of motion several times. Cycle the hoist and extend cylinders to bleed air from the system. Visually check for leaks.
21. Transfer any wasted hydraulic oil to a covered container and label as used oil. Dispose of properly.

Check the hydraulic oil level. Add hydraulic oil as required.

3.3 QUICK-ATTACH ASSEMBLY

This vehicle is equipped with a quick-attach system for easy attachment changes.

3.3.1 Disconnecting from an Attachment

1. Park the vehicle on hard, level ground.
2. Ground the attachment, place the travel select lever in NEUTRAL (N) and engage the parking brake switch.
3. Extend the boom approximately 10 ft (9 m) and tilt the carriage backward. Shut off the engine.

Note: If removing a standard carriage with forks, spread the forks apart on the carriage shaft. This will help give the carriage better support to stand alone.

4. Raise the quick-attach pin lock lever (Fig. 3–37) and pull out the lock pin at the bottom of the quick-attach.

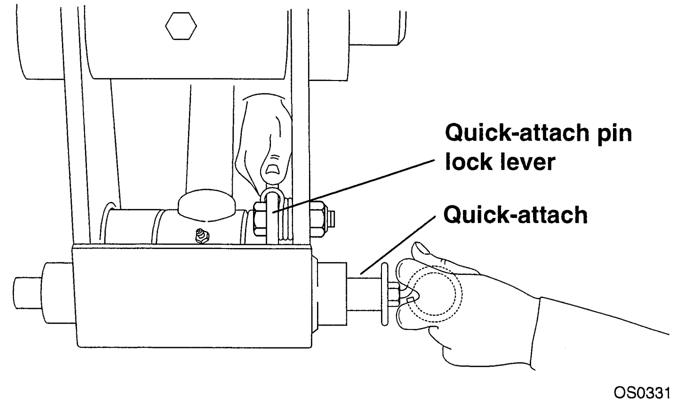


Figure 3–37. Raise the quick-attach pin lock lever and pull out the lock pin at the bottom of the quick-attach.

5. From the operator's seat with the seat belt fastened, lower the attachment to the ground in a level position. Tilt the attachment forward. This will rotate the quick-attach link back away from the attachment.
6. Lower, then retract the boom until the attachment pivot pins have disconnected from the attachment.

3.3.2 Connecting to an Attachment

1. Perform this procedure on level ground only. Position the vehicle directly behind the attachment.
2. Tilt the quick-attach backward.
3. Extend the boom approximately 10 feet (9 m) and drive the vehicle forward until the attachment pivot pins have seated fully in the hooks of the attachment.
4. Tilt the attachment up slightly. The quick-attach link should be tight up against the rear of the attachment and the holes in the link and the attachment should be aligned.
5. Place the travel select lever in NEUTRAL (N), engage the parking brake switch, unbuckle the seat belt and exit the vehicle using both hands.
6. Lift the quick-attach lever. Insert the quick-attach pin completely through the attachment and the quick-attach link. The quick-attach lock lever must lower and seat itself into the groove in the quick-attach pin. When the quick-attach lock lever lowers and seats itself into the groove in the quick-attach pin, it is ready for operation.

⚠	**WARNING: DO NOT** operate the vehicle unless you are in the operator's seat with the seat belt fastened around you. Serious injury or death could result if the seat belt is not securely fastened.

3.3.3 Quick-Attach Removal

1. Remove capscrews G and H, Fig. 3–38, and nuts K and L. Tap out pins I and J. Remove the quick-attach assembly from the attachment tilt cylinder and gooseneck; retain shim washers for reinstallation.
2. Carefully pry and unhook the spring (E) from the quick-attach lever/latch (C).
3. Remove nut (F) from capscrew (A). Remove capscrew (A) from tapped hole.
4. Remove washer (B), quick-attach lever/latch (C), spacer (D), and spring (E) previously secured by capscrew (A).

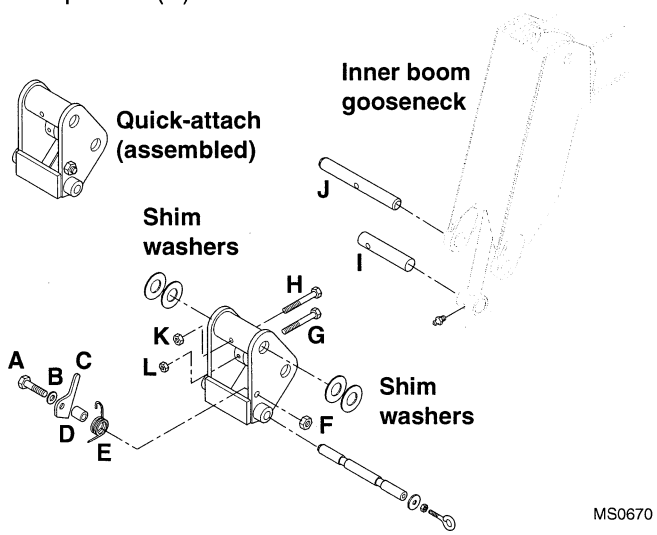


Figure 3–38. Quick-attach components.

3.3.4 Quick-Attach Installation

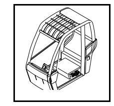
1. Assemble washer (B, Fig. 3–38), quick-attach lever/latch (C), spacer (D), and spring (E) to capscrew (A). Position straight end of spring as shown.
2. Thread capscrew (A) through tapped hole until latch is restrained, but free to travel in normal latching position. Lock capscrew with nut (F). Stretch and hook spring (E) over quick-attach lever (C).
3. Tap pins I and J through quick-attach assembly, shim washers (equally placed on both sides as required), attachment tilt cylinder and gooseneck. Secure pins with capscrews G and H and nuts K and L.

3.4 TROUBLESHOOTING

This section provides an easy reference guide covering the most common problems that occur during operation of the boom.

Boom Troubleshooting

Problem	Cause	Remedy
1. Fails to extend or to retract.	1. Broken hydraulic line and/or connection leaks.	1. Locate break and/or stop leaks.
	2. Faulty extend/retract cylinder.	2. Repair cylinder.
	3. Faulty components in extend/retract circuit.	3. Troubleshoot components; repair or replace.
	4. Broken chains or chain connections.	4. Repair or replace chains.
2. Fails to raise or lower.	1. Broken hydraulic line and/or connection leaks.	1. Locate break and/or stop leaks.
	2. Faulty hoist cylinder.	2. Repair cylinder.
	3. Faulty components in hydraulic raise/lower circuit.	3. Troubleshoot components; repair or replace.
3. Excessive boom pivot pin or cylinder pivot pin wear.	1. Improper grease intervals.	1. Replace worn pins and lubricate at regular intervals.
	2. Worn bearings.	2. Replace bearings and lubricate at regular intervals.
4. Rapid boom pad wear.	1. Improper wear pad shimming.	1. Check shim adjustment and shim properly.
	2. Excessive loads, rapid cycle times.	2. Reduce cycle times.
	3. Contaminated, corroded or rusted wear pad sliding surfaces (due to improper preparation for long term storage).	3. Prep boom properly for long-term storage.
5. Dropping chain, or jerky boom extend or retract functions.	1. Chain(s) out of adjustment.	1. Readjust chain(s).
	2. Chain(s) stretched.	2. Replace chain(s).
6. Attachment ("grille") tilt or auxiliary hydraulic circuit line failures.	1. Improper hose placement or hose misalignment.	1. Reset hoses properly.
	2. Cracked and/or broken hose.	2. Replace hose(s).
7. Excessive chain wear.	1. Chain out of adjustment.	1. Replace and readjust chains properly.
	2. Improper chain lubrication.	2. Replace chain(s) and lubricate at regular intervals.



Section 4
Cab, Covers and Mirrors

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Introduction

The welded metal cab features European styling and a modular design, allowing for a relatively quick, simple exchange of the entire cab and/or component parts. The cab is bolted to the cab mount, which in turn is bolted to the frame.

The operator's cab is a protective structure. The cab itself contains roll-over protective and falling object protective structures (ROPS/FOPS) for the operator.

WARNING: The protection offered by this ROPS/FOPS will be impaired if subjected to any modification or structural damage at which time replacement is necessary. ROPS/FOPS must be properly installed using fasteners of correct size and grade, torqued to their specified value.

DO NOT weld, grind, drill, repair or modify the cab in any way. Any modification or damage to cab structural components requires cab replacement. The lives of the operator and others are potentially at stake.

To help ensure optimum safety, protection and performance, replace the cab if it is damaged. Refer to the *SKY TRAK Model 3606 Parts Manual* for ordering information.

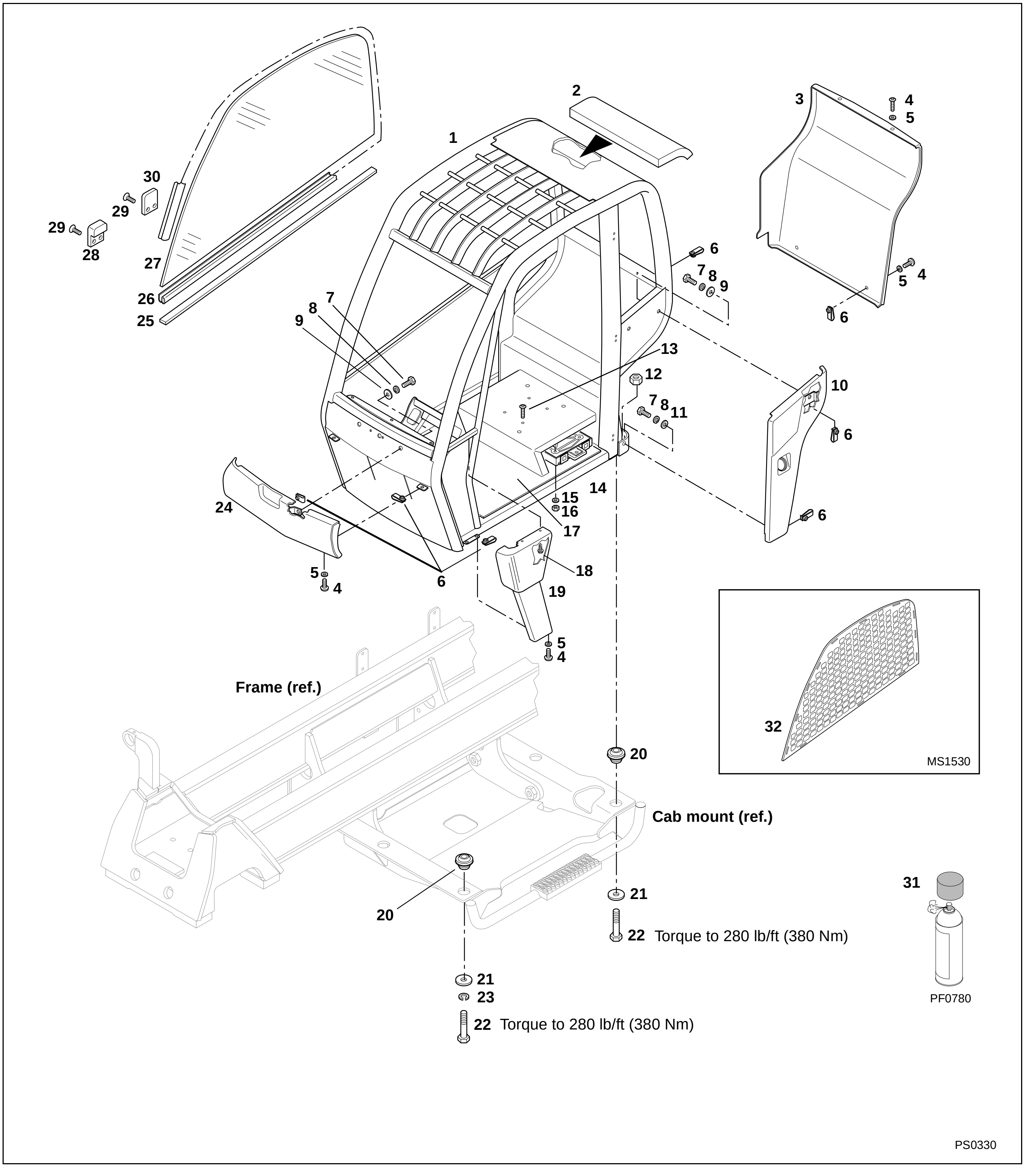
The cab contains the seat, operating controls, numerous panels, steering and brake components, and more.

Covers and mirrors on the vehicle exist for safety, protection and appearance. They are relatively simple to remove and replace.

Legend

1. Operator's Protective Structure ROPS/FOPS
2. Headliner
3. Cab rear panel
4. Button-head capscrew, 5/16-18 x 1
5. Flat plastic washer, 5/16"
6. Retaining nut, 5/16-18
7. Hex-head capscrew, 5/16-18 x 1
8. Lock washer, 5/16"
9. Rebound washer
10. Cab panel, rear LH
11. Flat washer, 5/16"
12. Hex-lock elastic nut, 3/4-10
13. Button-head capscrew, 1/4-20 x 3/4
14. Owners/Operators Manual holder
15. Flat washer, 1/4"
16. Hex-lock elastic nut, 1/4-20
17. Floor mat
18. Self-drilling screw, #12-14 x 1
19. Cab panel, front LH
20. Cab isolator
21. Rebound washer
22. Hex-head capscrew, 3/4-10 x 3-3/4", Grade 8
23. Lock washer, 3/4"
24. Cab panel, front
25. Window spacer
26. Window edge seal bulb
27. *Right side window
28. Window clip, w/offset
29. Screw
30. Window clip
31. Spray adhesive, 10 ounce spray can (for item 17)
32. *Steel mesh window (option), glued in

General Overview



4.1 SERIAL NUMBER DECAL

The cab serial number decal (Fig. 4–1) is located along the top right side of the cab, near the mirror. Information specified on the serial number plate includes the cab model number, the cab serial number and other data. Write this information down in a convenient location to use in cab correspondence.

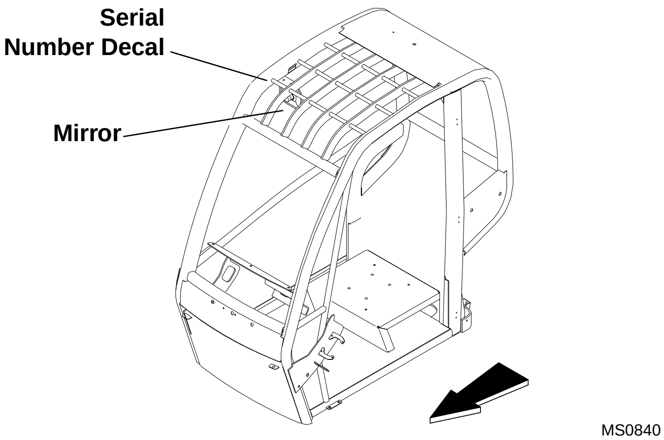


Figure 4–1. Location of the cab serial number decal.

4.2 CAB REPLACEMENT

> **WARNING:** Risk of death or severe personal injury. **NEVER** modify, weld or drill the cab.

> **WARNING:** The protection offered by this ROPS/FOPS will be impaired if subjected to any modification or structural damage at which time replacement is necessary. ROPS/FOPS must be properly installed using fasteners of correct size and grade torqued to their specified value.

IMPORTANT: To help ensure safety and optimum performance, replace the cab if it is damaged. Refer to the *SKY TRAK Model 3606 Parts Manual* for ordering information.

Before performing any inspection, maintenance or service operation, thoroughly clean the vehicle. **DO NOT** spray water or cleaning solution in, on, near or around the operator's dash panels and electrical components.

Inspect the cab, its welds and mounts. If modification, damage, a cracked weld and/or fatigued metal is discovered, replace the cab. Contact Sky Trak or the local Sky Trak distributor with any questions about the suitability or condition of a cab.

4.2.1 Cab Removal

> **WARNING:** Wear protective footwear with reinforced toe caps and slip-resistant soles. Failure to comply can result in foot injury from falling objects or other bodily injury from slipping or falling.

> **WARNING: NEVER** lift a heavy object without the help of at least one assistant or a suitable sling and hoist. Failure to comply can result in serious personal injury.

IMPORTANT: Remove and label cab panels and other components as needed *before* removing the cab from the vehicle. Label, disconnect and cap hydraulic hoses. Transfer cab parts to the replacement cab *after* the replacement cab is securely mounted on the vehicle.

1. Park the vehicle on a firm, level surface. Allow sufficient overhead and side clearance for cab removal. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut the engine OFF. Open the engine hood. Allow the engine and hydraulic fluid to cool.
2. Disconnect the battery negative (-) ground cable at the battery negative (-) terminal (Fig. 4–2).

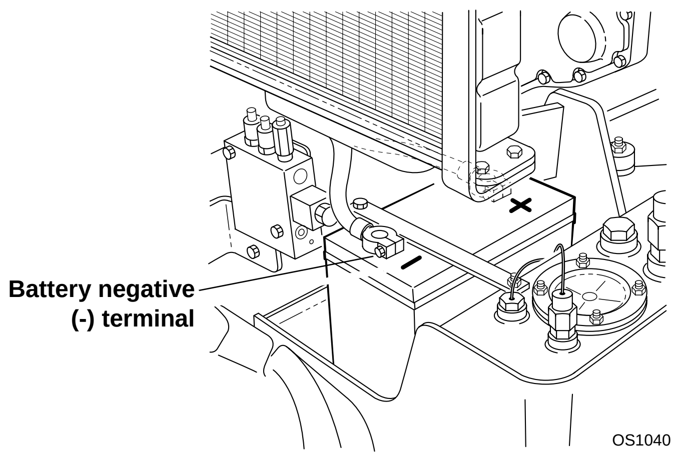


Figure 4–2. Disconnect the battery negative (-) cable.

3. Remove the joystick assembly (*see 4.2.6 Joystick Replacement*). Label, disconnect and cap the six hydraulic hoses mounted at the base of the joystick assembly.
4. Remove the logic board panel, mounted in the front dash, just forward of the joystick mounting location (see. Fig. 4–3). Disconnect the wiring connector.
5. Remove the front dash (1, Fig. 4–3), console support (12) and rear tool bin (19). Label and disconnect wiring leads as applicable.

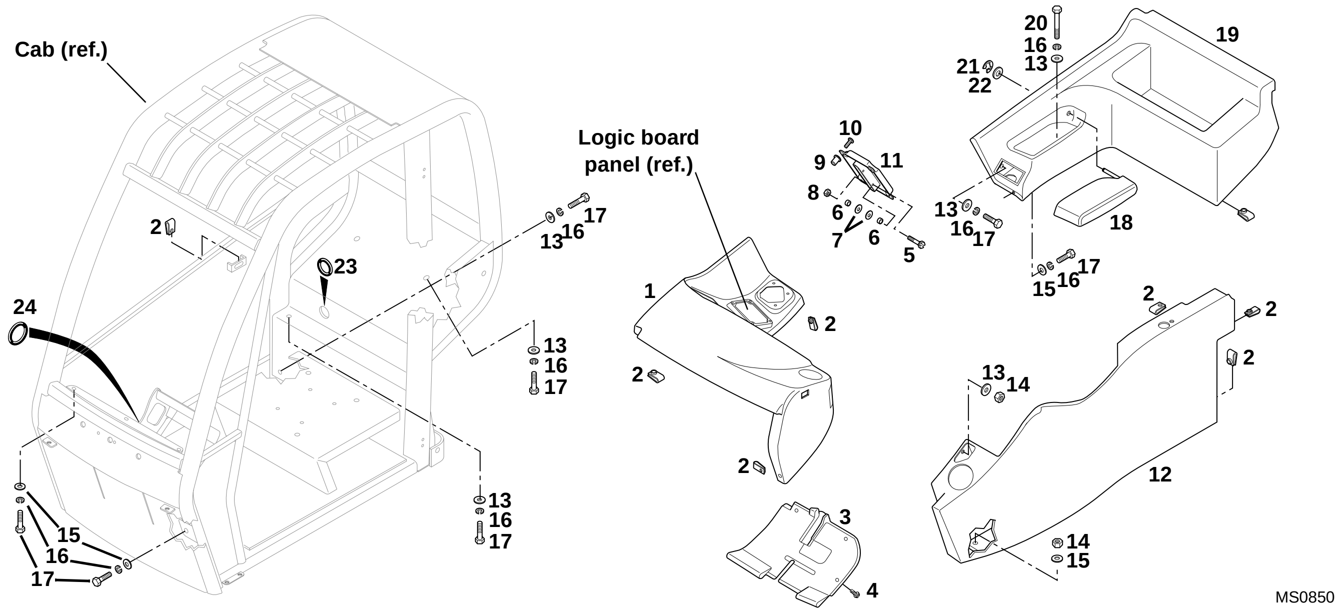


Figure 4–3. Operator's cab inner console and dash panel components.

1. Front dash
2. Retaining nut, 5/16-18
3. Lower dash cover
4. Self-drilling screw, #12-14 x 1"
5. Slotted hex-head capscrew, #10-24 x 1"
6. Spacer
7. Fender washer
8. Hex-lock elastic nut, #10-24
9. Well nut, #10-32
10. Button-head capscrew, #10-32 x 3/4"
11. Load chart holder
12. Console support
13. Rebound washer
14. Hex-lock elastic nut, 5/16-18
15. Flat washer, 5/16"
16. Lock washer, 5/16"
17. Hex-head capscrew, 5/16-18 x 1-1/4"
18. Armrest
19. Rear tool bin
20. Hex-head capscrew, 5/16-18 x 2"
21. Retaining ring
22. Flat washer, 1/2"
23. Conduit, 1/4" x 5" long
24. Conduit, 1/4" x 9" long

6. Route the joystick, power steering and service brake hydraulic hoses out of and away from the cab. Cut and dispose of plastic wire ties as needed. Wipe up any spilled hydraulic fluid.

> **WARNING:** Explosion and fire hazard. Cap or safely cover the fuel tank and beaded hose tee openings.

7. Remove the cab rear panel (item 3 in the *General Overview* illustration on page three). From behind the cab, loosen the lower clamp (Fig. 4–3) securing the fuel hose to the fuel tank. Remove the lower end of the fuel hose from the fuel tank. Cap or safely cover the fuel tank opening.
8. Loosen the clamp securing the fuel breather hose (Fig. 4–3) to the top of the beaded hose tee. Remove the lower end of the fuel breather hose from the hose tee. Cap or safely cover the hose tee opening.

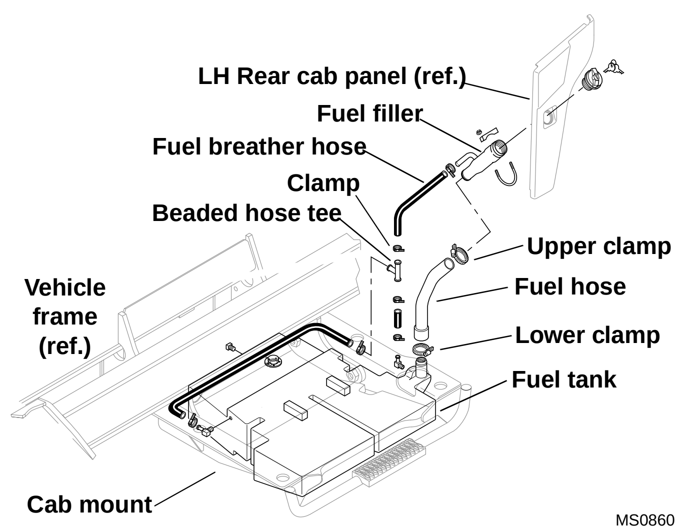


Figure 4–3. Loosen the clamps and remove the fuel tank hoses from their fittings. Cap or safely cover the openings.

9. Remove the front cab-to-cab-mount attaching hardware (refer to items in the *General Overview* illustration on page three). Front hardware includes 3/4-10 hex-lock elastic nuts (12), 3/4-10 x 3-1/2" Grade 8 hex-head capscrews (22), 3/4" lock washers (23) and rebound washers (21). Rear hardware includes 3/4-10 hex-lock elastic nuts (12), 3/4-10 x 3-1/2" Grade 8 hex-head capscrews (22), and rebound washers (21).

Note: ALWAYS replace elastic-lined nuts with new elastic-lined nuts to help ensure proper fastening.

10. Remove two 3/4-10 hex-lock elastic nuts (item 12 in the *General Overview* illustration on page three), two 3/4-10 x 3-3/4" Grade 8 hex-head capscrews (22) and two rebound washers (21). Tap the capscrews out of the cab isolators (20) from above, as required.
11. Disconnect the throttle cable at the engine bracket (Fig. 4–4). Route the cable out of the engine compartment, then close the engine hood. Allow the cable to hang beneath the cab mount for now.

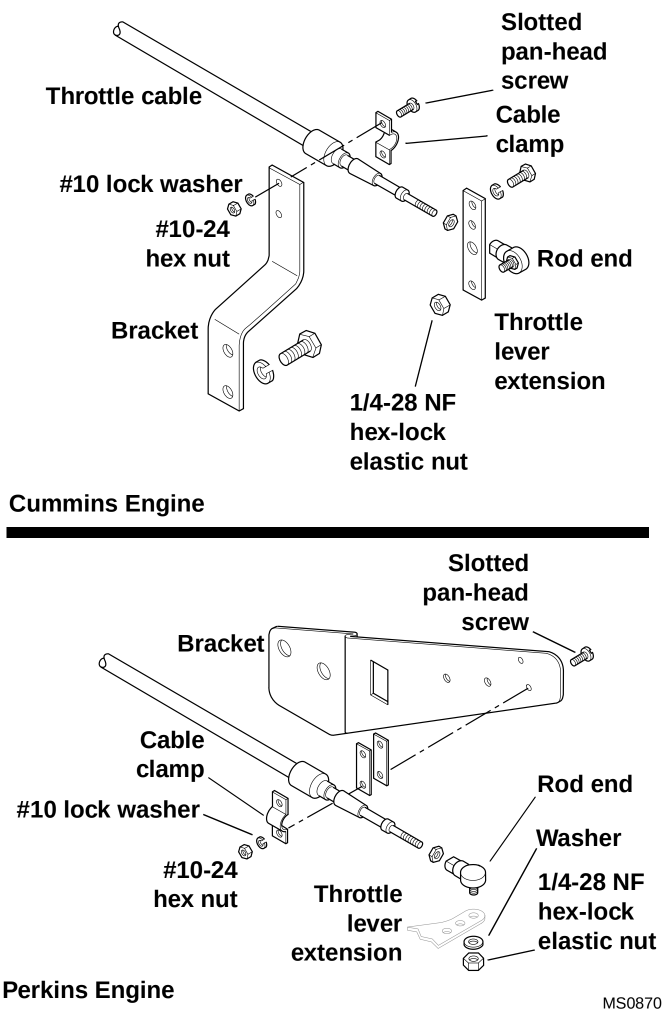
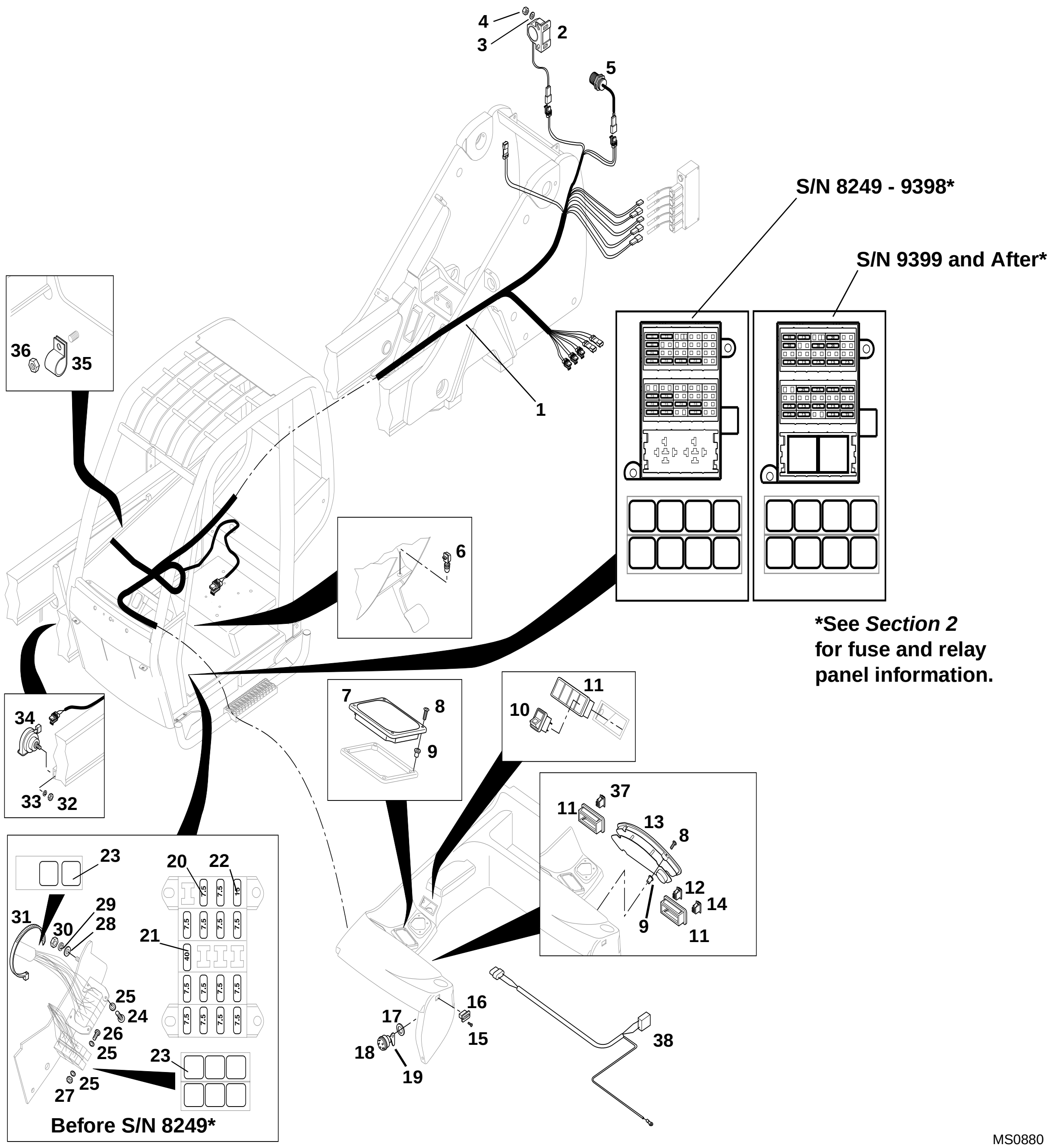


Figure 4–4. Throttle cable to engine bracket mounting.

12. Route the wiring harness out of the cab. Cut and dispose of plastic wire ties as needed. Secure the wiring harness against the frame, safely away from the cab.
13. Remove the mirrors and all other cab components, as needed, if not previously removed.
14. Use a hoist or overhead crane and sling attached to the cab. Carefully <u>*begin*</u> to lift the cab. Stop and check that all wiring, fuel tank components, hydraulic hoses and fasteners are disconnected or removed. If the throttle cable is still attached to the cab, reposition or remove the throttle cable as necessary.
15. When all wiring, hydraulic hoses and fasteners are disconnected or removed, carefully and slowly lift the cab and remove it from the cab mount. Readjust the position of the sling as needed to help balance the cab during removal.
16. When the cab is completely clear of the vehicle, carefully lower it to the ground. Block up or support the cab so that it does not move or fall. Assure that no personnel enter the cab while it is dismounted from the vehicle.
17. Inspect the condition of the fuel tank, fuel hoses, fittings, clamps, hydraulic hoses, cab isolators, etc. Replace parts as indicated by their condition.
18. Inspect and replace other vehicle parts that are exposed with the cab removed. Repair or replace as required.



1. Cab harness
2. Back-up alarm
3. Hex-lock elastic nut, 1/4-20
4. Flat washer, 1/4"
5. Boom sensor
6. Service brake switch
7. Side console (logic board) panel
8. Button-head capscrew, #10-32 x 3/4"
9. Well nut, #10-32
10. Steer select switch
11. Switch bezel
12. Auxiliary detent switch (optional)
13. Front console dash
14. Park brake switch
15. Round-head wood screw, #6 x 1/2"
16. Hourmeter
17. Machine bushing washer, 0.63" ID
18. Ignition switch (includes item 19)
19. Ignition key (set of two)
20. Fuse, 7.5 amp
21. Fuse, 40 amp
22. Fuse, 15 amp (Perkins cold start only)
23. Sealed relay, 12V, 40A
24. Slotted pan-head screw, #10-24 x 3/4"
25. Narrow flat washer, #10
26. Slotted pan-head screw, #10-24 x 5/8"
27. Hex-lock elastic nut, #10-24
28. Flat washer, 1/4"
29. Lock washer, 1/4"
30. Hex nut, 1/4-20
31. Plastic tie
32. Hex jam nut, M6-1 CI4
33. Lock washer, M6
34. Signal horn
35. Tube clip
36. Hex lock nut, 1/2-13
37. Attachment tilt mode switch
38. Attachment tilt direction harness

Figure 4–6. Label and disconnect wiring harnesses and wire leads at their connectors.

4.2.2 Cab Installation

WARNING: Explosion and fire hazard. Cap or safely cover the fuel tank and beaded hose tee openings.

WARNING: Wear protective footwear with reinforced toe caps and slip-resistant soles. Failure to comply can result in foot injury from falling objects or other bodily injury from slipping or falling.

WARNING: NEVER lift a heavy object without the help of at least one assistant or a suitable sling and hoist. Failure to comply can result in serious personal injury.

IMPORTANT: Transfer and install cab panels and other components as needed *after* the cab is securely mounted on the vehicle.

1. Cap or safely cover any fuel-tank or fuel-fitting openings. Inspect vehicle parts that are exposed with the cab removed. Repair or replace as required.
2. **Block all four wheels** to help prevent the vehicle from moving. Assure that there is sufficient overhead and side clearance for cab installation.
3. Disconnect the cable at the battery negative (-) terminal (Fig. 4–2) as required.
4. Install cab isolators (item 20 in the *General Overview* illustration on page three) into the mounting holes on the cab mount.
5. Use a hoist or overhead crane and sling attached to the cab (1). Carefully begin to lower the cab onto the cab mount. Stop and check that wiring, fuel tank components, hydraulic hoses, etc., will not be pinched or damaged as the cab is lowered.
6. Route the throttle cable (Fig. 4–4) from beneath the cab to the engine compartment by simply positioning the cable under the frame, then up between the transmission and engine. Bring the cable across the side of engine to the throttle cable bracket. **DO NOT** attach the cable to the throttle lever extension on the engine at this time.
7. Carefully and slowly lower the cab (item 1 in the *General Overview* illustration) onto the cab mount. Align the cab with the cab isolators (20) as the cab is lowered. Readjust the position of the sling as needed to help balance the cab during installation.
8. Install the cab-to-cab-mount attaching hardware (items 12, 21, 22 and 23). At the rear of the cab, install but **DO NOT** tighten the two 3/4-10 hex-lock elastic nuts (12), two rebound washers (21) and two 3/4-10 x 3-3/4" Grade 8 hex-head capscrews (22) that secure the cab (1) to the cab mount (ref.). Tap the capscrews into the cab isolators (20) from below, as required, but **DO NOT** distort or damage the cab isolators.

Note: ALWAYS replace elastic-lined nuts with new elastic-lined nuts to help ensure proper fastening.

9. At the front of the cab (1), install but **DO NOT** tighten the two 3/4-10 hex-lock elastic nuts, two 3/4" lock washers (23), two rebound washers (21) and two 3/4-10 x 3-1/2" Grade 8 hex-head capscrews (22). Tap the capscrews into the cab isolators (20) from below, as required, but **DO NOT** distort or damage the cab isolators.

Note: ALWAYS replace elastic-lined nuts with new elastic-lined nuts to help ensure proper fastening.

10. From behind the cab, position the lower clamp (Fig. 4–3) on the fuel hose. Remove any cap or safety cover from the fuel tank opening. If needed, secure the fuel filler to the cab and the top end of the fuel hose to the fuel filler.
11. Slip the lower end of the fuel hose onto the fuel hose neck on the fuel tank and tighten the lower clamp.
12. Position a clamp on the fuel breather hose (Fig. 4–3). Remove any cap or safety cover from the beaded hose tee. If needed, secure the top end of the fuel breather hose to the fuel filler with another clamp.
13. Secure the bottom end of the fuel breather hose to the beaded hose tee.
14. From beneath the cab, route and connect the cab wiring harness (Fig. 4–6). Install plastic conduit as required to protect the wiring as it passes through metal openings. Secure wiring with plastic wire ties as needed.
15. Route the joystick, power steering and service brake hydraulic hoses from the frame into the cab. Using the hose labels made and attached earlier, connect the hoses at the joystick, power steering valve and brake control valve. Wipe up any spilled hydraulic fluid.
16. Check that the cab is not distorting, pinching, crushing or damaging the throttle cable, wiring or hydraulic hoses. Make adjustments as necessary.
17. Tighten the cab-to-cab-mount hardware (refer to the *General Overview* illustration). Torque the 3/4-10 hex-lock elastic nuts (12) and 3/4-10 x 3-1/2" Grade 8 hex-head capscrews (22) to 280 lb/ft (380 Nm).
18. After the cab is securely mounted to the vehicle, install all parts in the cab as required.
19. Connect the throttle cable at the engine (Fig. 4–4) and, if necessary, to the throttle pedal.

20. Connect the battery negative (-) ground cable (Fig. 4–2).
21. Carefully examine all cab components, fasteners, etc., one last time before engine start-up. Rectify any faulty conditions.

WARNING: DO NOT use your hand or any part of your body to check for hydraulic leaks. Hydraulic oil leaking under pressure can penetrate the skin and cause severe personal injury. When checking for hydraulic leaks, wear safety glasses and gloves to help provide protection from spraying hydraulic oil. Use a piece of cardboard or paper to search for leaks.

22. Start the engine and check the operation of all controls. Check for hydraulic fluid leaks. Check the hydraulic fluid level in the tank and add fluid as required.

4.2.3 Operator's Seat and Seat Belt

Three types of operator's seats are used. These include the standard operator's seat (Fig. 4–7), and two optional seats that include a headrest and are covered in either deluxe vinyl or deluxe cloth material and include headrests. The seat belt is attached to the seat assembly.

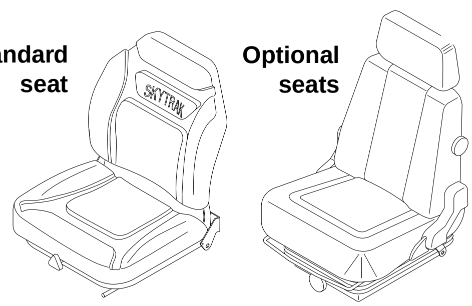


Figure 4–7. Seat styles include standard and optional.

The seat assembly consists of upper (backrest) and lower (bottom) cushions mounted on an adjustable suspension unit (Fig. 4–8). Three seat adjustments can be made: fore and aft position, suspension stiffness and backrest angle. Seat adjustment information is contained in the owners/operators manual.

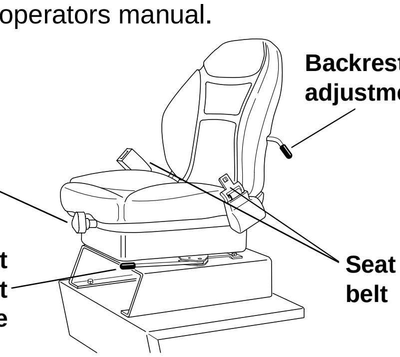


Figure 4–8. Seat positions and stiffness can be adjusted.

An optional three-inch wide seat belt is available for those locations that require a three-inch seat belt.

A. Seat Replacement

The seat can be removed from the cab by removing the fasteners, including two tether cables, which secure the seat to the cab. The seat belt is also easily removed by removing the nuts, spacers, washers and capscrews securing it to the seat frame. The seat tethers are secured to the seat with the seat belt capscrews.

The seat and seat slides may be removed from the suspension unit and mounting plate by removing four lock nuts and flat washers that attach the seat slides to the suspension unit.

Standard Seat Removal

Working from the outside rear of the cab, remove the rear cab panel (item 3 in the *General Overview* illustration) to gain access to the seat tether mounting hardware. The rear cab panel is secured to the cab with 5/16-18 button-head capscrews (4), 5/16" flat plastic washers (5) and 5/16-18 retaining nuts (6).

Note: Early production operator's cabs included a threaded hole for tether mounting. In Fig. 4–9, items 13 through 16 are *not* used on early production cabs.

1. Remove the 3/8-16 hex-lock elastic nuts (16, Fig. 4–9) and rebound washers (15) securing the tethers (2) to the rear of the cab.

Note: ALWAYS replace elastic-lined nuts with new elastic-lined nuts to help ensure proper fastening.

2. Access to the right-side tether is restricted due to the close proximity of the seat to the cab wall. Move the seat all the way forward, and tip the seat back all the way forward to gain access as needed to the tether mounting hardware from inside the cab. If necessary, remove the seat base mounting hardware before removing the right-side tether.

Note: Early production operator's cabs included a threaded hole for tether mounting. In Fig. 4–9, items 13 through 16 are *not* used on early production cabs.

3. Remove four 5/16-18 hex-lock elastic nuts (12, Fig. 4–9) and four 5/16 flat narrow washers securing the seat (1) to the seat support (9).

Note: ALWAYS replace elastic-lined nuts with new elastic-lined nuts to help ensure proper fastening.

4. Carefully remove the seat (Fig. 4–9) from the cab. Remove the seat belt assembly and tethers (or transfer these parts to the replacement seat) with the seat out of the cab.

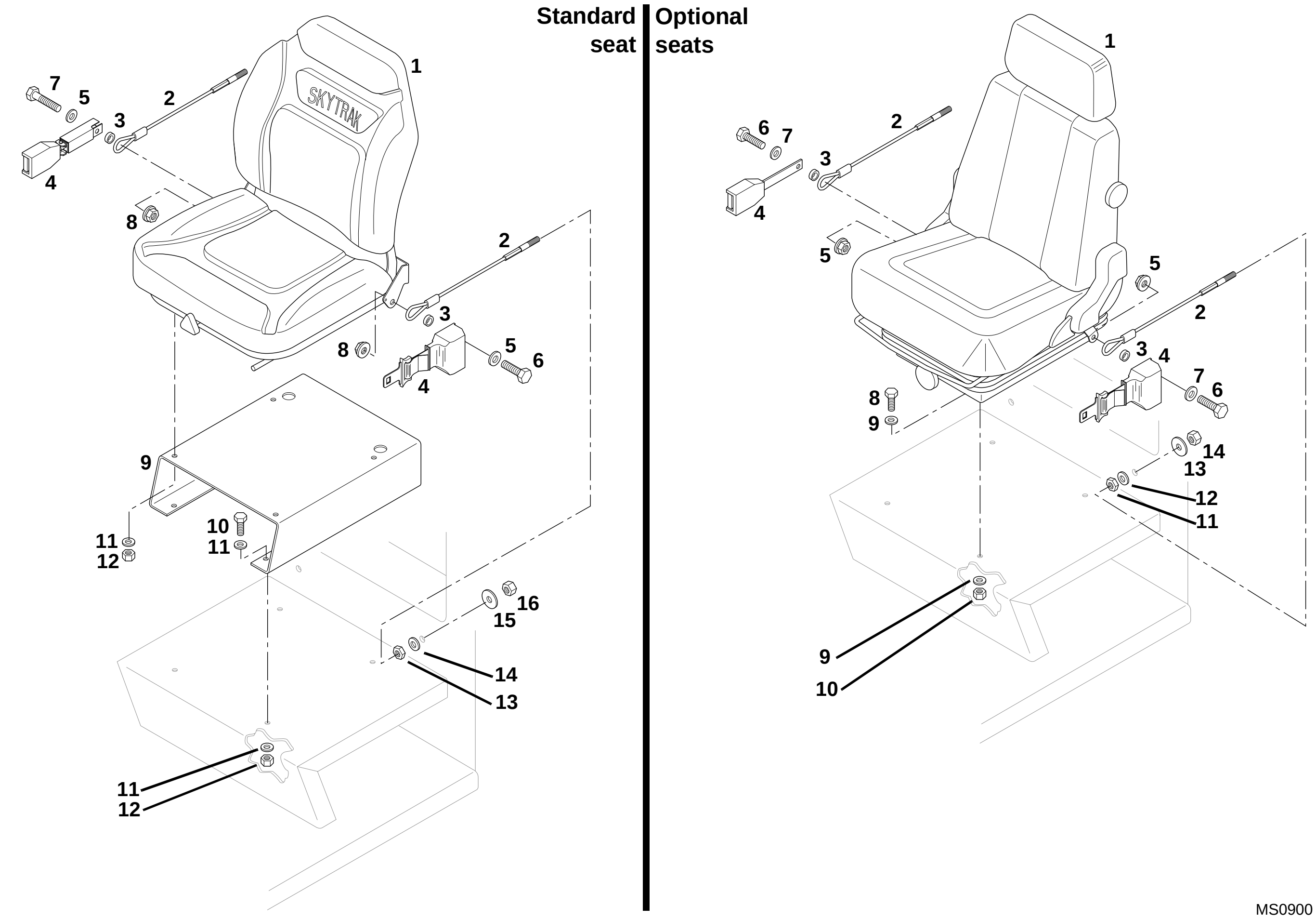


Figure 4–9. Standard (left) and optional (right) seats.

Standard Operator’s Seat Parts Legend

1. Seat
2. Tether
3. Spacer
4. Retractable seat belt assembly (includes items 5 through 8)
5. Washer
6. Hex-head capscrew
7. Hex-head capscrew
8. Hex nut
9. Seat support
10. Hex-head capscrew, 5/16-18 x 1", Grade 5
11. Narrow flat washer, 5/16"
12. Hex-lock elastic nut, 5/16-18
13. Hex jam nut, 3/8-16
14. Flat washer, 3/8"
15. Rebound washer
16. Hex-lock elastic nut, 3/8-16

Optional Operator’s Seat Parts Legend

1. Deluxe seat (covered with CLOTH or VINYL), with suspension
2. Tether
3. Spacer
4. Retractable seat belt assembly (includes items 5 through 8)
5. Hex nut
6. Hex-head capscrew
7. Flat washer
8. Hex-head capscrew, 5/16-18 x 1", Grade 5
9. Narrow flat washer, 5/16"
10. Hex-lock elastic nut, 5/16-18
11. Hex jam nut, 3/8-16
12. Flat washer, 3/8"
13. Rebound washer
14. Hex-lock elastic nut, 3/8-16

Standard Seat Installation

1. Install the seat belt assembly (4, Fig. 4–9) and tethers (2) on the seat with the seat out of the cab.
2. Within the cab, access to the right-side tether (Fig. 4–10) is restricted due to the closeness of the seat to the cab wall. Move the seat all the way forward, and tip the seat back all the way forward to gain access as needed to the tether mounting hardware from inside the cab. If necessary, install the right-side tether before securing the seat base mounting hardware.

Note: Early production cabs included a threaded hole for tether mounting. In Fig. 4–9, items 13 through 16 are *not* used on early production cabs.

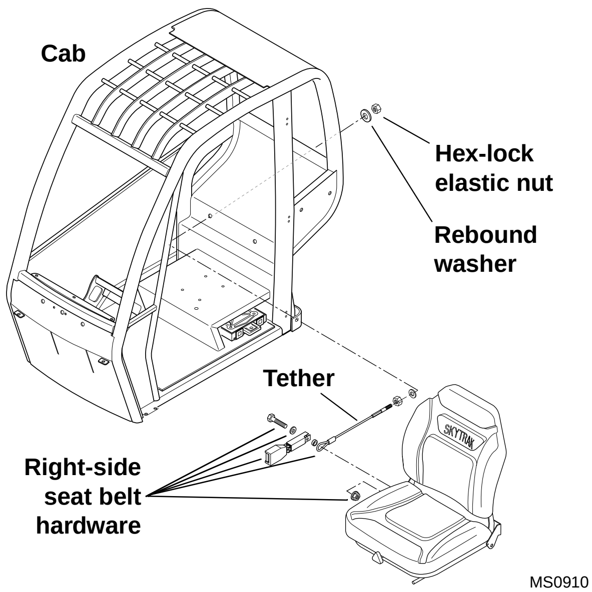


Figure 4–10. Typical late-model seatbelt tether attachment.

3. Position the seat on the seat support (9, Fig. 4–9). Align the seat bracket mounting holes with the holes in the seat support. Secure the seat to the seat support with four 5/16-18 hex-lock elastic nuts (12) and four 5/16 flat narrow washers securing the seat (1) to the seat support (9). Torque to 18 lb/ft (24 Nm).

Note: ALWAYS replace elastic-lined nuts with new elastic-lined nuts to help ensure proper fastening.

4. Working at the outside rear of the cab with the rear cab panel removed (refer to the *General Overview* illustration on page three), secure the tethers (2, Fig. 4–9) to the cab with 3/8-16 hex-lock elastic nuts (16) and rebound washers (15).

Note: Early production cabs included a threaded hole for tether mounting. In Fig. 4–9, items 13 through 16 are *not* used on early production cabs.

Note: ALWAYS replace elastic-lined nuts with new elastic-lined nuts to help ensure proper fastening.

5. Attach the rear cab panel (refer to the *General Overview* illustration) to the cab with 5/16-18 button-head capscrews, 5/16 plastic washers and 5/16-18 retaining nuts.

Optional Seat Removal

1. Working from the outside rear of the cab, remove the rear cab panel (refer to the *General Overview* illustration on page three) to gain access to the seat tether mounting hardware. The rear cab panel is secured to the cab with 5/16-18 button-head capscrews, 5/16 plastic washers and 5/16-18 retaining nuts.

Note: Early production cabs included a threaded hole for tether mounting. In Fig. 4–9, items 11 through 14 are *not* used on early production cabs.

2. Remove the 3/8-16 hex-lock elastic nuts (optional seat item 14, Fig. 4–9) and rebound washers (13) securing the tethers (2) to the rear of the cab.

Note: ALWAYS replace elastic-lined nuts with new elastic-lined nuts to help ensure proper fastening.

3. Access to the right-side tether (Fig. 4–10) is restricted due to the close proximity of the seat to the cab wall. Move the seat all the way forward, and tip the seat back all the way forward to gain access as needed to the tether mounting hardware from inside the cab. If necessary, remove seat base mounting hardware before removing the right-side tether.
4. Remove four 5/16-18 hex-lock elastic nuts (10, Fig. 4–9), eight 5/16 flat narrow washers (9), and four 5/16-18 x 1" Grade 5 hex-head capscrews (8) securing the seat (1) to the cab seat platform.

Note: ALWAYS replace elastic-lined nuts with new elastic-lined nuts to help ensure proper fastening.

5. Remove the seat from the cab. Remove the seat belt assembly and tethers (or transfer these parts to the replacement seat) with the seat out of the cab.

Optional Seat Installation

1. Install the seat belt assembly (4, Fig. 4–9) and tethers (2) on the replacement seat with the seat out of the cab.
2. Access to the right-side tether (Fig. 4–10) is restricted due to the closeness of the seat to the cab wall. Move the seat assembly all the way forward, and tip the seat backrest all the way forward to gain access as needed to the tether mounting hardware from inside the cab. If necessary, install the right-side tether before securing the seat base mounting hardware.

Note: Early production cabs included a threaded hole for tether mounting. In Fig. 4–9, items 11 through 14 are *not* used on early production cabs.

3. Position the seat on the seat base. Align the seat bracket mounting holes with the holes in the cab seat platform. Secure the seat to the seat base with four 5/16-18 hex-lock elastic nuts (10, Fig. 4–9), eight 5/16 flat narrow washers (9), and four 5/16-18 x 1" Grade 5 hex-head capscrews (8) securing the seat (1) to the seat support. Torque to 18 lb/ft (24 Nm).

Note: ALWAYS replace elastic-lined nuts with new elastic-lined nuts to help ensure proper fastening.

4. Working from the outside rear of the cab with the rear cab panel removed (refer to the *General Overview* illustration on page three), secure the tethers (2, Fig. 4–9) to the rear of the cab with rebound washers (13) and 3/8-16 hex-lock elastic nuts (14).

Note: ALWAYS replace elastic-lined nuts with new elastic-lined nuts to help ensure proper fastening.

5. Attach the rear cab panel (refer to the *General Overview* illustration on page 4-3) to the cab with 5/16-18 button-head capscrews, 5/16 plastic washers and 5/16-18 retaining nuts.

4.2.4 Controls

Operator's cab controls (Fig. 4–11) include the steering wheel, horn button, ignition switch, transmission shifter, service brake pedal, throttle pedal and joystick.

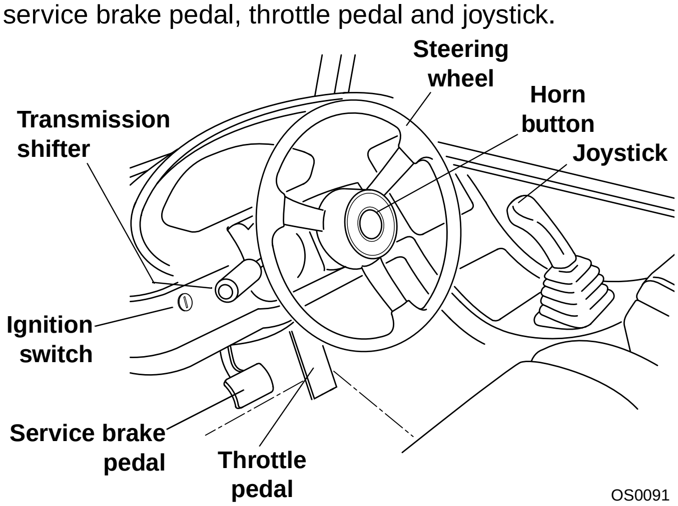


Figure 4–11. Operator's cab controls.

4.2.5 Steering Wheel, Column and Shifter

The steering wheel and transmission shift control switch are components of the steering column (Fig. 4–11).

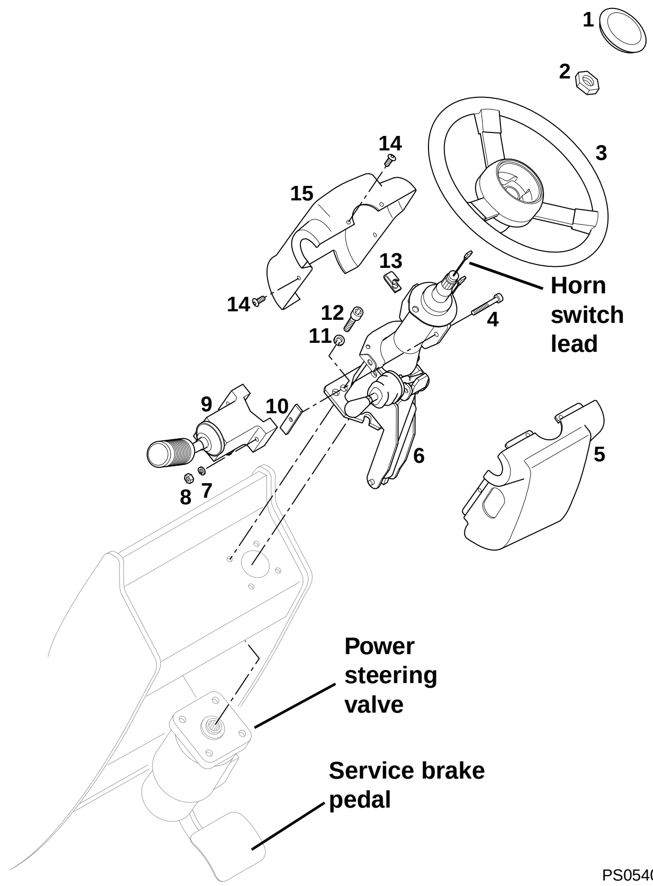


Figure 4–12. Steering column, steering wheel and shifter.

Steering Column Parts Legend

1. Horn button cover
2. Thin nut, M18-1,5
3. Steering wheel
4. Hex socket-head screw, #10-32 x 1-1/2"
5. Steering column bottom cover
6. Steering column
7. Lock washer, #10
8. Hex nut, #10-32
9. Transmission shift control switch
10. Transmission shifter spacer
11. Lock washer, 3/8"
12. Hex socket-head screw, 3/8-16 x 1"
13. J-nut, #10-24
14. Button-head screw, #10-24 x 5/8"
15. Steering column top cover

Steering Wheel Removal

1. Carefully pry the horn cover button out of its recess in the steering wheel. Disconnect the horn wire lead.
2. Remove the thin M18-1,5 nut securing the steering wheel to the splined steering column shaft.
3. Use a steering wheel puller to remove the steering wheel from the splined shaft.

Steering Wheel Installation

1. Install the steering wheel (Fig. 4–12) onto the splined steering column shaft.
2. Secure the steering wheel with a thin M18-1,5 nut. Torque the nut to 50 lb/ft (68 Nm).
3. Connect the horn wire lead, then press the horn cover button into its recess in the steering wheel.

Transmission Shift Control Switch Removal

1. Remove four #10-24 x 5/8" button head screws (item 14, Fig. 4–11) and four #10-24 J-nuts (13) securing the steering column bottom (5) and top (15) covers onto the steering column (6).
2. Remove the two #10-32 x 1-1/2" hex socket-head screws (item 4, Fig. 4–12), #10-32 hex nuts (8) and #10 lock washers (7) securing the transmission shift control switch (9) to the steering column (6).
3. Disconnect the electrical connector and remove the transmission shift control switch (9).

Transmission Shift Control Switch Installation

1. Position the transmission shift control switch (item 9, Fig. 4–12) onto the steering column (6).
2. Plug the electrical connector in to its harness lead.
3. Attach the transmission shift control switch with two #10-32 x 1-1/2" hex socket-head screws (4), #10-32 hex nuts (8) and #10 lock washers (7). Tighten the screws and nuts securely but **DO NOT** overtighten. Overtightening will cause the shift control switch to break.
4. Install the steering column bottom (5) and top (15) covers onto the steering column. Secure with four #10-24 x 5/8" button-head screws (14) and #10-24 J-nuts (13). **DO NOT** overtighten.

Steering Column Removal

1. Remove four #10-24 x 5/8" button-head screws (14) and #10-24 J-nuts (13) securing the steering column bottom (5) and top (15) covers onto the steering column.
2. Disconnect the transmission shift switch (9) and horn switch leads from the wiring harness.
3. Remove the four 3/8-16 x 1" hex socket-head screws (12) and 3/8 lock washers (11) securing the steering column (6) to the steering valve.
4. Remove the steering column from the cab.

Steering Column Installation

1. Position the steering column (item 6, Fig. 4–12) within the cab and engage the splined lower end of the steering shaft with the power steering valve. Press the steering column shaft down into the power steering valve. Fully engage the splines.
2. Align the four steering column mounting holes with the dash panel and power steering valve mounting holes. Secure the steering column with four 3/8-16 x 1" hex socket-head screws (12) and 3/8 lock washers (11). Torque to 31 lb/ft (42 Nm).
3. Connect the transmission shift switch (9) and horn switch leads to the wiring harness.
4. Install the steering column bottom (5) and top (15) covers onto the steering column. Secure with four #10-24 x 5/8" button-head screws (14) and #10-24 J-nuts (13).

4.2.6 Joystick Replacement

A. Joystick Handle Replacement

Joystick Handle Removal

1. Remove the rubber boot (Fig. 4–13) from the joystick. Slide the boot up and over the joystick to reveal wiring, a threaded shaft and mounting nut (jam nut).
2. Disconnect the wiring and loosen the upper jam nut securing the joystick to its base. Remove the joystick.

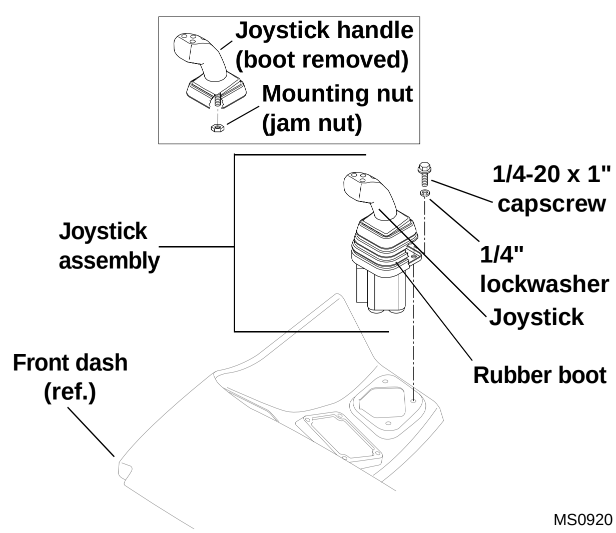


Figure 4–13. Joystick mounting arrangement.

Joystick Handle Installation

1. Apply Loctite® #272 (red) to the threaded stud on the joystick handle. Position the joystick mounting stud into the base mounting hole and turn the handle to thread it into the base. Align the joystick in the forward position.
2. Secure the joystick by tightening the mounting nut (jam nut) at the threaded end of the joystick onto the threaded shaft in the joystick assembly base.
3. Connect the joystick wire lead to the logic board plug and install the rubber boot over the joystick.
4. Check for proper operation of all joystick functions.

B. Joystick Assembly Replacement

Joystick Assembly Removal

1. Park the vehicle on a firm, level surface. Set the park brake, ground the carriage, place the transmission in NEUTRAL (N) and turn the ignition OFF.
2. Remove the boot from the joystick by pulling the boot off the base (Fig. 4–14).

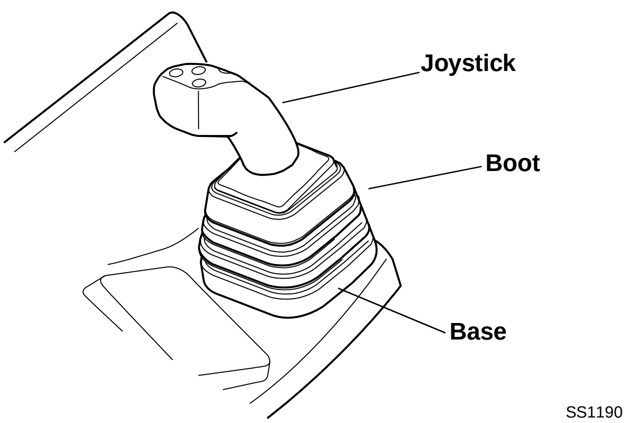


Figure 4–14. Remove the boot from the joystick.

3. Remove the four button-head capscrews holding the logic panel to the side console (Fig. 4–15). Carefully pry the logic console upward. Label, then disconnect the wiring harness leads at the logic panel. Remove the logic panel from the vehicle.

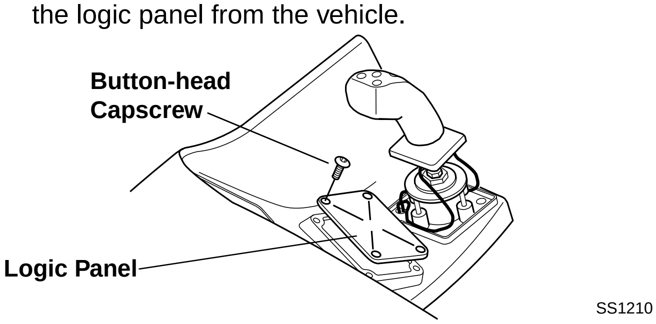


Figure 4–15. Remove the four button-head capscrews.

IMPORTANT: Before proceeding, determine which type of joystick mounting fasteners are used. Reach into the logic panel opening and back toward the joystick. From inside the console, feel along the front lower edge of the joystick base to determine whether "long" internally-threaded hex nuts are installed, or if nutserts are used. If long hex nuts are used, go to step 5 and follow the steps for *Early Production Vehicles*. If nutserts are used, go to step 4 and follow the steps for *Current Production Vehicles*.

4. *Current Production Vehicles*
   Remove the three flange-head capscrews and lockwashers securing the joystick assembly to its mounting hole in the side console (Fig. 4–16). Save the three flange-head capscrews and lockwashers for reuse later. *GO TO STEP 11.*

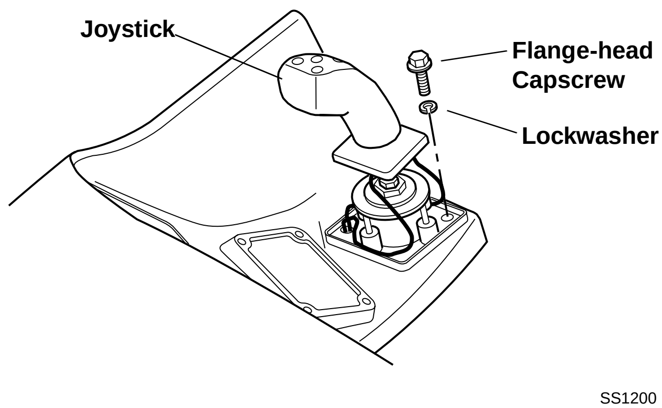


Figure 4–16. For *Current Production Vehicles,* remove the flange-head capscrews and lockwashers securing the joystick assembly to the console.

5. *Early Production Vehicles*
   Pry the entire switch bezel out and away from the side console (Fig. 4–17). Label, then disconnect the wiring harness leads at the switches. Remove the switch bezel from the vehicle.

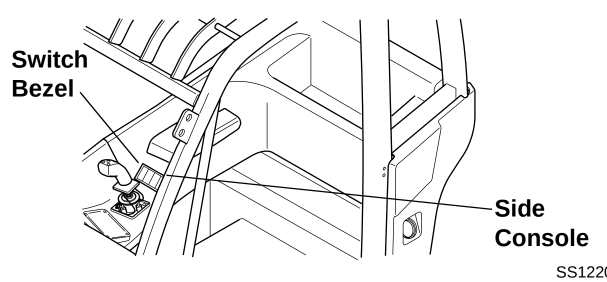


Figure 4–17. For *Early Production Vehicles,* remove the switch bezel from the vehicle.

6. From the outside rear of the cab (Fig. 4–18), remove the four button-head capscrews and plastic washers securing the outer rear panel to the cab. Remove the outer rear panel.

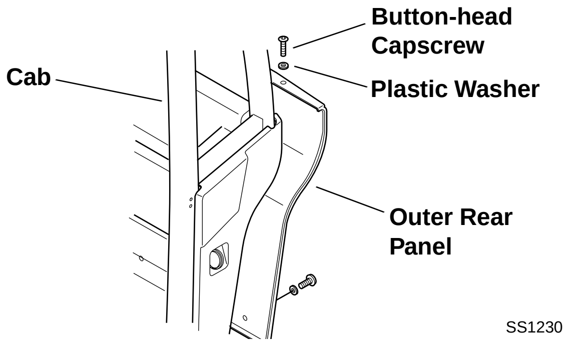


Figure 4–18. Remove the button-head capscrews and plastic washers securing the outer rear panel to the cab.

7. From the outside rear of the cab, remove the three hex-head capscrews, lockwashers and flat washers securing the rear tool bin to the cab (Fig. 4–19). Save the fasteners for reinstallation later.

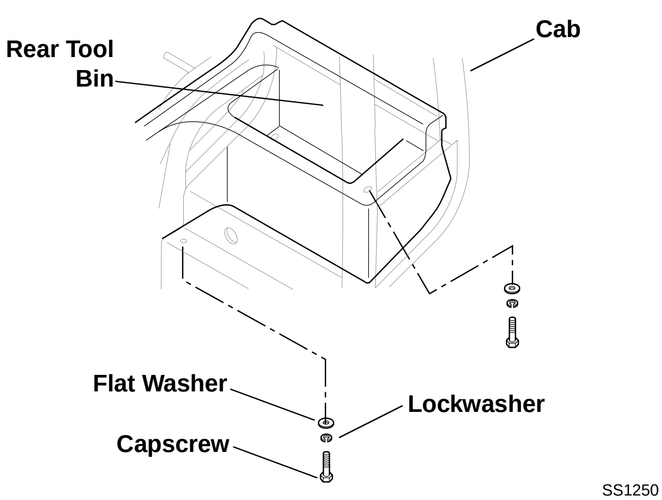


Figure 4–19. Remove the three hex-head capscrews, lockwashers and flat washers securing the rear tool bin to the cab.

8. Inside the cab, raise the glove box armrest. Inside the glove box (Fig. 4–20), remove the three capscrews, lockwashers and flat washers securing the rear tool bin to the right side of the cab, to the right side cab wall, and to the front dash. Slide the seat completely forward and remove the rear tool bin. Save the fasteners for reinstallation later.

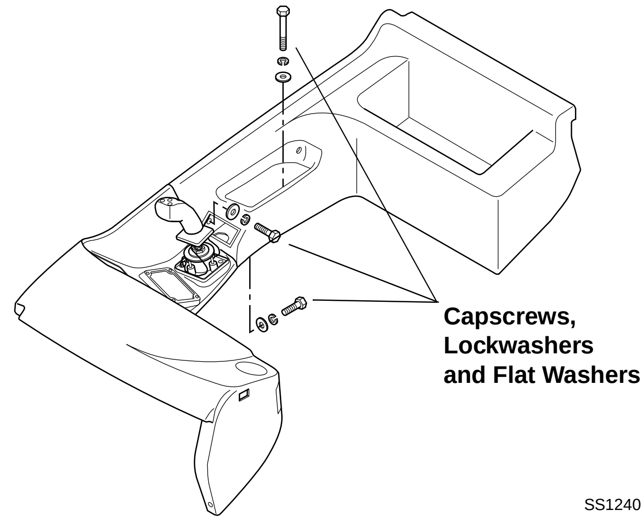


Figure 4–20. Remove the fasteners from inside the glove box.

9. Use a one-inch (25mm) wooden block (Fig. 4–21) or other suitable device to raise and hold the front dash, allowing access to the nuts on the underside of the joystick. Remove the three long nuts, lockwashers and flat washers from the underside of the joystick. Remove the three flange-head capscrews. Save the fasteners for reinstallation later.

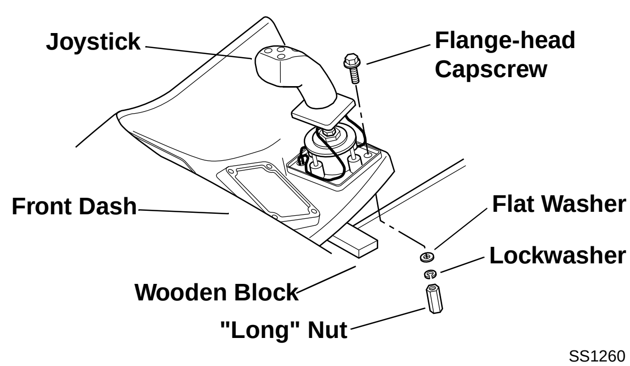


Figure 4–21. Raise the dash with a wooden block and remove the fasteners securing the joystick.

10. Reach through the logic panel opening and position the joystick wires as shown in Fig. 4–22 on the next page. Raise the joystick enough to expose and allow access to the hydraulic hose fittings connected to the joystick control valve on the underside of the joystick.

Note: As required, remove tie wraps securing the joystick hydraulic hoses together beneath the vehicle frame. Removing the tie wraps will allow the hoses to be pulled further out of the joystick opening in the console.

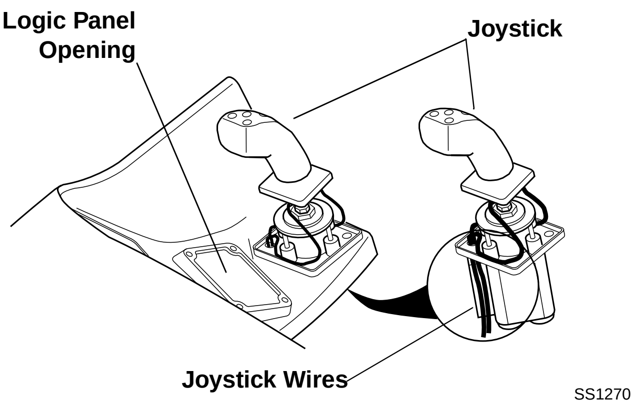


Figure 4–22. Reach through the logic panel opening and position the joystick wires as shown.

11. Use labels, tape or some type of permanent paint or marker to mark the six hoses on the underside of the joystick valve as shown in Fig. 4–23.

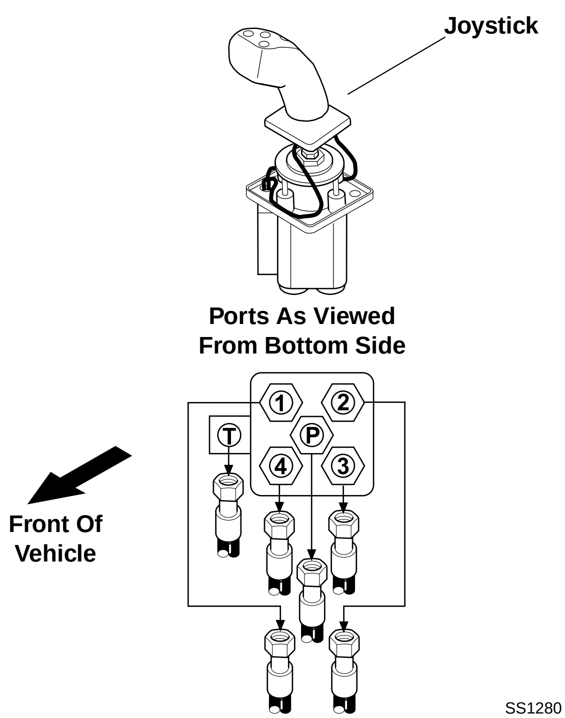


Figure 4–23. Label the joystick hoses and ports as shown.

12. Remove and plug the hose ends to help prevent excess hydraulic fluid spillage and to prevent contaminants from entering the hydraulic system.
13. Remove the joystick assembly from the vehicle.
14. Place the joystick in a vise or other suitable device. Remove the six straight fittings from the joystick valve ports (Fig. 4–24). Remove and discard all of the small and large O-rings from the joystick valve and fittings (to help avoid leaky connections, always use new O-rings when servicing the vehicle).

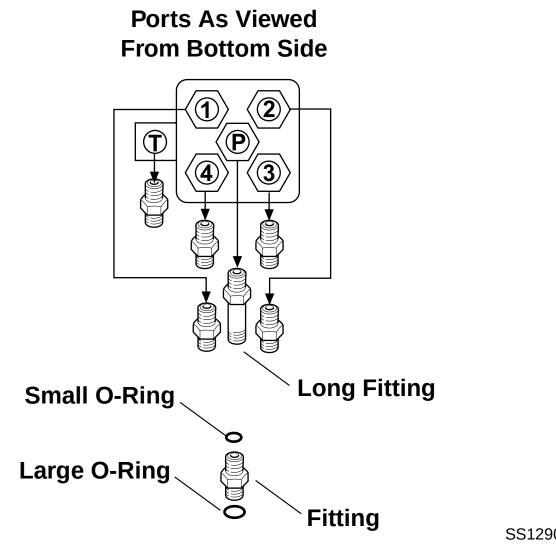


Figure 4–24. Joystick valve port fittings and O-rings.

Joystick Assembly Installation

1. As required, carefully remove the rubber boot from the joystick by pulling the boot off the joystick base (Fig. 4–14) and lifting it over the joystick handle. Save the boot for installation later.

Note: If installing a new joystick assembly, label or permanently mark the hose ports on the underside as shown in Fig. 4–24. Remove any port plugs before proceeding.

2. Place the joystick in a vise or other suitable device. Install new small and large O-rings and the six straight fittings into the joystick valve ports (Fig. 4–24) if necessary. To help avoid leaky connections, always use new O-rings when servicing the vehicle.
3. Position the joystick assembly above its mounting hole in the console. Remove the plug from the hose labeled "P" and secure the hose to the "P" port of the joystick valve.
4. Remove the plug from the hose labeled "T" and secure the hose to the "T" port of the joystick valve. Remove the plugs from the remaining hoses one at a time and secure each hose as labeled to the proper fitting on the joystick control valve. Tighten all fittings securely.
5. Position the lower joystick wires as indicated in Fig. 4–22. Reach in through the logic panel opening and guide the wires up through the logic panel opening while lowering the joystick assembly down into its mounting hole in the console.

6. Connect all wire leads to the proper connectors on the logic panel. Set the logic panel in its mounting hole, but **DO NOT** secure with fasteners at this time.
7. Check all joystick functions for proper operation:
8. Start the engine and move the joystick handle rearward, activating the boom hoist function. The boom should raise or lift.
9. Move the joystick handle forward, activating the boom lower function. The boom should go down.
10. Move the joystick handle to the right, activating the boom extend function. The boom should extend.
11. Move the joystick handle to the left, activating the boom retract function. The boom should retract.
12. If any of the functions fail to work as described, a hydraulic hose is most likely connected to the wrong joystick valve port. Relocate hoses as required to attain proper joystick function.
13. *Current Production Vehicles*
    Align the joystick assembly mounting holes with the console holes (Fig. 4–25). Secure the joystick assembly to the side console with three flange-head capscrews and lockwashers. *GO TO STEP 16.*

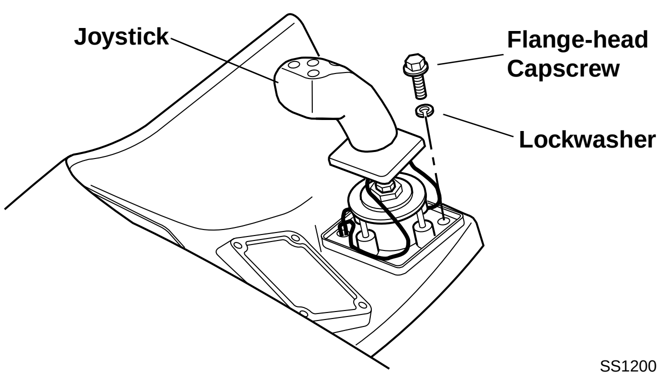


Figure 4–25. For *Current Production Vehicles,* remove the flange-head capscrews and lockwashers securing the joystick assembly to the console.

14. *Early Production Vehicles*
    Use a one-inch (25mm) wooden block or other suitable device to raise and hold the front dash (Fig. 4–26), allowing access to the underside of the joystick. Install three flange-head capscrews through the mounting holes in the base of the joystick assembly and through the corresponding joystick assembly mounting holes in the console.

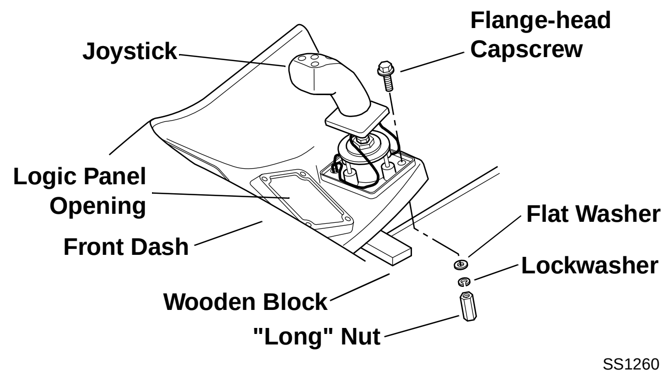


Figure 4–26. Raise the dash with a wooden block and install the fasteners to secure the joystick.

15. Reach through the logic panel opening and, from the underside of the joystick, secure the flat washers, lockwashers and long nuts to the flange-head capscrews. Tighten all fasteners securely.

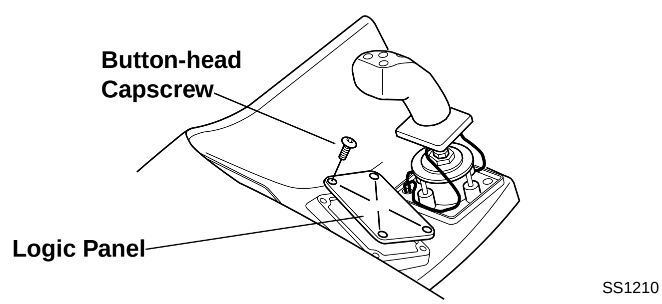


Figure 4–27. Secure the logic panel to the console with four button-head capscrews.

16. Connect the wiring harness leads to the logic panel terminal. Install the panel with the graphic symbols oriented properly as viewed from the operator's position. Secure the panel to the side console with four button-head capscrews (Fig. 4–27).

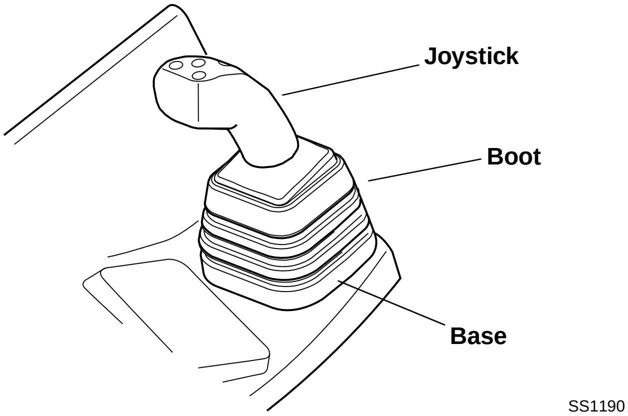


Figure 4–28. Slide the boot onto the joystick.

17. Install the joystick boot (Fig. 4–28) by pulling the boot over the joystick handle and down onto the base. Properly seat the boot "lip" within the grooves in the joystick base to help provide a water-tight seal.

Note: If any tie wraps were removed from the joystick hydraulic hoses beneath the vehicle frame, bundle the hoses and secure with new tie wraps as required to prevent the hoses from contacting any sharp edges or moving parts.

18. *Current Production Vehicles*
    Wipe up any spilled hydraulic oil. This completes the installation process for *Current Production Vehicles*.
19. *Early Production Vehicles*
    Move the seat all the way forward. Place the rear tool bin (Fig. 4–29) into position within the cab. Align the mounting holes at the front of the tool bin with the corresponding holes in the front dash panel.

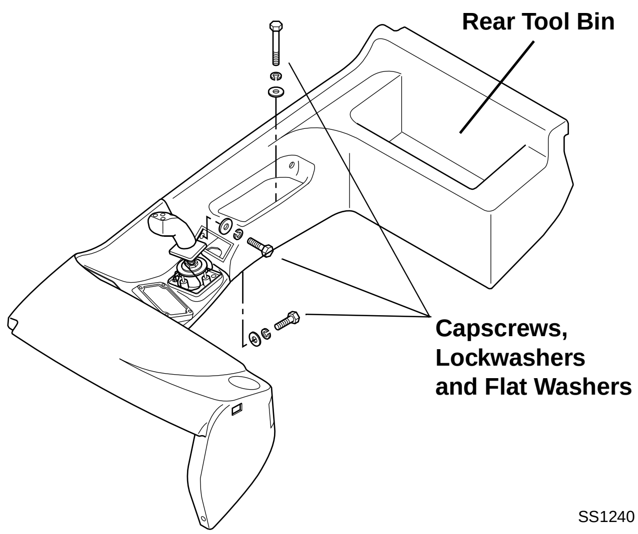


Figure 4–29. Install the fasteners from inside the glove box.

20. Raise the armrest. From inside the glove box, install the three capscrews, lockwashers and flat washers and secure the tool bin to the right side of the cab, to the right side cab wall, and to the front dash.
21. From the outside rear of the cab, secure the rear tool bin (Fig. 4–30) to the cab with three flat washers, lockwashers and hex-head capscrews.

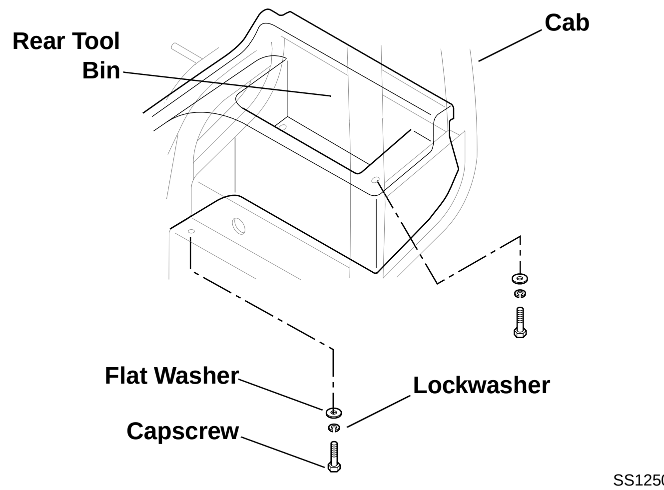


Figure 4–30. Install the three hex-head capscrews, lockwashers and flat washers securing the rear tool bin to the cab.

22. From the outside rear of the cab (Fig. 4–31), secure the outer rear panel to the cab with four plastic washers and button-head capscrews.

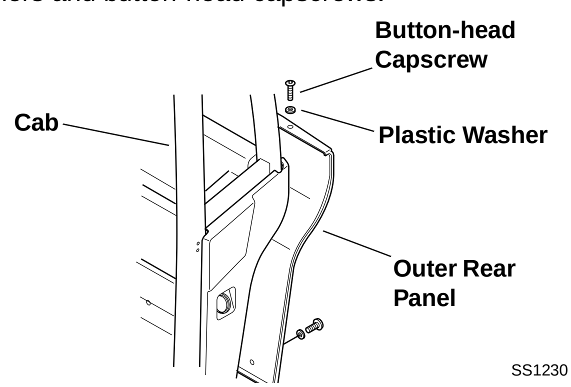


Figure 4–31. Install the plastic washers and button-head capscrews securing the outer rear panel to the cab.

23. Connect the wiring harness leads to the terminals of the switches within the switch bezel (Fig. 4–32). Snap the bezel into its console mounting hole.

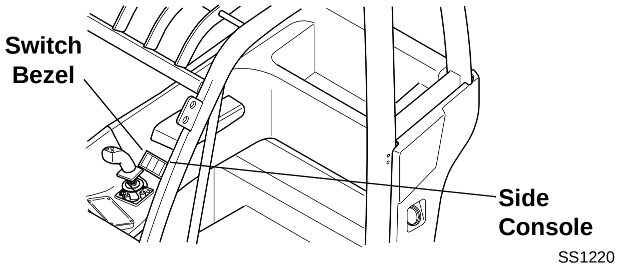


Figure 4–32. For *Early Production Vehicles,* snap the switch bezel into position in the side console.

24. Wipe up any spilled hydraulic oil. This completes the installation process for *Early Production Vehicles*.

4.2.7 Service Brake Pedal Replacement

Service Brake Pedal Removal

1. Remove the three #12-14 x 1" self-drilling screws (refer to item 4 in Fig. 4–3) securing the lower dash cover (3, Fig. 4–3) to the cab.
2. Remove the lower dash cover.
3. Remove the two 1/2-13 x 2" hex-head capscrews (Fig. 4–33) and 1/2-13 hex-lock elastic nuts securing the service brake pedal to the cab. Capture the four 1/2" flat washers and both brake pedal pivots as the capscrews are removed.

Note: ALWAYS replace elastic-lined nuts with new elastic-lined nuts to help ensure proper fastening.

4. Remove the service brake pedal from the cab.

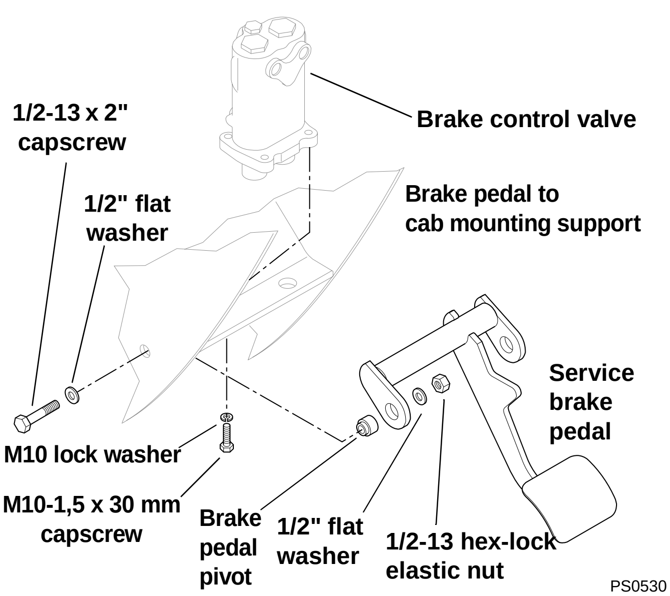


Figure 4–33. Service brake pedal mounting arrangement.

Service Brake Pedal Installation

1. Position the service brake pedal (Fig. 4–33) in its mounting location within the cab.
2. Insert two brake pedal pivots into their mounting locations on the service brake pedal.
3. Insert a 1/2" flat washer onto a 1/2-13 x 2" hex-head capscrew. Work the capscrew through one side of the brake pedal-to-cab mounting support. Secure with a 1/2" flat washer and a new 1/2-13 hex-lock elastic nut. Torque to 75 lb/ft (102 Nm).

Note: ALWAYS replace elastic-lined nuts with new elastic-lined nuts to help ensure proper fastening.

4. Check the operation of the brake switch; adjust by threading the switch in or out as required.
5. Install and secure the lower dash cover (item 3, Fig. 4–3) with three #12-14 x 1" self-drilling screws.

4.2.8 Throttle Pedal Replacement

Throttle Pedal Removal

1. Remove the three 1/4-20 x 1-1/4" hex-head capscrews (item B, Fig. 4–34), 1/4" lockwashers (C) and SAE flat 1/4" washers (D) securing the throttle pedal assembly (A) to the cab floor (ref.).
2. Remove the extension spring (F) as required from the throttle pedal assembly.
3. Remove the hex jam nut (E) and SAE flat 1/4" washer (D) securing the throttle cable (G) to the throttle pedal assembly (A).
4. Remove the throttle pedal assembly (A) from the cab.

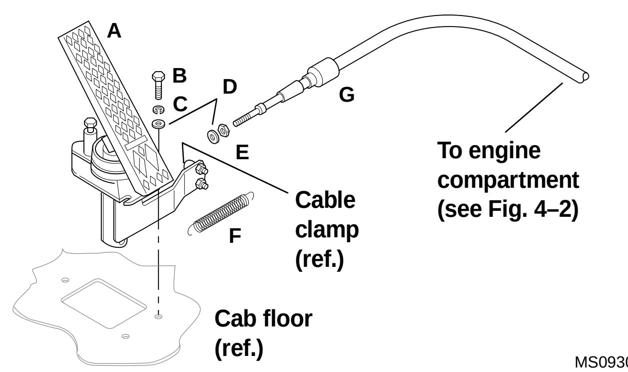


Figure 4–34. Throttle pedal mounting arrangement.

Throttle Pedal Installation

1. Install the hex jam nut (item E, Fig. 4–34) and SAE flat 1/4" washer (D) onto the end of the throttle cable (G). Secure the cable to the throttle pedal (A).

Note: If throttle cable (G) replacement is required (refer to Fig. 4–2), the cab must be unbolted from its mount and raised slightly to permit cable removal.

2. If needed, attach one end of the extension spring (F) to the throttle pedal lever beneath the pedal. Attach the other end of the spring to the cable clamp (ref.).
3. Align the throttle pedal assembly (A) with its mount holes in the cab floor (ref.).
4. Install three 1/4-20 x 1-1/4" hex-head capscrews (B), 1/4" lock washers (C) and SAE flat 1/4" washers (D) securing the throttle pedal assembly (A) to the cab floor. Torque to 9 lb/ft (12 Nm).

Throttle Adjustment

1. From within the cab, lightly depress the throttle pedal (Fig. 4–35) to full-throttle position. As needed, adjust the limit-stop screw until it touches the pedal. Tighten the locknut to 120 to 125 lb/in (13,6 to 14,1 Nm).

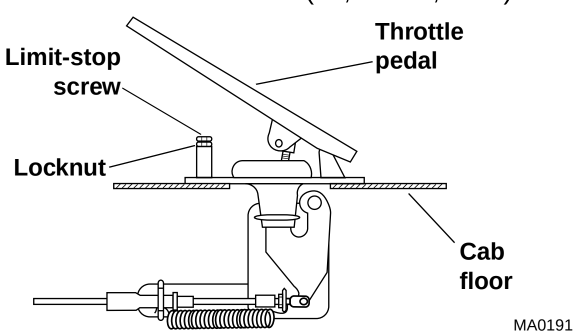


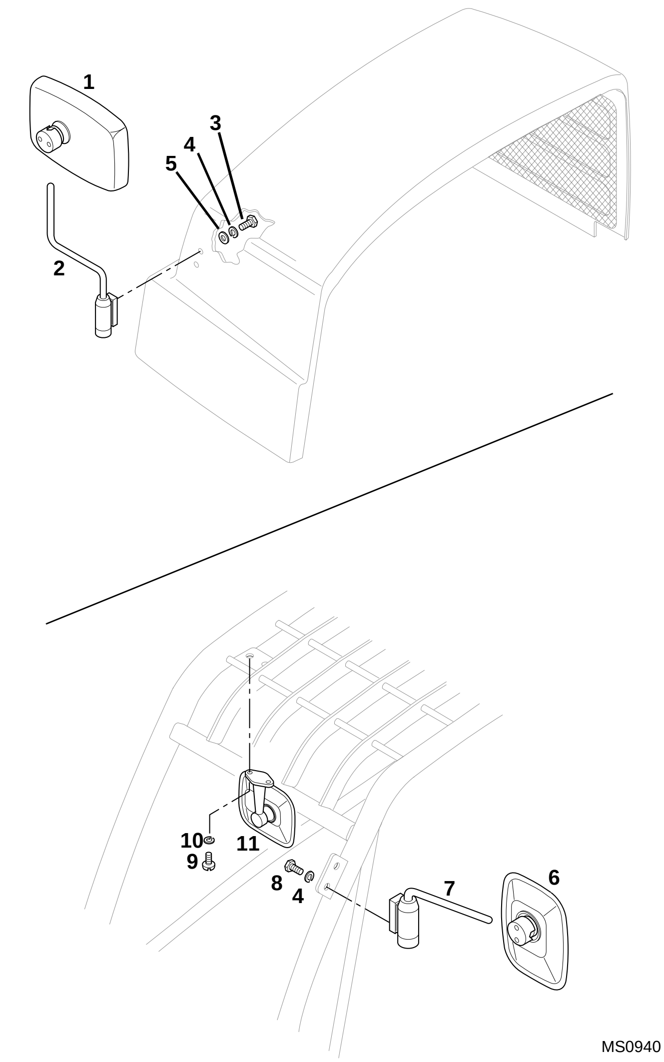
Figure 4–35. Adjust the throttle limit-stop screw.

IMPORTANT: *During the full throttle check:*
- **DO NOT** operate any hydraulic function;
- **DO NOT** steer or apply any pressure to the steering wheel;
- Keep the transmission in NEUTRAL (N).

2. Check the engine rpm at full throttle. If the rpm is not 2600 to 2800 rpm, readjust the throttle limit-stop screw at the throttle pedal within the cab.

4.2.9 Mirror Replacement

WARNING: A mirror with cracked glass can cause cuts. Handle a cracked or broken mirror with care to help avoid personal injury.



1. Convex mirror head
2. Mirror arm assembly
3. Hex-head capscrew, M6-1 x 20 mm
4. Lock washer, M6
5. SAE flat light washer, 1/4"
6. Rear view mirror
7. Mirror arm assembly
8. Hex-head capscrew, M6-1 x 14 mm
9. Slotted round-head screw, #10-24 x 5/8"
10. Lock washer, #10
11. Rear view mirror assembly

Figure 4–36. Mirror mounting arrangement.

The vehicle is equipped with three rear-view mirrors (Fig. 4–36). These include two cab-mounted mirrors (items 6 and 11), one on the left (6), another on the top right (11), and an engine hood mounted mirror (1).

Keep the mirrors clean for optimal operator performance.

Replace any mirror with cracked glass as vehicle use and vibration will eventually, if not immediately, cause the crack(s) to worsen or the mirror glass to fall out.

The mirror mounted on the left side of the cab (item 6, Fig. 4–36) and the hood-mounted mirror head (1) are attached to mirror arm assemblies. These mirror heads can be replaced independently of the arm and mounting hardware.

The mirror assembly (item 11, Fig. 4–36) and mirror assembly arms (2 and 7) are secured to the vehicle with screws (3, 8 and 9) and washers (4, 5 and 10). Removal and installation are easily accomplished by observing the mounting configurations illustrated in Fig. 4–36.

4.2.10 Cab Panel Replacement

The cab is equipped with various panels, as shown in Fig. 4–37 and in the *General Overview* illustration on page three. Removal and installation are easily accomplished by observing the mounting configurations as shown in the illustrations.

4.3 CAB COVERS AND GUARDS

4.3.1 Cover and Guard Replacement

The vehicle is equipped with various covers and guards (Fig. 4–37). Removal and installation are easily accomplished by observing the mounting configurations as shown in the illustration.

4.3.2 Engine Hood

Engine Hood Removal

WARNING: Risk of severe personal injury. Contact with hot engine or other components will cause burns. Allow engine and components to cool completely before proceeding. Failure to comply will result in personal injury.

1. Park the vehicle on a firm, level surface. Allow sufficient overhead clearance for engine hood removal. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut the engine OFF. Open the engine hood. Allow the engine and hydraulic fluid to cool.

Note: If performing this procedure outside where blowing wind is a factor, control hood movement at all times. Wind can cause the hood to move unexpectedly.

2. Unlock and raise the hood (item 1, Fig. 4–37).
3. Support the hood in a suitable manner. Disconnect the top spring clip (11) from the gas spring (15). Reattach the spring clip to the gas spring and lower the gas spring down out of the way. It is not necessary to detach the lower spring clip or to remove the gas spring.
4. Remove the cotter pins (18) and washers (4) from the clevis pins (19). Remove the clevis pins.
5. With the help of at least one assistant, carefully lift and remove the cover.
6. Store the cover securely to help prevent damage.

Engine Hood Installation

WARNING: Risk of severe personal injury. Contact with hot engine or other components will cause burns. Allow engine and components to cool completely before proceeding. Failure to comply will result in personal injury.

1. Park the vehicle on a firm, level surface. Allow sufficient overhead clearance for engine hood installation (item 1, Fig. 4–37). Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut the engine OFF. Allow the engine and hydraulic fluid to cool.

Note: If performing this procedure outside where blowing wind is a factor, control hood movement at all times. Wind can cause the hood to move unexpectedly.

2. With the help of at least one assistant, lift the hood into position, aligning the hinges (2 and 6) over their mounts on the engine panel (20).
3. Insert the cotter pins (18) through the hinges and engine panel mount. Secure with washers (4) and clevis pins (19).
4. Support the hood in a suitable manner. Attach the gas spring (15). Secure the gas spring with spring clips (11) as required. Remove the support.
5. Close the cover slowly and carefully, checking for, and rectifying, any obstruction or hinge binding.
6. Close and lock the cover. Pull up on the cover and assure it is securely latched.

Hood and Covers Parts Legend

1. Engine hood
2. Rear hood hinge
3. Black moulding, 7" long
4. Flat narrow washer, 3/8"
5. 1/4-20 x 1"
6. Front hood hinge
7. Latch retainer ring
8. Black moulding, 16" long
9. Latch, w/key (includes item 10)
10. Key
11. Clip spring
12. Ball stud, 13 mm
13. Flat washer, 5/16"
14. Hex-lock elastic nut, 5/16-18
15. Gas spring
16. Cover support
17. Hex-head capscrew, 5/16-18 x 1-1/4"
18. Cotter pin
19. Clevis pin, 3/8" diameter
20. Engine panel
21. Hex-head capscrew, 3/8-16 x 1-1/2"
22. Hex-head capscrew, 5/16-18 x 1"
23. Lock washer, 5/16"
24. Rear engine cover
25. Retainer nut, 5/16-18
26. Hex-lock elastic nut, 3/8-16
27. Front engine cover
28. Hex-head capscrew, 5/16-18 x 1/2"
29. Front cover bracket
30. Rear cover bracket
31. Rear door striker
32. Gas spring
33. Ball stud, 10 mm
34. Rear cover
35. Adjustable trigger latch
36. Heavy flat washer, 1/2"
37. Hex-lock elastic nut, 1/2-13
38. Hex-head capscrew, 1/2-13 x 1-1/4"
39. SAE flat light washer, 1/4"
40. Hex-lock elastic nut, 1/4-20
41. Flat washer, 1/4"
42. Hex-head capscrew, 1/4-20 x 2-1/4", Grade 5
43. Rubber hook
44. Anchor bracket
45. Hook bracket
46. Slotted pan-head screw, #10-24 x 1-1/4"
47. Flat washer, #10
48. Hex-lock elastic nut, #10-24

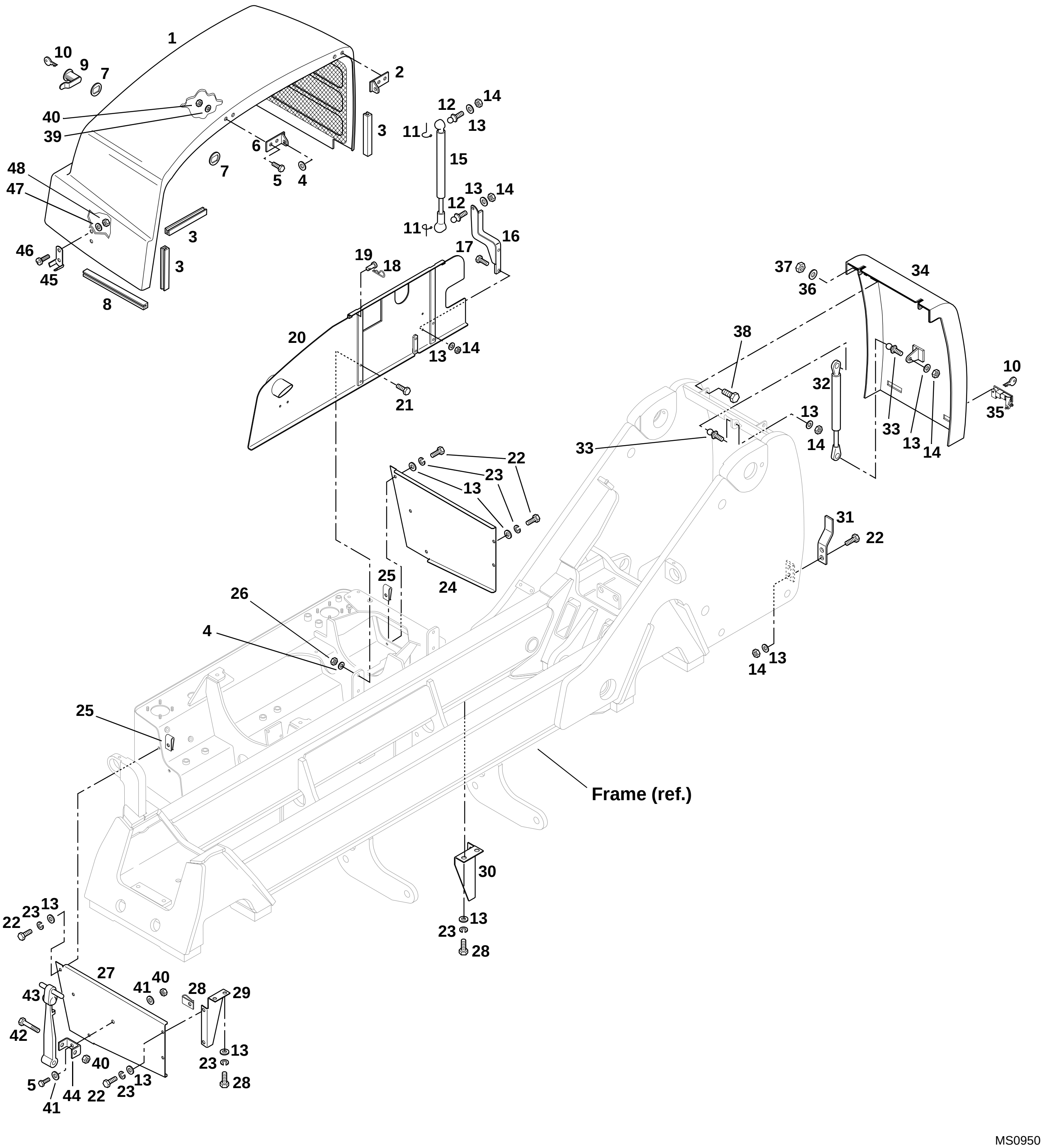


Figure 4–37. Covers and guards.

Section 5
Axles, Wheels and Tires

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NOTE: Detailed axle service instructions (covering the axle, differential, brakes and wheel-end safety, repair, disassembly, reassembly, adjustment and troubleshooting information) are provided in the *Carraro Model 26.25M Maintenance and Repair Manual*, part number *CA355027* (front axle with park brake) and *CA355028* (rear axle).

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Introduction

The front (park-brake equipped) and rear (no park brake) Carraro axles are designed for heavy-duty, off-road industrial use. Each axle consists of a beam-type axle case, housing the differential center section, inboard wet-disc brakes, a pair of trumpet-like shaft housings, and stub-axle/wheel-hub units at each end. O-rings and oil seals retain fluid within the axle. The axles have a semi-floating mounting configuration. Each axle center is secured to the vehicle frame with semi-rotating front and rear supports, and at one side with a cylinder, anchor and plate. The frame tilt cylinder is mounted on the right side of the front axle and the stabilizer cylinder is mounted on the left side of the rear axle. Steer cylinders and swivels are mounted inboard on each axle. Power to the axles is transmitted from the engine flywheel, connected to the transmission drive plate and torque converter, out through a driveshaft connected to the transfer case. The transfer case distributes power through output drive shafts to the front and rear axle differentials, which work through gearing to turn the wheel and tire assemblies and to ultimately cause the vehicle to move.

The front differential is equipped with limited-slip, self-locking gears, supported by two bearings. The design of the differential permits adjustment to the bevel gear set. Internal axle service and adjustment procedures are not the scope of this publication and are thoroughly covered in the appropriate Carraro axle manual. The beveled ring gear is adjusted by means of ring nuts located opposite each other. The position of the pinion, supported by two bearings, is adjusted through the addition or subtraction of adjusting shims.

The wheel hubs containing the epicyclic reduction gears are supported by two tapered roller bearings. The brakes are oil-bath (wet) disc type, operated by an annular piston and equipped with an automatic wear compensation device. The double-rod hydraulic steering cylinder is mounted on the differential support. Directional steering input is transmitted to the axles by means of articulated track rods that allow toe-in adjustments. Two specially designed support trunions (one front, one rear) attach the axle center to the chassis and allow the axle to pivot freely, limited by the cylinder attached to one side.

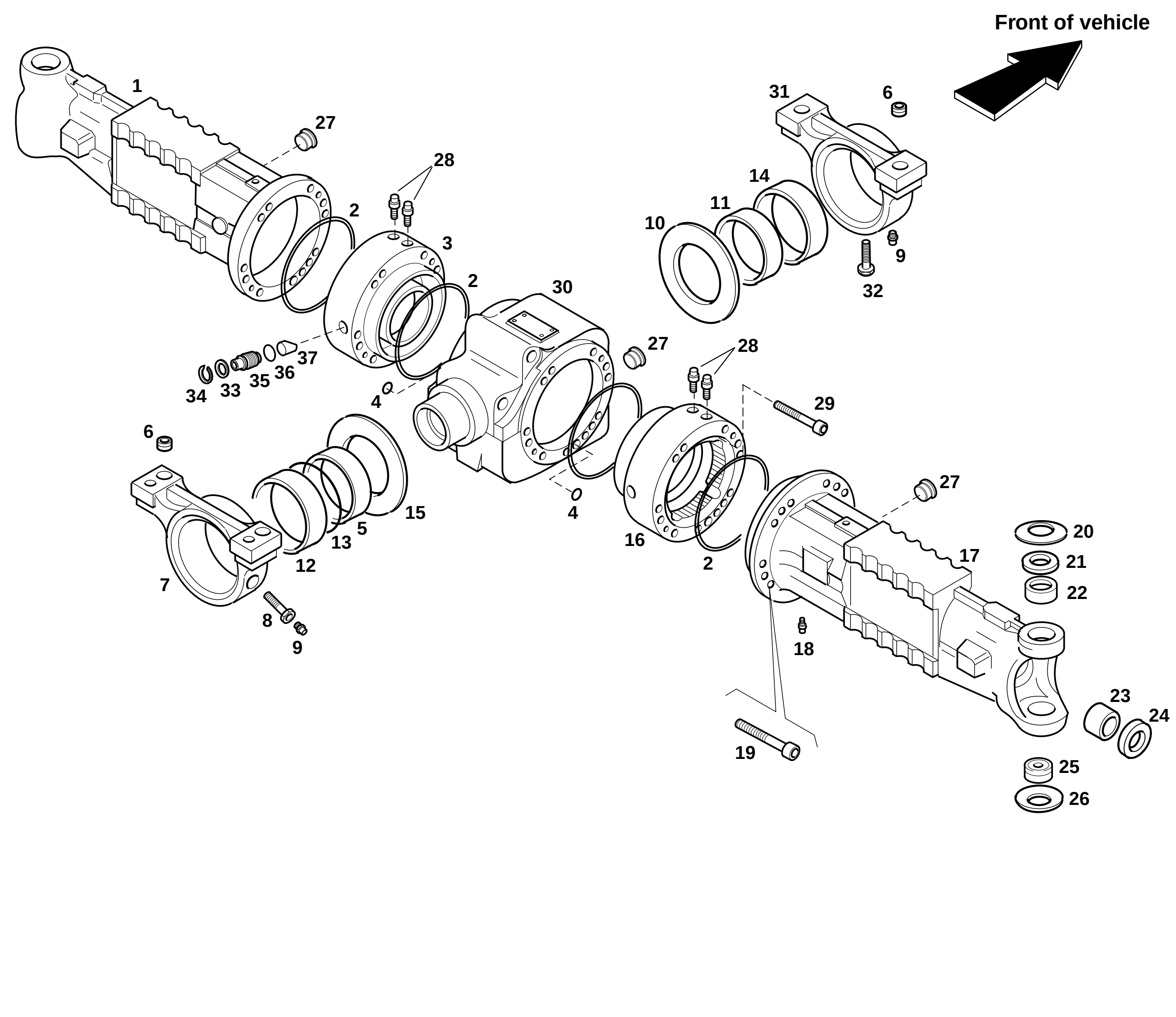
NOTE: Detailed axle service instructions (covering axle, brakes and wheel-end safety, repair, disassembly, reassembly, adjustment and troubleshooting information) are provided in the *Carraro Model 26.25M Maintenance and Repair Manual*, part number *CA355027* (front axle with park brake) and *CA355028* (rear axle).

One wheel type with nominal dimensions of 9" x 24" is used on the vehicle. The wheel is a welded two-piece design with ten one-inch diameter holes equally spaced on a 13.188" diameter bolt circle. A 12-ply, or better, directional-tread tire, 13.00 x 24 in size, can be used on this vehicle. Tires are filled only with air when the vehicle is shipped from the factory.

Legend

1. Left Beam Trumpet
2. O-ring
3. Left Brake Flange
4. O-ring
5. Bushing
6. Bushing
7. Rear Support
8. Bolt
9. Grease Nipple, M8-1
10. Thrust Washer
11. Bushing
12. Bushing
13. O-ring
14. Bushing
15. Thrust Washer
16. Right Brake Flange
17. Right Beam Trumpet
18. Breather, M10-1
19. Bolt
20. Belleville Washer
21. Shim
22. Bushing
23. Bushing
24. Oil Seal
25. Spherical Bearing
26. Belleville Washer
27. Oil Plug, M30-2
28. Breather, M10-1
29. Bolt, M12 X 110 Mm
30. Central Body
31. Front Support
32. Bolt
33. Washer
34. Internal Snap Ring
35. Bolt, M16-1,5
36. O-ring
37. Pin

General Overview



5.1 GENERAL INFORMATION

5.1.1 Axle Serial Number Plate

The front axle serial number plate is located on a mounting pad on the inboard portion of the right beam trumpet. The rear axle serial number plate is located on a mounting pad on the inboard portion of the left beam trumpet. Information on the serial number plate is required in correspondence regarding the axle.

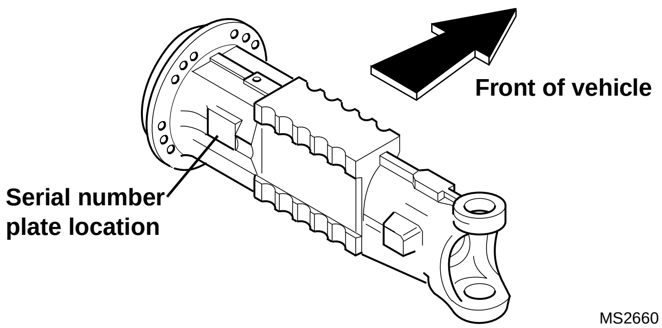


Figure 5–1. Axle serial number plate location (front axle shown).

Supply information from the axle serial number plate when communicating about an axle assembly or axle components.

5.1.2 Specifications

Axle, wheel and tire specifications are listed in *Section 2 General Information, Specifications and Maintenance Instructions.*

5.1.3 Maintenance

Axle, wheel and tire maintenance instructions are detailed in *Section 2 General Information, Specifications and Maintenance Instructions.*

5.2 AXLE ASSEMBLIES

Note: Detailed axle service instructions (covering axle, brakes and wheel-end safety, repair, disassembly, reassembly, adjustment and troubleshooting information) are provided in the *Carraro Model 26.25M Maintenance and Repair Manual*, part number *CA355027* (front axle with park brake) and *CA355028* (rear axle).

Several special axle service tools are required to properly service the axle assemblies. Contact the local Sky Trak International parts distributor or *Carraro USA* for ordering information.

WARNING: Risk of serious personal injury or death if components are assembled improperly, if incompatible, worn or damaged components are used, or if components are used in a non-approved application. Obtain proper training, follow recommended procedures, and use proper tools and safety equipment. Wear safety glasses at all times when working on the vehicle and vehicle components.

- **DO NOT** attempt carrier and differential removal and installation, and differential and pinion disassembly and assembly, without thoroughly understanding instructions in the appropriate Carraro publications.
- Before disassembling any parts inside the carrier, remove the entire axle assembly from the vehicle and securely support it with the pinion facing up in an appropriate stand or rack.
- When removing the axle assembly from the vehicle, properly support the vehicle. An improperly supported vehicle can cause serious injury or death.
- If servicing axle components with the axle attached to the vehicle, securely support the carrier, differential, pinion assemblies and wheel ends.
- Dispose of waste material in accordance with local regulations and procedures.

CAUTION: The use of replacement parts provided by other than the original manufacturer is not recommended, as such use may cause unit failure and affect vehicle safety. Supply information from the axle serial number plate when communicating about an axle assembly or axle components.

- Risk of personal injury. Exercise extreme care when using snap rings or spring-loaded retention devices.
- It is impossible to know, evaluate and advise regarding all conceivable ways in which service may be performed, or of the possible hazardous consequences of each method. Accordingly, whenever a service procedure or tool is used which is not recommended, assure that both personal safety and vehicle safety are maintained by the selected method.

IMPORTANT: When replacing a fastener, replace it with one of equal or higher grade and quality. Torque fasteners to the specified value for the application.

- Some service operations require the use of tools specifically designed for the purpose. Use the special tools when and as recommended.
- **DO NOT** pound, beat or hammer on end yokes and flanges to remove or to install them. Damage to axle components can occur. Remove and install end yokes and flanges by following the recommended procedures in the appropriate Carraro axle service manual.
- **DO NOT** reuse oil or grease seals.

CLEANING: Clean parts with machined or ground surfaces (such as gears, bearings, and shafts) with emulsion cleaners or petroleum-based cleaners. **DO NOT** steam clean internal components and the interior of the planetary hub and axle housing. Water can cause corrosion of critical parts. Rust contamination in the lubricant can cause gear and bearing failure. Remove old gasket material from all surfaces.

DRYING: Use clean, lintless towels to dry components after cleaning. **DO NOT** dry bearings by spinning them with compressed air. This can damage mating surfaces due to lack of lubrication. After drying, lightly coat components with oil or a rust-preventive chemical to help protect them from corrosion. If storing components for a prolonged period, wrap them in wax paper.

PERIODIC OPERATION REQUIREMENT: Every two weeks, drive the vehicle far enough to cause the drive-train components to make several complete revolutions. This will help assure that internal components receive lubrication to minimize deterioration caused by environmental factors such as high humidity.

SUBMERSION: If the vehicle has been exposed to water deep enough to cover the hubs, disassemble the wheel ends and inspect for water damage and contamination. If the carrier housing was submerged in water, especially if the water level was above the vent tube (breather), drain the axle and inspect internal parts for water damage and contamination. Before assembling and refilling the unit with the specified lubricant(s), clean, examine and replace damaged parts as necessary.

Note: Whenever bearings are removed, regardless of hours and condition, replace them with new bearings. Use a suitable puller for bearing removal. Clean, inspect and lubricate all bearings just prior to reassembly. If replacement of a damaged bearing cup or cone is necessary, replace the cup and cone as a set.

5.2.1 Axle Replacement

A. Removal

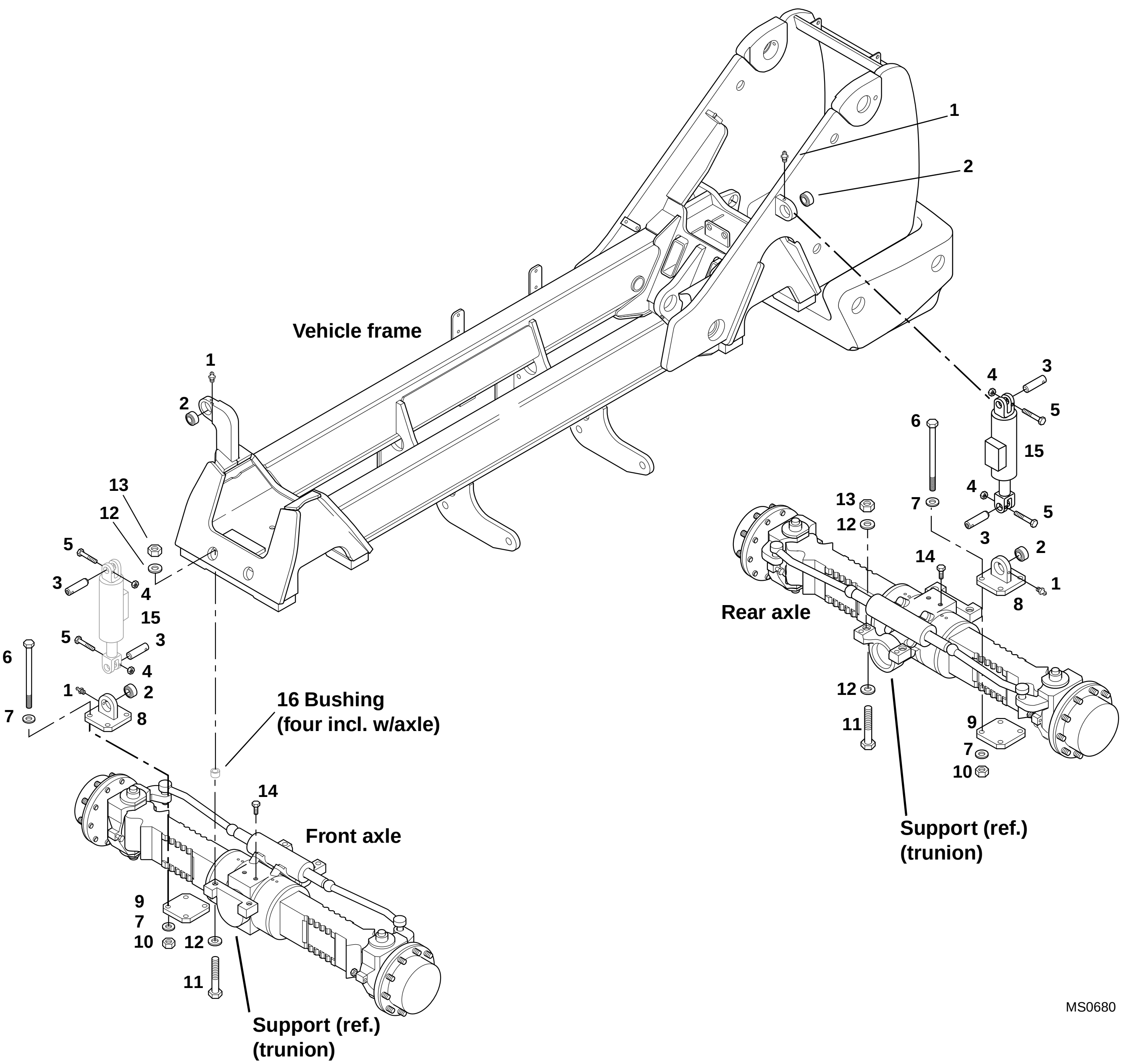
WARNING: Risk of death or severe personal injury. Safely raise and adequately support the vehicle so that it will remain stable and in place before attempting to remove an axle.

WARNING: Wait for the hydraulic fluid to cool before servicing any hydraulic component. Hot hydraulic fluid can cause severe burns.

WARNING: Relieve hydraulic pressure before servicing any hydraulic component. Escaping hydraulic fluid under pressure can penetrate the skin, causing serious injury.

The front and rear axle assemblies differ in that the front axle assembly is equipped with a park-brake mechanism and limited-slip feature; the rear axle has neither. The steps below outline a typical axle removal procedure, suitable for either the front or the rear axle assembly.

Cleanliness is of extreme importance. Before attempting to remove the axle, thoroughly clean the vehicle. Avoid spraying water or cleaning solution on the stabilizer solenoids and other electrical components. If using a steam cleaner, seal all openings before steam cleaning.



1. Self-tapping lube fitting, 1/8"
2. Self-align bearing, 1-1/2" ID
3. Cylinder-mount pin, 1.5" diameter
4. Hex-lock nut, 5/16-18
5. Hex-head capscrew, 5/16-18 x 3-1/2"
6. Hex-head capscrew, 7/8-9 x 12"
7. Flat hardened washer, 7/8"
8. Cylinder anchor
9. Anchor plate
10. Hex-lock nut, 7/8-9
11. Hex-head capscrew, 3/4-10 x 5-1/2" Grade 8
12. Flat hardened washer, 3/4"
13. Hex-lock elastic nut, 3/4"
14. Hex-head capscrew, M10-1,5 x 16 mm
15. Cylinder
16. Bushing

Figure 5–2. Axle to frame mounting configuration.

IMPORTANT: Clear the work area of all debris, unnecessary personnel, etc. Allow sufficient space to raise the vehicle and to remove the axle.

1. Park the vehicle on a firm, level surface. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the park brake switch, straighten all wheels and shut the engine OFF. Allow the hydraulic fluid to cool.
2. If the axle will be disassembled after removal, place a suitable receptacle under the axle drain plug. Remove the drain plug and allow the axle oil to drain into the receptacle. Transfer the used axle oil into a suitable covered container and label the container as used oil. Dispose of properly.
3. Label, disconnect and cap the steering and brake lines at the axle. Wipe up any spilled oil.
4. Block the front and rear of both tires on the axle that is not being removed. Ensure that the vehicle will remain in place during axle removal before proceeding.
5. Raise the vehicle using a suitable jack or hoist. Place suitable supports beneath the frame and lower the vehicle onto the supports. Ensure that the vehicle will remain in place during axle removal.
6. Support the axle that is being removed with a suitable jack, hoist or overhead crane and sling. **DO NOT** raise the axle or the vehicle.
7. Mark and remove both wheel and tire assemblies from the axle that is being removed.

Note: The wheel and tire assemblies must be reinstalled later with the directional tread pattern “arrows” facing in the direction of forward travel.

8. Mark the axle driveshaft flange yoke and unbolt it from the axle.

Note: The drive shaft assembly is a balanced assembly. Mark the yoke and axle so that these components can be returned to their original positions when reinstalled. The yokes at each end of the drive shaft must be in the same plane to help prevent excessive vibration (Fig. 5–3).

9. Remove the 5/16-18 x 3-1/2" hex-head capscrew (item 5, Fig. 5–2) and 5/16-18 hex-lock nut (4) securing the lower position 1-1/2" diameter cylinder-mount pin (3) to the cylinder (15). Tap out the cylinder mount pin, and move the cylinder (15) to prevent it from interfering with axle removal.
10. Remove the 3/4-10 x 5-1/2" Grade 8 hex-head capscrews (11), 3/4-10 hex-lock elastic nuts (13), and 3/4" hardened flat washers (12) securing the front and rear axle supports (rotating trunnions) to the vehicle frame.
11. Four bushings (item 16, Fig. 5–2) help locate the axle supports to the vehicle frame; tap the front and rear supports with a hammer as required to separate the supports from the bushings. Adjust the jack, hoist or overhead crane and sling supporting the axle as required to free the axle from the frame and bushings.
12. Remove the axle from the vehicle using the jack, hoist or overhead crane and sling supporting the axle. **DO NOT** raise or otherwise disturb the vehicle while removing the axle. Balance the axle and prevent it from tipping, turning or falling while removing it from beneath the vehicle. Place the axle on a suitable support or holding stand.

B. Axle Inspection, Internal Service and Repair

Detailed axle service instructions (covering axle, brakes and wheel-end safety, repair, disassembly, reassembly, adjustment and troubleshooting information) are provided in the *Carraro Model 26.25M Maintenance and Repair Manual*, part number *CA355027* (front axle with park brake) and *CA355028* (rear axle without park brake).

The axle should be checked, serviced and repaired only by experienced service technicians who are aware of all safety instructions and particular component features.

C. Installation

The front and rear axle assemblies differ in that the front axle assembly is equipped with a park-brake mechanism and limited-slip feature; the rear axle has neither. The steps below outline a typical axle installation procedure, suitable for either the front or the rear axle assembly.

1. Before proceeding, ensure that the vehicle will remain in place during axle installation. Block the front and rear of both tires on the axle that is already installed on the vehicle.
2. If applicable, raise the vehicle using a suitable jack or hoist. Place suitable supports beneath the frame and lower the vehicle onto the supports, allowing enough room for axle installation. Ensure that the vehicle will remain in place during axle installation.
3. Using a suitable jack, hoist or overhead crane and sling, remove the axle from its support or holding stand. Balance the axle and prevent it from tipping, turning or falling while positioning it beneath the vehicle. **DO NOT** raise or otherwise disturb the vehicle while installing the axle. Keep the axle supported and balanced on the jack, hoist or overhead crane and sling throughout the installation procedure.

4. Four bushings (Fig. 5–2) help locate the axle supports on the vehicle frame. Insert the bushings into the holes on the front and rear axle supports. Align the bushings and supports with the frame. Raise the axle as required to align the supports with the frame.
5. Install the 3/4-10 x 5-1/2" Grade 8 hex-head capscrews (item 11), new 3/4-10 hex-lock elastic nuts (13), and 3/4" hardened flat washers (12) securing the front and rear axle supports to the vehicle frame. Torque to 250 lb/ft (340 Nm).
6. If required, attach the cylinder anchor (8) and anchor plate (9) to the axle with 7/8-9 x 12" hex-head capscrews (6), 7/8" hardened flat washers (7), and new 7/8-9 hex-lock nuts (10). Torque to 380 lb/ft (515 Nm).

Note: Always use new lock nuts to help ensure proper fastening.

7. Move the cylinder (15) into position on the axle cylinder anchor (8). Insert a 1.5" diameter cylinder-mount pin (3) through the cylinder (15) and cylinder anchor (8). Secure the cylinder-mount pin (3) with a 5/16-18 x 3-1/2" hex-head capscrew (5) and a new 5/16-18 hex-lock nut (4). Torque to 18 lb/ft (24 Nm).

Note: Always use new lock nuts to help ensure proper fastening.

8. Apply multi-purpose grease through the self-tapping lube fitting (1) to lubricate the self-align bearing (2) and the cylinder-mount pin (3).
9. If reinstalling an axle previously removed from the vehicle, position the driveshaft flange yoke on the axle according to the alignment marks made earlier. If installing a new axle, note the position of the driveshaft yoke at the transfer case. Align the driveshaft yoke on the axle in the same plane as the yoke on the transfer case (Fig. 5–3).

Note: The drive shaft assembly is a balanced assembly. The yokes at each end of the drive shaft must be in the same plane to help prevent excessive vibration (Fig. 5–3).

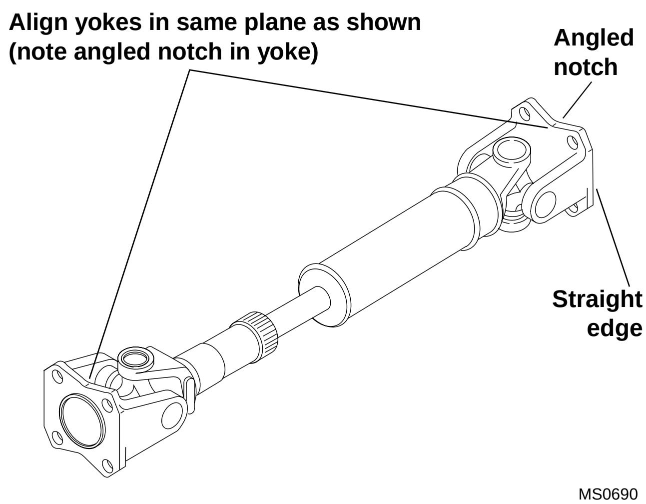


Figure 5–3. Align yokes in the same plane as shown.

10. Install the wheel and tire assemblies.

Note: The wheel and tire assemblies must be installed with the directional tread pattern “arrows” facing in the direction of forward travel (Fig. 5–4 and Fig. 5–6).

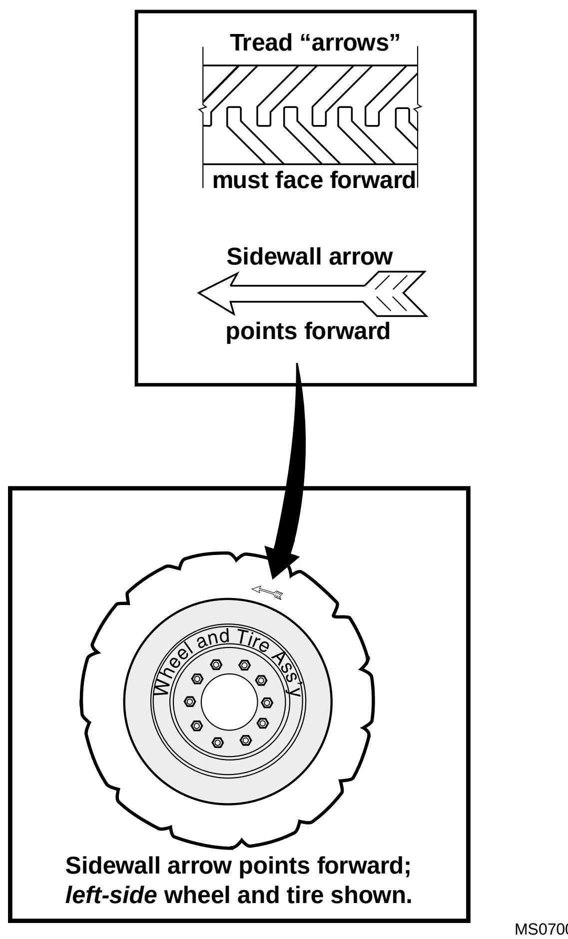


Figure 5–4. The tread “arrows” must point in the direction of forward travel (also see Fig. 5–6).

11. Torque the lug nuts to 370 lb/ft (500 Nm) using the alternating pattern depicted in Fig. 5–5.

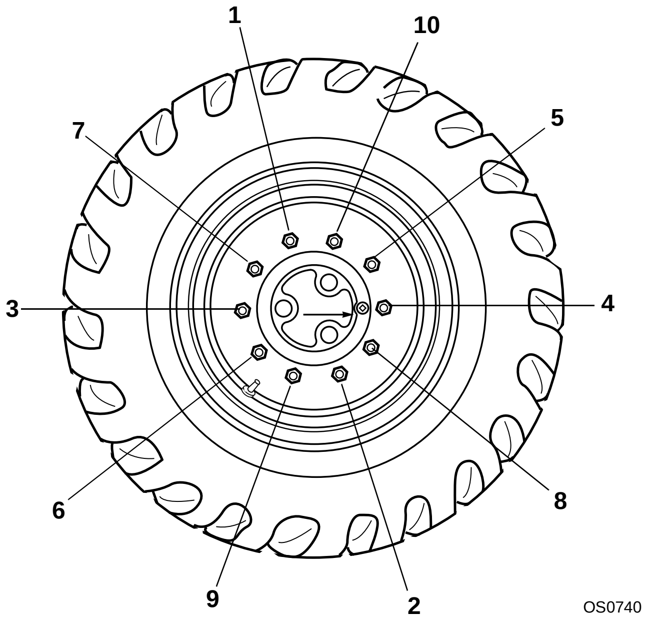


Figure 5–5. Lug nut torque sequence.

12. Carefully remove the jack, hoist or overhead crane and sling supporting the axle.
13. Carefully raise the vehicle using a suitable jack or hoist. Remove the supports from beneath the frame and lower the vehicle to the ground.
14. Remove the blocks from the front and rear of both tires on the other axle.
15. Uncap and connect the steering and brake lines at their axle fittings.

Note: Always use new flat-faced O-rings when connecting hydraulic fittings on the Model 3606.

16. Check wheel end and hydraulic reservoir oil levels.
17. Reactivate the parking brake on the front axle if it was deactivated earlier. Refer to *Section 2* for information on parking brake reactivation.

!	**WARNING:** Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

!	**WARNING:** Risk of serious personal injury. Before starting the engine, tighten all hydraulic connections and remove all tools from the vehicle. **NEVER** check for leaks using any part of the human body; use a piece of cardboard or wood instead. Wear heavy, protective gloves and eye protection.

18. Start the engine. Turn the steering wheel several times lock to lock, operate the frame tilt function several times in both directions, and check the function of the brakes. Check for hydraulic leaks and tighten or repair as necessary.

5.2.2 Axle Service and Troubleshooting

Detailed axle service instructions (covering axle, brakes and wheel-end safety, repair, disassembly, reassembly, adjustment and troubleshooting information) are provided in the *Carraro Model 26.25M Maintenance and Repair Manual*, part number *CA355027* (limited-slip front axle with park brake) and *CA355028* (rear axle).

The axle should be checked, serviced and repaired only by experienced service technicians who are aware of all safety instructions and particular component features.

5.3 WHEELS AND TIRES

!	**WARNING:** Risk of serious personal injury or death. Mismatched tire sizes, ply ratings or mixing of tire types (radial tires with bias-ply tires) may compromise vehicle stability and may result in vehicle tipover.

Welded 13.00 - 24 steel wheels are used on this vehicle.

The specified size and ply rating (star rating for radial tires) for this vehicle is 13.00 - 24, 12 PLY. Make sure the replacement tire is of the same size and ply rating (star rating for radial tires) as all the other tires. A higher ply rating (star rating for radial tires) can be used, but only when all four tires have the same ply rating.

The tires are filled with air only when the vehicle leaves the factory. Hydrofill (a calcium chloride solution), foam fill, or other tire-filling substances are not added to the tires as they alter the weight, stability and handling characteristics of the vehicle, especially under load. Large-bore valve stems are used to help expedite tire inflation and deflation. An inner tube may be used if a tire does not provide an airtight seal. Check tire inflation pressures when the tires are cold. When mounting a tire on the wheel, the tire must be mounted on the wheel respective of the directional tread pattern of the tire; this produces a left or right tire and wheel assembly.

The wheel and tire assemblies must be installed with the directional tread pattern “arrows” facing in the direction of forward travel (Fig. 5–4 and Fig. 5–6).

5.3.1 Removing Wheel and Tire Assembly from Vehicle

WARNING: Risk of serious personal injury. When removing a wheel and tire assembly from the vehicle:

- Position vehicle on a flat, hard surface and support vehicle with approved jack stands or suitable supports.
- Use appropriate safety glasses, safety shoes and appropriate clothing and equipment.
- **DO NOT** wear rings or jewelry. **DO NOT** wear hair or clothing that could become caught in machinery or pinch points such as those created between the tire and the hub.

1. Park the vehicle on a firm, level surface. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the park brake switch, straighten all wheels and shut the engine OFF.
2. Loosen but **DO NOT** remove the lug nuts on the wheel and tire assembly to be removed.
3. Place a suitable jack under the axle pad closest to the wheel being removed. Raise the vehicle and position a suitable support beneath the axle. Allow sufficient room to lower the vehicle onto the support and to remove the wheel and tire assembly.
4. Lower the vehicle onto the support.
5. Remove lug nuts and lug washers in an alternating pattern (Fig. 5–5).
6. Remove the wheel and tire assembly from the vehicle.

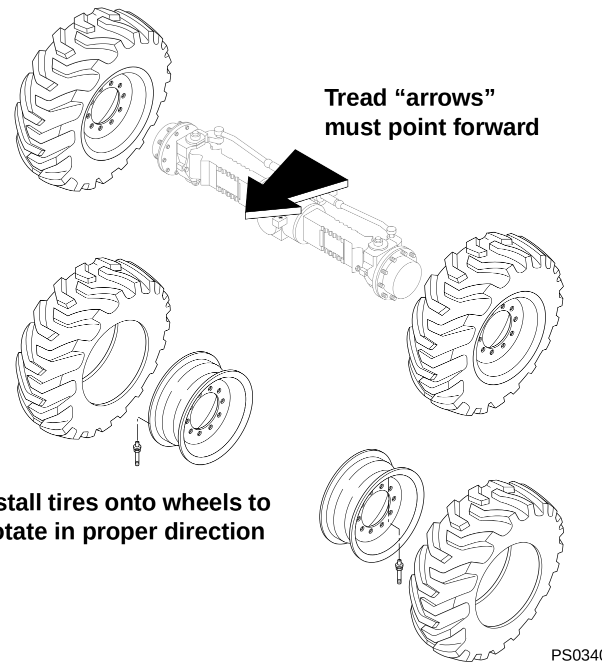


Figure 5–6. Install wheel and tire assemblies with the directional tread pattern “arrows” facing in the direction of forward travel (also see Fig. 5–4).

5.3.2 Wheel Cleaning

WARNING: Dirt and rust prevent the tire from seating properly on the wheel, which could result in an explosive separation. Such explosions could result in severe personal injury or death to the tire installer and to those in the area.

Remove all rust, corrosion, dirt and other foreign material from all metal surfaces. In particular, the bead area (tire-to-wheel mounting surface) must be especially clean.

5.3.3 Wheel Inspection and Replacement

WARNING: NEVER rework, heat, weld or braze a wheel rim.

Clean and inspect the wheel rim before installing a new tire. Verify that the wheel rim diameter exactly matches the tire rim diameter molded into the tire.

Check all surfaces of the wheel for rust, corrosion, cracks, bent flanges, deep marks or gouges. Replace a damaged, worn or cracked wheel. **NEVER** rework, heat, weld or braze a wheel rim.

Inspect the valve core and stem. Replace the entire valve if either component is damaged.

5.3.4 Installing Wheel and Tire Assembly onto Vehicle

IMPORTANT: The wheel and tire assemblies must be installed with the directional tread pattern “arrows” facing in the direction of forward travel (Fig. 5–4).

1. Position wheel onto studs on wheel end of axle.
2. Install wheel lug washers.
3. Install lug nuts and tighten in an alternating pattern (Fig. 5–5). Torque to 370 lb/ft (500 Nm).

5.3.5 Tires

A. Dismounting Tire from Wheel

WARNING: Risk of serious personal injury. When removing a tire from a wheel:

- Use safety chains, or place the wheel and tire assembly in a safety cage when deflating a tire or when inflating a newly mounted tire.
- Deflate tire completely before servicing. **NEVER** attempt to unseat the beads of an inflated tire.
- **NEVER** re-inflate a tire that has been run flat or seriously under-inflated without removing the tire from the wheel and checking for tire and wheel (rim) damage.
- **NEVER** hit a tire or wheel rim with a hammer or **NEVER** object.
- NEVER rework, heat, weld or braze a wheel rim.
- Use the appropriate specialty tools and equipment for mounting a tire to a wheel or for dismounting a tire from a wheel, or have a qualified professional perform the work. **DO NOT** attempt to mount or dismount a tire without the proper tools, training and equipment.

B. Wheel Inspection and Replacement

WARNING: Clean and inspect the wheel rim before installing a new tire. Verify that the wheel rim diameter exactly matches the tire rim diameter molded into the tire.

Inspect the inside of the tire for dirt, foreign material, loose cords, cuts, penetrating objects, and other damage. **DO NOT** use tires with irreparable damage.

Replace any tire that is worn or cut through the cords. When replacing a tire, follow the recommendations of the tire manufacturer.

C. Tire and Wheel Lubrication

WARNING: Risk of serious personal injury. Use an approved tire-mounting lubricant only. **NEVER** use antifreeze, silicones or petroleum-based lubricants.

Prior to mounting the tire on the rim, apply a suitable lubricant to the bead-seat area of the wheel rim and tire bead. Use a lubricant specified by the wheel and tire manufacturers.

D. Mounting Tire onto Wheel

WARNING: Risk of serious personal injury. When mounting a tire onto a wheel:

- Use the appropriate specialty tools and equipment for mounting a tire to a wheel or for dismounting a tire from a wheel, or have a qualified professional perform the work. **DO NOT** attempt to mount or dismount a tire without the proper tools, training and equipment.
- Clean and inspect the wheel rim before installing a new tire. Verify that the wheel rim diameter exactly matches the tire rim diameter molded into the tire.
- Inspect the inside of the tire for dirt, foreign material, loose cords, cuts, penetrating objects, and other damage.**DO NOT** use tires with irreparable damage.
- Use an approved tire-mounting lubricant only. **NEVER** use antifreeze, silicones or petroleum-based lubricants.
- Use safety chains, or place the wheel and tire assembly in a safety cage when deflating a tire or when inflating a newly mounted tire.
- Inflate the tire to the cold-operating pressure recommended by the tire manufacturer.

1. Read, understand and follow the above warning message.
2. Clean, inspect and repair the wheel if necessary. **DO NOT** use a damaged, rusty or cracked wheel.
3. Orient the tire in the direction of forward travel required.
4. Lubricate the inner tire and rim beads with an approved tire-mounting lubricant only. **NEVER** use antifreeze, silicones or petroleum-based lubricants.
5. Push the inner bead of the tire over and around as much of the wheel rim as possible. Use tire irons or a suitable, commercially available pneumatic tire installation machine to work the bead completely over the rim in small increments. Be careful not to damage the bead.
6. Lubricate the outer tire and rim beads with an approved tire-mounting lubricant.
7. Starting opposite the valve hole, use tire irons to work the outer tire bead over the wheel rim. Work the bead completely over the rim in small increments (DO NOT damage the bead).
8. Install a new valve stem into the valve stem hole on the wheel.
9. Center the tire on the wheel. Inflate the tire until it fully seats on the wheel rim or to 35 psi (241,1 kPa). **DO NOT** exceed 35 psi (241,1 kPa). Use an extension hose with a clip-on air chuck and pressure gauge to permit the installer to stand at a safe distance from the tire. Each tire bead will usually snap or pop into place, indicating that the bead is seated.

Note: If either bead should fail to seat at 35 psi (241,1 kPa), the tire may be pinched or another source may be interfering with proper mounting. **DO NOT** increase inflation pressure to seat the beads. Remove the valve core and completely deflate the tire. Break both beads loose from the rim and inspect the tire, rim and inner tube, if applicable. Lubricate the tire bead, install the valve core and repeat the 35 psi (241,1 kPa) inflation procedure until the beads seat properly.

10. After the beads have seated, remove the valve core and fully deflate the tire, but **DO NOT** break the bead or separate the tire from the wheel. Re-install the valve core and inflate the tire to 65 psi (551 kPa).

E. Tire Speed and Road Surface Limitations

The tires on this vehicle are designed for low-speed operations not to exceed 25 mph (40 km/hr). If the vehicle is towed at high speeds, high temperatures may develop under the tread bars, causing a shifting of the tread bars and a weakening of the tire material and cord fabric. There may be no visible evidence of this type of damage, but later, a failure can occur. If tires are to operate for any length of time on a paved road, highway or other hard surface, increase pressure in the tire to the maximum amount recommended by the tire manufacturer to help reduce the chances of damage, or arrange to have the vehicle transported on a flat-bed truck.

F. Care and Storage of Tires

Store unmounted tires vertically, standing on their tread. If stored for an extended period of time, rotate the tires periodically to help reduce stress concentrations in the ground contact area of the tread. Tires should not be stored flat or stacked vertically (“stove piped”) as they will become squashed and distorted, making mounting difficult, particularly for tubeless tires.

Store mounted tires as noted above, but reduce the inflation pressure to 10 psi (68,9 kPa).

Store tires indoors in a cool, dark, dry area away from drafts. Heat and light can cause oxidation on the tire surface, which leads to decomposition (“crazing”) and weather checking. Never store tires on oily surfaces or in contact with oil, grease, petroleum-based substances, antifreeze or solvents. Tires should not be stored near volatile substances. Tires absorb volatile substances, which damage and weaken the tire.

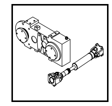
Tires should not be stored outside or in direct sunlight. If there is no other alternative, tires stored outside must be covered or otherwise protected from sunlight, wind and rain. Use an unbroken, opaque covering to help protect tires stored outdoors.

Store tires away from electric motors, generators, arc welders, etc., as these generate ozone, which attacks rubber and causes crazing and weather checking.

Exposure to weather will also cause cracking or crazing of the rubber as well as deterioration of the tire carcass, particularly where rain water is permitted to accumulate in the tire.

When extended vehicle storage is anticipated, the vehicle should be placed on suitable supports with the tires raised out of ground contact. Inflation pressure in the tire should then be reduced to 10 psi (68,9 kPa). Keep the tires out of contact with sunlight, wind and rain as noted above.

If it is not possible to raise the vehicle, increase tire inflation pressure by 25 percent. Move the vehicle periodically to change the location of stress concentrations in the tire ground contact area.



Section 6
Transfer Case and Drive Shafts

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Introduction

The Carraro Model TB 420 transfer case is a single-speed, mechanical unit designed for heavy-duty industrial use. The transfer case is located beneath the frame of the vehicle, mounted to the engine mount (subframe), behind the transmission and ahead of the rear axle.

Torque (twisting power) is transferred through a single output shaft from the Clark-Hurth T 12000 transmission, to the transfer case, and out to the drive axles via two drive shafts, one for the front axle, one for the rear axle. The transfer case is equipped with a set of four gears having a 1:1 drive ratio. The drive shafts are of industrial-duty, welded-steel, tube-type design, supported by Cardan-type cross and bearing tapered roller bearing assemblies (universal joints) secured to flanges and slip yokes.

Detailed transfer case service instructions covering repair, disassembly, reassembly, adjustment and troubleshooting information is provided in the *Carraro Model TB 420 Transfer Box Maintenance and Repair Manual*, Carraro part number CA355026. For example, transfer case shaft bearing adjustment is accomplished during disassembly/reassembly procedures not covered in this manual; consult the Carraro manual for information.

IMPORTANT: To help ensure optimum performance, the drive shaft assemblies are specially balanced as a unit at the factory. When servicing any flange yoke, slip yoke or drive shaft tube, order a complete assembly if components are bent or damaged. Refer to the *Sky Trak International Model 3606 Parts Manual* for ordering information.

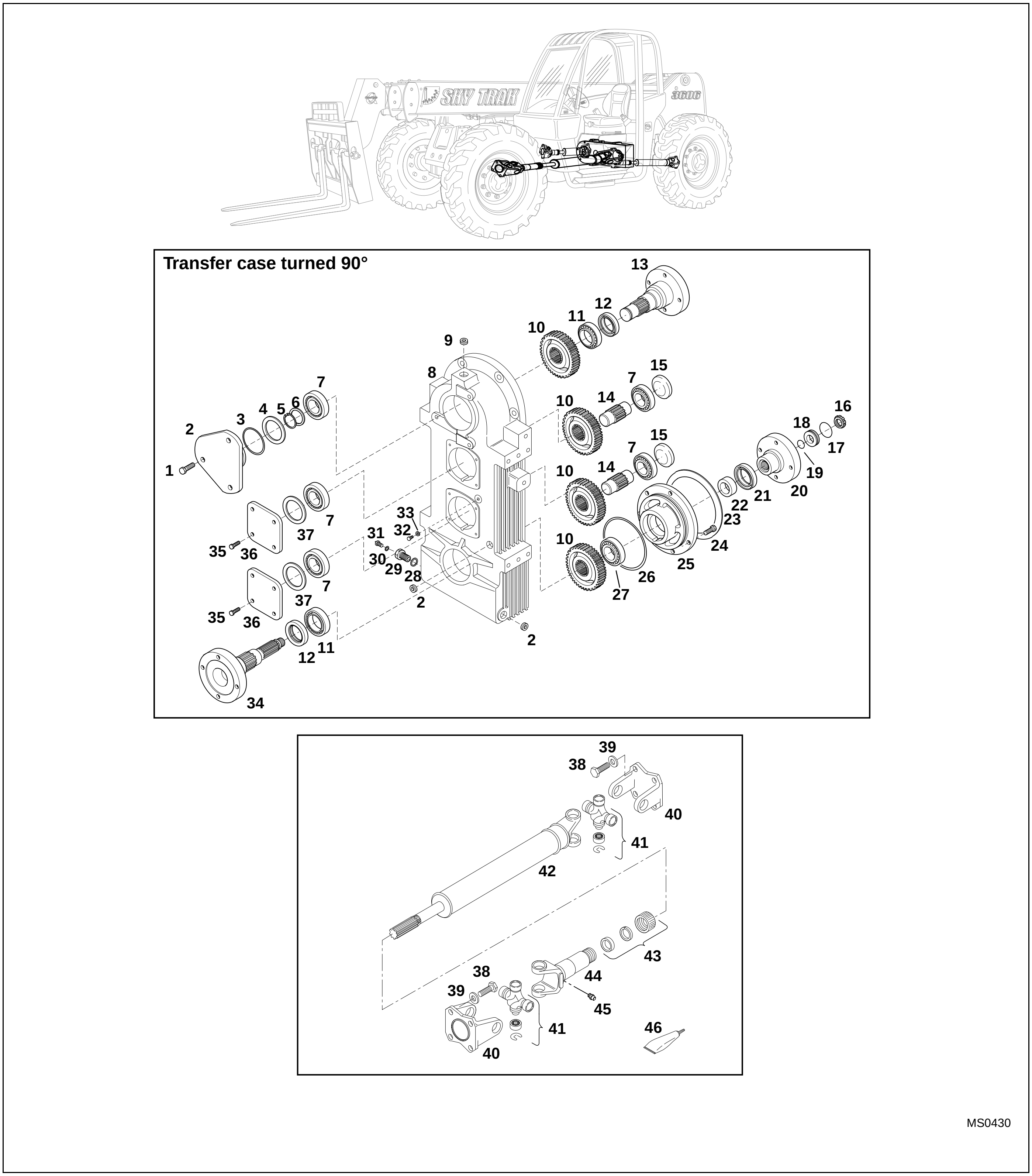
The transfer case and drive shafts should be checked and repaired only by experienced service technicians who are aware of all safety instructions and particular component features.

Legend

1. M12 x 30 Bolt
2. Shaft Cover
3. O-ring
4. Shim (different thicknesses available)
5. Snap Ring
6. Washer, 51 x 40,2 x 3
7. Bearing
8. Transfer Case Housing
9. Oil Plug, M22 x 1,5
10. Gear, Z=37
11. Bearing
12. Oil Seal Ring, 55 x 72 x 10
13. Input Shaft
14. Gear Pin
15. Plug
16. Ring Nut, M25 x 1,5
17. O-ring
18. Centering Ring
19. O-ring
20. Flange
21. Oil Seal Ring, 58 x 80 x 10
22. Spacer, 55 x 35 x 17
23. Shim (different thicknesses available)
24. Bolt, M10 x 30
25. Drop Box Cover
26. O-ring
27. Bearing
28. Washer, 22 x 26 x 1,5
29. Breather Extension
30. Washer, 10 x 14 x 1,5
31. Breather, M10 x 1
32. Bolt
33. Washer, 8 x 12 x 1,5
34. Output Shaft
35. Bolt, M8 x 22
36. Cover
37. Shim (different thicknesses available)
38. Hex Head Cap Screw, M12 x 1,75 x 35
39. Flat Washer, M12
40. Flange Yoke (see note)
41. Cross and Bearing Assembly
42. Tube Assembly (see note)
43. Dust Cap Kit
44. Slip Yoke (see note)
45. Grease Nipple
46. Loctite® #242 (blue)

NOTE: To help ensure optimum performance, drive shaft assemblies are specially balanced at the factory. When servicing any flange yoke, slip yoke, or drive shaft tube, order a complete assembly if components are bent or damaged. Refer to the *Sky Trak International Model 3606 Parts Manual* for ordering information.

General Overview



6.1 GENERAL INSTRUCTIONS

IMPORTANT: To help ensure optimum performance, the drive shaft assemblies are specially balanced as a unit at the factory. When servicing any flange yoke, slip yoke or drive shaft tube, order a complete assembly if components are bent or damaged. Refer to the *Sky Trak International Model 3606 Parts Manual* for ordering information.

Before performing any inspection, maintenance or service operation, thoroughly clean the unit. The transfer case and drive shafts should be checked and repaired only by experienced service technicians who are aware of all safety instructions and particular component features.

Use suitable products to thoroughly clean all disassembled mechanical parts to help prevent personal injury to the worker and damage to the parts. Carefully inspect the integrity of all moving parts (bearings, yokes, tubes, gears, shafts, etc.) and fasteners (nuts, bolts, washers, etc.) as they are subject to major stress and wear. Always replace elastic-lined nuts and any damaged, worn, cracked, seized, or otherwise improper parts that could affect the safe and proper functioning of the vehicle, transfer case and drive shafts.

6.1.1 Further Information

Detailed transfer case service instructions covering repair, disassembly, reassembly, adjustment and troubleshooting information is provided in the *Carraro Model TB 420 Transfer Box Maintenance and Repair Manual*, Carraro part number CA355026.

6.2 SPECIFICATIONS

Refer to *Section 2 General Information, Specifications and Maintenance Instructions*.

6.2.1 Serial Number Plate

The Carraro serial number plate is riveted to the rear of the transfer case above the center of three cover plates. Information specified on the serial number plate includes Drop Box Type (TB 420), Serial Number, Carraro reference number, Oil Specific (oil type), and Ratios (final gear ratio, 1:1). Write this information down in a convenient location to use in transfer case correspondence.

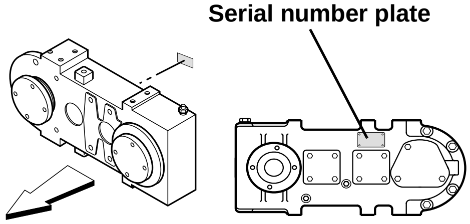


Figure 6–1. Location of Carraro serial number plate.

6.2.2 Technical Data

1.	Transfer Case Type:	Carraro Model TB 420
2.	Description:	Single-speed transfer case
3.	Forward Reduction Ratio:	1:1
4.	Reverse Reduction Ratio:	1:1
5.	Total Reduction Ratio:	1:1
6.	Parking Brake (front axle):	Spring applied, hydraulic release, wet-brake disc type
7.	Input Rotation:	Reversible; clockwise and counter-clockwise
8.	Maximum Input RPM:	3,000
9.	Oil Capacity:	1.5 quarts (1,425 liters)
10.	Oil Type:	SAE 80W90 EP or 80W140, to comply with API GL4, API GL5 (respectively), MIL-L-2105 and MIL-L-2105D Specifications
11.	Dry Weight:	N/A
12.	Bearing Preload:	125-130 lb/ft (55-59 Nm), measured without oil seal ring fitted

(**NOTE:** Transfer case shaft bearing adjustment procedures are not covered in this manual. Refer to the *Carraro Model TB 420 Transfer Box Maintenance and Repair Manual*, Carraro part number CA355026.)

13.	Sealing Compounds:	Loctite® 518, 540, 638

6.3 TRANSFER CASE

6.3.1 Transfer Case Inspection and Service

Whenever servicing the vehicle, conduct a visual inspection of the transfer case. A few moments spent doing this can help prevent further problems and down time later.

Inspect the transfer case in its entirety, especially the main casting, for any cracks, dents, or other damage. Look for oil seepage or leaks around the drive shaft flange mounts. Check all bolts for proper torque.

While the vehicle is under warranty, Sky Trak International does not recommend the servicing of gears, shafts or bearings inside the transfer case. Attempts at disassembly of these internal transfer case items may void the warranty, cause damage to other parts and to the transfer case casting (housing) itself. If internal service of the transfer case is required while still under warranty, return it to Sky Trak International for replacement with a new transfer case pursuant to the Sky Trak International warranty and return policy in effect when the vehicle was purchased.

If service of internal transfer case components is required and the transfer case is not under warranty, refer to the *Carraro Model TB 420 Transfer Box Maintenance and Repair Manual*, Carraro part number CA355026, or consult an authorized Carraro repair center or dealer.

6.3.2 Transfer Case Maintenance

Information regarding checking the transfer case oil level and/or changing the transfer case oil is located in *Section 2.12.13 Transfer Case Oil.*

6.3.3 Transfer Case Removal

1. Level the vehicle, ground the carriage, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut the engine OFF. Allow the engine to cool.
2. Remove the engine mount rear cover plate (Fig. 6–2).
3. Unbolt and remove the two M8 bolts securing the bulkhead fitting bracket to the transfer case. Safely swing the bracket and the hydraulic hoses out of the way to help prevent interference with removing the transfer case and drive shafts. Reinstall the bolts securing the left side of the center transfer case cover plate to the transfer case.

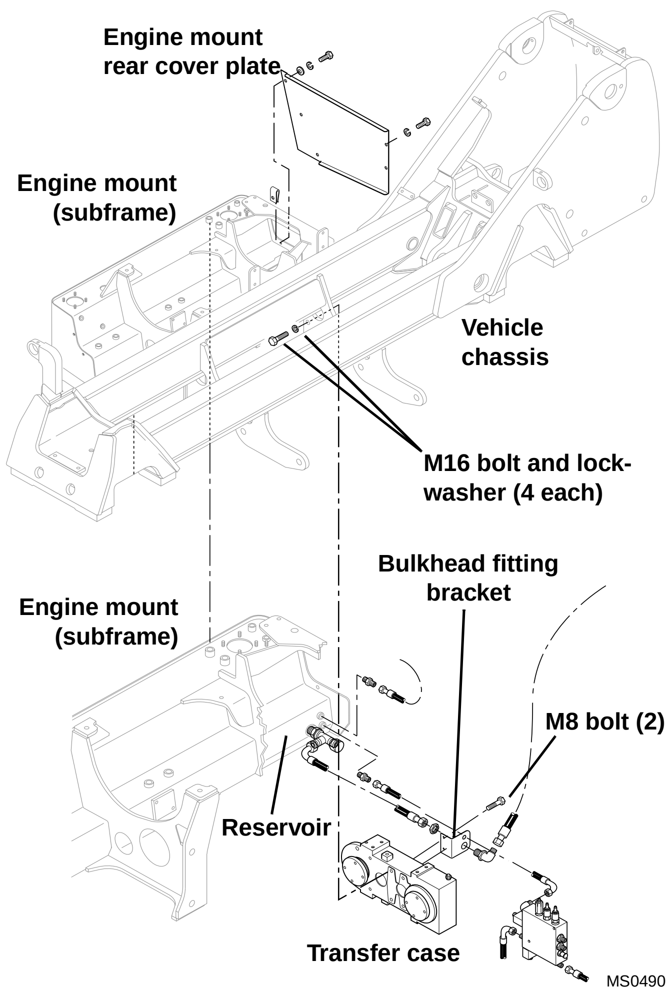


Figure 6–2. Transfer case mounting arrangement.

IMPORTANT: To help ensure optimum performance, the drive shaft assemblies are specially balanced as a unit at the factory. When servicing any flange yoke, slip yoke, or drive shaft tube, order a complete assembly if components are bent or damaged. Refer to the *Sky Trak International Model 3606 Parts Manual* for ordering information.

4. For reference, mark the transmission input drive shaft and flange yoke at the transfer case for return to their original positions upon reinstallation (Fig. 6–3). Unbolt the flange yokes from the transmission and from the transfer box. Move the drive shaft out of the way to allow clearance for transfer case removal.

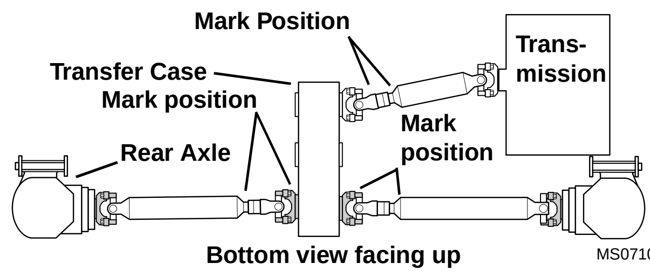


Figure 6–3. Mark the shafts and yokes for return to their original positions.

5. For reference, mark the front and rear axle output drive shafts and transfer case for return to their original positions upon reinstallation (Fig. 6–3). Unbolt the flange yokes from the axles and from the transfer box. Move the drive shaft out of the way to allow clearance for transfer case removal.
6. Position a transmission jack or suitable lifting device beneath the transfer case. Operate the jack to contact and support the transfer case, but **DO NOT** jack up or raise the transfer case itself. Secure the transfer case to the jack or lifting device with a sling.
7. Unbolt the M16 bolts and lock washers (Fig. 6–2) securing the transfer case to the vehicle chassis. Carefully lower the transfer case and remove it from beneath the vehicle.

6.3.4 Internal Transfer Case Repair

Detailed transfer case service instructions covering repair, disassembly, reassembly, adjustment and trouble-shooting information are provided in the *Carraro Model TB 420 Transfer Box Maintenance and Repair Manual*, Carraro part number CA355026.

6.3.5 Transfer Case Installation

IMPORTANT: To help ensure optimum performance, the drive shaft assemblies are specially balanced as a unit at the factory. When servicing any flange yoke, slip yoke, or drive shaft tube, order a complete assembly if components are bent or damaged. Refer to the *Sky Trak International Model 3606 Parts Manual* for ordering information.

1. Secure the transfer case to a suitable transmission jack or lifting device. Raise the transfer case into position under the vehicle (see Fig. 6–2), within the engine mount (subframe) and vehicle chassis. Use new, case hardened 8.8-rated M16 x 2,0 x 75 mm bolts and lock washers to fasten the transfer case to the chassis. Torque to 156 lb/ft (210 Nm).
2. Install the front and rear axle drive shafts to the transfer case (according to the alignment marks made during removal, unless installing new drive shafts). Bolt the flange yokes to the transfer case and axles as required. Use new, Loctite® 242 (blue) coated grade 8.8 M12 x 1,75 x 35 mm hex-head capscrews, flat washers and lockwashers. Torque to 83 lb/ft (113 Nm).
3. Install the transmission to transfer case input drive shaft according to the reference marks made during removal. Bolt the flange yokes to the transfer box and to the transmission with new, Loctite® 242 (blue) coated grade 8.8 M12 x 1,75 x 35 mm hex-head screws, flat washers and lockwashers. Torque to 83 lb/ft (113 Nm).
4. Move the hydraulic hoses into position and bolt the bulkhead fitting bracket to the transfer case using two of the M8 x 22 bolts securing the left side of the center cover plate to the transfer case. Torque to 18 lb/ft (25 Nm).
5. Uncap and connect the hydraulic hoses to the reservoir according to the marks made during removal.
6. Install the engine mount rear cover plate.

6.4 DRIVE SHAFTS

6.4.1 Drive Shaft Inspection and Service

Whenever servicing the vehicle, conduct a visual inspection of the drive shafts and cross and bearing assemblies (universal joints, or U-joints). A few moments spent doing this can help prevent further problems and down time later.

Inspect areas where the drive shaft flange yokes and slip yokes mount to the drive shafts. Attempt to turn each drive shaft in both directions. Look for excessive looseness, missing parts, cracks or other damage. Worn or damaged drive shafts (Fig. 6–4) and cross and bearing assemblies may cause an excessive amount of vibration or noise.

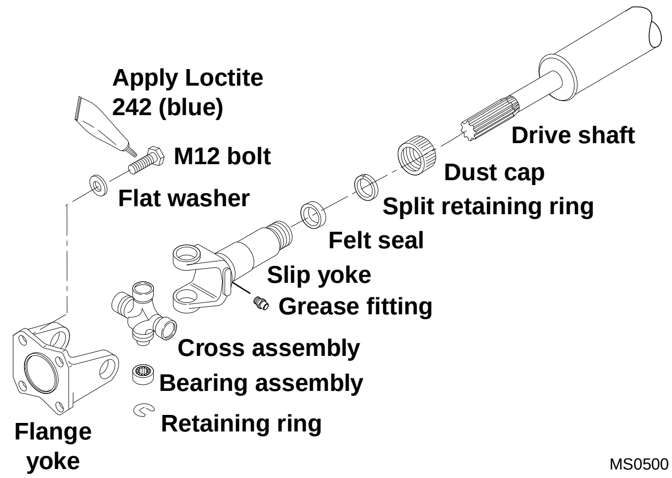


Figure 6–4. Drive shaft construction.

1. Individually inspect each cross, the bearing caps and the needle bearings for signs of wear or for missing parts.

Note: Replace the cross and bearing assembly as a complete assembly if any parts are worn or missing. If all parts of the cross and bearing assemblies are in good condition, pack the bearing caps with a premium grade of multi-purpose wheel-bearing grease. Reattach the bearing cap to the cross, assuring that all needle bearings are present. Then, reassemble the cross and bearing assembly into the drive shaft yoke.

2. Replace the felt seal if worn or damaged.
3. Replace the entire drive shaft assembly if any flange yoke, slip yoke, or drive shaft tube is severely dented or damaged.
4. Cross assemblies should flex and be free from excessive binding. A slight amount of drag or resistance is desirable on a new cross and bearing assembly. Excessive looseness causes unbalance.

6.4.2 Drive Shaft Maintenance

Information regarding checking lubricating the grease fittings on the drive shafts is located in *Section 2.5.3 Lubrication Points (grease fittings)*.

6.4.3 Drive Shaft Removal

IMPORTANT: To help ensure optimum performance, the drive shaft assemblies are specially balanced as a unit at the factory. When servicing any flange yoke, slip yoke, or drive shaft tube, order a complete assembly if components are bent or damaged. Refer to the *Sky Trak International Model 3606 Parts Manual* for ordering information.

Removal of any of the three drive shafts (front, rear, and transmission-to-transfer box) involves fairly straightforward and simple procedures. A typical removal sequence is outlined below:

1. Level the vehicle, ground the carriage, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut the engine OFF.
2. The drive shaft assembly is a balanced assembly. Mark the yoke and axle, transmission, transfer case, and the shaft and slip yoke so that these components can be returned to their original positions when reinstalled. Yokes at both ends of the drive shaft must be in the same plane to help prevent excessive vibration.
3. Remove the M12 hex-head capscrews (Fig. 6–4) and flat washers securing the flange yoke to the transfer box.
4. Remove the drive shaft assembly.

6.4.4 Drive Shaft Disassembly

IMPORTANT: To help ensure optimum performance, the drive shaft assemblies are specially balanced as a unit at the factory. When servicing any flange yoke, slip yoke, or drive shaft tube, order a complete assembly if components are bent or damaged. Refer to the *Sky Trak International Model 3606 Parts Manual* for ordering information.

1. Use an approved, non-flammable cleaning fluid to thoroughly clean the drive shaft assembly with a brush. Wipe dry before disassembling.
2. Place the drive shaft assembly in a bench vise.
3. Use a pair of pliers to pinch the ends of the retaining rings (see Fig. 6–4) securing the cross and bearing assemblies to the yokes. Remove the retaining rings from their grooves in the yokes.

Note: If the retaining rings fail to readily snap out of their grooves in the yokes, tap the end of the bearing cap lightly to help relieve pressure against the retaining rings.

4. Use a soft, round drive pin with a flat face approximately 1/32 of an inch (0,8 mm) smaller than the hole diameter in the yoke to drive on one end of the cross and bearing assembly until the opposite bearing assembly comes out of the yoke.
5. Turn the yoke over and tap on the exposed end of the cross until the opposite bearing assembly comes out of the yoke.
6. Remove the cross from the yoke.
7. Repeat Step 2 through Step 6 to remove the cross and bearing assembly on the other end of the drive shaft.
8. Mark the shaft and slip yoke so that they can be properly aligned when reassembled. Yokes at both ends of the drive shaft must be in the same plane to help prevent excessive vibration.
9. Unscrew the dust cap and slide the slip yoke off of the drive shaft spline.
10. Remove the dust cap, split retaining ring, and felt seal from the shaft assembly.

6.4.5 Drive Shaft Cleaning and Drying

1. Disassemble and clean all parts using an approved cleaning fluid. Allow to dry.
2. Remove any burrs or rough spots from any machined surfaces. Re-clean and dry as required.

6.4.6 Drive Shaft Assembly

1. Install the dust cap (Fig. 6–4), split retaining ring, and felt seal onto the splines of the drive shaft tube assembly.

IMPORTANT: Ensure that the reference marks made before removal on the drive shaft and slip yoke are aligned. The drive shaft and yokes must be in the same plane to help prevent excessive vibration.

2. Align the reference marks made before removal on the drive shaft and slip yoke.
3. Slide the slip yoke (Fig. 6–4) onto the splines of the drive shaft and tighten the dust cap securely. **DO NOT** overtighten or the cap will break.
4. Install the cross and bearing assembly into the yoke.
5. Secure the cross and bearing assembly in the yoke with retaining rings. Pinch each retaining ring with a pliers and insert them into their grooves in the yoke.

6.4.7 Drive Shaft Installation

IMPORTANT: To help ensure optimum performance, the drive shaft assemblies are specially balanced as a unit at the factory. When servicing any flange yoke, slip yoke, or drive shaft tube, order a complete assembly if components are bent or damaged. Refer to the *Sky Trak International Model 3606 Parts Manual* for ordering information.

Installation of any of the three drive shafts (front, rear, and transmission-to-transfer box) involves fairly straightforward and simple procedures.

To install a drive shaft:

1. The vehicle must be level, the carriage grounded, the travel select lever in NEUTRAL (N), the parking brake engaged and the engine OFF.
2. Raise the drive shaft assembly into position. The slip-yoke end of the transmission to transfer case drive shaft mounts toward the transmission. The slip-yoke end of an axle drive shaft mounts toward the axle. If reinstalling a drive shaft previously removed, align the flange yokes according to the alignment marks made during removal.

IMPORTANT: Yokes at both ends of the drive shaft must be in the same plane to help prevent excessive vibration.

3. Secure with new, Loctite® 242 (blue) coated grade 8.8 M12 x 1,75 x 35 mm hex-head screws, hardened flat washers and lockwashers. Torque to 83 lb/ft (113 Nm).

6.4.8 Slip Yokes

A. Slip Yoke Inspection

IMPORTANT: To help ensure optimum performance, the drive shaft assemblies are specially balanced as a unit at the factory. When servicing any flange yoke, slip yoke, or drive shaft tube, order a complete assembly if components are bent or damaged. Refer to the *Sky Trak International Model 3606 Parts Manual* for ordering information.

Replace slip yokes (Fig. 6–4) if worn or damaged.

B. Slip Yoke Removal

IMPORTANT: To help ensure optimum performance, the drive shaft assemblies are specially balanced as a unit at the factory. When servicing any flange yoke, slip yoke, or drive shaft tube, order a complete assembly if components are bent or damaged. Refer to the *Sky Trak International Model 3606 Parts Manual* for ordering information.

To remove a slip yoke:

1. Remove the cross and bearing assembly (Fig. 6–4) securing the slip yoke to the flange yoke (see *Section 6.4.4 Drive Shaft Disassembly* steps 3 through 6).
2. Remove the dust cap, split retaining ring, and felt seal from the other end of the slip yoke.
3. Remove the slip yoke from the drive shaft.

C. Slip Yoke Installation

IMPORTANT: To help ensure optimum performance, the drive shaft assemblies are specially balanced as a unit at the factory. When servicing any flange yoke, slip yoke, or drive shaft tube, order a complete assembly if components are bent or damaged. Refer to the *Sky Trak International Model 3606 Parts Manual* for ordering information.

To install a slip yoke:

1. Install the dust cap (Fig. 6–4), split retaining ring, and felt seal from the other end of the slip yoke.
2. Install the slip yoke onto the drive shaft splines.
3. Install the cross and bearing assembly securing the slip yoke to the flange yoke.

6.5 TROUBLESHOOTING

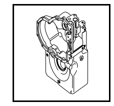
This section provides an easy reference guide covering the most common problems that occur during operation of the transfer case.

Transfer Case and Drive Shaft Troubleshooting

Problem	Cause	Remedy
1. Gear teeth worn or grooved.	1. Insufficient lubrication. 2. Contaminated lubricant.	• Replace gear. • Use correct lubricant. Fill to correct level and change at recommended intervals.
2. Gear teeth overheated (check color of gear teeth).	1. Prolonged operation at high temperatures. 2. Incorrect lubricant. 3. Low oil level. 4. Lubricant contaminated.	• Replace gear. • Use correct lubricant. Fill to correct level and change at recommended intervals.
3. Gear teeth pitted.	1. Intensive use. 2. Insufficient lubrication. 3. Lubricant contaminated.	• Replace gear. • Use correct lubricant. Fill to correct level and change at recommended intervals.
4. Transfer box housing bent or cracked.	1. Insufficient lubrication. 2. Lubricant contaminated. 3. Intensive use. 4. Normal wear. 5. Inadequate bearing preload.	• Replace bearings. • Use correct lubricant. Fill to correct level and change at recommended intervals. • Correct preload.
5. Leaks from oil seal ring.	1. Prolonged operation at high temperatures. 2. Seals fitted incorrectly. 3. Seal lip damaged. 4. Lubricant contaminated.	• Replace seal, and parent surface, if damaged. • Use correct lubricant. Fill to correct level and change at recommended intervals.
6. Worn shaft splines.	1. Intensive use. 2. Loose nut.	• Replace flanges. • Check shaft splines for excessive wear; replace as required.
7. Gear tooth fatigue fracture (check whether the fracture line is well-defined).	1. Intensive use. 2. Continuous overloading.	• Replace gear. • **DO NOT** overload.
8. Worn inside cup or worn tapered roller bearing.	1. Intensive use. 2. Excessive gear end float. 3. Insufficient lubrication. 4. Lubricant contaminated.	• Replace bearing. • Check end float. • Use correct lubricant. Fill to correct level and change at recommended intervals.
9. Noise when coasting; even slight transfer case noise can be heard when vehicle is coasting.	1. Worn splines on input flange, gears or shafts.	• Adjust or replace (see *Troubleshooting* step 10).

Transfer Case and Drive Shaft Troubleshooting

Problem	Cause	Remedy
10. Noise when driving.	1. Pinion and crown-wheel wear. 2. Gears and bearings loose. 3. Gears and bearings worn. 4. Excessive eccentricity of gears. 5. Lack of lubricant. 6. Incorrect lubricant.	1. Replace. 2. Adjust. 3. Replace. 4. Replace. 5. Fill to correct level. 6. Replace.
11. Intermittent noise.	1. Gear damaged. 2. Cover bolts loose.	1. Replace gear. 2. Tighten to proper torque.
12. Continuous noise.	1. Gear teeth damaged. 2. Worn bearings. 3. Shafts or gear splines worn.	1. Replace. 2. Replace. 3. Replace.
13. Excessive transfer case noise.	1. Incorrect installation. 2. Incorrect universal joint assembly. 3. Damaged or worn out transfer case parts. 4. Contamination in the transfer case or incorrect assembly of parts.	1. Remove and reinstall correctly. 2. Check assembly of the universal joint and of the flange. 3. Check the condition of gears, bearings, etc. Replace as required. 4. Look for foreign particles. Check assembly of transfer case components.
14. Friction noise.	1. Fatigued or worn out transfer case parts. 2. Contamination in the transfer case or incorrect assembly of components.	1. Check the condition of gears, bearings, etc. Replace as required. 2. Look for foreign particles. Check assembly of the various parts of the transfer case.
15. Vibration or intermittent noise when travelling.	1. Incorrect installation. 2. Incorrect universal joint assembly. 3. Incorrect use of product.	1. Remove and reinstall correctly. 2. Check assembly of the universal joint and of the flange. 3. Use product correctly.



Section 7
Transmission: Clark-Hurth T 12000

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Introduction

Instructions in this section pertain mainly to general specifications, towing, maintenance information, and transmission removal and installation procedures. Internal transmission service instructions and detailed specifications are provided in the Clark-Hurth T 12000 Powershift Transmission 3, 4, & 6 Speed Intermediate Drop Maintenance and Service Manual, part number SM T12-3,4,6 ID.

The Clark-Hurth T 12000 Powershift Transmission used in this vehicle is available in four-speed (Cummins and Perkins turbocharged engines) and three-speed (Perkins naturally-aspirated engines) configurations. One gear select lever is used for both applications; of course, a fourth gear will not be present if the vehicle is equipped with a three-speed transmission. The “intermediate drop” designation refers to the relative top-to-bottom length of the transmission case, chosen for its compatibility with vehicle chassis and operating requirements. Intermediate drop does not refer to an operational RPM shift or drop.

The flywheel provides engine input to the transmission and, ultimately, out of the transmission to the transfer case and drive axles. Hydraulic power flows through the transmission and torque converter, which is attached to the flywheel. The transmission and hydraulic torque converter operate together to transmit engine power to the axles via the transfer case (“drop box”) and drive shafts. The transmission and torque converter are powered by their own internal hydraulic (“transmission fluid”) system, separate from the vehicle hydraulic system. The transmission is equipped with an external oil cooler, mounted in the engine heat exchanger (radiator).

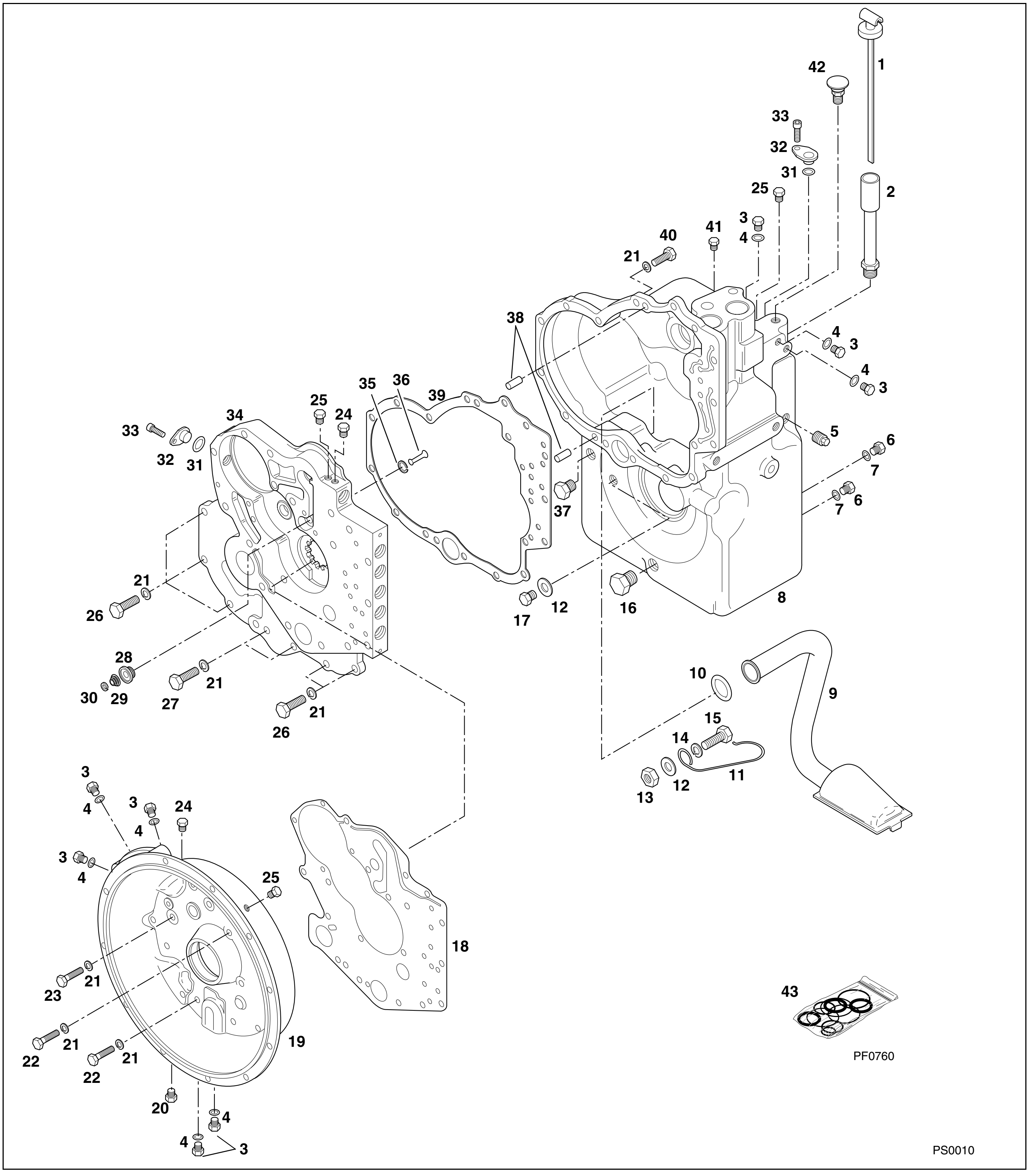
The transmission gear (or “speed”) select lever, an electric shift control, is located on the left side of the steering column in the operator's cab. Movement of the gear select lever energizes the selected transmission shift solenoid valves, which, in turn, direct the transmission fluid under pressure to the selected forward or reverse valve, and to the designated range (gear or “speed”) clutch. Several factors, including terrain, loading, engine RPM, axle/wheel-end gearing and the selected transmission gear determine actual vehicle speed.

To engage the clutch, the gear select lever is placed in the desired directional (forward or reverse) and range (gear or “speed”) position. Gear select lever movement energizes the selected direction and range (gear) solenoids, allowing transmission fluid under pressure to flow through tubes and passages to the selected clutch shafts. Oil sealing rings are located on the clutch shaft; these rings direct oil under pressure through a drilled passageway in the shaft to a desired clutch. Hydraulic pressure forces the piston and discs against the back-up plate. Discs, with edge tangs, clamp against toothed discs on the inner diameter, enabling the hub and the clutch shaft to lock together and drive as a unit, providing output power.

Legend

1. Dipstick Assembly
2. Dipstick Tube
3. Plug
4. O-ring
5. Sensor Port Plug
6. Oil Level Plug
7. Oil Level Plug O-ring
8. Transmission Case
9. Tube and Screen Assembly
10. Oil Supply Tube Seal Ring
11. Oil Supply Tube Retainer Clip
12. Seal Washer
13. Clip Retainer Screw Nut
14. Clip Retainer Screw Washer
15. Retainer Clip Screw
16. Magnetic Drain Plug
17. Screw
18. Converter Housing-to-Plate Gasket
19. Converter Housing
20. Temperature Pickup Plug
21. Lock Washer
22. Screw
23. Screw
24. Plug
25. Plug
26. Screw
27. Screw
28. Safety Valve Seat
29. Safety Valve Spring
30. Poppet Washer
31. Sensor O-ring
32. Sensor Port Plug
33. Speed Sensor Plug Screw
34. Spacer Plate
35. Seat Snap Ring
36. Converter Safety Valve Poppet
37. Drain Back Port Plug
38. Spacer Plate-to-Transmission Case Dowel Pin
39. Spacer Plate-to-Transmission Case Gasket
40. Transmission Case-to-Spacer Plate Screw
41. Filler Plug
42. Air Breather
43. Transmission Gasket and Sealing Kit (services entire transmission)

General Overview



7.1 TRANSMISSION SERIAL NUMBER

The transmission serial number plate (Fig. 7-1) is located on the engine side of the transmission at the bottom right, toward the hydraulic fluid reservoir (tank). Information specified on the serial number plate includes the transmission model number, the transmission serial number and other data. Information on the serial number plate is required in correspondence regarding the transmission.

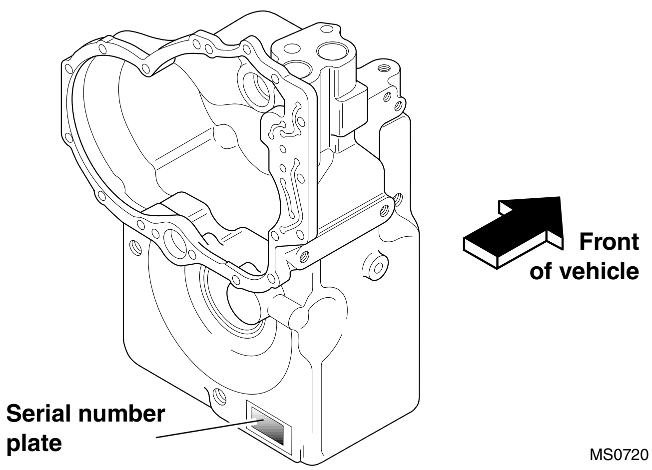


Figure 7-1. The transmission serial number plate is located on the engine side of the transmission at the bottom right, near the hydraulic fluid reservoir (tank).

7.2 TRANSMISSION SPECIFICATIONS

General transmission specifications are found in *Section 2 General Information, Specifications and Maintenance Instructions*. Transmission fluid information is found in *Section 2.5.6 Transmission*.

7.2.1 Transmission Performance Specifications

Performance criteria is based on full throttle engine speed unless otherwise specified or not applicable. The four-speed transmission is used with Cummins and Perkins turbocharged engines. The three-speed transmission is used with Perkins naturally-aspirated engines only.

Travel Speed (standard tires, no load)

	4-SPEED	**3-SPEED**
First gear	4.3 m.p.h. (6,9 km/hr)	4.2 m.p.h. (6,8 km/hr)
Second gear	9.1 m.p.h. (14,6 km/hr)	9.2 m.p.h. (14,8 km/hr)
Third gear	15.3 m.p.h. (24,6 km/hr)	17.7 m.p.h. (28,5 km/hr)
Fourth gear *(if equipped)*	20.8 m.p.h. (33,5 km/hr)	N/A

7.2.2 Transmission Lubrication

A. Transmission Fluid

Complete transmission fluid information is found in *Section 2.5.6 Transmission*.

B. Transmission Fluid (Oil) Capacity

Capacity w/ filter change ... 3.4 gal (12,9 l)
Filter .... 1.5 qt (1,4 l)

7.2.3 Transmission-related Fuse Ratings, Amps

- Display Panel 7.5
- Neutral Relay/Starter 7.5
- Neutral Sense 7.5
- Transmission Solenoids ..7.5
- Transmission Relay 7.5

7.3 TOWING A DISABLED VEHICLE

Towing a disabled vehicle should only be attempted as a last resort, after exhausting all other options. Follow the instructions in *Section 2.13.1 Towing A Disabled Vehicle*. Make every effort to repair the vehicle, and move it under its own power, *before* using the emergency towing procedures outlined in *Section 2.13.1*.

To prepare the vehicle for towing, the parking brake mechanisms at the front axle must be disabled. This will allow the front wheels to rotate freely during emergency towing. See *Section 2.13.2 Disabling the Parking Brakes* and *Section 2.13.3 Reactivating the Parking Brakes* to reactivate the parking brakes after towing and repair.

IMPORTANT: After the vehicle has been towed to a secure location, reactivate the parking brake. Carefully follow the procedures from start to finish. Consult your local Sky Trak distributor or the Sky Trak Service Department if you are unsure about any part of the procedure, or for specific instructions for your particular situation.

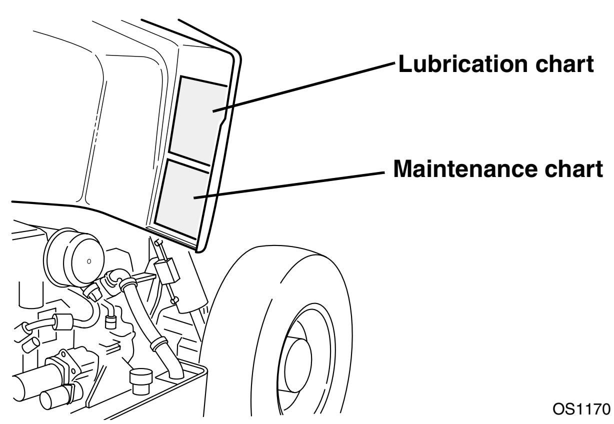


Figure 7-2. The lubrication and maintenance charts are located inside the engine cover.

7.4 TRANSMISSION MAINTENANCE

7.4.1 Maintenance Introduction

⚠	**WARNING:** To help avoid severe burns, **DO NOT** attempt this procedure when the engine, cooling, and hydraulic systems are hot. Wait until they have cooled before proceeding. • Exercise extreme care to help avoid skin rashes, fire hazards and inhalation of harmful vapors when using solvent and caustic cleaners. • Exercise extreme care when using a steam cleaner to help avoid burns.

IMPORTANT: These instructions cover only the routine maintenance of the transmission. Refer to the *Clark-Hurth T 12000 Powershift Transmission 3, 4, & 6 Speed Intermediate Drop Maintenance and Service Manual*, part number *SM T12-3,4,6 ID* for information on transmission diagnosis and internal component replacement. Cleanliness is of extreme importance. Before attempting any repairs, thoroughly clean the exterior of the transmission to help prevent dirt from entering while performing maintenance checks and procedures.

Section 7.4.2 Transmission Maintenance Schedule provides a suggested maintenance schedule with references to pertinent procedures and instructions in this manual. To help prevent transmission problems before they occur, follow the maintenance schedule.

Note: Lubrication and Maintenance Chart decals are located inside the engine compartment cover (see Fig. 7-2). These decals contain a general maintenance schedule that should be followed to maintain the vehicle in good operating condition (refer to *Section 2 General Information, Specifications and Maintenance Instructions*). The same schedule information is presented in *Section 2.12.10 Transmission Oil and Filter* with a detailed account of how to perform the procedures.

7.4.2 Transmission Maintenance Schedule

Complete transmission maintenance information is located in *Section 2.12.10 Transmission Oil and Filter*.

- At ten hour intervals, check the transmission oil level (see *Section 2.12.10 Transmission Oil and Filter*).
- When the vehicle completes its first 50 hours of use, change the transmission filter. Change the filter only; **DO NOT** change the transmission oil *and* the filter at the first 50 hour maintenance level (see *Section 2.12.10 Transmission Oil and Filter*).
- At 1,000 hour intervals, change the transmission oil and filter (see *Section 2.12.10 Transmission Oil and Filter*).

Periodically

Periodically, depending on operating conditions and other factors, back flush the transmission oil cooler, which is part of the radiator (Fig. 7-3). **ALWAYS** back flush the transmission oil cooler after removing the transmission for repair or replacement. The transmission oil cooler *outlet* hose, routed to the lower radiator fitting, is located on the right or hydraulic reservoir side of the transmission. The transmission oil cooler *inlet* hose, routed to the upper radiator fitting, is located on the left or boom side of the transmission, just below the position occupied by the main hydraulic pump (refer to *Section 8A.5.3 Perkins Engine Radiator and Oil Cooler Replacement*, or to *Section 8B.5.3 Cummins Engine Radiator and Oil Cooler Replacement* for replacement procedures). Disconnect and back flush the oil cooler portion of the radiator with oil and compressed air until all foreign material is removed. If necessary, remove the radiator from the vehicle and clean the oil cooler circuit using oil, compressed air and steam.

IMPORTANT: DO NOT use flushing compounds for cleaning purposes.

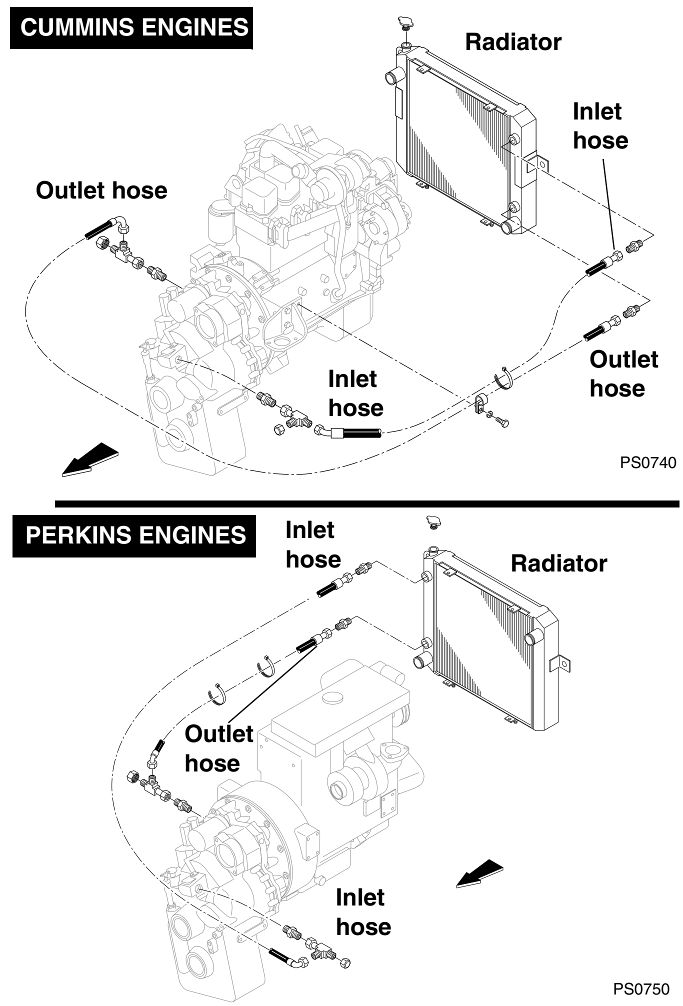


Figure 7-3. Transmission oil cooler hose routings.

7.5 TRANSMISSION REPLACEMENT

IMPORTANT: To help ensure safety and optimum performance, replace the transmission if it is damaged. Refer to the *Sky Trak International Model 3606 Parts Manual* for ordering information.

Cleanliness is of extreme importance. Before attempting to remove the transmission, thoroughly clean the exterior of the transmission to help prevent dirt from entering during the replacement process. Avoid spraying water or cleaning solution onto or near the transmission shift solenoids and other electrical components.

7.5.1 Transmission Removal

WARNING: Risk of severe personal injury. **NEVER** lift a transmission alone; enlist the help of at least one assistant or use a suitable hoist or overhead crane and sling.

1. Level the vehicle, ground the attachment, place the travel select lever in Neutral (N), turn the wheels fully to the left, and engage the parking brake switch.
2. Attach Accident Prevention Tags (see *Section 1 Safety*) to the ignition keyswitch and to the steering wheel.
3. Unlock and open the engine compartment cover. Allow the engine, transmission and hydraulic fluid to cool.
4. Disconnect the battery negative (-) ground terminal to help prevent the engine from starting accidentally.
5. Place a suitable receptacle under the transmission drain plug (Fig. 7-4). Remove the transmission drain plug and allow the transmission oil to drain into the receptacle. Transfer the used transmission oil into a suitable covered container and label the container as used oil. Dispose of properly. Clean and reinstall the transmission drain plug.
6. Disconnect the fuel run solenoid connection on the top of the engine so the pump will not accidentally operate, causing engine crankshaft rotation.
7. Remove the front engine cover plate (Fig. 7-5) from the vehicle frame.
8. Remove the engine air cleaner assembly and the bracket supporting the air cleaner inlet hose at the turbocharger assembly on turbocharged engines. Cover the air inlet to the turbo assembly on Cummins engines. On Perkins naturally-aspirated engines, cover the air intake.
9. Label, disconnect and cap the inlet and outlet hoses at the main hydraulic pump, mounted to the transmission.

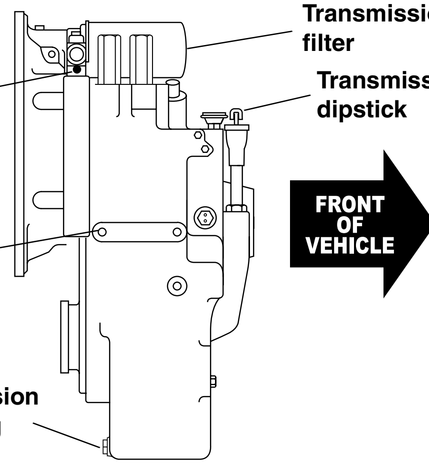


Figure 7-4. Place a suitable receptacle under the transmission drain plug.

10. Remove the main hydraulic pump from the transmission.
11. Label, disconnect and cap the transmission oil cooler inlet and outlet lines at the transmission. The transmission oil cooler outlet hose (Fig. 7-3), routed to the lower radiator fitting, is located on the right or hydraulic reservoir side of the transmission. The transmission oil cooler inlet hose, routed to the upper radiator fitting, is located on the left or boom side of the transmission, just below the position occupied by the main hydraulic pump.

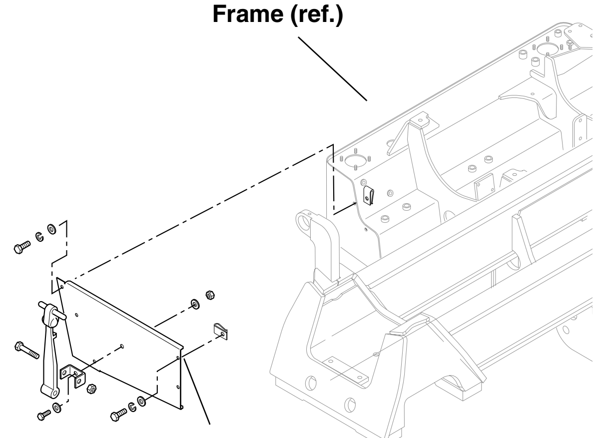


Figure 7-5. Engine front cover plate location.

12. Wipe up any spilled hydraulic and transmission oil.
13. Label and disconnect the transmission shift solenoid wiring harness connectors. Move the wiring harness safely out of the way.

IMPORTANT: To help ensure optimum performance, the drive shaft assemblies are specially balanced as a unit at the factory. Mark the drive shaft yoke at the transmission for return to its original position.

14. Mark the transmission to transfer case drive shaft yoke at the transmission-mounting flange. Remove the M12 hex-head capscrews and lock washers securing the flange yoke to the transmission. Lower the transmission end of the drive shaft safely to the ground, out of the way of the transmission.
15. FOR CUMMINS ENGINES: Working from beneath the vehicle, on the left or boom side of the engine, just behind the engine-to-chassis mount bracket, remove the rubber hole plug and metal cover plate. The plate covers a flywheel inspection hole (Fig. 7-6) on the engine.
    FOR PERKINS ENGINES: Remove the starter. Remove the rubber hole plug above and to the left of the starter opening.

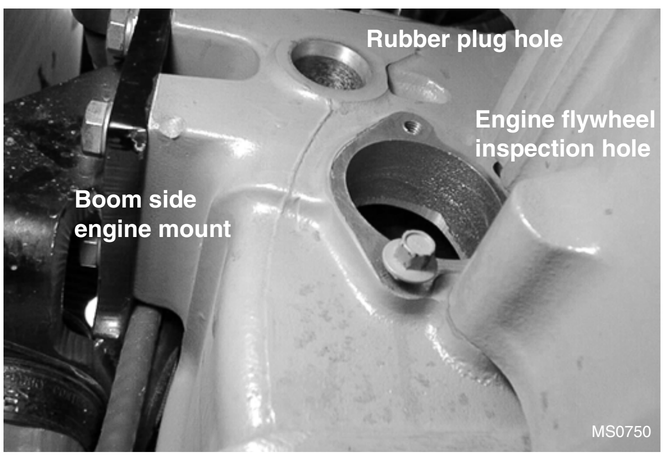


Figure 7-6. Cummins engine flywheel inspection hole.

IMPORTANT: The engine flywheel and the transmission drive plate are factory-balanced units. Mark the flywheel and the transmission drive plate for return to their original positions during re-installation.

16. Insert an engine barring tool into the rubber plug hole opening (Fig. 7-6, Cummins engine shown). If an engine barring tool is not available, use a pry bar or other suitable device to alternately turn and bar the engine flywheel. The tool will be used to advance, then lock, the flywheel to permit removal of the capscrews and washers securing the transmission drive plate to the flywheel.
17. Working through the flywheel inspection hole on the engine (Fig. 7-6, Cummins engine shown), remove the eight 3/8-24 NF x 1-3/4" Grade 8 hex-head capscrews (Cummins engine) or 3/8-24 NF x 2" Grade 8 hex-head capscrews (Perkins engine) and the eight 3/8" washers securing the transmission drive plate to the engine flywheel. Use the engine barring tool to prevent the flywheel from turning while removing the capscrews and washers.
18. Obtain four M12 x 80 mm capscrews with several washers each, as needed, and thread one capscrew/washer set into the tapped holes of each transmission mount bracket boss (Fig. 7-4).
19. Connect an engine lift strap or sling to the M12 x 80mm capscrews, and to a suitable hoist or overhead crane. Avoid sling contact with the transmission shift solenoids and the two modulation valve assemblies mounted on the top of the transmission. Operate the hoist or crane to remove slack from the sling, but **DO NOT** raise the transmission at this time.

IMPORTANT: Mark a capscrew locating hole on the transmission converter housing and the engine flywheel housing to aid in reinstallation, as the sides of the transmission case do not align vertically with the engine or with the chassis (Fig. 7-7).

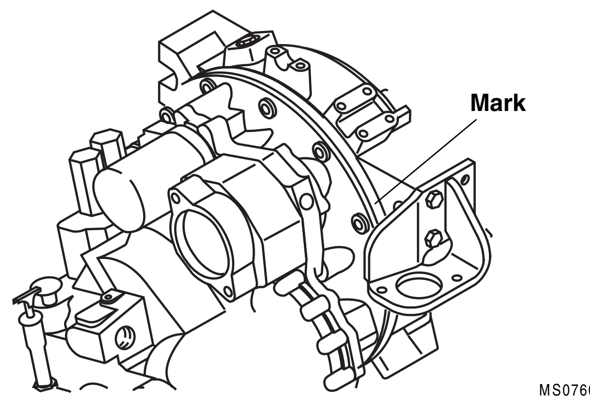


Figure 7-7. Mark a capscrew locating hole on the transmission converter housing and engine flywheel housing.

20. Remove the twelve M10 x 1,5 x 30mm PC8.8 hex-head capscrews and M10 lock washers securing the transmission to the engine. Separate the transmission from the engine.

⚠	**WARNING:** Risk of personal injury. The transmission may move while hoisting it out of the chassis. Carefully move the transmission and adjust the sling as needed. Keep fingers, hands, legs and other body parts clear of the transmission.

21. Carefully remove the transmission from the vehicle. Avoid causing damage to the transmission and to the drive plate. Reposition the lift strap as needed to adjust for load shifting during transmission removal.
22. Lift the transmission clear of the vehicle and lower it onto suitable supports or secure it to a stand built especially for transmission or engine service. Secure the transmission so that it will not move or fall.

23. Remove any external transmission components as required, including the transmission temperature switch (Fig. 7-4).
24. Remove the transmission oil filter and dispose of properly. Clean the filter mounting surface.

The transmission is now ready for inspection and/or further service. Refer to the *Clark-Hurth T 12000 Powershift Transmission 3, 4, & 6 Speed Intermediate Drop Maintenance and Service Manual*, part number *SM T12-3,4,6 ID* for information on transmission diagnosis and internal component repair or replacement.

7.5.2 Transmission Inspection and Internal Repair

The charging pump and flywheel housing may require removal for inspection and further transmission disassembly. Mark the housing for return to its original position as the sides of the transmission case do not align vertically with the engine or with the chassis (Fig. 7-10).

Refer to the *Clark-Hurth T 12000 Powershift Transmission 3, 4, & 6 Speed Intermediate Drop Maintenance and Service Manual*, part number *SM T12-3,4,6 ID* for information on transmission diagnosis and internal component repair or replacement. If replacing the entire transmission, transfer the transmission temperature switch to the replacement transmission. The gear shift solenoids are included with a new transmission.

7.5.3 Transmission Installation

> **WARNING:** Risk of severe personal injury. **NEVER** lift a transmission alone; enlist the help of at least one assistant or use a suitable hoist or overhead crane and sling.

> **WARNING:** The transmission must be properly installed using fasteners of correct size and grade torqued to their specified value.

1. Clean all mating surfaces on both the engine and the transmission prior to assembly.
2. Obtain and thread four M12 x 80 mm capscrews with several washers each, as needed, into each transmission mount bracket boss (Fig. 7-4) to aid in transmission installation.
3. Temporarily thread two M10 x 1,5 x 63,5mm guide studs into the engine flywheel housing (Fig. 7-8). These will be used as alignment dowels.
4. Notice the gaps between the upper and lower halves of the transmission-to-engine bolt circle (Fig. 7-9). Use the gaps as an aid in installation, as the sides of the transmission case do not align vertically with the engine or with the chassis (Fig. 7-10).

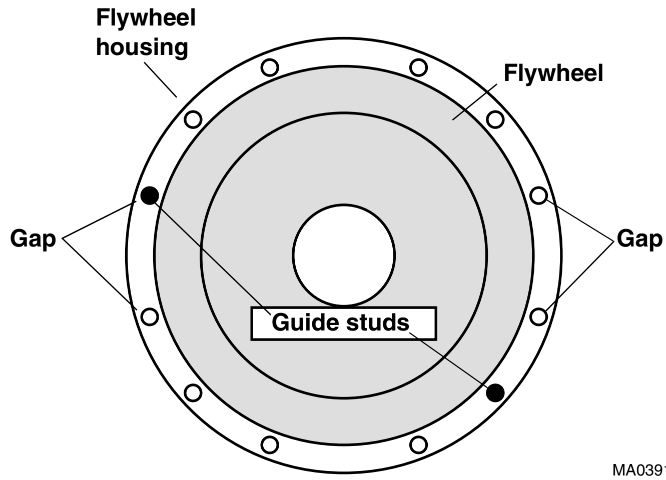


Figure 7-8. Engine flywheel housing guide studs.

5. Use a hoist or overhead crane and sling attached to the M12 x 80mm capscrews. Raise and position the transmission within the chassis. **DO NOT** mount or align the transmission with the engine using the two M10 x 1,5 x 63,5 mm guide studs (dowels) at this time.

IMPORTANT: The flywheel and the torque converter are factory-balanced units. If applicable, align the flywheel and the torque converter with the orientation marks made during the removal procedure.

6. Working through the engine flywheel inspection and access hole on Cummins engines (Fig. 7-6), or through the starter mount hole on Perkins engines, rotate and align a flywheel screw hole with a transmission drive plate weld nut. Obtain and thread a 3/8-24 NF x 4" threaded stud, to serve as a drive plate locating stud, through the flywheel screw hole and into the drive plate weld nut (Fig. 7-9).

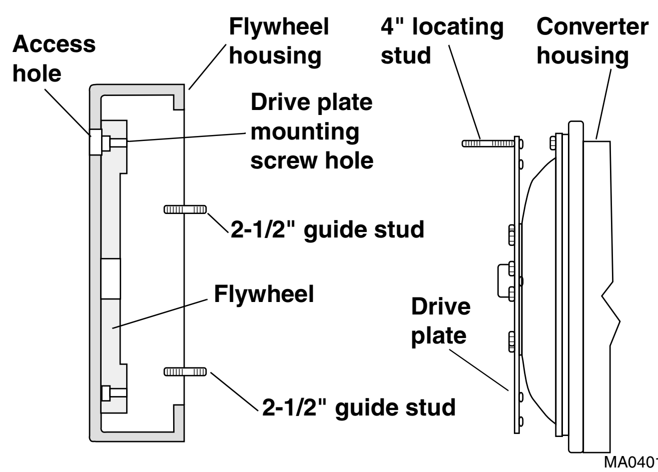


Figure 7-9. Flywheel and drive plate locating studs.

7. Position the transmission onto the two M10 x 1,5 x 63,5 mm guide studs (Fig. 7-8).

8. Begin securing the transmission to the flywheel housing with M10 lock washers and M10 x 1,5 x 30 mm PC8.8 hex-head capscrews. Remove the two M10 x 1,5 x 63,5 mm guide studs (dowels) after several capscrews and washers are installed. When installing the washers and capscrews, tighten bolts evenly in stages and assure that the transmission converter housing installs evenly against the engine flywheel housing.

Note: If the transmission is not aligned properly with the engine, the torque converter will angle against the drive plate and damage will occur when the engine is started.

9. When all twelve capscrews and washers are installed, torque each capscrew to 37 lb/ft (50 Nm).
10. Remove the 3/8-24 NF x 4" threaded stud, serving as a drive plate locating stud (Fig. 7–9), and install a 3/8-24 NF flywheel-to-drive plate capscrew with a 3/8" lock washer in place of the stud. Partially, but not completely, tighten the capscrew.

Note: Due to different flywheel thicknesses, different flywheel-to-drive plate capscrews are used. For the Cummins engine, 3/8-24 NF x 1-3/4" Grade 8 hex-head capscrews are used. For the Perkins engine, 3/8-24 NF x 2" Grade 8 hex-head capscrews are used. Use Loctite® #242 (blue) on all flywheel bolts.

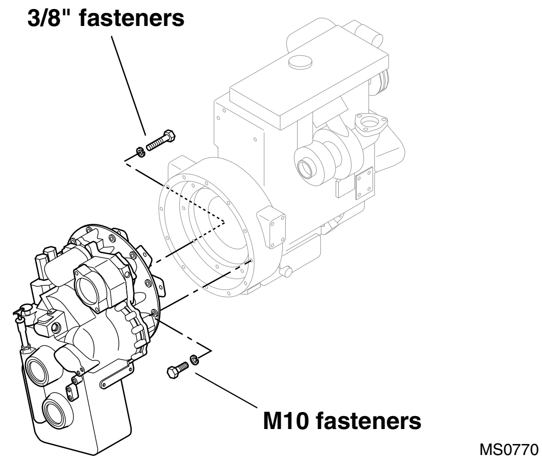


Figure 7–10. Transmission to engine fasteners.

11. Insert an engine barring tool into the sight plug hole (Fig. 7–6, Cummins engine shown) and advance the flywheel to the next screw hole and drive plate weld nut. Continue installing and partially tightening the remaining capscrews and washers and rotating the flywheel and drive plate.
12. When all eight capscrews and washers are installed, torque the capscrews to 26-29 lb/ft (35-39 Nm). This will require torquing each screw and rotating the engine flywheel until all eight of the capscrews are tightened.
13. Remove the hoist or overhead crane and sling.
14. Continue making hook-ups of previously disconnected items, hoses, etc. Before attaching the main pump hose, fill the pump with hydraulic fluid by hand to prime it.
15. Clean the transmission oil filter mounting surface.
16. Apply a clean film of clean 10W motor oil to the new filter gasket. Install the new filter and torque 20-25 lb/ft (27-34 Nm).

Note: 10W motor oil is recommended in most climates; however, 5W20 motor oil may be substituted for use in conditions -30°F to 70°F (-34°C to 21°C) only.

17. Transmission oil may be added through either the fill plug or dipstick holes. Remove the fill plug or dipstick and add approximately 3.4 gallons (12,9 liters) of 10W motor oil. Check the oil level by taking intermittent dipstick readings as outlined in *Checking the Transmission Oil Level*. **DO NOT** overfill. Reinstall the fill plug or dipstick when finished.
18. Coat the drive shaft yoke-to-transmission M12-1,75 x 35 mm hex-head capscrews with Loctite® #242 (blue). Install the yoke with the capscrews and hardened M12 flat washers. Torque the capscrews to 83 lb/ft (112,5 Nm).
19. Connect the wiring harness terminals to the transmission solenoids.
20. Remove the caps and install the transmission oil cooler inlet and outlet lines at the transmission (Fig. 7–3). The transmission oil cooler outlet hose, routed to the lower radiator fitting, is located on the right or hydraulic reservoir side of the transmission. The transmission oil cooler inlet hose, routed to the upper radiator fitting, is located on the left or boom side of the transmission, just below the position occupied by the main hydraulic pump.
21. Attach the main hydraulic pump to the transmission. Align the splined pump drive shaft with the transmission drive and secure the pump to the transmission with 1/2-13 x 1-1/2" hex-head capscrews, 1/2" lock washers and 1/2" plain washers. Torque capscrews to 75 lb/ft (102 Nm).
22. Uncap and install the hydraulic inlet and outlet hoses on the main hydraulic pump.
23. Install the engine air cleaner assembly and the bracket supporting the air cleaner inlet hose at the turbocharger assembly on turbocharged engines.

24. Attach the front engine cover plate (Fig. 7-5) to the vehicle frame. Secure with 5/16-18 x 1" hex-head capscrews, 5/16" lock washers and 5/16" flat washers. Torque capscrews to 18 lb/ft (24 Nm).
25. Connect the fuel run solenoid connector on the top of the engine near the radiator.
26. Wipe up any spilled fluids. Dispose of properly.
27. Connect the battery negative (-) ground terminal at the battery.

7.5.4 After Transmission Service or Replacement

Refer to the *Clark-Hurth T 12000 Powershift Transmission 3, 4, & 6 Speed Intermediate Drop Maintenance and Service Manual*, part number *SM T12-3,4,6 ID* for information on servicing the transmission after overhaul or repair. In general:

1. Check transmission oil level and add oil as required.
2. Install a new transmission filter.
3. Check the torque on the drive shaft yoke retaining bolts. Tighten these M12 bolts to 156 lb/ft (212 Nm).
4. Wear suitable eye protection. When an overhauled or repaired transmission is installed, thoroughly clean the oil cooler lines to and from the transmission.
5. Drain and flush the entire system.
6. Disconnect and clean all transmission lines (Fig. 7-3). When possible, remove transmission lines from the vehicle for cleaning.
7. Thoroughly clean transmission filter screens and cases, and replace transmission filter elements.
8. Back flush the transmission oil cooler portion of the radiator with oil and compressed air until all foreign material is removed. Flushing in the direction of normal oil flow does not adequately clean the cooler. If needed, remove the radiator from the vehicle.

IMPORTANT: DO NOT use flushing compounds for cleaning purposes.

9. Reassemble all components and fill the transmission with clean, fresh 10W motor oil through the filler opening until oil comes up to the FULL port on the transmission housing.
10. Remove the UPPER check plug. Fill the transmission with oil until oil runs from the UPPER oil hole. Replace the filler and the level plug.
11. Run the engine for two minutes at idle (1,000 - 1,100 rpm) rpm to help prime the torque converter and the transmission oil lines.
12. Recheck the level of the fluid in the transmission with the engine running at idle (1,000 - 1,100 rpm).
13. Add 10W motor oil as necessary to bring the fluid level up until it begins to run freely from the UPPER oil level check plug hole. Install the oil level plug. Recheck the oil level when it reaches operating temperature (180-200°F, or 83-94°C).
14. Recheck all drain plugs, lines, connections, etc., for leaks and tighten where necessary.

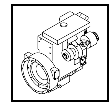
7.6 TRANSMISSION TROUBLESHOOTING

This section provides an easy reference guide covering the most common problems that occur during operation of the transmission.

Transmission Troubleshooting

Problem	Cause	Remedy
1. Low clutch pressure.	1. Low oil level.	1. Fill to the proper level.
	2. Clutch pressure regulating valve stuck open.	2. Clean the valve spool and housing.
	3. Faulty charge pump.	3. Replace the pump.
	4. Broken or worn clutch shaft or piston sealing rings.	4. Replace sealing rings.
	5. Clutch piston bleed valve stuck open.	5. Clean bleed valve thoroughly.
2. Low converter charging pump output.	1. Low oil level.	1. Locate the break and/or stop the leaks.
	2. Suction screen plugged.	2. Clean the suction pump.
	3. Defective oil pump.	3. Replace the pump.
3. Overheating.	1. Worn oil sealing rings.	1. Remove, disassemble and rebuild the converter assembly.
	2. Clogged radiator.	2. Clean radiator.
	3. Worn oil pump.	3. Replace the pump.
	4. Low oil level.	4. Fill to the proper level.
4. Noisy converter.	1. Worn oil pump.	1. Replace the pump.
	2. Worn or damaged bearings.	2. Disassemble the converter and determine which bearing is worn or damaged.
5. Lack of power.	1. Low engine RPM causes converter stall.	1. Adjust the engine RPM check governor.
	2. Worn oil sealing rings.	2. Remove, disassemble and rebuild the converter assembly.
	3. Worn oil pump.	3. Replace the pump.
	4. Low oil level.	4. Fill to the proper level.

Note: For further information, refer to:
Clark-Hurth T 12000 Powershift Transmission
3, 4, & 6 Speed Intermediate Drop
Maintenance and Service Manual
part number *SM T12-3,4,6 ID*.



Section 8A
Engine: Perkins 1004 Series

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Introduction

DISCLAIMER AND SCOPE

These instructions are written for worldwide use. In territories where legal requirements govern engine smoke emission, noise, safety factors, etc., apply all instructions, data and dimensions provided herein in such a way that after maintenance, service and repair of the engine, engine operation does not violate local regulations.

IMPORTANT: These instructions cover only the routine maintenance, removal, installation and troubleshooting of the engine. Refer to the local Perkins Engine Distributor and the applicable Perkins or Perkins Phaser/ Detroit Diesel Phaser/1000 Series engine service manual for assistance with comprehensive engine diagnosis, repair and component replacement.

A gradual running in (break in) of a new engine is not necessary. Full load can be applied to a new engine as soon as the engine is put into service and the coolant temperature is at least 140° F (60°C). Extended light-load operation during the early life of the engine is not recommended. DO NOT run the engine at high, no-load speeds. DO NOT apply an overload to the engine.

Throughout this section, the left or right side of the engine is as viewed from the flywheel end.

Legend

1. Perkins 1004-series Engine
2. Fan Belt
3. Ten-blade, 18"-Suction Fan
4. Alternator, 65 Amp
5. Hex-lock Elastic Nut, 7/16-14
6. Rebound Washer, 7/16"
7. Rear Left Side Engine Mount
8. Engine Mount
9. Hex-head Capscrew, 3/8-16 X 1-1/2, Grade 5
10. Flat Narrow Washer, 3/8"
11. Hex-lock Elastic Nut, 3/8-16
12. Flat Narrow Washer, 7/16"
13. Hex-head Capscrew, 7/16-14 X 3-1/4", Grade 8
14. Hex-head Capscrew, 5/8-11 X 4", Grade 8
15. Flat Narrow Washer, 5/8"
16. Engine Mount
17. Front Left Side Engine Mount
18. Hex-head Capscrew, M12-1,75 X 40 mm Pc 8,8
19. Lockwasher, M12
20. Rebound Washer, 5/8"
21. Hex-lock Elastic Nut, 5/8-11
22. Engine Oil Filter
23. Starter
24. Front Right Side Engine Mount
25. Hex-head Capscrew, 1/4-20 X 3/4"
26. Starter Relay
27. Hex-lock Elastic Nut, 1/4-20
28. Rear Right Side Engine Mount
29. Engine Block Heater

General Overview

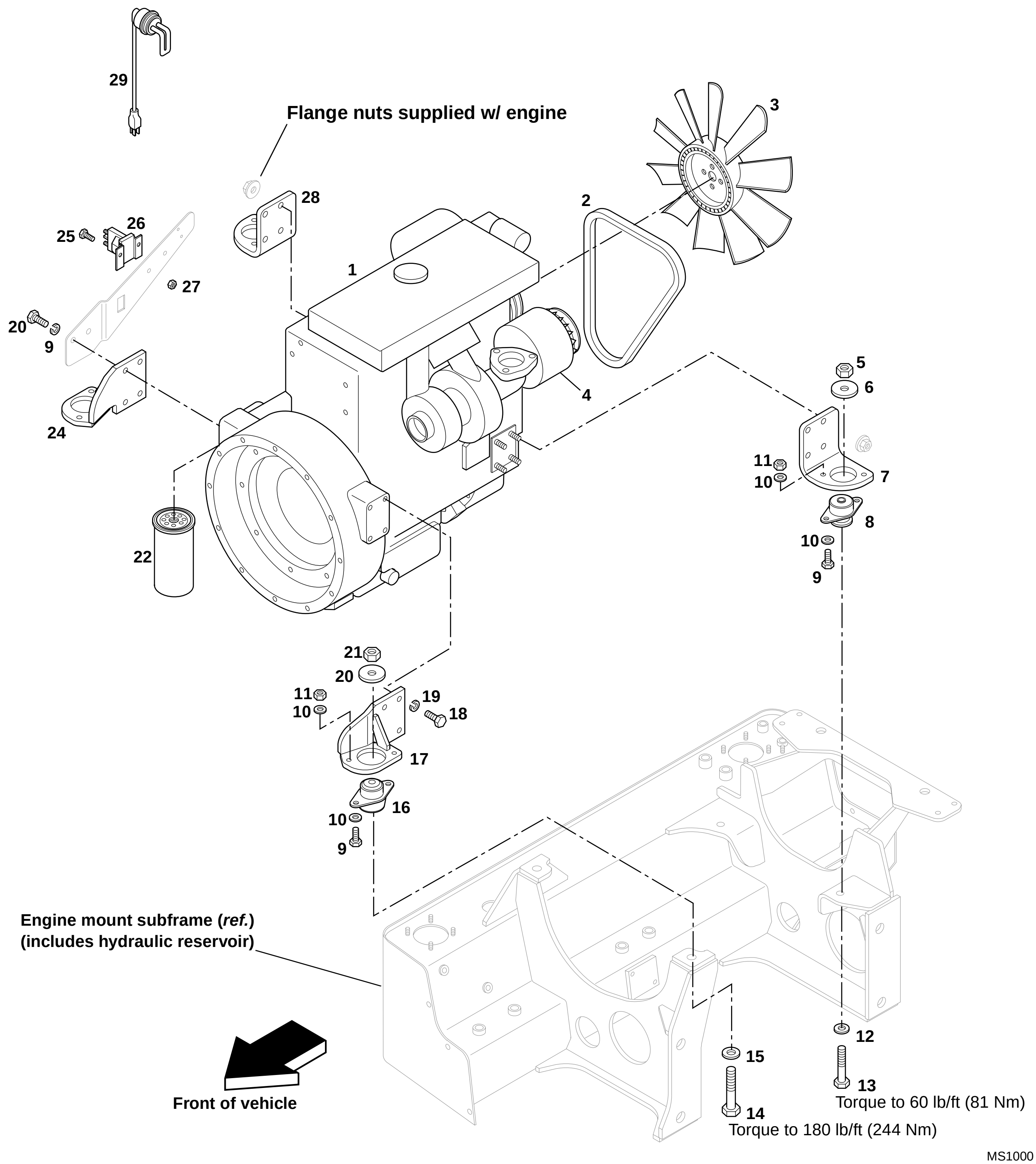


Figure 8A–1. Perkins engine general overview.

8A.1 SAFETY INFORMATION

General Vehicle Operation

WARNING: Before attempting to start the engine and/or operate the vehicle, read the owners/operators manual.
- Before operating the engine and/or the vehicle, install guards and clear all personnel from the immediate area.
- Check that the brakes are fully functional.
- **DO NOT** exceed the stability limits of the vehicle.
- Allow only ONE person to have control of the engine and the vehicle

Preparation

WARNING: Wear protective glasses and protective shoes.
- **Verify that the work area** is capable of supporting the weight of the vehicle and the torque created by any suspended load.
- **DO NOT** work on an engine or a vehicle that is supported ONLY by a hoist or lift jacks. Use blocks or suitable stands.

Engine Operation

WARNING: Operate the engine in a well-ventilated area only. Assure that engine operation will not produce a concentration of toxic emissions.
- **DO NOT** operate the engine in the presence of a fuel spill or gas leak. Such combustible vapors, when drawn into the engine, can cause engine over-acceleration, explosion, fire and extensive personal injury and property damage. Before operating in any hazardous environment, consult a recognized authority (such as the engine distributor) on engine operation in hazardous environments.
- **DO NOT** smoke or operate the engine during refueling.

Cleaning

WARNING: When using steam cleaners and pressure washers, wear protective glasses, gloves and clothing to help prevent personal injury.

WARNING: **NEVER** use gasoline or other flammable materials for cleaning parts. Use only approved cleaning solvents.

Engine Coolant (anti-freeze/anti-boilover)

WARNING: **DO NOT** remove the radiator cap while the engine and coolant are hot. Hot coolant under pressure is dangerous and can injure the eyes and cause severe burns.
- Cooling system corrosion inhibitors contain alkali (chemicals that break down organic substances such as skin and eye tissue). **DO NOT** swallow. Avoid prolonged or repeated contact with corrosion inhibitors. In case of skin con-tact, immediately wash affected area with soap and water. In case of contact with eyes, immediately flood eyes with large amounts of water for a minimum of 15 minutes. Obtain medical assistance immediately. Keep corrosion inhibitors out of the reach of children.
- **DO NOT** use salt water or other corrosive liquid in the cooling system.

Rotating Parts and Fan Blades

WARNING: Keep away from parts which rotate; the fan blades can appear invisible when the fan is rotating.
DO NOT pull or pry on the fan blades. This practice will cause fan failure. Use only approved methods and tools for manually rotating the engine.

Battery

WARNING: Keep sparks and fires away from batteries. Batteries produce hydrogen gas, which can explode and cause severe personal injury and property damage.
Battery fluid can burn the skin and injure the eyes. If you come in contact with battery acid, flush the affected area with large amounts of water and obtain medical assistance immediately.

Engine Oil

WARNING: Engine oil can cause skin disorders and other personal injury. Avoid prolonged or repeated contact with both new and used engine oil.

Diesel Fuel

WARNING: Diesel fuel can cause skin irritation. Use gloves or protective hand lotion when working on the fuel system

Engine Repair

WARNING: Before beginning any adjustments or repairs, place a DO NOT OPERATE tag in the operator's compartment and on the controls, and disconnect the battery negative cable.

- **DO NOT** operate, clean, lubricate or adjust the engine without proper training.
- **NEVER** attempt to perform an adjustment or repair that is not understood.
- Before servicing, relieve pressure in fuel, oil, coolant and hydraulic lines. Obtain medical assistance immediately if a high-pressure jet of fuel, oil, coolant or hydraulic fluid strikes the skin.
- **DO NOT** permit loose clothing, hair, etc., near moving parts.
- Keep *away* from parts which rotate; fan blades can appear invisible when the fan is rotating.
- To help prevent burns, avoid contact with components that remain hot after power is turned off or disconnected.
- Some of the gaskets on the engine obtain asbestos. Breathing asbestos dust is dangerous to health and may cause severe bodily harm. Avoid creating dust and follow local directives for handling and disposing of materials that contain asbestos.

Parts

WARNING: Always use factory-approved fasteners and parts. **DO NOT** use other than factory-approved fasteners and parts when replacement is necessary.

8A.2 PERKINS ENGINE SERIAL NUMBER

The Perkins 1004-series engine serial number is stamped on a label which is fastened to the side of the engine block, toward the vehicle hydraulic reservoir. Information contained in the serial number is required in correspondence regarding the engine.

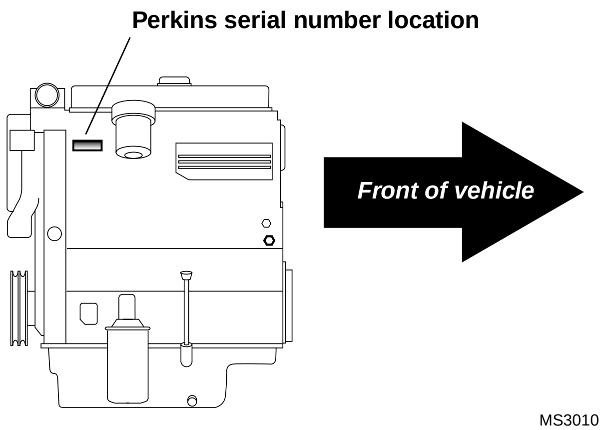


Figure 8A–2. Perkins engine serial number label location.

Supply the engine serial number when communicating about an engine or engine components.

8A.3 PERKINS SPECIFICATIONS AND MAINTENANCE INFORMATION

Engine, coolant and oil specifications and maintenance information appear in *Section 2 General Information, Specifications, and Maintenance Instructions*.

Note: Detailed Perkins engine service instructions (covering disassembly, inspection, internal repair, assembly, adjustment and troubleshooting information) are provided in the appropriate Perkins engine service manual.

8A.4 PERKINS ENGINE STANDARD PRACTICES

Left and Right Sides of the Engine

Throughout this section, the left or right side of the engine is as viewed from the flywheel end.

Cleanliness

Cleanliness is very important during engine repair. Contamination of the engine during repair will reduce the life of an engine. Thoroughly clean the engine and engine compartment area before attempting to service or repair the engine.

DO NOT steam clean the following parts:

- Electrical Components
- Wiring
- Injectors
- Fuel Pump
- Belts and Hoses
- Bearings

During reassembly and inspection, thoroughly clean all parts, and, where present, remove burrs and scales.

Gaskets and O-rings

NEVER re-use a gasket or O-ring. Use new gaskets and O-rings. Thoroughly clean sealing surfaces before installing a new gasket or O-ring. Always install new flat-faced O-rings when servicing hydraulic fittings. Cover any open ports of high-precision components (such as fuel system equipment) exposed by removal or disassembly to help prevent the entry of foreign material.

Capscrews and Metric Parts

When replacing capscrews, always use a capscrew of the same size and strength as the capscrew being replaced. Incorrect capscrews cause engine damage.

Return capscrews removed from the engine to their original locations.

The Perkins 1004 series engine uses parts that are of metric dimensions. Metric capscrews are described, in millimeters, in terms of major thread diameter, distance between threads, and overall length.

Metric capscrew dimensions:

M8 x 1.25 - 25

- 25 — Length, in millimeters
- 1.25 — Distance between threads, in millimeters
- M8 — Major thread diameter, in millimeters

Verify that the correct type of part is used at all times.

8A.5 PERKINS ENGINE COOLING SYSTEM

The Perkins engine cooling system is a closed, pressurized system that consists of coolant passages in the engine, plus the oil cooler, thermostat, water pump, hoses, radiator and radiator overflow bottle. The engine is cooled by the circulation of coolant through passages in the cylinder block and head. Circulation is by thermosiphon action, assisted by an impeller-type water pump, driven by a fan belt from the crankshaft pulley. The water pump bearings are prepacked with a special grease and do not require service. Replace a faulty water pump. General engine cooling specifications and maintenance procedures are listed in *Section 2 General Information, Specifications, and Maintenance Instructions*.

8A.5.1 Radiator Pressure Cap

The cooling system is designed to use a radiator pressure cap to help prevent the coolant from boiling. In addition, the pressure helps to eliminate the formation of steam pockets within the engine and ensures coolant circulation throughout all coolant passageways of the engine. For a 210° F (99° C) system, use a 7 psi (48 kPa) radiator cap. An incorrect or malfunctioning cap can result in the loss of coolant and a hot-running engine.

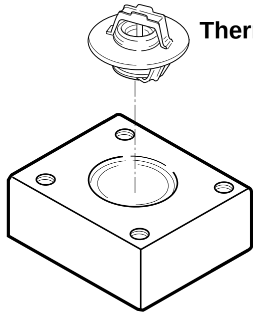


Figure 8A–3. Perkins 1004-series engine thermostat housing (typical).

8A.5.2 Thermostat Replacement

Before considering thermostat replacement, check the coolant level, fan belt tension and dash panel temperature gauge. If the engine seems to take a long time to warm up, the thermostat (Fig. 8A–3) may be stuck in the open position and requires replacement. If the engine runs hot, check the temperature of the upper radiator hose. If the hose is not hot, the thermostat may be stuck in the closed position. If the engine has overheated, performance may suffer, indicating other damage including a leaking cylinder head gasket, cracked cylinder head or block, and/or other internal engine damage.

To replace the thermostat:

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut off the engine.

> **WARNING: DO NOT** attempt this procedure when the engine is hot. Wait for the engine, muffler, and tailpipes to cool down before proceeding. Failure to do so could result in severe burns

2. Unlatch, unlock and open the engine cover. Allow the engine to cool before proceeding. Draining the cooling system while the engine is hot can cause cracks in the engine block.
3. Disconnect the negative (-) battery cable.

> **WARNING: NEVER** remove the radiator cap while the engine is hot. The cooling system is under pressure. Hot coolant can cause severe burns or eye injury. Wear protective clothing and safety glasses.

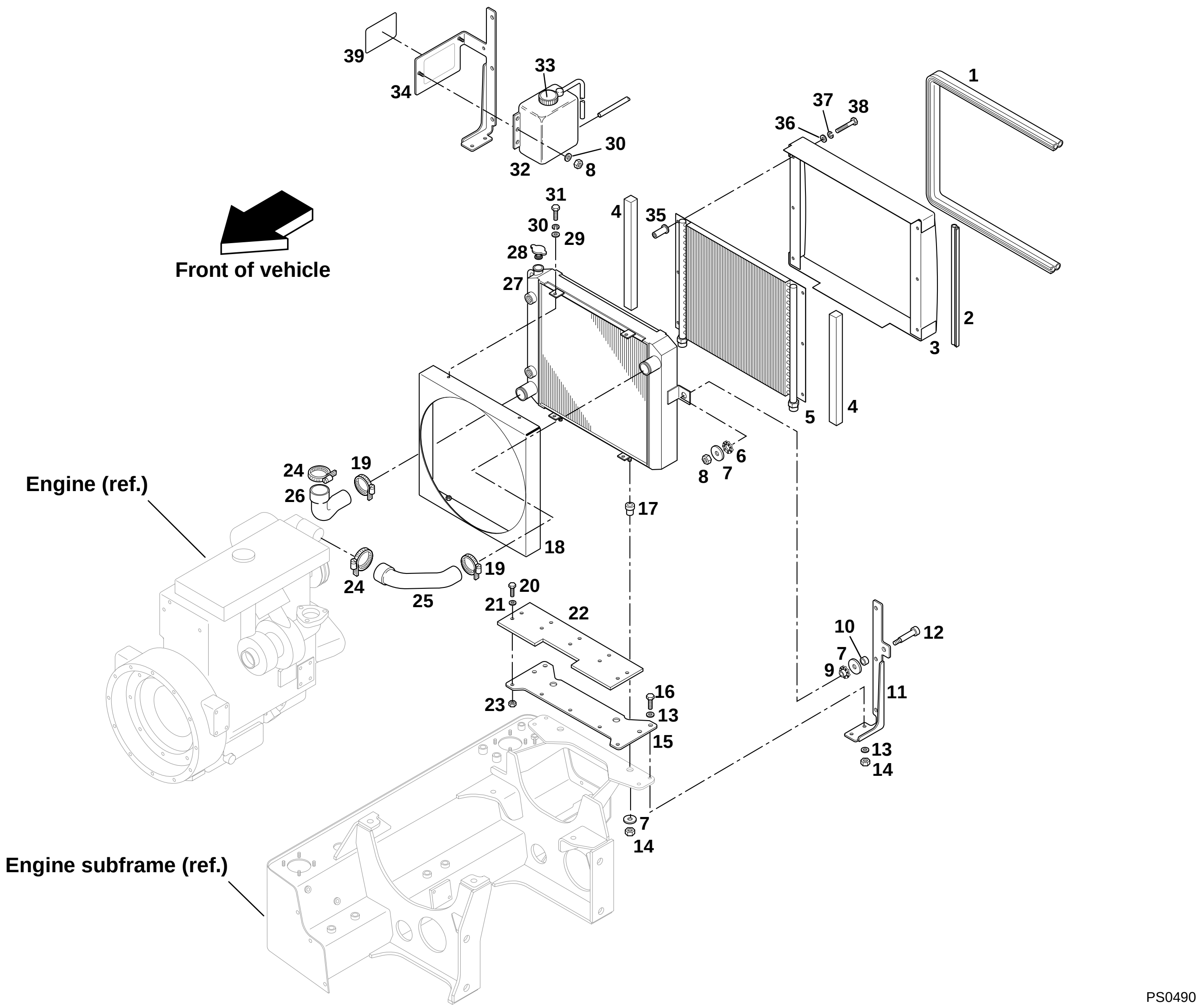
4. Drain approximately two quarts (2 liters) of coolant. Slowly turn the radiator cap to the first stop and allow any pressure to escape. Remove the radiator cap. Place a funnel at the base of the radiator to channel the drained coolant into a container. Open the radiator drain plug or petcock and allow the coolant to drain into the funnel. Transfer the coolant into a properly labeled container. Save for reuse later or dispose of properly. Close the radiator drain plug or petcock.
5. Remove the setscrews securing the water outlet connection to the engine, and remove the water outlet connection and thermostat gasket.
6. Remove the thermostat and clean the gasket surfaces. DO NOT let any debris into the thermostat opening while the thermostat is removed.

IMPORTANT: Always use the correct thermostat. NEVER operate the engine without a thermostat, or engine damage will result.

7. Install the thermostat, gasket and water outlet connection. Secure with the setscrews removed earlier. Tighten the setscrews.
8. Fill the cooling system. Run the engine to operating temperature. Visually check for leaks with the engine running. Check the coolant level in the overflow bottle and fill, or drain, as necessary.

8A.5.3 Perkins Engine Radiator and Oil Cooler Replacement

Before considering radiator or oil cooler replacement for other than obvious damage, conduct a cooling system pressure test, check the coolant specific gravity, coolant level, fan belt tension and dash panel temperature gauge. If the engine runs hot, check the temperature of the upper radiator hose. If the hose is not hot, the thermostat may be stuck in the closed position. If the engine has overheated, performance may suffer, indicating other damage including a leaking cylinder head gasket, cracked cylinder head or block, and/or other internal engine damage.



1. Bulb seal
2. Bulb seal molding
3. Radiator baffle assembly
4. Foam baffle
5. Oil cooler
6. Radiator mount ring
7. Rebound washer, 3/8"
8. Hex-lock elastic nut, 5/16-18
9. Radiator mount bushing
10. Spacer
11. Left radiator bracket
12. Hex-socket head shoulder bolt, 3/8 x 1-1/2 x 5/16-18
13. Wide flat washer, 3/8"
14. Hex-lock elastic nut, 3/8-16
15. Sheet
16. Hex-head capscrew, 3/8-16 x 1-1/2 Grade 5
17. Rubber mount
18. Radiator shroud
19. Radiator hose clamp (radiator)
20. Hex-head capscrew, 1/4-20 x 3/4"
21. Narrow flat washer, 1/4"
22. Baffle
23. Hex-lock elastic nut, 1/4-20
24. Radiator hose clamp (engine)
25. Radiator input hose
26. Radiator return hose
27. Radiator assembly (*incl. item 28*)
28. Radiator cap, 13 psi (89,6 kPa)
29. Narrow flat washer, 5/16"
30. Lockwasher, 5/16"
31. Hex-head capscrew, 5/16-18 x 3/4" Grade 5
32. Overflow tank, 3 qt. (incl. item 33)
33. Cap w/tether
34. Right radiator bracket assembly
35. Well nut
36. Wide flat washer, 1/4"
37. Lockwasher, 1/4"
38. Hex-head capscrew, 1/4-20 x 1-1/2
39. Fan warning decal

Figure 8A–4. Perkins engine radiator and oil cooler.

To remove the radiator and oil cooler:

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut off the engine. Remove the ignition key. Secure accident prevention tags to both the steering wheel and the ignition switch.

WARNING: DO NOT attempt this procedure when the engine is hot. Wait for the engine, muffler, and tailpipes to cool down before proceeding. Failure to do so could result in severe burns.

2. Unlatch, unlock and open the engine cover. Allow the engine to cool before proceeding. Draining the cooling system while the engine is hot can cause cracks in the engine block.
3. Disconnect the negative (-) battery cable.

WARNING: NEVER remove the radiator cap while the engine is hot. The cooling system is under pressure. Hot coolant can cause severe burns or eye injury. Wear protective clothing and safety glasses.

4. Place a suitable container beneath the radiator petcock. Slowly turn the radiator cap to the first stop and allow any pressure to escape. Remove the radiator cap.
5. Place a funnel at the base of the radiator to channel the drained coolant into the container. Open the radiator drain plug or petcock and allow the coolant to drain into the funnel. Transfer the coolant into a properly labeled container. Dispose of properly if coolant needs to be replaced. Close the radiator drain plug or petcock.
6. Loosen clamps (items 19 and 24, Fig. 8A–4) on the radiator return (lower) hose (26). Work the hose off the radiator. Position the hose out of the way to allow radiator removal, or remove the hose from the engine. Inspect the hose and replace if necessary.
7. Loosen clamps (19 and 24, Fig. 8A–4) on the radiator input (upper) hose (25). Work the hose off the radiator. Position the hose out of the way to allow radiator removal, or remove the hose from the engine. Inspect the hose and replace if necessary.
8. Loosen the fan belt and remove the fan (item 3, Fig. 8A–1). Remove the four hex-head capscrews (not shown) and lockwashers (not shown) securing the fan (3) to the engine water pump.
9. At the radiator, disconnect and cap the transmission inlet and outlet hoses (Fig. 8A–5).

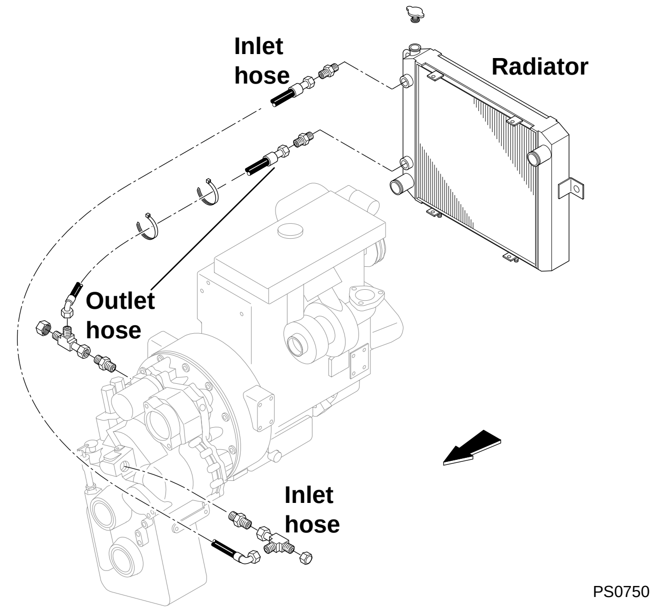


Figure 8A–5. Transmission hose routings.

10. Working above the radiator, remove two 5/16-18 x 3/4" Grade 5 hex-head capscrews (item 31, Fig. 8A–4), 5/16" lockwashers (30) and 5/16" narrow flat washers (29) securing the radiator (27) at the upper mounting tabs to the radiator shroud (18). The radiator shroud contains 5/16" weld nuts that retain the capscrews.
11. Working below the radiator, remove two 5/16-18 x 3/4" Grade 5 hex-head capscrews (31), 5/16" lockwashers (30) and 5/16" narrow flat washers (29) securing the radiator at the lower mounting tabs to the radiator shroud (18).
12. Working from beneath the radiator, remove two 3/8-16 hex-lock elastic nuts (14), 3/8" rebound washers (7) and rubber mounts (17) secured to the welded studs on the bottom of the radiator.
13. At the sides of the radiator, remove the 3/8 x 1-1/2 x 5/16-18 hex-socket head shoulder bolts (12), spacers (10), 3/8" rebound washers (7), radiator mount bushings (9), radiator mount rings (6), and 5/16-18 hex-lock elastic nuts (8) securing the radiator at its side mounting tabs to the radiator brackets (8 and 34). Carefully remove the radiator from the vehicle.
14. At the bottom of the hydraulic system oil cooler (Fig. 8A–6), disconnect and cap the 90° elbow. Remove and discard the flat-faced O-ring seal. Disconnect and cap the 3/4" I.D. x 28" hose.
15. Remove the six 1/4-20 x 1-1/2" hex-head capscrews (38, Fig. 8A–4), 1/4" lockwashers (37), 1/4" flat wide washers (36) and well nuts (35) securing the radiator baffle assembly (3) to the oil cooler (5).

16. Remove the oil cooler (Fig. 8A–6).

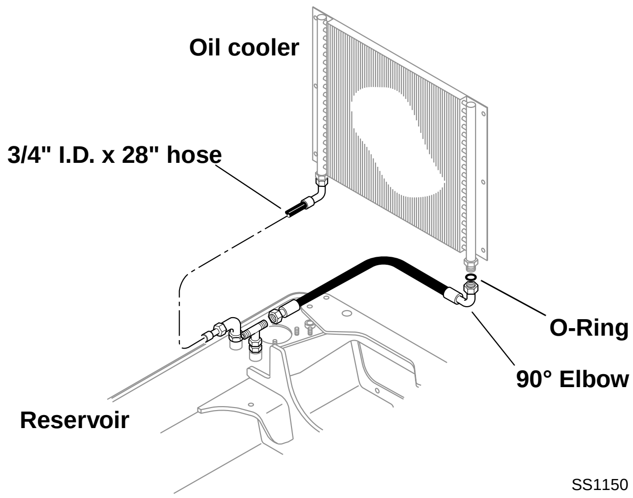


Figure 8A–6. Perkins oil cooler hose routings.

17. Remove, inspect and replace the seal bulb (1), seal bulb moulding (2), and foam baffles (4) as required.

Radiator and Oil Cooler Installation

1. Install the seal bulb (item 1, Fig. 8A–4), seal bulb moulding (2), and foam baffles (4) as required.
2. Position the oil cooler (5) within the radiator assembly baffle (3).
3. Install the six 1/4-20 x 1-1/2" hex-head capscrews (38, Fig. 8A–4), 1 /4" lockwashers (37), 1/4" flat wide washers (36) and well nuts (35) securing the radiator baffle assembly (3) to the oil cooler (5). Torque to 9 lb/ft (12 Nm).
4. At the bottom of the hydraulic system oil cooler (Fig. 8A–6), install a new flat-faced O-ring seal in the 90° elbow and secure the elbow fitting to the cooler. Use a back-up wrench and torque the elbow fitting to 155-165 lb/ft (210-224 Nm).
5. Secure the 3/4" I.D. x 28" hose (Fig. 8A–6) to the oil cooler.
6. Carefully place the radiator into position at the oil cooler. As required, place two foam baffles (item 4, Fig. 8A–4) between the radiator and the oil cooler.
7. At the sides of the radiator, install the 3/8 x 1-1/2 x 5/16-18 hex-socket head shoulder bolts (item 12, Fig. 8A–4), spacers (10), 3/8" rebound washers (7), radiator mount bushings (9), radiator mount rings (6), and 5/16-18 hex-lock elastic nuts (8) securing the radiator at its side mounting tabs to the radiator brackets (11 and 34).
8. Working from beneath the radiator, install two 3/8-16 hex-lock elastic nuts (14), 3/8" rebound washers (7) and rubber mounts (17) secured to the welded studs on the bottom of the radiator. Torque to 31 lb/ft (42 Nm).
9. Working below the radiator, install two 5/16-18 x 3/4" Grade 5 hex-head capscrews (31), 5/16" lockwashers (30) and 5/16" narrow flat washers (29) securing the radiator at the lower mounting tabs to the radiator shroud (18). Torque to 18 lb/ft (24 Nm).
10. Working above the radiator, install two 5/16-18 x 3/4" Grade 5 hex-head capscrews (31), 5/16" lockwashers (30) and 5/16" narrow flat washers (29) securing the radiator at the upper mounting tabs to the radiator shroud (18). The radiator shroud contains 5/16" weld nuts that retain the capscrews. Torque to 18 lb/ft (24 Nm).
11. Uncap and connect the transmission inlet and outlet hoses (Fig. 8A–5).
12. Install the fan (item 3, Fig. 8A–1) on the water pump pulley on the front of the engine. Secure with four hex-head capscrews (not shown) and lockwashers (not shown). Install the fan belt.
13. Install clamps (19 and 24, Fig. 8A–4) on the radiator input (upper) hose (25). Work the hose onto both the engine and then the radiator. Tighten the clamps.
14. Install clamps (19 and 24) on the radiator return (lower) hose (26). Work the hose onto both the engine and then the radiator. Tighten the clamps.

Fill the cooling system. Run the engine to operating temperature. Visually check for leaks with the engine running. Check the coolant level in the overflow bottle and fill, or drain, as necessary.

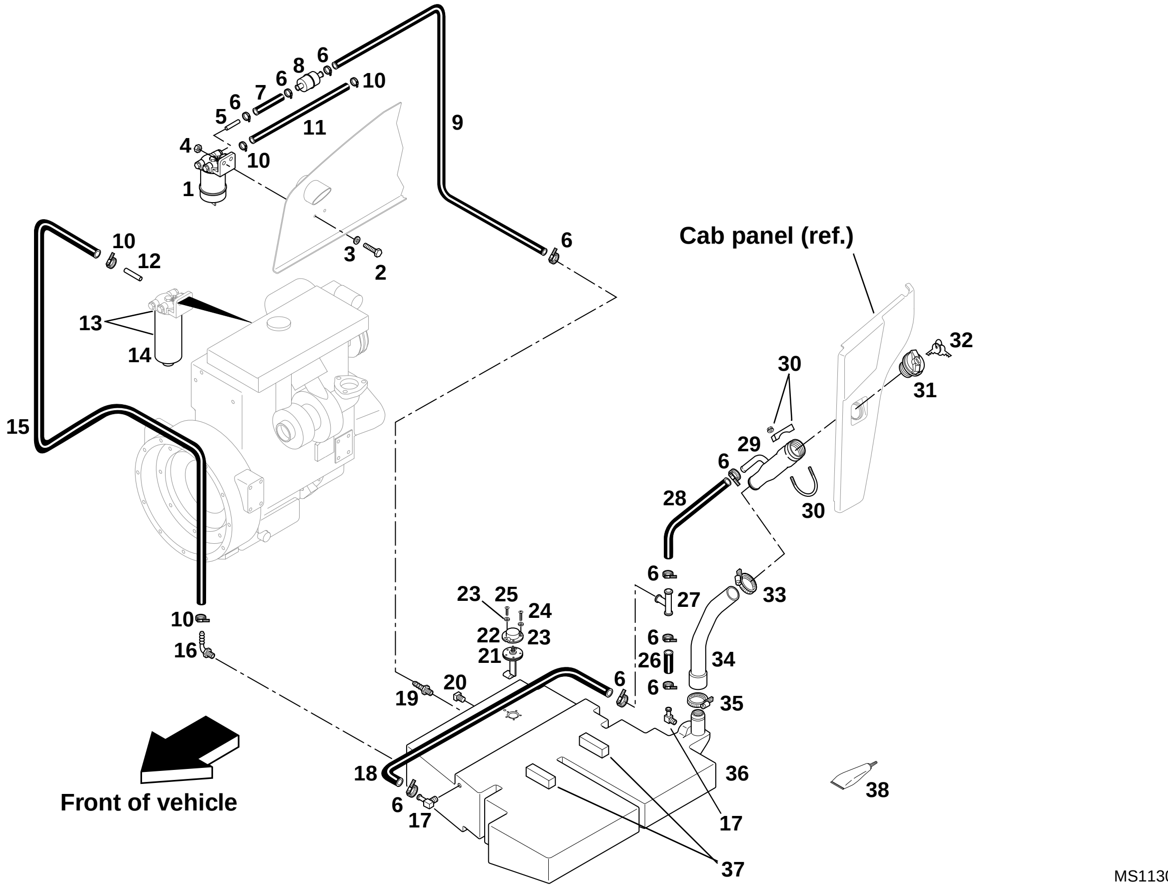
8A.6 PERKINS ENGINE ELECTRICAL SYSTEM

Refer to *Section 10 Electrical System* for information covering the Perkins engine electrical system, including the starter, alternator and primary wiring.

8A.7 PERKINS ENGINE FUEL SYSTEM

The Perkins engine fuel system includes a fuel tank (item 36, Fig. 8A–7), fuel level sender (21) and dash panel gauge, fuel strainer (8), fuel lift pump, fuel filter (14), and fuel supply and return lines.

The threaded fuel filler (29) has a keyed fuel cap (31) and permits entry of diesel fuel into the tank. The fuel level sender (21) and dash panel gauge are described in *Section 10 Electrical System*. A fuel supply hose (9) carries fuel from the tank to the engine lift pump and then under pressure to the fuel filter (14). Filtered fuel is directed to the fuel injection pump and to the individual fuel injectors. Surplus fuel at the fuel injector pump is returned to the tank via the fuel return hose (15).



1. Fuel/water separator
2. Hex-head capscrew, 5/16-18 x 1-1/4"
3. Flat narrow washer, 5/16"
4. Hex-lock elastic nut, 5/16-18
5. Tube union, 5/16"-13/32"
6. Hose clamp, SAE Type F
7. Fuel hose, 3/8" x 4"
8. Fuel strainer
9. Fuel tank-to-engine hose, 3/8" x 68"
10. Mini hose clamp, 7/32" diameter
11. Fuel hose, 5/16" x 18"
12. Tube union, 1/4"-5/16"
13. Fuel filter assembly (incl. Item 14)
14. Fuel filter
15. Fuel return hose
16. 90° hose barb elbow, #5-6P*
17. 90° hose barb elbow, #10-6P*
18. Fuel breather hose
19. Hose barb coupling, #6-6P*
20. Square head black plug, MI #6P*
21. Fuel sender w/ gasket
22. Fuel sender cover
23. Lockwasher, #10
24. Pan-head screw, #10-24 x 3/4"
25. Pan-head screw, #10-24 x 5/8"
26. Fuel breather hose
27. Beaded hose tee
28. Fuel breather hose
29. Fuel filler
30. U-type muffler clamp, 2"
31. Fuel cap w/keys (incl. Item 32)
32. Keys (set of two)
33. Upper hose clamp, SAE Type F
34. Fuel filler hose
35. Lower hose clamp, SAE Type F
36. Fuel tank
37. Gasket
38. Pipe thread sealant w/Teflon®, 8oz; use w/ ALL threaded fittings

Figure 8A–7. Perkins engine fuel system.

8A.7.1 Diesel Fuel

Fuel represents a major portion of vehicle operating costs and therefore must be used efficiently. Always use a premium brand of high-quality, clean diesel fuel. Low cost, inferior fuel can lead to poor performance and expensive engine repair.

Note: Use only diesel fuel designed for diesel engines. Some heating fuels contain harmful chemicals that can seriously affect engine efficiency and performance.

IMPORTANT: Due to the precise tolerances of diesel injection systems, keep the fuel clean and free of dirt and water. Dirt and water in the fuel system can cause severe damage to both the injection pump and the injection nozzles.

Use ASTM No. 2 D fuel with a minimum cetane rating of 40. No. 2 diesel fuel gives the best economy and performance under most operating conditions. Fuels with Cetane numbers higher than 40 may be needed in high altitudes or extremely low ambient temperatures to help prevent misfiring and excessive smoking.

Inform the owner/operator of the vehicle to use No. 2 D diesel fuel, unless ambient temperatures are below 32° F (0° C). When temperatures are below 32° F (0° C), a blend of No. 1 D and No. 2 D fuels, known as “winterized” No. 2 D, may be used.

Note: No. 1 D fuel may be used, however, fuel economy will be reduced.

WARNING: DO NOT mix gasoline or alcohol with diesel fuel. The mixture can cause an explosion.

Use a low-sulfur content fuel with a cloud point (the temperature at which wax crystals form in diesel fuel) at least 10° below the lowest expected fuel temperature.

The viscosity of the fuel *must* be kept above 1.3 centistrokes to provide adequate fuel system lubrication.

Note: When using diesel fuel with a sulfur content below 1.3 percent, the filter change interval must be reduced by 75 hours. The use of fuel with a sulfur content above 1.3 percent is not recommended.

8A.7.2 Fuel Tank

The fuel tank (item 36, Fig. 8A–7) is located directly beneath the operator’s cab.

A. Removal

The operator’s cab must be partially removed in order to remove the fuel tank. Follow the directions for removing the operator’s cab in *Section 4 Cab, Covers and Mirrors*, then remove the fuel tank.

If a leaking fuel tank is suspected, check that all fuel tank inlets and outlets are not the cause of the leak before removing the cab and the fuel tank from the vehicle.

B. Disassembly

1. Remove the four #10-24 x 3/4" pan-head screws (item 24, Fig. 8A–7), the #10-24 x 5/8" pan-head screw (25), and the five #10 lockwashers (23) securing the fuel sender cover (22) and fuel sender with gasket (21) to the fuel tank.
2. Remove the black MI #6P square-head plug (20), the #6-6P hose barb coupling (19), the #5-6P 90° hose barb elbow (16) and both #10-6P 90° hose barb elbows (17).

C. Cleaning and Drying

If contaminated fuel or foreign material is in the tank, the tank can usually be cleaned. Replace a leaking or damaged tank. DO NOT attempt to repair, plug or patch a leaking or damaged fuel tank. The tank is manufactured using an injection molding process and cannot be repaired.

To clean the fuel tank:

1. Have a dry chemical (Class B) fire extinguisher near the work area.

WARNING: NEVER drain or store fuel in an open container due to the possibility of explosion or fire. Discard the fuel in an approved manner.

2. Invert and tilt the tank from side to side. Safely drain any fuel into a suitable container. Dispose of properly.
3. Clean the fuel tank with a high-pressure washer, or flush the tank with hot water for five minutes. Invert the tank, tilt it from side to side, and drain the water.
4. If necessary, add a diesel fuel emulsifying agent to the tank. Refer to the manufacturer’s instructions for the correct emulsifying agent-to-water mixture ratio. Refill the tank with water, and agitate the mixture for 10 minutes. Drain the tank completely.

5. Refill the fuel tank with water until it overflows. Completely flush the tank with water. Empty the tank and allow it to dry completely.

D. Inspection

1. Inspect the fuel tank thoroughly for any cracks, slices, leaks or other damage. Replace a leaking or damaged tank. DO NOT attempt to repair, plug or patch a leaking or damaged fuel tank. The tank is manufactured using an injection molding process and cannot be repaired.
2. With the fuel tank removed from the vehicle, plug all openings except one elbow fitting. Install the elbow fitting and apply approximately 1 to 1-1/2 psi (7 to 10 kPa) of air pressure through the elbow. Check the tank for leaks by applying a soap solution to the exterior of the tank, or by submerging the tank in water and looking for bubbles to appear at the cracked or damaged area.

E. Assembly and Replacement

1. Install the fuel sender with gasket (item 21, Fig. 8A–7) and the fuel sender cover (22) to the fuel tank. Secure with four #10-24 x 3/4" pan-head screws (24), and four #10 lockwashers (23).
2. Coat threads with Teflon® (38) and install the black MI #6P square-head plug (20), the #6-6P hose barb coupling (19), the #5-6P 90° hose barb elbow (16) and both #10-6P 90° hose barb elbows (17).
3. Replace the fuel tank in the cab mount subframe. Attach the fuel level gauge wire to the #10-24 x 5/8" pan-head screw (25), slide a #10 lockwasher (23) onto the screw and secure the screw to the fuel tank at the fuel sender cover.
4. Reconnect the fuel hoses and follow the directions in *Section 4 Cab, Covers and Mirrors* to replace the other fuel system components and the cab.

8A.7.3 Fuel Level Sender and Gauge

The fuel level sender and gauge assembly is described in *Section 10 Electrical System*.

8A.7.4 Fuel Lift Pump Testing

To test the diaphragm, remove the fuel inlet line from the lift pump (Fig. 8A–8). Block the fuel inlet with a finger and operate the priming lever. A properly operating pump will provide suction that will remain until the finger is removed from the inlet. To test pump performance, disconnect the outlet line from the fuel lift pump to the fuel filter and rotate the engine; a spurt of fuel should occur for every two engine revolutions.

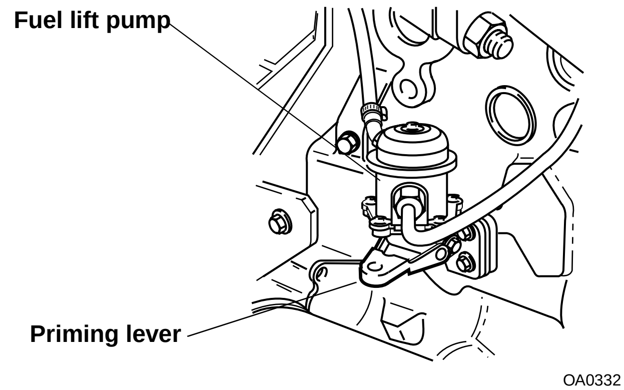


Figure 8A–8. Typical fuel lift pump.

To Check Pressure with Pump in Position:

1. Fit a 0 to 10 psi (0 to 0,69 bar) pressure gauge to the pump outlet. Ensure that there are no leaks at the connections between the gauge and the pump.
2. Crank the engine for 10 seconds and note the maximum gauge pressure. If the *maximum* gauge pressure is less than 4.5 psi (0,31 kgf/cm^2 or 31 kN/m^2), replace the pump.
3. Stop cranking the engine and time how long it takes for the pressure to drop to *half* the maximum pressure noted. If less than 30 seconds elapses, replace the pump.

A. Fuel Lift Pump Removal

1. Clean debris from around the lift pump.
2. Disconnect the fuel lines.
3. Remove the capscrews, gasket, and fuel lift pump.

B. Cleaning and Drying

Clean the exterior of the pump with mineral spirits and blow dry with compressed air.

Note: Parts replacement is not practical. The fuel lift pump is serviced as an entire assembly.

C. Fuel Lift Pump Installation

1. Clean the mounting surface on the cylinder block.
2. Install the fuel lift pump with a new gasket. Install and torque the capscrews to 18 lb/ft (24 Nm).
3. Connect the fuel lines.

8A.7.5 Fuel Filter

Refer to *Section 2 General Information, Specifications, and Maintenance Instructions* for information on removing and replacing the fuel filter (item 1, Fig. 8A–7).

8A.7.6 Venting Air from the Fuel System

Refer to *Section 2 General Information, Specifications, and Maintenance Instructions*, paragraph 2.12.7 D, Venting Air from the Fuel System.

8A.7.7 Fuel Injectors

The Perkins engine uses closed nozzle hole-type injectors (or "atomizers"). The injectors have different part numbers for different engine ratings. The Perkins fuel injector code (stamped on the fuel injector body) identify the injector.

IMPORTANT: Use only the specified injector for the engine.

During the injection cycle, high pressure from the injection pump rises to the operating (or "pop") pressure, which causes the needle valve in the injector to lift. Fuel is then injected into the cylinder. A shimmed spring is used to force the needle valve closed as the injection pressure drops below the pop pressure to seal off the nozzle after injection. Failure of the needle valve to lift and to close at the correct time, or a needle valve that is stuck open, can cause the engine to misfire and produce low power. Fuel leaking from the open nozzle can cause a fuel knock, poor performance, smoke, poor fuel economy, and rough running.

A. Locating Faulty Fuel Injectors

A faulty fuel injector can cause:

- Misfiring
- Knocking
- Overheating
- Loss of power
- Smoky (black) exhaust
- Increased fuel consumption

The particular faulty fuel injector(s) may be determined by releasing the pipe union nut on each fuel injector in turn, with the engine running at a fast "tick-over." If, after slackening a pipe union nut, the engine revolutions remain constant, a faulty fuel injector has been identified.

To test a fuel injector:

1. Remove the fuel injector from the cylinder head.
2. Invert the fuel injector with the nozzle facing out, then retighten the unions.
3. Loosen the unions of the other fuel injector pipes (to help avoid the possibility of the engine starting).

WARNING: KEEP CLEAR of spraying fuel. Diesel fuel will spray when venting high pressure lines. The fuel pressure is sufficient to penetrate the skin and cause serious bodily injury. Wear protective clothing and safety glasses.

4. Operate the starter to turn the engine over until fuel sprays from the nozzle. Examine the shape of the spray. If the spray is unduly "wet" or "streaky", or obviously sprays to one side, or if the nozzle "dribbles" fuel, it may only be necessary to probe the nozzle holes to remove blockage.

IMPORTANT: DO NOT attempt to adjust injection pressure without a testing pump and pressure gauge. It is impossible to accurately adjust the setting of fuel injectors without the proper equipment.

A perfect fuel injector, when tested by pumping fuel through it in the open air, gives a short "pinging" sound as the fuel emerges from the holes. After the fuel injector has been in service for some time, the pinging changes to a crackling sound. It is not until the fuel injector sounds "dead" that its condition is likely to affect the running of the engine.

B. Injector Replacement

Preparatory steps:

- Thoroughly clean around the injector(s)
- Disconnect the high-pressure fuel line(s)
- Disconnect the fuel drain manifold

IMPORTANT: The injector must not rotate in the bore of the cylinder head or damage to the cylinder head will occur. If rust has formed on the hold-down nut, soak the nut with rust-penetrating solvent for a minimum of three minutes. Then, tap the injector body with a drift pin to help loosen any rust.

To Replace a Fuel Injector:

1. Remove the fuel leak-off pipe.
2. Remove the high-pressure pipe union nuts from the fuel injector and fuel injection pump and release the pipe.
3. Remove the fuel injector flange nuts and remove the fuel injector and seat washer.

4. Place the new fuel injector and new seat washer into position. DO NOT misalign the fuel injector. Tighten the flange nuts evenly in small increments up to a final torque of 14 lb/ft (19 Nm).

⚠	**WARNING: KEEP CLEAR** of spraying fuel. Diesel fuel will spray when venting high pressure lines. The fuel pressure is sufficient to penetrate the skin and cause serious bodily injury. Wear protective clothing and safety glasses.

5. Connect the high-pressure fuel pipe. Torque the nut to 15 lb/ft (20 Nm).
6. Connect the fuel leak-off pipe.
7. Run the engine and check for fuel and air leakage.
8. Bleed the fuel system in accordance with the instructions in *Section 2 General Information, Specifications, and Maintenance Instructions*.

8A.7.8 After Fuel System Service

1. Drain and flush the fuel tank if it was contaminated.
2. Vent air from the fuel system (see *Section 2 General Information, Specifications, and Maintenance Instructions*, paragraph 2.12.7 D).
3. Fill the fuel tank with fresh, clean diesel fuel as required.

8A.8 PERKINS ENGINE EXHAUST SYSTEM

⚠	**WARNING:** Exhaust fumes contain carbon monoxide, a colorless, odorless gas which is fatal when inhaled in a confined area. Avoid breathing exhaust fumes and prevent engine operation from becoming a cause of toxic emissions. Exhaust system components reach high temperatures and can cause severe burns. **DO NOT** come into contact with hot exhaust system components.

The exhaust system (Fig. 8A–9) is supported by the engine and the vehicle frame to help minimize the transfer of noise and vibration into the operator's cab. The tail pipe directs exhaust fumes to the right side of the vehicle, away from the cab.

Annoying rattles and noise vibrations in the exhaust system are usually caused by misalignment of parts. When aligning the system, leave all capscrews and nuts slightly loose until all parts are properly aligned, then tighten all fasteners working from the front of the system to the rear.

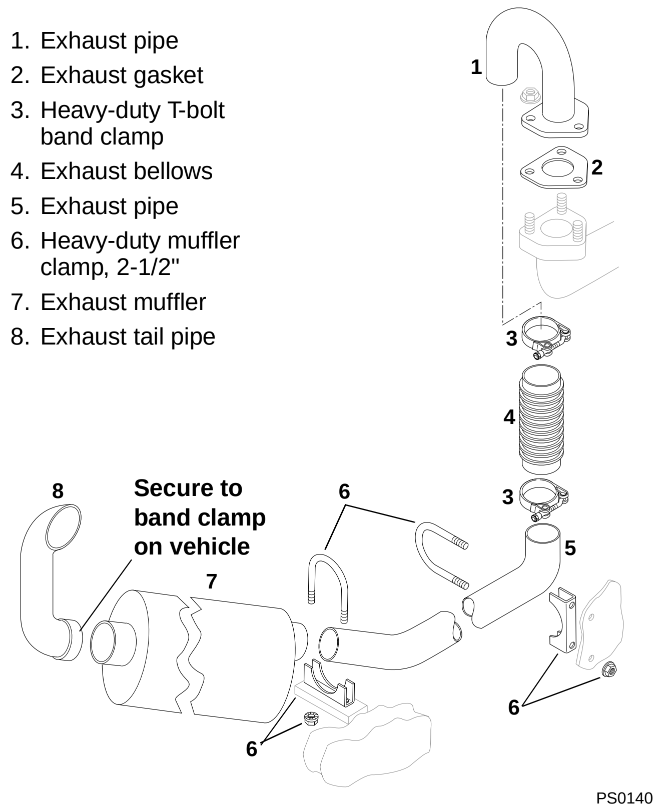


Figure 8A–9. Perkins engine exhaust system.

When replacing the muffler, also replace the tail pipe.

Before assembling components, use exhaust system sealer at all slip joint connections.

When installing exhaust system components, allow sufficient clearance between the components and other vehicle pipes, hoses and wiring that could be adversely affected by excessive heat.

When installing an exhaust system, provide for parts expansion when the system is hot.

Whenever performing service on the vehicle, check the condition of the exhaust system. Check the entire exhaust system for broken, damaged, missing or mispositioned parts, open seams, holes, loose connections and other deterioration which could permit exhaust fumes to seep into the operator's cab. Correct any damaged areas immediately.

8A.9 PERKINS ENGINE REPLACEMENT

Removal and installation of the engine can be done with or without the transmission attached. For information on removing the transmission from, and installing it to, the engine, refer to *Section 7 Transmission*.

8A.9.1 Engine Removal

> **WARNING:** To avoid severe burns, **DO NOT** attempt to remove the engine when the engine, cooling system and hydraulic system are hot. Wait until all parts and systems are cool before proceeding.

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut off the engine. Allow the engine, cooling system and hydraulic system to cool.
2. Label and disconnect the negative (-) battery ground cable at the battery (Fig. 8A–10) Also, disconnect the negative lead from at the starter mounting bolt.

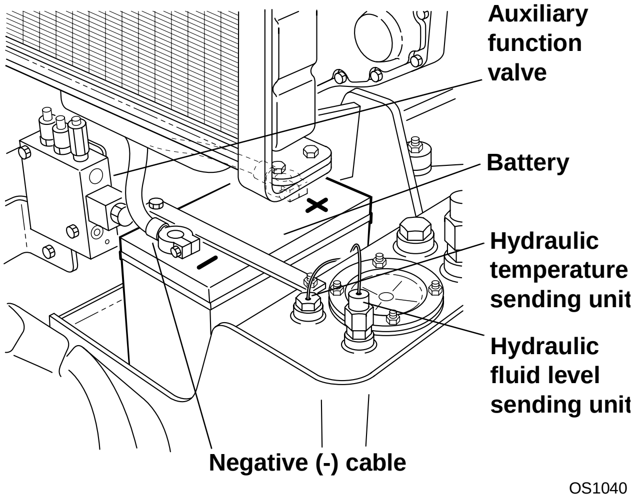


Figure 8A–10. Disconnect the negative (-) battery cable.

3. Remove the hood with the help of at least one assistant (refer to *Section 4 Cab, Covers and Mirrors*).
4. Position a suitable container beneath the radiator (Fig. 8A–11). Remove the radiator cap and open the radiator drain petcock. Allow the coolant to drain into the container. At the engine, loosen the upper and lower radiator hose clamps. Pry the hoses away from the engine.

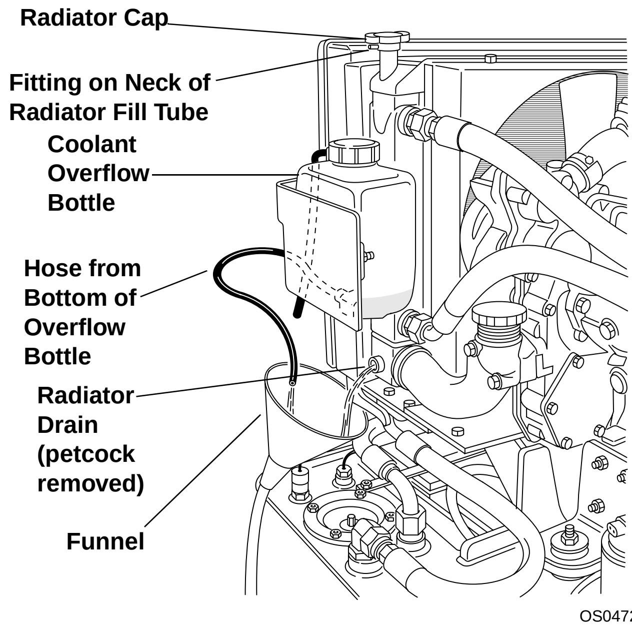
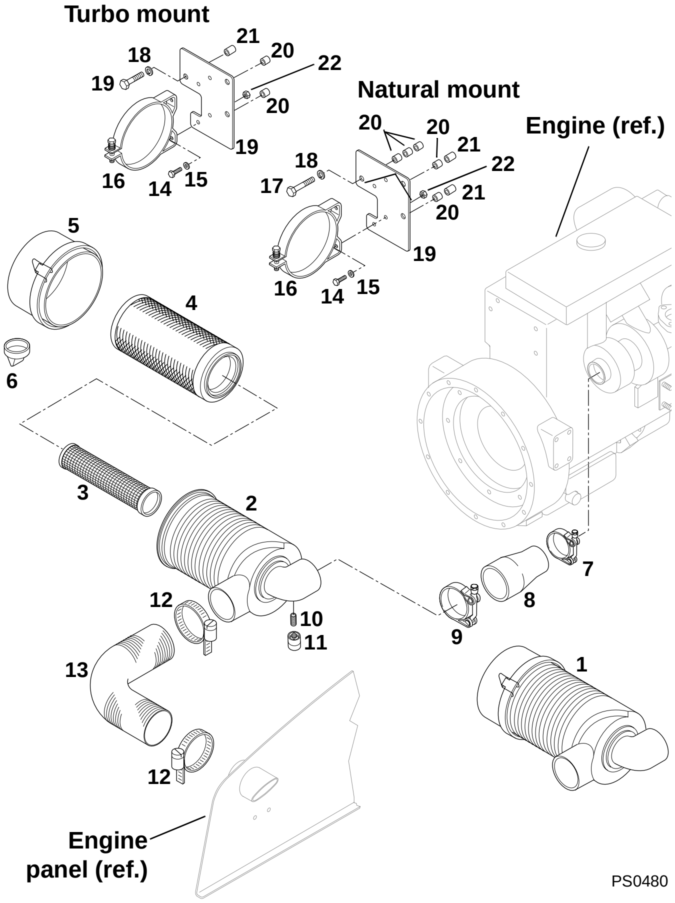


Figure 8A–11. Drain the radiator.

5. Remove either the fan or the radiator to help prevent damage to the radiator when the engine is removed.
6. Detach and remove the air cleaner (Fig. 8A–12). Loosen the clamp securing the air intake hose to the engine panel. Remove the hose from the engine panel (ref.).
7. If equipped with a turbocharger, loosen the air cleaner mount band assembly (Fig. 8A–12) securing the air cleaner hose to the turbocharger engine intake. Remove the hose from the turbocharger intake, and cover the intake to help prevent debris, etc. from entering the opening.
8. Unscrew the clamp securing the air cleaner body (Fig. 8A–12) to the mount plate on the engine. Remove the air cleaner assembly in its entirety. Place it in a secure location.
9. If equipped with a turbocharger, disconnect the turbocharger-to-exhaust connection, secured with a stainless steel V-band clamp. Cover the exhaust opening to help prevent debris, etc. from entering.



1. Air cleaner assembly (incl. items 2-6)
2. Body assembly
3. Safety filter
4. Primary filter
5. Cover assembly
6. Vactuator valve
7. Heavy-duty T-bolt clamp
8. Air cleaner hose
9. Heavy-duty T-bolt clamp
10. Close nipple, #2
11. Vacuum switch
12. Hose clamp, SAE Type F
13. Air intake hose
14. Hex-head capscrew, 5/16-18 x 3/4"
15. Flat narrow washer, 5/16"
16. Air cleaner mount band assembly
17. Hex-head capscrew, M10-1,5 x 60 mm PC 8,8 (Natural only) or M10-1,5 x 60 mm PC 8,8 (Turbo only)
18. Lockwasher, M10
19. Air cleaner mount plate
20. Spacer, 0.40"
21. Spacer, 0.710"
22. Hex-lock elastic nut, 5/16-18

Figure 8A–12. Perkins air cleaner.

10. Disconnect the exhaust pipe (Fig. 8A–9) from the exhaust bellows, secured with a heavy-duty T-bolt band clamp. Cover the exhaust opening to help prevent debris, etc. from entering.

11. Label and disconnect the alternator wire connector (Fig. 8A–13) and both alternator ground wires.

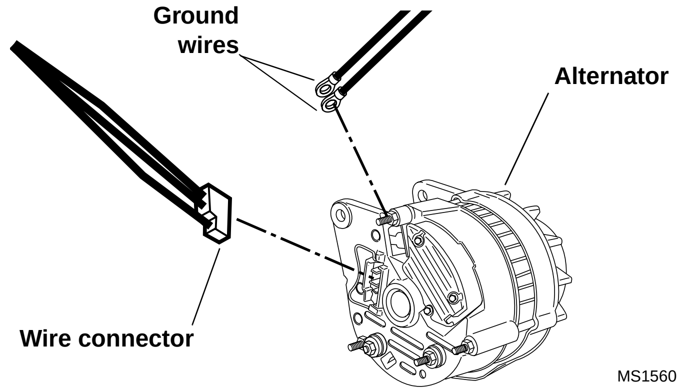


Figure 8A–13. Label and disconnect the alternator wire connector and both ground wires.

12. Disconnect (unplug) the hydraulic fluid level indicator lead (Fig. 8A–10 and Fig. 8A–14) and the hydraulic temperature sending unit lead (Fig. 8A–10) from the wiring harness connector.

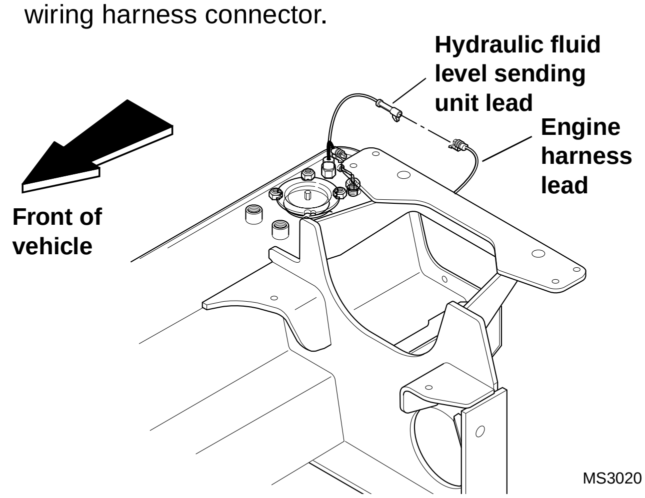


Figure 8A–14. Disconnect the hydraulic fluid level indicator lead.

13. Label and disconnect the wires at the main ground stud (Fig. 8A–15),

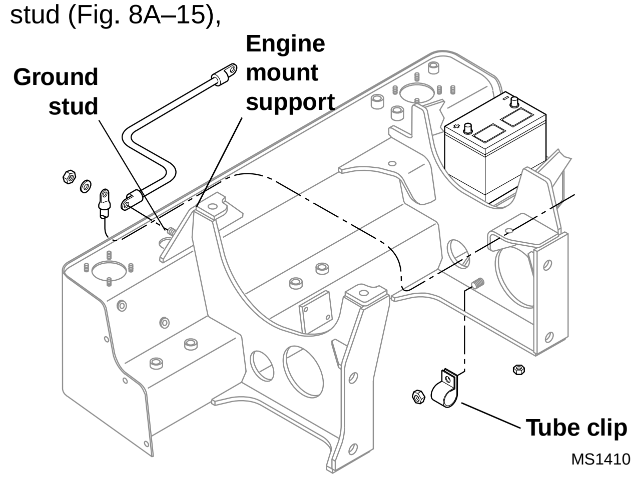


Figure 8A–15. Disconnect wires at the main ground stud.

14. At the starter, label and disconnect the positive (+) battery cable.
15. Label and disconnect the engine water temperature switch lead (Fig. 8A–16), engine oil pressure switch lead, and transmission temperature lead.

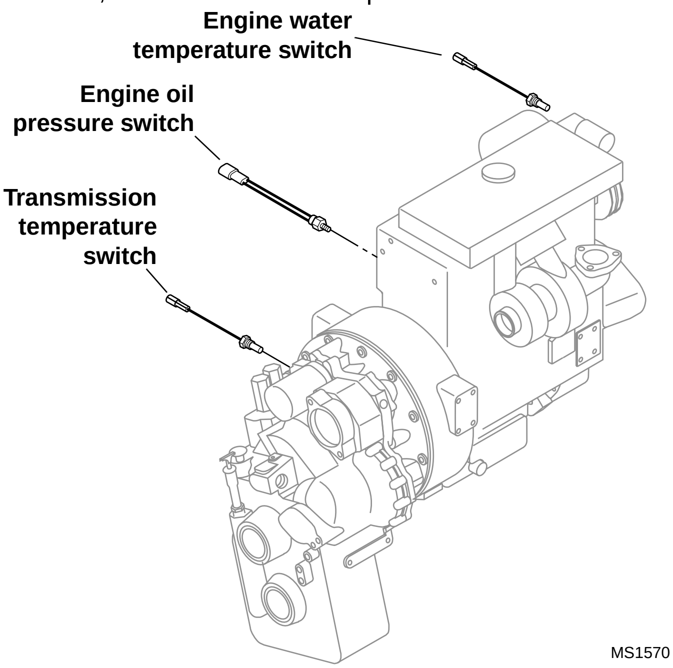


Figure 8A–16. Label and disconnect the engine water temperature and oil pressure switch leads, and the transmission temperature lead.

16. If removing the engine and transmission as a unit:
    - Place a suitable container beneath the hydraulic reservoir side of the radiator. Disconnect the transmission cooler hoses at the radiator and cap the connectors to help prevent excess fluid drainage. Secure the hoses out of the way on top of the engine.
    - Move the container beneath the transmission. Disconnect and cap the inlet and outlet hoses at the main hydraulic pump. Disconnect the pump inlet hose from the hydraulic reservoir and cover the opening to help prevent debris, etc. from entering the pump. Move the hoses out of the way to allow engine and transmission removal.
    - Label and disconnect all transmission wire leads.
    - Mark the transmission and transmission driveshaft flange yoke. Disconnect the transmission-to transfer case driveshaft at the transmission flange yoke. Secure the U-joints with tape. Lower the driveshaft to the ground.

Note: The drive shaft assembly is a balanced assembly. Mark the yoke and transmission so that these components can be returned to their original positions when the transmission is reinstalled. The yokes at each end of the drive shaft must be in the same plane to help prevent excessive vibration (Fig. 8A–26).

17. Working from beneath the vehicle, label and disconnect all engine wire harness leads (refer to *Section 10 Electrical System* as required for detailed views of harness leads). Remove plastic tie wraps as required to allow access to the wiring harness and wire leads.
18. Disconnect the engine wiring harness bulkhead connector from the cab wiring harness bulkhead connector along the vehicle frame.
19. Label and disconnect the wiring harness at the steer select valve.
20. Label and disconnect the wiring connectors at the auxiliary function valve solenoids (Fig. 8A–10 and Fig. 8A–17), located near the battery. Move all wiring out of the way to allow engine removal.

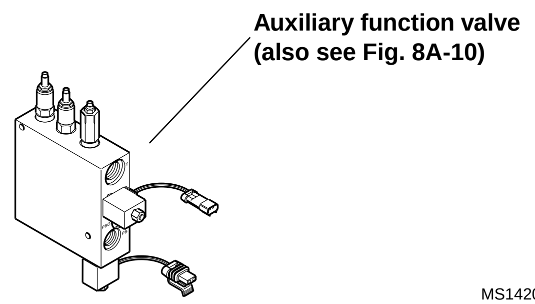


Figure 8A–17. Disconnect the wiring at the auxiliary function valve solenoids.

21. Working from the side of the vehicle, disconnect the fuel return line (Fig. 8A–18) at the fuel injector pump.

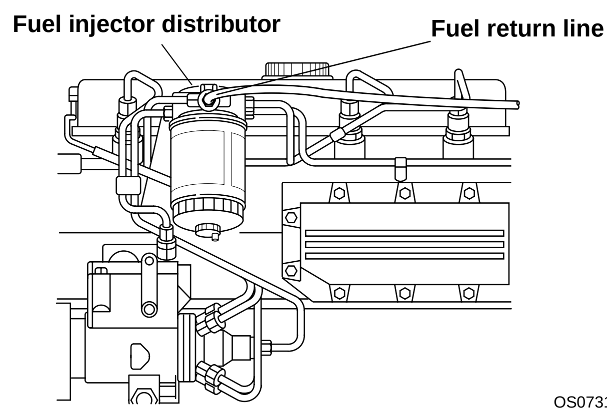


Figure 8A–18. Disconnect the fuel return line to the fuel injector distributor.

22. Disconnect the fuel inlet line at the fuel lift pump (Fig. 8A–20).

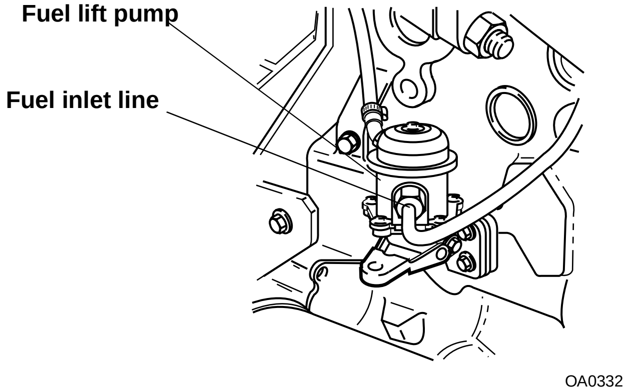


Figure 8A–19. Fuel inlet line to lift pump connection.

23. Mark the location of the throttle cable at its engine mount bracket (Fig. 8A–20).
24. Disconnect the throttle cable at the bracket above the starter (Fig. 8A–20).
25. At the hydraulic fluid reservoir, disconnect the engine harness wire lead (Fig. 8A–10 and Fig. 8A–22) from the hydraulic fluid-level sending unit.
26. Connect a suitable engine hoist to the engine lift plates (Fig. 8A–21).

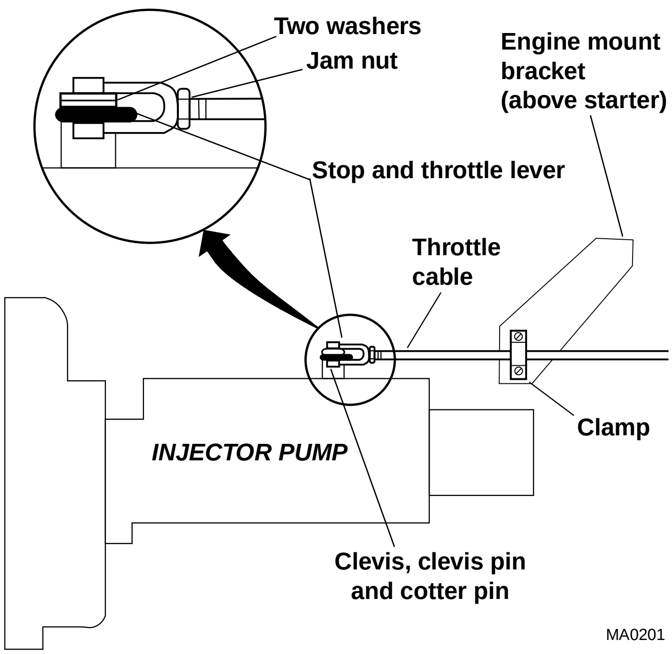


Figure 8A–20. Throttle cable connection at engine.

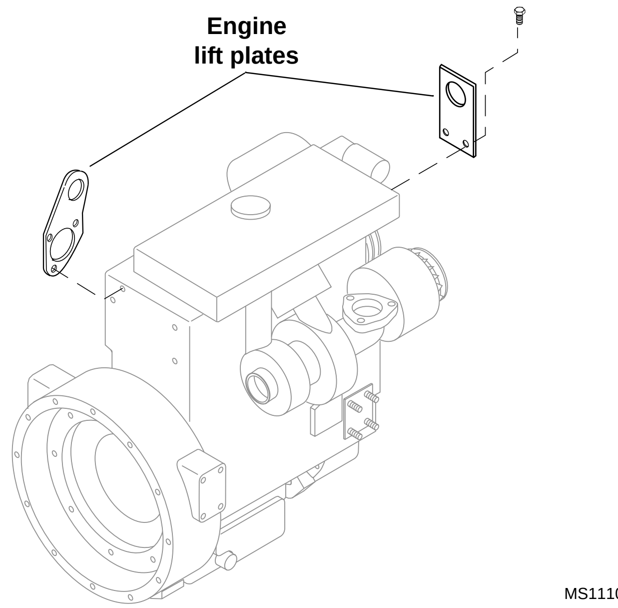


Figure 8A–21. Engine lift plates.

27. In four locations, remove the nuts, washers and capscrews securing the engine mounts (Fig. 8A–1) to the hydraulic reservoir/engine mount subframe.
28. Begin removing the engine from the vehicle with the hoist or overhead crane.
29. As the engine is lifted away and removed, reposition the debris shield at the base of the radiator to prevent damage and allow engine removal. Avoid damaging the oil filter and oil filter housing.
30. Carefully lift the engine out and away from the vehicle. Place the engine safely onto ground supports, or in a suitable engine stand. **DO NOT** rest the engine on its oil pan, or damage will occur.

8A.9.2 Engine Disassembly, Inspection, and Service

Engine disassembly, internal inspection, service, repair and assembly procedures are covered in the Perkins 1004 series service manual. Several special engine service tools are required to properly service the Perkins engine. Contact the local Perkins parts distributor for further information.

8A.9.3 Engine Installation

Removal and installation of the engine can be done with or without the transmission attached. For information on installing the transmission to the engine, refer to *Section 7 Transmission*.

1. Place the engine mounts (items 8 and 16, Fig. 8A–1) into the appropriate locations within the hydraulic reservoir/engine mount subframe on the vehicle.

2. Attach a suitable engine hoist to the engine lift plates (Fig. 8A–21).
3. Carefully install the engine onto the engine mounts (items 7, 8, 16, 17, 24 and 28, Fig. 8A–1). Make sure the bracket-type engine mounts align properly with the engine mounts in the subframe.
4. In four locations, install the nuts, washers and capscrews securing the engine mounts (Fig. 8A–1) to the hydraulic reservoir/engine mount subframe. Torque the 7/16-14 x 3-1/4" Grade 8 capscrews to 60 lb/ft (81 Nm). Torque the 5/8-11 x 4" Grade 8 capscrews to 180 lb/ft (244 Nm).
5. Install the fan and/or radiator as required.
6. Connect the engine harness and hydraulic fluid-level sending unit leads (Fig. 8A–22).

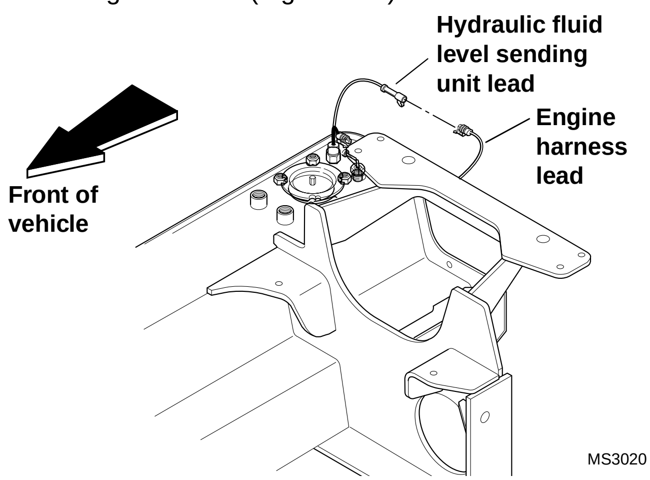


Figure 8A–22. Connect the engine harness lead to the hydraulic fluid level sending unit lead.

7. Secure the throttle cable (Fig. 8A–20) to the bracket located just above the starter.
8. Connect the throttle cable at the engine mount bracket (Fig. 8A–20).
9. Connect the fuel inlet line to the fuel lift pump (Fig. 8A–23).

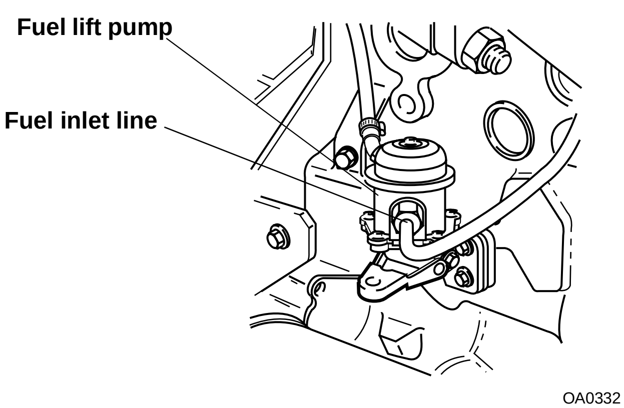


Figure 8A–23. Fuel inlet line to lift pump connection.

10. Connect the fuel return line to the fuel injector distributor (Fig. 8A–24).

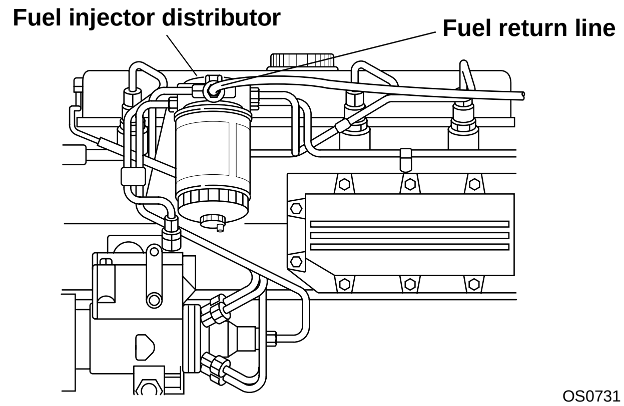


Figure 8A–24. Connect the fuel return line to the fuel injector distributor.

11. Connect the engine wiring harness leads to the steer select valve leads (Fig. 8A–25).

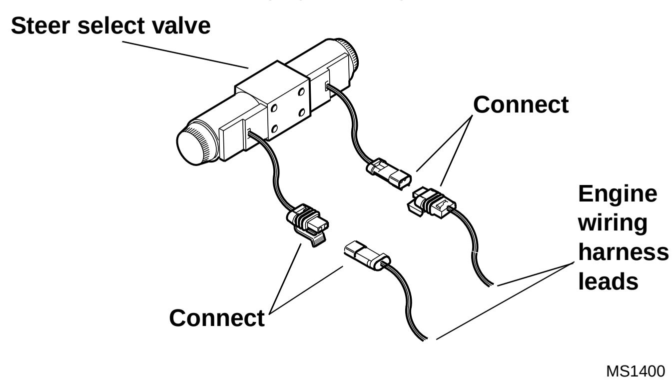


Figure 8A–25. Connect the engine wiring harness leads to the steer select valve leads.

12. Connect the engine wiring-harness bulkhead connector to the bulkhead receptacle.
13. Working from beneath the vehicle, connect all engine wire harness leads as necessary (refer to *Section 10 Electrical System* for detailed views of each component). Secure the harness with tube clips and plastic tie wraps as required to prevent the wiring harness and wire leads from hanging below the vehicle and from coming into contact with moving parts.
14. If the engine and transmission were NOT installed as a unit, attach the transmission to the engine at this time. Refer to *Section 7 Transmission*.

Note: The drive shaft is a balanced assembly. The yokes at each end of the drive shaft must be in the same plane to help prevent excessive vibration (Fig. 8A–26).

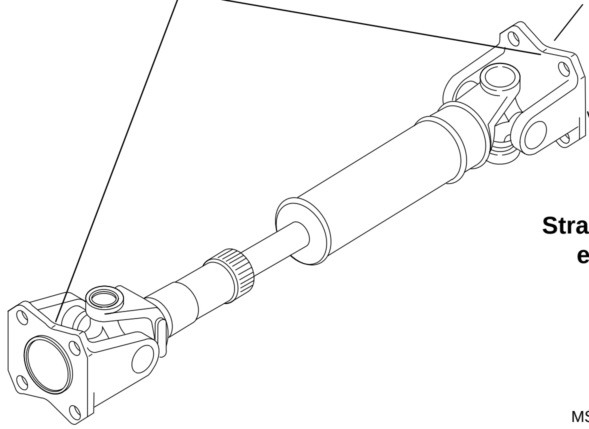


Figure 8A–26. Align yokes in the same plane as shown.

15. Coat the M12 transmission driveshaft yoke retaining capscrews with Loctite #242 (blue), install lockwashers and torque to 83 lb/ft (112,5 Nm).
16. Connect all transmission wire leads at the shift solenoids.
17. Connect the hydraulic system inlet and outlet hoses at the main hydraulic pump. Connect the inlet hose to the hydraulic reservoir if necessary. Refer to *Section 9 Hydraulic System* as required.
18. Connect the transmission hoses to the radiator (Fig. 8A–6).
19. Connect the engine coolant temperature and oil pressure switch leads (Fig. 8A–16).
20. Connect the positive (+) battery cable at the starter.
21. Attach all wiring harness connectors and leads (refer to *Section 10 Electrical System* as required for detailed views of harness leads).
22. Connect the alternator wire leads (Fig. 8A–13).
23. Connect the exhaust pipe (Fig. 8A–9) to the exhaust bellows. Secure with a heavy-duty T-bolt band clamp. For turbocharged engines, connect the turbocharger exhaust connection. Secure with a stainless steel V-band clamp.
24. Secure the air cleaner mount band assembly (Fig. 8A–12) and mount plate to the engine with the necessary fasteners.
25. Install the air cleaner assembly (Fig. 8A–12) in its entirety. Install the air cleaner hose to the turbocharger intake port. Secure the air cleaner hose with a heavy-duty T-bolt clamp.
26. Install the air intake hose (Fig. 8A–12) at the engine panel. Tighten the SAE Type F clamp to secure the air intake hose to the engine panel.
27. Attach the upper and lower radiator hoses (Fig. 8A–4) to the engine water pump (and to the radiator, if necessary) and secure with hose clamps.
28. Open the radiator cap (Fig. 8A–4) and fill the radiator with a 50/50 mixture of water and ethylene glycol. More coolant will need to be added later. Replace and tighten the radiator cap.
29. Install the hood with the help of at least one assistant (refer to *Section 4 Cab, Covers and Mirrors*).
30. Connect the positive (+) battery cable at the starter, then at the battery.
31. Connect the negative (-) battery ground cable lead to the starter mounting bolt.
32. Check that all hydraulic system, electrical system, cooling system, fuel system, and exhaust system connections are correctly and tightly connected.
33. From within the cab, lightly depress the throttle pedal (Fig. 8A–27) to full-throttle position. As needed, adjust the limit-stop screw until it touches the pedal. Tighten the locknut to 120 to 125 lb/in (13,6 to 14,1 Nm).
34. Have an assistant stand by with a Class B fire extinguisher. Start and idle the engine.
35. Check for leaks from the engine, main hydraulic pump and lines, transmission, hydraulic reservoir and fuel tank. Check the levels of all fluids and lubricants. Fill as required.

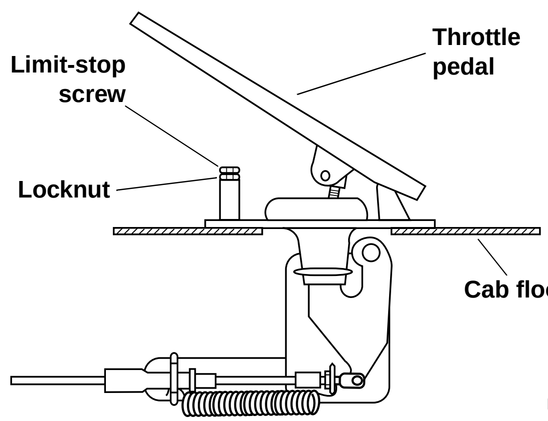


Figure 8A–27. Adjust the throttle limit-stop screw.

IMPORTANT: *During the full throttle check:*
- DO NOT operate any hydraulic function;
- DO NOT steer or apply any pressure to the steering wheel;
- Keep the transmission in NEUTRAL (N).

36. Obtain and connect an appropriate engine analyzer or tachometer. Check the engine rpm at full throttle. If the rpm is not 2600 to 2800 rpm, readjust the throttle limit-stop screw at the throttle pedal within the cab.

37. Purge the hydraulic system of air by operating all boom functions through their entire range of motion several times. Check the hydraulic oil level.
38. Check for proper operation of all components.
39. Turn the engine OFF.

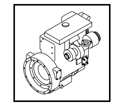
8A.10 PERKINS ENGINE STORAGE

If the engine is properly protected and stored according to the following recommendations, no corrosion damage will normally occur. Perkins Engine Company, Inc. and Sky Trak International are not responsible for any damage that occurs in relation to a service storage period.

Use the following procedures immediately upon removing engine from service if being stored for an extended period of time.

1. Clean the outside of the engine.
2. When using a preservative fuel, drain the fuel system and fill with the preservative fuel. When not using preservative fuel, keep the fuel system charged with regular fuel, which, along with the fuel filter, will have to be drained and discarded at the end of the storage period.
3. Run the engine to operating temperature. Correct any fuel, fluid, oil or air leaks. Stop the engine and drain the oil.
4. Replace the oil filter.
5. Fill the crankcase (sump) to the FULL mark on the dipstick with new, clean oil or with an approved preservative fluid. If a preservative fluid is used, it must be drained and replaced with regular lubricating oil before the engine is returned to service.
6. Drain the cooling system. To provide protection against corrosion, fill the cooling system with a coolant containing a corrosion inhibitor. If frost protection is needed, use the appropriate mixture of antifreeze and water. If frost protection is not required, use an appropriate mixture of water with an approved corrosion mixture.
7. Run the engine for a short period to distribute lubricating oil and coolant throughout the engine.
8. Clean out the engine breather pipe (where fitted) and seal the end of the pipe.
9. Remove the fuel injectors and spray clean engine lubricating oil into cylinder bores, four ounces (118,3 ml) of lubricating oil divided evenly between the four cylinders.
10. Remove the air filter and any pipe installed between the air filter and the induction manifold. Seal the manifold with waterproof tape.
11. Remove the exhaust pipe. Seal the manifold with waterproof tape.
12. Disconnect the battery and store it safely, in a fully charged condition. Before the battery is put into storage, give the battery terminals a protection against corrosion with a light coating of dielectric grease or petroleum jelly.
13. Seal the vent pipe of the fuel tank or the fuel filler cap with waterproof tape.
14. Remove and store the fan drive belt.

Note: Before starting the engine after storage, operate the starter motor with one of the fuel-run solenoid wires disconnected until oil pressure shows on the oil pressure gauge, or until the low oil-pressure warning light goes out.



8A.11 TROUBLESHOOTING

Items 1 through 60 in the Key cover both naturally-aspirated and turbocharged engines. *There are no items that pertain to naturally-aspirated engines only.* Items 61 through 64 cover *turbocharged* engines *ONLY*.

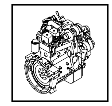
Trouble	Possible Causes (see key, below)
Low Cranking Power	1, 2, 3, 4
Will Not Start	5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 31, 32, 33
Difficult Starting	5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24, 29, 31, 32, 33, 61*, 63*
Lack of Power	8, 9, 10, 11, 12, 13, 14, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 31, 32, 33, 61*, 63*, 64*
Misfiring	8, 9, 10, 12, 13, 14, 16, 18, 19, 20, 25, 26, 28, 29, 30, 32
Excessive Fuel Consumption	11, 13, 14, 16, 18, 19, 20, 22, 23, 24, 25, 27, 28, 29, 31, 32, 33, 63*
Black Exhaust	11, 13, 14, 16, 18, 19, 20, 22, 24, 25, 27, 28, 29, 31, 32, 33, 61*, 63*
Blue/White Exhaust	4, 16, 18, 19, 20, 25, 27, 31, 33, 34, 35, 45, 56, 62*
Low Oil Pressure	4, 36, 37, 38, 39, 40, 42, 43, 44, 58
Knocking	9, 14, 16, 18, 19, 22, 26, 28, 29, 31, 33, 35, 36, 45, 46, 59
Erratic Running	7, 8, 9, 10, 11, 12, 13, 14, 16, 20, 21, 23, 26, 28, 29, 30, 33, 35, 45, 59
Vibration	13, 14, 20, 23, 25, 26, 29, 30, 33, 45, 47, 48, 49
High Oil Pressure	4, 38, 41
Overheating	11, 13, 14, 16, 18, 19, 24, 25, 45, 50, 51, 52, 53, 54, 57, 64*
Excessive Crankcase Pressure	25, 31, 33, 34, 45, 55, 60
Poor Compression	11, 19, 25, 28, 29, 31, 32, 33, 34, 46, 59
Starts and Stops	10, 11, 12

Key to Possible Causes

1. Battery capacity low
2. Bad electrical connection
3. Faulty starter motor
4. Incorrect grade of lubricating oil
5. Low cranking speed
6. Fuel tank empty
7. Faulty stop control operation
8. Blocked fuel feed line
9. Faulty fuel lift pump
10. Choked fuel filter
11. Restriction in air cleaner
12. Air in fuel system
13. Faulty fuel injection pump
14. Faulty fuel injectors or incorrect type
15. Incorrect use of cold start equipment
16. Faulty cold start equipment
17. Broken fuel injection pump drive
18. Incorrect fuel pump timing
19. Incorrect valve timing
20. Poor compression
21. Blocked fuel tank vent
22. Incorrect grade of fuel
23. Sticking throttle or restricted movement
24. Exhaust pipe restriction
25. Leaking cylinder head gasket
26. Overheating
27. Cold running
28. Incorrect tappet adjustment
29. Sticking valves
30. Incorrect high pressure pipes
31. Worn cylinder bores
32. Pitted valves and seats
33. Broken, worn or sticking piston ring(s)
34. Worn valve stems and guides
35. Over-full air cleaner
36. Worn or damaged bearings
37. Insufficient oil in sump
38. Inaccurate gauge
39. Oil pump worn
40. Pressure relief valve sticking open
41. Pressure relief valve sticking closed
42. Broken relief valve spring
43. Faulty suction pipe
44. Choked oil filter
45. Piston seizure / pick up
46. Incorrect piston height
47. Damaged fan
48. Faulty engine mounting
49. Incorrectly aligned flywheel housing or incorrectly aligned flywheel
50. Faulty thermostat
51. Restriction in water jacket
52. Loose fan belt
53. Choked radiator
54. Faulty water pump
55. Choked breather pipe
56. Damaged valve stem oil deflectors (if fitted)
57. Coolant level too low
58. Blocked sump strainer
59. Broken valve spring
60. Exhauster or vacuum pipe leak

*For **turbocharged** engines:

61. Turbo impeller damaged or dirty
62. Turbo lubricating oil seal leak
63. Turbo induction system leaks
64. Turbo waste-gate operating improperly (if equipped)



Section 8B
Engine: Cummins 4BT3.9

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Introduction

DISCLAIMER AND SCOPE

These instructions are written for worldwide use. In territories where legal requirements govern engine smoke emission, noise, safety factors, etc., apply all instructions, data and dimensions provided herein in such a way that after maintenance, service and repair of the engine, engine operation does not violate local regulations.

IMPORTANT: These instructions cover only the routine maintenance, removal, installation and troubleshooting of the engine. Refer to the local Cummins Engine Distributor and the applicable Cummins engine service manual for assistance with comprehensive engine diagnosis, repair and component replacement.

A gradual running in (break in) of a new engine is not necessary. Full load can be applied to a new engine as soon as the engine is put into service and the coolant temperature is at least 140° F (60°C). Extended light-load operation during the early life of the engine is not recommended. **DO NOT** run the engine at high, no-load speeds. **DO NOT** apply an overload to the engine.

Throughout this section, the left or right side of the engine is as viewed from the flywheel end.

Legend

1. Cummins 4BT3.9 Turbo Engine
2. Fan Belt
3. Suction Fan, 18"
4. Hex-head Capscrew, M10-1,5 x 90 mm
5. Lockwasher, M10
6. Alternator Fan
7. Alternator, 65 Amp
8. Flat-face Straight Connector, #10 ORB x #12
9. Flat-face Elbow Swivel, #12
10. Remote Oil Filter Hose Assembly
11. Tie Wrap
12. Hex-lock Elastic Nut, 7/16-14
13. Rebound Washer, 7/16"
14. Lockwasher, M12
15. Hex-head Capscrew, M12-1,75 x 30 mm PC 8,8
16. Rear Left-side Engine Mount
17. Engine Mount
18. Hex-head Capscrew, 3/8-16 x 1-1/4 Grade 5
19. Narrow Flat Washer, 3/8"
20. Hex-lock Elastic Nut, 3/8-16
21. Narrow Flat Washer, 7/16"
22. Hex-head Capscrew, 7/16-14 x 3-1/4" Grade 8
23. Hex-head Capscrew, 5/8-11 x 4" Grade 8
24. Narrow Flat Washer, 5/8"
25. Hex-head Capscrew, 3/8-16 x 1-1/2 Grade 5
26. Engine Mount
27. Front Left-side Engine Mount
28. Hex-head Capscrew, M12-1,75 x 40 mm PC 8,8
29. Rebound Washer, 5/8"
30. Hex-lock Elastic Nut, 5/8-11
31. Front Right-side Engine Mount
32. Rear Right-side Engine Mount
33. Engine Oil Filter
34. Flat-face Elbow, 90°, #12 ORB x #12
35. Oil Filter Bracket
36. Lockwasher, 1/4"
37. Hex-head Capscrew, 1/4-20 x 5/8"
38. Hex-head Capscrew, M12-1,75 x 25 mm
39. Starter
40. Starter Relay Mount
41. Hex-lock Elastic Nut, 1/4-20
42. Starter Relay
43. Hex-head Capscrew, 1/4-20 x 3/4"

General Overview

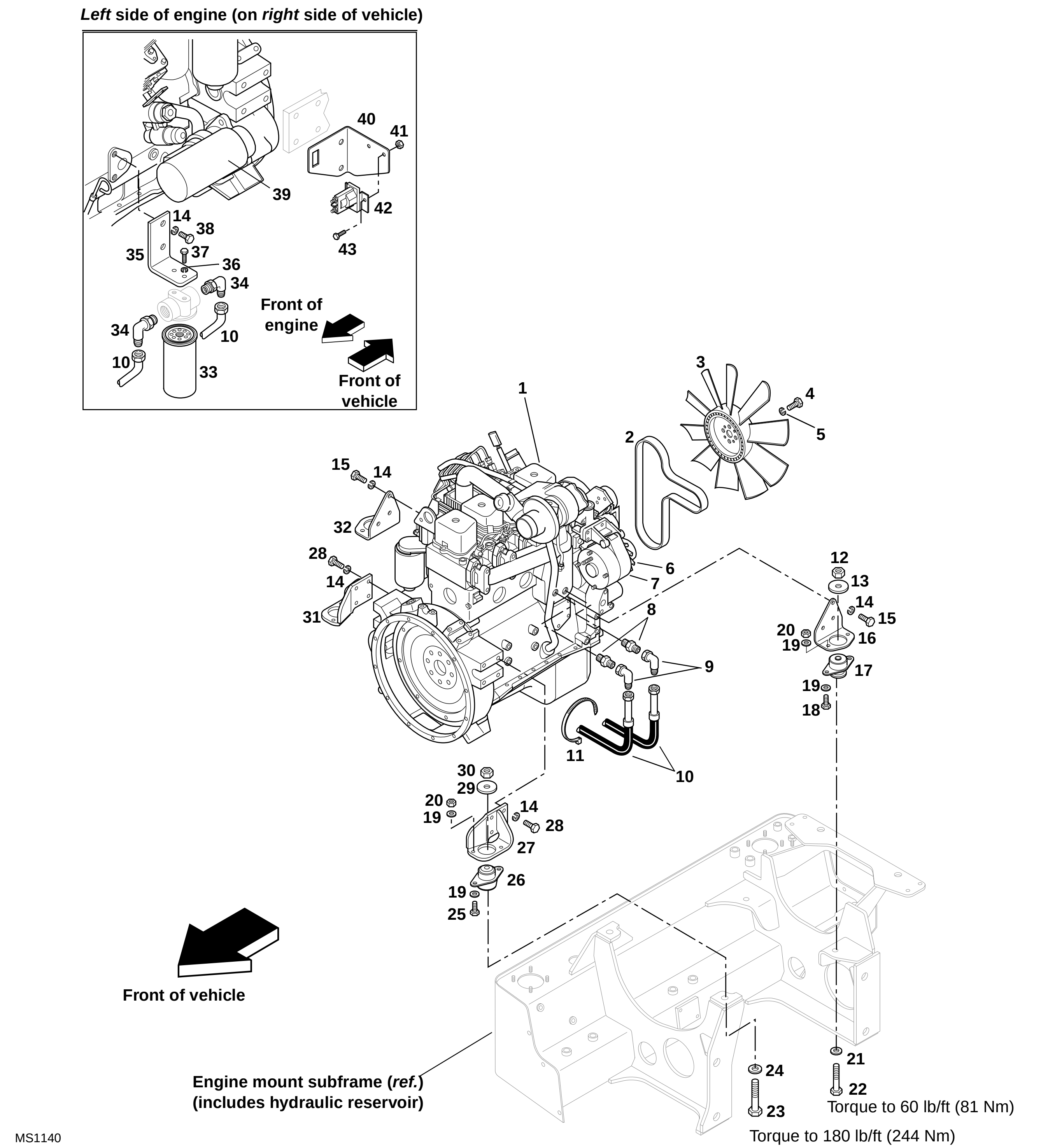


Figure 8B–1. Cummins engine general overview.

8B.1 SAFETY INFORMATION

General Vehicle Operation

WARNING: Before attempting to start the engine and/or operate the vehicle, read the owners/operators manual.

- Before operating the engine and/or the vehicle, install guards and clear all personnel from the immediate area.
- Check that the brakes are fully functional.
- **DO NOT** exceed the stability limits of the vehicle.
- Allow only ONE person to have control of the engine and the vehicle.

Preparation

WARNING: Wear protective glasses and protective shoes.

- **Verify that the work area** is capable of supporting the weight of the vehicle and the torque created by any suspended load.
- **DO NOT** work on an engine or a vehicle that is supported ONLY by a hoist or lift jacks. Use blocks or suitable stands.

Engine Operation

WARNING: Operate the engine in a well-ventilated area only. Assure that engine operation will not produce a concentration of toxic emissions.

- **DO NOT** operate the engine in the presence of a fuel spill or gas leak. Such combustible vapors, when drawn into the engine, can cause engine over-acceleration, explosion, fire and extensive personal injury and property damage. Before operating in any hazardous environment, consult a recognized authority (such as the engine distributor) on engine operation in hazardous environments.
- **DO NOT** smoke or operate the engine during refueling.

Cleaning

WARNING: When using steam cleaners and pressure washers, wear protective glasses, gloves and clothing to help prevent personal injury.

WARNING: **NEVER** use gasoline or other flammable materials for cleaning parts. Use only approved cleaning solvents.

Engine Coolant (anti-freeze/anti-boilover)

WARNING: **DO NOT** remove the radiator cap while the engine and coolant are hot. Hot coolant under pressure is dangerous and can injure the eyes and cause severe burns.

- Cooling system corrosion inhibitors contain alkali (chemicals that break down organic substances such as skin and eye tissue). **DO NOT** swallow. Avoid prolonged or repeated contact with corrosion inhibitors. In case of skin con-tact, immediately wash affected area with soap and water. In case of contact with eyes, immediately flood eyes with large amounts of water for a minimum of 15 minutes. Obtain medical assistance immediately. Keep corrosion inhibitors out of the reach of children.
- **DO NOT** use salt water or other corrosive liquid in the cooling system.

Rotating Parts and Fan Blades

WARNING: Keep away from parts which rotate; the fan blades can appear invisible when the fan is rotating.
DO NOT pull or pry on the fan blades. This practice will cause fan failure. Use only approved methods and tools for manually rotating the engine.

Battery

WARNING: Keep sparks and fires away from batteries. Batteries produce hydrogen gas, which can explode and cause severe personal injury and property damage.
Battery fluid can burn the skin and injure the eyes. If you come in contact with battery acid, flush the affected area with large amounts of water and obtain medical assistance immediately.

Engine Oil

WARNING: Engine oil can cause skin disorders and other personal injury. Avoid prolonged or repeated contact with both new and used engine oil.

Diesel Fuel

WARNING: Diesel fuel can cause skin irritation. Use gloves or protective hand lotion when working on the fuel system.

Engine Repair

WARNING: Before beginning any adjustments or repairs, place accident prevention tags in the operator's compartment and on the controls, and disconnect the battery negative cable.

- **DO NOT** operate, clean, lubricate or adjust the engine without proper training.
- **NEVER** attempt to perform an adjustment or repair that is not understood.
- Before servicing, relieve pressure in fuel, oil, coolant and hydraulic lines. Obtain medical assistance immediately if a high-pressure jet of fuel, oil, coolant or hydraulic fluid strikes the skin.
- **DO NOT** permit loose clothing, hair, etc., near moving parts.
- Keep *away* from parts which rotate; fan blades can appear invisible when the fan is rotating.
- To help prevent burns, avoid contact with components that remain hot after power is turned off or disconnected.
- Some of the gaskets on the engine obtain asbestos. Breathing asbestos dust is dangerous to health and may cause severe bodily harm. Avoid creating dust and follow local directives for handling and disposing of materials that contain asbestos.

Parts

WARNING: ALWAYS use factory-approved fasteners and parts. **DO NOT** use other than factory-approved fasteners and parts when replacement is necessary.

8B.2 CUMMINS ENGINE SERIAL NUMBER

The Cummins 4BT3.9 serial number is stamped on the front of the engine block, near the fan pulley. Information contained in the serial number is required in correspondence with the engine manufacturer.

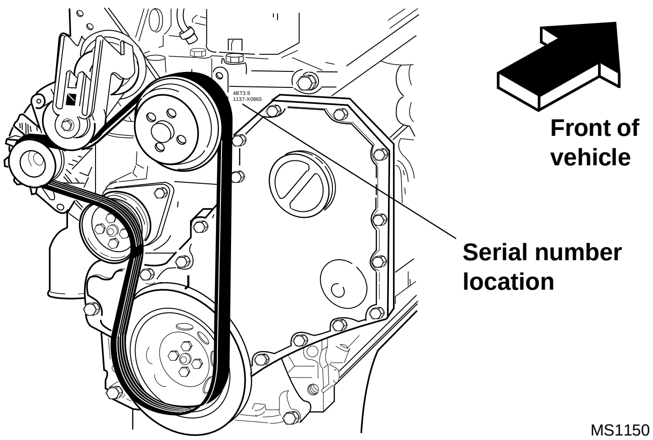


Figure 8B–2. Cummins engine serial number location.

Supply the engine serial number and/or data tag information when communicating about an engine or engine components.

8B.3 CUMMINS SPECIFICATIONS AND MAINTENANCE INFORMATION

Engine, coolant and oil specifications and maintenance information appear in *Section 2 General Information, Specifications, and Maintenance Instructions*.

Note: Detailed Cummins engine service instructions (covering disassembly, inspection, internal repair, assembly, adjustment and troubleshooting information) are provided in the appropriate Cummins engine service manual.

8B.4 CUMMINS ENGINE STANDARD PRACTICES

Left and Right Sides of the Engine

Throughout this section, the left or right side of the engine is as viewed from the flywheel end.

Cleanliness

Cleanliness is very important during engine repair. Contamination of the engine during repair will reduce the life of an engine. Thoroughly clean the engine and engine compartment area before attempting to service or repair the engine.

DO NOT steam clean the following parts:

- Electrical Components
- Wiring
- Injectors
- Fuel Pump
- Belts and Hoses
- Bearings

During reassembly and inspection, thoroughly clean all parts, and, where present, remove burrs and scales.

Gaskets and O-rings

NEVER re-use a gasket or O-ring. Use new gaskets and O-rings. Thoroughly clean sealing surfaces before installing a new gasket or O-ring. **ALWAYS** install new flat-faced O-rings when servicing hydraulic fittings.

Cover any open ports of high-precision components (such as fuel system equipment) exposed by removal or disassembly to help prevent the entry of foreign material.

Capscrews and Metric Parts

When replacing capscrews, **ALWAYS** use a capscrew of the same size and strength as the capscrew being replaced. Incorrect capscrews can result in engine damage. Return capscrews removed from the engine to their original locations.

The Cummins 4BT3.9 engine uses parts that are of metric dimensions. Metric capscrews are described, in millimeters, in terms of major thread diameter, distance between threads, and overall length.

Metric capscrew dimensions:

M8 x 1,25 - 25

- 25 — Length, in millimeters
- 1,25 — Distance between threads, in millimeters
- M8 — Major thread diameter, in millimeters

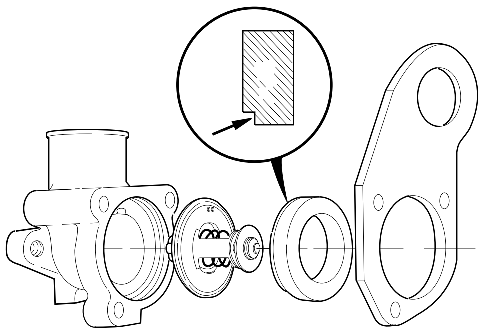
Verify that the correct type of part is used at all times.

8B.5 CUMMINS ENGINE COOLING SYSTEM

The Cummins engine cooling system is a closed, pressurized system that consists of coolant passages in the engine, plus the oil cooler, thermostat, water pump, hoses, radiator and radiator overflow bottle. The engine is cooled by the circulation of coolant through passages in the cylinder block and head. Circulation is by thermosiphon action, assisted by an impeller-type water pump, driven by a fan belt from the crankshaft pulley. The water pump bearings are prepacked with a special grease and do not require service. Replace a faulty water pump. General engine cooling specifications and maintenance procedures are listed in *Section 2 General Information, Specifications, and Maintenance Instructions*.

8B.5.1 Radiator Pressure Cap

The cooling system is designed to use a radiator pressure cap to help prevent the coolant from boiling. In addition, the pressure helps to eliminate the formation of steam pockets within the engine and ensures coolant circulation throughout all coolant passageways of the engine. For a 210° system, use a 7 psi (48 kPa) radiator cap. An incorrect or malfunctioning cap can result in the loss of coolant and a hot-running engine.



MS1160

Figure 8B–3. Typical Cummins engine thermostat housing.

8B.5.2 Thermostat Replacement

Before considering thermostat replacement, check the coolant level, fan belt tension and dash panel temperature gauge. If the engine seems to take a long time to warm up, the thermostat may be stuck in the open position and requires replacement. If the engine runs hot, check the temperature of the upper radiator hose. If the hose is not hot, the thermostat may be stuck in the closed position. If the engine has overheated, performance may suffer, indicating other damage including a leaking cylinder head gasket, cracked cylinder head or block, and/or other internal engine damage.

To replace the thermostat:

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut off the engine.

WARNING: DO NOT attempt this procedure when the engine is hot. Wait for the engine, muffler, and tailpipes to cool down before proceeding. Failure to do so could result in severe burns.

2. Unlatch, unlock and open the engine cover. Allow the engine to cool before proceeding. Draining the cooling system while the engine is hot can cause cracks in the engine block.
3. Disconnect the negative (-) battery cable.

WARNING: NEVER remove the radiator cap while the engine is hot. The cooling system is under pressure. Hot coolant can cause severe burns or eye injury. Wear protective clothing and safety glasses.

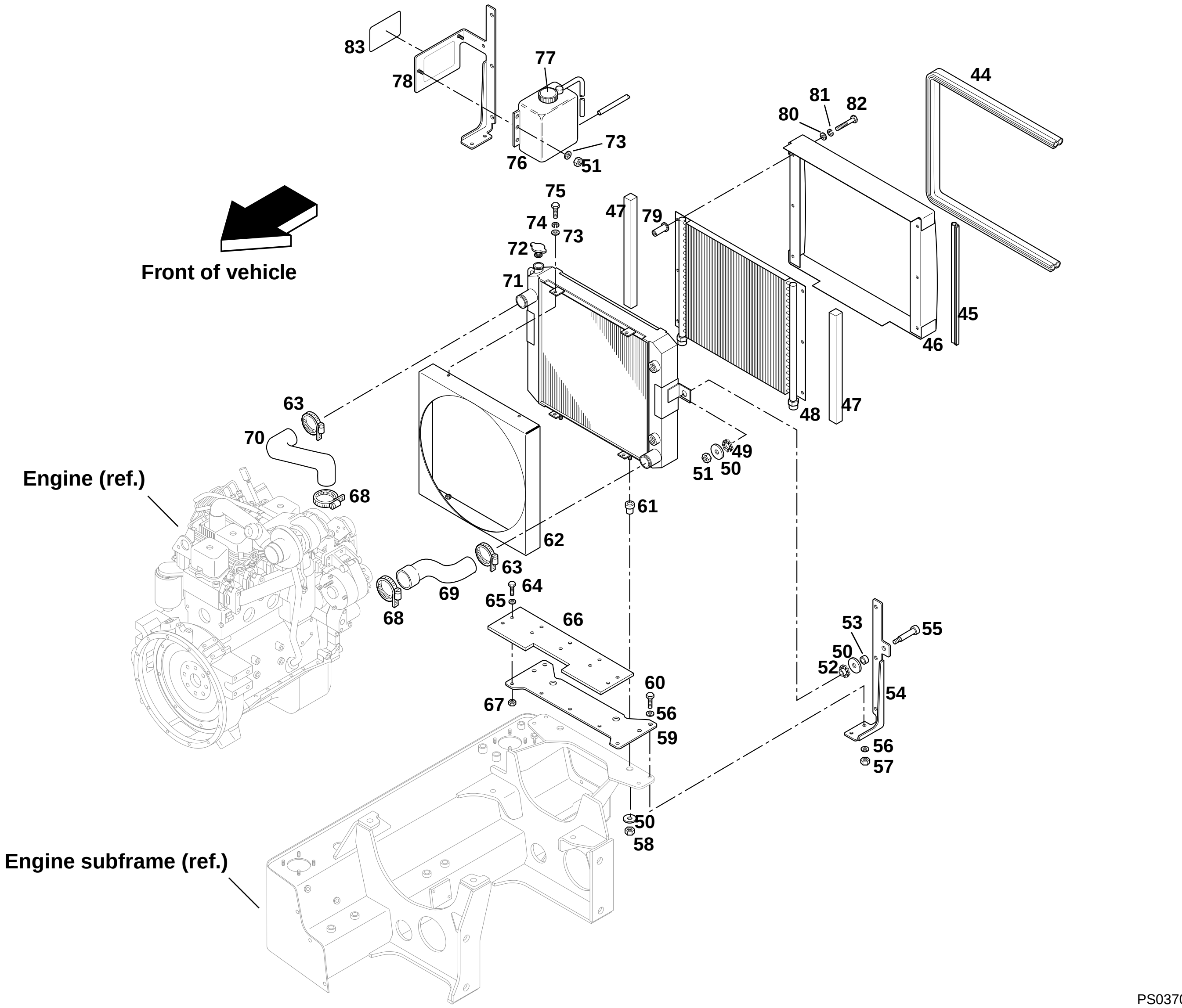
4. Drain approximately two quarts (2 liters) of coolant. Slowly turn the radiator cap to the first stop and allow any pressure to escape. Remove the radiator cap. Place a funnel at the base of the radiator to channel the drained coolant into a container. Open the radiator drain plug or petcock and allow the coolant to drain into the funnel. Transfer the coolant into a properly labeled container. Dispose of properly. Close the radiator drain plug or petcock.
5. Remove the fan drive belt. Loosen the alternator link capscrew on the bottom of the alternator. Remove the alternator mounting capscrew and lower the alternator.
6. Remove the three capscrews securing the thermostat housing (Fig. 8B–3) to the engine.
7. Remove the thermostat and clean the gasket surfaces. **DO NOT** let any debris into the thermostat opening while the thermostat is removed.

IMPORTANT: ALWAYS use the correct thermostat. **NEVER** operate the engine without a thermostat, or engine damage will result.

8. Install the thermostat, engine lift bracket, gasket and thermostat housing. Secure with the three capscrews removed earlier. Torque to 18 lb/ft (24 Nm).
9. Raise the alternator and install the mounting capscrew. Torque to 32 lb/ft (43 Nm).
10. Install the fan drive belt, then fill the cooling system. Run the engine to operating temperature. Visually check for leaks with the engine running. Check the coolant level in the overflow bottle and fill, or drain, as necessary.

8B.5.3 Cummins Engine Radiator and Oil Cooler Replacement

Before considering radiator or oil cooler replacement for other than obvious damage, conduct a cooling system pressure test, check the coolant specific gravity, coolant level, fan belt tension and dash panel temperature gauge. If the engine runs hot, check the temperature of the upper radiator hose. If the hose is not hot, the thermostat may be stuck in the closed position. If the engine has overheated, performance may suffer, indicating other damage including a leaking cylinder head gasket, cracked cylinder head or block, and/or other internal engine damage.



44. Bulb seal
45. Bulb seal molding
46. Radiator baffle assembly
47. Foam baffle
48. Oil cooler
49. Radiator mount ring
50. Rebound washer, 3/8"
51. Hex-lock elastic nut, 5/16-18
52. Radiator mount bushing
53. Spacer
54. Left radiator bracket
55. Hex-socket head shoulder bolt, 3/8 x 1-1/2 x 5/16-18
56. Wide flat washer, 3/8"
57. Hex-lock elastic nut, 3/8-16
58. Hex-lock nut, 3/8-16
59. Sheet
60. Hex-head capscrew, 3/8-16 x 1-1/2 Grade 5
61. Rubber mount
62. Radiator shroud
63. Radiator hose clamp (radiator)
64. Hex-head capscrew, 1/4-20 x 3/4"
65. Narrow flat washer, 1/4"
66. Baffle
67. Hex-lock elastic nut, 1/4-20
68. Radiator hose clamp (engine)
69. Radiator return hose
70. Radiator input hose
71. Radiator assembly (incl. item 72)
72. Radiator cap, 13 psi (89,6 kPa)
73. Narrow flat washer, 5/16"
74. Lockwasher, 5/16"
75. Hex-head capscrew, 5/16-18 x 3/4" Grade 5
76. Overflow tank, 3 qt. (incl. item 77)
77. Cap w/tether
78. Right radiator bracket assembly
79. Well nut
80. Wide flat washer, 1/4"
81. Lockwasher, 1/4"
82. Hex-head capscrew, 1/4-20 x 1-1/2
83. Fan warning decal

Figure 8B–4. Cummins engine radiator and oil cooler.

To replace the radiator and oil cooler:

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut off the engine. Remove the ignition key. Secure accident prevention tags to the steering wheel and ignition switch.

> **WARNING: DO NOT** attempt this procedure when the engine is hot. Wait for the engine, muffler, and tailpipes to cool down before proceeding. Failure to do so could result in severe burns.

2. Unlatch, unlock and open the engine cover. Allow the engine to cool before proceeding. Draining the cooling system while the engine is hot can cause cracks in the engine block.
3. Disconnect the negative (-) battery cable.

> **WARNING: NEVER** remove the radiator cap while the engine is hot. The cooling system is under pressure. Hot coolant can cause severe burns or eye injury. Wear protective clothing and safety glasses.

4. Place a suitable container beneath the radiator petcock. Slowly turn the radiator cap to the first stop and allow any pressure to escape. Remove the radiator cap.
5. Place a funnel at the base of the radiator to channel the drained coolant into the container. Open the radiator drain plug or petcock and allow the coolant to drain into the funnel. Transfer the coolant into a properly labeled container. Dispose of properly if coolant needs to be replaced. Close the radiator drain plug or petcock.
6. Loosen clamps (items 63 and 68, Fig. 8B–4) on the radiator return (lower) hose (69). Work the hose off the radiator. Position the hose out of the way to allow radiator removal, or remove the hose from the engine. Inspect the hose and replace if necessary.
7. Loosen clamps (63 and 68, Fig. 8B–4) on the radiator input (upper) hose (70). Work the hose off the radiator. Position the hose out of the way to allow radiator removal, or remove the hose from the engine. Inspect the hose and replace if necessary.
8. Loosen the fan belt and remove the fan (item 1, Fig. 8B–1). Remove the four M10-1,5 x 90 mm hex-head capscrews (4) and M10 lockwashers (5) securing the fan (3) to the engine.
9. Disconnect and cap the transmission inlet and outlet hoses (Fig. 8B–5).

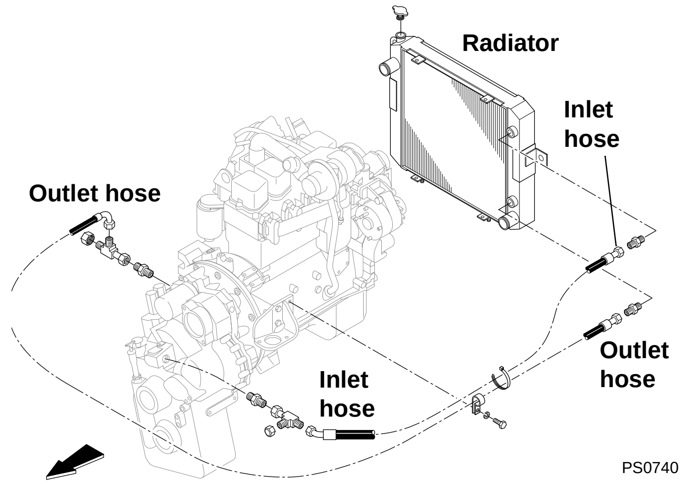


Figure 8B–5. Transmission hose routings.

10. Working above the radiator, remove two 5/16-18 x 3/4" Grade 5 hex-head capscrews (item 75, Fig. 8B–4), 5/16" lockwashers (74) and 5/16" narrow flat washers (73) securing the radiator at the upper mounting tabs to the radiator shroud (62). The radiator shroud contains 5/16" weld nuts that retain the capscrews.
11. Working below the radiator, remove two 5/16-18 x 3/4" Grade 5 hex-head capscrews (75), 5/16" lockwashers (74) and 5/16" narrow flat washers (73) securing the radiator at the lower mounting tabs to the radiator shroud (62).
12. Working from beneath the radiator, remove two 3/8-16 hex-lock nuts (58), 3/8" rebound washers (50) and rubber mounts (61) secured to the welded studs on the bottom of the radiator.
13. At the sides of the radiator, remove the 3/8 x 1-1/2 x 5/16-18 hex-socket head shoulder bolts (55), spacers (53), 3/8" rebound washers (50), radiator mount bushings (52), radiator mount rings (49), and 5/16-18 hex-lock elastic nuts (51) securing the radiator at its side mounting tabs to the radiator brackets (54 and 78). Carefully remove the radiator from the vehicle.
14. At the bottom of the oil cooler (Fig. 8B–6), use wrench and a back-up wrench to disconnect the 90° elbow. Cap the elbow. Remove and discard the flat-faced O-ring seal. Disconnect and cap the 3/4" I.D. x 28" hose.
15. Remove the six 1/4-20 x 1-1/2" hex-head capscrews (item 82, Fig. 8B–4), 1/4" lockwashers (81), 1/4" flat wide washers (80) and well nuts (79) securing the radiator baffle assembly (46) to the oil cooler (48).

16. Remove the oil cooler (Fig. 8B–6).

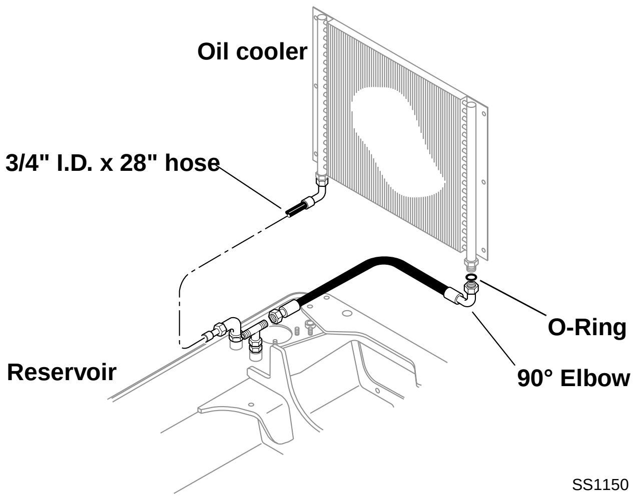


Figure 8B–6. Cummins oil cooler hose routings.

17. Remove, inspect and replace the seal bulb (item 44, Fig. 8B–4), seal bulb moulding (45), and foam baffles (47) as required.

Radiator and Oil Cooler Installation

1. Install the seal bulb (item 1, Fig. 8B–4), seal bulb moulding (45), and foam baffles (47) as required.
2. Position the oil cooler (48) within the radiator assembly baffle (46).
3. Install the six 1/4-20 x 1-1/2" hex-head capscrews (82, Fig. 8B–4), 1 /4" lockwashers (81), 1/4" flat wide washers (80) and well nuts (79) securing the radiator baffle assembly (46) to the oil cooler (48). Torque to 9 lb/ft (12 Nm).
4. At the bottom of the hydraulic system oil cooler (Fig. 8B–6), install a new flat-faced O-ring seal in the elbow and secure the hose to the cooler. Use a back-up wrench and torque to 155-165 lb/ft (210-224 Nm).
5. Secure the 3/4" I.D. x 28" hose (Fig. 8B–6) to the oil cooler.
6. Carefully place the radiator into position at the oil cooler. As required, place two foam baffles (item 4, Fig. 8B–4) between the radiator and the oil cooler.
7. At the radiator sides, install the 3/8 x 1-1/2 x 5/16-18 hex-socket head shoulder bolts (55), spacers (53), 3/8" rebound washers (50), radiator mount bushings (52), radiator mount rings (49), and 5/16-18 hex-lock elastic nuts (51) securing the radiator at its side mounting tabs to the radiator brackets (54 and 78).
8. Working from beneath the radiator, install two 3/8-16 hex-lock nuts (58), 3/8" rebound washers (50) and rubber mounts (61) secured to the welded studs on the bottom of the radiator. Torque to 31 lb/ft (42 Nm).
9. Working below the radiator, install two 5/16-18 x 3/4" Grade 5 hex-head capscrews (75), 5/16" lockwashers (74) and 5/16" narrow flat washers (73) securing the radiator at the lower mounting tabs to the radiator shroud (62). Torque to 18 lb/ft (24 Nm).
10. Working above the radiator, install two 5/16-18 x 3/4" Grade 5 hex-head capscrews (75), 5/16" lockwashers (74) and 5/16" narrow flat washers (73) securing the radiator at the upper mounting tabs to the radiator shroud (62). The radiator shroud contains 5/16" weld nuts that retain the capscrews. Torque to 18 lb/ft (24 Nm).
11. Uncap and connect the transmission inlet and outlet hoses (Fig. 8B–5).
12. Install the fan (item 3, Fig. 8B–1) on the water pump pulley on the front of the engine. Secure with four M10-1,5 x 90 mm hex-head capscrews (4) and M10 lockwashers (5). Torque to 37 lb/ft (50 Nm). Install the fan belt.
13. Install clamps (63 and 68, Fig. 8B–4) on the radiator input (upper) hose (70). Work the hose onto both the engine and then the radiator. Tighten the clamps.
14. Install clamps (63 and 68) on the radiator return (lower) hose (69). Work the hose onto both the engine and then the radiator. Tighten the clamps.
15. Fill the cooling system. Run the engine to operating temperature. Visually check for leaks with the engine running. Check the coolant level in the overflow bottle and fill, or drain, as necessary.

8B.6 CUMMINS ENGINE ELECTRICAL SYSTEM

The Cummins engine electrical system, including the starter, alternator and primary wiring, is described in *Section 10 Electrical System*.

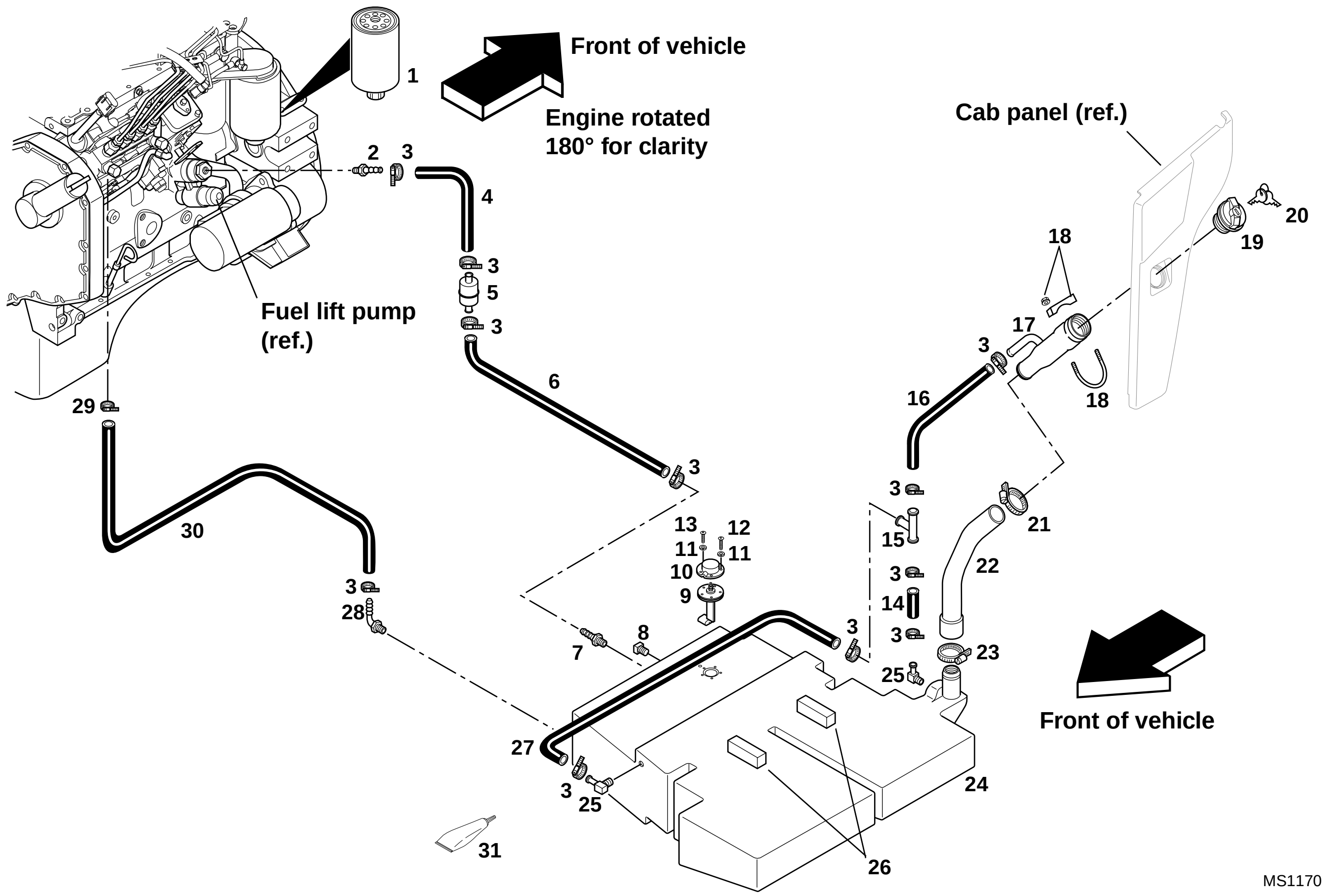
8B.7 CUMMINS ENGINE FUEL SYSTEM

The Cummins engine fuel system includes a fuel tank (item 24, Fig. 8B–7), fuel level sender (9) and dash panel gauge, fuel strainer (5), fuel lift pump (ref.), fuel filter (1), and fuel supply and return lines.

The threaded fuel filler (17) has a keyed fuel cap (19) and permits entry of diesel fuel into the tank.

The fuel level sender (9) and dash panel gauge are described in *Section 10 Electrical System*.

A fuel supply hose (6) carries fuel from the tank to the engine lift pump (ref.) and then under pressure to the fuel filter (1). Filtered fuel is directed to the fuel injection pump and to the individual fuel injectors. Surplus fuel at the fuel injector pump is returned to the tank via the fuel return hose (30).



1. Fuel filter
2. Straight barb connector, #6-4P
3. Hose clamp, SAE Type F
4. Fuel hose, 3/8" x 10"
5. Fuel strainer
6. Fuel tank-to-engine hose, 3/8" x 85"
7. Hose barb coupling, #6-6P, use with Item 31
8. Square-head black plug, MI#6, use with Item 31
9. Fuel sender w/gasket
10. Fuel sender cover
11. Lockwasher, #10
12. Pan-head screw, #10-24 x 3/4"
13. Pan-head screw, #10-24 x 5/8"
14. Fuel breather hose
15. Beaded hose tee
16. Fuel breather hose
17. Fuel filler
18. U-type muffler clamp, 2"
19. Fuel cap w/keys (incl. Item 20)
20. Keys (set of two)
21. Upper hose clamp, SAE Type F
22. Fuel filler hose
23. Lower hose clamp, SAE Type F
24. Fuel tank
25. 90° hose barb elbow, #10-6P, use with Item 31
26. Gasket
27. Fuel breather hose
28. 90° hose barb elbow, #5-6P, use with Item 31
29. Mini hose clamp, 7/32" diameter
30. Fuel return hose
31. Pipe thread sealant w/Teflon®, 8oz; use w/ ALL threaded fittings

Figure 8B–7. Cummins engine fuel system.

8B.7.1 Diesel Fuel

Fuel represents a major portion of vehicle operating costs and therefore must be used efficiently. **ALWAYS** use a premium brand of high-quality, clean diesel fuel. Low cost, inferior fuel can lead to poor performance and expensive engine repair.

Note: Use only diesel fuel designed for diesel engines. Some heating fuels contain harmful chemicals that can seriously affect engine efficiency and performance.

IMPORTANT: Due to the precise tolerances of diesel injection systems, keep the fuel clean and free of dirt and water. Dirt and water in the fuel system can cause severe damage to both the injection pump and the injection nozzles. Use ASTM No. 2 D fuel with a minimum cetane rating of 40. No. 2 diesel fuel gives the best economy and performance under most operating conditions. Fuels with Cetane numbers higher than 40 may be needed in high altitudes or extremely low ambient temperatures to help prevent misfiring and excessive smoking.

Inform the owner/operator of the vehicle to use No. 2 D diesel fuel, unless ambient temperatures are below 32° F (0° C). When temperatures are below 32° F (0° C), a blend of No. 1 D and No. 2 D fuels (known as "winterized" No. 2 D) may be used.

Note: No. 1 D fuel may be used, however, fuel economy will be reduced.

WARNING: DO NOT mix gasoline or alcohol with diesel fuel. The mixture can cause an explosion.

Use a low-sulfur content fuel with a cloud point (the temperature at which wax crystals form in diesel fuel) at least 10° below the lowest expected fuel temperature. The viscosity of the fuel *must* be kept above 1.3 centistrokes to provide adequate fuel system lubrication.

Note: When using diesel fuel with a sulfur content below 1.3 percent, the filter change interval must be reduced by 75 hours. The use of fuel with a sulfur content above 1.3 percent is not recommended.

8B.7.2 Fuel Tank

The fuel tank (item 24, Fig. 8B–7) is located directly beneath the operator's cab.

A. Removal

The operator's cab must be partially removed in order to remove the fuel tank. Follow the directions for removing the operator's cab in *Section 4 Cab, Covers and Mirrors*, then remove the fuel tank. If a leaking fuel tank is suspected, check that all fuel tank inlets and outlets are not the cause of the leak before removing the cab and the fuel tank from the vehicle.

B. Disassembly

1. Remove the four #10-24 x 3/4" pan-head screws (item 12, 8B–7), the #10-24 x 5/8" pan-head screw (13), and the five #10 lockwashers (11) securing the fuel sender cover (10) and fuel sender with gasket (9) to the fuel tank.
2. Remove the black MI #6P square-head plug (8), the #6-6P hose barb coupling (7), the #5-6P 90° hose barb elbow (28) and both #10-6P 90° hose barb elbows (25).

C. Cleaning and Drying

If contaminated fuel or foreign material is in the tank, the tank can usually be cleaned. Replace a leaking or damaged tank. **DO NOT** attempt to repair, plug or patch a leaking or damaged fuel tank. The tank is manufactured using an injection molding process and cannot be repaired.

To clean the fuel tank:

1. Have a dry chemical (Class B) fire extinguisher near the work area.

WARNING: NEVER drain or store fuel in an open container due to the possibility of explosion or fire. Discard the fuel in an approved manner.

2. Invert and tilt the tank from side to side. Safely drain any fuel into a suitable container. Dispose of properly.
3. Clean the fuel tank with a high-pressure washer, or flush the tank with hot water for five minutes. Invert the tank, tilt it from side to side, and drain the water.
4. If necessary, add a diesel fuel emulsifying agent to the tank. Refer to the manufacturer's instructions for the correct emulsifying agent-to-water mixture ratio. Refill the tank with water, and agitate the mixture for 10 minutes. Drain the tank completely.
5. Refill the fuel tank with water until it overflows. Completely flush the tank with water. Empty the tank and allow it to dry completely.

D. Inspection

1. Inspect the fuel tank thoroughly for any cracks, slices, leaks or other damage. Replace a leaking or damaged tank. **DO NOT** attempt to repair, plug or patch a leaking or damaged fuel tank. The tank is manufactured using an injection molding process and cannot be repaired.
2. With the fuel tank removed from the vehicle, plug all openings except one elbow fitting. Install the elbow fitting and apply approximately 1 to 1-1/2 psi (7 to 10 kPa) of air pressure through the elbow. Check the tank for leaks by applying a soap solution to the exterior of the tank, or by submerging the tank in water and looking for bubbles to appear at the cracked or damaged area.

E. Assembly and Replacement

1. Install the fuel sender with gasket (item 9, Fig. 8B–7) and the fuel sender cover (10) to the fuel tank. Secure with four #10-24 x 3/4" pan-head screws (12), and four #10 lockwashers (11).
2. Coat threads with Teflon® (31) and install the black MI #6P square-head plug (8), the #6-6P hose barb coupling (7), the #5-6P 90° hose barb elbow (28) and both #10-6P 90° hose barb elbows (25).
3. Replace the fuel tank in the cab mount subframe. Attach the fuel level gauge wire to the #10-24 x 5/8" pan-head screw (13), slide a #10 lockwasher (11) onto the screw and secure the screw to the fuel tank at the fuel sender cover.

4. Reconnect the fuel hoses and follow the directions in *Section 4 Cab, Covers and Mirrors* to replace the other fuel system components and the cab.

8B.7.3 Fuel Level Sender and Gauge

The fuel level sender and gauge assembly is described in *Section 10 Electrical System*.

8B.7.4 Fuel Lift Pump Testing

Inspect the camshaft lever and return spring for excessive wear. To test the diaphragm, remove the fuel inlet line from the lift pump. Block the fuel inlet with a finger (Fig. 8B–8) and operate the hand plunger. A properly operating pump will provide suction that will remain until the finger is removed from the inlet.

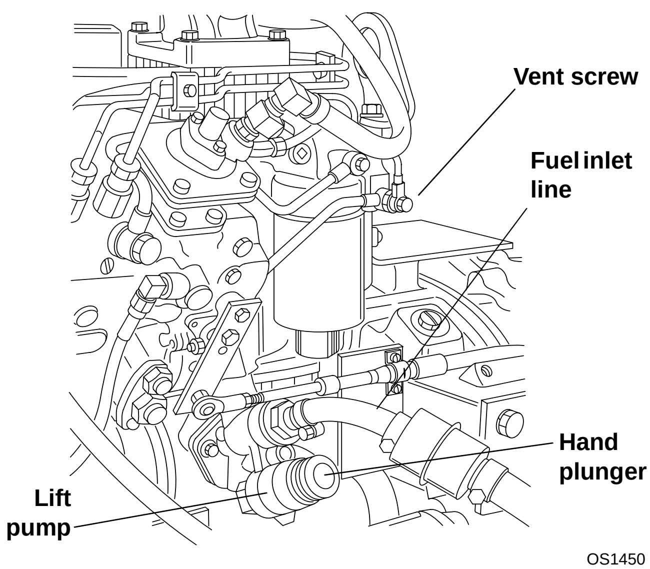


Figure 8B–8. Testing a typical fuel lift pump.

A. Fuel Lift Pump Removal

1. Clean debris from around the lift pump.
2. Disconnect the fuel lines.
3. Remove the capscrews, gasket, and fuel lift pump.

B. Cleaning and Drying

Clean the exterior of the pump with mineral spirits and blow dry with compressed air.

Note: Parts replacement is not practical. The fuel lift pump is serviced as an entire assembly.

C. Fuel Lift Pump Installation

1. Clean the mounting surface on the cylinder block.
2. Install the fuel lift pump with a new gasket. Install and torque the capscrews to 18 lb/ft (24 Nm).
3. Connect the fuel lines.

8B.7.5 Fuel Filter

Refer to *Section 2 General Information, Specifications, and Maintenance Instructions* for information on removing and replacing the fuel filter (item 1, Fig. 8B–7).

8B.7.6 Venting Air from the Fuel System

Refer to *Section 2 General Information, Specifications, and Maintenance Instructions*, paragraph 2.12.7 D, Venting Air from the Fuel System.

8B.7.7 Fuel Injectors

The Cummins engine uses Bosch 17 mm closed nozzle hole-type injectors. The injectors have different part numbers for different engine ratings. The last four digits of the Cummins part number (stamped on the bottom portion of the injector) identify the injector.

IMPORTANT: Use only the specified injector for the engine.

During the injection cycle, high pressure from the injection pump rises to the operating (or "pop") pressure, which causes the needle valve in the injector to lift. Fuel is then injected into the cylinder. A shimmed spring is used to force the needle valve closed as the injection pressure drops below the pop pressure to seal off the nozzle after injection. Failure of the needle valve to lift and to close at the correct time, or a needle valve that is stuck open, can cause the engine to misfire and produce low power. Fuel leaking from the open nozzle can cause a fuel knock, poor performance, smoke, poor fuel economy, and rough running.

A. Locating Faulty Fuel Injectors

A faulty fuel injector can cause:

- Misfiring
- Knocking
- Overheating
- Loss of power
- Smoky (black) exhaust
- Increased fuel consumption

The particular faulty fuel injector(s) may be determined by releasing the pipe union nut on each fuel injector in turn, with the engine running at a fast "tick-over." If, after slackening a pipe union nut, the engine revolutions remain constant, a faulty fuel injector has been identified.

To test a fuel injector:

1. Remove the fuel injector from the cylinder head.
2. Invert the fuel injector with the nozzle facing out, then retighten the unions.
3. Loosen the unions of the other fuel injector pipes (to help avoid the possibility of the engine starting).

WARNING: KEEP CLEAR of spraying fuel. Diesel fuel will spray when venting high pressure lines. The fuel pressure is sufficient to penetrate the skin and cause serious bodily injury. Wear protective clothing and safety glasses.

4. Operate the starter to turn the engine over until fuel sprays from the nozzle. Examine the shape of the spray. If the spray is unduly “wet” or “streaky”, or obviously sprays to one side, or if the nozzle “dribbles” fuel, it may only be necessary to probe the nozzle holes to remove blockage.

IMPORTANT: DO NOT attempt to adjust injection pressure without a testing pump and pressure gauge. It is impossible to accurately adjust the setting of fuel injectors without the proper equipment.

A perfect fuel injector, when tested by pumping fuel through it in the open air, gives a short “pinging” sound as the fuel emerges from the holes. After the fuel injector has been in service for some time, the pinging changes to a crackling sound. It is not until the fuel injector sounds “dead” that its condition is likely to affect the running of the engine.

B. Injector Replacement

Preparatory steps:

- Thoroughly clean around the injector(s)
- Disconnect the high-pressure fuel line(s)
- Disconnect the fuel drain manifold

IMPORTANT: The injector must not rotate in the bore of the cylinder head or damage to the cylinder head will occur. If rust has formed on the hold-down nut, soak the nut with rust-penetrating solvent for a minimum of three minutes. Then, tap the injector body with a drift pin to help loosen any rust.

1. Use a 16 mm wrench to prevent the injector body (Fig. 8B–9) from turning. Loosen the hold-down nut with a 24 mm box wrench.

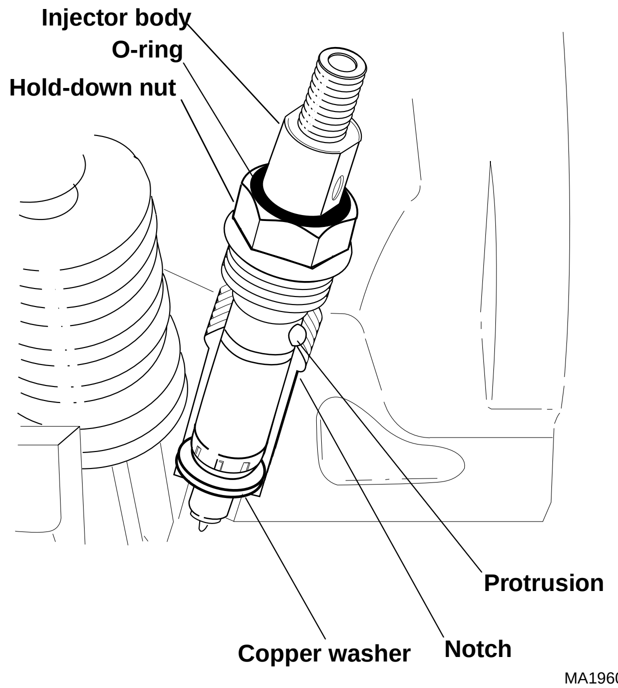


Figure 8B–9. Fuel injector.

2. Clean the injector nozzle bore.
3. Remove the injector hold-down nut from the injector body.
4. Apply a light coat of anti-seize compound to the new injector surface. Avoid getting anti-seize compound into the fuel drain hole.
5. Install the hold-down nut on the injector body.
6. Install a new O-ring into the recessed groove in the top of the hold-down nut. Make sure the O-ring is not cut or twisted during installation.
7. Apply a light coat of anti-seize compound to the to the threads of the injector hold-down nut.
8. Assemble the injector and new copper washer. Use only ONE copper washer. A light coat of clean 15W40 engine oil placed between the washer and the injector will help keep the washer from falling during installation.
9. Install the injector with the protrusion on the side of the nozzle fitting into the notch in the head.
10. Tighten the hold-down nut and torque to 44 lb/ft (60 Nm).
11. Install the fuel drain manifold and torque to 6 lb/ft (8 Nm).
12. Install the high-pressure fuel lines and torque to 18 lb/ft (24 Nm).
13. Run the engine and check for fuel and air leakage.

14. Bleed the fuel system in accordance with the instructions in *Section 2 General Information, Specifications, and Maintenance Instructions*.

8B.7.8 After Fuel System Service

1. Drain and flush the fuel tank if it was contaminated.
2. Vent air from the fuel system (see *Section 2 General Information, Specifications, and Maintenance Instructions*, paragraph 2.12.7 D).
3. Fill the fuel tank with fresh, clean diesel fuel as required.

8B.8 CUMMINS ENGINE EXHAUST SYSTEM

> **WARNING:** Exhaust fumes contain carbon monoxide, a colorless, odorless gas which is fatal when inhaled in a confined area. Avoid breathing exhaust fumes and prevent engine operation from becoming a cause of toxic emissions.
> Exhaust system components reach high temperatures and can cause severe burns. **DO NOT** come into contact with hot exhaust system components.

The exhaust system (Fig. 8B–10) is supported by the engine and the vehicle frame to help minimize the transfer of noise and vibration into the operator's cab. The tail pipe directs exhaust fumes to the right side of the vehicle, away from the cab.

Annoying rattles and noise vibrations in the exhaust system are usually caused by misalignment of parts. When aligning the system, leave all capscrews and nuts slightly loose until all parts are properly aligned, then tighten all fasteners working from the front of the system to the rear.

When replacing the muffler, also replace the tail pipe.

Before assembling components, use exhaust system sealer at all slip joint connections.

1. V-band clamp
2. Exhaust pipe
3. Heavy-duty T-bolt band clamp
4. Exhaust bellows
5. Exhaust pipe
6. Heavy-duty muffler clamp, 2-1/2"
7. Exhaust muffler
8. Exhaust tail pipe

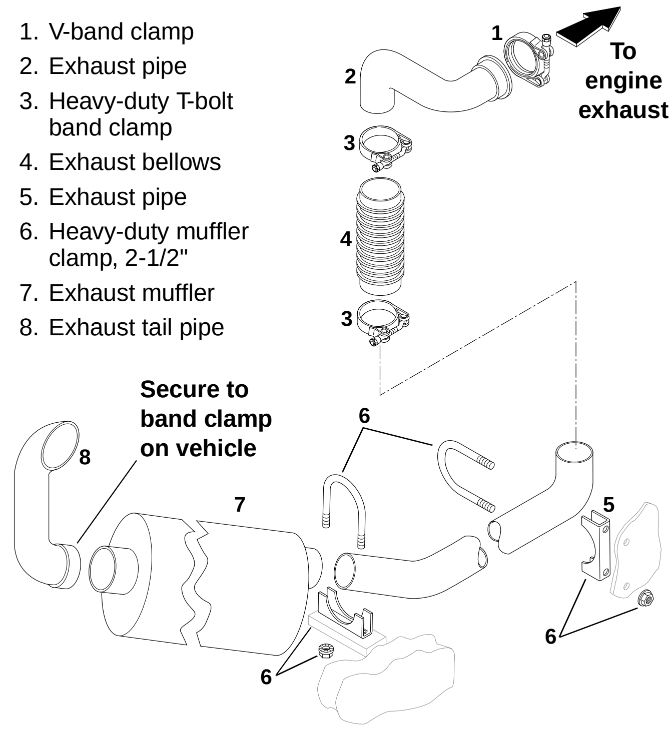


Figure 8B–10. Cummins engine exhaust system.

When installing exhaust system components, allow sufficient clearance between the components and other vehicle pipes, hoses and wiring that could be adversely affected by excessive heat.

When installing an exhaust system, provide for parts expansion when the system is hot.

Whenever performing service on the vehicle, check the condition of the exhaust system. Check the entire exhaust system for broken, damaged, missing or mispositioned parts, open seams, holes, loose connections and other deterioration which could permit exhaust fumes to seep into the operators cab. Correct any damaged areas immediately.

8B.9 CUMMINS ENGINE REPLACEMENT

Removal and installation of the engine can be done with or without the transmission attached. For information on removing the transmission from, and installing it to, the engine, refer to *Section 7 Transmission*.

8B.9.1 Engine Removal

WARNING: To avoid severe burns, **DO NOT** attempt to remove the engine when the engine, cooling system and hydraulic system are hot. Wait until all parts and systems are cool before proceeding.

1. Level the vehicle, ground the attachment, place the travel select lever in NEUTRAL (N), engage the parking brake switch and shut off the engine. Allow the engine, cooling system and hydraulic system to cool.
2. Label and disconnect the negative (-) battery ground cable at the battery (Fig. 8B–11). Also, disconnect the negative lead from at the starter mounting bolt.

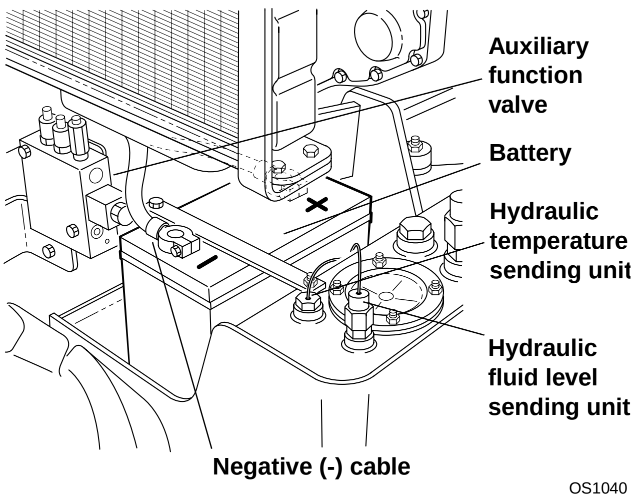


Figure 8B–11. Disconnect the negative (-) battery cable.

3. Remove the hood with the help of at least one assistant (refer to *Section 4 Cab, Covers and Mirrors*).
4. Position a suitable container beneath the radiator (Fig. 8B–12). Remove the radiator cap and open the radiator drain petcock. Allow the coolant to drain into the container. At the engine, loosen the upper and lower radiator hose clamps and pry the hoses away from the engine.

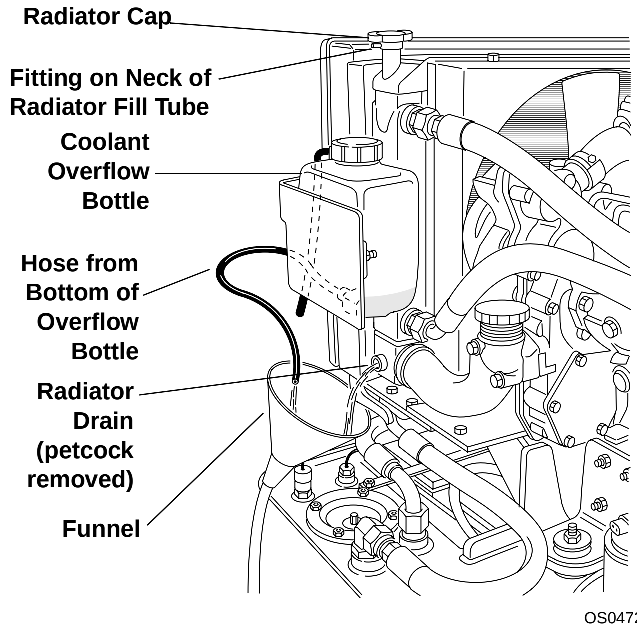
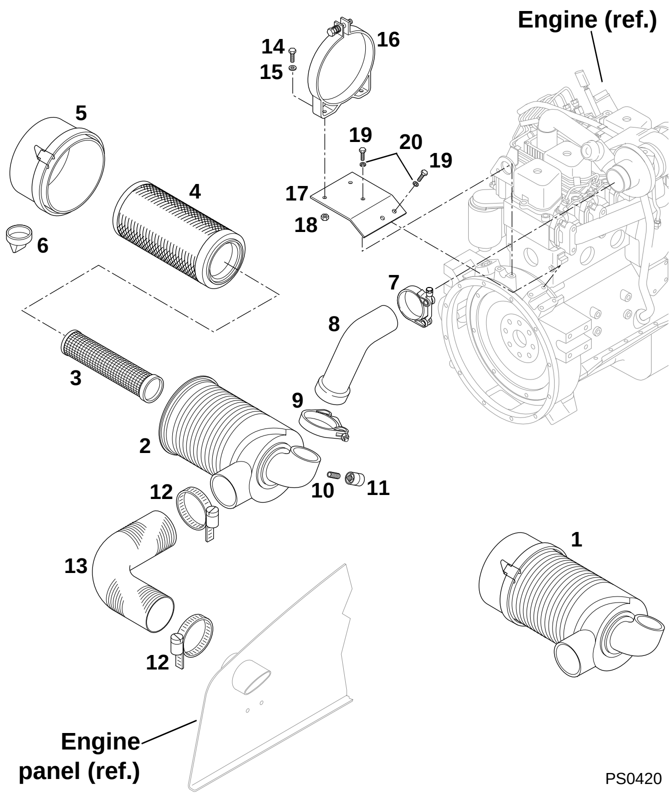


Figure 8B–12. Drain the radiator.

5. Detach and remove the air cleaner (Fig. 8B–13). Loosen the clamp securing the air intake hose to the engine panel. Remove the hose at the engine panel.
6. Loosen the air cleaner mount band assembly (Fig. 8B–13) securing the air cleaner hose to the turbocharger intake on the engine. Remove the turbocharger intake hose. Cover the intake to help prevent debris, etc. from entering.
7. Unscrew the clamp securing the air cleaner body assembly (Fig. 8B–13) to the mount plate on the engine. Remove the air cleaner assembly in its entirety and store securely.



1. Air cleaner assembly (incl. items 2-6)
2. Body assembly
3. Safety filter
4. Primary filter
5. Cover assembly
6. Vactuator valve
7. Heavy-duty T-bolt clamp
8. Air cleaner hose
9. T-bolt clamp
10. Close nipple, #2
11. Vacuum switch
12. Hose clamp, SAE Type F
13. Air intake hose
14. Hex-head capscrew, 5/16-18 x 3/4"
15. Flat narrow washer, 5/16"
16. Air cleaner mount band assembly
17. Air cleaner mount plate
18. Hex-lock elastic nut, 5/16-18
19. Hex-head capscrew, 3/8-16 x 1-1/4" Grade 5
20. Lockwasher, 3/8"

Figure 8B–13. Cummins air cleaner.

8. Disconnect the turbocharger exhaust connection, secured with a stainless steel V-band clamp, and cover the exhaust to prevent debris, etc. from entering. Disconnect the exhaust pipe (Fig. 8B–10) from the exhaust bellows, secured with a heavy-duty T-bolt band clamp.

9. Label and disconnect the alternator wire leads (Fig. 8B–14).

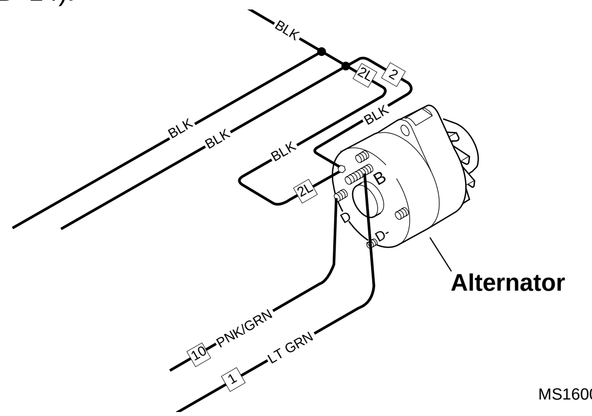


Figure 8B–14. Label and disconnect the alternator wire leads.

10. Disconnect (unplug) the hydraulic fluid level indicator lead (Fig. 8B–11 and Fig. 8B–15) and the hydraulic temperature sending unit lead (Fig. 8B–11) from the wiring harness connector.

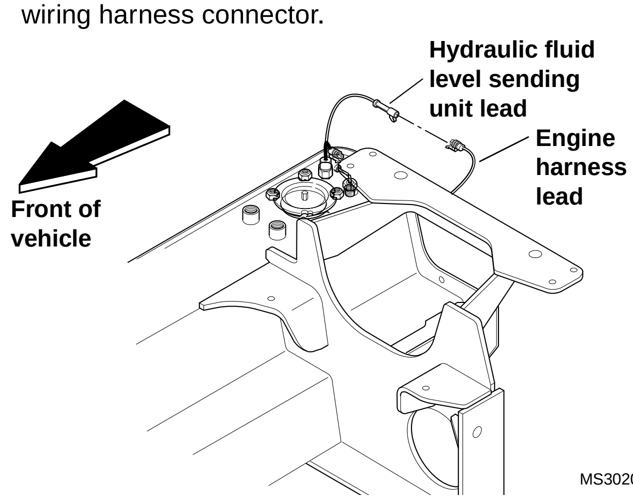


Figure 8B–15. Disconnect the hydraulic fluid level indicator lead.

11. Label and disconnect the wires at the main ground stud (Fig. 8B–16).

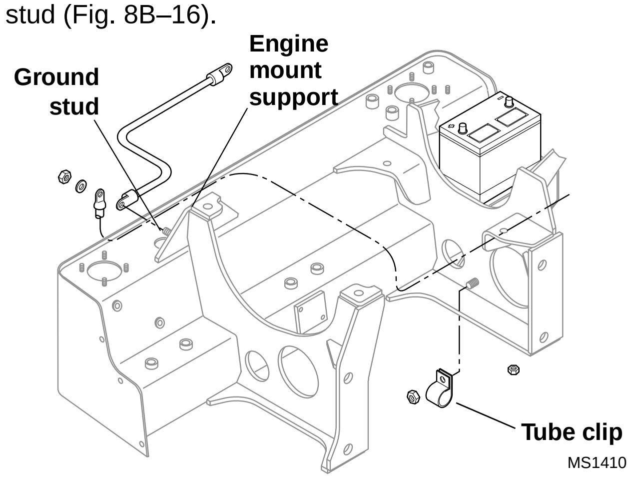


Figure 8B–16. Disconnect wires at the main ground stud.

12. Label and disconnect the positive (+) battery cable at the starter.
13. Label and disconnect the engine water temperature switch lead (Fig. 8B–17), engine oil pressure switch lead, and transmission temperature lead.

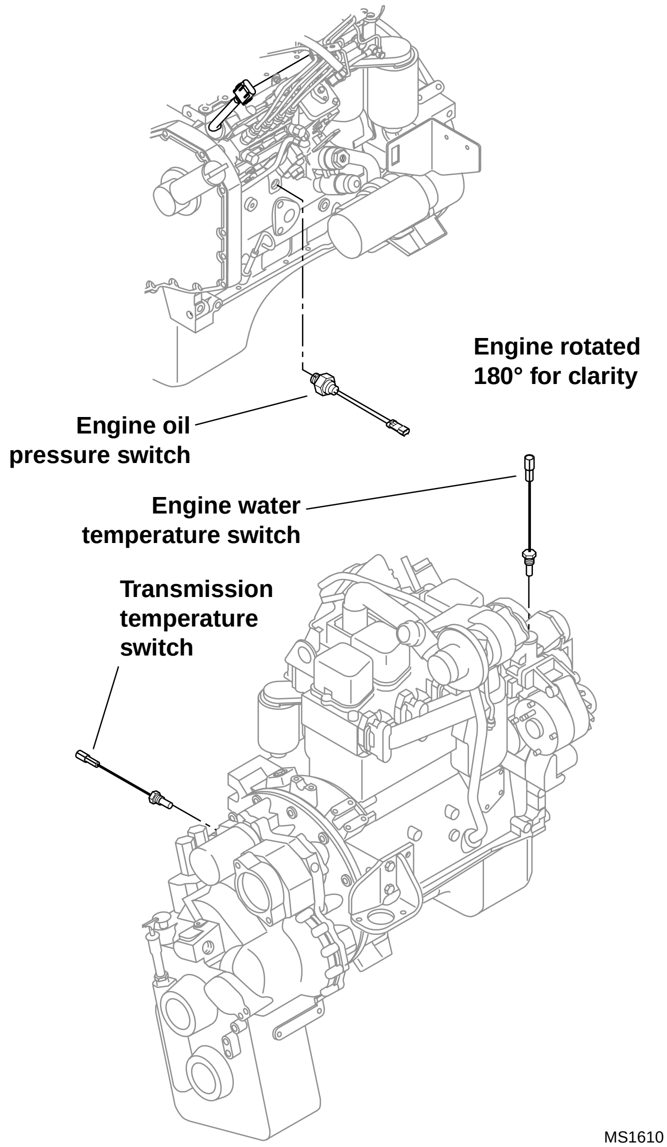


Figure 8B–17. Label and disconnect the engine water temperature and oil pressure switch leads, and the transmission temperature switch lead.

14. If removing the engine and transmission as a unit:
    - Place a suitable container beneath the vehicle frame side of the radiator. Disconnect the transmission cooler hoses at the radiator and cap the connectors to help prevent excess fluid drainage. Secure the hoses out of the way on top of the engine.
    - Move the container beneath the transmission.Disconnect and cap the inlet and outlet hoses at the main hydraulic pump. Disconnect the pump inlet hose from the hydraulic reservoir and cover the opening to help prevent debris, etc. from entering the pump. Move the hoses out of the way to allow engine and transmission removal.
    - Label and disconnect all transmission wire leads.
    - Mark the transmission and transmission driveshaft flange yoke. Disconnect the transmission-to transfer case driveshaft at the transmission flange yoke. Secure the U-joints with tape. Lower the driveshaft to the ground.

Note: The drive shaft assembly is a balanced assembly. Mark the yoke and transmission so that these components can be returned to their original positions when the transmission is reinstalled. The yokes at each end of the drive shaft must be in the same plane to help prevent excessive vibration (Fig. 8B–23).

15. Working from beneath the vehicle, label and disconnect all engine wire harness leads (refer to *Section 10 Electrical System* as required for detailed views of harness leads). Remove plastic tie wraps as required to allow access to the wiring harness and wire leads.
16. Disconnect the engine wiring harness bulkhead connector from the cab wiring harness bulkhead connector along the vehicle frame.

17. Label and disconnect the wiring harness at the steer select valve (Fig. 8B–18).

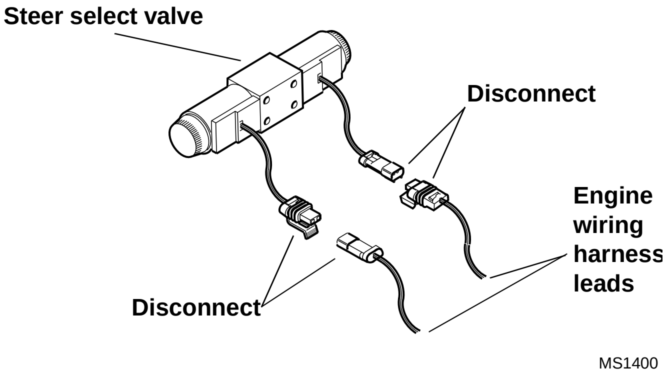


Figure 8B–18. Label and disconnect the wiring at the steer select valve.

18. Label and disconnect the wiring connectors at the auxiliary function valve solenoids (Fig. 8B–19). Move all wiring out of the way to allow engine removal.

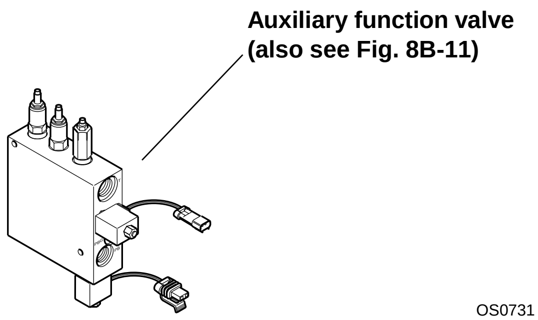


Figure 8B–19. Disconnect the wiring at the auxiliary function valve solenoids.

19. Working from the side of the vehicle, disconnect the fuel return line at the fuel injector pump.
20. Disconnect the fuel inlet line (Fig. 8B–20) at the fuel lift pump.

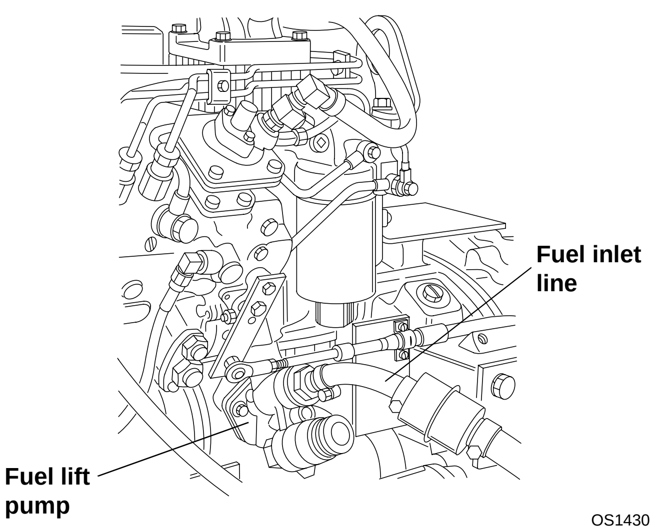


Figure 8B–20. Fuel inlet line to lift pump connection.

21. Mark the location of the throttle cable at its engine mount bracket (Fig. 8B–21).

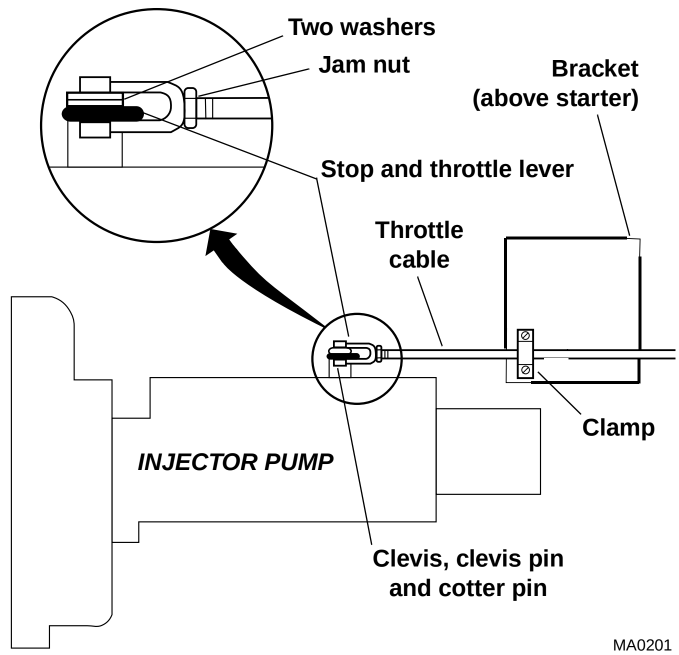


Figure 8B–21. Throttle cable connection at engine.

22. Disconnect the throttle cable (Fig. 8B–21) at the bracket above the starter.
23. At the hydraulic fluid reservoir, disconnect the engine harness wire lead (Fig. 8B–11) from the hydraulic fluid-level sending unit.
24. Connect a suitable engine hoist to the engine lift plates (Fig. 8B–22).

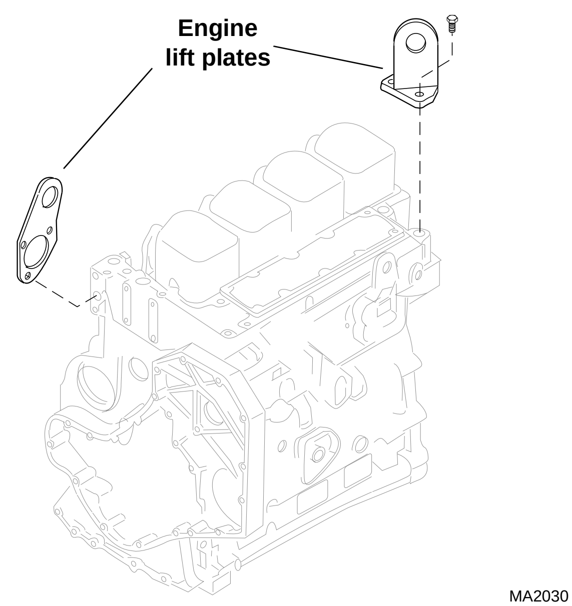


Figure 8B–22. Typical engine lift plates.

25. In four locations, remove the nuts, washers and capscrews securing the engine mounts (Fig. 8B–1) to the hydraulic reservoir/engine mount subframe.
26. Remove either the fan or the radiator to help prevent damage to the radiator when the engine is removed.
27. Begin removing the engine from the vehicle with the hoist or overhead crane.
28. As the engine is lifted away and removed, reposition the debris shield at the base of the radiator to prevent damage and allow engine removal. Avoid damaging the oil filter and oil filter housing.
29. Carefully lift the engine out and away from the vehicle. Place the engine safely onto ground supports, or in a suitable engine stand. **DO NOT** rest the engine on its oil pan, or damage will occur.

8B.9.2 Engine Disassembly, Inspection and Service

Engine disassembly, internal inspection, service, repair and assembly procedures are covered in the Cummins 4BT3.9 service manual. Several special engine service tools are required to properly service the Cummins engine. Contact the local Cummins parts distributor for further information.

8B.9.3 Engine Installation

Removal and installation of the engine can be done with or without the transmission attached. For information on installing the transmission to the engine, refer to *Section 7 Transmission*.

1. Place the engine mounts (items 17 and 26, Fig. 8B–1) into the appropriate locations within the hydraulic reservoir/engine mount subframe on the vehicle.
2. Attach a suitable engine hoist to the engine lift plates (Fig. 8B–22).
3. Carefully install the engine onto the engine mounts (Fig. 8B–1). Make sure the bracket-type engine mounts align properly with the engine mounts in the subframe.
4. In four locations, install the nuts, washers and capscrews securing the engine mounts (Fig. 8B–1) to the hydraulic reservoir/engine mount subframe. Torque the 7/16-14 x 3-1/4" Grade 8 capscrews to 60 lb/ft (81 Nm). Torque the 5/8-11 x 4" Grade 8 capscrews to 180 lb/ft (244 Nm).
5. Install the fan and/or radiator as required.
6. At the hydraulic fluid reservoir, connect the engine harness wire lead (Fig. 8B–11) to the hydraulic fluid-level sending unit.
7. Secure the throttle cable to the bracket (Fig. 8B–21), located just above the starter.
8. Connect the throttle cable (Fig. 8B–21) at the engine mount bracket.
9. Connect the fuel inlet line (Fig. 8B–20) to the fuel lift pump.
10. Connect the fuel return line to the fuel injector pump.
11. Attach the wiring connectors at the auxiliary function valve solenoids (Fig. 8B–19).
12. Connect the wiring harness leads to the steer select valve leads (Fig. 8B–18).
13. Connect the engine wiring-harness bulkhead connector to the bulkhead receptacle along the vehicle frame.
14. Working from beneath the vehicle, connect all engine wire harness leads (refer to *Section 10 Electrical System* as required for detailed views of harness leads). Secure with plastic tube clips and tie wraps as required to prevent the wiring harness and wire leads from hanging below the vehicle and from coming into contact with moving parts.
15. If the engine and transmission were NOT installed as a unit, attach the transmission to the engine at this time. Follow the procedure in *Section 7 Transmission*.

Note: The drive shaft is a balanced assembly. The yokes at each end of the drive shaft must be in the same plane to help prevent excessive vibration (Fig. 8B–23).

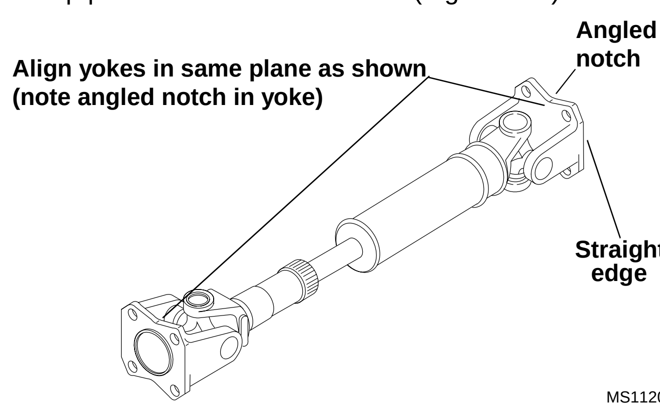


Figure 8B–23. Align yokes in the same plane as shown.

16. Coat the M12 transmission driveshaft yoke retaining capscrews with Loctite #242 (blue), install lockwashers and torque to 83 lb/ft (112,5 Nm).
17. Connect all transmission wire leads.

18. For priming purposes, pour hydraulic oil into the main hydraulic pump. Connect the hydraulic system inlet and outlet hoses at the main hydraulic pump. If necessary, connect the inlet hose to the hydraulic reservoir. Refer to *Section 9 Hydraulic System* as required.
19. Connect the transmission hoses (Fig. 8B–5) to the radiator.
20. Connect the engine coolant temperature switch lead (Fig. 8B–17) and oil pressure switch lead (refer to *Section 10 Electrical System* for detailed views of harness leads).
21. Connect the hydraulic oil pressure and temperature wiring harness leads (Fig. 8B–11 and Fig. 8B–15).
22. Connect the alternator wire leads (Fig. 8B–14), then connect the positive (+) battery cable to the starter, then to the battery. **DO NOT** connect the negative (-) lead at this time.
23. Connect the exhaust pipe (Fig. 8B–10) to the exhaust bellows. Secure with a heavy-duty T-bolt band clamp. For turbocharged engines, connect the turbocharger outlet to the exhaust. Secure with a stainless steel V-band clamp.
24. Secure the air cleaner mount band assembly (Fig. 8B–13) and mount plate to the engine with two 3/8-16 x 1-1/4 Grade 5 hex-head capscrews and two 3/8" lockwashers.
25. Install the air cleaner assembly (Fig. 8B–13) in its entirety. Install the air cleaner hose to the turbocharger intake port. Secure the air cleaner hose with a heavy-duty T-bolt clamp.
26. Install the air intake hose (Fig. 8B–13) at the engine panel. Tighten the SAE Type F clamp to secure the air intake hose to the engine panel.
27. Attach the upper and lower radiator hoses (Fig. 8B–4) to the engine water pump (and to the radiator, if necessary) and secure with hose clamps.
28. Open the radiator cap (Fig. 8B–4) and fill the radiator with a 50/50 mixture of water and ethylene glycol. More coolant will need to be added later. Replace and tighten the radiator cap.
29. Install the hood with the help of at least one assistant (refer to *Section 4 Cab, Covers and Mirrors*).
30. Connect the positive (+) battery cable at the starter, then at the battery.
31. Connect the negative (-) battery ground cable lead to the starter mounting bolt. Connect the negative (-) battery cable at the starter, and the negative frame ground cable to the frame stud (Fig. 8B–16).
32. Check that all hydraulic system, electrical system, cooling system, fuel system, and exhaust system connections are correctly and tightly connected.
33. From within the cab, lightly depress the throttle pedal (Fig. 8B–24) to full-throttle position. As needed, adjust the limit-stop screw until it touches the pedal. Tighten the locknut to 120 to 125 lb/in (13,6 to 14,1 Nm).

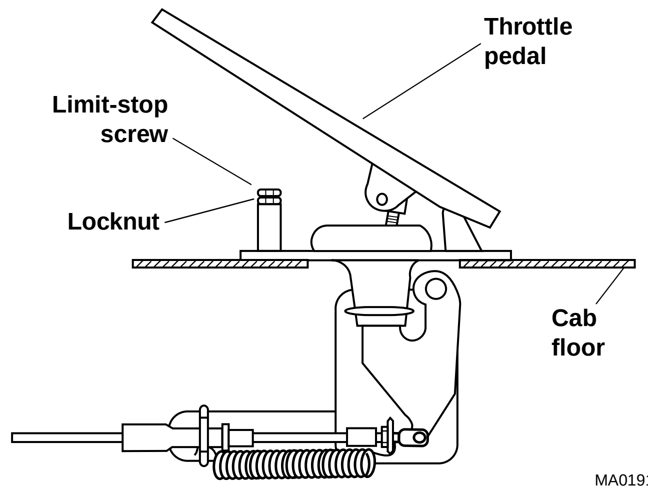


Figure 8B–24. Adjust the throttle limit-stop screw.

34. Have an assistant stand by with a Class B fire extinguisher. Start and idle the engine.
35. Check for leaks from the engine, main hydraulic pump and lines, transmission, hydraulic reservoir and fuel tank. Check the levels of all fluids and lubricants. Fill as required.

IMPORTANT: *During the full throttle check:*
- **DO NOT** operate any hydraulic function;
- **DO NOT** steer or apply any pressure to the steering wheel;
- Keep the transmission in NEUTRAL (N).

36. Obtain and connect an appropriate engine analyzer or tachometer. Check the engine rpm at full throttle. If the rpm is not 2600 to 2800 rpm, readjust the throttle limit-stop screw at the throttle pedal within the cab.
37. Purge the hydraulic system of air by operating all boom functions through their entire range of motion several times. Check the hydraulic oil level.
38. Check for proper operation of all components.
39. Turn the engine OFF.

8B.10 CUMMINS ENGINE STORAGE

If the engine is properly protected and stored according to the following recommendations, no corrosion damage will normally occur. Cummins Engine Company, Inc. and Sky Trak International are not responsible for any damage that occurs in relation to a service storage period.

Use the following procedures immediately upon removing engine from service if being stored for an extended period of time.

1. Clean the outside of the engine.
2. When using a preservative fuel, drain the fuel system and fill with the preservative fuel. When not using preservative fuel, keep the fuel system charged with regular fuel, which, along with the fuel filter, will have to be drained and discarded at the end of the storage period.
3. Run the engine to operating temperature. Correct any fuel, fluid, oil or air leaks. Stop the engine and drain the oil.
4. Replace the oil filter.
5. Fill the crankcase (sump) to the FULL mark on the dipstick with new, clean oil or with an approved preservative fluid. If a preservative fluid is used, it must be drained and replaced with regular lubricating oil before the engine is returned to service.
6. Drain the cooling system. To provide protection against corrosion, fill the cooling system with a coolant containing a corrosion inhibitor. If frost protection is needed, use the appropriate mixture of antifreeze and water. If frost protection is not required, use an appropriate mixture of water with an approved corrosion mixture.
7. Run the engine for a short period to distribute lubricating oil and coolant throughout the engine.
8. Clean out the engine breather pipe (where fitted) and seal the end of the pipe.
9. Remove the fuel injectors and spray clean engine lubricating oil into cylinder bores, four ounces (118,3 ml) of lubricating oil divided evenly between the four cylinders.
10. Remove the air filter and any pipe installed between the air filter and the induction manifold. Seal the manifold with waterproof tape.
11. Remove the exhaust pipe. Seal the manifold with waterproof tape.
12. Disconnect the battery and store it safely, in a fully charged condition. Before the battery is put into storage, give the battery terminals a protection against corrosion with a light coating of dielectric grease or petroleum jelly.
13. Seal the vent pipe of the fuel tank or the fuel filler cap with waterproof tape.
14. Remove and store the fan drive belt.

Note: Before starting the engine after storage, operate the starter motor with one of the fuel-run solenoid wires disconnected until oil pressure shows on the oil pressure gauge, or until the low oil-pressure warning light goes out.

8B.11 TROUBLESHOOTING

Trouble	Possible Causes (see key, below)
Low Cranking Power	1, 2, 3, 4
Will Not Start	5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 31, 32, 33
Difficult Starting	5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24, 29, 31, 32, 33, 61, 63
Lack of Power	8, 9, 10, 11, 12, 13, 14, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 31, 32, 33, 61, 63
Misfiring	8, 9, 10, 12, 13, 14, 16, 18, 19, 20, 25, 26, 28, 29, 30, 32
Excessive Fuel Consumption	11, 13, 14, 16, 18, 19, 20, 22, 23, 24, 25, 27, 28, 29, 31, 32, 33, 63
Black Exhaust	11, 13, 14, 16, 18, 19, 20, 22, 24, 25, 27, 28, 29, 31, 32, 33, 61, 63
Blue/White Exhaust	4, 16, 18, 19, 20, 25, 27, 31, 33, 34, 35, 45, 56, 62
Low Oil Pressure	4, 36, 37, 38, 39, 40, 42, 43, 44, 58
Knocking	9, 14, 16, 18, 19, 22, 26, 28, 29, 31, 33, 35, 36, 45, 46, 59
Erratic Running	7, 8, 9, 10, 11, 12, 13, 14, 16, 20, 21, 23, 26, 28, 29, 30, 33, 35, 45, 59
Vibration	13, 14, 20, 23, 25, 26, 29, 30, 33, 45, 47, 48, 49
High Oil Pressure	4, 38, 41
Overheating	11, 13, 14, 16, 18, 19, 24, 25, 45, 50, 51, 52, 53, 54, 57
Excessive Crankcase Pressure	25, 31, 33, 34, 45, 55, 60
Poor Compression	11, 19, 25, 28, 29, 31, 32, 33, 34, 46, 59
Starts and Stops	10, 11, 12

Key to Possible Causes

1. Battery capacity low
2. Bad electrical connection
3. Faulty starter motor
4. Incorrect grade of lubricating oil
5. Low cranking speed
6. Fuel tank empty
7. Faulty stop control operation
8. Blocked fuel feed line
9. Faulty fuel lift pump
10. Choked fuel filter
11. Restriction in air cleaner
12. Air in fuel system
13. Faulty fuel injection pump
14. Faulty fuel injectors or incorrect type
15. Incorrect use of cold start equipment
16. Faulty cold start equipment
17. Broken fuel injection pump drive
18. Incorrect fuel pump timing
19. Incorrect valve timing
20. Poor compression
21. Blocked fuel tank vent
22. Incorrect grade of fuel
23. Sticking throttle or restricted movement
24. Exhaust pipe restriction
25. Leaking cylinder head gasket
26. Overheating
27. Cold running
28. Incorrect tappet adjustment
29. Sticking valves
30. Incorrect high pressure pipes
31. Worn cylinder bores
32. Pitted valves and seats
33. Broken, worn or sticking piston ring(s)
34. Worn valve stems and guides
35. Over-full air cleaner
36. Worn or damaged bearings
37. Insufficient oil in sump
38. Inaccurate gauge
39. Oil pump worn
40. Pressure relief valve sticking open
41. Pressure relief valve sticking closed
42. Broken relief valve spring
43. Faulty suction pipe
44. Choked oil filter
45. Piston seizure / pick up
46. Incorrect piston height
47. Damaged fan
48. Faulty engine mounting
49. Incorrectly aligned flywheel housing or incorrectly aligned flywheel
50. Faulty thermostat
51. Restriction in water jacket
52. Loose fan belt
53. Choked radiator
54. Faulty water pump
55. Choked breather pipe
56. Damaged valve stem oil deflectors (if fitted)
57. Coolant level too low
58. Blocked sump strainer
59. Broken valve spring
60. Exhauster or vacuum pipe leak
61. Turbo impeller damaged or dirty
62. Turbo lubricating oil seal leak
63. Induction system leaks

Section 9
Hydraulic System

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Introduction

The hydraulic system consists of fluid, a reservoir, filters, the gear pump, numerous valves, cylinders and other components that provide vehicle operation and function, plus a fluid cooler and all of the related lines, connectors and hoses. Hydraulic functions are actuated through interface with electrical system components (such as switches, solenoids and sensors); therefore, when a hydraulic system malfunction is suspected, also consider the electrical aspect of the particular circuit in question. For further information on electrical components, refer to Section 10 Electrical System in this manual.

The text in this section discusses each hydraulic circuit and its components, as well as component function and replacement. Comprehensive circuit schematics and exploded view illustrations are used to represent component operation and to aid in performing procedures. A troubleshooting table appears at the conclusion of this section.

The number one cause of hydraulic component failure is contamination. Thus, cleanliness and filtration are of the utmost importance. Keep the hydraulic fluid as clean as possible to help avoid downtime and repairs.

Dirt and other contaminants that enter the system will wear away at precision components, ultimately resulting in their failure. Sand, grit and other contaminants can damage the finely machined surfaces within hydraulic components. Keep the fluid clean and filtered. If operating in an exceptionally dirty environment, change filters and inspect the fluid more often.

When servicing the system, protect system components from airborne contaminants. Cap or plug hydraulic fittings, hoses and tube assemblies. Plug all cylinder ports, valves, and the hydraulic reservoir and pump openings until installation occurs. Protect threads from contamination and damage.

General Overview

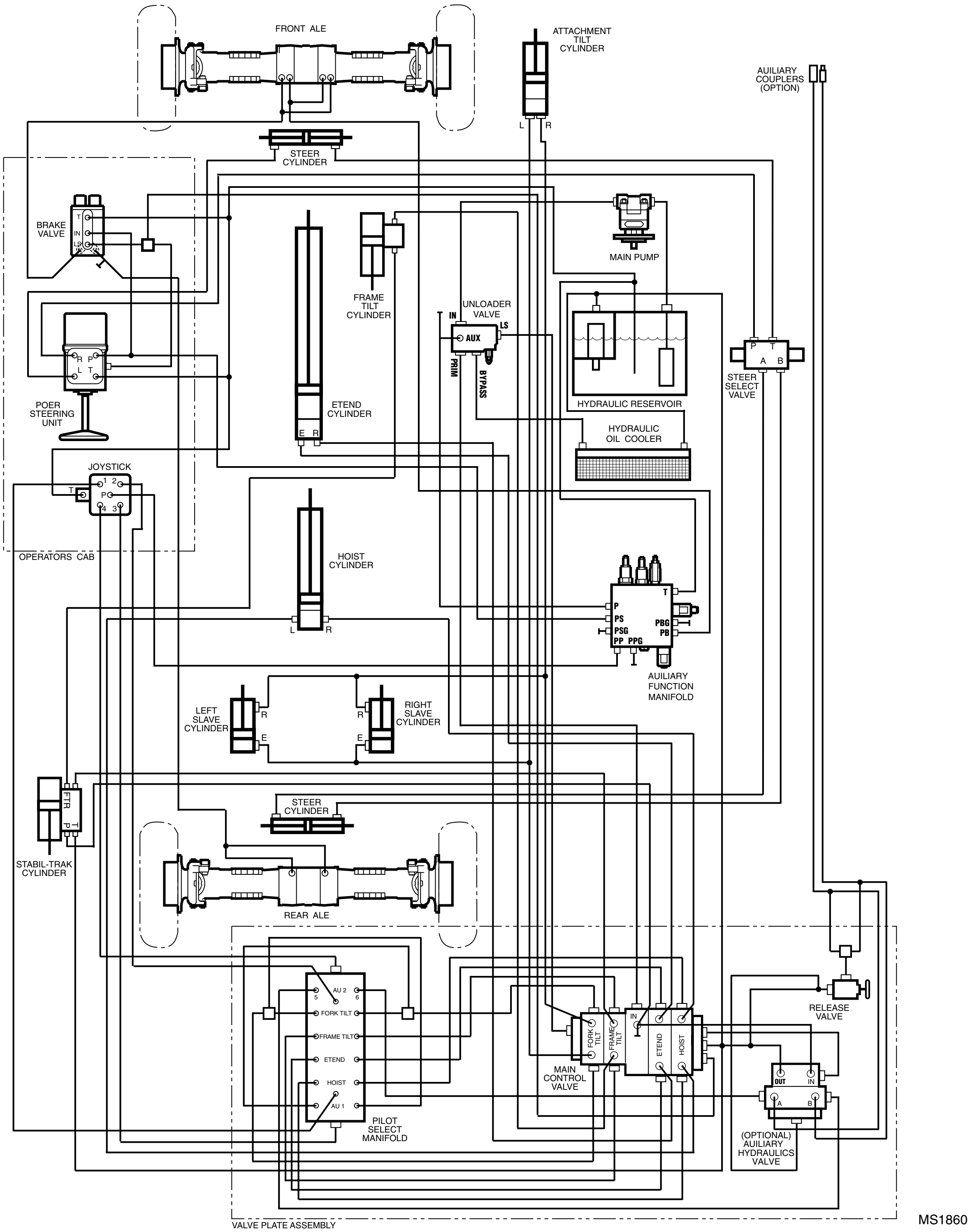


Figure 9-1. Major hydraulic system components.

9.1 SAFETY INFORMATION

General

Petroleum-based hydraulic fluids are used in this vehicle. Temperature increases occur to hydraulic fluid during operation of various hydraulic functions. A heated petroleum-based hydraulic fluid presents a considerable fire hazard, especially when an ignition source is present. Hydraulic fluid has a flash point that ranges from 300° to 600° F (150° to 318° C) and an auto-ignition temperature of 500° to 750° F (262° to 402° C).

Accordingly, periodically inspect all hydraulic system components, hoses, tubes, lines, fittings, etc. Carefully examine any deterioration and determine whether any further use of the component would constitute a hazard. If in doubt, replace the component.

WARNING: Hot hydraulic fluid can cause severe burns. Wait for hydraulic fluid to cool before servicing any hydraulic component.

WARNING: Escaping hydraulic fluid under pressure can penetrate the skin, causing serious injury. Relieve hydraulic pressure before servicing any hydraulic component.

Note: Residual pressure may remain in hydraulic cylinders, hoses, valve bodies, components, etc. If the hydraulic lines going to or from a component are taught, slowly, carefully relieve ("bleed off") pressure.

To relieve hydraulic pressure:

On units equipped with AUXILIARY HYDRAULICS, PULL the knob on the manually-operated release valve located at the rear of the frame (Fig. 9-2) beneath the rear cover. The pressure in the auxiliary system should be relieved. The pull knob on the valve is spring loaded and will return when released.

The quick couplers can now be connected or disconnected between the attachment and the vehicle.

For ALL units, when attempting to disconnect a hydraulic line, coupler, fitting, or other component, SLOWLY loosen the part involved. A hissing sound or slow seepage of hydraulic fluid may occur in most cases. After the hissing sound has ceased, continue removing the part. Cap or otherwise block off the part to prevent further fluid seepage. Wipe up any hydraulic fluid.

WARNING: Risk of severe personal injury. Before starting the engine, verify that all hydraulic connections are properly tightened and that all tools are removed from the vehicle.

Hydraulic system maintenance will, at times, require that the engine be operated. Always follow safety precautions.

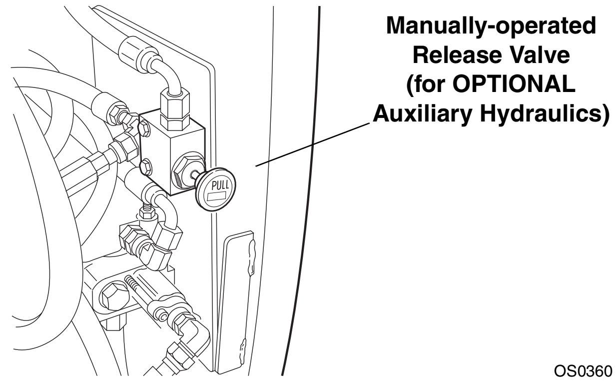


Figure 9-2. Pull the knob on the manually-operated release valve located at the rear of the frame to relieve pressure in the auxiliary hydraulic system.

9.2 SPECIFICATIONS

Refer to *Section 2 General Information, Specifications and Maintenance Instructions* for hydraulic system specifications.

9.3 HYDRAULIC PRESSURE DIAGNOSIS

Just as vehicle maintenance cannot be performed without the proper tools and other equipment, hydraulic system maintenance and problem diagnosis cannot be properly performed without a hydraulic pressure diagnostic kit (Fig. 9-3) and flowmeter kit (Fig. 9-4).

Sky Trak offers these kits, which include all of the necessary fittings, couplers, hoses, gauges and laminated guide sheets to test hydraulic system pressures and flow rates on Sky Trak vehicles.

Figure 9-3. Hydraulic pressure diagnostic kit.

Contact Sky Trak or the nearest Sky Trak distributor for ordering information.

MS2120 MS2130

Figure 9-4. Flowmeter hydraulic diagnostic kit.

9.3.1 Pressure Checks and Adjustments

When diagnosing trouble in the hydraulic system, use the hydraulic testing information on the pages 9-6 and 9-7.

Note: Duplicate pages have been provided on pages 9-8 through 9-11 in the event the technician needs the information for field use or to laminate and store elsewhere.

Keep in mind that what may at first seem to be a hydraulic problem could actually be a mechanical or electrical problem. The true cause of the trouble must be diagnosed and cured, or the problem will recur.

The following specifications are important to consider when conducting pressure checks and adjustments:

- In the boom hoist/lower cylinder, the counterbalance valve in the base end of the cylinder is rated at 4000 psi (276 bar).
- The pop-off emergency relief valve port relief built into the working section of the main control valve is rated at 3750 psi (258,75 bar).
- If system pressure exceeds 3500 psi (241,5 bar), the main relief valve will open, allowing oil to return to the reservoir.
- If the return filter becomes plugged, hydraulic oil will bypass the filter when pressure reaches 25 psi (1,725 bar).

In general, follow the steps below whenever conducting pressure checks and performing adjustments:

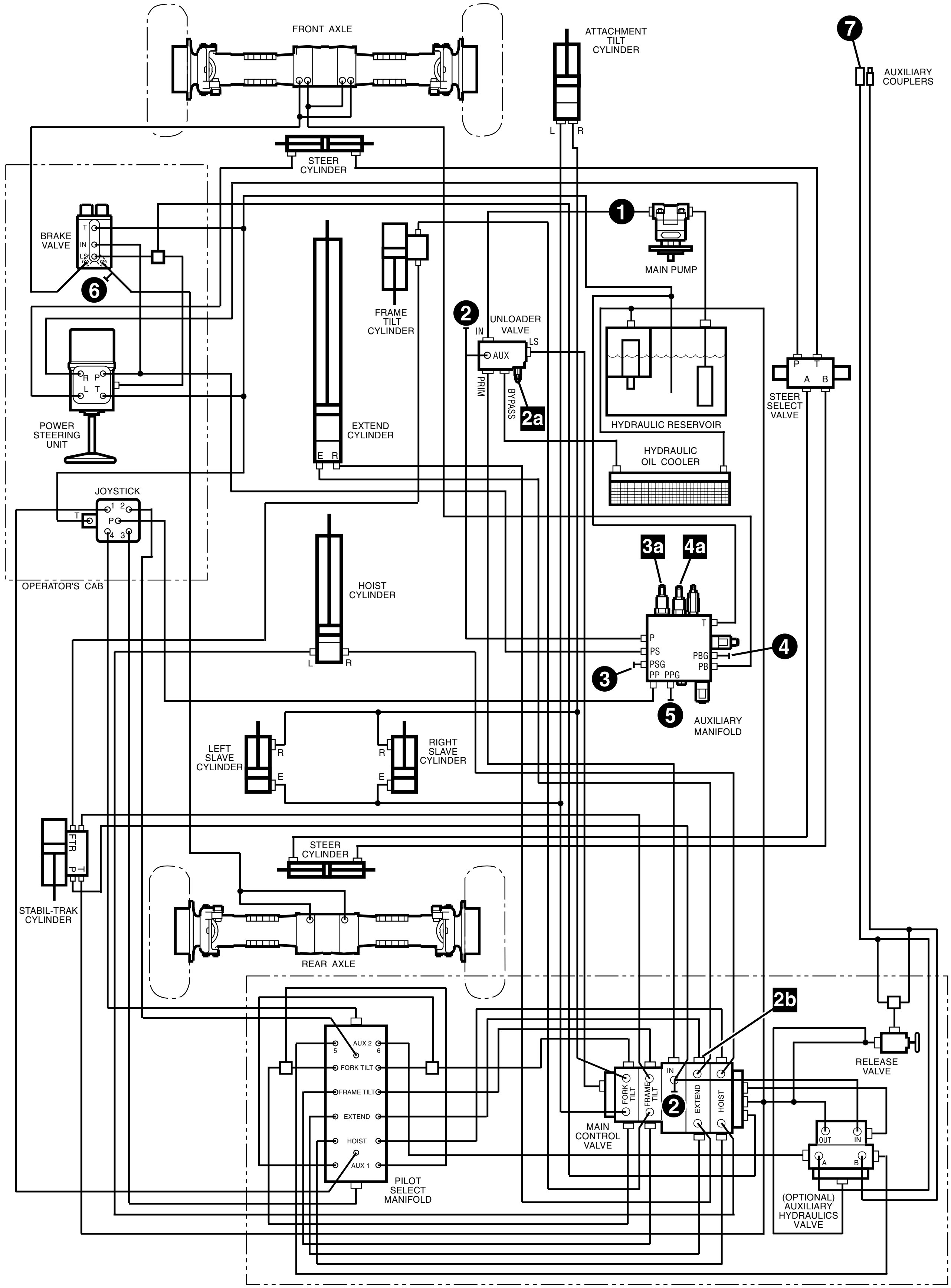
1. Park the vehicle on a firm, level surface. Engage the park brake, place the travel select lever in NEUTRAL (N), level the boom and turn the engine OFF.
2. Pressure tee fittings are conveniently located in each hydraulic circuit. Install a pressure gauge capable of measuring at least 10% more pressure than that which the circuit being checked operates under.
   If the vehicle is equipped with optional auxiliary hydraulics, relieve pressure by pulling the manually-operated release valve handle (Fig. 9-2).

⚠	**WARNING:** Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

3. Start the engine. Operate vehicle functions several times to allow hydraulic oil to reach operating temperature. The hydraulic oil temperature should be between 100 and 120° F (38 and 49° C). If a temperature gauge or thermometer is unavailable, the hydraulic oil reservoir should be warm to the touch.
4. Refer to *Pressure Test Procedures* on page 9-7.
5. Fully depress the accelerator pedal as required. Place and hold the joystick in the position needed to operate the particular vehicle function being checked. Continue holding the joystick in position until pressure readings are taken.
6. Check the pressure gauge reading. It should read as specified in the *Pressure Readings* column on page 9-7. If the reading is not as specified, turn the engine OFF and check other components in the system. Verify that all related hydraulic components and electrical switches, sensors, solenoids, etc. are operating correctly.
7. As a last resort, adjust the appropriate relief valve, if applicable. Turning the adjustment screw clockwise will increase the pressure; turning the screw counterclockwise will decrease the pressure

⚠	**WARNING:** Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

8. Start the engine and check the pressure again. Turn the engine OFF, pull the manually-operated release valve handle on units equipped with the optional auxiliary hydraulic system, then disconnect or remove the pressure gauge from the vehicle.


FRONT AXLE
ATTACHMENT TILT CYLINDER
L
R
7
AUXILIARY COUPLERS
STEER CYLINDER
BRAKE VALVE
T
IN
LS
1
6
MAIN PUMP
FRAME TILT CYLINDER
2
UNLOADER VALVE
IN
LS
AUX
PRIM
BYPASS
2a
R
P
L
T
POWER STEERING UNIT
EXTEND CYLINDER
E
HYDRAULIC RESERVOIR
HYDRAULIC OIL COOLER
STEER SELECT VALVE
A
B
JOYSTICK
1
2
4
3
OPERATOR'S CAB
3a
4a
HOIST CYLINDER
PS
PSG
PP
PPG
PBG
PB
4
3
5
AUXILIARY MANIFOLD
LEFT SLAVE CYLINDER
RIGHT SLAVE CYLINDER
FTR
STABIL-TRAK CYLINDER
REAR AXLE
2b
AUX 2
5
6
FORK TILT
FRAME TILT
EXTEND
HOIST
AUX 1
PILOT SELECT MANIFOLD
FORK TILT
FRAME TILT
MAIN CONTROL VALVE
RELEASE VALVE
OUT
(OPTIONAL) AUXILIARY HYDRAULICS VALVE
VALVE PLATE ASSEMBLY

3606 HYDRAULIC TESTING

Engine Information

Idle . . . . 1,050 ± 50 rpm
Full Speed . . . . 2,750 ± 50 rpm

Hydraulic Oil Information

Oil Type - 10W, meets MIL-L-2104C or ISO Grade 46
Capacity - Reservoir . . . . .32.2 gal. (114,7 liter)
Capacity - System . . . . .59.5 gal. (225,2 liter)

Note: To adjust relief settings or pressure reducing settings, turn the adjustment screw clockwise to increase pressure or counterclockwise to decrease pressure.

The hydraulic oil temperature for the pump flow test should be between 100° F (38° C) and 120° F (49° C) (tank hot to the touch) during testing.

Equipment Needed To Perform Tests From Hydraulic Diagnostic Test Kit

Circuit	Gauge	Fittings
1 2 3	4,000 PSI Gauge (275,6 bar)	Unit equipped with fittings from factory.
4	1,000 PSI Gauge (68,9 bar)	
5	1,000 PSI Gauge (68,9 bar)	
6	1,000 PSI Gauge (68,9 bar)	
7	4,000 PSI Gauge (275,6 bar)	Requires a male or female quick-disconnect coupler with test fitting.

TEST LOCATION	Hydraulic Pump Flow Test
1	**To check flow readings a flow meter capable of measuring 60 gpm (3,8 ltr/sec) and a load valve capable of 6,000 psi (413,4 bar) will be required (not included with Hydraulic Diagnostic Test Kit).** 2,000 psi (137,8 bar) load @ Engine Speed of 2,500 ± 25 rpm — Flow rate should be 28 to 32 GPM (1,8 to 2,0 ltr/sec)
2	**STANDBY PRESSURE** 250 to 350 psi (17,25 to 24,15 bar) at idle.

TEST LOCATION	ADJUST. LOCATION	COMPONENT DESCRIPTION	PRESSURE READINGS	PRESSURE TEST PROCEDURES
2	2a	Unloader Valve	Main System Relief 3,500 ± 100 psi (241,3 ± 7 bar)	With engine at FULL throttle, use control lever ("joystick") to lower boom fully. Hold over relief. Check readings. If incorrect, adjust or replace cartridge.
2	2b	Main Control Valve	Extend Base Port Relief 3,200 ± 100 psi (220,6 ± 7 bar)	With engine at FULL throttle, use control lever ("joystick") to extend boom fully. Hold over relief. Check readings. If incorrect, adjust or replace cartridge.
2	N/A	Attachment Tilt Relief/FORWARD or REARWARD	3,700 ± 100 psi (255 ± 7 bar)	CONSULT FACTORY
3	3a	Auxiliary Manifold	Steering Relief 2,500 ± 100 psi (172,3 ± 7 bar)	With engine at FULL throttle, turn the steering wheel all the way to one direction and hold while checking pressure. If pressure is not correct, adjust or replace the pressure-reducing cartridge.
4	N/A	Auxiliary Manifold	Park Brake Release 450 - 700 psi (31,0 - 48,2 bar)	With engine at idle, switch Park Brake to disengaged position with secondary function held over relief. Check pressure.
5	4a	Auxiliary Manifold	Pilot Pressure 550 ± 100 psi (37,9 ± 7 bar)	With engine at FULL throttle, move joystick to boom retract position. Hold joystick to over relief and check pressure. If pressure is not correct, adjust or replace the cartridge in the auxiliary manifold.
6	N/A	Brake Valve (Manual Brake Pressure)	300 psi minimum (20,7 bar)	With engine OFF, depress and hold brake pedal. If pressure is incorrect, check for external leaks. If no leaks are found, refer to service manual brake system information.
6	N/A	Brake Valve (Service Brake Pressure)	400 psi minimum (27,6 bar)	With engine at idle, depress and hold brake pedal. **DO NOT turn steering wheel**. Check pressure. If pressure is not correct, consult service manual.
7			Auxiliary 3,500 ± 100 psi (241,3 ± 7 bar)	With engine at full throttle, auxiliary button on joystick depressed and held, move joystick left or right. Hold joystick to over relief and check pressure. If pressure is not correct, check unloader pressure per 2. If 2 is ok check port reliefs in aux. valve (consult Factory).

9.4 HYDRAULIC FLUID

General information and specifications pertaining to hydraulic fluid are found in *Section 2 General Information, Specifications and Maintenance Instructions*.

Use only clean, filtered fluid in the hydraulic system.

After servicing or replacing a hydraulic system component, cycle all vehicle functions several times to remove (purge or "bleed") air from the hydraulic system. **DO NOT** build maximum pressure at the end of stroke by continuing to hold the joystick function.

Inspect the hydraulic system and fluid frequently, and be vigilant for problems or conditions including the following:

• Aeration

Aeration is the presence of air bubbles in hydraulic fluid. Sudden, violent inward collapse of the air (known as implosion) can occur when compressed air bubbles are subjected to system pressure. Aeration can thus lead to damage and overheating of components.

Pump aeration will produce a loud crackling sound, as though rocks or marbles were being forced through the pump. Excessive aeration will give the hydraulic fluid a cloudy or milky appearance, and cause erratic operation of hydraulic system components.

Aeration is caused by air being introduced into the system, possibly through a leaky seal or joint in the pump or elsewhere in the system. Check for leaky hydraulic cylinders and threaded fittings; introduction of a special dye, visible under fluorescent light, may be helpful in determining the source of the leak.

• Cavitation

Cavitation occurs when hydraulic fluid fails to entirely fill an existing space. Cavitation, like aeration, can produce a loud crackling sound, as though rocks or marbles were being forced through the system. Cavitation can be due to a low hydraulic oil level in the reservoir, a restricted intake line, or improperly high fluid viscosity.

• Contamination

Contamination, or dirt, can be any material other than hydraulic fluid that causes harm or decreases the performance of the system. Contaminants include solids, liquids, and gasses. Most contaminants are abrasive in nature, causing rapid wear or damage to the system.

• Excessive heat

Excessive heat is a relative thermal condition that effects fluid viscosity. Extreme operating conditions, such as excessive operation, outside air temperature, and factors including aeration, cavitation, contamination and over-pressurization can cause fluid and component temperatures to go beyond their specified limits. Excessive heat causes oxidation in hydraulic fluid to occur more rapidly, breaking down its viscosity. A chain reaction then results, and can lead to component damage or failure. The true cause of an excessive heat condition must be diagnosed and cured, or the problem will recur.

• Implosion

An implosion is a sudden, violent inward collapse, and can often cause a vacuum effect. Imploding air bubbles within a hydraulic system can cause component damage.

• Over-pressurization

Over-pressurization is, simply, pressure greater than that for which a component was engineered to withstand or operate under. Over-pressurization can cause equipment damage. **DO NOT** attempt to adjust or tamper with pressure cartridges, settings, etc., unless otherwise specified.

• Viscosity

Viscosity is the property of a fluid or semi-fluid that enables it to develop and maintain shearing stress dependent upon flow rate (velocity), and to offer continued resistance to flow. In other words, viscosity is a measurement of a fluid's resistance to flow (internal friction).

9.5 HOSES, TUBE LINES, FITTINGS, ETC.

There are numerous hydraulic hoses, tube lines, fittings, etc., used on this vehicle. Periodically inspect all of these and carefully examine any signs of wear, abrasion and/or deterioration. Determine whether any further use of the component would constitute a hazard. If in doubt, replace the component. Conditions including but not limited to the following are sufficient for considering replacement:

a. Any evidence of hydraulic fluid leakage at the surface of a flexible hose or its junction with the metal and couplings;

b. Any blistering or abnormal deformation to the outer covering of a hydraulic hose;

c. Hydraulic oil leakage at any threaded or clamped joint that cannot be eliminated by normal tightening or other recommended procedures; and/or

d. Evidence of excessive abrasion or scrubbing on the outer surface of a hose, rigid tube, or hydraulic fitting. Modification must be made to eliminate the interference of the elements in contact with one another, or to otherwise protect the components from contact with one another. Slightly moving a hose or adjusting a plastic tie wrap may often be all that is necessary to eliminate interference; evaluate each situation and proceed as required by the individual circumstances.

9.5.1 Hose, Tube, Line and Fitting Replacement

Before removing a hydraulic hose or component, always mark or otherwise label the related parts and the exact location the hose or component is being removed from to aid in proper re-installation. Hydraulic fluid is a good cleaner and will, if only inadvertently, remove most liquid-ink type markings, so make sure the mark or label will remain intact. Alternative methods to using so-called “magic” markers, include color-coded tie wraps, number-tag sets, alpha-numeric stampings or markings, and suitably-labeled pieces of tape. Select an appropriate marking method for the conditions and proceed accordingly.

NEVER replace a hydraulic hose or other component with a part not specifically designed for this vehicle. For example, replacing a hydraulic hose rated for use in a 3700 psi (255 bar) circuit with a common garden hose can result in an exploded garden hose, hydraulic fluid spray, and other damage or personal injury. Use only factory-approved parts for best performance and safety.

Removal and replacement of hoses, tube lines, fittings, etc., usually involves straightforward procedures. When removing a hydraulic hose or other component, be aware that O-rings are used throughout the hydraulic system. Always replace a used O-ring with a new one.

Check all routing of hoses, wiring and tubing for sharp bends or interference with any rotating members. Install appropriate protective devices such as tie wraps and conduit to help shield hoses from damage. All tube and hose clamps must be tight.

9.6 HYDRAULIC RESERVOIR

The hydraulic reservoir (Fig. 9-5) includes the engine mounting crossmembers. The reservoir is secured to the right side of the vehicle frame with 1-8 x 2-3/4" Grade 8 hex-head capscrews, 1" hardened washers and 1-8 hex-lock nuts.

Occasionally, fluid may seep, leak or be more forcefully expelled from the filter head (15, Fig. 9-5) or breather when system pressure exceeds the rating of the filter head or breather. If the return filter becomes plugged, return hydraulic oil will bypass the filter when pressure reaches 25 psi (1,725 bar) and return to the reservoir unfiltered.

Carefully examine fluid seepage or leaks from the hydraulic reservoir to determine the exact cause. A slightly different breather was installed on vehicles ***after*** Serial Number 10017 to help eliminate potential seepage problems. Clean the reservoir and note where seepage occurs, if any does occur.

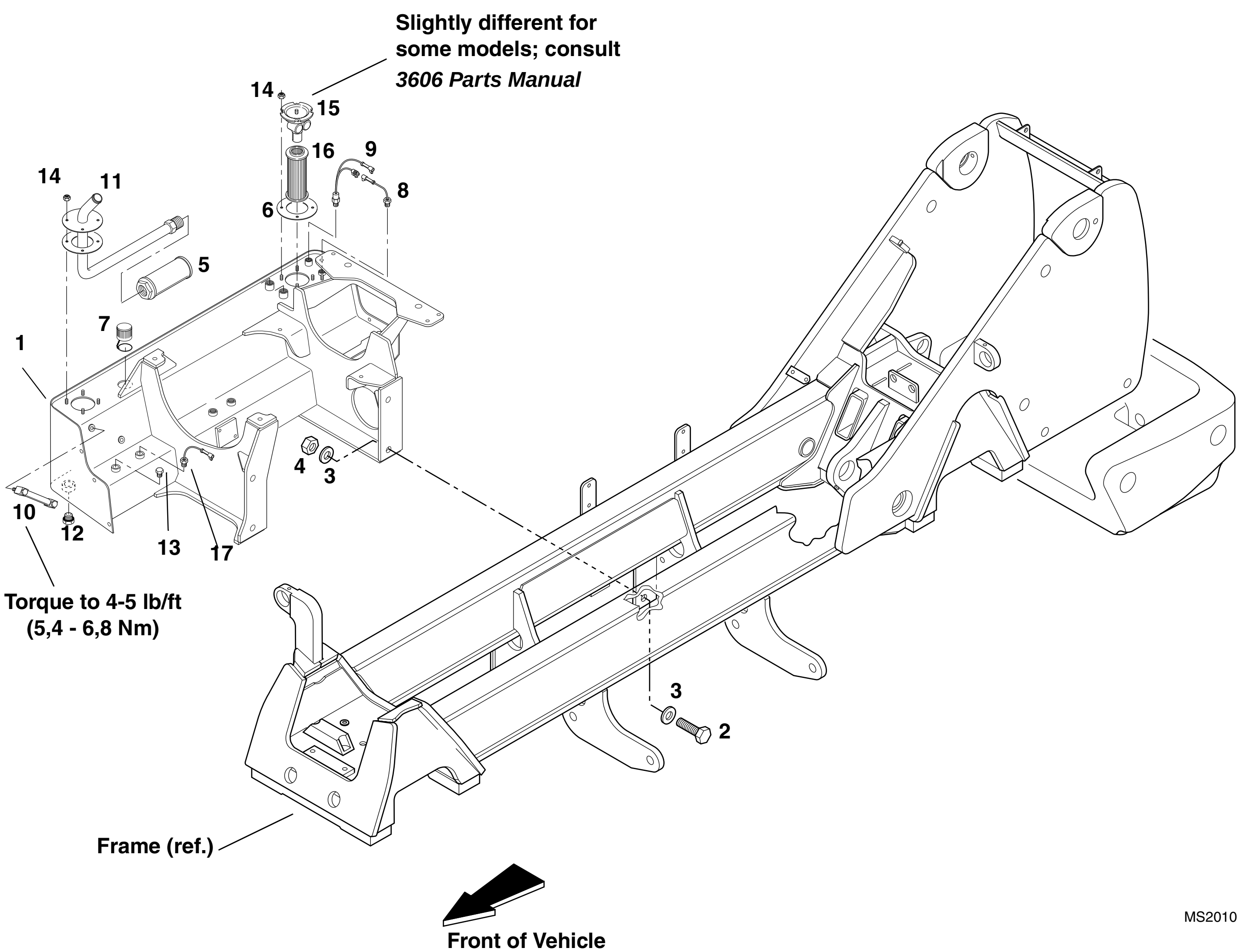
DANGER: Risk of death or severe personal injury. **NEVER** weld in, on, near or around the hydraulic reservoir. Hydraulic fluid and fumes can cause the reservoir to explode.

Leaks from a cracked or damaged reservoir require that the reservoir be removed from the vehicle, flushed completely with water, and repaired by a certified welder using approved techniques. If these conditions cannot be met, the reservoir must be replaced in its entirety. Contact Sky Trak or the nearest Sky Trak distributor should reservoir welding or replacement be required.

Hydraulic Reservoir Replacement

In order to remove the hydraulic reservoir, the engine and transmission assemblies must first be removed, along with all brackets, hoses, wiring, etc., Follow the procedures for engine and transmission removal in the appropriate sections of this manual.

After the engine and transmission assemblies and all related brackets, hoses, wiring, etc. are removed, the hydraulic reservoir must be supported with a suitable device and unbolted from the vehicle frame. Install the replacement reservoir and secure it to the vehicle with 1-8 x 2-3/4" Grade 8 hex-head capscrews, 1" hardened washers and 1-8 hex-lock nuts (Fig. 9-5). Torque the nuts to 585 lb/ft (793 Nm).



1. Hydraulic Reservoir
2. Hex-head Capscrew, Grade 8, 1-8 x 2-3/4"
3. Hardened Washer, 1"
4. Hex-lock Nut, 1-8
5. Strainer
6. Gasket
7. Breather
8. Temperature Switch, 195° F (76° C)
9. Oil Pressure Switch, 20 psi (1,4 kPa)
10. Sight Gage (includes seals and fasteners)
    Torque to 4-5 lb/ft (5,4 - 6,8 Nm)
11. Inlet Tube Assembly
12. Magnetic Drain Plug, 24 ORB
13. Plug, 8 ORB
14. Elastic Lock Nut, 5/16-18
15. Filter Head
16. Filter Element
17. Temperature Switch, 95° F (35° C)

Figure 9-5. Hydraulic reservoir/engine mount.

9.7 HYDRAULIC SYSTEM PUMP

The main gear pump (1, Fig. 9-6) is attached to the top of the transmission and driven via the pump main shaft via meshing with an internal transmission gear.

The pump draws fluid through a 1-1/2" inside diameter hose via negative displacement, commonly but *incorrectly* referred to as *vacuum* or *suction*.

Fluid is forced from the pump through a 3/4" inside diameter hose to the unloader valve. Hydraulic system pressure begins at the main pump. Various factors are involved in creating the relatively high pressure used in the hydraulic system. Main pump rpm, controlled via a transmission idler gear (and dependent on engine rpm), in addition to the internal pump gears and passageways, as well as the differential between pump inlet (1-1/2" I.D.) and outlet (3/4" I.D.) openings, all contribute to pressure supplied to the unloader valve. The unloader valve ultimately regulates maximum system-operating pressure (3500 psi, or 241,5 bar) for various vehicle functions.

9.7.1 Pump, Unloader Valve and Cooling Circuit

The pump, unloader valve and cooling circuit are shown for reference purposes in Fig. 9-6.

Oil cooler replacement instructions are provided in the appropriate engine section of this manual.

9.7.2 Pump Failure Analysis

The pump is the "heart" of the hydraulic system, and whenever there is a problem in the system, the pump almost always is blamed. Yet, pump failure is seldom due to failure of pump components. Pump failure usually indicates another problem in the hydraulic system.

According to pump manufacturer statistics, ninety to ninety-five percent of pump failures are due to one or more of the following causes:

- Aeration
- Cavitation
- Contamination
- Excessive heat
- Over-pressurization
- Improper fluid

In the event of pump failure, investigate further to determine the cause of the problem.

Legend for Pump, Unloader Valve and Cooling Circuit

1. Main Gear Pump
2. Unloader Valve
3. Main Gear Pump Gasket
4. T-Bolt Band Clamp
5. Hose, 1-1/2" I.D. x 19"
6. Hose, 3/4" I.D. x 39"
7. Hose, 3/4" I.D. x 36"
8. Hose, 3/4" I.D. x 81-1/2"
9. Hose, 3/8" I.D. x 89-1/2"
10. Flange Half, 1-1/2"
11. Flange Half, 3/4"
12. Flange Half, 1"
13. O-Ring, 3/4" SF
14. O-Ring, 1" SF
15. O-Ring, 1-1/2" SF
16. Connector, SAE 12-16 - Str. Thd. ORB x O-Ring Face Seal
17. Plain Washer, 5/16"
18. Plain Washer, 1/2"
19. Lockwasher, 5/16"
20. Lockwasher, 3/8"
21. Lockwasher, 1/2"
22. Hex-head Capscrew, 3/8-16 x 1-1/4"
23. Hex-head Capscrew, 1/2-13 x 1-1/2"
24. Hex-head Capscrew, 5/16-18 x 3-1/4"
25. Dust Plug
26. Diagnostic Nipple
27. Branch Tee, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
28. Relief Valve Assembly - Preset at 3500 psi (241 bar)
29. Tee, Swivel Run, SAE 12 - o-ring face seal
30. Diagnostic Nipple
31. Branch Tee, SAE 8 - Str. Thd. ORB x O-Ring Face Seal
32. Hose, 1/2" I.D. x 28.3" Long
33. Connector, SAE 8 - Str. Thd. ORB x O-Ring Face Seal
34. Connector, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
35. Hose, 3/4" I.D. x 28"
36. 90°, SAE 12 - Str. Thd. ORB x O-Ring Face Seal
37. Male Flat-face Tube Connector, w/ Inlet Check 8ORB-8FF
38. Hose
39. Washer, SAE 5/16"
40. Tie Wrap

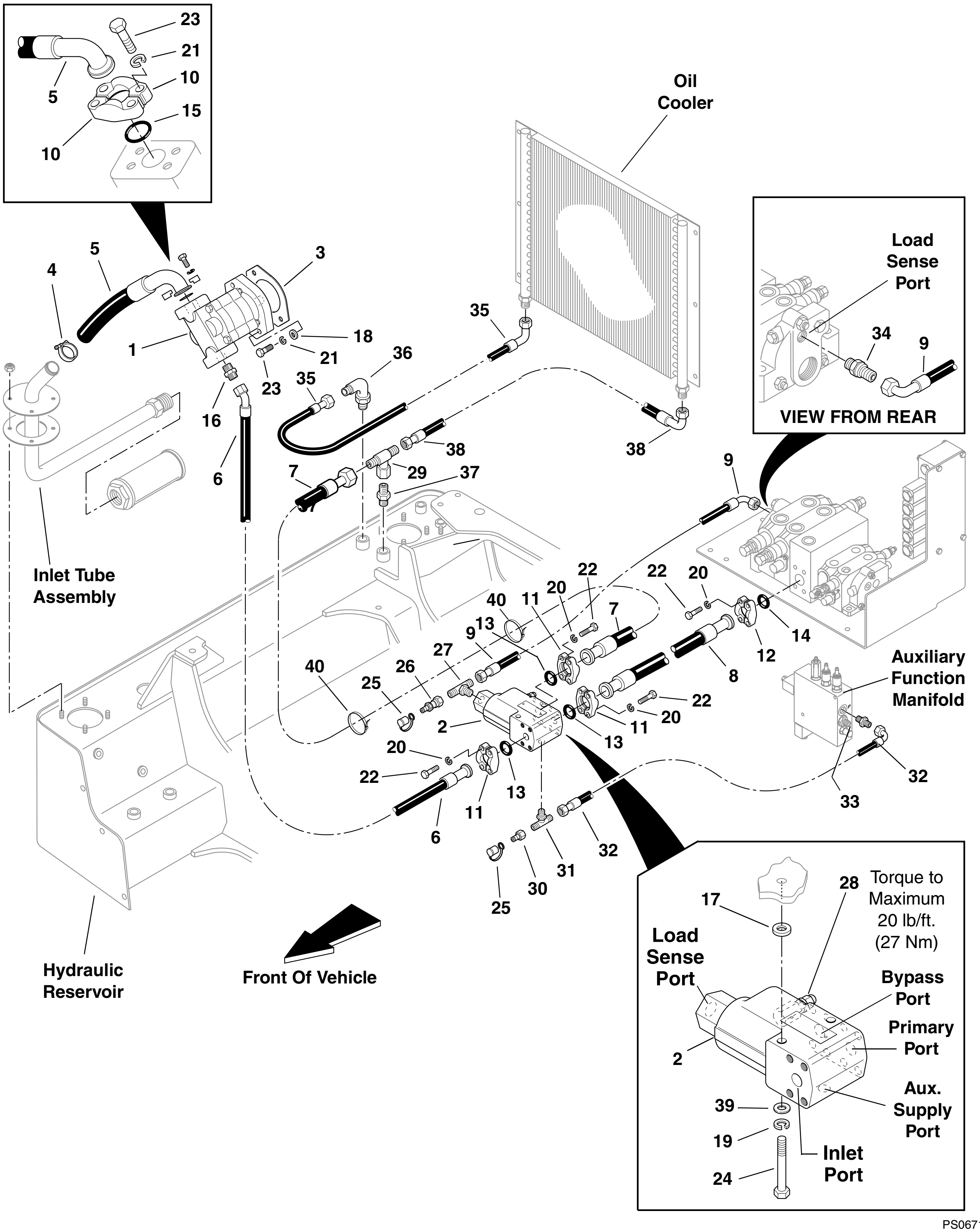


Figure 9-6. Pump, unloader valve and cooling circuit.

9.7.3 Pump Replacement

a. Pump Removal

1. Park the vehicle on a firm, level surface, fully retract all hydraulic cylinders, ground the attachment (if any), place the travel select lever in NEUTRAL (N), engage the park brake switch and shut the engine OFF.

WARNING: Hot hydraulic fluid can cause severe burns. Wait for hydraulic fluid to cool before servicing any hydraulic component.

2. Unlatch, unlock and open the engine cover. Allow the hydraulic fluid to cool.

WARNING: Escaping hydraulic fluid under pressure can penetrate the skin, causing serious injury. Relieve hydraulic pressure before servicing any hydraulic component.

3. Remove the four 3/8-16 x 1-1/4" hex-head capscrews (23, Fig. 9-6) and 1/2" lockwashers (21) securing the 1-1/2" flange halves (10) to the pump (1). Remove the inlet hose (5) and SF O-ring (15).

Note: It is not necessary to remove the T-bolt band clamp (4) and inlet hose (5) from the inlet tube assembly.

4. Disconnect the outlet hose (6) from the connector (16). Cap the outlet hose to prevent unnecessary fluid spillage.
5. Remove both 1/2-13 x 1-1/2" hex-head capscrews (23), 1/2" lockwashers (21) and 1/2" plain washers (18) securing the pump (1) to the transmission. Remove the pump and gasket (3) from the vehicle. Wipe up hydraulic oil spillage.

b. Tools Required for Pump Repair

The following tools are required for servicing the pump:

1. A bushing puller made from Collet #33863 of Blind Hole Puller Set 981 by *Owatonna® Tool Company* or an equivalent puller from another supplier. Modify the collet as shown in Fig. 9-7.

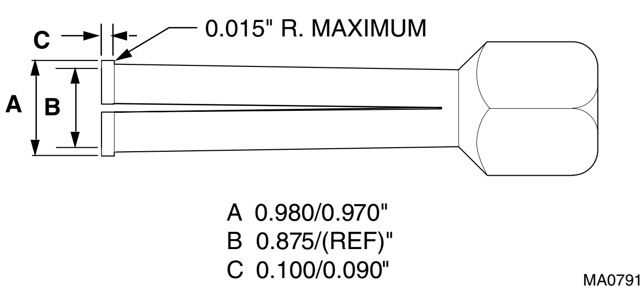


Figure 9-7. Bushing puller.

2. A seal removal tool made by heating the tip of a quality forged screwdriver and bending it as shown in Fig. 9-8. Grind off the tip to fit the notch behind the main pump shaft seal.

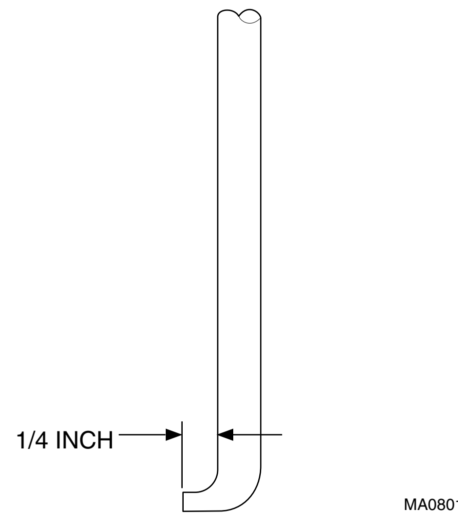


Figure 9-8. Seal removal tool.

3. A bushing installation tool made from A.I.S.I. 8620 heat-treated, bearing-quality steel, as indicated in Fig. 9-9.

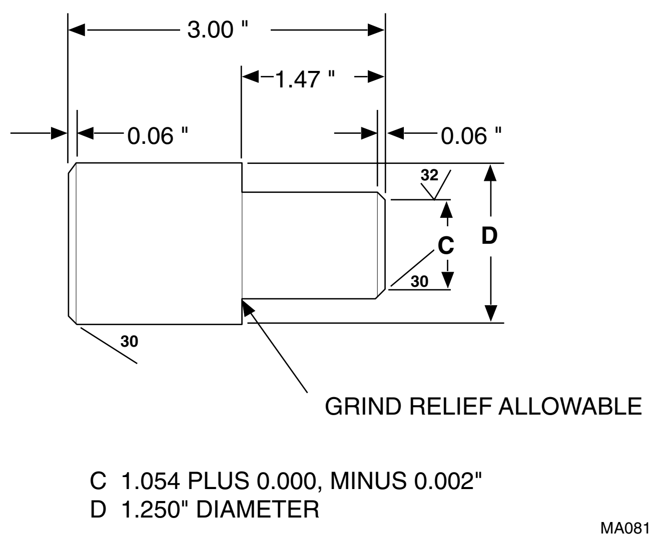
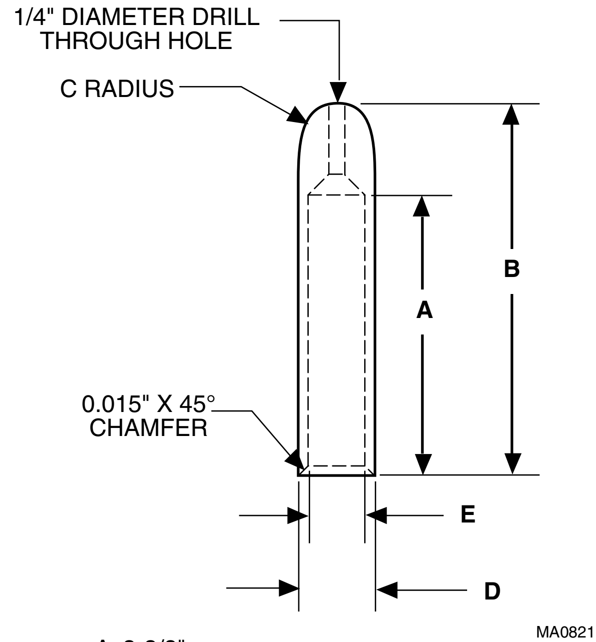


Figure 9-9. Bushing installation tool dimensions.

4. A special steel sleeve made from round steel bar stock, 1-1/4" to 1-1/2" (31,75 to 38,1mm) in diameter by 4-5/8" (117,5mm) as shown in Fig. 9-10. This sleeve is used to insert the drive shaft through the lip seal without causing damage.



A 3-3/8"
B 4-1/2"
C 9/16" R
D 1.065 PLUS 0.000, MINUS 0.002"
E 1.002 PLUS 0.002, MINUS 0.000"

Figure 9–10. Special steel sleeve dimensions.

5. A lip seal installation bar, made from round steel bar stock 1-3/4" (44,45mm) in diameter by 2" (50,8mm) long. Grind the edges slightly to form the tool.
6. The following tools will also be required:
   - arbor press
   - awl
   - clean, lintless cloths
   - metal deburring tool
   - machinist's hammer
   - soft hammer
   - non-hardening sealant (Permatex® Aviation Form-A-Gasket No. 3) or equivalent
   - medium-grit Carborundum stone
   - oil and grease
   - snap-ring pliers
   - scale, 1/32" (0,79mm) or 1/64" (0,40mm) graduations
   - small screwdriver
   - torque wrench
   - vise with 8" minimum open spread

c. General Repair Precautions

1. To facilitate repair of the pump and before any work is done, first, read and understand all of the steps used in the disassembly and assembly instructions.
2. The first requirement of good hydraulic equipment maintenance is cleanliness. Perform procedures in a clean area.
3. If it becomes necessary to pry sections apart, be extremely careful to avoid damaging the finely-machined surfaces. Excessive force used while prying can result in misalignment and serious damage to parts.
4. Match-mark the exterior surfaces of any housings before separating the components. Use the marks to return components to their original location during assembly.
5. Gears are closely-matched sets which wear in together. Keep gears together as sets when removing them from a unit. Handle gears with care to avoid damaging the journals or teeth. Avoid touching gear journals. Always replace matched parts as a set.
6. To help prevent damage, **DO NOT** grip machined surfaces in a vise.
7. If parts are difficult to fit together during assembly, tap gently with a soft hammer. **NEVER** use an iron or steel hammer to tap parts.
8. **NEVER** hammer bushings into bores. Use an arbor press and bushing drivers of appropriate sizes to install bushings.

d. Pump Disassembly (Fig. 9–11)

1. Secure the pump with the pump drive shaft pointing down in a suitable holding device or bench vise if possible. Scribe or otherwise make a mark across the two pump housings (4 and 13, Fig. 9–11) and the gear housing (11) perpendicular to the parting lines for easy identification and proper alignment during assembly later.
2. Remove the four capscrews (3) and washers (2) that secure the two pump housings (4 and 13) together.
3. Carefully separate the pump housings (4 and 13) from the gear housing (11). If it becomes necessary to pry the components apart, proceed carefully and **DO NOT** damage the machined surfaces or internal components. Dowel pins (5) will remain installed in most cases; however, **DO NOT** remove dowel pins unless they are damaged.
4. Remove the square “R” seal (10), channel seals (8), backup seals (7) and thrust plates (9).

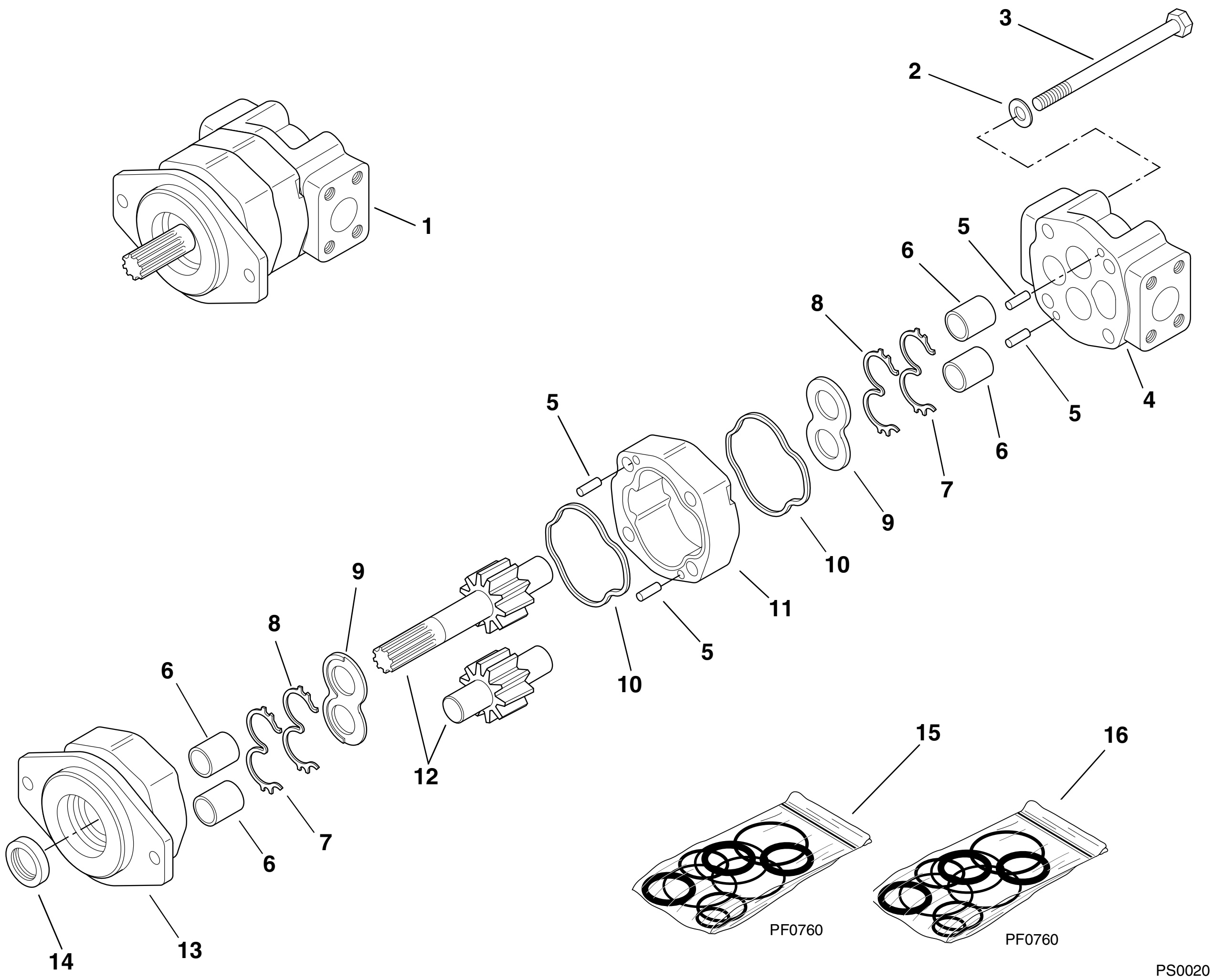


Figure 9–11. Hydraulic system pump.

Legend for Pump

1. Main Pump
2. Washer
3. Capscrew
4. PEC Housing
5. Dowel Pin
6. Bushing
7. Back-up Seal
8. Channel Seal
9. Thrust Plate
10. Square "R" Seal
11. Gear Housing
12. Gear Set
13. SEC Housing
14. Lip Seal
15. Seal Kit (includes items 7, 8, 10 and 14)
16. Seal Kit w/Thrust Plates (includes items 7, 8, 9, 10 and 14)

5. Carefully remove the drive and driven gear set (12). To help avoid damaging the gears, **DO NOT** tap the gear teeth together or against other hardened surfaces. Keep the matched gears together as a set.
6. Carefully clamp the SEC housing (13) in a vise with the mounting face down. Remove the lip seal (14) with a suitable seal removal tool.

e. Pump Cleaning

Clean all pump components with a suitable cleaner such as trichlorethylene.

f. Pump Inspection

1. Inspect internal pump components for wear, damage, etc. If inner surfaces of the pump do not display an ultra-smooth, polished finish, or are damaged in any way, replace the damaged part. Most often, dirty hydraulic fluid causes failure of internal pump seals and damage to the polished surfaces within the pump and other hydraulic system components.
2. If a dowel (5, Fig. 9–11) or dowel-mounting hole is damaged, replace the dowel or housing as required.
3. Examine thrust plates for wear (9), scoring, erosion, pitting, discoloration, abrasions or other damage and replace if necessary. The thrust plates seal the gear set at the sides. Worn thrust plates allow internal slippage (oil bypasses the pump). A maximum 0.002" (0,05mm) of wear is allowable. Check the center of the thrust plates, where the gears mesh together. Erosion at the center of the thrust plates indicates oil contamination. Pitted thrust plates indicate cavitation or oil aeration. Discolored thrust plates indicate overheating, probably due to low hydraulic oil level in the reservoir.
4. Examine the gear set (12). Replace the gears as a matched set if there is any scoring (particularly scoring on the gear hubs), grooves or burrs on the outside edges of teeth, or any nicks, grooves, frets or other damage to teeth surfaces.
5. If the gear set is replaced (always replace the gears as a set), the bushings (6) must be replaced. Inspect all bushings for scoring or discoloration and replace if necessary. Use a bushing puller (Fig. 9–7) to remove the bushings.
6. Examine the housings (4, 11 and 13) and replace if necessary. Place a straight edge across each bore. Attempt to slip a 007" (0,18mm) feeler gauge under the straight edge and into the bore. If bore expansion is moderate, 007" (0,18mm) or less, the housing may be reused. If wear or distortion exceeds 0.007" (0,18mm), replace the housing and examine the gear set (12) and bushings (6) for wear. Replace as required.
   Operating pressure pushes the gears against the low-pressure side of the housing. As the hubs and bushings wear, the bore increases. Excessive bore expansion in a short period of time indicates excessive pressure or oil contamination. If the relief valve settings are within prescribed limits, check for shock pressures or tampering. Check an oil sample and the reservoir for dirt.
7. Always use new seals, O-rings, gaskets, etc. to help ensure proper pump sealing and operation. Replace all flexible seals, including the square “R” seal (10), lip seal (14), backup seals (7) and channel seals (8).

g. Pump Assembly

1. Stone all surfaces with a medium grit carborundum stone or equivalent.

Note: Carborundum is boron nitride (c-BN) with cubic or “diamond” molecular structure. c-BN is a hard, abrasive composition.

2. If bushings have been removed, deburr the bushing bores with fine grit emery cloth.
3. Rinse all parts in an approved solvent. Blow dry and wipe the parts with a clean, lintless cloth before beginning assembly.
4. Install new bushings (6) in bores as required. Support the housings so that they are square and level. Press the bushings into the bores using the special installation tool (Fig. 9–9) and an arbor press. The bushings must be flush with the casting surface after installation. Stone and rinse the components as described in steps 1 and 3.
5. Coat the outer edge of the new lip seal (14) with a non-hardening sealant (*Permatex®* Aviation Form-A-Gasket No. 3 or equivalent). With the metal side of the lip seal facing up, press the seal into the mounting flange side of the shaft end cover with an arbor press and a suitable lip seal driver. **DO NOT** damage the lip seal. Press the seal into the housing until the lip is flush with the housing recess. Wipe off excess sealant.
6. Place the SEC housing (13), with the transmission-mounting surface down, in a suitable holding device or bench vise if possible.
7. Install new dowels (5) as required. Verify that dowels are clean and free of burrs. Gently tap the dowels in with a soft hammer.
8. Lubricate both new square “R” seals with clean hydraulic oil. Insert the seals into their grooves in each side of the gear housing (11).
9. Place new channel seals (8) into the grooves in both thrust plates (9) with the flat side of the seal facing away from the thrust plate (Fig. 9–11).
10. Place a new backup seal (7) into the grooves in both thrust plates (9) above the channel seals (8).
11. Install one thrust plate (with channel and backup seals) into the SEC housing (13) so that the groove in the thrust plate will face away from the gear housing (11). The flat side of the seal should face down with the relief groove facing the outlet side of the housing.

12. Lubricate the gear set (12) with clean hydraulic oil from a filtered source. Slide the gear set into position within the SEC housing (13). Avoid damaging the lip seal (14) when the driven gear passes through the housing. Apply additional oil to the gears after installation.
13. Install the other thrust plate (with channel and with backup seals) over the gears so that the groove in the thrust plate will face away from the gear housing (11). The flat side of the seal should face up with the relief groove facing the outlet side of the housing.
14. Place the gear housing (11) over the gear set. Align the pump housings according to the alignment mark made during disassembly. Insert the dowel pins (5) in the gear housing into the holes in the SEC housing (13). **DO NOT** pinch the square “R” seal (10). Gently tap the gear housing around the edges with a soft hammer as needed to further engage the dowels and to bring the housings together for final seating.
15. Place the PEC housing (4) over the gear set. Align the pump housings according to the alignment mark made during disassembly. Insert the dowel pins (5) in the PEC housing with the holes in the gear housing (11). **DO NOT** pinch the square “R” seal (10). Gently tap the PEC housing in the center with a soft hammer as needed to further engage the dowels and to bring the housings together for final seating.
16. Install the four capscrews (4, Fig. 9–11) and washers (2) that secure the pump housings (4, 11 and 13) together. Tighten the capscrews in a criss-cross pattern to evenly draw the housing sections together. Rotate the drive shaft to verify that there is no binding within the pump. After the capscrews are tight and there is no internal binding, torque the capscrews to specification in a criss-cross pattern. Refer to the torque specification chart in *Section 2 General Information, Specifications and Maintenance Instructions*.

h. Pump Installation

1. Place the pump (1), Fig. 9–6 and a new gasket (3) into position on the transmission. Align the pump gear shaft with the internal transmission gear so that the machined teeth mesh together.
2. Align the gasket bolt holes with the pump mount holes. Secure the pump to the transmission with two plain 1/2" washers (3), 1/2" lockwashers (21) and 1/2-13 x 1-1/2" hex-head capscrews (23). Torque the capscrews to 75 lb/ft (102 Nm).
3. If necessary, slide the T-bolt band clamp (4) onto the pump inlet hose (5). Secure the hose to the inlet tube assembly (item 8, P/C 6.11) with the T-bolt band clamp.
4. Thread the outlet hose (6) onto the connector (16).
5. Prime the pump by filling the pump inlet opening with fresh, filtered hydraulic oil before attaching the inlet hose (5).
6. Place a new 1-1/2" SF O-ring (15) into position over the opening and secure the 1-1/2" I.D. x 19" long inlet hose (5) with two 1-1/2" flange halves (10), four 1/2" lockwashers (21) and four 3/8-16 x 1-1/4" hex-head capscrews (23). Torque the capscrews to 31 lb/ft (42 Nm).
7. Check all routing of hoses, wiring and tubing for sharp bends or interference with any rotating members. All tube and hose clamps must be tight.

WARNING: Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

8. Start the engine and run at approximately one-third to one-half throttle for about one minute without moving the vehicle or operating any hydraulic functions.

WARNING: Escaping hydraulic fluid under pressure can penetrate the skin, causing serious injury. Relieve hydraulic pressure before servicing any hydraulic component.

9. Inspect for leaks and check all fluid levels. The hydraulic reservoir oil level must be visible in the sight gage.

Note: Check for leaks and repair as required before continuing.

i. Pump Pressure Check Test

Attach a 500 psi (34,5 bar) gauge to the unloader valve inlet port. Monitor the pump pressure at the unloader valve. It must exceed 200 psi (13,8 bar) within moments after starting the engine. Failure to achieve this pressure means that the pump is not properly functioning.

Checking pump stand-by pressure

Connect a 1000 psi (69 bar) pressure gage to the pressure tap on the inlet of the main control valve center section.

Start the engine and run at idle. **DO NOT** operate any functions for at least one minute. Record the system standby pressure while still at idle. It must be 250/350 psi (17,25/24,15 bar).

9.8 HYDRAULIC CIRCUITS

This section describes each hydraulic circuit and includes, on the following pages, a circuit schematic and a discussion of the hydraulic function involved.

The hydraulic system consists of several components that operate with each other and in conjunction with the electrical system to produce the desired function via input from operator controls or automated vehicle systems (such as the patented Stabil-TRAK system).

Components of the hydraulic system include the hydraulic fluid, reservoir, filters, cooler, pump, unloader valve, the main control valve, auxiliary function valve, pilot select manifold, joystick control valve, cylinders, steering select valve, brake valve, steering unit, hoses and fittings.

The gear pump produces flow of the hydraulic fluid for the system. When the gear pump is operating, the atmospheric pressure condition on the inlet side of the pump is lower and hydraulic fluid flows from the reservoir, through a strainer (filter) and hose, to the pump. The pump sends the fluid through a hose to the unloader valve and from there to various places within the system.

The unloader valve acts as a pressure regulator and as a pressure relief for the hydraulic system.

The main control valve directs flow of fluid to the appropriate circuit via spool valve movement.

The auxiliary function valve contains pressure-reducing valves and a pressure-relief valve to regulate circuit pressure in the pilot pressure system, brake system, and steering system.

The pilot select manifold contains solenoids which, when activated, open passages in the manifold to direct pilot pressure flow to operate the spool valves in the main control valve.

The joystick control valve contains four valves that are activated by moving the joystick, plus a reservoir return valve. Activated valves result in fluid flow being directed to the pilot select manifold. The joystick contains switches that, when pressed, activate solenoids in the pilot select manifold, producing a combination of functions.

The steer select valve is comprised of two electrical solenoids that act on a spool valve to direct flow to the steering cylinders, providing steering action.

The service brake valve is comprised of two identical brake valves mounted next to each other in the same casting. As force is applied to the brake pedal, the valve sends oil to the service brakes at pressure that is proportional to the force that is applied to the pedal.

In the manual mode of operation (ignition keyswitch OFF, engine OFF), the brake valve operates as a two-stage pump. The first stage pumps a high volume of oil at a relatively low amount of pressure. The second stage then pumps a low volume of oil for higher braking pressure, ultimately resulting in braking action.

The power steering unit consists of a control valve and metering sections. The control valve section contains mechanically actuated linear spool that is torsion bar centered and is of the open-center type. It directs fluid to and from the metering section and steering cylinders and regulates the flow supplied to the steering cylinders. The metering section of the steering unit consists of a commutator and a bi-directional gear-rotor element. It meters the amount of fluid sent to the steering cylinders.

The main control valve contains four working sections, plus an inlet section, and two end caps. Operating or working sections for the hoist/lower, extend/retract, frame tilt, and attachment tilt circuits are mounted between the end cap sections, forming a valve stack. The main control valve directs fluid to and from the various hydraulic circuits.

9.8.1 Brake Circuit

The brake system circuit (Fig. 9–12) includes the park brake and the service brake, along with the auxiliary function manifold, main control valve and various hoses, fittings and other components.

With the vehicle at rest (ignition keyswitch OFF, engine OFF), the park brake is ON.

The vehicle is designed so that the service brake can be used to stop the vehicle with the engine OFF.

The the park brake itself is part of the front axle ONLY. The service brakes are contained within both the front and rear axles. Refer to *Section 5 Axles, Wheels and Tires* for further information.

a. Park Brake Circuit

The front axle (only) is equipped with a spring-applied, pressure-released park brake. The park brake operates via two solenoids at the auxiliary function manifold. With the engine running and the park brake switch ON, one of the solenoids is normally open and the other is normally closed. This prevents flow in one direction but allows it in another. Spring pressure within the front axle engages the park brake. Oil is prevented from flowing to the front axle and releasing the park brake.

With the engine running and the park brake switch OFF, oil flows from the main hydraulic pump, to the auxiliary function valve, through the park brake solenoid valve, out the park brake port PB, to the front axle and to the park brake section of the front axle. Oil pressure overcomes the spring pressure within the front axle, and the park brake is released. Oil is prevented from flowing back to the reservoir because of the closed solenoid valve at the auxiliary function manifold.

With the engine OFF and the park brake switch OFF, spring pressure at the front axle engages the park brake.

b. Service Brake Circuit

A hydraulic line from auxiliary function manifold port PS (Fig. 9–12) provides flow to the service brake valve when the engine is running. A reservoir line is installed on the service brake valve at port T. There are also lines for the front wheel brakes, rear wheel brakes, and a shuttle in line on the service brake valve. Pressure can be checked at auxiliary function manifold port PSG and at the pressure tap fitting installed in the rear brake line.

The service brake valve itself is a severe-duty type valve used in a variety of agricultural and industrial applications. The valve actually consists of two identical brake valves mounted next to each other in the same casting. Each valve can operate independently of the other.

The service brake valve operates much the same as a pressure reducing valve in the power mode. As force is applied to the brake pedal, the valve sends oil to the vehicle brakes at pressure that is proportional to the force that is applied to the pedal.

In the manual mode of operation (engine OFF), the brake valve operates as a two-stage pump. The first stage pumps a high volume of oil up to a low amount of pressure. The second stage then pumps a low volume of oil for higher braking pressure.

At rest (or “standby”), system pressure exists at the service brake valve, ready for pedal application.

Fluid Flow When Brake Pedal is NOT Pressed

System pressure from the main pump flows to the unloader valve, then to the auxiliary function manifold. From there, the oil is routed out to the brake valve, located above the brake pedal and beneath the dash. With the pedal NOT depressed, the spool valves are closed and no oil is allowed to flow to the axles.

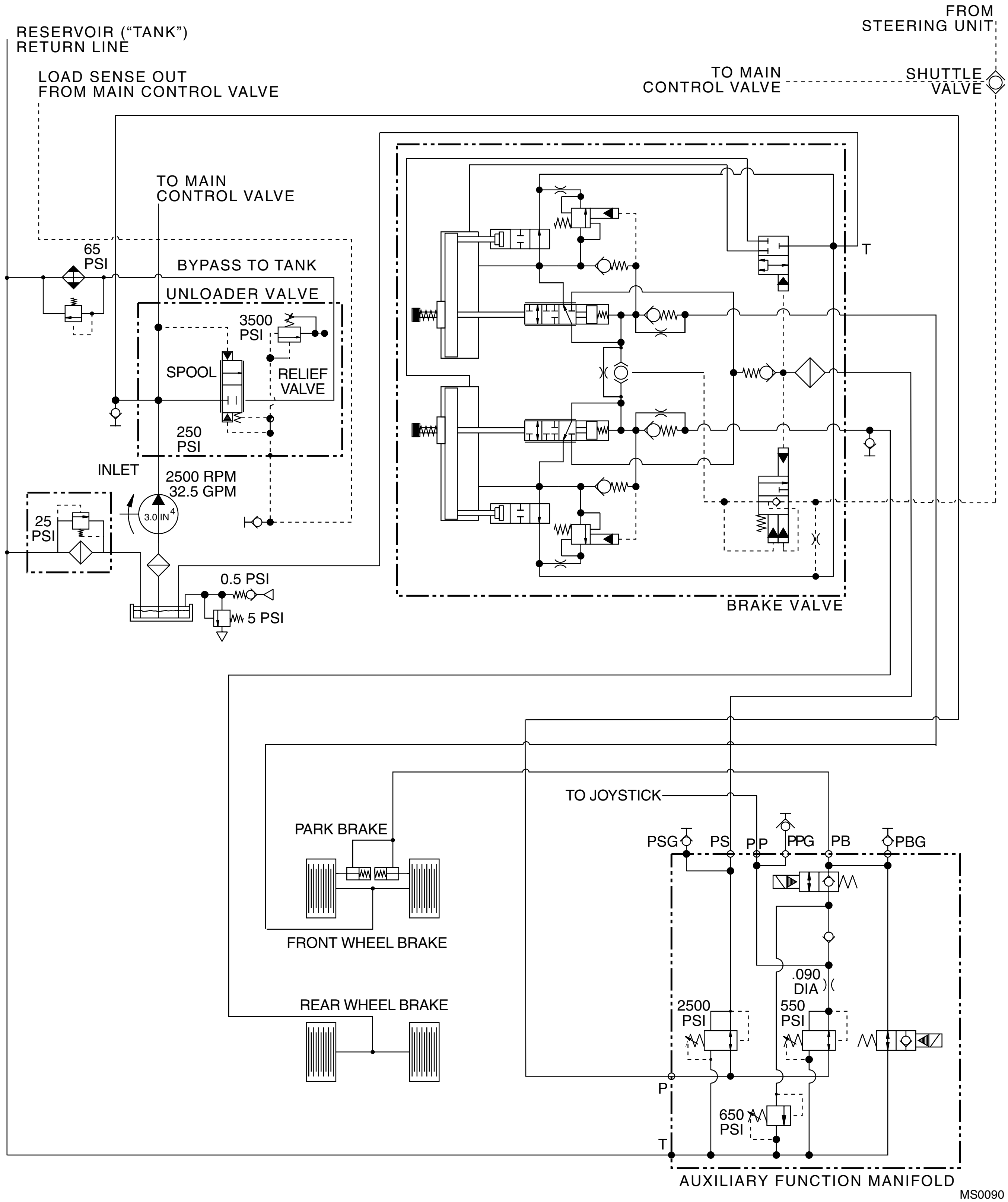


Figure 9–12. Brake system circuit schematic.

Legend for Brake Circuit

1. Service Brake Valve
2. 90° Elbow, SAE 6 - Str. Thd. ORB x O-ring face seal
3. Swivel Run Tee, SAE 6, O-ring face seal
4. 90° Swivel, SAE 6, O-ring face seal
5. Diagnostic Nipple
6. Dust Plug
7. Auxiliary Function Manifold
8. Connector, SAE 6 - Str. Thd. ORB x O-ring face seal
9. Diagnostic Nipple, 9/16-18
10. 90° Elbow, SAE 8 - Str. Thd. ORB x O-ring face seal
11. Hose, 1/2” I.D. x 17”
12. Hose, 3/8” I.D. x 106”
13. Hose, 3/8” I.D. x 32”
14. Hose, 3/8” I.D. x 136-1/2”
15. Hose, 3/8” I.D. x 81”
16. Hose, 3/8” I.D. x 111”
17. 90° Swivel Elbow, SAE 4, O-ring face seal
18. Swivel Run Tee, SAE 4, O-ring face seal
19. Connector, SAE 8- Str. Thd. ORB x O-ring face seal
20. Connector, M10-4, Metric Str. Thd. ORB x O-ring face seal
21. Cap, SAE 4 - O-ring face seal

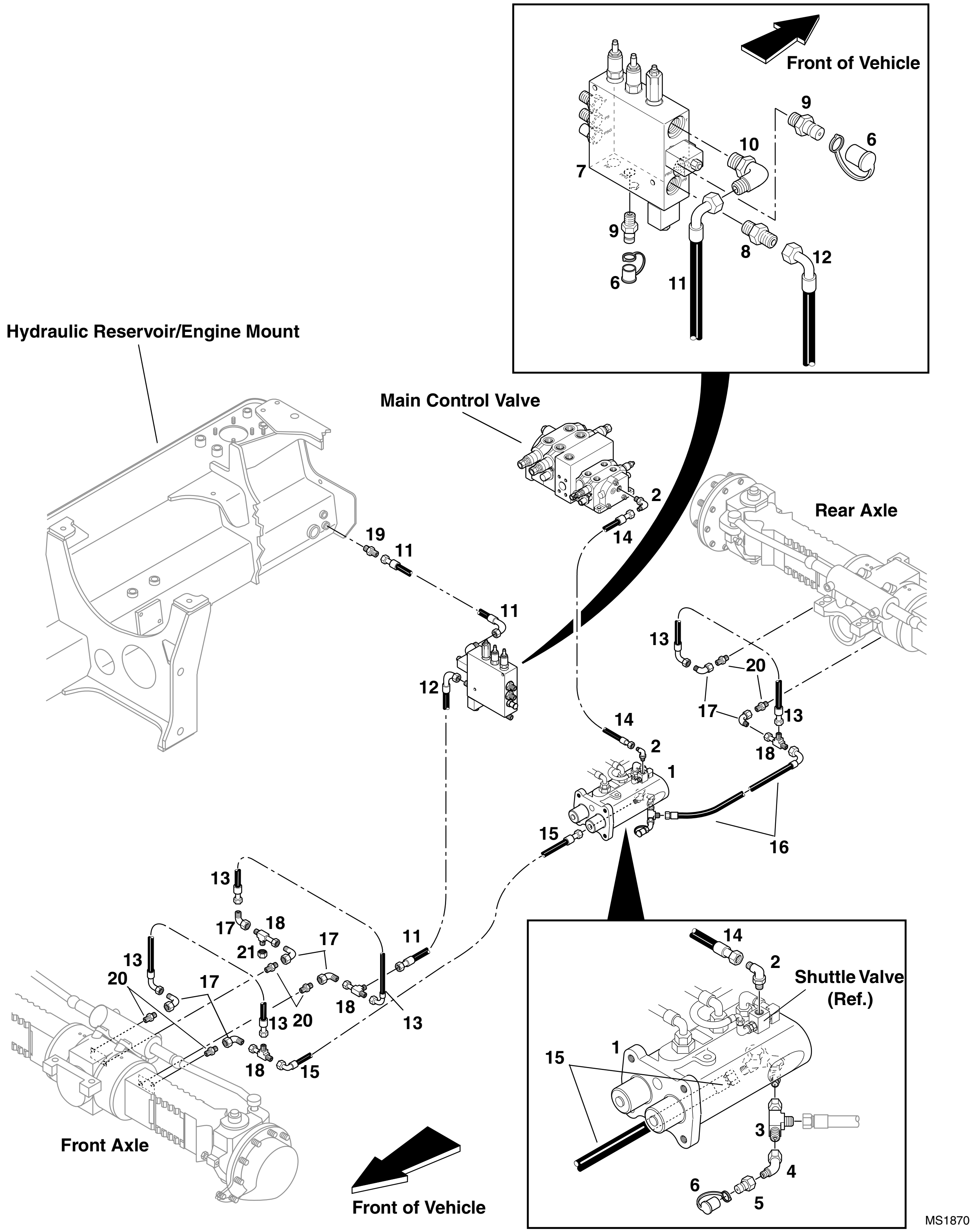


Figure 9–13. Vehicle brake circuit.

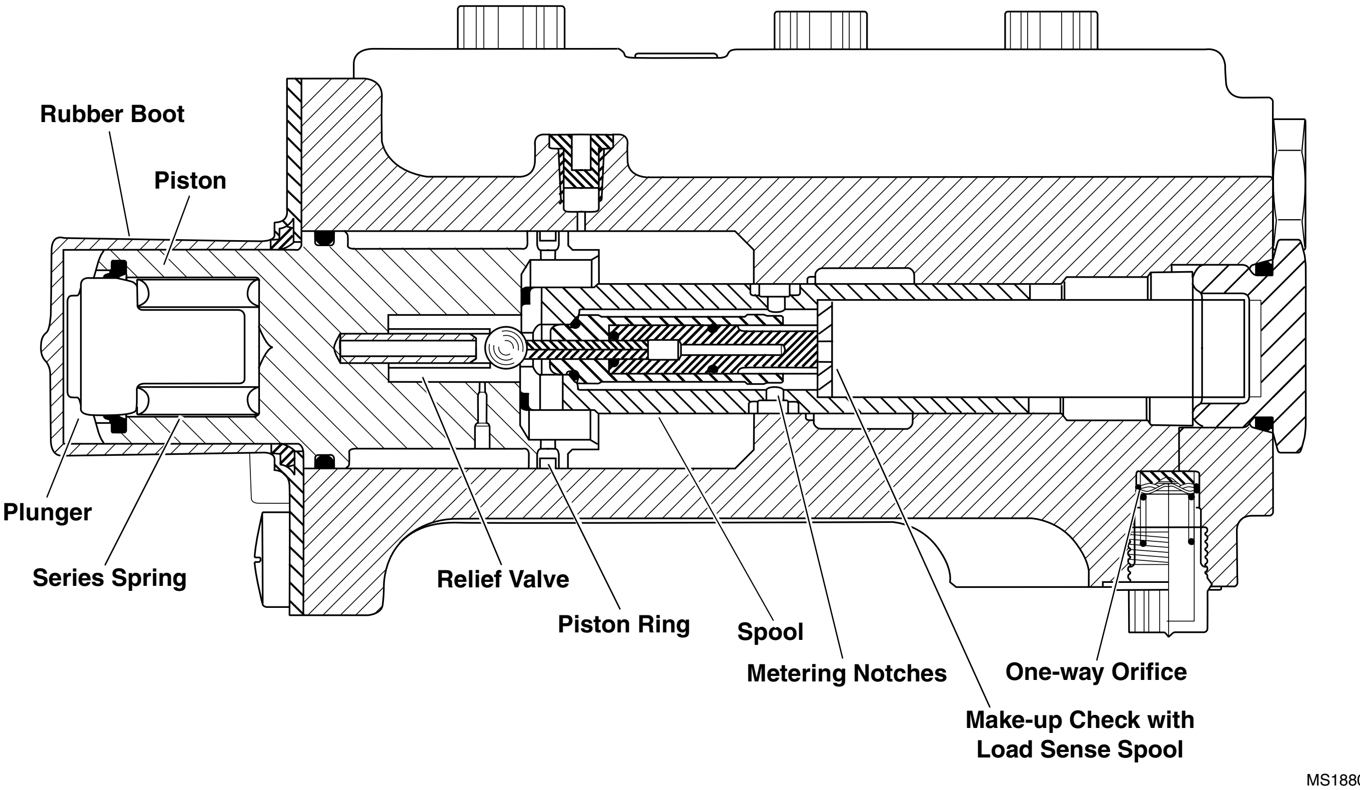


Figure 9–14. Cross section of service brake valve.

Fluid Flow When Brake Pedal is Pressed

System pressure from the main pump flows to the unloader valve, to the auxiliary function manifold, to the brake valve. With the pedal depressed, spool valves open and oil is allowed to flow through the brake valve and out to the axles.

Service Brake Valve Operation

Valve operation occurs in two modes, *Power Mode* and *Manual Mode*. The steps below describe service brake valve function in both of those modes.

Power Mode

1. Displacement of the brake pedal is transmitted to the valve at the plunger (Fig. 9–14).
2. The series spring transmits plunger displacement to the piston. The series spring also absorbs slight pedal pressure variations, and helps to provide smoother braking.
3. At rest (or “standby”), system pressure exists at the service brake valve, and the lines are vented to the reservoir. The reservoir venting is restricted as pedal pressure is applied, causing the piston to contact the piston sealing ring. The piston is blocked when the fluid return metering notches on the spool are covered by the spool bore.
4. Pressure in both the front and rear axle brake lines is equal. A groove in each of the two spools opens to a cross-hole between the two spool bores, preventing uneven brake pressure. This feature is called the equalizer function.
5. Power-mode braking begins when the metering notches in the spool meter oil from the inlet port to the spool chamber. Oil flows from the spool chamber, through the one-way orifice, and into the brake lines. Brake pressure is controlled by a force balance between the force applied at the pedal and the resulting force from pressure in the spool area.
6. The load sense bleed orifice helps provide stability and aids in purging air from the system.

Manual Mode

In the event that hydraulic pressure at the inlet port is too low to provide the braking force required, the service brake valve automatically transitions to the manual mode to provide braking power.

Flow paths out of the valve that would rob efficiency are automatically blocked in the manual mode. The inlet port check valve seals off the inlet port, and the load sense shutoff valve closes. The service brake valve then acts as a two-stage pump.

1. Brake pedal displacement is transmitted to the valve at the plunger (Fig. 9–14).
2. The series spring transmits plunger displacement to the piston.
3. The piston and spool, functioning as pumps, send oil to the brake lines. Initially, the brake lines are vented to the reservoir by an annular gap between a stepped-down piston diameter and the piston bore. Flow to the reservoir is restricted when the piston contacts the piston sealing ring.
4. Volume generated by piston displacement causes the spool make-up check device to unseat. Oil flows into the spool chamber and out to the brake lines.
5. Pressure in both the front and rear axle brake lines is equal. A groove in each of the two spools opens to a cross-hole between the two spool bores, preventing uneven brake pressure. This feature is called the equalizer function.
6. At a set piston chamber pressure, a relief valve begins to meter oil and limits the pressure within the piston chamber. The pressure in the piston chamber becomes isolated from the pressure in the spool chamber when the make-up check device reseats itself.
7. Further displacement of the service brake pedal causes higher pressure in the spool chamber. The load sense pin in the make-up check device is sensitive to the increased pressure and transmits a force to the relief ball. The increasing force on the relief ball effectively lowers the relief setting within the piston chamber. Eventually, piston chamber pressure reaches zero, and the valve has moved completely from the first stage to the second stage. The smaller area of the second stage permits the brake valve to develop higher braking pressure.
8. Controlling the force applied to the service brake pedal controls the amount of braking power.
9. If the first application of force applied to the service brake pedal was not enough to deliver the braking required, the one way orifices at the work ports help give the brake valve “pump up” ability. The one-way orifices allow unrestricted flow to the brake lines but also restrict the rate of decompression.

9.8.2 Boom Hoist/Lower Circuit

a. Hoist Circuit

With the joystick in the boom lift position, pilot pressure shifts the hoist/lower spool valve (Fig. 9–15) in the directional control valve to direct system pressure to ports A-D through E-B and through the check valve to the base end of the hoist cylinder.

Return oil from the rod end of the cylinder flows through ports C-F of the spool valve to the return filter and then to the hydraulic fluid reservoir (Fig. 9–16).

- If system pressure exceeds 3500 psi (241,5 bar), the main relief will open, allowing oil to return to the reservoir.
- If the return filter becomes plugged, return hydraulic oil will bypass the filter when pressure reaches 25 psi (1,725 bar) and return to the reservoir unfiltered.

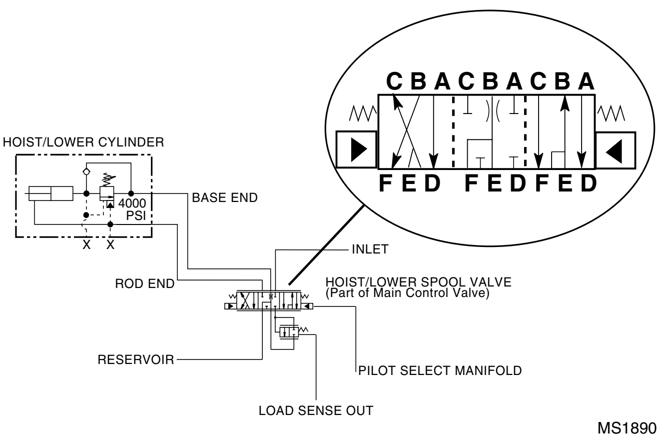


Figure 9–15. Hoist/lower spool valve schematic.

b. Lower Circuit

When the joystick is in the boom lowering position, pilot pressure shifts the hoist/lower spool valve (Fig. 9–15) in the directional control valve to direct system pressure through ports A-D, through the flow compensator. Oil is then directed through ports F-B to the rod end of the hoist cylinder. System pressure also pilots open the counterbalance valve in the hoist cylinder.

The open counterbalance valve allows return oil from the base of the cylinder to flow to ports C-E of the directional control valve, to the return filter and then to the hydraulic fluid reservoir (Fig. 9–16).

- If system pressure exceeds 3500 psi (241,5 bar), the main relief will open allowing oil to return to the reservoir.
- If the return filter becomes plugged, return hydraulic oil will bypass the filter when pressure reaches 25 psi (1,725 bar) and return to the reservoir unfiltered.

The counterbalance valve in the boom hoist cylinder serves another main function for safety purposes. This function can be described as follows:

Should any of the hydraulic lines routed to the hoist cylinder fail, there will be a loss of hydraulic system pressure to the cylinder. For example, if a hydraulic line failure occurred in the pressurized lowering line during lowering, the counterbalance valve would lose pilot pressure, closing off flow returning to the reservoir. The oil in the base end of the cylinder would then be trapped, which would immediately stop boom lowering and prevent an elevated load from falling to the ground uncontrolled.

The load can be lowered safely to the ground by following the *Emergency Boom Lowering* procedures in *Section 3 Boom* of this manual.

IMPORTANT: DO NOT attempt to reset the counterbalance valve cartridges. In the event that the counterbalance valve cartridges were disabled for emergency boom lowering, or if any unauthorized adjustments are ever made to these cartridges, remove and replace both cartridges with new parts. Failure to replace these cartridges with new parts may alter the holding characteristics of the counterbalance valves, creating an unsafe condition for vehicle operation.

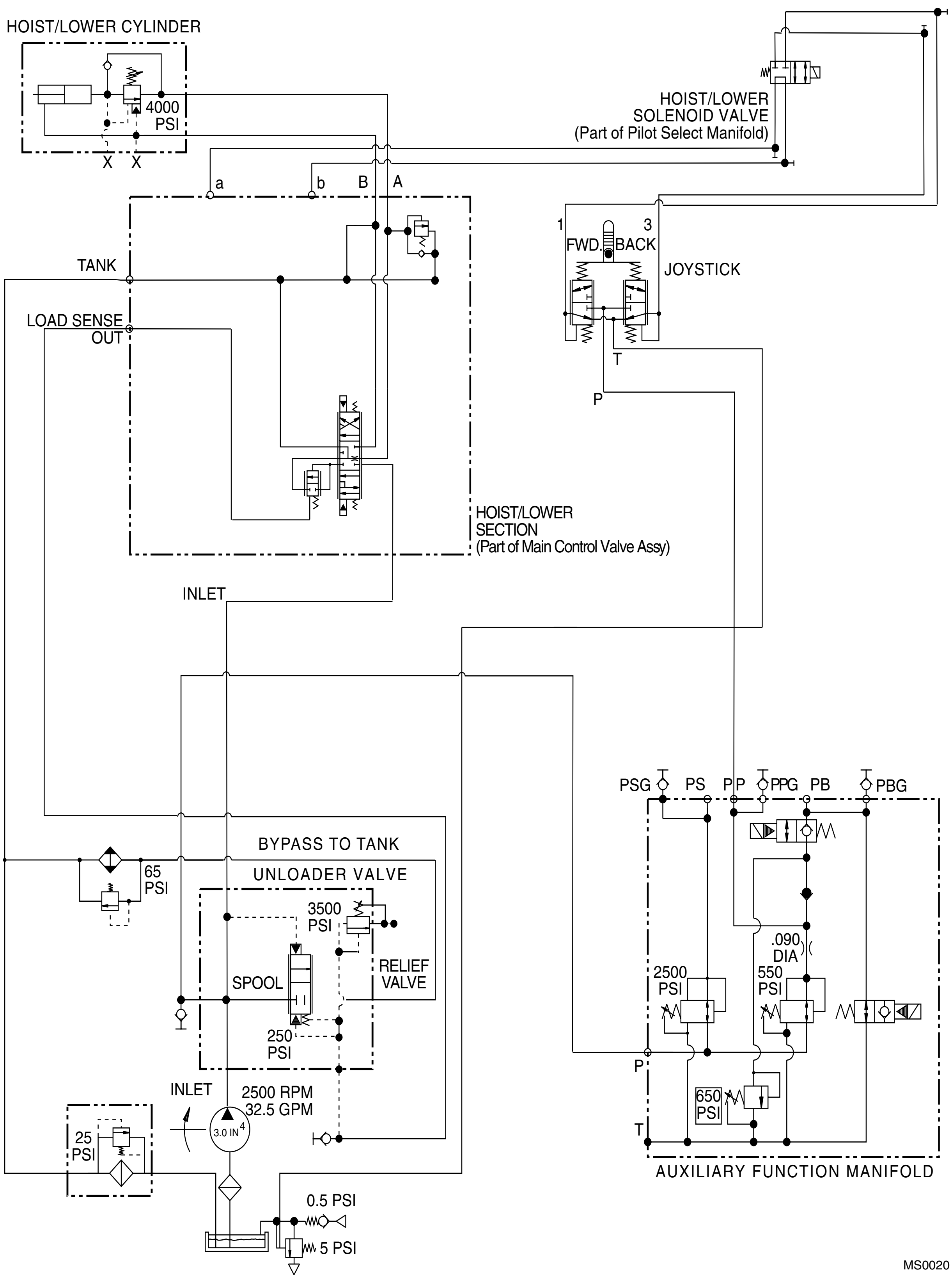


Figure 9–16. Boom hoist/lower hydraulic circuit schematic.

9.8.3 Boom Extend/Retract Circuit

Hydraulic flow is applied in the boom extend/retract circuit (Fig. 9–17 and Fig. 9–18) by the hydraulic gear pump. System pressure is directed to either side of the extend/retract cylinder by the shifting of the spool valve in the directional control valve of the main control valve. The spool valve is shifted by pilot pressure, regulated by the position of the joystick.

a. Center Position

When the joystick is in the center or NEUTRAL (N) position, the extend/retract spool valve (Fig. 9–17) in the main control valve is centered so system pressure cannot flow through the ports to the cylinder. No boom movement occurs with the joystick in the center position.

b. Extend Position

When the joystick is in the boom EXTEND position, the spool valve (Fig. 9–17) is shifted by pilot pressure so flow is directed through extend/retract spool valve ports A-D, then E-B, through the check valve to the base end of the extend/retract cylinder. If system pressure exceeds 3200 ± 50 psi (220,8 ± 3,5 bar), the extend port relief will open and allow hydraulic oil to return to the reservoir.

Return oil from the rod end of the cylinder attempts to exit through the counterbalance valve. The counterbalance valve is piloted open by high oil pressure and oil will pass from the cylinder to ports C-F of the spool valve to the return filter and the reservoir.

If the return filter is plugged, the oil returning to the reservoir bypasses the filter when the filter's internal pressure reaches 25 psi (1,725 bar).

c. Retract Position

When the joystick is in the boom RETRACT position, the extend/retract spool valve (Fig. 9–17) is shifted by pilot pressure so that system pressure is directed through ports A-D, then F-B of the spool valve, to the rod end of the extend/retract cylinder. The counterbalance valve is piloted open by high pressure, allowing return oil from the base end of the cylinder to flow through ports C-E of the spool valve to the return filter and the reservoir. If system pressure reaches 3500 ± 50 psi (241,5 ± 3,5 bar), the main relief valve opens, allowing hydraulic oil to return to the reservoir.

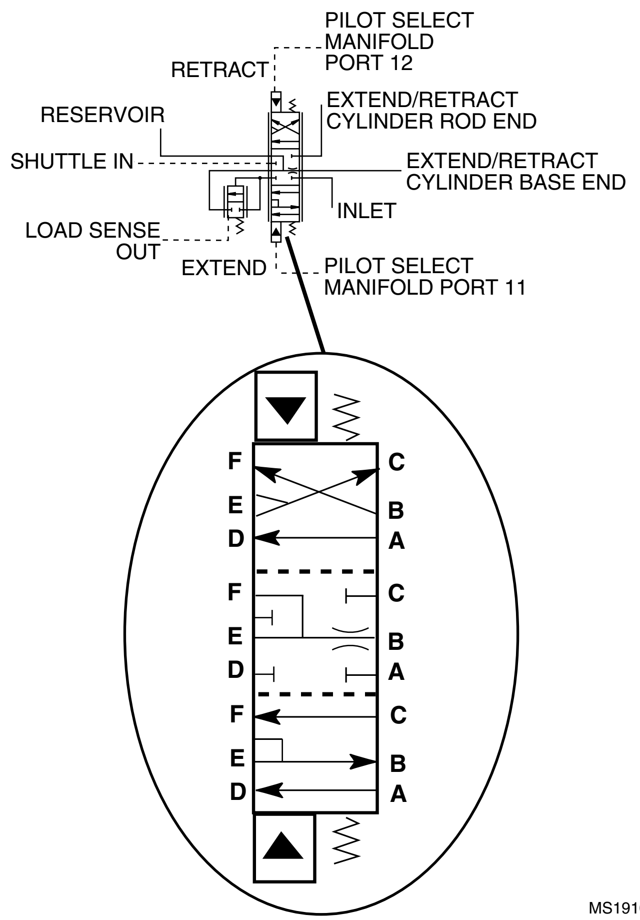


Figure 9–17. Extend/retract spool valve schematic.

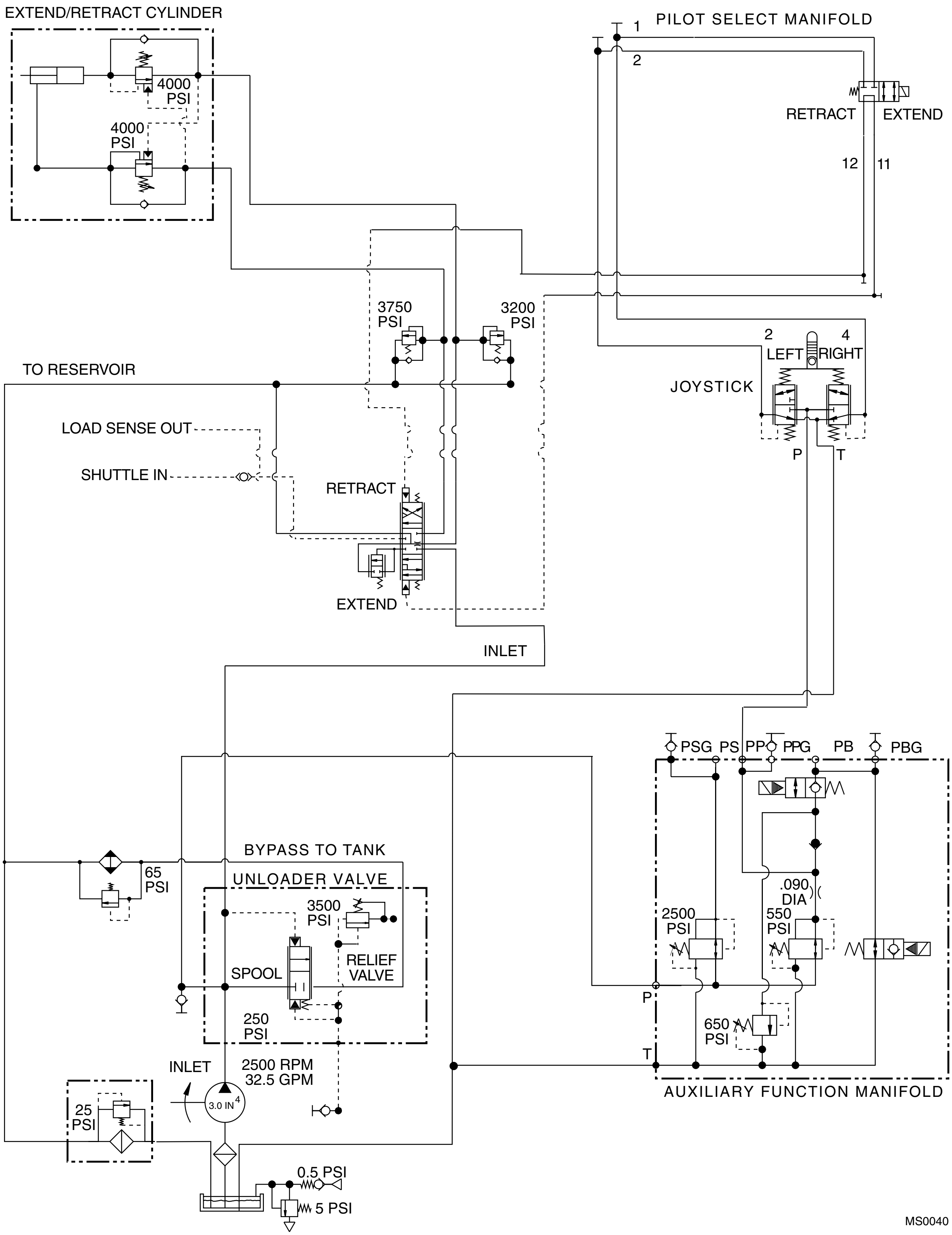
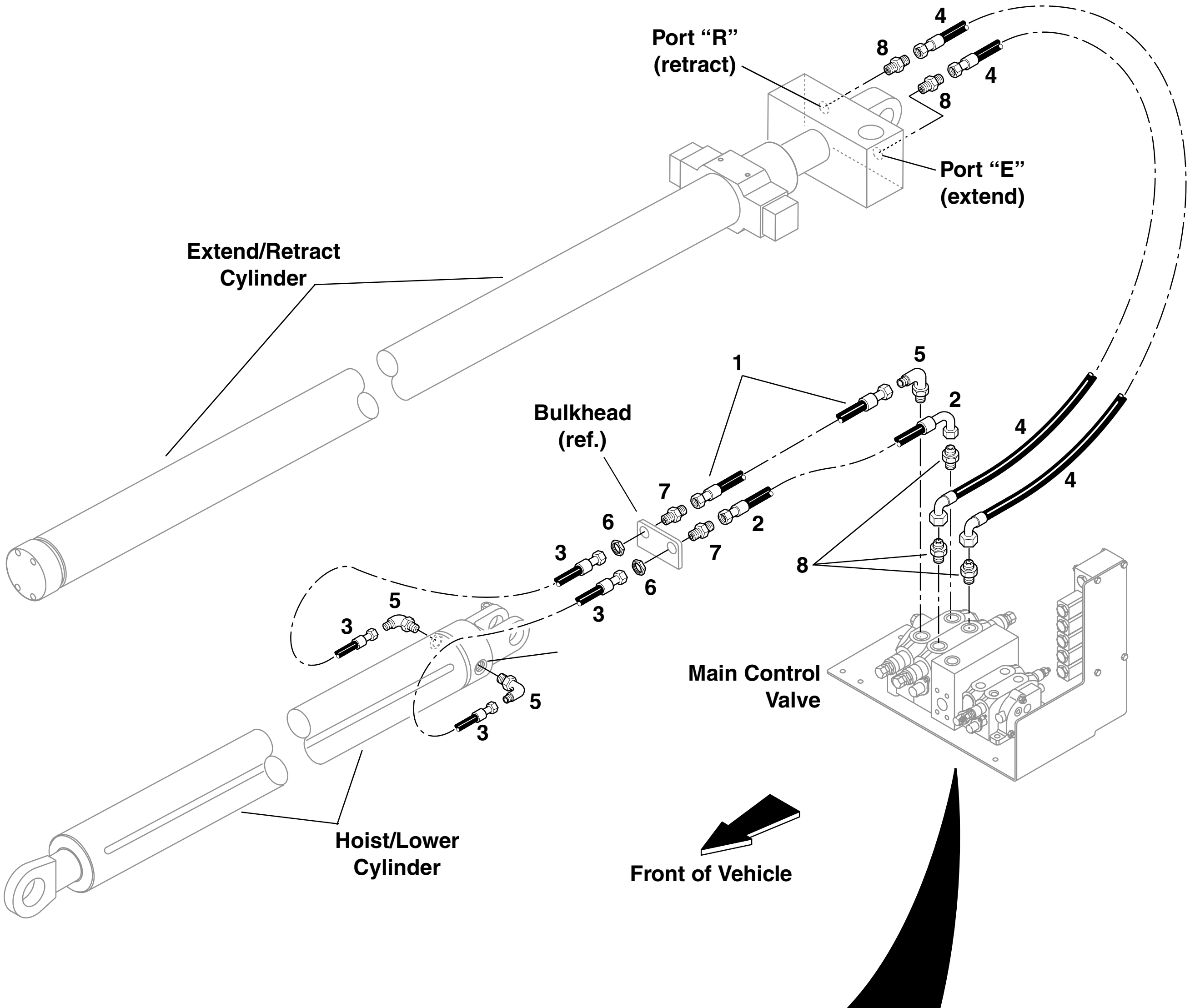
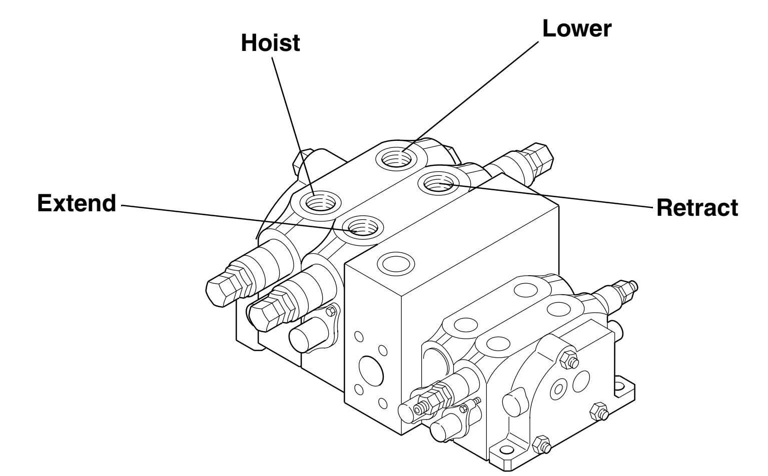


Figure 9–18. Extend/retract hydraulic circuit schematic.



Legend

1. Hose, 3/4” I.D. x 21-1/2”
2. Hose, 3/4” I.D. x 27”
3. Hose, 3/4” I.D. x 45”
4. Hose, 3/4” I.D. x 36”
5. 90° Elbow, SAE 12 - Str. Thd. ORB x O-Ring Face Seal
6. Bulkhead Nut, SAE 12 O-Ring Face Seal
7. Bulkhead Connector, SAE 12 O-Ring Face Seal
8. Connector, SAE 12 - Str. Thd. ORB x O-Ring Face Seal



Directional Control Valve Ports

PS0690

Figure 9–19. Hoist/lower and extend/retract components.

d. Extend/Retract Cylinder Counterbalance Valve

The extend/retract cylinder (Fig. 9–19) includes two counterbalance valves (Fig. 9–20). The valves serve two main functions. One of the functions is to help prevent component damage.

The other counterbalance valve function can be described as follows:

- If the vehicle is travelling and the boom runs into a solid object, pressure will build up on the base end of the cylinder. Without a counterbalance valve, the cylinder rod would bend, damaging the cylinder. With the counterbalance valve installed, the pressure will build up until it reaches 4000 psi (276 bar) and then the counterbalance valve will be internally piloted open, allowing the pressure to return to the reservoir. This condition will only exist if the cylinder has been extended. If the cylinder is already fully retracted, the counterbalance valve will have no effect and damage can result.
- Should any of the hydraulic lines going to the extend/retract cylinder (Fig. 9–19) fail, there will be a loss of hydraulic system pressure to the cylinder.

  Example: If there was a hydraulic line failure in the pressurized retract line during retracting, the counterbalance valve would lose pilot pressure, closing off flow returning to the reservoir. The oil in the base end of the cylinder would then be trapped, which would immediately stop boom retraction, preventing an elevated load from uncontrolled retraction. The load can be lowered safely to the ground by following the *Emergency Boom Lowering* procedures in *Section 3 Boom* of this manual.

IMPORTANT: DO NOT attempt to reset a counterbalance valve cartridge. In the event that a counterbalance valve cartridge was disabled for emergency boom lowering or any unauthorized adjustments are ever made to this cartridge, remove and replace the cartridge with a new part. Failure to replace this cartridge with a new part may alter the holding characteristics of the counterbalance valve, creating an unsafe condition for vehicle operation.

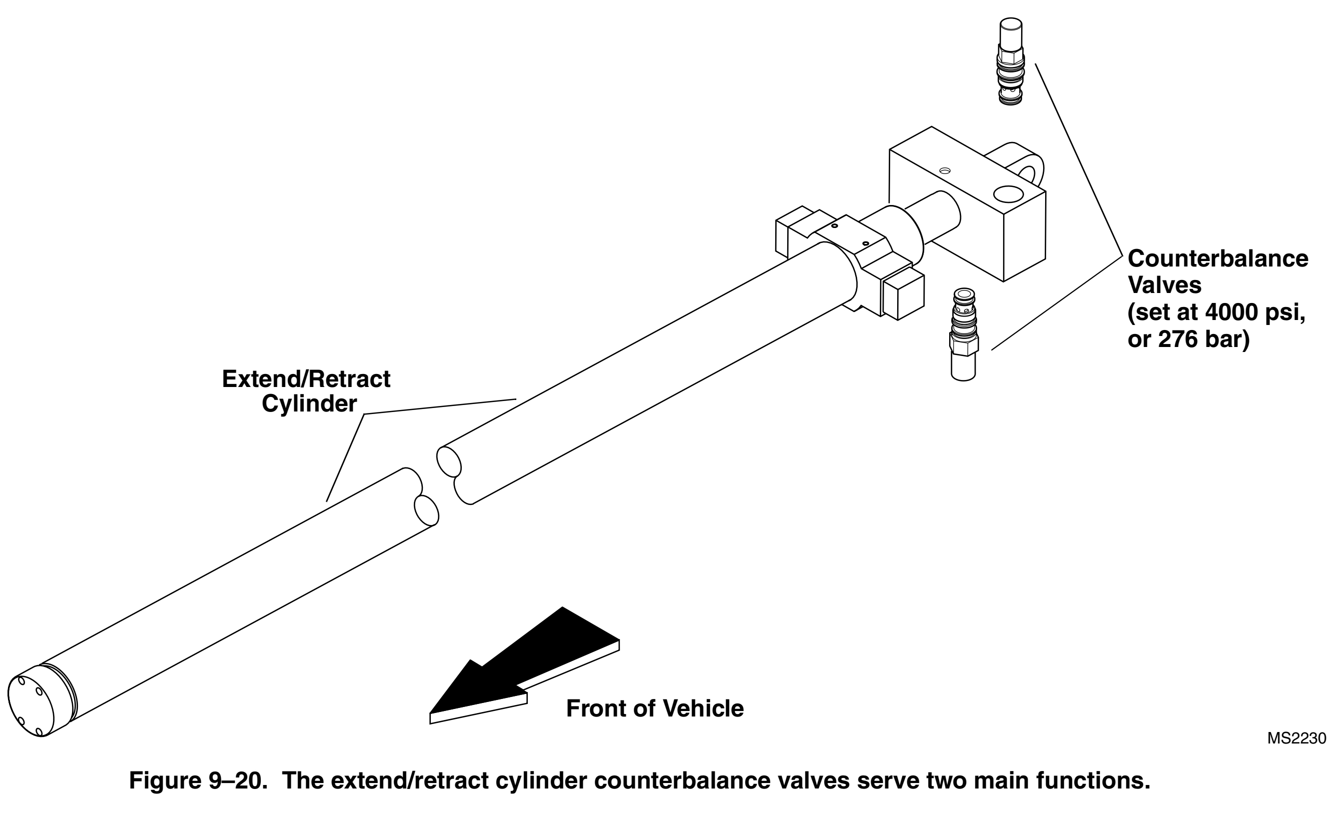


Figure 9–20. The extend/retract cylinder counterbalance valves serve two main functions.

9.8.4 Frame Tilt Circuit

a. Frame Tilt LEFT

With the two frame tilt select buttons on the joystick depressed and held, and the joystick moved to the left, the spool valve in the frame tilt directional control valve (Fig. 9–21) of the main control valve assembly (see Fig. 9–22) is shifted by pilot pressure. System pressure is directed to ports A-D (Fig. 9–21), then B-F of the spool valve (in the main control valve), and from there to the base end of the frame tilt cylinder. Oil from the rod end of the frame tilt cylinder flows through a check valve, unseated by system pressure, to the stabilizer cylinder, through the solenoid valve, back to the spool valve through ports E-C to the return filter and the reservoir.

b. Frame Tilt RIGHT

With the two frame tilt select buttons on the joystick depressed and held, and the joystick moved to the right, the spool valve in the frame tilt directional control valve of the main control valve assembly is shifted by pilot pressure.

System pressure is directed to ports D-A then B-E of the spool valve (Fig. 9–21), then to the stabilizer cylinder, through the solenoid valve, back to the frame tilt cylinder, where it flows to the rod end of the cylinder. Oil from the base end of the cylinder flows through the check valve, which was unseated by system pressure, then to ports F-C of the spool valve, to the return filter and the hydraulic fluid reservoir.

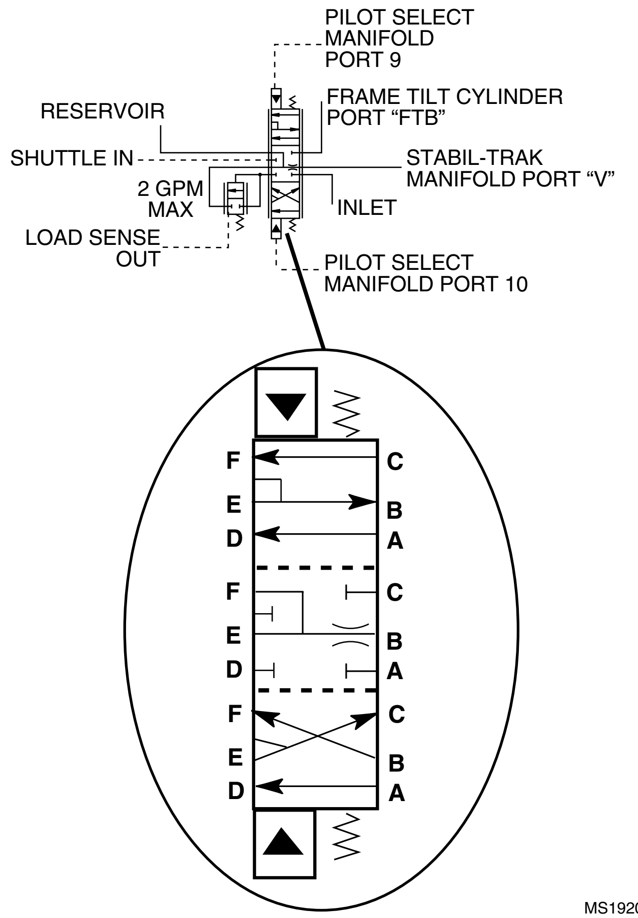


Figure 9–21. Frame tilt spool valve circuit schematic.

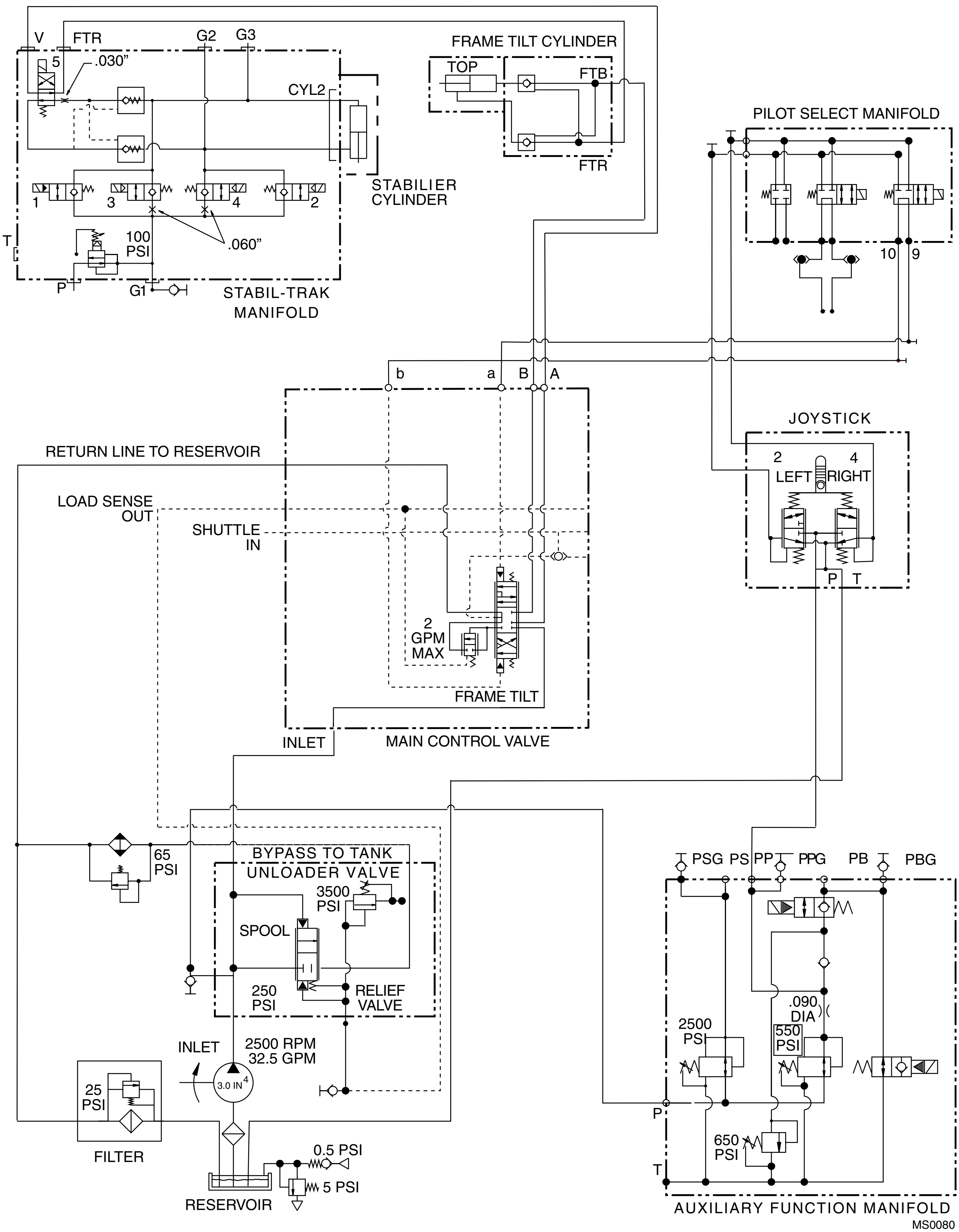


Figure 9–22. Frame tilt and stabilizer hydraulic schematic.

9.8.5 Stabil-TRAK Hydraulic Circuit

a. Stabil-TRAK System

The patented rear axle lock or Stabil-TRAK system works to stabilize the vehicle under various conditions. The *SKY TRAK Owners/Operators Manual Model 3606* contains basic Stabil-TRAK information; a copy of the owners/ operators manual should always be available in the storage compartment beneath the operators seat.

The stabilizing system operates via an interface between the boom proximity switch, the park brake, service brake and travel select lever hydraulic and electrical circuits, and five solenoid-operated valves on the Stabil-TRAK manifold (Fig. 9–23) mounted on the left side of the rear axle.

The frame tilt cylinder is also involved in the Stabil-TRAK system, but only passively as hydraulic fluid is cycled to accommodate Stabil-TRAK system operation.

The rear axle lock system can only be activated when the boom angle is greater than 40 degrees. Any one, any two or all three of the following selections will activate the system:

- Engaging the Parking Brake Switch
- Placing the Travel Select Lever in (N) NEUTRAL
- Depressing and holding the Service Brake

With the boom lowered to an angle of less than 40 degrees, the rear axle lock system is not active and none of these functions will affect the rear axle lock system.

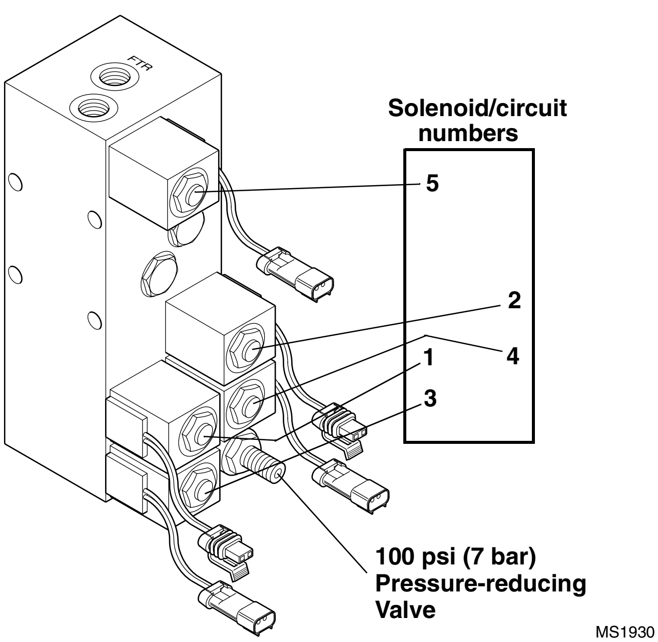


Figure 9–23. Stabil-TRAK manifold.

Frame Tilt/Stabilizer Legend

1. Stabil-TRAK Manifold
2. Dual Pilot Operated Check Manifold
3. Tie Wrap
4. Hose, 3/8” I.D. x 158”
5. Hose, 3/8” I.D. x 104”
6. Hose, 3/8” I.D. x 160”
7. Hose, 3/8” I.D. x 93”
8. Hose, 3/8” I.D. x 117”
9. 90° Elbow, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
10. Connector, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
11. Swivel Elbow, SAE 6, O-Ring Face Seal
12. Lockwasher, SAE 3/8”
13. Lockwasher, 3/8”
14. Grade 8 Hex-head Capscrew, 3/8-16 x 3-3/4”
15. Grade 8 Hex-head Capscrew, 3/8-16 x 4-3/4”
16. Branch Tee, SAE 8 - Str. Thd. ORB x O-Ring Face Seal
17. 90° Swivel Elbow, SAE 8, O-Ring Face Seal (w/o Aux. Hyd. option)
    Swivel Run Tee, SAE 8, O-Ring Face Seal (w/ Aux. Hyd. option)
18. Long Connector, SAE 8 - Str. Thd. ORB x O-Ring Face Seal
19. Connector, SAE 6-8 - Str. Thd. ORB x O-Ring Face Seal
20. Swivel Branch Tee, SAE 16, ORB x O-Ring Face Seal
21. Reducer, SAE 16, O-Ring Face Seal x SAE 8 O-Ring Face Seal
22. Tube Nut, SAE 16, O-Ring Face Seal
23. Connector, SAE 16-12 - Str. Thd. ORB x O-Ring Face Seal
24. Hex-head Plug, SAE 4, Male Str. Thd. O-Ring
25. Manifold
26. O-Ring
27. Socket-head Capscrew, 3/8-16 x 1-1/2”
28. Hex-head Plug, SAE 6, Male Str. Thd. O-Ring
29. Connector, SAE 8-6 - Str. Thd. ORB x O-Ring Face Seal
30. 90° Swivel Elbow, SAE 8, O-Ring Face Seal
31. Reducer, SAE 8, O-Ring Face Seal x SAE 6 O-Ring Face Seal
32. Hex-head Capscrew, 5/16-18 x 1-1/4”
33. Lockwasher, 5/16”
34. Twin Clamp Cover
35. Twin Hose Clamp Set, 0.68” I.D.
36. Stacking Bolt, 5/8” Long
37. Stacking Bolt, 1-1/8” Long
38. Locking Plate
39. Twin Hose Clamp Set, 0.78” I.D.
40. Grade 8 Hex-head Capscrew, 5/16-18 x 1-1/2”
41. Tie Wrap
42. Loctite®, 0.5 ounce

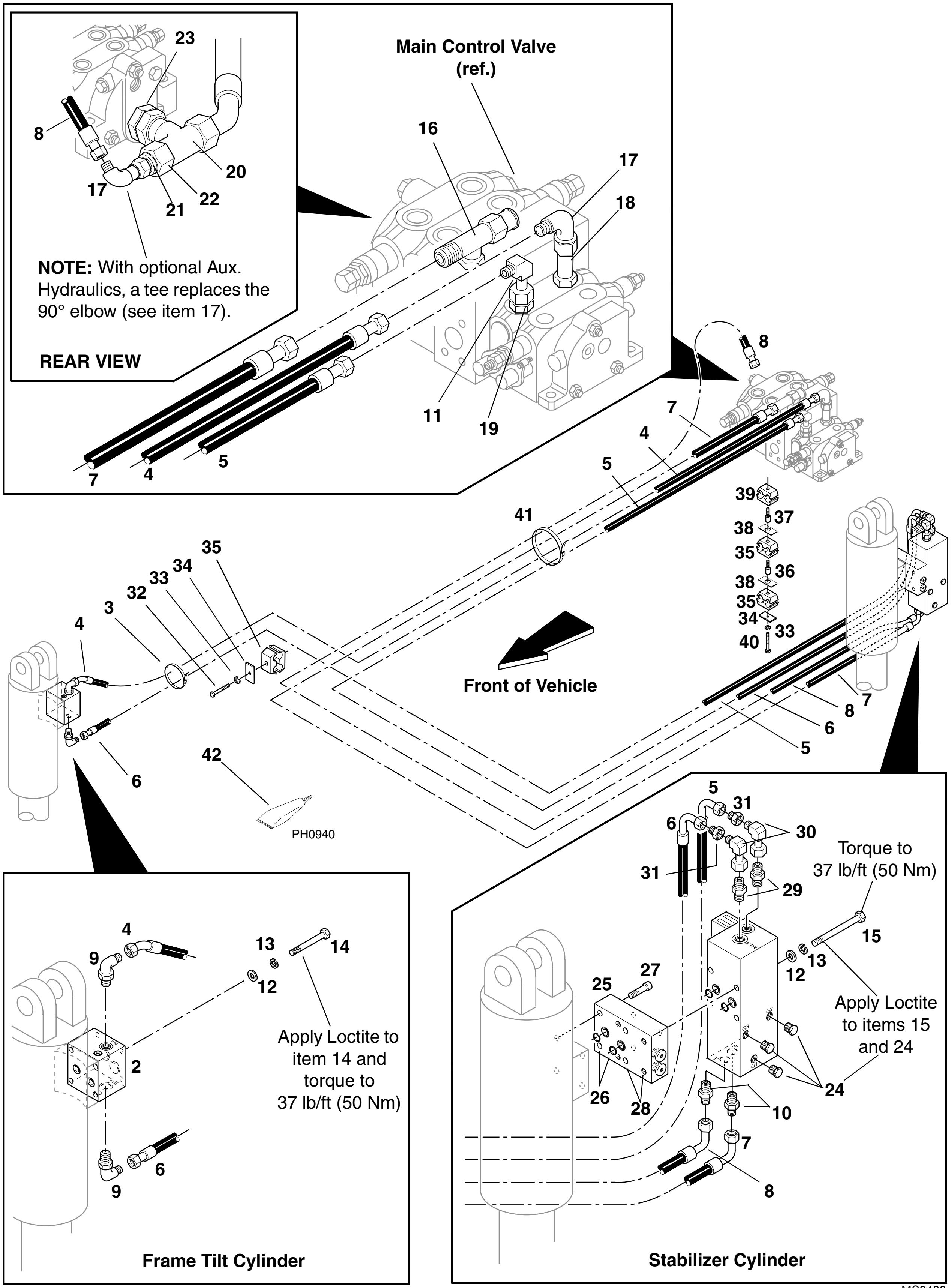


Figure 9–24. Frame tilt and stabilizer components.

b. Stabil-TRAK Modes

The function of the Stabil-TRAK system varies under different operating conditions. The basic modes include the free pivot mode (Fig. 9–25), final positioning mode (Fig. 9–26), and locked mode (Fig. 9–27). A hydraulic circuit diagram of each of the modes is included on the following pages.

Free Pivot Mode
(Fig. 9–25)

• Rod Oil OUT

Conditions: Boom angle is below 40°. Rear axle pivots freely, solenoids 1 and 2 energized, the travel select lever is in FORWARD (F) or REVERSE (R), park brake OFF and service brake OFF.

With solenoids 1 and 2 energized, hydraulic fluid from the rod end of the stabilizer cylinder flows through the stabilizer block and solenoid-operated valves, to the base side of the stabilizer cylinder. Because the volume of oil needed on the base side is larger than that needed on the rod side, the extra oil needed is supplied from the main hydraulic system through a 100 psi (7 bar) reducing cartridge in the stabilizer block.

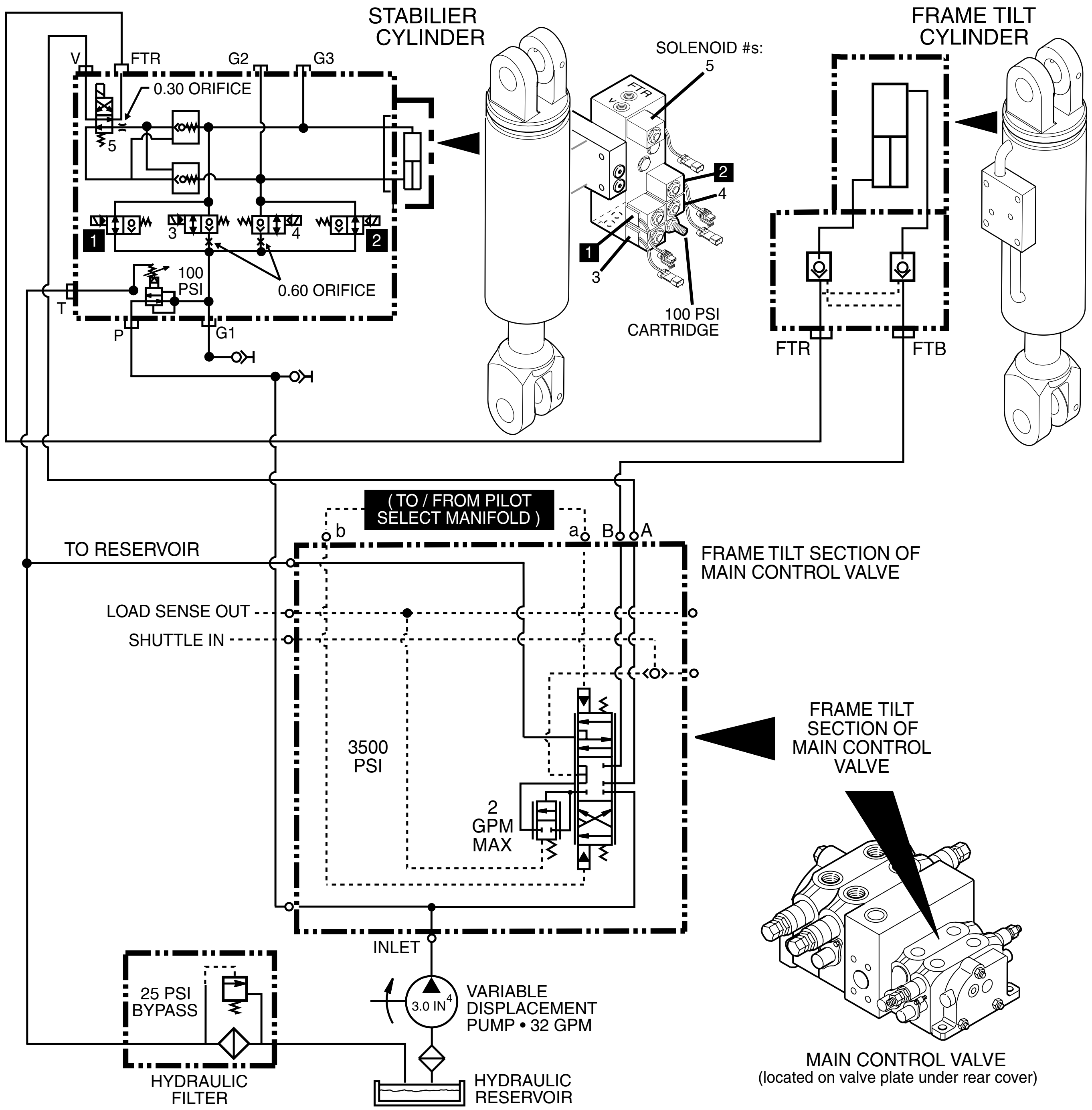
Free Pivot Mode
(Fig. 9–25)

• Base Oil OUT

Conditions: Boom angle is below 40°. Rear axle pivots freely, solenoids 1 and 2 energized, the travel select lever is in FORWARD (F) or REVERSE (R), park brake OFF and service brake OFF.

With solenoids 1 and 2 energized, hydraulic fluid from the base end of the stabilizer cylinder flows through the stabilizer block and solenoid-operated valves, to the rod side of the stabilizer cylinder. Because the volume of oil needed on the rod side is less than that needed on the base side, excess oil is returned to the tank through a 100 psi (7 bar) reducing cartridge in the stabilizer block.

3606 Stabil-TRAK HYDRAULIC CIRCUIT
Free Pivot Mode



CONDITIONS:

- Boom angle is below 40°.
- Rear axle pivots freely.
- Solenoids 1 and 2 energized.
- Park Brake ***and*** Service Brake OFF.
- Travel Select Lever in (F) FORWARD or (R) REVERSE.

Figure 9–25. Free pivot mode hydraulic circuit.

Final Positioning Mode
(Fig. 9–26)

• Rod Oil OUT

Conditions: Boom angle is above 40°, park brake OFF, and service brake released, and travel select lever in FORWARD (F) or REVERSE (R) position; solenoids 3 and 4 are energized.

From the rod end of the stabilizer cylinder, oil flows through solenoid-operated valve 4, through a 0.060" orifice, through another 0.060" orifice, then through solenoid/valve 3, then to the base end. Because of the larger volume of oil in the base end, extra oil will be supplied from the main system through the 100 psi (7 bar) reducing cartridge in the stabilizer block. The restrictions produce the slow movement, or “final positioning” mode.

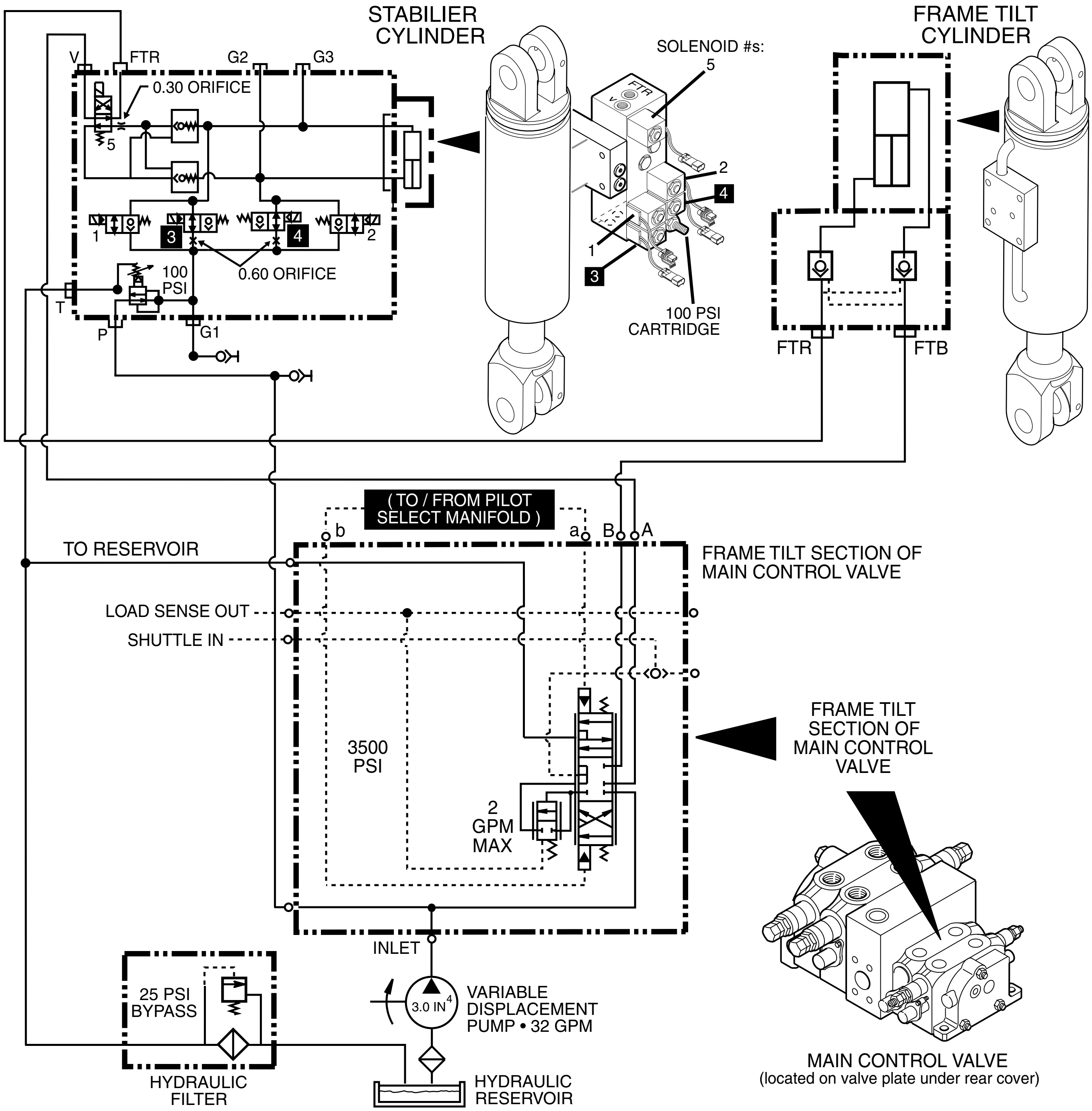
Final Positioning Mode
(Fig. 9–26)

• Base Oil OUT

Conditions: Boom angle is above 40°, park brake OFF and service brake released, and travel select lever in FORWARD (F) or REVERSE (R) position; solenoids 3 and 4 are energized.

From the base end of the stabilizer cylinder, oil flows through solenoid-operated valve 3, through a 0.060" orifice, through another 0.060" orifice, through solenoid valve 4, to the rod end. Because of the larger volume of oil in the base end, extra oil is returned to the tank through the 100 psi (7 bar) reducing cartridge in the stabilizer block. The restrictions produce the slow movement, or “final positioning” mode.

3606 Stabil-TRAK HYDRAULIC CIRCUIT
Final Positioning Mode



CONDITIONS:

- Boom angle is above 40°.
- Park Brake is OFF.
- Service Brake released.
- Travel Select Lever in F or R.

- Boom angle is above 40°.
- Solenoids 3 and 4 energized.
- Rear axle pivots slowly.

Figure 9–26. Final positioning mode hydraulic circuit.

Locked Mode
(Fig. 9–27)

• Rod Oil OUT

Conditions: Boom angle is above 40°, park brake ON, or service brake applied, or travel select lever in neutral.

In the locked mode, oil is prevented from flowing through the stabilizer valve block because of check valves that stop the flow of oil.

• Base Oil OUT

Conditions: Boom angle is above 40°, park brake ON, or service brake applied, or travel select lever in NEUTRAL (N).

In the locked mode, oil is prevented from flowing through the stabilizer valve block because of check valves that stop the flow of oil.

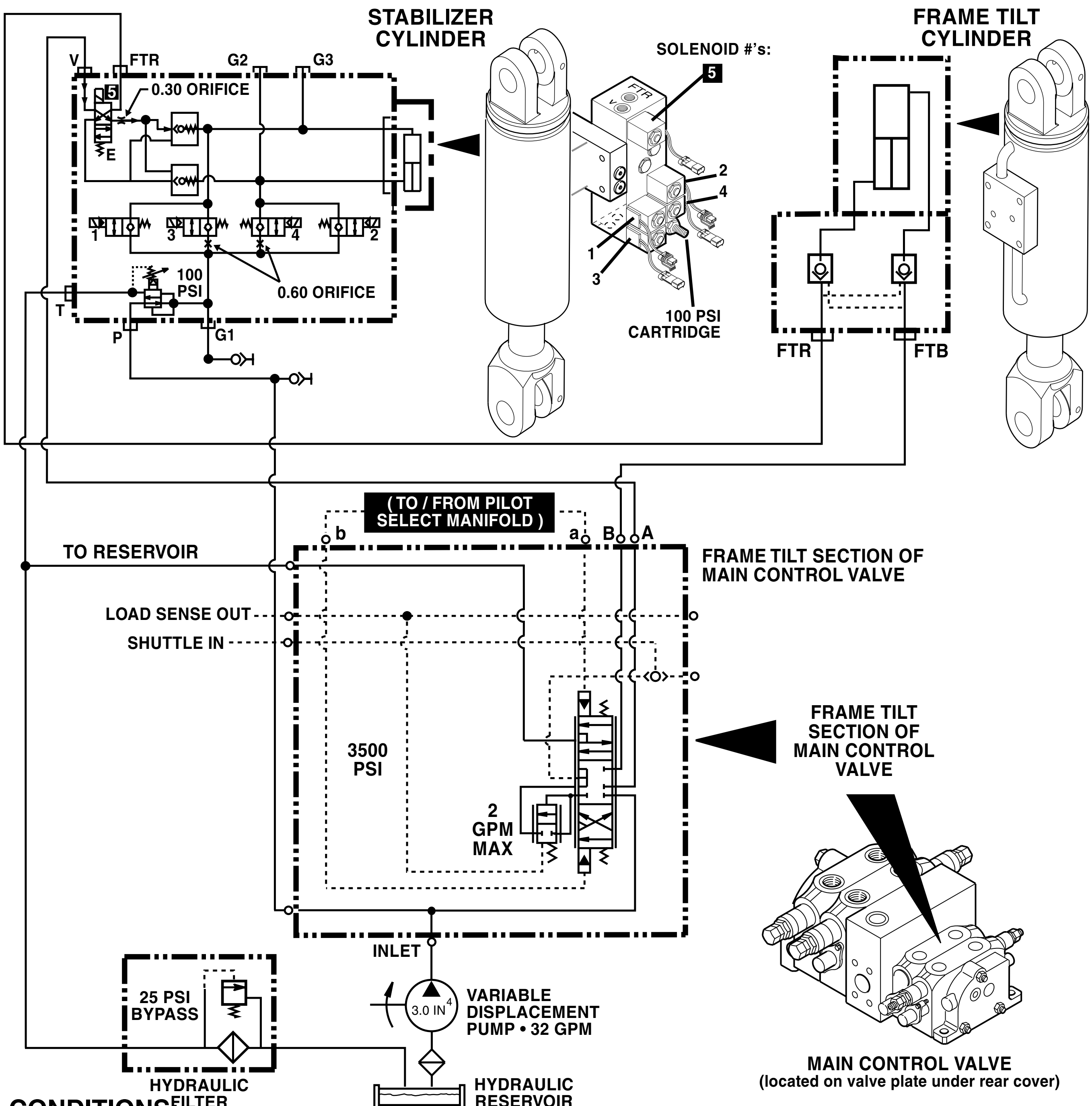
• Frame TILT RIGHT

Oil flows from the spool and is shifted by pilot pressure in the frame tilt section of the main control valve to Stabil-TRAK manifold port V, through solenoid cartridge #5, through a 0.030" orifice, to the base end of the stabilizer cylinder. Rod end oil from the stabilizer cylinder flows through a check valve opened by pilot pressure in the stabilizer manifold. Solenoid #5 is energized, allowing oil to flow through its cartridge valve and to the rod end of the frame tilt cylinder. Oil from the base end of the frame tilt cylinder flows through a piloted-open check valve and back through the frame tilt section of the main control valve, dumping to the reservoir.

• Frame TILT LEFT

Oil flows to the base end of the frame-tilt cylinder. Oil from the rod-end of the frame-tilt cylinder flows through a check valve (which was unseated by pilot pressure), then flows to port FTR on the stabilizer valve block. From there, oil flows through solenoid valve #5, through a passage in the stabilizer valve block, then unseats another check valve, and goes to the rod end of the stabilizer cylinder. Oil from the base end of the stabilizer cylinder flows through a check valve (which was unseated by pilot pressure), through a 0.030" orifice, through solenoid valve #5, to the frame tilt section of the main control valve.

3606 Stabil-TRAK HYDRAULIC CIRCUIT
Locked Mode



CONDITIONS:

- Boom angle is above 40°.
- Park Brake is ON, *or* Service Brake applied, *or* Travel Select Lever in N.

- Boom angle is above 40°.
- Solenoid 5 is energized.
- Rear axle does not pivot.

Figure 9–27. Stabil-TRAK locked mode hydraulic circuit.

9.8.6 Steering Circuit

Vehicle steering modes are two-wheel steer, four wheel steer and crab steer. Fig. 9–35 shows an exploded view of the steering circuit components.

a. Two-wheel Steer

• Left Turn
(Fig. 9–28)

With the steer select switch in the two-wheel steer position, when a left turn is made, system pressure from the auxiliary function manifold is applied through ports E-C of the intake side of the steering unit metering section. A specific amount of hydraulic oil is exhausted from the metering section and routed to the control section, where it is channeled through ports B-A to the left rod end of the front steering cylinder. Return oil from the right side rod end of the front steering cylinder flows through ports P-T of the steer select valve and through ports D-F of the steering control valve, to the reservoir (Fig. 9–30).

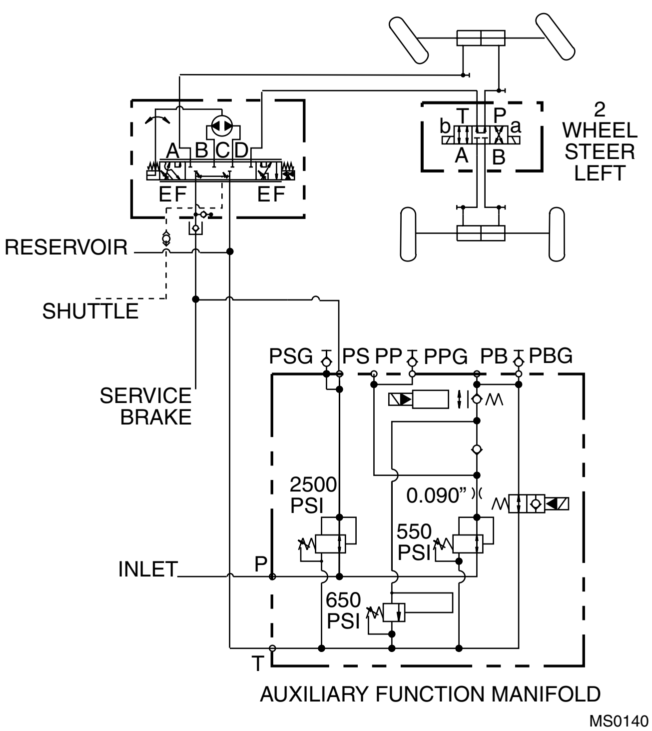


Figure 9–28. Two-wheel steer mode, left turn.

b. Two-wheel Steer

• Right Turn
(Fig. 9–29)

With the steer select switch in the two-wheel steer position, when a right turn is made, the steering control valve spool is shifted so that system pressure is applied through ports E-B of the intake side of the steering unit metering section. A specific amount of hydraulic oil is exhausted from the metering section and routed to the control section, where it is channeled through ports C-D. System oil is routed from port T-P in the steer select valve. Both solenoids in the steer select valve are de-energized. Oil flows to the right side rod end of the front steering cylinder. Oil from the left side rod end of the same cylinder flows to ports A-F in the steering control valve section and then to the reservoir (Fig. 9–30).

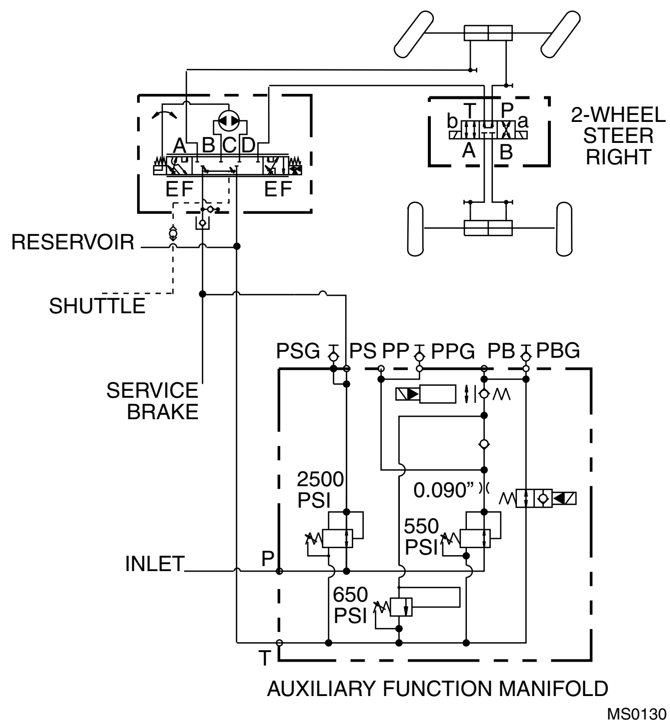


Figure 9–29. Two-wheel steer mode, right turn.

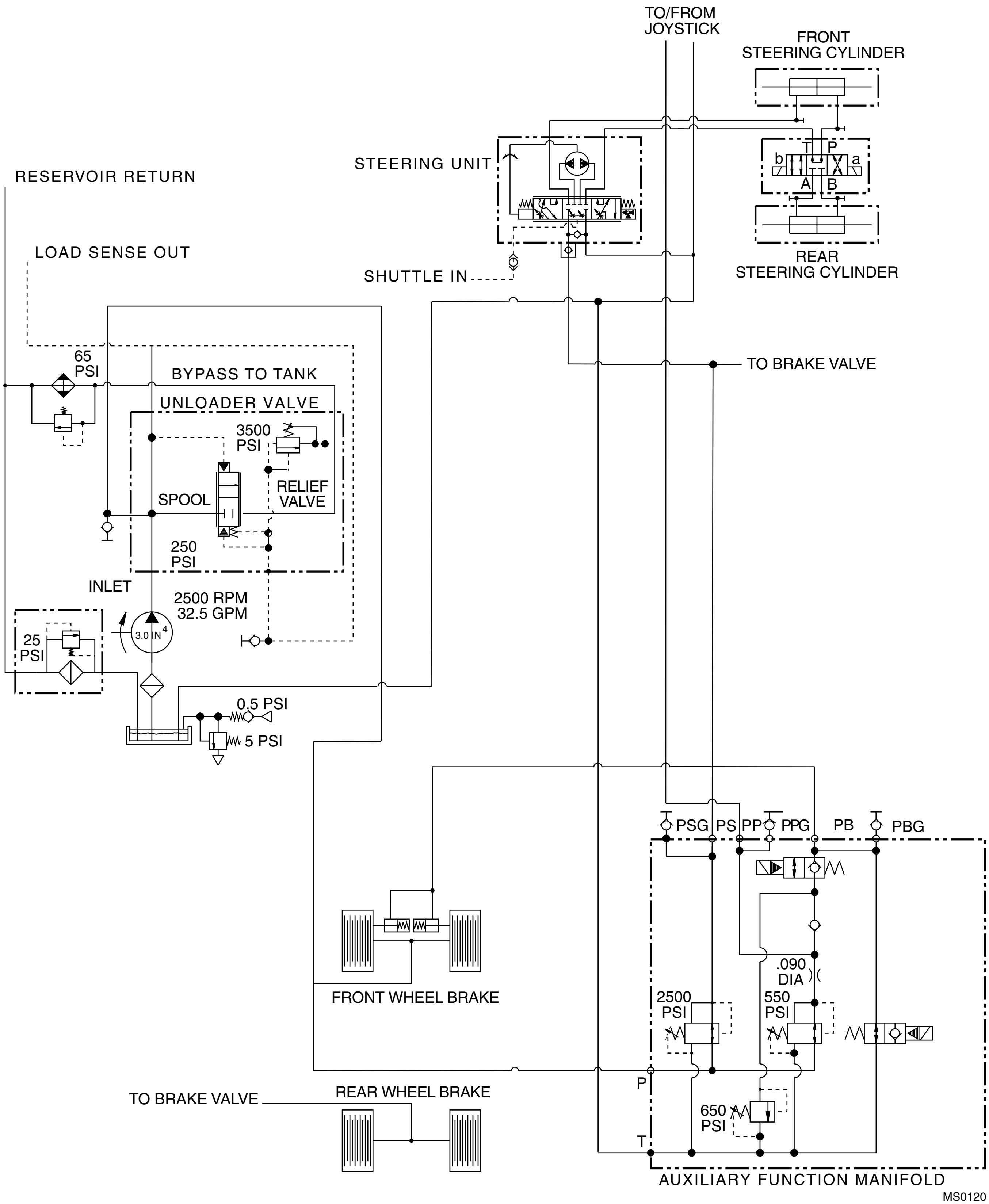


Figure 9–30. Steering hydraulic circuit schematic.

c. Four-wheel Steer

• Left Turn
(Fig. 9–31)

With the steer select switch in the four-wheel steer position, the steering unit control valve spool is shifted so that the system pressure is applied through ports E-C to the intake side of the power steering unit metering section. A specific amount of hydraulic oil is exhausted from the metering section and routed back to the control valve section where it is channeled through ports B-A to the left rod end of the front steering cylinder. Return oil from the right side rod end of the front steering cylinder flows through ports P-A of the steer select valve to the left side rod end of the rear steer cylinder. Oil from the right side rod end of the rear steer cylinder flows through ports B-T in the steer select valve to ports D-F in the steering control valve, then to the reservoir.

• Right Turn
(Fig. 9–32)

With the steer select switch in the four-wheel steer position, the steering unit control valve spool is shifted so that the system pressure is applied through ports E-B to the intake side of the power steering unit metering section. A specific amount of hydraulic oil is exhausted from the metering section and routed back to the control section where it is channeled through ports T-B in the steer select valve; oil flows to the right side rod end of the rear steering cylinder. Oil from the left side rod end of the same cylinder flows through ports A-P in the steer select valve, to the right side rod end of the front steer cylinder. Return oil from the left side rod end of the front steer cylinder flows through ports A-F in the steering control and to the reservoir.

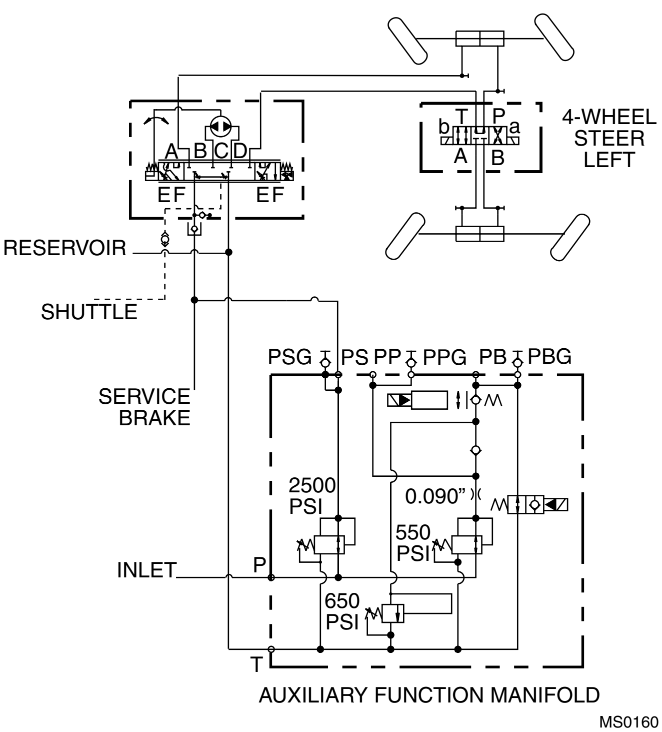


Figure 9–31. Four-wheel steer mode, left turn.

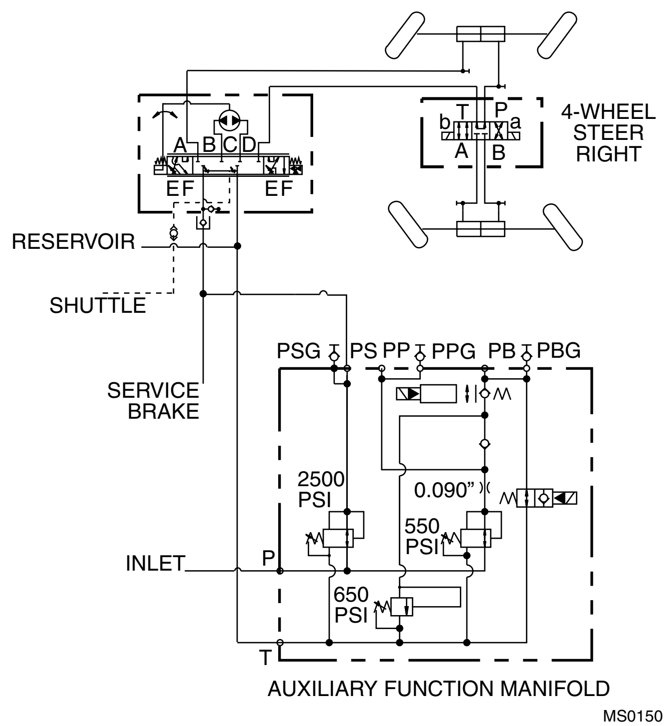


Figure 9–32. Four-wheel steer mode, right turn.

d. Crab Steer

• Left Turn
(Fig. 9–33)

With the steer select switch in the crab steer position, the steering control valve spool is shifted so that system pressure is applied through ports E-C to the intake side of the steering unit metering section. A specific amount of hydraulic oil is exhausted from the metering section and routed back to the control valve section where it is channeled through ports B-A to the left rod end side of the front steer cylinder. The steer select valve solenoid is energized and shifts the valve spool. Oil from the right side rod end of the front steer cylinder is channeled through ports P-B of the steer select valve to the right side rod end of the rear steer cylinder. Oil from the left side rod end of the rear steer cylinder flows through ports A-T of the steer select valve to ports D-F in the steering control valve, then to the reservoir.

• Right Turn
(Fig. 9–34)

With the steer select switch in the crab steer position, the steering control valve spool is shifted so that system pressure is applied through ports E-B to the intake side of the steering unit metering section. A specific amount of hydraulic oil is exhausted from the metering section and routed back to the control section where it is channeled through ports C-D. The steer select valve solenoid is energized and shifts the valve spool. Oil is channeled through ports T-A in the steer select valve then flows to the left side rod end of the rear steer cylinder. Oil from the right side rod end of the same cylinder flows through ports B-P in the steer select valve to the right side rod end of the front steer cylinder. Return oil from the left side rod end of the front steer cylinder flows to ports A-F in the steering control valve and to the reservoir.

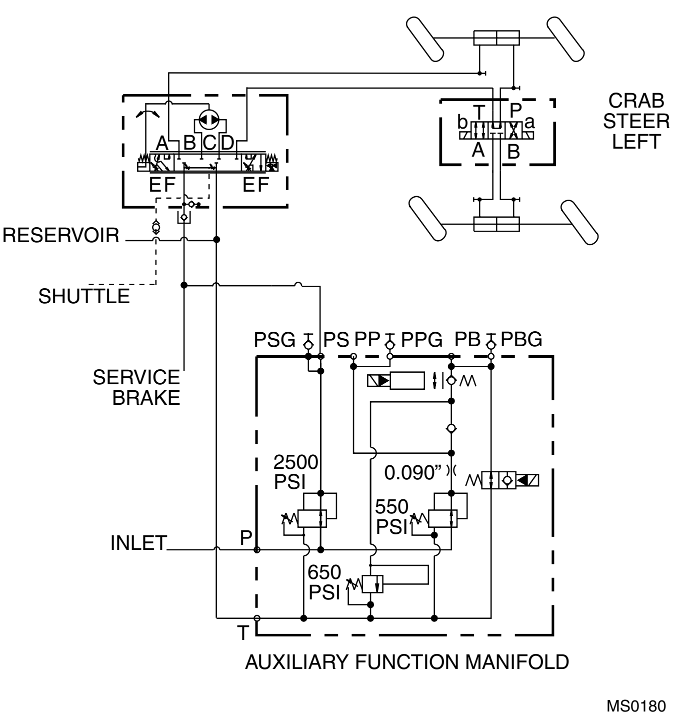


Figure 9–33. Crab steer mode, left turn.

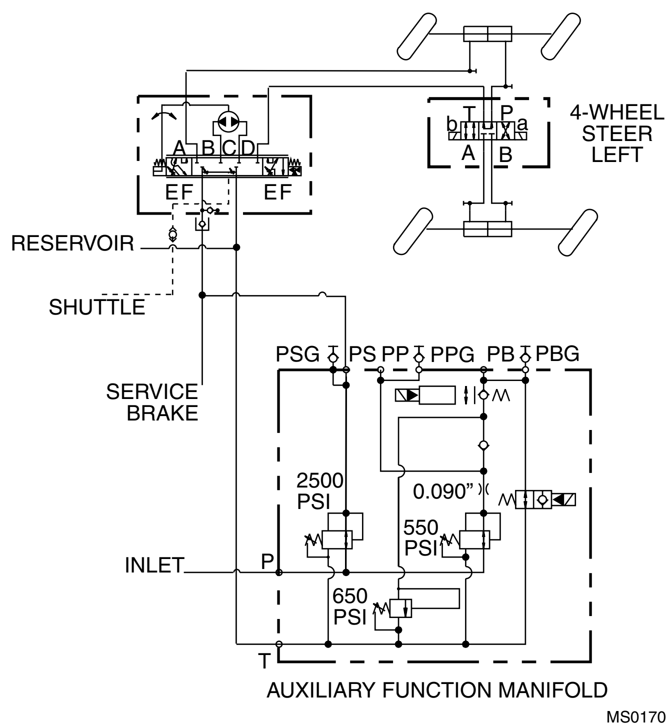


Figure 9–34. Crab steer mode, right turn.

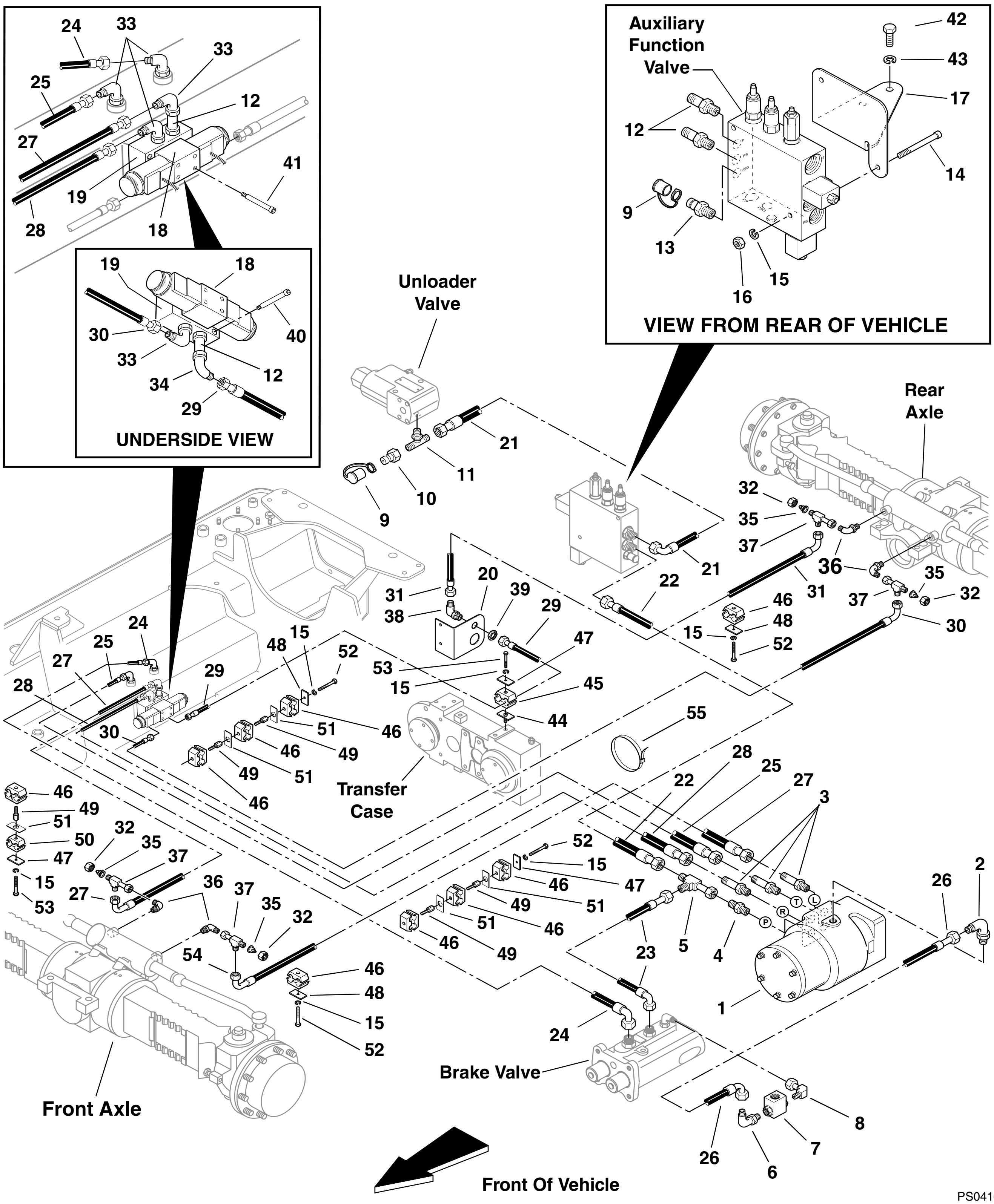


Figure 9–35. Steering circuit.

Steering Circuit Legend

1. Steering Unit
2. 90° Elbow, SAE 6-4 - str. thd. ORB x o-ring face seal
3. Long Connector, SAE 8 - str. thd. ORB x o-ring face seal
4. Check Valve 8-8
5. Swivel Run Tee, SAE 6 - o-ring face seal
6. 90° Elbow, SAE 6 - str. thd. ORB x o-ring face seal
7. Shuttle Valve
8. 90° Elbow, SAE 6 - str. thd. ORB x o-ring face seal swivel
9. Dust Plug
10. Diagnostic Nipple
11. Branch Tee, SAE 8 - str. thd. ORB x o-ring face seal
12. Connector, SAE 8 - str. thd. ORB x o-ring face seal
13. Diagnostic Nipple, 9/16-18
14. Hex-head Capscrew, 5/16-18 x 2-1/2"
15. Lockwasher, 5/16"
16. Hex Nut, 5/16-18
17. Auxiliary Valve Mounting Bracket
18. Steer Select Valve
19. Steer Select Manifold
20. Bulkhead Fittings Bracket
21. Hose, 1/2" I.D. x 28.3"
22. Hose, 1/2" I.D. x 84"
23. Hose, 1/2" I.D. x 14"
24. Hose, 1/2" I.D. x 98"
25. Hose, 1/2" I.D. x 87"
26. Hose, 3/8" I.D. x 13"
27. Hose, 1/2" I.D. x 76-1/2"
28. Hose, 1/2" I.D. x 78"
29. Hose, 1/2" I.D. x 42"
30. Hose, 1/2" I.D. x 112"
31. Hose, 1/2" I.D. x 30"
32. Nut, SAE 8
33. 90° Elbow, SAE 8 - str. thd. ORB x o-ring face seal
34. 90° Swivel Elbow, SAE 8 - o-ring face seal
35. Bleed Adapter Cap, 8 - o-ring face seal
36. 90° Elbow, M18-8 - metric str. thd. ORB x o-ring face seal
37. Swivel Run Tee, SAE 8 - o-ring face seal
38. 90° Bulkhead Elbow, SAE 8 - o-ring face seal
39. Bulkhead Nut, SAE 8 - o-ring face seal
40. Socket-head Capscrew, 5/16-18 x 1-1/8"
41. Socket-head Capscrew, #10-24 x 1-1/8"
42. Hex-head Capscrew, M14-2,0 x 20mm
43. Lockwasher, M14
44. Clamp Base
45. Twin Hose Clamp Set, 0.62" I.D.
46. Twin Hose Clamp Set, 0.78" I.D.
47. Twin Weld Cover
48. Twin Weld Cover
49. Stacking Bolt, 1-1/8"
50. Twin Hose Clamp Set, 0.68" I.D.
51. Locking Plate
52. Hex-head Capscrew, 5/16-18 x 2"
53. Hex-head Capscrew, 5/16-18 x 1-1/2" Gr. 8
54. Hose, 1/2" I.D. x 74"
55. Tie Wrap

9.8.7 Attachment Tilt and Slave Cylinder Circuit

The attachment tilt functions are dependent on the position of the attachment tilt mode switch (Fig. 9–36 and Fig. 9–37) and can be achieved by pressing and holding the button on the top right of the joystick. Moving the joystick backward controls attachment tilt UP. Moving the joystick forward controls attachment tilt DOWN.

Flow is directed to either side of the attachment tilt and slave cylinder pistons by shifting of the spool valve (Fig. 9–39) in the attachment tilt section of the main control valve assembly. The spool valve is shifted by pilot pressure, actuated by joystick control and electrical solenoids.

System pressure is applied in the attachment tilt and slave cylinder circuit (Fig. 9–38 and Fig. 9–40) from the attachment tilt section of the main control valve.

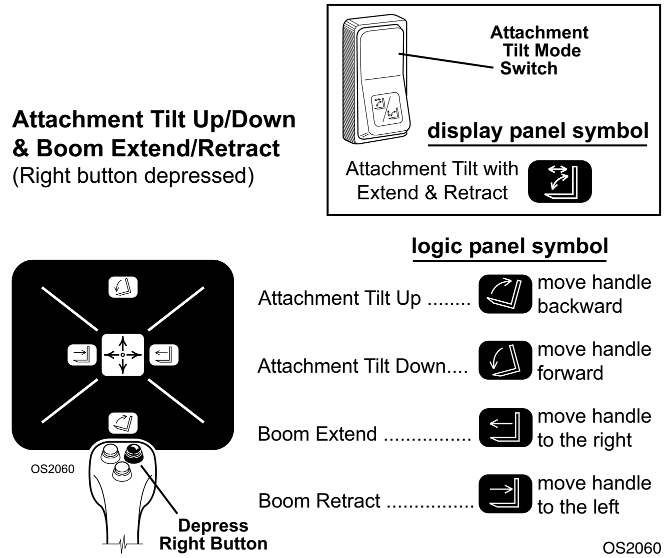


Figure 9–36. Control positions for attachment tilt up/down and boom extend/retract.

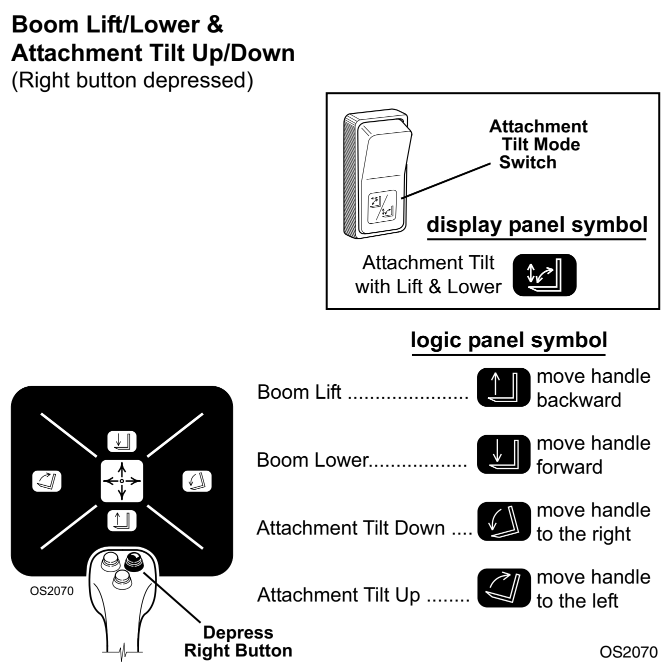


Figure 9–37. Control positions for boom lift/lower and attachment tilt up/down.

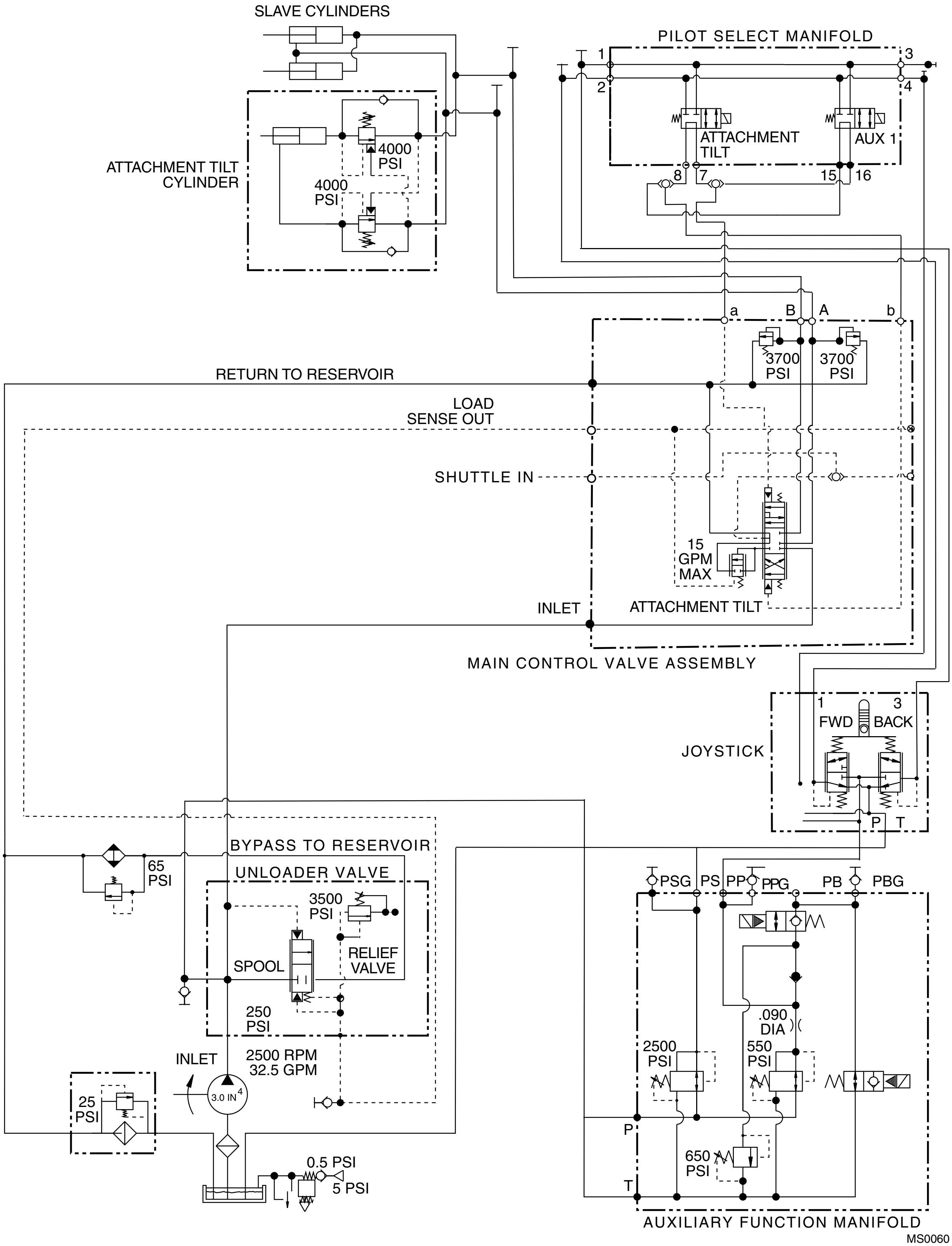


Figure 9–38. Attachment tilt/slave cylinder schematic.

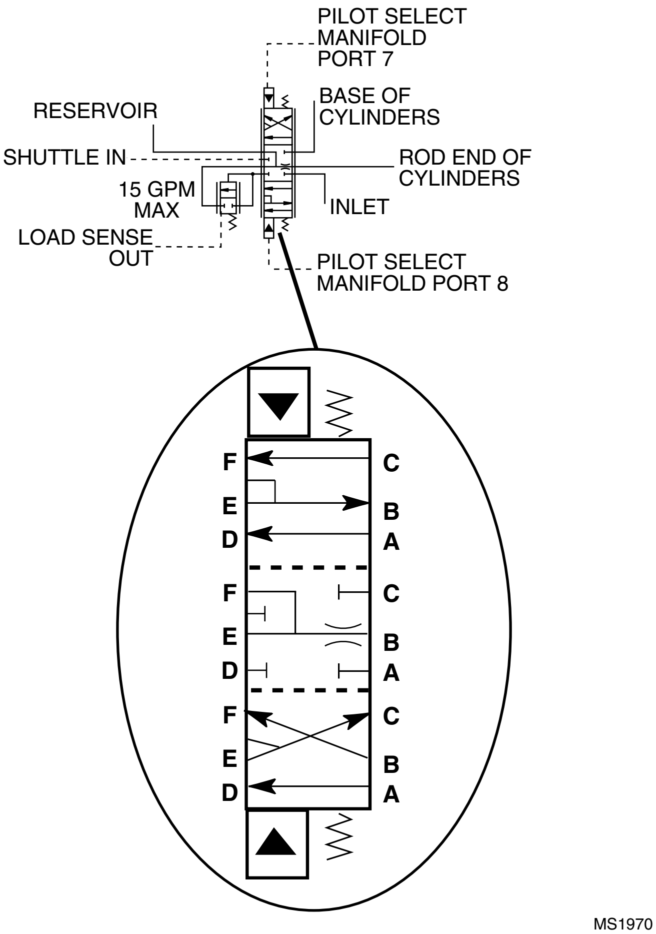


Figure 9–39. Attachment tilt spool valve circuit.

a. Center Position

When the joystick is in the center or neutral position, the attachment tilt spool valve (Fig. 9–39) in the directional control valve is positioned to prevent flow to any of the working ports.

b. UP Position

With the right button depressed and held on the joystick, and the joystick moved to the left, the attachment tilt spool valve (Fig. 9–39) in the directional control valve is shifted so system pressure is directed to ports A-D, through ports B-F to the base end of the attachment tilt cylinder and slave cylinders. The extension of the slave cylinders is fixed by the position of the boom so that only the attachment tilt cylinder is extended to tilt the attachment upward.

If system pressure reaches 3500 ± 50 psi (241,5 ± 3,5 bar) the main relief will open, allowing hydraulic oil to flow to the return filter and to the reservoir. If the return filter becomes restricted, hydraulic oil will bypass the filter when the pressure reaches 25 psi (1,7 bar).

Return oil from the rod side of the attachment tilt cylinder is directed back to the attachment tilt section of the main control valve through ports E-C of the spool valve, to the return filter and to the reservoir. If the return filter becomes restricted, hydraulic oil will bypass the filter when the pressure reaches 25 psi (1,7 bar).

c. DOWN Position

With the right button depressed and held on the joystick, and the joystick moved to the right, the attachment tilt spool valve (Fig. 9–39) in the directional control valve is shifted so system pressure is directed to ports A-D, through ports E-B to the rod end of the attachment tilt cylinder and the slave cylinders. The extension of the slave cylinders is fixed by the position of the boom so that only the attachment tilt cylinder is retracted to tilt the attachment downward. This system pressure also pilots open the counterbalance valve. The open counterbalance valve allows return oil from the base of the attachment tilt cylinder to flow to ports C-F of the attachment tilt section of the main control valve, to the return filter and ultimately to the reservoir. If system pressure reaches 3500 ± 50 psi (241,5 ± 3,5 bar) the main relief will open and allow hydraulic oil to return to the return filter and to the reservoir. In any case, if the return filter becomes restricted, hydraulic oil will bypass the filter when the pressure reaches 25 psi (1,7 bar).

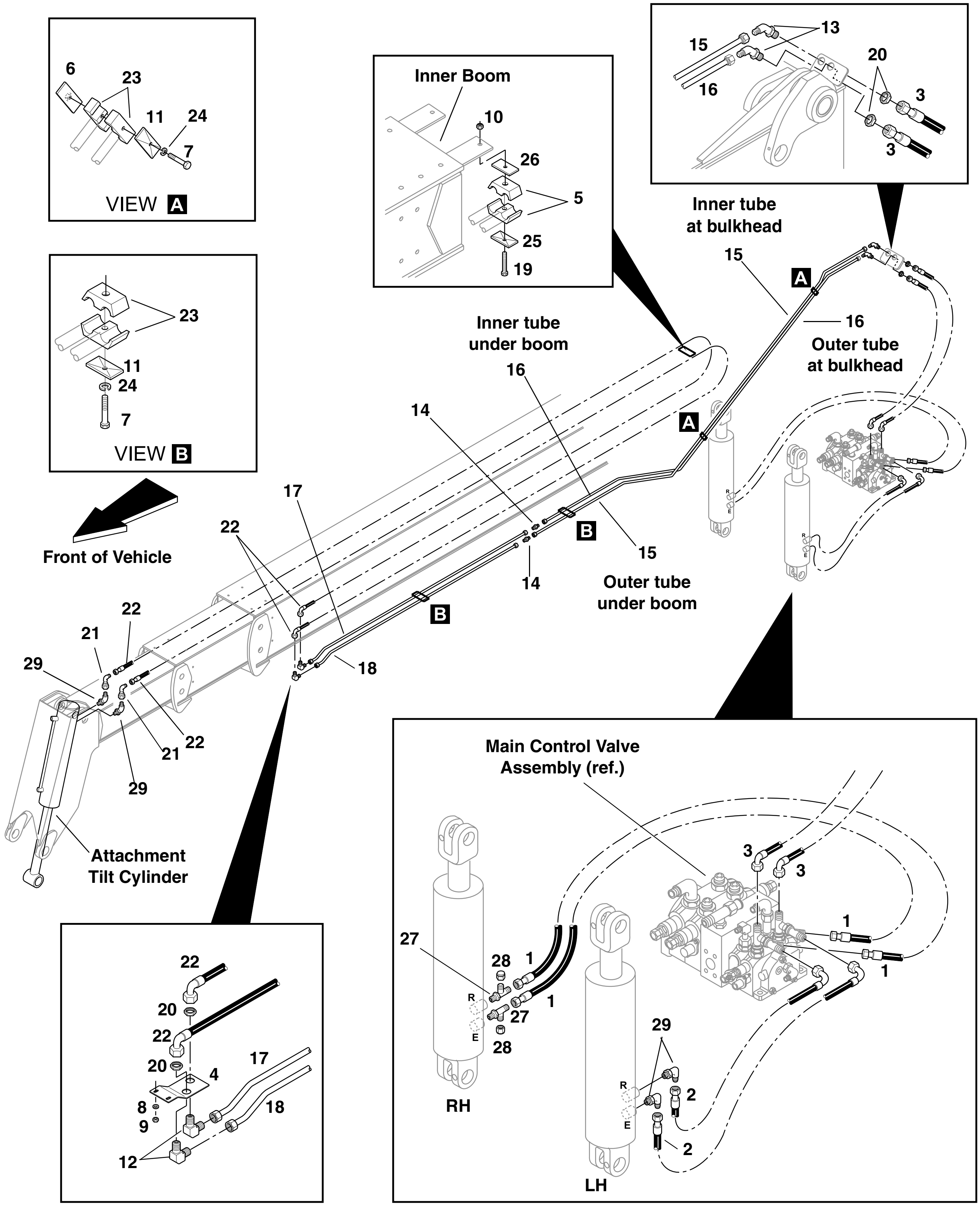


Figure 9–40. Attachment tilt/slave cylinder circuit.

Attachment Tilt/Slave Cylinder Legend

1. Hose, 1/2” I.D. x 33-1/2”
2. Hose, 1/2” I.D. x 16”
3. Hose, 1/2” I.D. x 39”
4. Bulkhead Fitting Support
5. Twin Hose Clamp Set, 0.78” I.D.
6. Twin Welding Plate
7. Hex-head Capscrew, 5/16-18 x 1-1/2”
8. Plain Washer, 1/4”
9. Hex-lock Nut, 1/4-20
10. Hex-lock Nut, 5/16-18
11. Cover Plate
12. 90° Bulkhead Elbow, SAE 10 - O-Ring Face Seal
13. 45° Bulkhead Elbow, SAE 10 - O-Ring Face Seal
14. Union Connector, SAE 10 - O-Ring Face Seal
15. Attachment Tilt Retract Tube Assembly
16. Attachment Tilt Extend Tube Assembly
17. Tube Assembly
18. Tube Assembly
19. Grade 5 Fully-threaded Tap Bolt, 5/16-18 x 2-1/2”
20. Bulkhead Nut, SAE 10 - O-Ring Face Seal
21. 90° Swivel Elbow, SAE 8 - O-Ring Face Seal
22. Hose, 1/2” I.D. x 321”
23. Twin Hose Clamp Set, 0.62” I.D.
24. Lockwasher, 5/16”
25. Cover Plate
26. Twin Welding Plate
27. Male Run Tee, SAE 8 - ORFS Tube End x Str. Thd. O-Ring
28. Cap, SAE 8 - O-Ring Face Seal
29. 90° Elbow, SAE 8 - Str. Thd. ORB x O-Ring Face Seal

9.8.8 Joystick Circuit

Joystick hydraulic circuit (Fig. 9–43) commands are achieved through electric and hydraulic signals via a set of cartridge-type, solenoid-operated control valves mounted in an array at the pilot select manifold (Fig. 9–42).

The cartridge valves shift to allow hydraulic oil to flow to the proper circuit as commanded by joystick position. Hydraulic oil flows from the joystick valve to the pilot select manifold (Fig. 9–41), then to the appropriate working section of the main control valve.

The valve plate assembly is provided in either standard (Fig. 9–44) or optional auxiliary hydraulics (Fig. 9–45) configurations. The valve plate assembly includes the pilot select manifold and the main control valve.

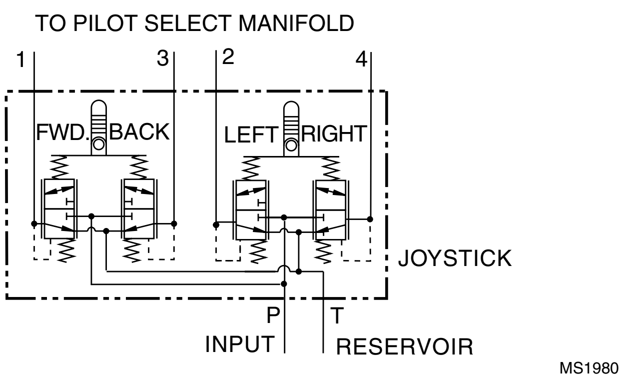


Figure 9–41. Joystick hydraulic circuit schematic.

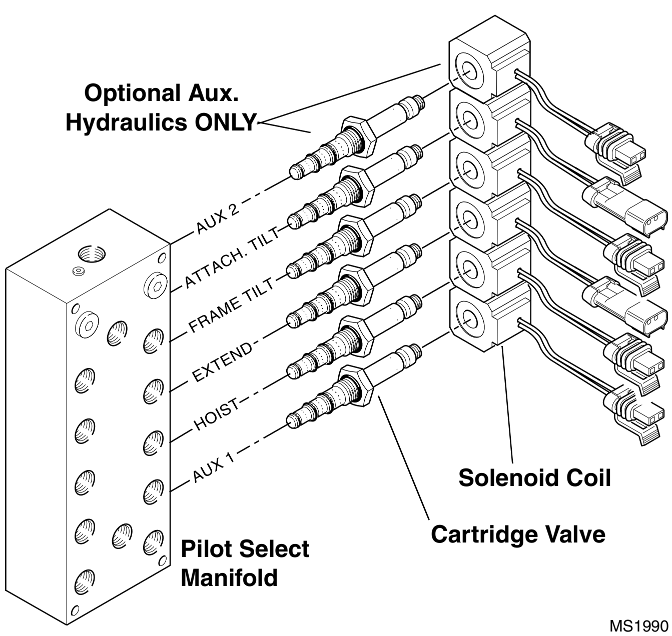


Figure 9–42. Pilot select manifold.

Joystick Circuit Legend

1. Joystick Valve
2. Connector, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
3. Long Connector, SAE 6
4. Hose, 3/8” I.D. x 67”
5. Hose, 3/8” I.D. x 120-1/2”
6. Hose, 3/8” I.D. x 116”
7. Swivel Run Tee, SAE 6 - O-Ring Face Seal
8. Cap, SAE 6 - O-Ring Face Seal
9. Branch Tee, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
10. 90° Elbow, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
11. 90° Elbow, SAE 6-8 - Str. Thd. ORB x O-Ring Face Seal

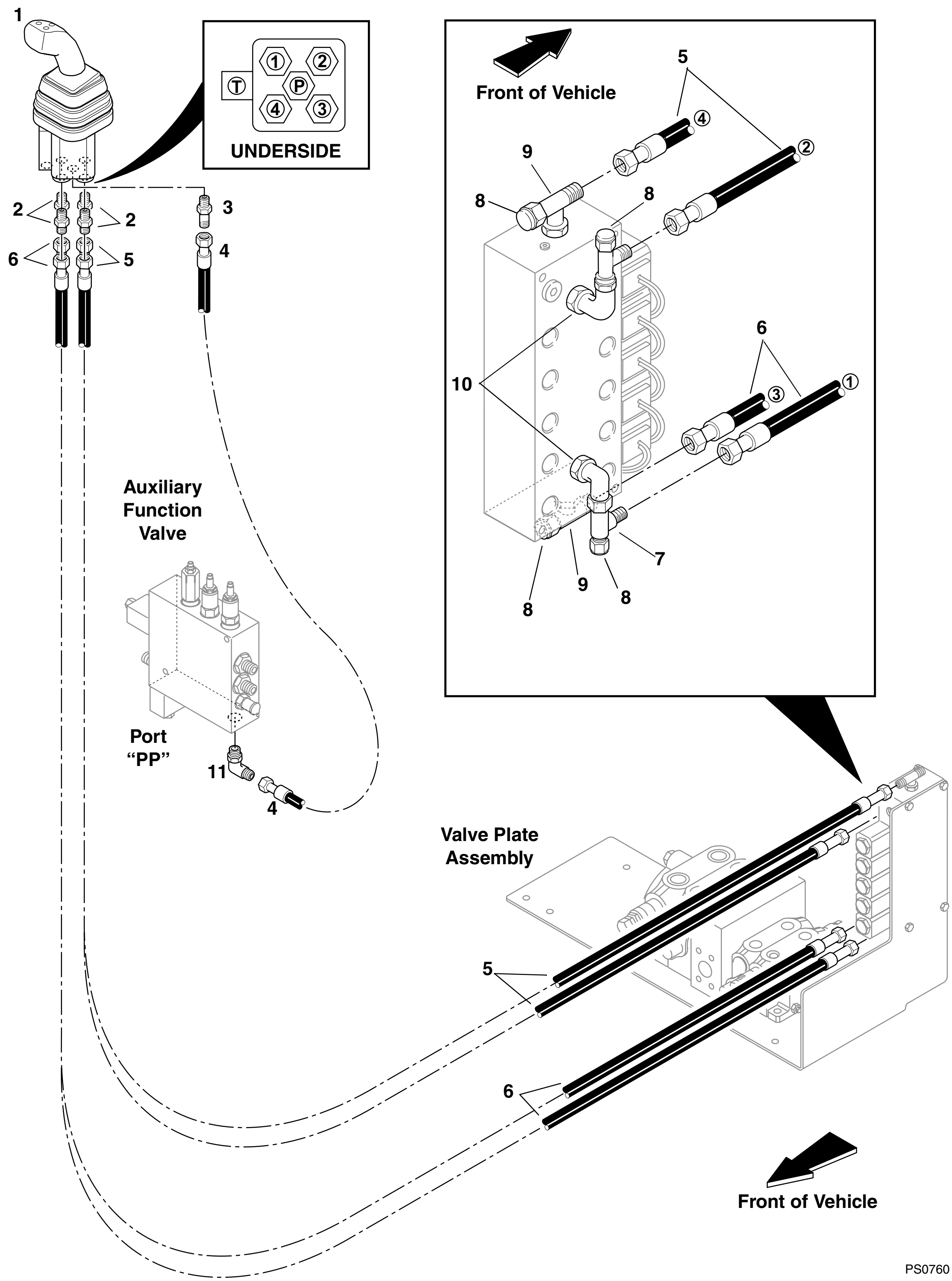


Figure 9–43. Joystick circuit.

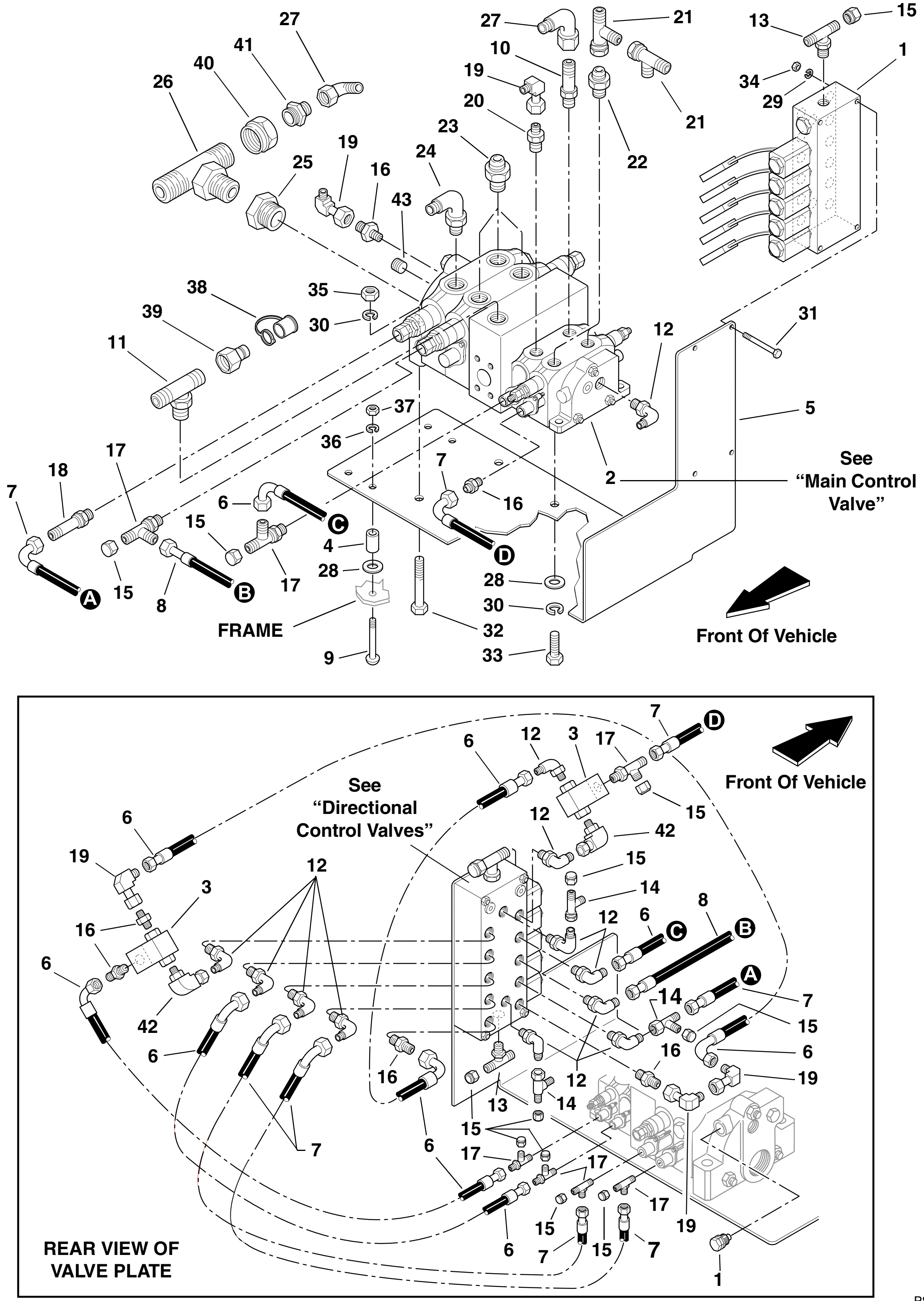


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Figure 9–44. Valve plate assembly (without auxiliary hydraulics).

Valve Plate Assembly Legend (without auxiliary hydraulics)

1. Pilot Select Manifold
2. Main Control Valve
3. Shuttle Valve
4. Spacer
5. Main Valve Bracket
6. Hose, 3/8" I.D. x 18"
7. Hose, 3/8" I.D. x 19.3"
8. Hose, 3/8" I.D. x 20"
9. Carriage Bolt, 3/8-16 x 2-1/4"
10. Long Connector, SAE 8 - Str. Thd. ORB x O-Ring Face Seal
11. Branch Tee, SAE 8 - Str. Thd. ORB x O-Ring Face Seal
12. 90° Elbow, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
13. Branch Tee, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
14. Swivel Run Tee, SAE 6 - O-Ring Face Seal
15. Cap, SAE 6 - O-Ring Face Seal
16. Connector, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
17. Male Run Tee, SAE 6 - ORFS Tube End x Str. Thd. O-Ring
18. Long Connector, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
19. 90° Swivel Elbow, SAE 6 - O-Ring Face Seal
20. Connector, SAE 6-8 - Str. Thd. ORB x O-Ring Face Seal
21. Swivel Run Tee, SAE 8 - O-Ring Face Seal
22. Connector, SAE 8 - Str. Thd. ORB x O-Ring Face Seal
23. Connector, SAE 12 - Str. Thd. ORB x O-Ring Face Seal
24. 90° Elbow, SAE 12 - Str. Thd. ORB x O-Ring Face Seal
25. Connector, SAE 16-12 - Str. Thd. ORB x O-Ring Face Seal
26. Swivel Branch Tee, SAE 16 - O-Ring Face Seal
27. 90° Swivel Elbow, SAE 8 - O-Ring Face Seal
28. Washer, Plain 1/2"
29. Lockwasher, 1/4"
30. Lockwasher, 1/2"
31. Hex-head Capscrew, 1/4-20 x 2-1/2" Gr. 5
32. Hex-head Capscrew, 1/2-13 x 3-1/2" Gr. 5
33. Hex-head Capscrew, 1/2-13 x 1" Gr. 5
34. Hex Nut, 1/4-20
35. Hex Nut, 1/2-13
36. Lockwasher, 3/8"
37. Hex Nut, 3/8-16
38. Dust Plug
39. Diagnostic Nipple
40. Tube Nut, SAE 16 - O-Ring Face Seal
41. Reducer, SAE 16 - O-Ring Face Seal x SAE 8 - O-Ring Face Seal
42. 90° Swivel Elbow, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
43. Hex-head Plug, SAE 6 - Male Str. Thd. O-Ring
44. Shut-off Plug

NOTE:
The Auxiliary Hydraulic System is an option that consists of the parts shown on this page PLUS the parts shown on the "Valve plate assembly without auxiliary hydraulics"

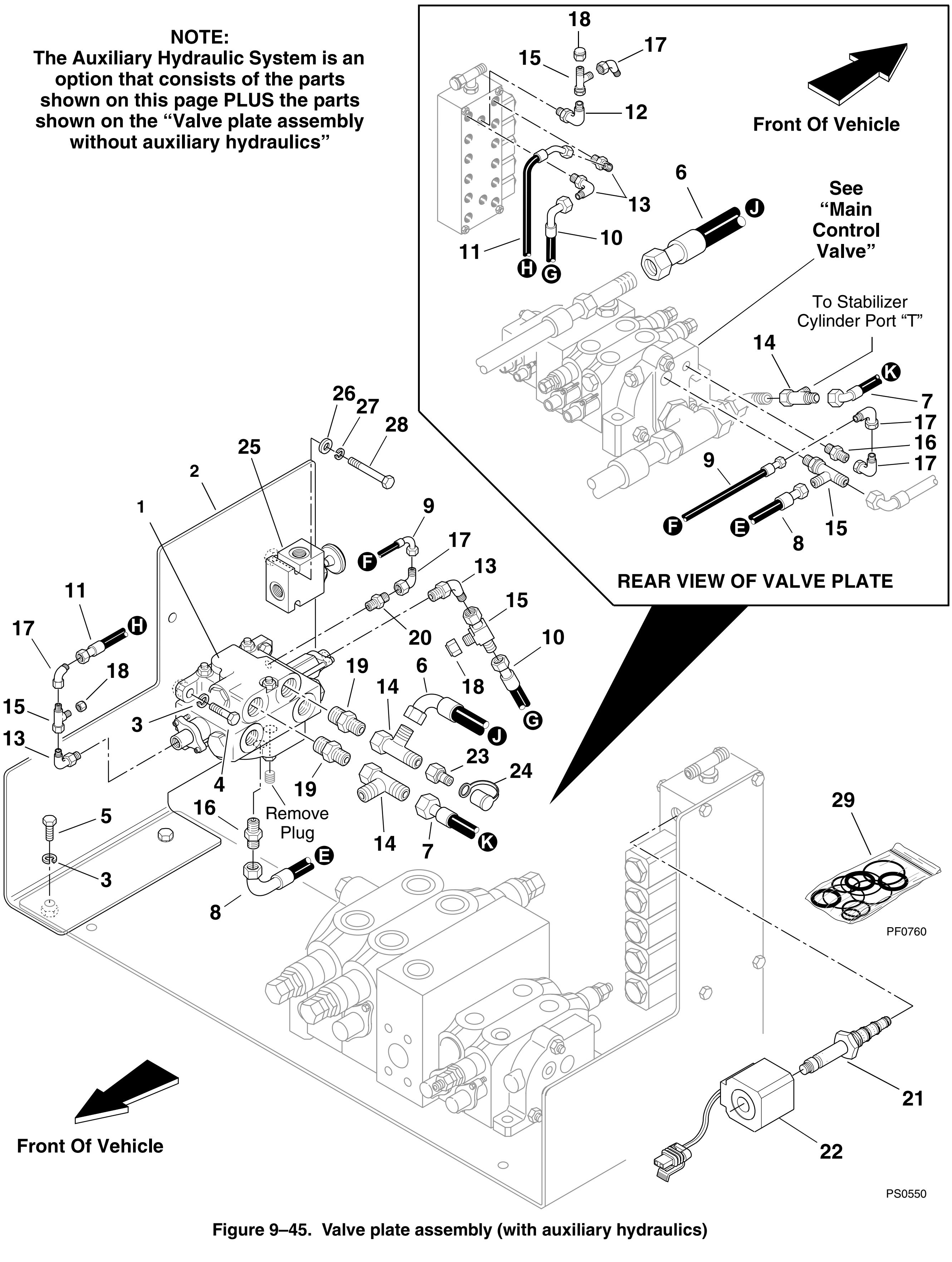


Figure 9–45. Valve plate assembly (with auxiliary hydraulics)

Valve Plate Assembly Legend (with auxiliary hydraulics)

1. Auxiliary Control Valve
2. Auxiliary Control Valve Mounting Bracket
3. Lockwasher, 3/8"
4. Hex-head Capscrew, 3/8-16 x 1-1/4"
5. Hex-head Capscrew, 3/8-16 x 3/4" Gr. 5
6. Hose, 1/2" ID x 21"
7. Hose, 1/2" ID x 26"
8. Hose, 3/8" ID x 21-1/2"
9. Hose, 3/8" ID x 10-1/2"
10. Hose, 3/8" ID x 26"
11. Hose, 3/8" ID x 41"
12. Modified 90° Elbow, SAE 6, Str. Thd. ORB x O-Ring Face Seal
13. 90° Elbow, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
14. Swivel Run Tee, SAE 8 - O-Ring Face Seal
15. Swivel Run Tee, SAE 6 - O-Ring Face Seal
16. Connector, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
17. 90° Swivel Elbow, SAE 6 - O-Ring Face Seal
18. Cap, SAE 6 - O-Ring Face Seal
19. Connector, SAE 8-10 - Str. Thd. ORB x O-Ring Face Seal
20. Union Connector, SAE 6-4, O-Ring Face Seal x O-Ring Face Seal
21. Solenoid Valve (service with Kit, Item 29)
22. Coil w/Female Pins
23. Diagnostic Nipple
24. Dust Plug
25. Manually Operated Relief Valve
26. Plain Washer, 1/4"
27. Lockwasher, 1/4"
28. Hex-head Capscrew, 1/4-20 x 2"
29. Kit, Valve Seal

9.8.9 Auxiliary Hydraulics Circuit (***optional***)

The optional auxiliary hydraulic circuit (Fig. 9–47 and Fig. 9–48) functions can be achieved by pressing and holding the center button on the joystick. Moving the joystick to the left controls auxiliary function in one direction, usually forward, if the auxiliary device is so designed. Moving the joystick to the right controls auxiliary functions in reverse, or the opposite direction.

With the center button on the joystick pressed and held, and the joystick moved to the left, pilot pressure will shift the auxiliary spool valve, allowing oil to flow from the auxiliary spool valve to the male connection of the auxiliary hydraulic coupler. From the coupler, oil flows to the attachment, back to the female auxiliary coupler, and to the auxiliary spool valve, then to the return oil filter and reservoir.

With the center button depressed and held on the joystick, and the joystick moved to the right, pilot pressure will shift the auxiliary spool valve, allowing system pressure to flow from the auxiliary spool valve to the female connection of the auxiliary hydraulic coupler. From the coupler, oil flows to the attachment, back to the male auxiliary coupler, and to the auxiliary spool valve, then to the return oil filter and reservoir.

Manually Operated Pressure Relief Valve

The optional auxiliary hydraulic circuit contains a manually operated pressure relief valve (Fig. 9–46) to facilitate attaching or detaching the couplers. The purpose of this pressure relief is to relieve residual pressure trapped in the auxiliary hydraulic system. Pulling the knob releases pressure in the auxiliary hydraulic circuit. The valve is spring-loaded, and the knob will return to its original position after being pulled.

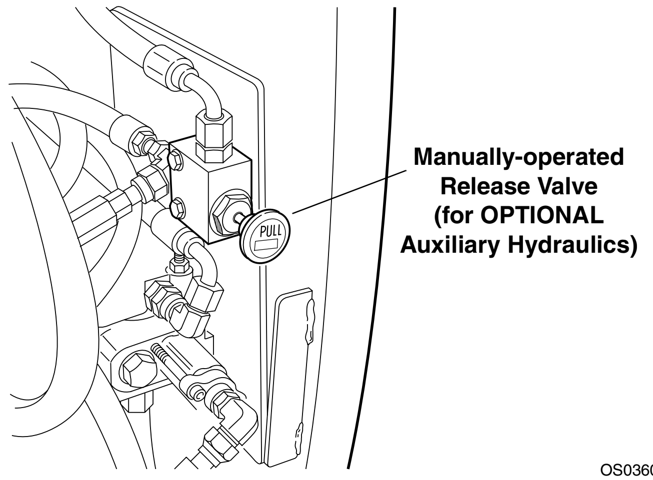


Figure 9–46. The manually-operated release valve, located at the rear of the frame, is part of the *optional* auxiliary hydraulic system.

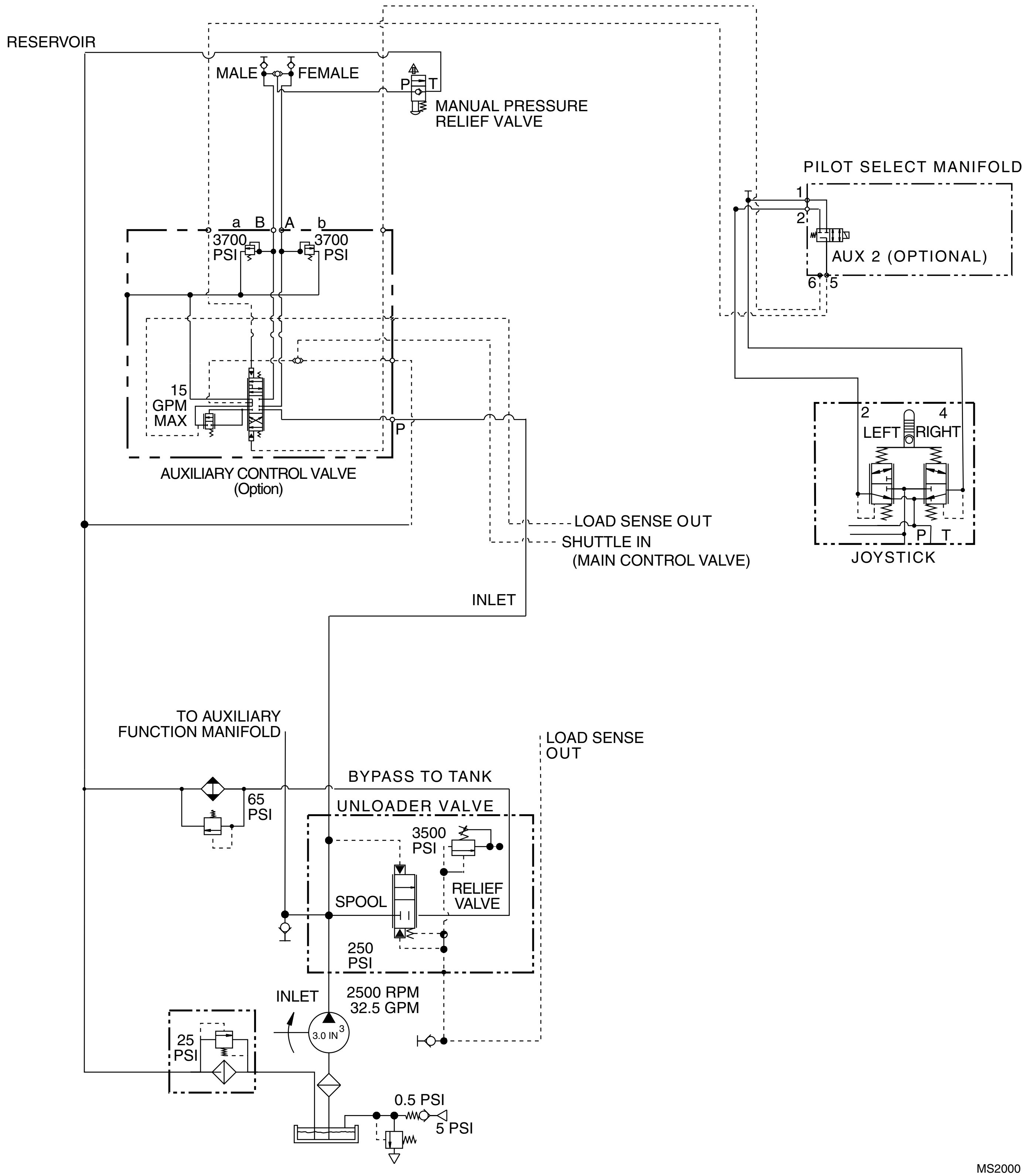


Figure 9–47. Optional auxiliary hydraulic schematic.

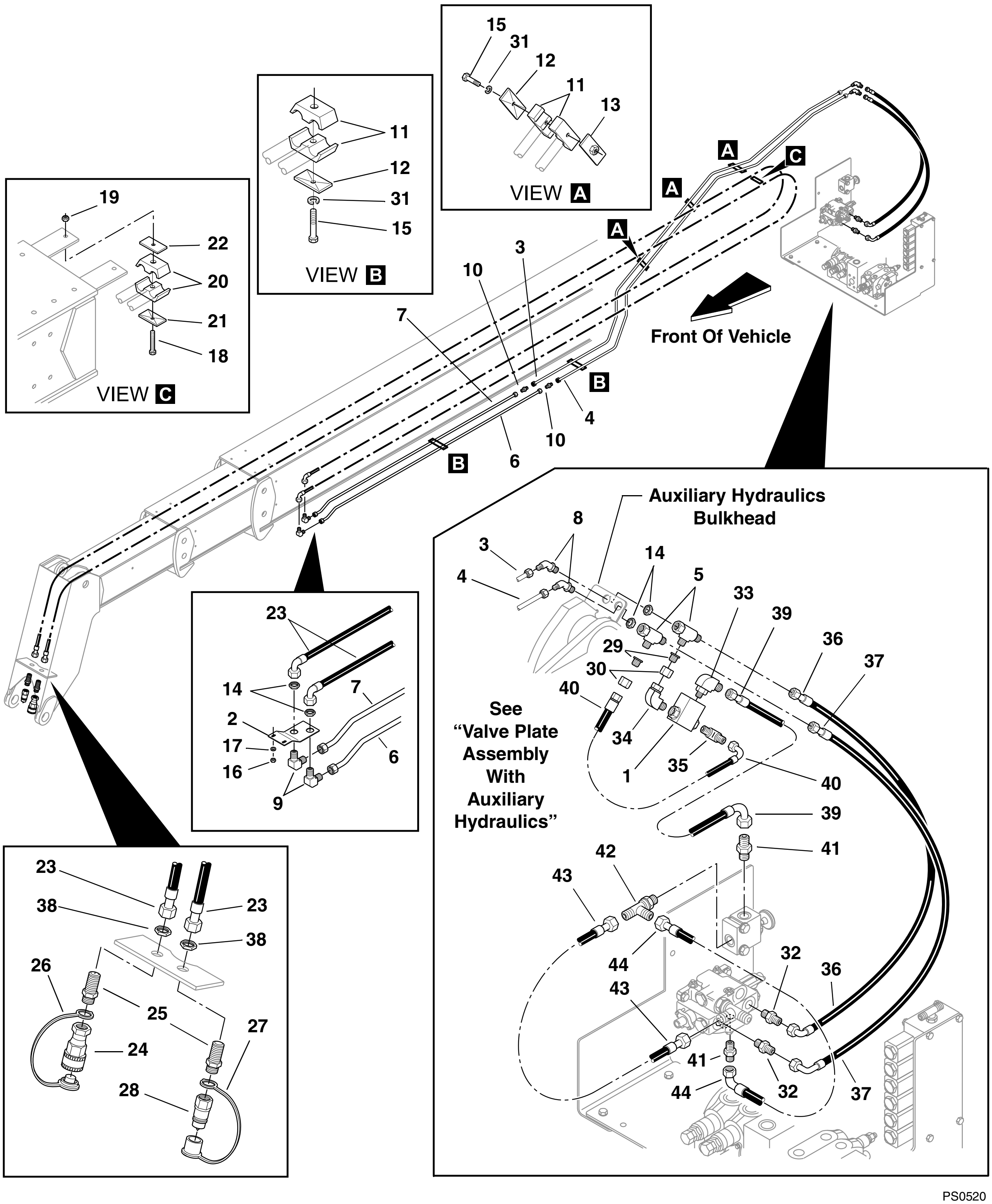


Figure 9–48. Optional auxiliary hydraulic circuit.

Auxiliary Hydraulics Legend

1. Shuttle Valve
2. Bulkhead Fitting Support Bracket
3. Tube Assembly, Outer-Aux. Hydraulics (Rear)
4. Tube Assembly, Inner-Aux. Hydraulics (Rear)
5. Swivel Run Tee, #10
6. Tube Assembly, Inside-Aux. Hydraulics (Front)
7. Tube Assembly, Outside-Aux. Hydraulics (Front)
8. 45° Bulkhead Elbow, SAE 10 - O-Ring Face Seal
9. 90° Bulkhead Elbow, SAE 10 - O-Ring Face Seal
10. Connector, Union, SAE 10 - O-Ring Face Seal
11. Twin Hose Clamp Set, 0.62"
12. Cover Plate
13. Twin Weld Plate
14. Bulkhead Nut, SAE 10 - O-Ring Face Seal
15. Hex-head Capscrew, 5/16-18 x 1-1/2"
16. Hex-lock Elastic Nut, 1/4-20
17. Plain Washer, 1/4"
18. Hex-head Tap Bolt, 5/16 x 2-1/2" Gr. 5
19. Hex-lock Elastic Nut, 5/16-18
20. Twin Hose Clamp Set, 0.78"
21. Cover Plate
22. Twin Welding Plate
23. Hose, 1/2" ID x 340"
24. Female Quick Disconnect, SAE 8-8 ORB - Female Internal
25. Bulkhead Connector, SAE 8 - Str. Thd. ORB x O-Ring Face Seal
26. Dust Plug
27. Dust Cap
28. Male Quick Disconnect, SAE 8-8 ORB - Female Internal
29. Reducer, SAE 10 - O-Ring Face Seal x SAE 6 - O-Ring Face Seal
30. Tube Nut, SAE 10 - O-Ring Face Seal
31. Spring Lockwasher, 5/16"
32. Connector, SAE 8 - Str. Thd. ORB x O-Ring Face Seal
33. 90° Elbow, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
34. 90° Elbow, SAE 6 - Str. Thd. ORB x O-Ring Face Seal swivel
35. 45° Elbow, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
36. Hose, 1/2" ID x 35-1/2"
37. Hose, 1/2" ID x 39"
38. Bulkhead Nut, SAE 8 - O-Ring Face Seal
39. Hose, 3/8" I.D. x 31-1/2"
40. Hose, 3/8" I.D. x 18"
41. Connector, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
42. Male Run Tee, SAE 6 - ORFS tube end x Str. Thd. O-Ring
43. Hose, 3/8" I.D. x 18"
44. Hose, 3/8" I.D. x 22"

9.9 VALVES AND MANIFOLDS

Valves are devices that open or close passageways. Manifolds (derived from the words, "many folds") contain circuit passageways involved in the distribution of hydraulic fluid flowing under pressure. There are various valves and manifolds in use on this vehicle. As valves open and close, hydraulic fluid is directed to flow through various passageways to the prescribed circuit, causing vehicle functions occur.

9.9.1 Unloader Valve

The unloader valve (Fig. 9-49 **)** creates system pressure and distributes the hydraulic fluid for various vehicle functions via its load sense, bypass, primary, and auxiliary supply ports.The unloader valve distributes fluid to the hydraulic system oil cooler (Fig. 9-6) and is secured to the underside of the frame near the transmission.

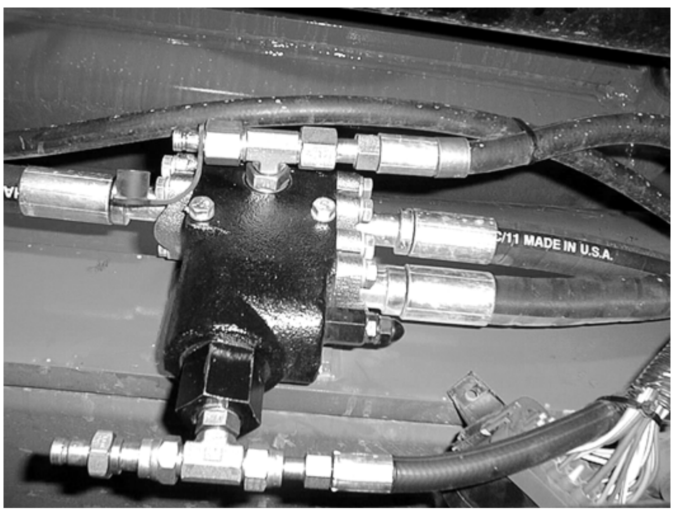


Figure 9-49. The unloader valve is secured to the underside of the frame, located near the transmission.

DO NOT loosen, disassemble or attempt to adjust any of the cartridges unless specifically instructed by Sky Trak to do so! Tampering with the cartridges will irrevocably alter pressure in the affected circuits. A new cartridge will be required to rectify the situation.

a. Unloader Valve Removal

1. Park the vehicle on a firm, level surface, fully retract all hydraulic cylinders, ground the attachment (if any), place the travel select lever in NEUTRAL (N), engage the park brake switch and shut the engine OFF.

WARNING: Hot hydraulic fluid can cause severe burns. Wait for hydraulic fluid to cool before servicing any hydraulic component.

2. Unlatch, unlock and open the engine cover. Allow the hydraulic fluid to cool.

WARNING: Escaping hydraulic fluid under pressure can penetrate the skin, causing serious injury. Relieve hydraulic pressure before servicing any hydraulic component.

3. Label, disconnect and cap the hydraulic lines at the unloader valve.
4. Remove the two 5/16-18 x 3-1/4" hex-head capscrews, two 5/16" lockwashers and two 5/16" SAE washers securing the unloader valve (Fig. 9-49) to the vehicle frame. Remove the valve from the vehicle. Wipe up any spilled hydraulic fluid.

b. Unloader Valve Disassembly

Safely secure the unloader valve (1, Fig. 9-50) in a bench vise or by other suitable means. Remove the cap (2), O-ring (3), spool spring (4), tube spacer (5), spool (6), and relief valve assembly (8) from the unloader valve housing (7). Discard the O-ring (3). Always replace O-rings with new O-rings lubricated with clean hydraulic oil.

c. Cleaning and Drying

Clean metal parts in an approved solvent such as triclorethylene and blow dry.

d. Inspection

Inspect all sealing surfaces. They must be clean, smooth, and free of damage, and have no indication of wear. Replace parts if damaged or worn.

e. Reassembly

Safely secure the unloader valve (1, Fig. 9-50) in a bench vise or by other suitable means. Install the relief valve assembly (8) and torque to 20 lb/ft (27 Nm). Install the spool (6), tube spacer (5), spool spring (4), and new O-ring (3). Always replace O-rings with new O-rings lubricated with clean hydraulic oil. Thread the cap (2) tightly into the unloader valve housing (7).

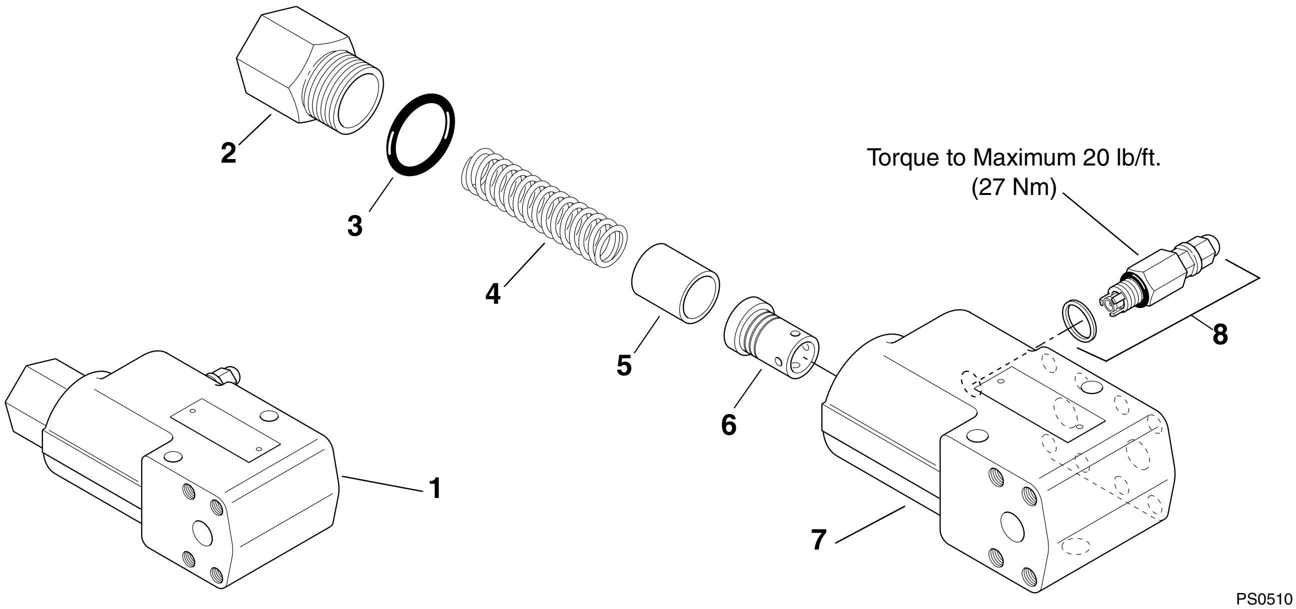


Figure 9–50. Unloader valve detail.

Unloader Valve Legend

1. Unloader Valve (includes items 2 through 8)
2. Cap
3. O-Ring
4. Spool Spring
5. Tube Spacer
6. Spool
7. Valve Housing
8. Relief Valve Assembly
   Preset at 3500 psi ± 100 psi (241 bar ± 7 bar)

f. Unloader Valve Installation

1. Secure the unloader valve to the vehicle frame near the transmission (Fig. 9–49) with two 5/16" SAE washers, two 5/16" lockwashers and two 5/16-18 x 3-1/4" hex-head capscrews. Torque the capscrews to 18 lb/ft (24 Nm).
2. Connect the hydraulic lines to their appropriate ports on the unloader valve.
3. Check the routing of all hoses, wiring and tubing for sharp bends or interference with any rotating members. All tube and hose clamps must be tight.

WARNING: Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

4. Start the engine and run at approximately one-third to one-half throttle for approximately one minute without moving the vehicle or operating any hydraulic functions.
5. Inspect for leaks and check all fluid levels. The hydraulic reservoir oil level must be visible in the sight gage.

Note: Check for leaks and tighten fittings or repair as required before continuing. Wipe up any spilled hydraulic fluid.

g. Unloader Valve Pressure Check Test

Attach a 4000 psi (276 bar) gauge to the unloader valve inlet port. Monitor the outlet pressure at the unloader valve. It must provide 250 to 350 psi (17,25 to 24,15 bar) within moments after starting the engine. Failure to achieve this pressure means that the unloader valve is not properly functioning.

9.9.2 Main Control Valve

The main control valve assembly (2, Fig. 9–51) is located at the rear of the vehicle, beneath the rear cover, secured to the valve plate assembly. The main control valve assembly consists of various working sections with their own valve assemblies, each with a particular purpose in providing vehicle functions.

If service to the main control valve assembly is required, label, disconnect and cap the hoses leading to the main control valve assembly and remove the assembly from the vehicle. Secure the control valve assembly to a work bench, vise, or stabilize by other suitable means.

Always replace O-rings with new O-rings lubricated with clean hydraulic oil.

a. Main Control Valve Replacement

The main control valve assembly (2, Fig. 9–51), pilot select manifold (1), plus the auxiliary hydraulics control valve and mounting bracket (Fig. 9–52), IF EQUIPPED, are fastened to the main valve bracket (5, Fig. 9–51). These instructions cover the removal of the main control valve plate assembly and bracket in its entirety with the main control valve, pilot select manifold and auxiliary hydraulics control valve and mounting bracket, IF EQUIPPED, in place on the bracket.

b. Main Control Valve Removal

1. Park the vehicle on a firm, level surface, fully retract all hydraulic cylinders, ground the attachment (if any), place the travel select lever in NEUTRAL (N), engage the park brake switch and shut the engine OFF.

> **WARNING:** Hot hydraulic fluid can cause severe burns. Wait for hydraulic fluid to cool before servicing any hydraulic component.

2. Unlatch, unlock and open the engine cover. Allow the hydraulic fluid to cool.

> **WARNING:** Escaping hydraulic fluid under pressure can penetrate the skin, causing serious injury. Relieve hydraulic pressure before servicing any hydraulic component.

3. Thoroughly clean the pilot select manifold, main control valve, optional auxiliary hydraulic control valve (IF EQUIPPED) and surrounding area, including all hoses and fittings, before proceeding.
4. Label or otherwise mark the hydraulic hoses at the main control valve, pilot select manifold, and, IF EQUIPPED, the auxiliary hydraulic control valve. Place a suitable container to catch hydraulic fluid drainage beneath the rear ballast weight. Disconnect and cap all hoses and fittings, etc. Label and disconnect all wire terminal leads.
5. Remove the four hex nuts (37, Fig. 9–51) and lock washers (36) securing the main control valve (2) to the main valve bracket (5). Remove the four carriage bolts (9) from beneath the vehicle frame, and remove the four plain washers (28) and spacers (4) from beneath the main valve bracket.
6. Remove the entire valve plate assembly, including the pilot select manifold, main control valve and, IF EQUIPPED, the optional auxiliary hydraulic control valve from the vehicle.
7. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle and the work area.

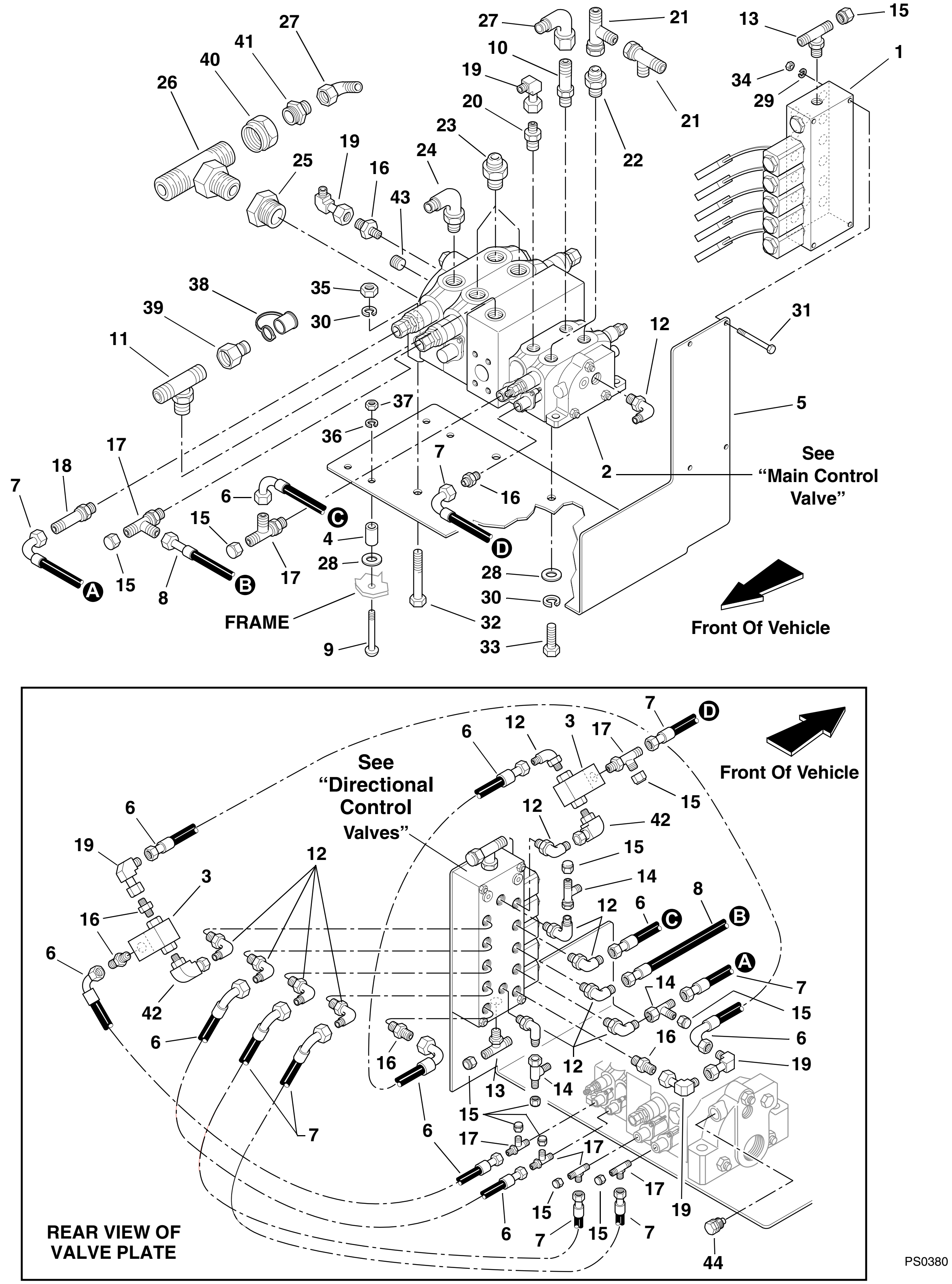


Figure 9–51. Main control valve plate assembly (without auxiliary hydraulics).

Main Control Valve Plate Assembly Legend (without auxiliary hydraulics)

1. Pilot Select Manifold
2. Main Control Valve
3. Shuttle Valve
4. Spacer
5. Main Valve Bracket
6. Hose, 3/8" I.D. x 18"
7. Hose, 3/8" I.D. x 19.3"
8. Hose, 3/8" I.D. x 20"
9. Carriage Bolt, 3/8-16 x 2-1/4"
10. Long Connector, SAE 8 - Str. Thd. ORB x O-Ring Face Seal
11. Branch Tee, SAE 8 - Str. Thd. ORB x O-Ring Face Seal
12. 90° Elbow, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
13. Branch Tee, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
14. Swivel Run Tee, SAE 6 - O-Ring Face Seal
15. Cap, SAE 6 - O-Ring Face Seal
16. Connector, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
17. Male Run Tee, SAE 6 - ORFS Tube End x Str. Thd. O-Ring
18. Long Connector, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
19. 90° Swivel Elbow, SAE 6 - O-Ring Face Seal
20. Connector, SAE 6-8 - Str. Thd. ORB x O-Ring Face Seal
21. Swivel Run Tee, SAE 8 - O-Ring Face Seal
22. Connector, SAE 8 - Str. Thd. ORB x O-Ring Face Seal
23. Connector, SAE 12 - Str. Thd. ORB x O-Ring Face Seal
24. 90° Elbow, SAE 12 - Str. Thd. ORB x O-Ring Face Seal
25. Connector, SAE 16-12 - Str. Thd. ORB x O-Ring Face Seal
26. Swivel Branch Tee, SAE 16 - O-Ring Face Seal
27. 90° Swivel Elbow, SAE 8 - O-Ring Face Seal
28. Washer, Plain 1/2"
29. Lockwasher, 1/4"
30. Lockwasher, 1/2"
31. Hex-head Capscrew, 1/4-20 x 2-1/2" Gr. 5
32. Hex-head Capscrew, 1/2-13 x 3-1/2" Gr. 5
33. Hex-head Capscrew, 1/2-13 x 1" Gr. 5
34. Hex Nut, 1/4-20
35. Hex Nut, 1/2-13
36. Lockwasher, 3/8"
37. Hex Nut, 3/8-16
38. Dust Plug
39. Diagnostic Nipple
40. Tube Nut, SAE 16 - O-Ring Face Seal
41. Reducer, SAE 16 - O-Ring Face Seal x SAE 8 - O-Ring Face Seal
42. 90° Swivel Elbow, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
43. Hex-head Plug, SAE 6 - Male Str. Thd. O-Ring
44. Shut-off Plug

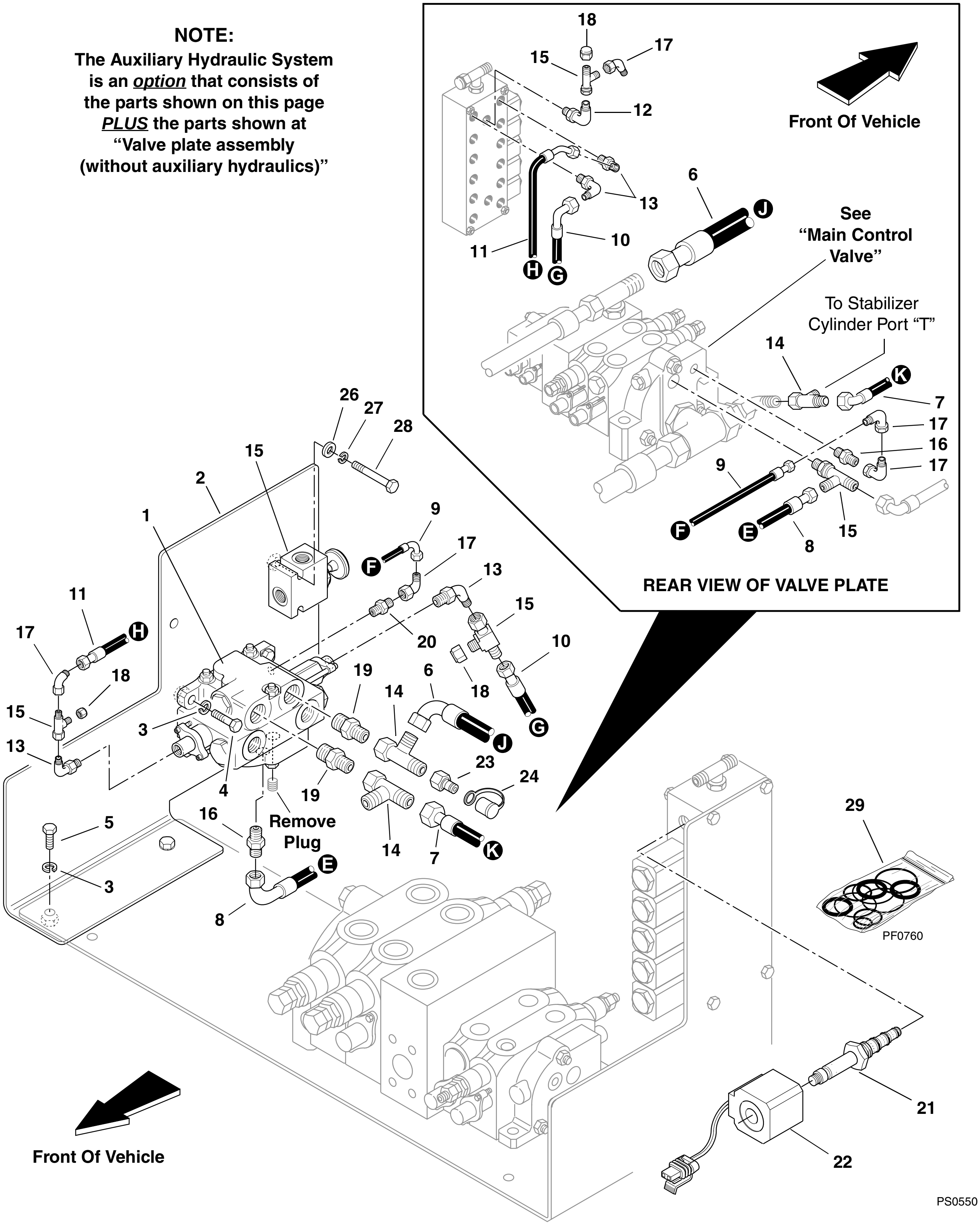


Figure 9–52. Main control valve plate assembly (with auxiliary hydraulics)

Main Control Valve Assembly Legend (with auxiliary hydraulics)

1. Auxiliary Control Valve
2. Auxiliary Control Valve Mounting Bracket
3. Lockwasher, 3/8"
4. Hex-head Capscrew, 3/8-16 x 1-1/4"
5. Hex-head Capscrew, 3/8-16 x 3/4" Gr. 5
6. Hose, 1/2" ID x 21"
7. Hose, 1/2" ID x 26"
8. Hose, 3/8" ID x 21-1/2"
9. Hose, 3/8" ID x 10-1/2"
10. Hose, 3/8" ID x 26"
11. Hose, 3/8" ID x 41"
12. Modified 90° Elbow, SAE 6, Str. Thd. ORB x O-Ring Face Seal
13. 90° Elbow, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
14. Swivel Run Tee, SAE 8 - O-Ring Face Seal
15. Swivel Run Tee, SAE 6 - O-Ring Face Seal
16. Connector, SAE 6 - Str. Thd. ORB x O-Ring Face Seal
17. 90° Swivel Elbow, SAE 6 - O-Ring Face Seal
18. Cap, SAE 6 - O-Ring Face Seal
19. Connector, SAE 8-10 - Str. Thd. ORB x O-Ring Face Seal
20. Union Connector, SAE 6-4, O-Ring Face Seal x O-Ring Face Seal
21. Solenoid Valve (service with Kit, Item 29)
22. Coil w/Female Pins
23. Diagnostic Nipple
24. Dust Plug
25. Manually Operated Relief Valve
26. Plain Washer, 1/4"
27. Lockwasher, 1/4"
28. Hex-head Capscrew, 1/4-20 x 2"
29. Kit, Valve Seal

c. Main Control Valve Disassembly

The main control valve (Fig. 9–53 and Fig. 9–54) consists of various section assemblies held together by three tie rods (items 4 and 5, Fig. 9–54), secured with special hex nuts (2 and 3). From left to right, the section assemblies are the attachment and frame tilt outlet section assembly, attachment tilt section assembly, frame tilt section assembly, mid inlet section assembly, boom extend/retract section assembly, boom hoist/lower section assembly, and the extend/retract and hoist/lower outlet section assembly. Each section assembly includes a pre-adjusted relief valve assembly that regulates pressure in a specific circuit.

IMPORTANT: DO NOT adjust any of the relief valve assemblies! Tampering with a relief valve assembly will irrevocably alter pressure in the affected circuit, requiring re-calibration or a new relief valve assembly.

To disassemble the main control valve:

1. Place the valve plate assembly on a suitable work surface.
2. Working from beneath the main valve bracket (5, Fig. 9–51), remove the hex-head capscrews (32 and 33), lockwashers (30) and plain washers (28) securing the main control valve (2) to the bracket (5). Remove the main control valve from the bracket.
3. Disassemble the main control valve by removing the special nuts (2 and 3, Fig. 9–54) from one end of the tie rods (4 and 5). Pull the tie rods out through the section assemblies.
4. Disassemble each section assembly as required.

Outlet Section

Remove the SAE plug (7, Fig. 9–53) and O-ring (8) from the outlet section assembly (6) to facilitate cleaning and removal of any debris from within the outlet section.

Attachment Tilt Section

1. Carefully separate the outlet section assembly (6, Fig. 9–53) from the attachment tilt section assembly (9). Avoid dislodging or loosing the shuttle (12), spring (13) and control valve (C.V.) compensator (14).
2. Remove the O-ring (11) from between the two sections.
3. Remove the shuttle (12), spring (13) and control valve (C.V.) compensator (14) from the attachment tilt section casting (9).
4. Remove both socket-head capscrews (15) securing the seal plate (16) to the section assembly (9).
5. Remove the seal plate (16), spool end (17), spool cap (18), spring seat (19), spring (20), and another spring seat (19).
6. Remove and discard the O-rings (21 and 22).
7. Remove the spool cap retainer (23).
8. Remove and discard the O-ring (24).
9. Remove both socket-head capscrews (26) securing the seal plate (16) to the section assembly (9).
10. Remove the spool cap (25) and O-ring (24). Discard the O-ring.

Frame Tilt Section

1. Carefully separate the attachment tilt section assembly (9, Fig. 9–53) from the frame tilt section assembly (10), being careful not to dislodge or loose the small internal parts. Remove the O-ring (11) from between the two sections. Remove the shuttle (12), spring (13) and control valve (C.V.) compensator (14) from the frame tilt section casting (10).
2. Remove both socket-head capscrews (15) securing the seal plate (16) to the section assembly (10).
3. Remove the seal plate (16), spool end (17), spool cap (18), spring seat (19), spring (20), and another spring seat (19).
4. Remove and discard the O-rings (21 and 22).
5. Remove the spool cap retainer (23).
6. Remove and discard the O-ring (24).
7. Remove both socket-head capscrews (26) securing the seal plate (16) to the section assembly (10).
8. Remove the spool cap (25) and O-ring (24). Discard the O-ring.

Relief Valve

The relief valve assembly (27, Fig. 9–53) is part of the attachment and frame tilt section assemblies. The valve is preset at 3700± 50 psi (255 ± 3,5 bar).

1. Remove the relief valve assembly (27, Fig. 9–53) from the applicable section assembly.
2. Grip the housing (40) with a suitable tool and use another tool to remove the acorn nut (48), revealing an O-ring (35) and the adjustment screw (47). Discard the O-ring.
3. Remove the O-ring, then loosen the jam nut (46) and remove the adjustment screw, jam nut, and another O-ring (35). Discard the O-ring.
4. Carefully remove the plug (45), O-ring (36), spring (34), pilot poppet (44), wave spring (32), back-up ring (31), O-ring (30), spring (33), O-ring (28), back-up ring (29), and relief valve poppet (43). Discard the O-rings, back-up rings and wave rings.

Remove the check valve poppet (42), piston (41) and O-ring (37). Discard the O-ring.

Mid Inlet Section

1. Carefully separate the frame tilt section assembly (10, Fig. 9–53) from the mid inlet section assembly (37, Fig. 9–54). Remove and discard the O-ring (38).
2. Carefully separate the boom extend/retract section assembly (8, Fig. 9–54) with the boom hoist/lower assembly (9) and outlet section assembly (7) from the mid inlet section assembly (37). Remove and discard the O-ring (39).
3. Remove the shuttle (40), SAE plug assembly (41) and O-ring (42). Discard the O-ring (42).

Boom Extend/Retract Section

1. Carefully separate the boom extend/retract section assembly (8, Fig. 9–54) from the boom hoist/lower section assembly (9) and outlet section assembly (7). Remove and discard the O-ring (20).
2. Remove the shuttle (21), spring (25) and poppet (24).

Relief Valve

The relief valve assembly (27, Fig. 9–54) is oriented toward the rear of the vehicle and is preset at 3750± 50 psi (258 ± 3,5 bar). Relief valve assembly (28, Fig. 9–54) is oriented toward the front of the vehicle and is preset at 3200± 50 psi (220 ± 3,5 bar).

1. Use a wrench on the housing (51, Fig. 9–54) to remove the relief valve assembly (27 and/or 28) from the section assembly.

2. Remove the plug (45), poppet (46), back-up rings (47), and jam nut (48). Keep the back-up rings (47) for re-use later during assembly.
3. Carefully remove the plug (49) with O-ring (29) from the housing (51), exposing the spring (36) and pilot poppet (50). Discard the O-ring (29).
4. Remove the check valve poppet (54) from the housing (51).
5. Remove the relief valve poppet (53), O-ring (30), and back-up ring (35). Discard the O-ring (30) and back-up ring (35).
6. Remove the piston (52), spring (33), back-up ring (32), O-ring (31), and another back-up ring (32). Discard the O-ring (31) and back-up rings (32).
7. Remove the spring (34) and O-ring (29) from the housing (51). Discard the O-ring (29).

Boom Hoist/Lower Section

1. Carefully separate the boom hoist/lower section assembly (9, Fig. 9–54) from the outlet section assembly (7). Remove and discard the O-ring (20).
2. Remove the shuttle (21), spring (25) and poppet (24).
3. Remove the anti-void assembly (26).

Extend/Retract and Hoist/Lower Outlet Section

Remove the shut-off plug assembly orifice (6, Fig. 9–54) from the outlet section assembly (7).

d. Main Control Valve Parts Cleaning

Clean all components with a suitable cleaner, such as triclorethylene, before continuing. Blow dry.

e. Main Control Valve Parts Inspection

Inspect all parts and internal passageways for wear, damage, etc. If inner surfaces of any component do not display an ultra-smooth, polished finish, or are damaged in any way, replace the damaged part. Most often, dirty hydraulic fluid causes failure of internal seals, damage to the polished surfaces within the component, and wear of and/or harm to other parts.

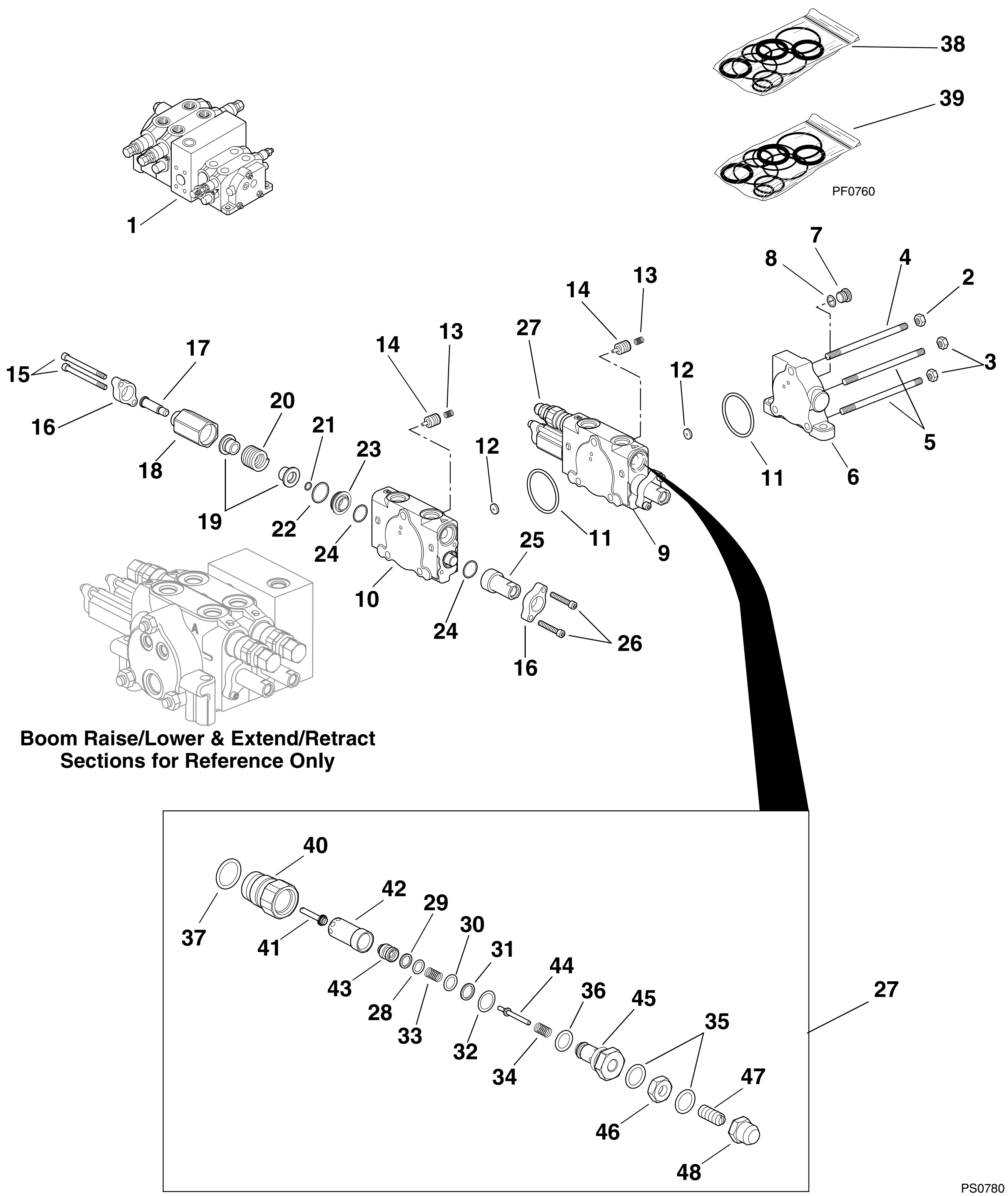


Figure 9–53. Attachment tilt and frame tilt sections.

Main Control Valve Legend
Attachment Tilt and Frame Tilt Sections

1. Main Control Valve Assembly
(includes items 2 through 37)
2. Special Upper Nut
3. Special Lower Nut
4. Upper Tie Rod
5. Lower Tie Rod
6. Outlet Section Assembly
7. SAE Plug
8. O-Ring
9. Attachment Tilt Section Assembly
(includes items 11 through 26)
10. Frame Tilt Section Assembly
(includes items 11 through 26)
11. O-Ring
12. Shuttle
13. Spring
14. C.V. Compensator Piston
15. Socket-head Capscrew
16. Seal Plate
17. End Spool
18. Spool Cap
19. Spring Seat
20. Spring
21. O-Ring
22. O-Ring
23. Spool Cap Retainer
24. O-Ring
25. Spool Cap
26. Socket-head Capscrew
27. Relief Valve Assembly, preset at 3700 ± 50 psi
(255 ± 3,5 bar),
(includes items 28 through 37)
28. O-Ring
29. Back-up Ring
30. O-Ring
31. Back-up Ring
32. Wave Spring
33. Spring
34. Spring
35. O-Ring
36. O-Ring
37. O-Ring
38. Seal and Spring Kit, relief valve
(includes items 28 through 37)
39. Seal Kit, entire valve
(includes items 8, 11, 21, 22 and 24 and additional items on Boom Hoist/Lower and Extend/Retract Sections)
40. Housing
41. Piston
42. Check Valve Poppet
43. Relief Valve Poppet
44. Pilot Poppet
45. Plug
46. Jam Nut
47. Adjustment Screw
48. Acorn Nut

f. Main Control Valve Reassembly

Note: Always replace O-rings with new O-rings to help ensure a leak-proof seal and proper vehicle performance.

Attachment and Frame Tilt Outlet Section Assembly

Install a new O-ring (8, Fig. 9–53), and the SAE plug (7), into the outlet section assembly (6).

Attachment Tilt Section

The section can be identified by manufacturing markings made for the inlet (triangle) and outlet ("B") ports. The inlet side faces the front of the vehicle when installed; the outlet faces the rear of the vehicle. Install a new O-ring (24, Fig. 9–53) and spool cap (25) in the inlet side lower port.

1. Secure the seal plate (16, Fig. 9–53) to the section assembly (9) with two socket-head capscrews (26).
2. On the outlet ("B") port side, install a new O-ring (24) and the spool cap retainer (23) into the lower port.
3. Install new O-rings (21 and 22).
4. Install the spring seat (19), spring (20), another spring seat (19), spool cap (18), spool end (17), and seal plate (16).
5. Secure the seal plate (16) to the section assembly (9) with two socket-head capscrews (15).
6. Install the control valve (C.V.) compensator (14), spring (13) and shuttle (12) into the attachment tilt section casting (9).
7. Place a new O-ring (11) between the attachment tilt section assembly and outlet section assembly (6).
8. Avoid dislodging or loosing the shuttle (12), spring (13) and control valve (C.V.) compensator (14). Carefully join the outlet section assembly (6) to the attachment tilt section assembly (9).

Frame Tilt Section

The section can be identified by markings made for the inlet (triangle) and outlet ("B") ports. The inlet side faces the front of the vehicle when installed; the outlet faces the rear of the vehicle. Install a new O-ring (24, Fig. 9–53) and spool cap (25) in the inlet side lower port.

1. Secure the seal plate (16, Fig. 9–53) to the section assembly (10) with two socket-head capscrews (26).
2. On the outlet ("B") port side, install a new O-ring (24) and the spool cap retainer (23) into the lower port.
3. Install new O-rings (21 and 22).
4. Install the spring seat (19), spring (20), another spring seat (19), spool cap (18), spool end (17), and seal plate (16).
5. Secure the seal plate (16) to the section assembly (10) with two socket-head capscrews (15).
6. Install the control valve (C.V.) compensator (14), spring (13) and shuttle (12) into the frame tilt section casting (10).
7. Place a new O-ring (11) between the attachment tilt section assembly (10) and frame tilt section assembly (10) being careful not to dislodge or loose the control valve (C.V.) compensator (14), spring (13) or shuttle (12).

Assembling the Relief Valve

The relief valve assembly is part of both the attachment and frame tilt section assemblies and is preset at 3700± 50 psi (255 ± 3,5 bar).

1. Install the check valve poppet (42, Fig. 9–53) and piston (41) into the housing (40).
2. Carefully install the relief valve poppet (43), back-up ring (29), new O-ring (28), spring (33), new O-ring (30), back-up ring (31), wave spring (32), pilot poppet (44), spring (34), new O-ring (36), and plug (45) into the housing (40).
3. Install a new O-ring (35) into the housing (40) on top of the plug (45).
4. Thread the jam nut (46) onto the adjustment screw (47), then thread the adjustment screw and jam nut into the plug (45) within the housing (40).
5. Install another new O-ring (35) over the jam nut (46) and adjustment screw (47), then thread the acorn nut (48) onto the adjustment screw.
6. Place a new O-ring (37) onto the housing and install the relief valve assembly (27) into the section assembly (27). Tighten securely.

Assembling the Mid Inlet Section

1. Install a new O-ring (42, Fig. 9–53), and the SAE plug assembly (41) and shuttle (40) into the mid inlet section assembly (37).
2. Install a new O-ring (39, Fig. 9–53) into the mid inlet section assembly (37). Carefully attach the boom extend/retract section assembly (8) with the boom hoist/lower assembly (9) and outlet section assembly (7) to the mid inlet section assembly (37).
3. Install a new O-ring (38, Fig. 9–53). Carefully attach the frame tilt section assembly (10, Fig. 9–54) to the mid inlet section assembly (37, Fig. 9–53).

Boom Extend/Retract Section

1. Install the poppet (24, Fig. 9–54), spring (25) and shuttle (21) into the boom extend/retract section assembly (8).
2. Install a new O-ring (20) into the boom extend/retract section assembly (8).
3. Carefully attach the boom extend/retract section assembly (8) to the boom hoist/lower section assembly (9) and outlet section assembly (7).

Assembling the Relief Valve Assemblies

Relief valve assembly (27, Fig. 9–54) is oriented toward the rear of the vehicle and is preset at 3750± 50 psi (258 ± 3,5 bar). Relief valve assembly (28) is oriented toward the front of the vehicle and is preset at 3200± 50 psi (220 ± 3,5 bar).

For each relief valve assembly (27 and 28, Fig. 9–54):

1. Install a new O-ring (29, Fig. 9–54) and the spring (34) into the housing (51).
2. Install a new back-up ring (32), new O-ring (31), another new back-up ring (32), spring (33), and the piston (52) into the housing (51).
3. Install the relief valve poppet (53), new O-ring (30), and new back-up ring (35).
4. Install a new back-up ring (35), new O-ring (30), and the relief valve poppet (53) into the housing (51), then install the check valve poppet (54) into the housing (51).
5. Place the pilot poppet (50) and spring (36) into the housing (51), then add a new O-ring (29) and secure with the plug (49).
6. Install jam nut (48), back-up rings (47), poppet (46), and plug (45).
7. Use a wrench on the housing (51) to install the relief valve assembly (27 and/or 28) into the section assembly.

Boom Hoist/Lower Section

1. Install the anti-void assembly (26, Fig. 9–54) into the boom hoist/lower section assembly (9).
2. Install the poppet (24), spring (25) and shuttle (21).
3. Install a new O-ring (20), then carefully attach the boom hoist/lower section assembly (9) to the outlet section assembly (7).

Extend/retract and hoist/lower outlet section assembly

Install the shut-off plug assembly orifice (6, Fig. 9–54) into the outlet section assembly (7).

g. Main Control Valve Installation

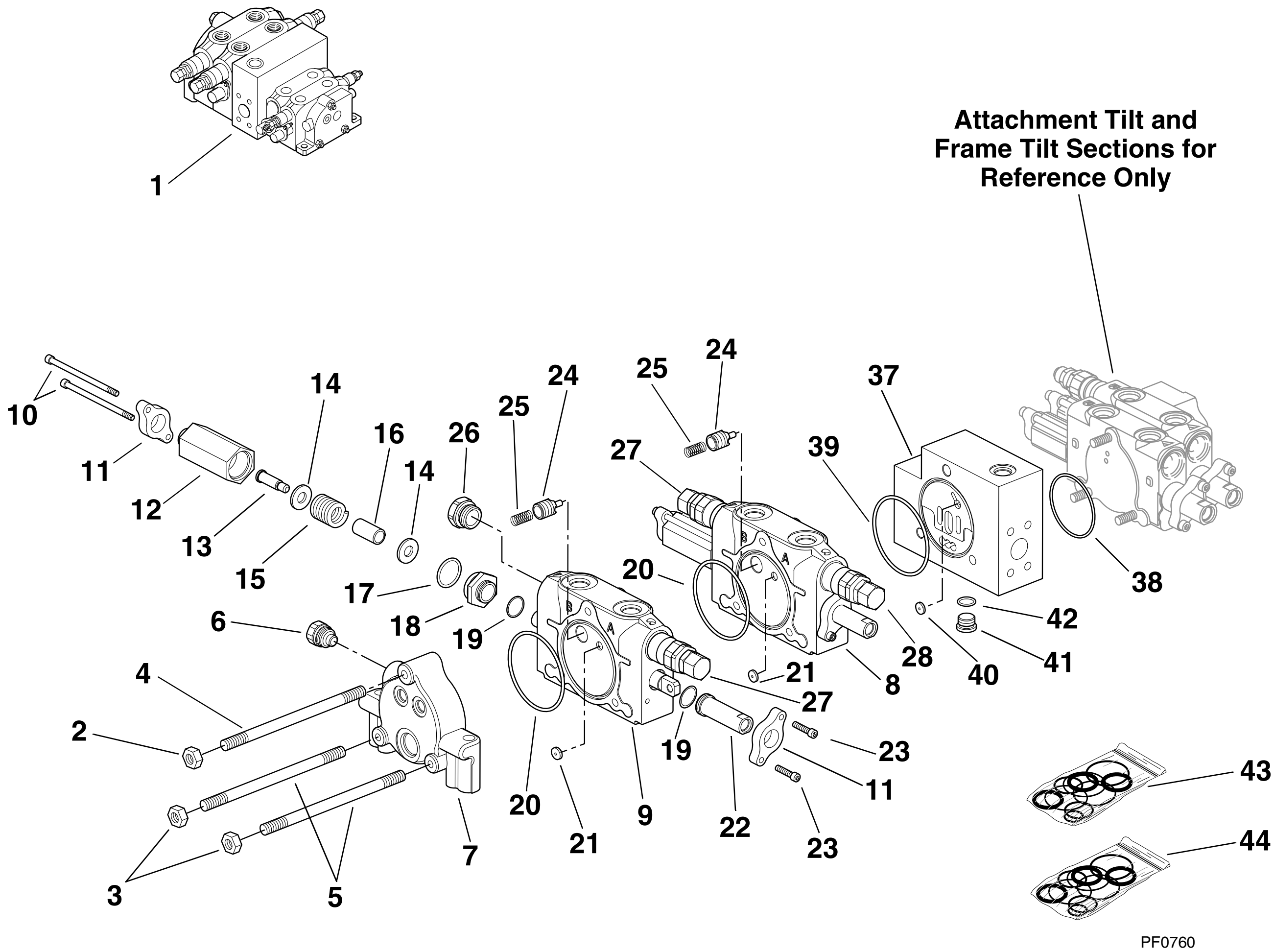
1. Place the main control valve into position on the valve plate assembly.
2. Align gaskets, bolt holes, etc. with component mount holes. Secure the main control valve with the necessary fasteners. Torque fasteners to specification. Refer to the torque specification chart in *Section 2 General Information, Specifications and Maintenance Instructions*.
3. Prime the main control valve by filling the inlet openings with fresh, filtered hydraulic oil before attaching the hoses.
4. Use new O-rings as required. Reattach and secure all hoses, clamps, etc.
5. Check the routing of all hoses, wiring and tubing for sharp bends or interference with any rotating members, and install tie wraps and/or protective conduit as required. Tighten all tube and hose clamps.

WARNING: Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

6. Start the engine and run at approximately one-third to one-half throttle for about one minute without moving the vehicle or operating any hydraulic functions.
7. Inspect for leaks and check the level of the hydraulic fluid in the reservoir. Shut the engine OFF.

Note: Check for leaks and repair as required before continuing. Add hydraulic fluid to the reservoir as needed.

8. Conduct a pressure check of the hydraulic system in its entirety. Adjust pressure(s) as required.
9. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle, work area and tools.



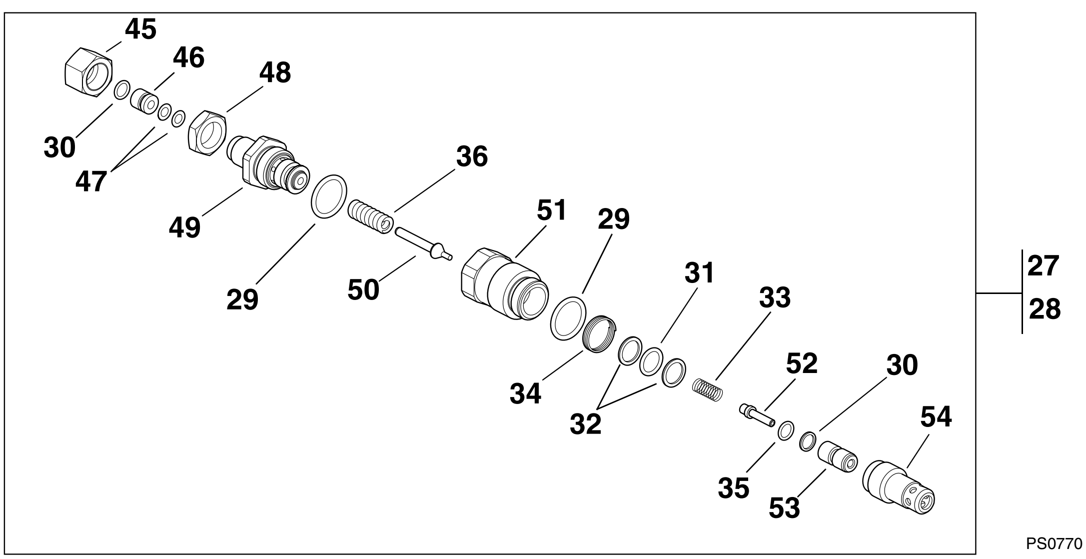


Figure 9–54. Hoist/lower and extend/retract sections.

Main Control Valve Legend
Hoist/Lower and Extend/Retract Sections

1. Main Control Valve Assembly (includes items 2 through 42)
2. Special Upper Nut
3. Special Lower Nut
4. Upper Tie Rod
5. Lower Tie Rod
6. Orifice Shut-off Plug Assembly
7. Outlet Section Assembly
8. Boom Extend/Retract Section Assembly (includes items 10 through 25)
9. Boom Hoist/Lower Section Assembly (includes items 10 through 26)
10. Socket-head Capscrew
11. Retainer
12. Spool Cap
13. Shoulder Socket-head Screw
14. Flat Washer
15. Spring
16. Spacer
17. O-Ring
18. Spool Cap Retainer
19. O-Ring
20. O-Ring (see KITS)
21. Shuttle
22. Spool Cap
23. Socket-head Capscrew
24. Poppet
25. Spring
26. Anti-void Assembly
27. Relief Valve Assembly, preset at 3750 ± 50 psi (258,75 ± 3,5 bar) (includes items 29 through 36)
28. Relief Valve Assembly, preset at 3200 ± 50 psi (220,8 ± 3,5 bar), (includes items 29 through 36)
29. O-Ring
30. O-Ring
31. O-Ring
32. Back-up Ring
33. Spring
34. Spring
35. Back-up Ring
36. Spring
37. Mid Inlet Section Assembly (includes items 38 through 40)
38. O-Ring
39. O-Ring
40. Shuttle
41. SAE Plug Assembly
42. O-Ring
43. Seal Kit, entire valve (includes items 17, 19, 20 and 42 and additional items on Attachment Tilt and Frame Tilt Sections)
44. Seal and Spring Kit, relief valve
45. Plug
46. Poppet
47. Back-up Ring
48. Jam Nut
49. Plug
50. Pilot Poppet
51. Housing
52. Piston
53. Relief Valve Poppet
54. Check Valve Poppet

9.9.3 Auxiliary Function Manifold

The auxiliary function manifold (Fig. 9-55) is located near the battery, secured to a bracket at the hydraulic fluid
reservoir/engine mount with two capscrews and lock-washers.

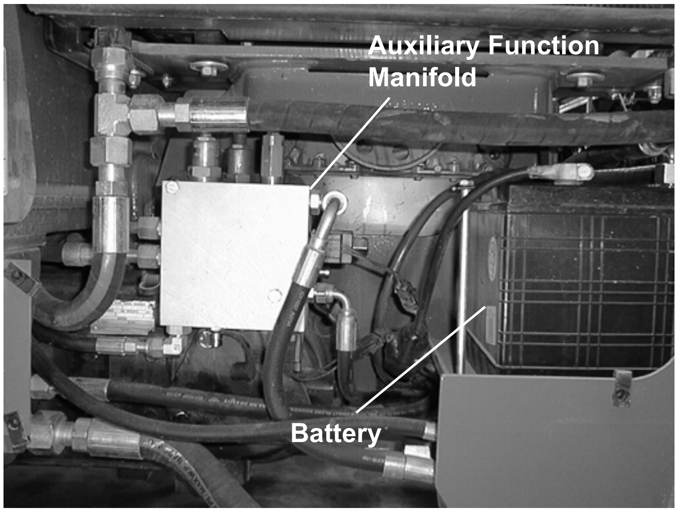


Figure 9-55. The auxiliary function manifold is located near the battery.

The auxiliary function manifold (Fig. 9-56) is a machined block with ports for three pressure reducing valves, two solenoid valves, and related hose fittings. The auxiliary function manifold also contains a check valve that can be replaced if defective.

Pressure reducing valve "PS" is set at 2500 psi (172 bar); valve "PB" is set at 550 psi (38 bar), and the pressure relief valve is set at 650 psi (45 bar).

Verify the correct operation of the solenoids before considering replacement of the auxiliary function manifold. The manifold itself is not serviceable and must be replaced in its entirety if replacement of parts does not solve the problem.

DO NOT loosen, disassemble or attempt to adjust any of the pressure valves unless specifically instructed by **Sky Trak** to do so! Tampering with a pressure valve will irrevocably alter pressure in the affected circuits. A new pressure reducing valve will be required to rectify the situation.

a. Auxiliary Function Manifold Replacement

1. Park the vehicle on a firm, level surface, fully retract all hydraulic cylinders, ground the attachment (if any), place the travel select lever in NEUTRAL (N), engage the park brake switch and shut the engine OFF.

WARNING: Hot hydraulic fluid can cause severe burns. Wait for hydraulic fluid to cool before servicing any hydraulic component.

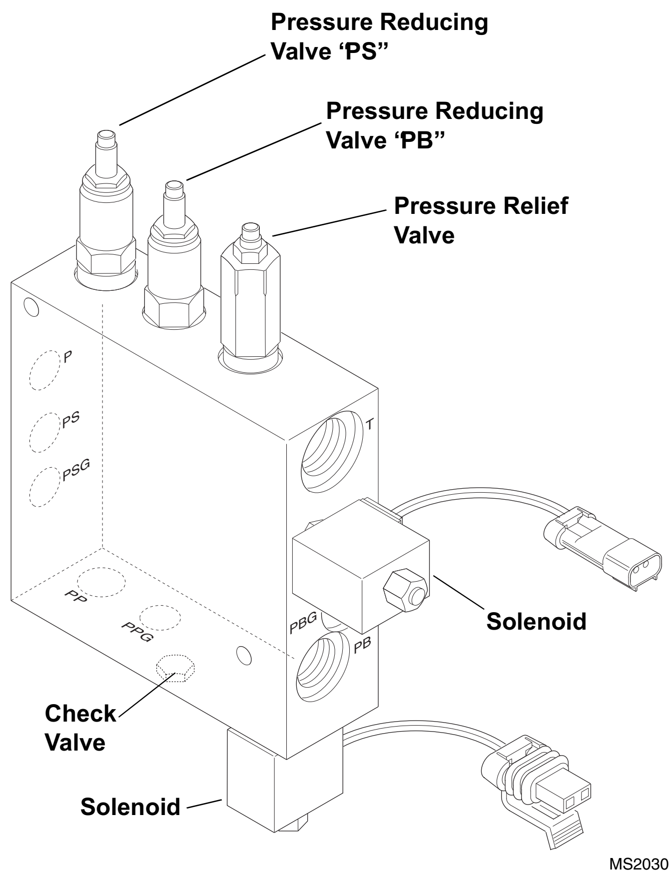


Figure 9-56. Auxiliary function manifold components.

1. Unlatch, unlock and open the engine cover. Allow the hydraulic fluid to cool.

WARNING: Escaping hydraulic fluid under pressure can penetrate the skin, causing serious injury. Relieve hydraulic pressure before servicing any hydraulic component.

2. Label or otherwise mark the hydraulic hoses in relation to the auxiliary function manifold (Fig. 9-55). Disconnect and cap all hoses, fittings, solenoid wire terminal leads, etc.
3. Remove the auxiliary function manifold from the vehicle. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle.

b. Auxiliary Function Manifold Disassembly, Cleaning, Inspection and Reassembly

1. Secure the auxiliary function manifold (Fig. 9–56) in a suitable bench vise if possible.
2. Remove the pressure-reducing valve “PS” (Fig. 9–56) set at 2500 psi (172 bar).
3. Remove the pressure-reducing valve “PB” set at 550 psi (38 bar).
4. Remove the pressure-relief valve set at 650 psi (45 bar).
5. Remove the check valve.
6. Remove the diagnostic nipples at “PPG” and PBG”.
7. Clean all components with a suitable cleaner before inspection.
8. Inspect internal passageways of the auxiliary function manifold and it component parts for wear, damage, etc. If inner surfaces of the auxiliary function manifold do not display an ultra-smooth, polished finish, or components are damaged in any way, replace the auxiliary function manifold or appropriate part. Most often, dirty hydraulic fluid causes failure of internal seals and damage to the polished surfaces within the auxiliary function manifold.

Note: Always replace seals, O-rings, gaskets, etc. with new parts to help ensure proper sealing and operation.

c. Auxiliary Function Manifold Installation

1. Align the auxiliary function manifold with its mount holes on the hydraulic reservoir/engine mount near the battery (Fig. 9–55).
2. Align gaskets, bolt holes, etc. with component mount holes. Secure the auxiliary function manifold with the necessary fasteners. Torque fasteners to specification.
3. Before attaching the hoses, prime the auxiliary function manifold by filling the hydraulic hose ports with fresh, filtered hydraulic oil.
4. Use new O-rings as required. Reattach and secure all valves, diagnostic nipples, hoses, clamps, solenoids and wiring, etc.
5. Check the routing of all hoses, wiring and tubing for sharp bends or interference with any rotating members, and install tie wraps and/or protective conduit as required. Tighten all tube and hose clamps.

WARNING: Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

6. Start the engine and run at approximately one-third to one-half throttle for about one minute without moving the vehicle or operating any hydraulic functions.
7. Inspect the auxiliary function manifold for leaks and check the level of the hydraulic fluid in the reservoir. Shut the engine OFF.

Note: Check for leaks and repair as required before continuing. Add hydraulic fluid to the reservoir as needed.

8. Conduct a pressure check of the service brake and steering hydraulic circuits.
9. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle, work area and tools.

9.9.4 Joystick Valve

The joystick valve (1, Fig. 9–43) is part of the joystick assembly. Refer to *Section 4 Cab, Covers and Mirrors* for further information regarding replacement of the joystick assembly.

Joystick commands are actuated both electrically and hydraulically via a set of solenoid-operated control valves mounted in an array at the pilot select manifold.

Verify the correct operation of the joystick switches and circuit solenoids before considering replacement of the joystick valve. The valve itself is not serviceable and must be replaced in its entirety if replacement of electrical parts does not solve the problem.

9.9.5 Pilot Select Manifold

The pilot select manifold (Fig. 9–57) is a precisely-machined block located inside the rear cover, secured at its four corners by capscrews and lockwashers to the main control valve plate assembly (Fig. 9–51) near the left inside frame rail. The pilot select manifold contains ports for cartridge valves and hose fittings.

DO NOT loosen, disassemble or attempt to adjust any of the cartridges unless specifically instructed by Sky Trak to do so!

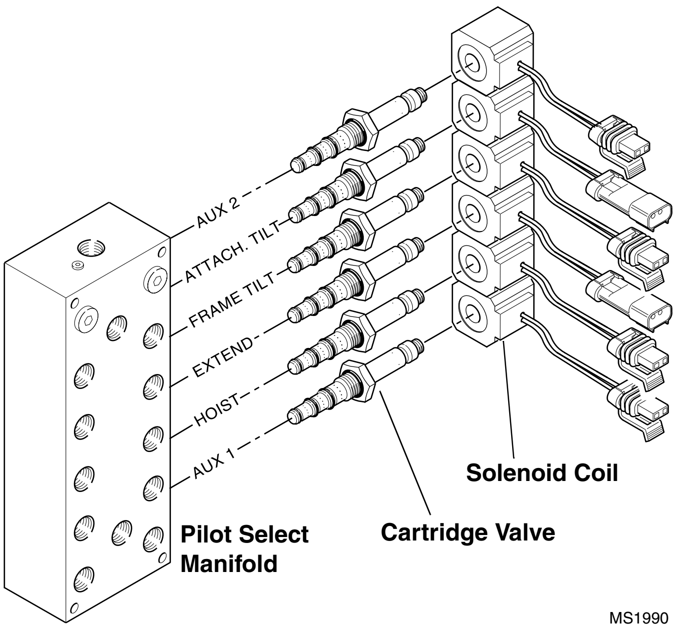


Figure 9–57. Pilot select manifold.

a. Pilot Select Manifold Replacement

1. Park the vehicle on a firm, level surface, fully retract all hydraulic cylinders, ground the attachment (if any), place the travel select lever in neutral (N), engage the park brake switch and shut the engine OFF.

> **WARNING:** Hot hydraulic fluid can cause severe burns. Wait for hydraulic fluid to cool before servicing any hydraulic component.

2. Unlatch, unlock and open the engine cover. Allow the hydraulic fluid to cool.

> **WARNING:** Escaping hydraulic fluid under pressure can penetrate the skin, causing serious injury. Relieve hydraulic pressure before servicing any hydraulic component.

3. Label or otherwise mark all of the hydraulic hoses and solenoid wire terminal leads in relation to the pilot select manifold. Disconnect the wiring, and cap all hoses, fittings, etc.
4. Remove the four 1/4-20 x 2-1/2 Grade 5 hex-head capscrews (31, Fig. 9–51), 1/4-20 hex nuts (34) and 1/4” lockwashers (29) securing the manifold (1) to the main control valve plate bracket (5).
5. Remove the pilot select manifold (1) from the vehicle. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle.

b. Pilot Select Manifold Disassembly, Cleaning, Inspection and Reassembly

1. Secure the pilot select manifold in a suitable bench vise if possible. Remove the solenoid coils (Fig. 9–57) and cartridge valves from the manifold.
2. Clean all components with a suitable cleaner before inspection.
3. Inspect internal passageways and parts for wear, damage, etc. If inner surfaces of the pilot select manifold do not display an ultra-smooth, polished finish, or are damaged in any way, replace the manifold in its entirety. Most often, dirty hydraulic fluid causes failure of internal seals and damage to the polished surfaces within the component.

Note: Always replace seals, O-rings, gaskets, etc. with new parts to help ensure proper sealing and operation.

c. Pilot Select Manifold Installation

1. Place the pilot select manifold (1, Fig. 9–51) into position on the main valve plate bracket (5) at the left rear inner frame wall of the vehicle.
2. Install the four 1/4-20 x 2-1/2 Grade 5 hex-head capscrews (31), 1/4-20 hex nuts (34) and 1/4” lockwashers (29) to secure the pilot select manifold to the main valve plate bracket (5). Torque fasteners to 9 lb/ft (12 Nm).
3. Prime the pilot select manifold by adding a small quantity of fresh, filtered hydraulic oil through the port holes before attaching the hoses.
4. Use new O-rings as required. Reattach and secure all hoses, clamps, wire terminals, etc.
5. Check the routing of all hoses, wiring and tubing for sharp bends or interference with any rotating members, and install tie wraps and/or protective conduit as required. Tighten all tube and hose clamps.

> **WARNING:** Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

6. Start the engine and run at approximately 1/3 to 1/2 throttle for about one minute without moving the vehicle or operating any hydraulic functions.
7. Inspect for leaks and check the level of the hydraulic fluid in the reservoir. Shut the engine OFF.

Note: Check for leaks and repair as required before continuing. Add hydraulic fluid to the reservoir as needed.

8. Conduct a pressure check of all boom function hydraulic circuits.
9. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle, work area and tools.

9.9.6 Steering Valve

The steering valve (Fig. 9-58) is located at the base of the steering wheel shaft, concealed by the lower dash cover. The valve is not serviceable and must be replaced in its entirety if defective.

Steering Valve Replacement

Refer to *Section 4 Cab, Covers and Mirrors* for steering valve replacement information. **DO NOT** attempt to disassemble the steering valve.

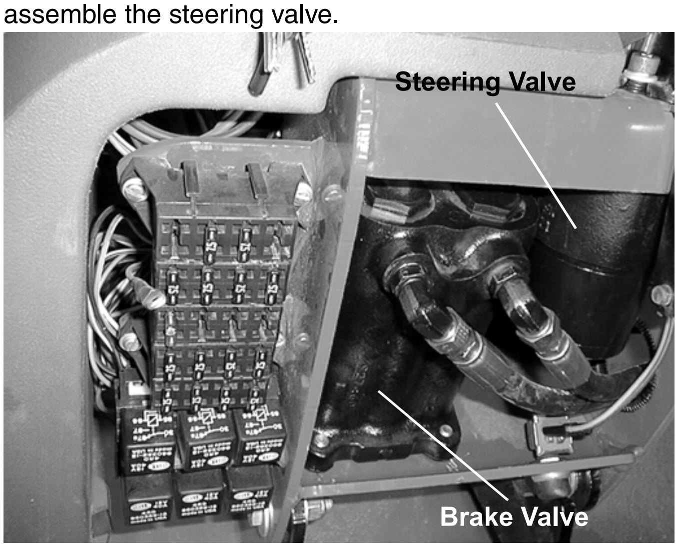


Figure 9-58. Steering valve.

9.9.7 Steer Select Valve

The steer select valve and manifold (Fig. 9-59 and Fig. 9-60) are secured with four capscrews and O-rings to the hydraulic fluid reservoir/engine mount.

The steer select valve contains two solenoids that direct the flow of hydraulic fluid according to steering input. The valve is a direct dual-solenoid operated, spool-type directional control valve.

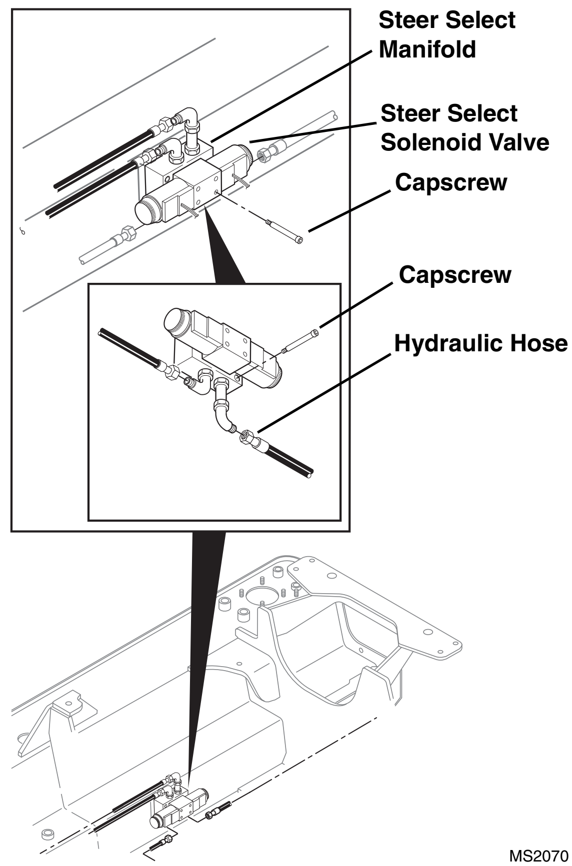


Figure 9-59. Steer select valve location and mounting.

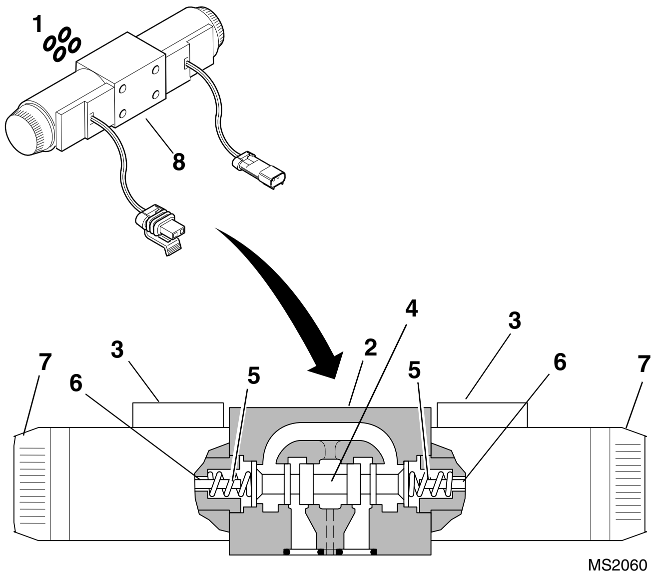
The steer select valve controls the start, stop and direction of hydraulic fluid flow to the steering cylinders mounted on each axle.

The valve consists of a housing (2, Fig. 9-60), two solenoids (3), a control spool (4), and two return springs (5). In the de-energized state, the spool (4) is held by the return springs (5) in the center position.

The spool is shifted via the action of the two wet-pin type solenoids (3). The force of an acting solenoid pushes against the push pin (6) on the end of the spool (4).

The spool is shifted from its normal position to the end position for selected flow. The selected flow pattern will be one of two possible patterns: either P to A and B to T, or P to B and A to T.

When the solenoid is de-energized, the control spool (4) is returned to its normal condition by the centering springs (5).



1. O-rings
2. Housing
3. Solenoids (2)
4. Control Spool
5. Return Springs
6. Push Pin
7. Manual Override
8. Solenoid-operated Valve

Figure 9–60. Steer select valve location.

When troubleshooting a steering problem, also check the steer select valve solenoids for proper operation, and check the wiring for continuity or shorts.

Refer to *Section 10 Electrical System* for further information on electrical components. Replace a defective or faulty steer select valve with a new unit.

9.9.8 Shuttle Valve

The shuttle valve (Fig. 9–61 and Fig. 9–62) is attached to the brake valve (Fig. 9–58) with a 90° elbow fitting. The shuttle valve joins the steering valve shuttle fluid input line, shuttle-in line from the main control valve, and the brake valve load-sense line. The shuttle valve contains a pressure-dependent two-way check and is a non-serviceable item. It must be replaced in its entirety if defective.

a. Shuttle Valve Removal

1. Park the vehicle on a firm, level surface, fully retract all hydraulic cylinders, ground the attachment (if any), place the travel select lever in neutral (N), engage the park brake switch and shut the engine OFF.

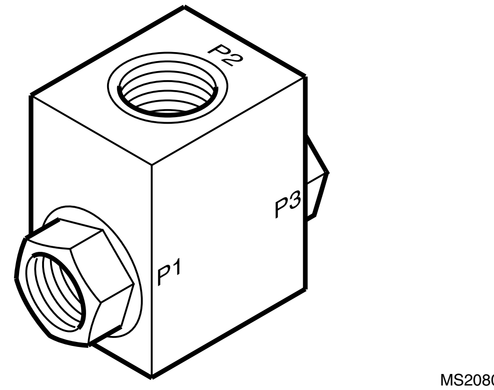


Figure 9–61. Shuttle valve.

⚠	**WARNING:** Hot hydraulic fluid can cause severe burns. Wait for hydraulic fluid to cool before servicing any hydraulic component.

2. Unlatch, unlock and open the engine cover. Allow the hydraulic fluid to cool.

⚠	**WARNING:** Escaping hydraulic fluid under pressure can penetrate the skin, causing serious injury. Relieve hydraulic pressure before servicing any hydraulic component.

3. Label or otherwise mark the hydraulic hoses (Fig. 9–62) at the service brake valve in relation to the shuttle valve. Disconnect and cap all hoses and fittings, etc.
4. Remove the shuttle valve from the vehicle. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle.

b. Shuttle Valve Cleaning, Inspection and Reassembly

1. Clean the shuttle valve with a suitable cleaner before inspection.
2. Inspect internal passageways and the shuttle valve overall for wear, damage, etc. If inner surfaces of the component do not display an ultra-smooth, polished finish, or are damaged in any way, replace the shuttle valve. Most often, dirty hydraulic fluid causes failure of internal seals and damage to the polished surfaces within the shuttle valve.
3. Replace a defective shuttle valve with a new one.

Note: Always replace seals, O-rings, gaskets, etc. with new parts to help ensure proper sealing and operation.

c. Shuttle Valve Installation

1. Attach the shuttle valve (Fig. 9–61) to the brake valve (Fig. 9–62) with a 90° elbow fitting. The shuttle valve (Fig. 9–61) joins the steering valve shuttle fluid input line (port P1, Fig. 9–61), shuttle-in line from the main control valve (port P2), and the brake valve load-sense line (port P3). Use new O-rings as required. Reattach and secure all hoses, clamps, etc.
2. Check the routing of all hoses, wiring and tubing for sharp bends or interference with any rotating members, and install tie wraps and/or protective conduit as required. Tighten all tube and hose clamps.

WARNING: Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

3. Start the engine and run at approximately 1/3 to 1/2 throttle for about one minute without moving the vehicle or operating any hydraulic functions.
4. Inspect for leaks and check the level of the hydraulic fluid in the reservoir. Shut the engine OFF.

Note: Check for leaks and repair as required before continuing. Add hydraulic fluid to the reservoir as needed.

5. Conduct a pressure check of the service brake and steering hydraulic circuits.
6. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle, work area and tools.

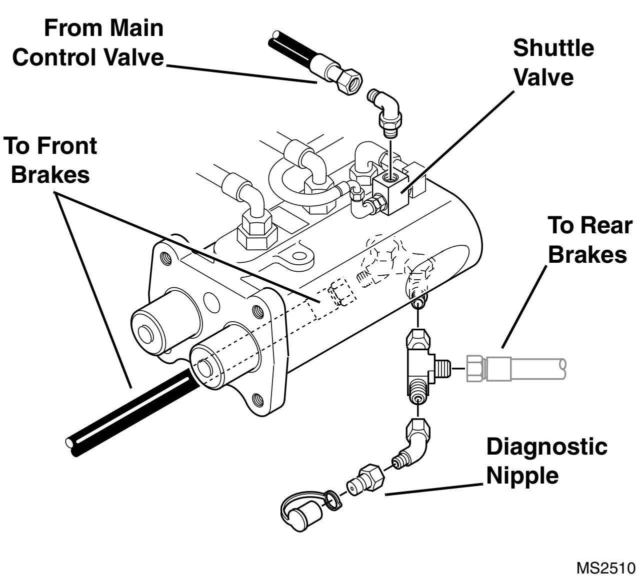


Figure 9–62. Service brake valve and shuttle valve detail.

9.9.9 Service Brake Valve

The service brake valve (Fig. 9–58 and Fig. 9–63) is secured with four capscrews and lockwashers at the base of the steering column support, concealed by the lower dash cover.

The service brakes themselves are part of the axles (the park brake is part of the front axle only). Refer to *Section 5 Axles, Wheels and Tires* for further information.

Service Brake Valve Replacement

Refer to *Section 4 Cab, Covers and Mirrors* for information on replacing the service brake valve.

DO NOT disassemble the service brake valve. The service brake valve is not serviceable and must be replaced in its entirety if defective as no replacement parts are available for internal components.

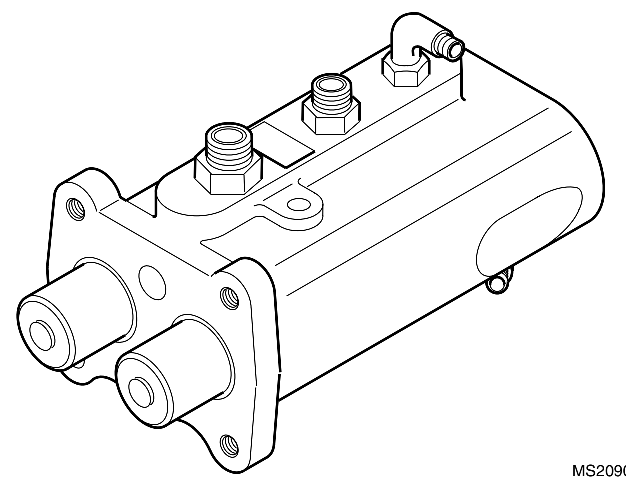


Figure 9–63. Service brake valve.

9.10 CYLINDERS

There are many factors involved with the proper disassembly, cleaning, inspection, repair and reassembly of hydraulic cylinders; therefore, only qualified professionals with proper training, supervision, tools and equipment should rebuild the cylinders used on this vehicle.

For example, special pin spanner wrenches of the correct size are needed to disassemble the cylinders. Also, the hoist/lower cylinder rod locknut must be torqued to 1550-1750 lb/ft (2034-2305 Nm); this requires a special torque wrench and/or torque multiplier. If the proper knowledge and equipment are not available, the cylinders must be sent out for rebuilding by a competent professional at a company that specializes in rebuilding agricultural and industrial heavy-equipment hydraulic cylinders.

Rebuild cylinders only in a clean, well-lighted area where all components can be carefully and thoroughly inspected. If leaving a cylinder dismantled for any length of time longer than the immediate rebuilding period, and especially in high-humidity environments, coat the metal parts with a suitable preservative and place them in protective storage.

Refer to the specific instructions for removal, rebuilding and installation of each cylinder.

a. General Cylinder Disassembly Instructions

WARNING: To help prevent severe burns, proceed with caution when applying heat to parts. Avoid the use of excessive heat, which will damage parts and make them unusable.

Some cylinder parts are sealed with a “special organic” sealant and locking compound. Before attempting to disassemble these parts, remove any accessible seals from the area of the bonded parts. Wipe off any hydraulic oil, then heat the part(s) uniformly to break the bond. A temperature of 300° F to 400° F (149° C to 204° C) will destroy the bond. Avoid overheating, or the parts may become distorted or damaged. Apply sufficient torque for removal while the parts are still hot. The sealant often leaves a white, powdery residue on threads and other parts, which must be removed by brushing with a soft brass wire brush prior to reassembly.

Note: Significant pressure may be trapped inside the cylinder. Exercise caution when removing counter-balance valves from a cylinder and when disassembling a cylinder with a pilot-to-open check valve.

DO NOT attempt to salvage cylinder seals, sealing rings or O-rings. Always use a new, complete seal kit when rebuilding hydraulic components. Consult the parts catalog for ordering information.

Note: An additional O-ring may be included at the base of the cylinder rod. This additional O-ring may be discarded, as it served only in a temporarily protective role to keep paint off the rod while the cylinder was painted at the factory.

b. General Cylinder Cleaning Instructions

Clean all reusable metal parts thoroughly after disassembly and prior to inspection. Use an approved solvent such as trichlorethylene.

c. General Cylinder Assembly Instructions

1. Before reassembly, assure that parts are clean and free from foreign matter. Use an approved solvent for cleaning, such as trichlorethylene.
2. Use the proper tools for specific installation tasks. Clean tools are required for installation.
3. Protect the finish on the rod at all times. Damage to the rod can cause premature seal failure.
4. Always use new O-rings, seals, gaskets, etc. **DO NOT** over-stretch seals, wipers and O-rings. After installing such parts, verify that they are not twisted in their grooves.
5. To aid in installation, lubricate piston seals and the seal installation path with clean, filtered hydraulic oil.
6. Lubricate the outer surfaces of the seals and O-rings and the inside of the tube, piston and head gland with clean hydraulic oil from a filtered source. Use a suitable installation or compression tool when installing the piston and head gland into the cylinder to help prevent twisting or damaging the seals and O-rings. When sliding the rod and piston assembly in the tube, **DO NOT** damage the piston by scraping it against the threads in the tube. Keep the rod in line with the tube to prevent binding.
7. Follow the manufacturer's instructions when applying primer, locking or retaining compounds that are specified in the cylinder assembly procedures. The use of primer is recommended in some cases to decrease cure time. Allow sealant to cure fully before proceeding with the assembly procedure. The curing process may be hastened by the use of a heat gun to blow warm, dry air on the parts.
8. After assembling a cylinder, test the cylinder at low operating pressures. Verify that the piston and rod move freely in both directions.
9. Increase the operating pressure to the maximum pressure recommended for the cylinder. Check for external leakage and for free movement in both directions.
10. Retracting the piston fully. Cap the hydraulic fittings.

9.10.1 Attachment Tilt Cylinder

The attachment tilt cylinder (Fig. 9–64) is attached at the front of the inner boom inside the gooseneck.

a. Attachment Tilt Cylinder Removal

1. Park the vehicle on a firm, level surface, fully retract all hydraulic cylinders, ground and remove the attachment. Allow sufficient work space at the front of the boom. Raise the boom enough to allow the quick attach or the bottom of the gooseneck to clear the ground. Place the travel select lever in NEUTRAL (N), engage the park brake switch and shut the engine OFF.

WARNING: Hot hydraulic fluid can cause severe burns. Wait for hydraulic fluid to cool before servicing any hydraulic component.

2. Unlatch, unlock and open the engine cover. Allow the hydraulic fluid to cool.

WARNING: Escaping hydraulic fluid under pressure can penetrate the skin, causing serious injury. Relieve hydraulic pressure before servicing any hydraulic component.

3. Label or otherwise mark the hydraulic hoses in relation to the attachment tilt cylinder. Disconnect and cap both hoses and attachment tilt cylinder fittings. Refer to *Section 3 Boom* as required.
4. Unbolt the lower pivot pin.
5. Screw an eyelet, hook, or other suitable fastener into the tapped hole on top of the attachment tilt cylinder. Make sure the device used can actually support the cylinder. Attach a suitable sling to an overhead crane or other appropriate lifting device and to the attachment tilt cylinder at the eyelet or hook.
6. Remove the two 2" external retaining rings securing the attachment tilt cylinder base pin to the boom.
7. Remove the attachment tilt cylinder base pin by tapping it out through the top of the gooseneck.
8. Remove the lower attachment tilt cylinder pin by tapping it out through the bottom of the quick attach (if installed).
9. Remove the attachment tilt cylinder from the vehicle. Wipe up any hydraulic fluid spillage in, on, near or around the vehicle.

b. Attachment Tilt Cylinder Disassembly

Note: An additional O-ring may be included at the base of the cylinder rod. This additional O-ring may be discarded, as it served only in a temporarily protective role to keep paint off the rod while the cylinder was painted at the factory.

1. Clean the attachment tilt cylinder (Fig. 9–64) with a suitable cleaner before inspection.
2. Place the attachment tilt cylinder in a soft-jawed vise or other acceptable holding equipment if possible. **DO NOT** damage the tube. If necessary, remove the grease fitting from the end of the rod weldment (18).

Note: Significant pressure may be trapped inside the cylinder. Exercise caution when removing the counterbalance valves (2) from the cylinder.

3. Remove the two 4000 psi (276 bar) counterbalance valves (2) from the attachment tilt cylinder.
4. Extend the rod weldment (18) to allow access to the base of the cylinder.
5. Using a pin spanner wrench, unscrew the head gland (14) from the tube (3). The gland was originally torqued to 300-400 lb/ft (407-542 Nm), so a considerable amount of force is required to remove it. Slide the gland down along the rod toward the eyelet end, away from the cylinder tube (3).

IMPORTANT: Protect the finish on the rod at all times. Damage to the surface of the rod can cause seal failure.

6. Carefully pull the rod (18) along with the head gland and all attachments straight out of the tube (3).

IMPORTANT: When sliding the rod and piston assembly in the tube, prevent the threaded end of the tube from damaging the piston (6). Keep the rod centered within the tube to help prevent binding.

7. Fasten the eye of the rod in a soft-jawed vise and put a padded support below and near the threaded end of the rod to help prevent damage to the rod.
8. Remove the 1.50-12 NF lock nut (4) from the rod (18). The lock nut is a deformed-thread type nut torqued at 1100-1250 lb/ft (1492-1695 Nm).

Note: It may be necessary to apply heat to break the bond of the sealant between the 1.50-12 NF lock nut (4) and the rod (18) before the piston (6) can be removed. Some parts of cylinders are sealed with a special organic sealant and locking compound. Before attempting to disassemble these parts, remove any accessible seals from the area of the bonded joint. Wipe off any hydraulic oil and heat the joint uniformly to break the bond. A temperature of 300° to 400° F (149° to 204° C) will destroy the bond. Avoid overheating or the parts may become distorted or damaged. Apply sufficient torque or pressure for removal while the parts are still hot. Breakdown of sealant will leave a white, powdery residue on threads and parts. Clean the residue away with a soft brass wire brush prior to reassembly, and wipe with Loctite "T" cleaner before reinstallation.

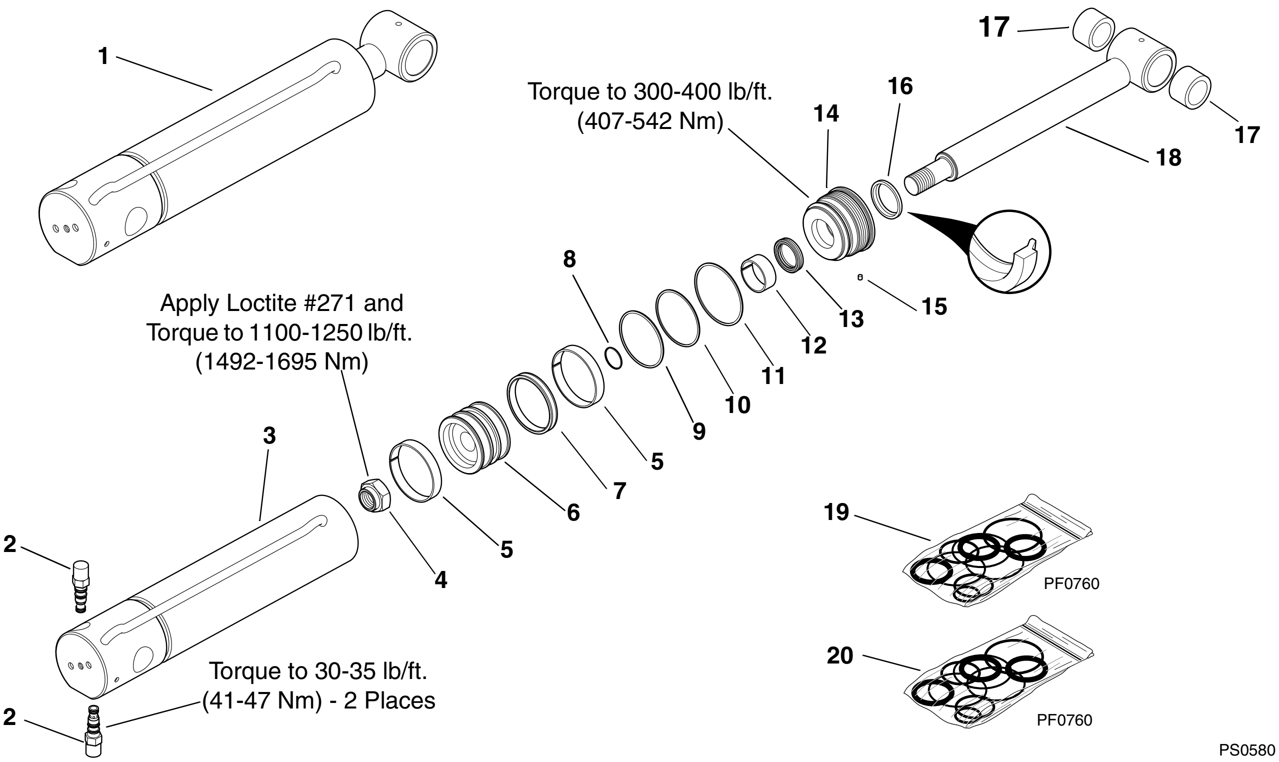


Figure 9–64. Attachment tilt cylinder.

Attachment Tilt Cylinder Legend

1. Attachment Tilt Cylinder w/Bushings (includes items 2 through 18)
2. Counterbalance Valve - Set at 4000 psi (276 bar)
3. Tube
4. Lock Nut, 1.50-12 NF
5. Precision Wearband
6. Piston
7. Capped T-Seal, Type 730
8. O-Ring
9. O-Ring
10. Backup Ring
11. O-Ring
12. Precision Wearband
13. Deep Z-Seal with Rod Backup
14. Head Gland
15. Locking Insert
16. HD Rod Wiper, Sealed OD
17. Bushing
18. Rod Weldment

KITS

19. Seal Kit (includes items 5, 7-13 & 15-16)
20. Seal Kit (for item 2)

9. Remove the piston (6) and the head gland (14) from the rod (18).
10. Remove the O-ring (9), back-up ring (10), O-ring (11), precision wearband (12) and deep Z-seal with rod backup (13) from the head gland (14).
11. Remove the locking insert (15) from its hole in the head gland threads. Pry or drill out the insert as required. **DO NOT** damage the head gland threads. A new locking insert will be required for reassembly.
12. Remove both precision wearbands (5) and the Type 730 capped T-seal (7) from the piston (6).

Note: The T-seal actually consists of four components; a wide, flexible inner band, the flexible T-seal band itself, and two supportive split caps that mount on either side of the “T” itself.

13. Remove the sealed outside diameter heavy-duty rod wiper (16) from the head gland (14).
14. Remove the small O-ring (8) from within the piston (6).
15. If the bushings (17) need replacement, support the rod (18) in a soft-jawed vise or other suitable holding device. Carefully press the bushings from the rod.

c. Attachment Tilt Cylinder Cleaning

1. Thoroughly clean the inner surface of the attachment tilt cylinder (Fig. 9–64) with trichlorethylene or another approved cleaner.
2. Discard all seals, backup rings and O-rings. Replace with new items from a complete seal kit to help ensure proper cylinder function.
3. Clean all metal parts with an approved cleaning solvent such as trichlorethylene. Carefully clean cavities, grooves, threads, etc.

Note: If a white, powdery residue is present on threads and parts, it can be removed. Clean the residue away with a soft brass wire brush prior to reassembly, and wipe with Loctite "T" cleaner before reinstallation.

d. Attachment Tilt Cylinder Inspection

1. Inspect internal surfaces and all parts for wear, damage, etc. If inner surface of the tube (3, Fig. 9–64) does not display a smooth finish, or is scored or damaged in any way, replace the tube. Most often, dirty hydraulic fluid causes failure of internal seals and damage to the smooth surface within the tube. Remove slight scratches on the piston, rod, or inner surface of the tube with very fine grit emery cloth. Use the emery cloth in a rotary motion to polish out and blend the scratch(es) into the surrounding surface.
2. Inspect all other components for wear, damage, etc. Clean parts with trichlorethylene.
3. Check that the rod (18) is straight. If it is bent, a new rod must be installed.

e. Attachment Tilt Cylinder Assembly

Note: Follow *Section 9.10 c. General Cylinder Assembly Instructions*.

1. If the bushings (17, Fig. 9–64) need replacement, support the rod (18) in a soft-jawed vise or other suitable holding device. Carefully press the bushings into the rod eyelet. Install the grease fittings and lubricate with multi-purpose grease after installing the attachment tilt cylinder onto the inner boom.
2. Install the small O-ring (8) into the rod-end of the piston (6).

IMPORTANT: Install the sealed outside diameter heavy-duty rod wiper (16) into the outside end of the head gland (14).

3. Install both precision wearbands (5) and the Type 730 capped T-seal (7) onto the piston (6).

Note: The T-seal actually consists of four components; a wide, flexible inner band, the flexible T-seal band itself, and two supportive split caps that mount on either side of the "T" itself.

4. Install the O-ring (9), back-up ring (10), O-ring (11), precision wearband (12) and deep Z-seal with rod backup (13) onto the head gland (14).
5. Install the head gland (14) and piston (6) onto the rod weldment (18).

IMPORTANT: When sliding the rod and piston assembly in the tube, prevent the threaded end of the tube from damaging the piston (6). Keep the rod centered within the tube to help prevent binding.

6. Place the attachment tilt cylinder in a soft-jawed vise or other acceptable holding equipment if possible. **DO NOT** damage the tube. Carefully insert the rod (18) with all attachments straight into the tube (3).

IMPORTANT: Protect the finish on the rod at all times. Damage to the surface of the rod can cause seal failure.

7. Fasten the eye of the rod in a soft-jawed vise and put a padded support below and near the threaded end of the rod to help prevent damage to the rod.Apply Loctite #271 (red) and install the 1.50-12 NF lock nut (4) onto the rod (18). Torque the nut to 1100-1250 lb/ft (1492-1695 Nm). The threads will deform upon tightening, locking the nut in place.
8. Using a pin spanner wrench, thread the head gland (14) almost completely into the tube (3), leaving just enough room to install a new locking insert (15) into its hole in the head gland threads.
9. Install a new locking insert (15). Thread the head gland tightly into the tube and torque to 300-400 lb/ft (407-542 Nm).
10. Thread the two 4000 psi (276 bar) counterbalance valves (2) into the attachment tilt cylinder. Torque to 30-35 lb/ft (41-47 Nm).
11. If necessary, install a grease fitting into the tapped hole in the end of the rod weldment (18). Lubricate the bearings in the rod end through the grease fitting with multi-purpose grease before the vehicle is operated.

f. Attachment Tilt Cylinder Installation

1. Screw an eyelet, hook, or other suitable fastener into the tapped hole on top of the attachment tilt cylinder (Fig. 9–64). Make sure the device used can actually support the cylinder. Attach a suitable sling to an overhead crane or other suitable device and to the attachment tilt cylinder at the eyelet or hook. Place the attachment tilt cylinder in position within the gooseneck. Refer to *Section 3 Boom* as required.

2. Install the lower attachment tilt cylinder pin by tapping it out through the bottom of the quick attach (if installed).
3. Coat the attachment tilt cylinder base pin with anti-seize compound and install the pin by tapping it in through the top of the gooseneck.
4. Secure the attachment tilt cylinder base pin to the boom with two 2" external retaining rings.
5. Install the lower pivot pin and quick attach as required.
6. Connect the attachment tilt cylinder hydraulic hoses in relation to the labels or markings made during removal.

WARNING: Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

7. Start the engine and run at approximately one-third to one-half throttle for about one minute without moving the vehicle or operating any hydraulic functions.
8. Inspect for leaks and check the level of the hydraulic fluid in the reservoir. Add hydraulic fluid to the reservoir as needed. Shut the engine OFF.
9. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle, work area and tools.
10. Conduct a pressure check of the attachment tilt cylinder hydraulic circuit and bleed the circuit as outlined below.

g. Attachment Tilt Cylinder Pressure Checking and Circuit Bleeding

1. Attach a 4000 psi (276 bar) gauge to the main control valve at the extend base port relief to test the attachment tilt cylinder hydraulic system circuit pressure. The unit is equipped with test fittings from the factory. Pressure readings should be 3200 psi ± 100 psi (220,6 ± 7 bar).
2. With no accessory installed on the quick attach, start with the hoist and fork tilt cylinders fully retracted.
3. Fully extend the fork tilt cylinder. Hold the fork tilt joystick at full extend while fully raising the hoist cylinder.
4. Fully retract the fork tilt cylinder. Hold the fork tilt joystick at full retract while fully retracting the hoist cylinder.
5. Repeat steps 3 and 4 five times.

9.10.2 Slave Cylinders

Each slave cylinder (Fig. 9–65) is secured to the vehicle frame and outer boom with cylinder mount pins, hex-head capscrews and nuts.

a. Slave Cylinder Removal

Note: An additional O-ring may be included at the base of the cylinder rod. This additional O-ring may be discarded, as it served only in a temporarily protective role to keep paint off the rod while the cylinder was painted at the factory.

1. Park the vehicle on a firm, level surface, fully retract all hydraulic cylinders, then raise the boom to approximately a 30-degree angle. Place the travel select lever in NEUTRAL (N), engage the park brake switch and shut the engine OFF.

WARNING: Hot hydraulic fluid can cause severe burns. Wait for hydraulic fluid to cool before servicing any hydraulic component.

2. Unlatch, unlock and open the engine cover. Allow the hydraulic fluid to cool.

WARNING: Escaping hydraulic fluid under pressure can penetrate the skin, causing serious injury. Relieve hydraulic pressure before servicing any hydraulic component.

3. Label or otherwise mark the hydraulic hoses in relation to the slave cylinder being removed. Disconnect and cap the hydraulic hoses and slave cylinder fittings.
4. Securely support the slave cylinder. Remove the nuts, hex-head capscrews and cylinder pins securing the slave cylinder to the vehicle frame and outer boom. Refer to *Section 3.2.3 A. Outer Boom Removal* as required.
5. With the help of at least one assistant, remove the slave cylinder from the vehicle. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle.

b. Slave Cylinder Disassembly

1. Clean the slave cylinder (Fig. 9–65) with a suitable cleaner before inspection.
2. Place the slave cylinder in a soft-jawed vise or other acceptable holding equipment if possible. **DO NOT** damage the tube. If necessary, remove the grease fitting from the end of the rod weldment (15).
3. Extend the rod weldment (15) to allow access to the base of the cylinder.

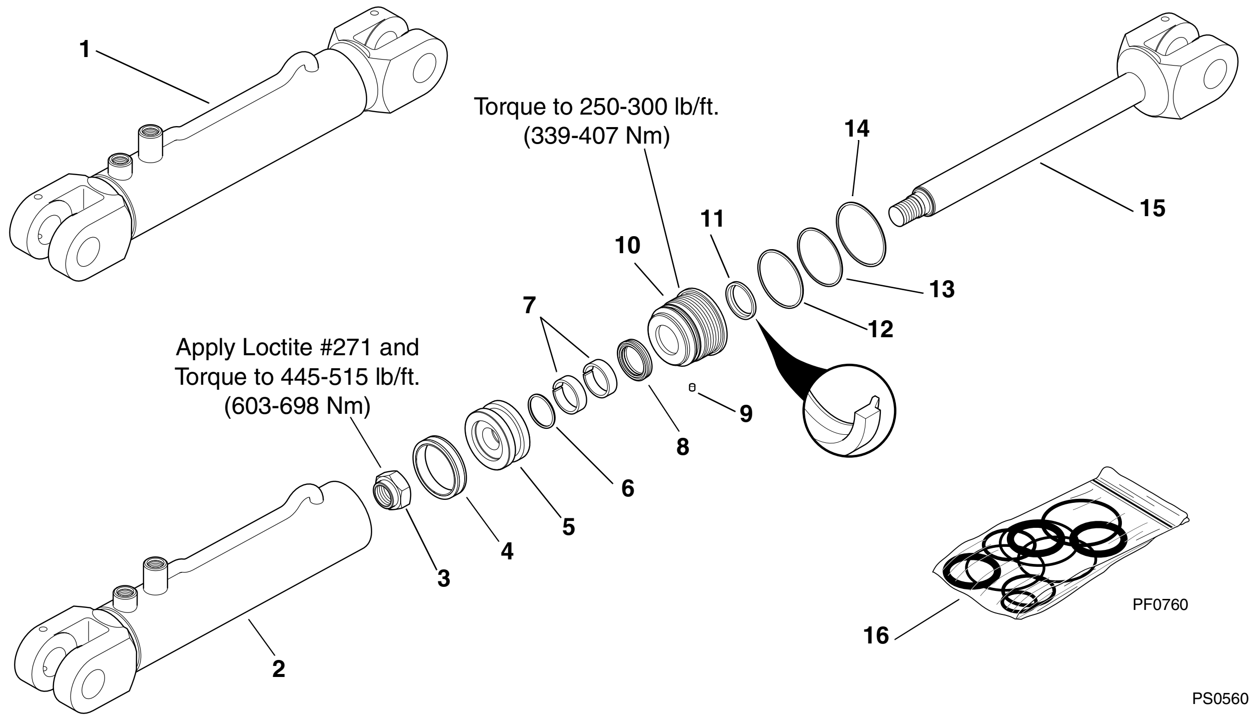


Figure 9–65. Slave cylinder exploded view drawing.

Slave Cylinder Legend

1. Slave Cylinder (includes items 2 through 15)
2. Tube
3. Lock Nut, 1.125 - 12 NF
4. Capped T-Seal
5. Piston
6. O-Ring
7. Precision Wearband
8. Deep Z-Seal with Rod Backup
9. Locking Insert
10. Head Gland
11. Heavy-duty Rod Wiper, Sealed OD
12. O-Ring
13. Backup Ring
14. O-Ring
15. Weldment Rod

KITS

16. Seal Kit (includes items 4, 6-9 & 11-14)

4. Using a pin spanner wrench, unscrew the head gland (10) from the tube (2). The gland was originally torqued at 250-300 lb/ft (339-407 Nm). Slide the gland down along the rod toward the eyelet end, away from the cylinder tube (2).

IMPORTANT: Protect the finish on the rod at all times. Damage to the surface of the rod can cause seal failure.

5. Carefully pull the rod (15) with all attachments straight out of the tube (2).

IMPORTANT: When sliding the rod and piston assembly in the tube, prevent the threaded end of the tube from damaging the piston (5). Keep the rod centered within the tube to help prevent binding.

6. Fasten the eye of the rod in a soft-jawed vise and put a padded support below and near the threaded end of the rod to help prevent damage to the rod.
7. Remove the O-ring (12), back-up ring (13), O-ring (14), precision wearband (12) and deep Z-seal with rod backup (13) from the head gland (10).
8. Remove the locking insert (15) from its hole in the head gland threads. Pry or drill out the insert as required. **DO NOT** damage the head gland threads. A new locking insert will be required for reassembly.

9. Remove the capped T-seal (4) from the piston (5).

Note: The T-seal actually consists of four components; a wide, flexible inner band, the flexible T-seal band itself, and two supportive split caps that mount on either side of the “T” itself.

c. Slave Cylinder Cleaning

1. Remove all hydraulic fluid, dirt and debris from the inner surface of the cylinder.
2. Discard all seals, backup rings and O-rings. Replace with new items from a complete seal kit to help ensure proper cylinder function.
3. Clean all metal parts with an approved cleaning solvent such as trichlorethylene. Carefully clean cavities, grooves, threads, etc.

Note: If a white, powdery residue is present on threads and parts, it can be removed. Clean the residue away with a soft brass wire brush prior to reassembly, and wipe with Loctite “T” cleaner before reinstallation.

4. Remove the 1.125-12 NF lock nut (3, Fig. 9–65) from the rod (15). The deforming-thread type nut was coated with Loctite #271 (red) and torqued to 445-515 lb/ft (603-698 Nm). Discard the nut.

Note: It may be necessary to apply heat to break the bond of the sealant between the 1.125-12 NF lock nut (3) and the rod (15) before the piston (5) can be removed. Some parts of cylinders are sealed with a special organic sealant and locking compound. Before attempting to disassemble these parts, remove any accessible seals from the area of the bonded joint. Wipe off any hydraulic oil and heat the joint uniformly to break the bond. A temperature of 300° to 400° F (149° to 204° C) will destroy the bond. Avoid overheating or the parts may become distorted or damaged. Apply sufficient torque or pressure for removal while the parts are still hot. Breakdown of sealant will leave a white, powdery residue on threads and parts. Clean the residue away with a soft brass wire brush prior to reassembly, and wipe with Loctite “T” cleaner before reinstallation.

5. Remove the piston (5) and head gland (10) from the rod (15).
6. From within the head gland (10), remove the precision wearband (7), the deep Z-seal with backup (8), and the sealed outside diameter heavy-duty rod wiper (11).
7. From within the piston (5), remove the precision wearband (7) and the small O-ring (8).

d. Slave Cylinder Inspection

1. Inspect internal surfaces and all parts for wear, damage, etc. If inner surface of the tube (2, Fig. 9–65) does not display a smooth finish, or is scored or damaged in any way, replace the tube. Most often, dirty hydraulic fluid causes failure of internal seals and damage to the smooth surface within the tube. Remove slight scratches on the piston, rod, or inner surface of the tube with very fine grit emery cloth. Use the emery cloth in a rotary motion to polish out and blend the scratch(es) into the surrounding surface.
2. Clean parts with trichlorethylene.
3. Check that the rod (15) is straight. If it is bent, install a new rod.

e. Slave Cylinder Assembly

Note: Follow *Section 9.10 c. General Cylinder Assembly Instructions*.

IMPORTANT: Use a suitable installation tool or compression sleeve to help prevent twisting or damaging the seals and O-rings when installing the piston and head gland into the cylinder. When sliding the rod and piston assembly in the tube, **DO NOT** damage the piston by scraping it against the threads in the tube. Keep the rod in line with the tube to prevent binding.

1. Fasten the eye of the rod in a soft-jawed vise and put a padded support below and near the threaded end of the rod to help prevent damage to the rod.
2. Within the piston (5), install the small O-ring (6, Fig. 9–65) and the precision wearband (7).
3. From within the head gland (10), install the sealed outside diameter heavy-duty rod wiper (11), the deep Z-seal with backup (8), and the precision wearband (7).
4. Carefully install the piston (5) and head gland (10) onto the rod (15).

IMPORTANT: When sliding the rod and piston assembly in the tube, prevent the threaded end of the tube from damaging the piston (5). Keep the rod centered within the tube to help prevent binding.

Note: If a white, powdery residue remains on the threads and parts, clean the residue away with a soft brass wire brush prior to reassembly, and wipe with Loctite “T” cleaner before proceeding.

5. Apply Loctite Threadlocker #271 (red) to the 1.125-12 NF lock nut (3). Thread the lock nut onto the rod (15) and torque to 445-515 lb/ft (603-698 Nm). The threads will deform upon tightening, locking the nut in place.

6. Install the capped T-seal (4) onto the piston (5).

Note: The T-seal actually consists of four components; a wide, flexible inner band, the flexible T-seal band itself, and two supportive split caps that mount on either side of the “T” itself.

7. Install the deep Z-seal with rod backup (13), precision wearband (7), O-ring (14), back-up ring (13), and O-ring (12) onto the head gland (10).
8. Carefully insert the rod (15) with all attachments straight into the tube (2).

IMPORTANT: When sliding the rod and piston assembly in the tube, prevent the threaded end of the tube from damaging the piston (5). Keep the rod centered within the tube to help prevent binding. Protect the finish on the rod at all times. Damage to the surface of the rod can cause seal failure.

9. Install the locking insert (9) into its hole in the head gland threads.
10. Using a pin spanner wrench, thread the head gland (10) into the tube (2). Torque to 250-300 lb/ft (339-407 Nm).

f. Slave Cylinder Installation

1. Align the slave cylinder with its mounting bosses within the rear frame uprights.
2. Align the mount pin bolt holes with the slave cylinder mount holes. Align the self-aligning bearing. Secure the slave cylinder with the cylinder pins, hex-head capscrews and nuts. Torque the hex-head capscrews and nuts to specification. Refer to the fastener torque chart in *Section 2 General Information, Specifications and Maintenance Instructions*.
3. Use new O-rings and reattach and secure the hydraulic hoses to the slave cylinder fittings.

> **WARNING:** Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

4. Start and run the engine at approximately one-third to one-half throttle for about one minute without moving the vehicle or operating any hydraulic functions.
5. Inspect for leaks and check the level of the hydraulic fluid in the reservoir. Shut the engine OFF.

Note: Check for leaks and repair as required before continuing. Add hydraulic fluid to the reservoir as needed.

6. Conduct a pressure check of the attachment tilt/slave cylinder hydraulic circuit.
7. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle, work area and tools.
8. Conduct a pressure check of the attachment tilt cylinder hydraulic circuit and bleed the circuit as outlined below.

g. Slave Cylinder Pressure Checking and Circuit Bleeding

1. Attach a 4000 psi (276 bar) gauge to the main control valve at the fork tilt port to test the fork tilt and slave cylinder hydraulic system circuit pressure. The unit is equipped with test fittings from the factory. Pressure readings should be 3700 psi ± 100 psi (255 ± 7 bar).
2. With no accessory installed on the quick attach, start with the hoist and fork tilt cylinders fully retracted.
3. Fully extend the fork tilt cylinder. Monitor pressure while fully raising the hoist cylinder.
4. Fully retract the fork tilt cylinder. Monitor pressure while fully retracting the hoist cylinder.
5. Repeat steps 3 and 4 five times.

9.10.3 Extend/Retract Cylinder

The extend/retract cylinder (Fig. 9–66) is located within the inner boom.

a. Extend/Retract Cylinder Removal

Procedures for replacing the extend/retract cylinder appear in *Section 3.2.1 Inner Boom Replacement*.

b. Extend/Retract Cylinder Disassembly

Note: An additional O-ring may be included at the base of the cylinder rod. This additional O-ring may be discarded, as it served only in a temporarily protective role to keep paint off the rod while the cylinder was painted at the factory.

1. Clean the extend/retract cylinder (Fig. 9–66) with a suitable cleaner. Remove all dirt, debris and grease from the cylinder.
2. Secure the extend/retract cylinder in a soft-jawed vise or other acceptable holding equipment if possible. **DO NOT** damage the tube (19).

Note: Significant pressure may be trapped inside the cylinder. Exercise caution when removing the counterbalance valves (18) from the cylinder.

3. Remove both counterbalance valves (18) from the rod weldment (17).

IMPORTANT: DO NOT tamper with or attempt to reset the counterbalance valve cartridges. If adjustment or replacement is necessary, replace a counterbalance valve with a new one.

4. Extend the rod weldment (17, Fig. 9–66) as required to allow access to the base of the cylinder.
5. Using a pin spanner wrench, unscrew the head gland (14) from the tube (19). The gland was originally torqued to 250-300 lb/ft (339-407 Nm), so a considerable amount of force is required. Slide the gland down along the rod toward the eyelet end, away from the cylinder tube (19).

IMPORTANT: Protect the finish on the rod at all times. Damage to the surface of the rod can cause seal failure.

6. Carefully pull the rod (17) with all attachments straight out of the tube (19).

IMPORTANT: When sliding the rod and piston assembly in the tube, prevent the threaded end of the tube from damaging the piston (4). Keep the rod centered within the tube to help prevent binding.

7. Fasten the rear of the rod in a soft-jawed vise and put a padded support below and near the threaded end of the rod to help prevent damage to the rod.
8. Remove the locking insert (15) from its hole in the head gland threads. Pry or drill out the insert as required. **DO NOT** damage the head gland threads. A new locking insert will be required for reassembly.
9. Remove the 5/16-18 UNC x 0.63 set screw (5) from the piston (4). The set screw is used to provide a secondary lock on the piston.
10. Remove the piston (4) from the rod spacer (8) and rod weldment (17). The piston was installed with Loctite #271 (red) and torqued to 1500-1700 lb/ft (2034-2305 Nm).

Note: It may be necessary to apply heat to break the bond of the sealant between piston (4) and the rod (17) before the piston can be removed. Some parts of cylinders are sealed with a special organic sealant and locking compound. Before attempting to disassemble these parts, remove any accessible seals from the area of the bonded joint. Wipe off any hydraulic oil and heat the joint uniformly to break the bond. A temperature of 300° to 400° F (149° to 204° C) will destroy the bond. Avoid overheating or the parts may become distorted or damaged. Apply sufficient torque or pressure for removal while the parts are still hot. Breakdown of sealant will leave a white, powdery residue on threads and parts. Clean the residue away with a soft brass wire brush prior to reassembly, and wipe with Loctite T cleaner before reinstallation.

11. Remove the rod spacer (8).
12. Remove both precision wearbands (6) and the capped T-seal (7) from the piston (4).

Note: The T-seal actually consists of four components; a wide, flexible inner band, the flexible T-seal band itself, and two supportive split caps that mount on either side of the “T” itself.

13. Remove the O-ring (9), backup ring (10) and O-ring (11) from the head gland (14). Slide the rings over the rod spacer (8) and piston (4) to remove them from the rod weldment (17).
14. Remove the precision wearband (12) and deep Z-seal with rod backup (13) from the head gland (14).
15. From within the head gland (14), remove the precision wearbands (12), the deep Z-seal with backup (13), and, from the other end, remove the sealed outside diameter heavy-duty rod wiper (16).
16. From within the piston (4), remove the hytrel backup rings (2) and the small O-ring (3).

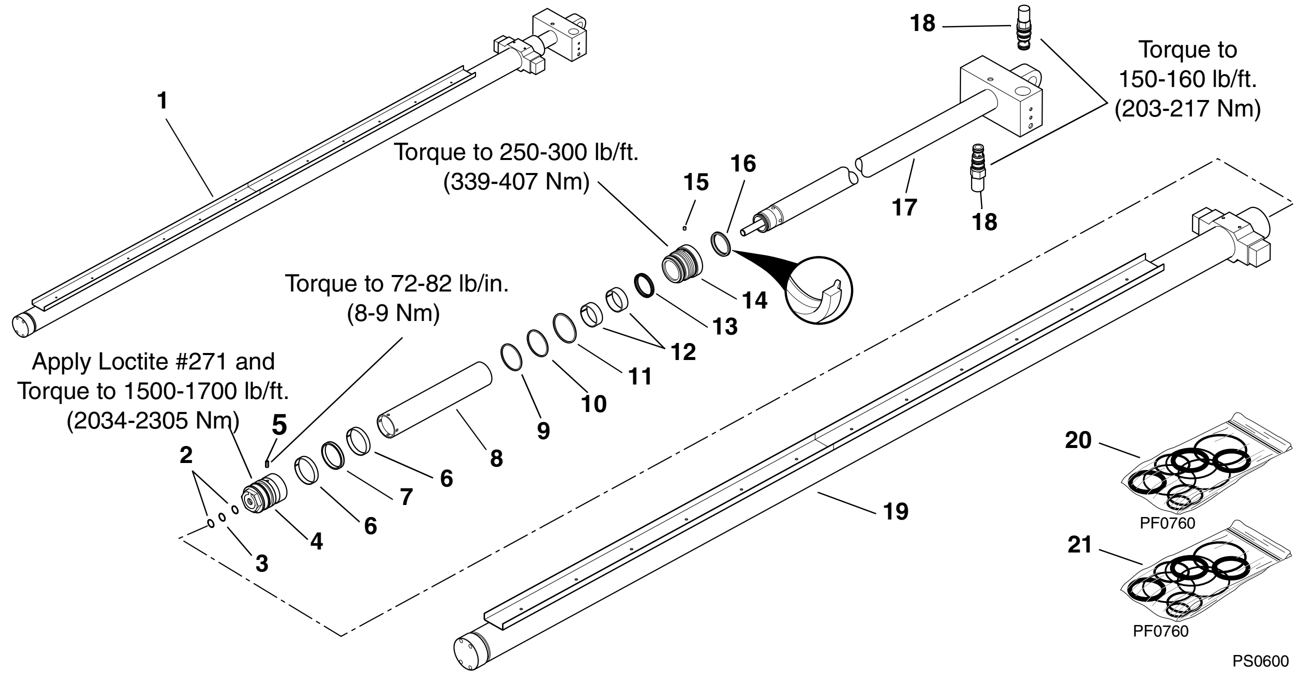


Figure 9–66. Extend/retract cylinder.

Extend/Retract Cylinder Legend

1. Extend/Retract Cylinder (includes items 2 through 19)
2. Hytrel Backup Ring
3. O-Ring
4. Piston
5. Setscrew, 5/16-18 UNC x 0.63”
6. Precision Wearband
7. Capped T-Seal, Type 730
8. Rod Spacer
9. O-Ring
10. Backup Ring
11. O-Ring
12. Precision Wearband
13. Deep Z-Seal with Rod Backup
14. Head Gland
15. Locking Insert
16. Heavy-duty Rod Wiper, Sealed OD
17. Weldment Rod
18. Counterbalance Valve, set at 4000 psi (276 bar)
19. Tube

KITS

20. Seal Kit (includes items 2, 3, 6, 7, 9-13, 15, 16)
21. Seal Kit (for item 18)

c. Extend/Retract Cylinder Cleaning

1. Remove all hydraulic fluid, dirt and debris from the inner surface of the cylinder tube (19, Fig. 9–66).
2. Discard all seals, backup rings, O-rings, etc. Replace with new items from a complete seal kit to help ensure proper cylinder function.
3. Clean all metal parts with an approved cleaning solvent such as trichlorethylene. Carefully clean cavities, grooves, threads, etc.

Note: If a white, powdery residue is present on threads and parts, it can be removed. Clean the residue away with a soft brass wire brush prior to reassembly, and wipe with Loctite “T” cleaner before reinstallation.

d. Extend/Retract Cylinder Inspection

1. Inspect internal surfaces and all parts for wear, damage, etc. If the inner surface of the tube (19, Fig. 9–66) does not display a smooth finish, or is scored or damaged in any way, replace the tube. Most often, dirty hydraulic fluid causes failure of internal seals and damage to the smooth surface within the tube. Remove slight scratches on the piston, rod, or inner surface of the tube with very fine grit emery cloth. Use the emery cloth in a rotary motion to polish out and blend the scratch(es) into the surrounding surface.

2. Clean parts with trichlorethylene.
3. Check that the rod (17) is straight. If it is bent, install a new rod.

e. Extend/Retract Cylinder Assembly

Note: Follow *Section 9.10 c. General Cylinder Assembly Instructions*.

1. Install a new hytrel backup ring (2, Fig. 9–66), small O-ring (3) and another hytrel backup ring (2) into forward end of the piston (4).
2. Install the capped T-seal (7) and both precision wearbands (6) onto the piston (4).

Note: The T-seal actually consists of four components; a wide, flexible inner band, the flexible T-seal band itself, and two supportive split caps that mount on either side of the “T” itself.

3. Install the precision wearbands (12) and the deep Z-seal with backup (13) into the front end of the head gland (14), and, at the rear end, install the sealed outside diameter heavy-duty rod wiper (16).
4. Install a new O-ring (7), backup ring (10) and O-ring (11) onto the head gland (14).
5. Fasten the rear of the rod in a soft-jawed vise and put a padded support below and near the threaded end of the rod to help prevent damage to the rod.
6. Carefully slide the head gland (14), then the rod spacer (8) onto the rod weldment (17).
7. Carefully slide the piston (4) onto the rod spacer (8) and weldment (17). Apply Loctite Threadlocker #271 (red) and torque the piston to 1500-1700 lb/ft (2034-2305 Nm).
8. Turn the rod spacer (8) as required to align the piston set screw holes. The set screw is used to provide a secondary lock on the piston. Thread the 5/16-18 UNC x 0.63 set screw (5) into the piston (4). Torque the set screw to 72-82 lb/in (8-9 Nm).
9. Install a new locking insert (15) into its hole in the head gland threads.
10. Secure the extend/retract cylinder in a soft-jawed vise or other acceptable holding equipment if possible. **DO NOT** damage the tube (19).
11. Lubricate the inside of the tube (19) and outside of the piston (4) and head gland (14) with clean, filtered hydraulic oil.
12. Apply a compression sleeve or other suitable tool to the head and piston in order to compress the O-rings, backup rings and seals while inserting the assembled piston, rod and head into the tube (19). Carefully insert the rod (17) with all attachments straight into the tube (19).

IMPORTANT: When sliding the rod (17) and piston assembly in the tube, prevent the threaded end of the tube from damaging the piston (4). Keep the rod centered within the tube to help prevent binding. Protect the finish on the rod at all times. Damage to the surface of the rod can cause seal failure.

13. Using a pin spanner wrench, thread the head gland (14) into the tube (19). Torque the gland to 250-300 lb/ft (339-407 Nm).
14. Lubricate the counterbalance valves (18) with clean, filtered hydraulic oil. Thread both counterbalance valves into the rod weldment (17). Torque to 150-160 lb/ft (203-217 Nm).

IMPORTANT: DO NOT tamper with or attempt to reset the counterbalance valve cartridges. If adjustment or replacement is necessary, replace a counterbalance valve with a new one.

15. Test the cylinder at low operating pressure (100 psi or 6,9 bar). Verify that the piston and the rod move freely in both directions.
16. Increase the operating pressure to the maximum amount for the cylinder (4000 or 275 bar) and again check for free movement in both directions.
17. Retract the rod fully into the tube and cap and plug the hydraulic hose ports.

f. Extend/Retract Cylinder Installation

Installation procedures are covered in *Section 3.2.1 Inner Boom Replacement.*

g. Extend/Retract Cylinder Pressure Checking and Circuit Bleeding

1. Attach a 4000 psi (276 bar) gauge to the main control valve at the extend base port relief to test the extend/retract cylinder hydraulic system circuit pressure. The unit is equipped with test fittings from the factory. Pressure readings should be 3200 psi ± 100 psi (220,6 ± 7 bar).
2. With no accessory installed on the quick attach, start with the hoist and fork tilt cylinders fully retracted.
3. Fully extend the extend/retract cylinder. Hold the joystick at full extend while fully raising the hoist cylinder.
4. Fully retract the fork tilt cylinder. Hold the fork tilt joystick at full retract while fully retracting the hoist cylinder.
5. Repeat steps 3 and 4 five times.

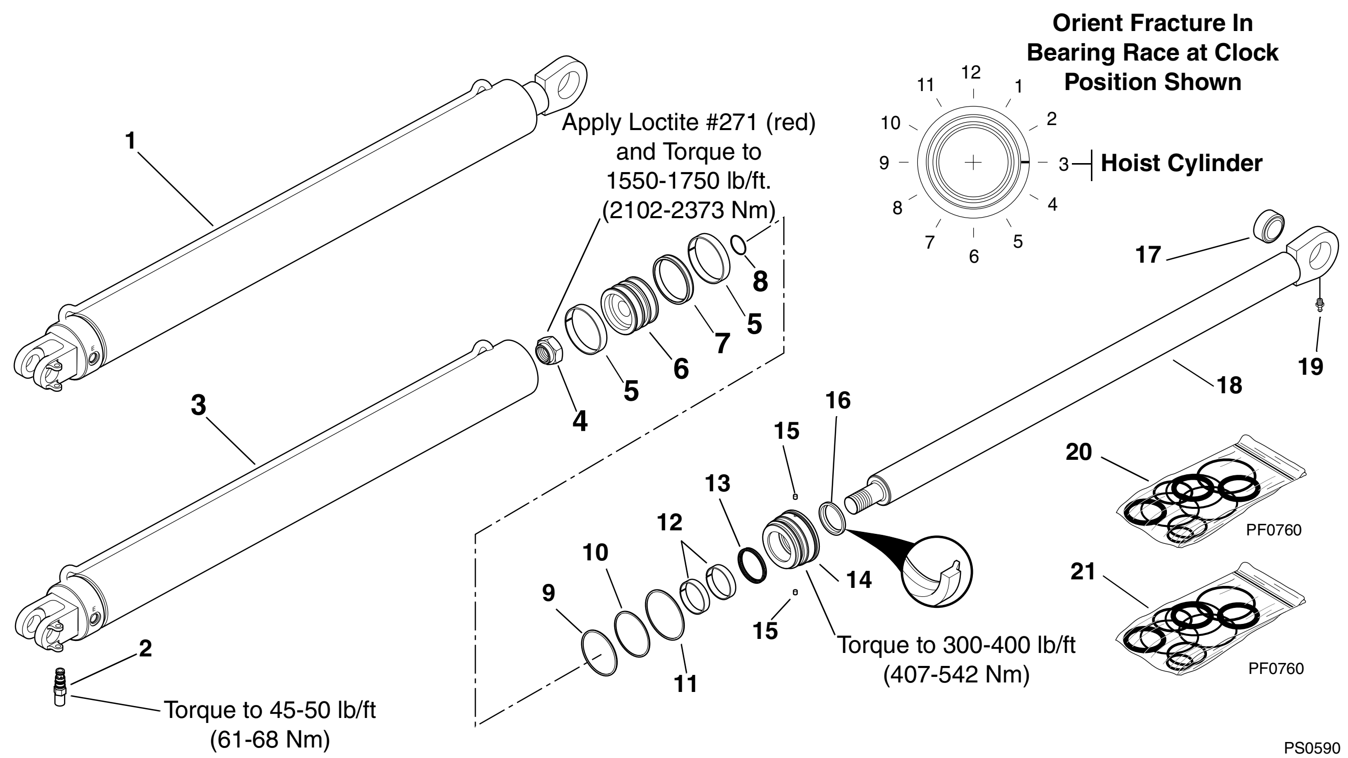


Figure 9–67. Hoist/lower cylinder.

Hoist/Lower Cylinder Legend

1. Hoist/Lower Cylinder with Bearing (includes items 2 through 18)
2. Counterbalance Valve, set at 4000 psi (276 bar)
3. Tube
4. Lock Nut, 2.00 - 12 UN
5. Precision Wearband
6. Piston
7. Capped T-Seal
8. O-Ring
9. O-Ring
10. Backup Ring
11. O-Ring
12. Precision Wearband
13. Deep Z-Seal with Rod Backup
14. Head Gland
15. Locking Insert
16. Heavy-duty Rod Wiper, Sealed OD
17. Self-aligning Bearing
18. Weldment Rod
19. Self-tapping Lube Fitting, 1/8 NPT

KITS

20. Seal Kit (includes items 5, 7-13, & 15, 16)
21. Seal Kit (for item 2).

9.10.4 Hoist/Lower Cylinder

The hoist/lower cylinder (1, Fig. 9–67) is anchored to the underside of the outer boom and to the vehicle frame.

a. Hoist/Lower Cylinder Removal

1. Park the vehicle on a firm, level surface, fully retract all hydraulic cylinders, ground the attachment (if any), place the travel select lever in NEUTRAL (N), engage the park brake switch and shut the engine OFF.

> **WARNING:** Hot hydraulic fluid can cause severe burns. Wait for hydraulic fluid to cool before servicing any hydraulic component.

2. Unlatch, unlock and open the engine cover. Allow the hydraulic fluid to cool.

> **WARNING:** Escaping hydraulic fluid under pressure can penetrate the skin, causing serious injury. Relieve hydraulic pressure before servicing any hydraulic component.

3. Raise and support the boom to allow removal of the hoist/lower cylinder (1, Fig. 9–67). Label or otherwise mark the hoist/lower cylinder hydraulic hoses. Disconnect and cap all hoses and fittings.

4. Attach a sling to the hoist/lower cylinder and to a hoist or an overhead crane. Support the hoist/lower cylinder in the sling, and remove both nuts, capscrews and cylinder mount pins from the cylinder.
5. Safely and carefully, remove the hoist/lower cylinder from the vehicle. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle.

b. Hoist/Lower Cylinder Disassembly

Note: An additional O-ring may be included at the base of the cylinder rod. This additional O-ring may be discarded, as it served only in a temporarily protective role to keep paint off the rod while the cylinder was painted at the factory.

1. Clean the hoist/lower cylinder (1, Fig. 9–67) with a suitable cleaner. Remove all dirt, debris and grease from the cylinder.
2. Secure the hoist/lower cylinder in a soft-jawed vise or other acceptable holding equipment if possible. **DO NOT** damage the tube (3).

Note: Significant pressure may be trapped inside the cylinder. Exercise caution when removing the counter-balance valve (2) from the eyelet end of the tube (3).

3. Remove the counterbalance valve (2) from the eyelet end of the tube (3).

IMPORTANT: DO NOT tamper with or attempt to reset the counterbalance valve cartridge. If adjustment or replacement is necessary, replace the counterbalance valve with a new one.

4. If necessary, remove the grease fitting (19) from the tapped hole in the end of the rod weldment (18).
5. If the self-align bearing (17) needs replacement, support the rod (18) in a soft-jawed vise or other suitable holding device. Carefully press the bearing out of the rod eyelet.
6. Extend the rod weldment (18) as required to allow access to the base of the cylinder.
7. Using a pin spanner wrench, unscrew the head gland (14) from the tube (3). The gland was originally torqued to 300-400 lb/ft (407-542 Nm), so a considerable amount of force is required. Carefully slide the gland down along the rod toward the eyelet end, away from the cylinder tube (3).

IMPORTANT: Protect the finish on the rod at all times. Damage to the surface of the rod can cause seal failure.

8. Carefully pull the rod (18) with all attachments straight out of the tube (3).

IMPORTANT: When sliding the rod and piston assembly in the tube, prevent the threaded end of the tube from damaging the piston (6). Keep the rod centered within the tube to help prevent binding.

9. Fasten the rear of the rod in a soft-jawed vise and put a padded support below and near the threaded end of the rod to help prevent damage to the rod.
10. Remove both locking inserts (15) from their installation holes in the head gland threads. Pry or drill out the inserts as required. **DO NOT** damage the head gland threads. New locking inserts will be required for reassembly.
11. Remove the 2.00-12 UN locknut (4) from the rod weldment (18). The nut was installed with Loctite #271 (red) and torqued to 1550-1750 lb/ft (2102-2373 Nm).

Note: It may be necessary to apply heat to break the bond of the sealant between 2.00-12 UN locknut (4) and the rod (18) before the piston (6) can be removed. Some parts of cylinders are sealed with a special organic sealant and locking compound. Before attempting to disassemble these parts, remove any accessible seals from the area of the bonded joint. Wipe off any hydraulic oil and heat the joint uniformly to break the bond. A temperature of 300° to 400° F (149° to 204° C) will destroy the bond. Avoid overheating or the parts may become distorted or damaged. Apply sufficient torque or pressure for removal while the parts are still hot. Breakdown of sealant will leave a white, powdery residue on threads and parts. Clean the residue away with a soft brass wire brush prior to reassembly, and wipe with Loctite “T” cleaner before reinstallation.

12. Remove the piston (6) from the rod weldment (18).
13. Remove both precision wearbands (5) and the capped T-seal (7) from the piston (6).

Note: The T-seal actually consists of four components; a wide, flexible inner band, the flexible T-seal band itself, and two supportive split caps that mount on either side of the “T” itself.

14. Remove the O-ring (9), backup ring (10) and O-ring (11) from the head gland (14). Slide the rings off over the rod (18) and piston (6) to remove them from the rod weldment (18).
15. From within the head gland (14), remove the precision wearbands (12), the deep Z-seal with backup (13), and, from the other end, remove the sealed outside diameter heavy-duty rod wiper (16).
16. From within the piston (6), remove the small O-ring (8).

c. Hoist/Lower Cylinder Cleaning

1. Remove all hydraulic fluid, dirt and debris from the inner surface of the cylinder tube (3, Fig. 9–67).
2. Discard all seals, backup rings, O-rings, etc. Replace with new items from a complete seal kit to help ensure proper cylinder function.
3. Clean all metal parts with an approved cleaning solvent such as trichlorethylene. Carefully clean cavities, grooves, threads, etc.

Note: If a white, powdery residue is present on threads and parts, it can be removed. Clean the residue away with a soft brass wire brush prior to reassembly, and wipe with Loctite “T” cleaner before reinstallation.

d. Hoist/Lower Cylinder Inspection

1. Inspect internal surfaces and all parts for wear, damage, etc. If inner surface of the tube (3, Fig. 9–67) does not display a smooth finish, or is scored or damaged in any way, replace the tube. Most often, dirty hydraulic fluid causes failure of internal seals and damage to the smooth surface within the tube. Remove slight scratches on the piston, rod, or inner surface of the tube with very fine grit emery cloth. Use the emery cloth in a rotary motion to polish out and blend the scratch(es) into the surrounding surface.
2. Clean parts with trichlorethylene.
3. Check that the rod (18) is straight. If it is bent, install a new rod.

e. Hoist/Lower Cylinder Assembly

Note: Follow *Section 9.12 c. General Assembly Instructions*.

1. Install a new small O-ring (8, Fig. 9–67) into the piston (6).
2. Install the capped T-seal (7) and both precision wearbands (5) onto the piston (6).

Note: The T-seal actually consists of four components; a wide, flexible inner band, the flexible T-seal band itself, and two supportive split caps that mount on either side of the “T” itself.

3. Install the deep Z-seal with backup (13) and the precision wearbands (12) into the forward end of the head gland (14), and, at the rear end, install the sealed outside diameter heavy-duty rod wiper (16).
4. Install a new O-ring (9), backup ring (10) and O-ring (11) onto the head gland (14).
5. Fasten the rear of the rod in a soft-jawed vise and put a padded support below and near the threaded end of the rod to help prevent damage to the rod.
6. Carefully slide the head gland (14) onto the rod weldment (18).
7. Carefully slide the piston (6) onto the rod weldment (18).
8. Apply Loctite Threadlocker #271 (red) to the threads of the 2.00-12 UN locknut (4). Thread the lock nut onto the rod weldment (18). Torque to 1550-1750 lb/ft (2102-2373 Nm). The threads will deform upon tightening, locking the nut in place.
9. Install two new locking inserts (15) into their holes in the head gland threads.
10. Secure the hoist/lower cylinder in a soft-jawed vise or other acceptable holding equipment if possible. **DO NOT** damage the tube (3).
11. Lubricate the inside of the tube (3) and outside of the piston (6) and head gland (14) with clean, filtered hydraulic oil.
12. Apply a compression sleeve or other suitable tool to the head and piston in order to compress the O-rings, backup rings and seals while inserting the assembled piston, rod and head into the tube (3). Carefully insert the rod (18) with all attachments straight into the tube (3).

IMPORTANT: When sliding the rod (18) and piston assembly in the tube, prevent the threaded end of the tube from damaging the piston (6). Keep the rod centered within the tube to help prevent binding. Protect the finish on the rod at all times. Damage to the surface of the rod can cause seal failure.

13. Using a pin spanner wrench, thread the head gland (14) into the tube (3). Torque the gland to 300-400 lb/ft (407-542 Nm).
14. Lubricate the counterbalance valve (2) with clean, filtered hydraulic oil. Thread the counterbalance valve into tube (3). Torque to 45-50 lb/ft (61-68 Nm).

IMPORTANT: DO NOT tamper with or attempt to reset the counterbalance valve cartridge. If adjustment or replacement is necessary, replace a counterbalance valve with a new one.

15. Test the cylinder at low operating pressure (100 psi or 6,9 bar). Verify that the piston and the rod move freely in both directions.
16. Increase the operating pressure to the maximum amount for the cylinder (4000 psi, or 276 bar) and again check for free movement in both directions.
17. Retract the rod fully into the tube and cap and plug the hydraulic hose ports.
18. If the self-align bearing (17) needs replacement, support the rod (18) in a soft-jawed vise or other suitable holding device. Carefully press a new bearing into the rod eyelet.

19. If necessary, install a grease fitting (19) into the tapped hole in the end of the rod weldment (18). Lubricate the self-align bearing (17) in the rod end through the grease fitting (19) with multi-purpose grease before the boom is operated.

f. Hoist/Lower Cylinder Installation

1. Raise and support the boom to allow installation of the hoist/lower cylinder (1, Fig. 9–67).
2. Attach a sling to the hoist/lower cylinder and to a hoist or an overhead crane. Safely and carefully, position the hoist/lower cylinder between the frame rails, aligning the rod and base eyelets with mounting bosses of the frame and boom.
3. Secure the cylinder with cylinder mount pins, capscrews and nuts.
4. Connect all hoses according to the labels or other marks used to identify their location during removal.

WARNING: Escaping hydraulic fluid under pressure can penetrate the skin, causing serious injury. Relieve hydraulic pressure before servicing any hydraulic component.

5. Operate the vehicle to check all boom functions and for hydraulic system leaks.
6. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle. Perform the pressure check and circuit bleeding procedure below.

g. Hoist/Lower Cylinder Pressure Checking and Circuit Bleeding

1. Attach a 4000 psi (276 bar) gauge to the main control valve at the extend base port relief to test the hoist/lower cylinder hydraulic system circuit pressure. The unit is equipped with test fittings from the factory. Pressure readings should be 3200 psi ± 100 psi (220,6 ± 7 bar).
2. With no accessory installed on the quick attach, start with the hoist and fork tilt cylinders fully retracted.
3. Fully raise and fully extend the boom. Hold the joystick at full extend while fully raising the hoist cylinder.
4. Fully retract the fork tilt cylinder. Hold the joystick at full retract while fully lowering the boom.
5. Repeat steps 3 and 4 five times.

9.10.5 Frame Tilt and Stabilizer Cylinders

The frame tilt cylinder is attached to the right side of the frame at the front axle and to a cylinder anchor plate on the axle.

The Stabil-TRAK cylinder is attached to the left side of the frame at the rear axle and to a cylinder anchor plate on the axle.

Although the cylinders (Fig. 9–68) do have different manifold blocks, the cylinders themselves are identical and interchangeable. The Stabil-TRAK manifold attached to the stabilizer cylinder at the left rear of the vehicle provides the operating characteristics for the patented Stabil-TRAK system.

a. Frame Tilt or Stabilizer Cylinder Removal

1. Park the vehicle on a firm, level surface, fully retract all hydraulic cylinders, ground the attachment (if any), place the travel select lever in NEUTRAL (N), engage the park brake switch and shut the engine OFF.

WARNING: Hot hydraulic fluid can cause severe burns. Wait for hydraulic fluid to cool before servicing any hydraulic component.

2. Unlatch, unlock and open the engine cover. Allow the hydraulic fluid to cool.

WARNING: Escaping hydraulic fluid under pressure can penetrate the skin, causing serious injury. Relieve hydraulic pressure before servicing any hydraulic component.

3. Label or otherwise mark the hydraulic hoses in relation to the cylinder being removed. Safely position suitable supports between the frame and axle to prevent the frame from leaning to one side.
4. Disconnect and cap all hoses and fittings, etc.
5. Use a sling and hoist or other suitable lifting device to support the cylinder. Remove the nuts, capscrews, and cylinder mount pins securing the cylinder to the frame and anchor plate.
6. Remove the cylinder from the vehicle. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle.

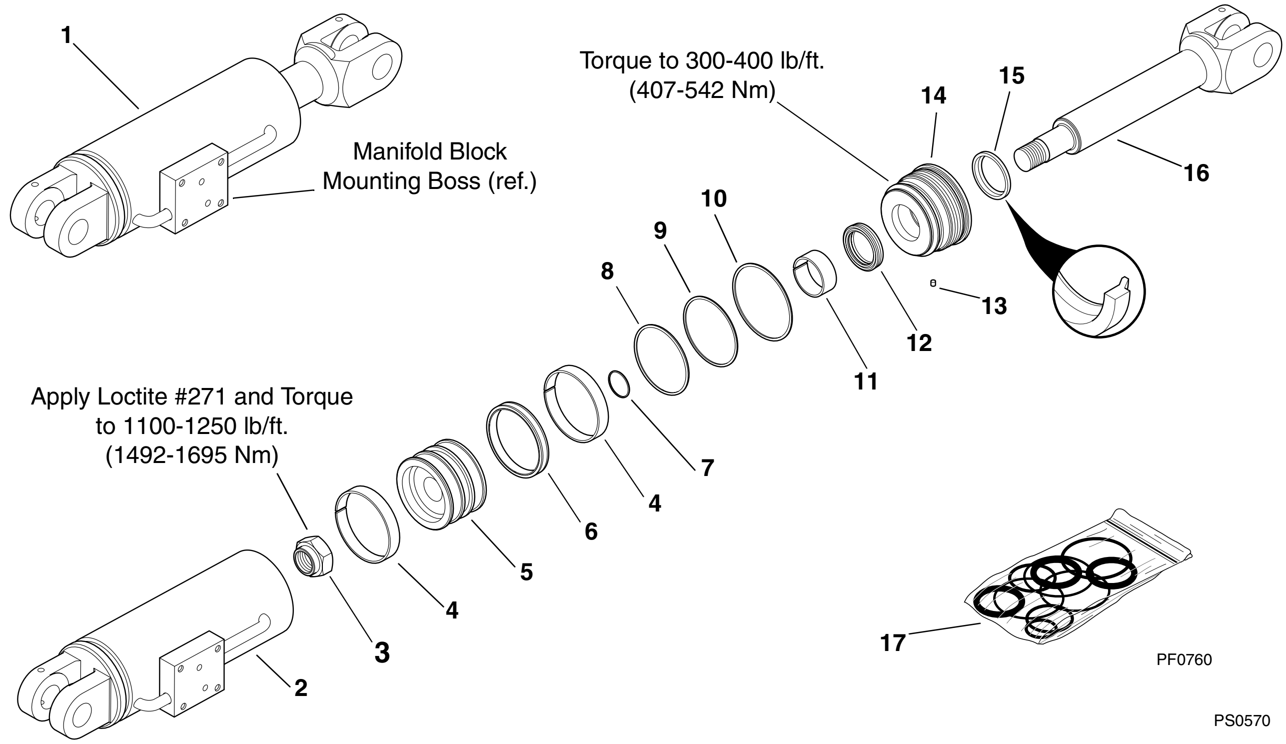


Figure 9–68. Frame tilt and/or stabilizer cylinder.

Frame Tilt and Stabilizer Cylinder Legend

1. Frame Tilt/Stabilizer Cylinder (includes items 2 through 16)
2. Tube
3. Lock Nut, 1.50 - 12 UN
4. Precision Wearband
5. Piston
6. Capped T-Seal, Type 730
7. O-Ring
8. O-Ring
9. Backup Ring
10. O-Ring
11. Precision Wearband
12. Deep Z-Seal with Rod Backup
13. Locking Insert
14. Head Gland
15. Heavy-duty Rod Wiper, Sealed OD
16. Weldment Rod

KITS

17. Seal Kit (includes items 4, 6-13, & 15)

b. Frame Tilt or Stabilizer Cylinder Disassembly

Note: An additional O-ring may be included at the base of the cylinder rod. This additional O-ring may be discarded, as it served only in a temporarily protective role to keep paint off the rod while the cylinder was painted at the factory.

1. Clamp the cylinder (1, Fig. 9–68) in a soft-jawed vise or other holding device, and place a suitable container beneath the cylinder to catch hydraulic fluid run-off.
2. Remove the manifold block from the mounting boss (ref.) as required. Loosen the 3/8-16 x 3-3/4" hex-head capscrews securing the manifold block to the cylinder mounting boss in an alternating pattern.

Note: Significant pressure may be trapped inside the cylinder. Exercise caution when removing the manifold block.

3. Remove the 3/8-16 x 3-3/4" hex-head capscrews, 3/8" lockwashers, four SAE 3/8" washers, and O-rings. Remove the dual pilot-operated check manifold from the cylinder at the manifold block mounting boss (ref.).

4. Remove the locking insert (13) from its hole in the head gland threads. Pry or drill out the insert as required. **DO NOT** damage the head gland threads. A new locking insert will be required for reassembly.
5. Use a pin spanner wrench to unthread the head gland (14) from the tube (2).

Note: The head gland is installed at a torque of 300-400 lb/ft (407-542 Nm). Use suitable tools to remove the head gland.

IMPORTANT: Protect the finish on the rod at all times. Damage to the rod can cause premature seal failure.

6. Carefully withdraw the rod weldment (16) straight out of the tube (2). Keep the rod straight during withdrawal to help avoid scratching, nicking or damaging the tube.

IMPORTANT: When sliding the rod and piston assembly in the tube, **DO NOT** damage the piston by scraping it against the threads in the tube. Keep the rod in line with the tube to prevent binding.

7. Secure the rod eyelet and remove the 1.50-12 NF nut (3) from the threaded end of the rod. Discard the nut; a new nut will be required for reassembly.

Note: Heating the nut to approximately 300° F (150° C) may also be required to break the seal formed by the Loctite Threadlocker #271 (red) applied to the nut when installed. The application of significant force is required to overcome the 1100-1250 lb/ft (1492-1695 Nm) of torque the nut was tightened to when originally installed.

8. Remove the piston (5) from the rod (2).
9. Remove the small O-ring (7).
10. Remove the head gland (14) from the rod (2).
11. Remove both precision wearbands (4) from the piston (5).
12. Remove the Type 730 capped T-seal (6) from the piston (5).

Note: The T-seal actually consists of four components; a wide, flexible inner band, the flexible T-seal band itself, and two supportive split caps that mount on either side of the “T” seal band.

13. Remove the O-ring (8) from the head gland (14).
14. Remove the backup ring (9) from the head gland (14).
15. Remove the O-ring (10) from the head gland (14).
16. Remove the heavy-duty rod wiper (15).

Note: An additional O-ring may be included at the base of the rod on some units. This additional O-ring may be discarded, as it served only in a temporarily protective role to keep paint off the rod while the cylinder was painted at the factory.

17. Remove the precision wearband (11) and deep Z-seal with rod backup (12) from inside the head gland (14).

Note: Discard all seals and O-rings. Always replace seals, O-rings, gaskets, etc. with new parts to help ensure proper sealing and operation.

c. Frame Tilt or Stabilizer Cylinder Internal Cleaning

1. Remove all hydraulic fluid, dirt and debris from the inner surface of the cylinder.
2. Discard all seals, backup rings and O-rings. Replace with new items from a complete seal kit to help ensure proper cylinder function.
3. Clean all metal parts with an approved cleaning solvent such as trichlorethylene. Carefully clean cavities, grooves, threads, etc.

d. Frame Tilt Cylinder Inspection and Repair

In general, inspect all parts for wear, damage, etc. If inner surfaces of the cylinder (1, Fig. 9–68) do not display an ultra-smooth, polished finish, or are damaged in any way, replace the damaged part. Most often, dirty hydraulic fluid causes failure of internal seals and damage to the polished surfaces within the component.

1. Check that the rod weldment (16, Fig. 9–68) is straight. If the rod is bent, install a new rod.
2. Inspect the inside of the tube (2) for scoring and other damage. If the tube is damaged, replace it with a new tube.
3. Remove small scratches on the rod or inside of the tube with very fine grit emery cloth. Use the emery cloth in a rotary motion to polish out small imperfections in the metal
4. Remove any burrs from components with a fine file. Clean the parts with trichlorethylene after repair.

e. Frame Tilt or Stabilizer Cylinder Assembly

Note: Follow *Section 9.12 c. General Assembly Instructions*.

1. Install the deep Z-seal with rod backup (12, Fig. 9–68) into the head gland.
2. Install the precision wearband (11) into the head gland.
3. Install the heavy-duty rod wiper (15) with the raised portion of the lip seal oriented toward the rod eyelet as shown.

Note: The wiper lip should be toward the outer end of the gland and seal lips toward the inner end of the gland. Use tools that will not damage the seals. If the backup ring is not flat on both sides, the side with the arc must be toward the O-ring.

4. Install the O-ring (10) onto the head gland (14).
5. Install the backup ring (9) onto the head gland (14).
6. Install the O-ring (8) onto the head gland (14).
7. Install the head gland (14) onto the rod (2). If necessary, use a soft hammer to drive the head gland onto the rod.
8. Install the small O-ring (7) into the piston (5).
9. Install the Type 730 capped T-seal (6) onto the piston (5).

Note: The T-seal actually consists of four components; a wide, flexible inner band, the flexible T-seal band itself, and two supportive split caps that mount on either side of the “T” seal band.

10. Install the two precision wearbands (4) onto the piston (5).
11. Install the piston (5) onto the rod (2).
12. Secure the rod eyelet in a soft-jawed vise or other suitable holding device. Place a padded support below the threaded end of the rod to help prevent damaging the rod.
13. Apply Loctite Primer “T” and Threadlocker #271 (red), to a new 1.50-12 NF nut (3) in accordance with Loctite instructions. Install the nut onto the threaded end of the rod. Torque the nut to 1100-1250 lb/ft (1492-1695 Nm).
14. Fasten the tube (2) in a soft-jawed vise or other suitable holding device. **DO NOT** damage the tube.
15. To aid in installation, lubricate the O-rings and the inside of the tube, piston and head gland with clean, filtered hydraulic oil.

IMPORTANT: Use a suitable installation tool or compression sleeve to help prevent twisting or damaging the seals and O-rings when installing the piston and head gland into the cylinder. When sliding the rod and piston assembly in the tube, **DO NOT** damage the piston by scraping it against the threads in the tube. Keep the rod in line with the tube to prevent binding.

16. Keep the rod weldment (16) straight and carefully insert the rod weldment into the tube (2). Avoid scratching, nicking or damaging the tube while installing the rod.
17. Begin threading the head gland (14) into the tube (2). Place the locking insert (13) in its hole in the head gland threads just before the hole is threaded into the tube. Use a suitable pin spanner wrench to thread the head gland (14) completely into the tube (2). Torque to 300-400 lb/ft (407-542 Nm).
18. Attach the dual pilot-operated check manifold to the cylinder at the manifold block mounting boss with two new O-rings, four SAE 3/8" washers, 3/8" lockwashers and 3/8-16 x 3-3/4" hex-head capscrews. In an alternating pattern, slowly tighten the bolts securing the valve body to the cylinder. Torque to 31 lb/ft (42 Nm).
19. Test the cylinder at low operating pressure (100 psi or 6,9 bar) to verify that the piston and rod move freely in both directions.
20. Increase the operating pressure to the maximum for the cylinder (4000 psi or 275 bar) and check for external leakage and for free movement in both directions.
21. Retract the piston fully and cap or plug the dual pilot-operated check manifold ports.

f. Frame Tilt or Stabilizer Cylinder Installation

1. Lubricate the 1.5" diameter cylinder pins with multi-purpose lithium-based grease.
2. Use a sling and hoist or other suitable lifting device to help install the cylinder. Orient the cylinder with the cylinder eyelet on top, the rod eyelet on the bottom and the dual pilot-operated check valve facing the rear of the vehicle.
3. Install the upper cylinder pin. Drive the lubricated cylinder pin through the cylinder eyelet, frame mount and self-aligning bearing. Secure the pin with a 5/16-18 x 3-1/2" capscrew and 5/16-18 hex-lock nut. Torque to 18 lb/ft (24 Nm).
4. Use new flat-faced O-rings when installing the upper and lower hydraulic hoses. Install and tighten the hoses onto the appropriate fittings on the dual pilot-operated check manifold.

WARNING: Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

5. With the help of an assistant, start the engine. Carefully and slowly, operate the joystick frame tilt function to properly align the rod with the anchor plate as required. Turn the engine OFF.
6. Install the lower cylinder pin. Drive the lubricated cylinder pin through the rod eyelet, anchor plate and self-aligning bearing. Secure the pin with a 5/16-18 x 3-1/2" capscrew and 5/16-18 hex-lock nut. Torque to 18 lb/ft (24 Nm).
7. Remove all tools, etc. from the vehicle. Carefully remove the blocking supporting the vehicle frame at the front and rear axles.
8. Start the engine and run at approximately one-third to one-half throttle for about one minute without moving the vehicle or operating any hydraulic functions. Operate the joystick to fully tilt the frame left and right at least five times each.
9. Inspect for leaks and check the level of the hydraulic fluid in the reservoir. Shut the engine OFF.

Note: Check for leaks and repair as required before continuing. Add hydraulic fluid to the reservoir as needed.

10. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle, work area and tools.

g. Frame Tilt or Stabilizer Cylinder Pressure Checking and Circuit Bleeding

1. Attach a 4000 psi (276 bar) gauge to the main control valve at the extend base port relief to test the frame tilt/stabilizer cylinder hydraulic system circuit pressure. The unit is equipped with test fittings from the factory. Pressure readings should be 3200 psi ± 100 psi (220,6 ± 7 bar).
2. Start with the frame tilt and stabilizer cylinders balanced; that is, with the frame level.
3. Tilt the vehicle fully left. Hold the joystick at full tilt left for several seconds, then tilt the vehicle fully right and hold the joystick at full tilt right for several seconds. Observe the readings on the gauge during the frame tilt operations.
4. Level the frame. While leveling the frame, check the pressure reading on the gauge.
5. Repeat steps 3 and 4 five times.

9.10.6 Swing Carriage (*optional*)

The optional swing carriage (1, Fig. 9–69) provides a way to swing the carriage attachment from side to side. The swing carriage includes two cylinders that operate to provide the side to side motion.

Swing Carriage (optional) Legend

1. Carriage
2. Cover, Clamp
3. HHCS, 5/16-18 x 1-1/2”
4. Pin, Carriage Pivot
5. Base, Pivot
6. Pin, Cylinder Pivot (Rod End)
7. Pin, Cylinder Pivot (Base End)
8. Shim, 2” I.D. x 10 Ga.
9. Bearing, Self Lube
10. Shim, 2” I.D. x 18 Ga.
11. Shim, 1-1/2” I.D. x 10 Ga.
12. Connector, Straight, SAE 4 - male JIC 37° x male str. thd. O-ring
13. Tie Wrap
14. Hose Assembly
15. Shim, 1-1/2” I.D. x 18 Ga.
16. Quick Disconnect, Male, SAE 8-8ORB - female internal (Includes Item 17)
17. Seal, Nose (Not Shown)
18. Quick Disconnect, Female, SAE 8-8ORB - female internal (Includes Items 19, through 21)
19. Seal, Nose (Not Shown)
20. Seal, Large, Coupler Body (Not Shown)
21. Back-up Ring for Large Seal (Not Shown)
22. Bearing, Thrust
23. Cap, Dust
24. Plug, Dust
25. Ring, Retaining
26. Hose Assembly
27. Elbow, 90° SAE 6-8 - male JIC 37° x male str. thd. O-ring
28. Elbow, 90° SAE 6 - male JIC 37° x male str. thd. O-ring
29. Clamp, Half
30. Shaft, Fork Pivot 52”
31. Hub, Lock
32. HHCS, 5/8-11 x 4”
33. Nut, Hex Lock 5/8-11
34. Fork, Pallet 48” x 4” x 2” (4,000 lb Rating)
    Fork, Lumber (Not Shown)
    Fork, Blocking (Not Shown)
35. Chart, Capacity
36. Decal, Danger - Tip Over Hazard
37. Nut, SAE 6 - JIC 37°
38. Reducer, Tube End, SAE 6-4 - JIC 37°
39. Elbow, 90° SAE 6-4 - male JIC 37° x male str. thd. O-ring
40. Reducer, SAE 4-6 - male str. thd. O-ring x female internal O-ring boss
41. Decal, Danger - No Truss Boom
42. Plug, Trim 2-1/2” Diameter

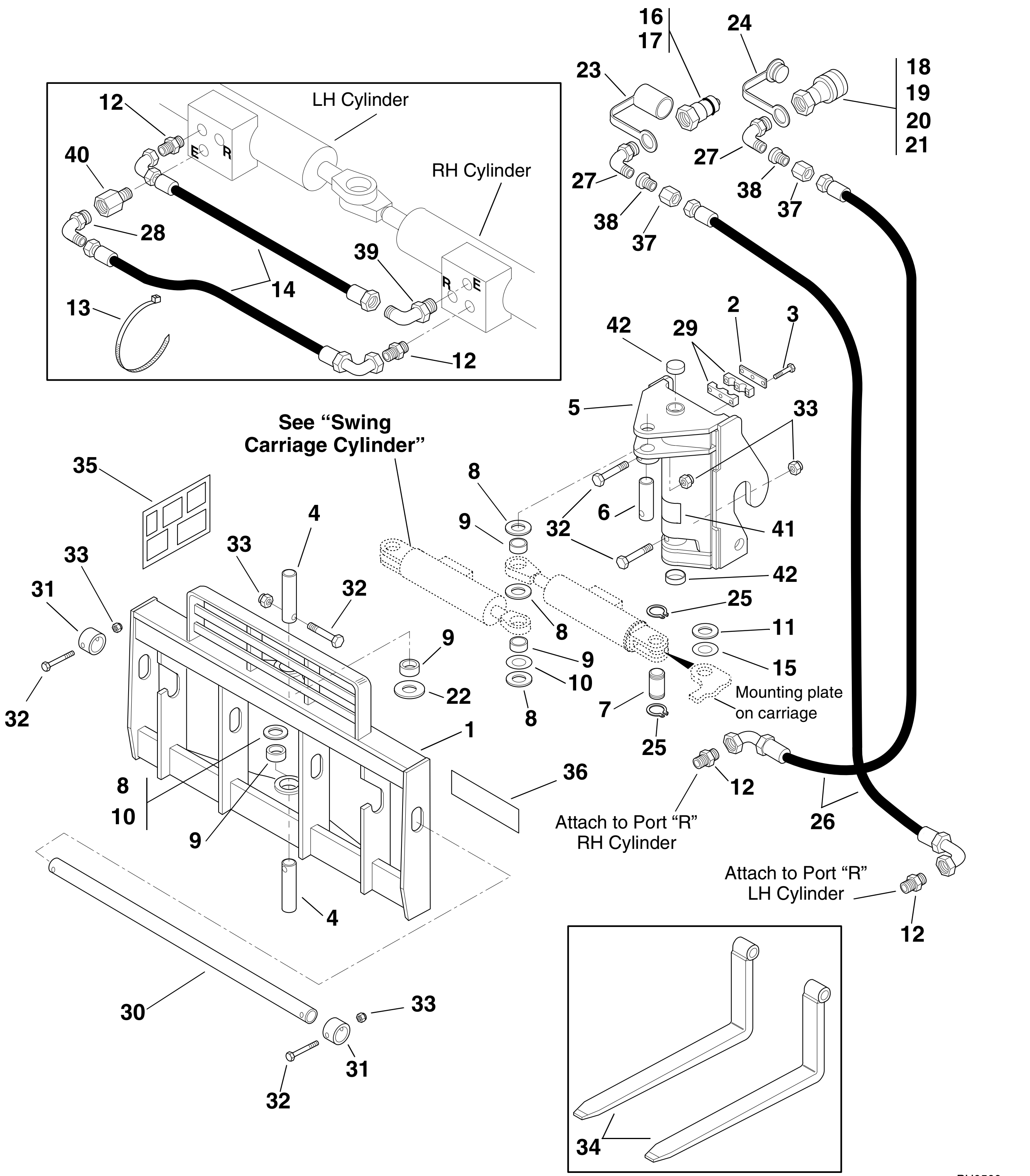


Figure 9–69. Swing carriage (optional).

a. Swing Carriage Cylinder Removal

1. Level the boom (place the boom in a horizontal boom).
2. Swing the carriage to the centered position.
3. Lower the boom until the carriage is resting firmly on the ground.
4. Place the travel select lever in NEUTRAL (N), engage the park brake switch and shut the engine OFF.

> **WARNING:** Hot hydraulic fluid can cause severe burns. Wait for hydraulic fluid to cool before servicing any hydraulic component.

5. Unlatch, unlock and open the engine cover. Allow the hydraulic fluid to cool.

> **WARNING:** Escaping hydraulic fluid under pressure can penetrate the skin, causing serious injury. Relieve hydraulic pressure before servicing any hydraulic component.

6. Pull the knob on the manually-operated release valve (Fig. 9–70) located at the rear of the frame to relieve pressure in the auxiliary hydraulic system.

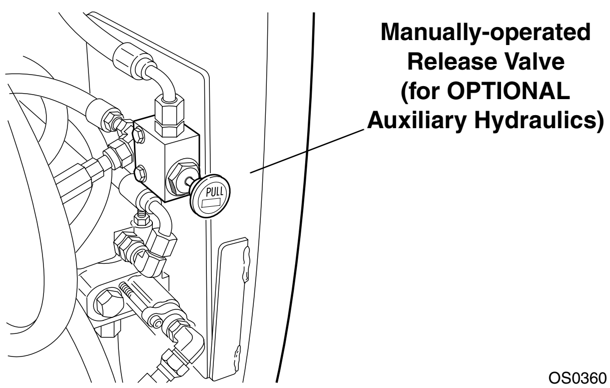
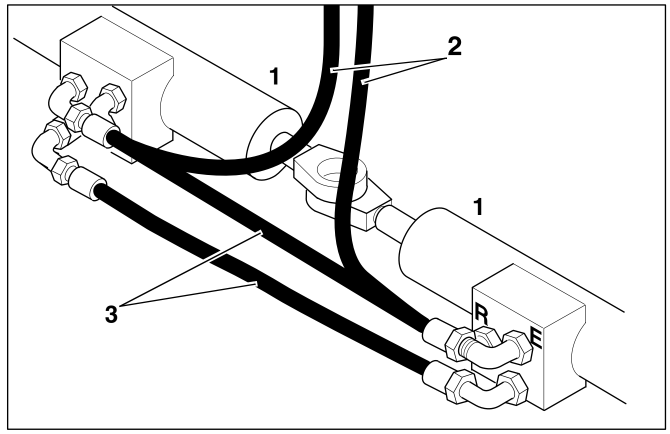
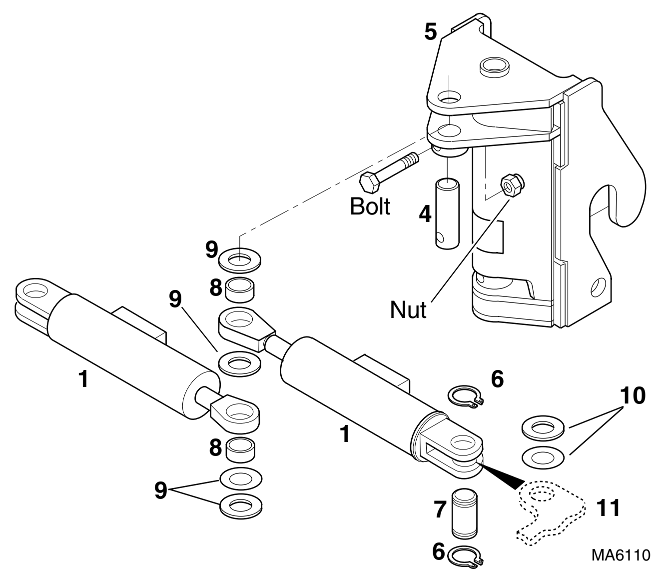


Figure 9–70. Pull the knob on the manually-operated release valve located at the rear of the frame to relieve pressure in the auxiliary hydraulic system.

7. Remove all dirt and grease from the swing carriage cylinders (Fig. 9–71) and their hydraulic lines (2 and 3).
8. Label or otherwise mark the hydraulic lines (2 and 3).
9. Disconnect and cap all hoses and fittings, etc.
10. Use a sling and hoist or other suitable lifting device to support the cylinder. Remove the bolt and nut holding the center mounting pin (4) to the pivot mount (5). Remove the pin.
11. Remove the snap rings (6) and cylinder base end pins (7) from the mounting plates on the carriage (11).





1. Cylinder
2. Auxiliary Hydraulic Hoses
3. Cylinder Hoses
4. Center Mounting Pin
5. Pivot Mount
6. Snap Rings
7. Cylinder Base-end Pins
8. Rod-end Bearings
9. Shims, 2” I.D.
10. Shims, 1-1/2” I.D.
11. Mounting Plates (part of carriage)

Figure 9–71. Swing carriage cylinder detail.

12. Identify and mark the location of the 1-1/2” I.D. shims (9) at the base end of the cylinder.
13. Remove the cylinder(s) from the pivot mount and the mounting plates using the strap sling and hoist or other suitable lifting equipment. While removing the cylinder(s), identify the locations of the 2” I.D. shims (9) at the rod end(s) of the cylinder(s). DO NOT lose the bearing(s) (8) in the cylinder rod end(s).
14. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle.

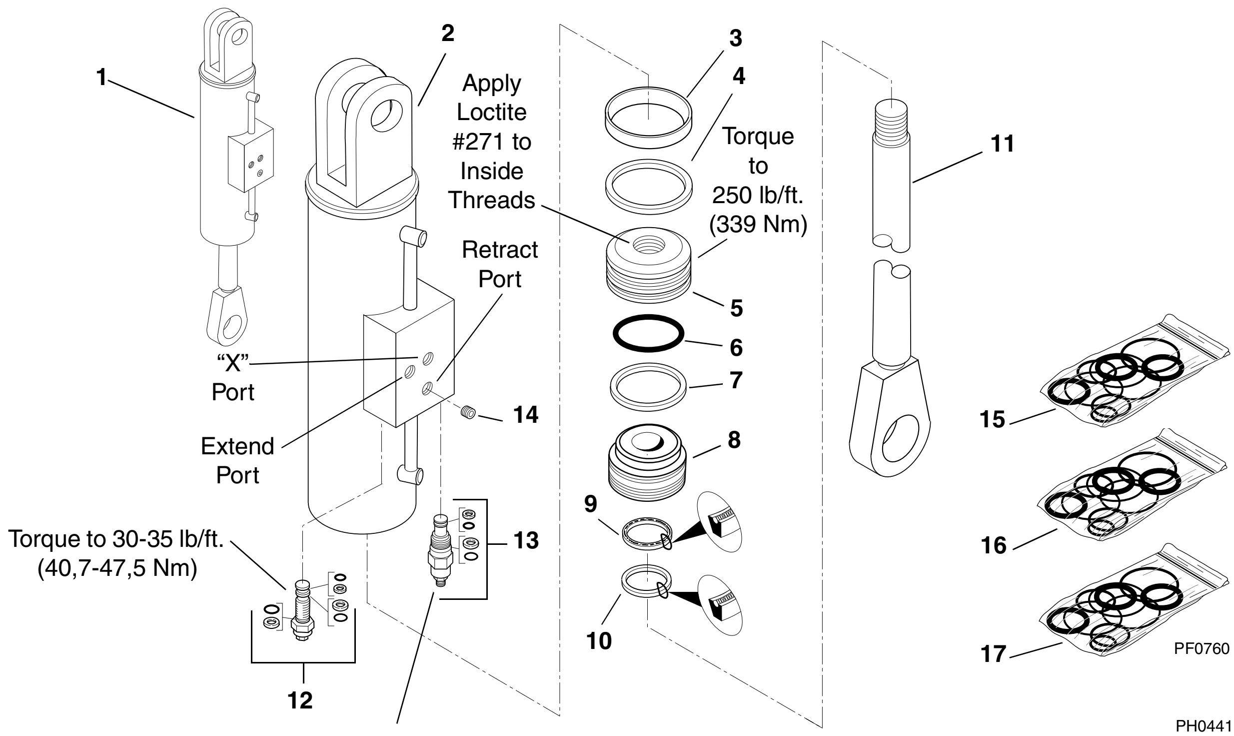


Figure 9–72. Swing carriage cylinder (optional).

Swing Carriage Cylinder Legend

1. Swing Carriage Cylinder (OPTIONAL) (includes items 2 through 14)
2. Cylinder Tube
3. Wear Ring
4. Piston Seal
5. Piston
6. O-Ring
7. Backup Ring
8. Gland
9. Rod Seal
10. Wiper
11. Rod
12. Counterbalance Cartridge Valve - Preset to 3000 psi (207 bar)
13. Direct-acting Relief Valve, Preset to 2000 psi (138 bar)
14. Orifice, 0.038" diameter

KITS

15. Swing Carriage Cylinder Seal Kit (includes items 3, 4, 6, 7, 9, & 10)
16. Valve Seal Kit for item 12 (includes three O-Rings and three Backup Rings)
17. Valve Seal Kit for item 1 (includes two O-Rings, one Backup Ring and one Gland Ring)

b. Swing Carriage Cylinder Disassembly

Note: An additional O-ring may be included at the base of the cylinder rod. This additional O-ring may be discarded, as it served only in a temporarily protective role to keep paint off the rod while the cylinder was painted at the factory.

1. Clean the swing carriage cylinder (1, Fig. 9–72) with a suitable cleaner to remove dirt, debris, grease, etc.
2. Place the swing carriage cylinder in a soft-jawed vise or other acceptable holding equipment if possible. **DO NOT** damage the tube.

Note: Significant pressure may be trapped inside the cylinder. Exercise caution when removing the counter-balance valve (12) and direct-acting relief valve (13).

3. Remove the 3000-psi (207-bar) counterbalance cartridge (12), 2000-psi (138-bar) direct-acting relief valve (13) and the 0.038" diameter orifice (14) from the swing carriage cylinder. Also remove the O-rings and backup rings from the valves.
4. Extend the rod (11) to access the cylinder base.

5. Using a pin spanner wrench, unscrew the gland (8) from the cylinder tube (2). Slide the gland down along the rod toward the eyelet, away from the tube (2).

IMPORTANT: Protect the finish on the rod at all times. Damage to the surface of the rod can cause seal failure.

6. Carefully pull the rod (11) with all attachments straight out of the tube (2).

IMPORTANT: When sliding the rod and piston assembly in the tube, prevent the threaded end of the tube from damaging the piston (5). Keep the rod centered within the tube to help prevent binding.

7. Fasten the eye of the rod in a soft-jawed vise and put a padded support below and near the threaded end of the rod to help prevent damage to the rod.
8. Remove piston (5) and gland (8) from rod (11).

Note: Loctite Threadlocker #271 (red) and 250 lb/ft (339 Nm) were applied to the piston when it was installed. It may be necessary to apply heat to break the bond of the sealant between the piston (5) and the rod (11) before the piston can be unthreaded and removed. Some parts of cylinders are sealed with a special organic sealant and locking compound. Before attempting to disassemble these parts, remove any accessible seals from the area of the bonded joint. Wipe off any hydraulic oil and heat the joint uniformly to break the bond. A temperature of 300° to 400° F (149° to 204° C) will destroy the bond. Avoid overheating or the parts may become distorted or damaged. Apply sufficient torque or pressure for removal while the parts are still hot. Breakdown of sealant will leave a white, powdery residue on threads and parts. Clean the residue away with a soft brass wire brush prior to reassembly, and wipe with Loctite “T” cleaner before reinstallation.

9. Remove the piston seal (4) and wear ring (3) from the piston (5).
10. Remove the O-ring (6), backup ring (7), wiper (10) and rod seal (9) from the gland (8).

c. Swing Carriage Cylinder Cleaning

1. Remove all hydraulic fluid, dirt and debris from the swing carriage cylinder (1, Fig. 9–72).
2. Discard all seals, backup rings and O-rings. Replace with new items from a complete seal kit to help ensure proper cylinder function.
3. Clean all metal parts with an approved cleaning solvent such as trichlorethylene. Carefully clean cavities, grooves, threads, etc.
4. If a white, powdery residue is present on threads and parts, it can be removed. Clean the residue away with a soft brass wire brush prior to reassembly, and wipe with Loctite “T” cleaner before reinstallation.

d. Swing Carriage Cylinder Inspection

1. Inspect internal surfaces and all parts for wear, damage, etc. If inner surface of the tube (2, Fig. 9–72) does not display a smooth finish, or is scored or damaged in any way, replace the tube. Most often, dirty hydraulic fluid causes failure of internal seals and damage to the smooth surface within the tube. Remove slight scratches on the piston, rod, or inner surface of the tube with very fine grit emery cloth. Use the emery cloth in a rotary motion to polish out and blend the scratch(es) into the surrounding surface.
2. Remove any burrs with a fine file. Clean parts with trichlorethylene after repair.
3. Check that the rod (11) is straight. If it is bent, install a new rod.

e. Swing Carriage Cylinder Assembly

Note: Follow the information in *Section 9.12 c. General Cylinder Assembly.*

1. Install a new rod seal (9), wiper (10), backup ring (7) and O-ring (6) onto the gland (8). Orient the rod seal (9) and wiper (10) as shown in Fig. 9–72.
2. Fasten the eye of the rod in a soft-jawed vise and put a padded support below and near the threaded end of the rod to help prevent damage to the rod.
3. Push the gland (8) onto the rod (11). If necessary, use a soft hammer to drive the gland onto the rod.
4. Install a new piston seal (4) and wear ring (3) onto the piston (5).
5. Apply Loctite Primer “T” and Threadlocker #271 (red) to the threads of the piston (5) in accordance with Loctite instructions. Thread the piston onto the rod (11) and torque to 250 lb/ft (339 Nm).
6. Place the cylinder tube (2) in a soft-jawed vise or other acceptable holding equipment if possible. **DO NOT** damage the tube.
7. Lubricate the piston (5), gland and the inside of the tube (2) with clean, filtered hydraulic oil.
8. Apply a compression sleeve or other suitable tool to the gland in order to compress the O-ring (6). Carefully insert the rod (11) with all attachments straight into the tube (2). Use a pin spanner wrench to thread the gland into the tube. Remove the compression tool.

IMPORTANT: When sliding the rod and piston assembly in the tube, prevent the threaded end of the tube from damaging the piston (5). Keep the rod centered within the tube to help prevent binding.

9. Install new O-rings and backup rings on the counterbalance cartridge (12) and direct-acting relief valve (13). Lubricate the cartridge, valve, and rings with clean, filtered hydraulic oil. Install and torque to 30-35 lb/ft (40,7 to 47,5 Nm).
10. Install the orifice (14) into the valve block.
11. Test the cylinder at low operating pressure (100 psi, or 6,9 bar). Verify that the piston and rod move freely in both directions.
12. Increase the operating pressure to the maximum for the cylinder (3000 psi, or 207 bar). Verify that the piston and rod move freely in both directions.
13. Retract the piston fully and cap the hydraulic hose ports. Install the cylinder on the carriage.

f. Swing Tilt Carriage Cylinder Installation

1. Install the swing tilt carriage cylinder onto the swing tilt carriage at the pivot mount. Secure the rod end to the swing tilt carriage.
2. Secure the tube end to the pivot base with snap rings.
3. Lubricate the pivot pins with multi-purpose grease.

> **WARNING:** Risk of severe personal injury. Before starting the engine, verify that all hydraulic connections are properly tightened and that all tools are removed from the vehicle.

4. Remove all plugs and caps from the hydraulic lines and securely tighten the lines to the cylinder.
5. Start the engine and remove any blocking from the carriage.
6. Operate the swing carriage five times through its full range or until operation of the swing tilt carriage is normal (no jerks or spongy feel).
7. Shut the engine OFF. Check the hydraulic level and fill as required.

g. Swing Carriage Cylinder Installation

1. Install the swing carriage cylinder(s) (1, Fig. 9–71) on the pivot mount (5). Secure the rod ends to the pivot mount using the shims (9) and bearings (8). Insert the pin (4) and secure with the bolt and nut.
2. Secure the tube end to the mount plates (11) using the shims (10 and pins (7). Secure with snap rings.
3. Lubricate the tube ends with multi-purpose lithium-based grease.

> **WARNING:** Risk of severe personal injury. Before starting the engine, verify that all hydraulic connections are properly tightened and that all tools are removed from the vehicle.

4. Remove all plugs and caps from the hydraulic lines and securely tighten the lines to the cylinder(s).

> **WARNING:** Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

5. Start the engine.
6. Swing the carriage five times through its full range or until the operation of the swing carriage is normal (no jerks or spongy feel).
7. Shut the engine OFF. Check the hydraulic level and fill as required.

h. Swing Carriage Cylinder Pressure Checking and Circuit Bleeding

1. Attach a 4000 psi (276 bar) gauge to the main control valve at the extend base port relief to test the swing carriage cylinder hydraulic system circuit pressure. The unit is equipped with test fittings from the factory. Pressure readings should be 3200 psi ± 100 psi (220,6 ± 7 bar).
2. Start with the swing carriage cylinders balanced; that is, with the carriage centered.
3. Swing the carriage fully left. Hold the joystick at full swing left for several seconds, then swing the carriage fully right and hold the joystick at full swing right for several seconds. Observe the readings on the gauge during the carriage swinging operations.
4. Center the carriage. While centering the carriage, check the pressure reading on the gauge.
5. Repeat steps 3 and 4 five times.

9.10.7 Side Tilt Carriage Cylinder (*optional*)

The optional side tilt carriage cylinder (1, Fig. 9–75) provides a way to tilt the carriage attachment from side to side. The side tilt carriage includes a cylinder that operates to provide the side tilt motion.

a. Side Tilt Carriage (*optional*) Removal

1. Level the boom (place the boom in a horizontal boom).
2. Tilt the carriage (1, Fig. 9–75) to fully retract the side tilt carriage cylinder.
3. Use suitable blocks to support the side tilt carriage (1) in this position.
4. Engage the park brake switch, place the travel select lever in NEUTRAL (N) and shut the engine OFF.

> **WARNING:** Hot hydraulic fluid can cause severe burns. Wait for hydraulic fluid to cool before servicing any hydraulic component.

5. Unlatch, unlock and open the engine cover. Allow the hydraulic fluid to cool.

> **WARNING:** Escaping hydraulic fluid under pressure can penetrate the skin, causing serious injury. Relieve hydraulic pressure before servicing any hydraulic component.

6. Pull the knob on the manually-operated release valve (Fig. 9–73) located at the rear of the frame to relieve pressure in the auxiliary hydraulic system.

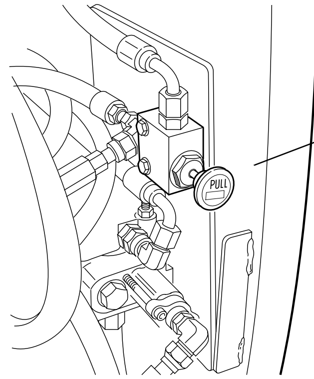


Figure 9–73. Pull the knob on the manually-operated release valve located at the rear of the frame to relieve pressure in the auxiliary hydraulic system.

7. Remove all dirt and grease from the side tilt carriage cylinder and the auxiliary hydraulic lines.
8. Label or otherwise mark the hose assembly (14, Fig. 9–74).
9. Disconnect and cap all hoses and fittings, etc.
10. Remove the snap rings (11) and cylinder base end pins (6 and 7) from the mounting plates on the carriage (1) and pivot base (5).
11. Remove the cylinder using a strap sling and hoist or other suitable lifting equipment.
12. Wipe up any hydraulic fluid spillage in, on, near and around the vehicle.

Side Tilt Carriage Legend

1. Carriage, Side Tilt
2. Pad, Wear
3. HHCS, 5/16-18 x 1-1/4”
4. Nut, Hex Lock 5/16-18
5. Base, Pivot
6. Pin, Cylinder. Base
7. Pin, Cylinder. Rod
8. Spacer
9. Bushing, Self Align
10. Ring, Snap
11. Ring, Snap
12. Connector, Straight SAE 6-6P - male JIC 37° x male str. thd. O-ring
13. Tie Wrap
14. Hose Assembly
15. Connector, Straight, SAE 6-8 - male JIC 37° x male str. thd. O-ring
16. Quick Disconnect, Male, SAE 8-8ORB - female internal (Includes Item 17)
17. Seal, Nose (Not Shown)
18. Quick Disconnect, Female, SAE 8-8ORB - female internal (Includes Items 19 through 21)
19. Seal, Nose (Not Shown)
20. Seal, Large, Coupler Body (Not Shown)
21. Back-up Ring for Large Seal (Not Shown)
22. Plug, Pipe Hex Skt 1/8” NPT
23. Cap, Dust
24. Plug, Dust
25. Molding
26. Pin, Pivot
27. Collar, Pin Locking
28. HHCS, 3/8-16 x 2-3/4”
29. Locknut, 3/8-16 ESNA
30. Shaft, Fork Pivot
31. Hub, Lock
32. HHCS, 5/8-11 x 4”
33. Nut, Hex Lock 5/8-11
34. Fork, Pallet 48” x 4” x 2” (4,000 lb Rating)
    Fork, Lumber (Not Shown)
    Fork, Blocking (Not Shown)
35. Washer, Flat Heavy
36. Shim
37. Decal, Capacity Chart
38. Plate, Capacity

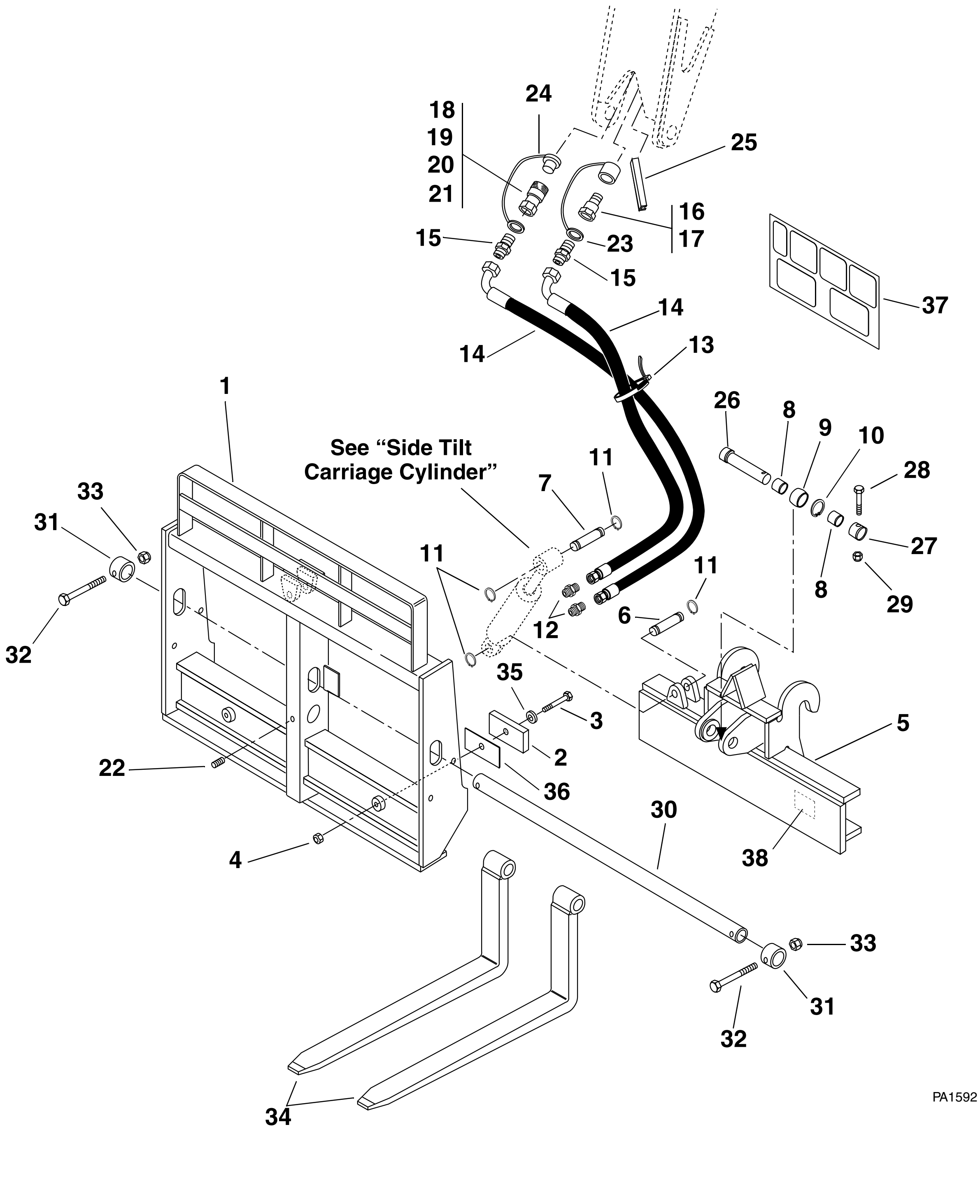


Figure 9–74. Side tilt carriage (optional).

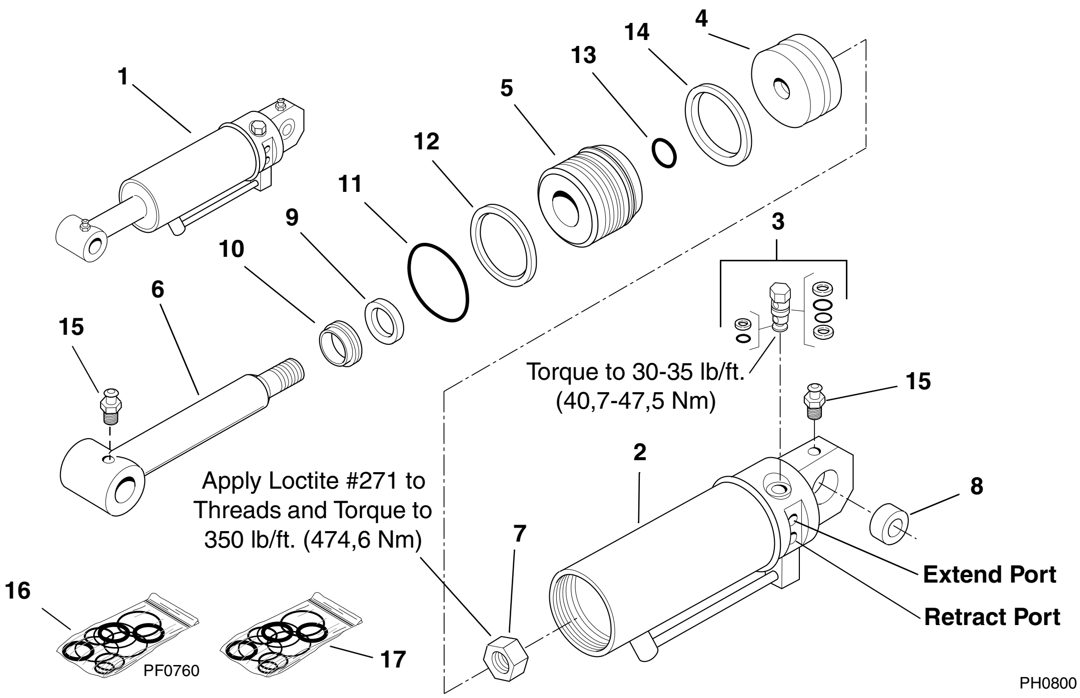


Figure 9–75. Side tilt carriage cylinder (optional).

Side Tilt Carriage Cylinder Legend

1. Side Tilt Carriage Cylinder (OPTIONAL) (includes items 2 through 14)
2. Cylinder Tube
3. Pilot Check Valve
4. Piston
5. Gland
6. Rod
7. Piston Nut
8. Self-aligning Bearing
9. Rod Seal
10. Wiper
11. O-Ring
12. Backup Ring
13. O-Ring
14. Piston Seal
15. Grease Fitting

KITS

16. Side Tilt Carriage Cylinder Seal Kit (includes items 9-14)
17. Pilot Check Valve Seal Kit for item 3

b. Side Tilt Carriage Cylinder Disassembly

Note: An additional O-ring may be included at the base of the cylinder rod. This additional O-ring may be discarded, as it served only in a temporarily protective role to keep paint off the rod while the cylinder was painted at the factory.

1. Clean the side tilt carriage cylinder (1, Fig. 9–75) with a suitable cleaner to remove dirt, debris, grease, etc.
2. If necessary, remove both grease fittings (15) from the cylinder tube eyelet.
3. If necessary, press the self-align bearing (8) from the cylinder tube eyelet.
4. Place the side tilt carriage cylinder (1) in a soft-jawed vise or other acceptable holding equipment if possible. **DO NOT** damage the tube (2).

Note: Significant pressure may be trapped inside the cylinder. Exercise caution when removing the pilot check valves (3) from the side tilt carriage cylinder.

5. Remove both pilot check valves (3) from the side tilt carriage cylinder. Remove the O-rings and backup rings from the pilot check valves.
6. Extend the rod (6) to allow access to the base of the cylinder.

7. Using a pin spanner wrench, unscrew the gland (5) from the cylinder tube (2).

IMPORTANT: Protect the finish on the rod at all times. Damage to the surface of the rod can cause seal failure.

8. Carefully pull the rod (6) with all attachments straight out of the tube (2).

IMPORTANT: When sliding the rod and piston assembly in the tube, prevent the threaded end of the tube from damaging the piston (4). Keep the rod centered within the tube to help prevent binding.

9. Fasten the eye of the rod (6) in a soft-jawed vise and put a padded support below and near the threaded end of the rod to help prevent damage to the rod.
10. Remove the piston nut (7), piston (4) and gland (5) from the rod (6).

Note: Loctite Threadlocker #271 (red) and 350 lb/ft (474,6 Nm) of torque were applied to the piston nut when it was installed. It may be necessary to apply heat to break the bond of the sealant between the piston nut (7) and the rod (6) before the parts can be removed. Some parts of cylinders are sealed with a special organic sealant and locking compound. Before attempting to disassemble these parts, remove any accessible seals from the area of the bonded joint. Wipe off any hydraulic oil and heat the joint uniformly to break the bond. A temperature of 300° to 400° F (149° to 204° C) will destroy the bond. Avoid overheating or the parts may become distorted or damaged. Apply sufficient torque or pressure for removal while the parts are still hot. Breakdown of sealant will leave a white, powdery residue on threads and parts. Clean the residue away with a soft brass wire brush prior to reassembly, and wipe with Loctite "T" cleaner before reinstallation.

11. Remove the piston seal (14) from the piston (4).
12. Remove the small O-ring (13) from inside the piston (4).
13. Remove the O-ring (11), backup ring (12), wiper (10) and rod seal (9) from the gland (5).

c. Side Tilt Carriage Cylinder Cleaning

1. Remove all hydraulic fluid, dirt and debris from the inner surface of the cylinder tube (2, Fig. 9–75).
2. Discard all seals, backup rings and O-rings. Replace with new items from a complete seal kit to help ensure proper cylinder function.
3. Clean all metal parts with an approved cleaning solvent such as trichlorethylene. Carefully clean cavities, grooves, threads, etc.If a white, powdery residue is present on threads and parts, it can be removed.
4. Clean the residue away with a soft brass wire brush prior to reassembly, and wipe with Loctite T cleaner before reinstallation.

d. Side Tilt Carriage Cylinder Inspection

1. Inspect internal surfaces and all parts for wear, damage, etc. If inner surface of the tube (2, Fig. 9–75) does not display a smooth finish, or is scored or damaged in any way, replace the tube. Most often, dirty hydraulic fluid causes failure of internal seals and damage to the smooth surface within the tube. Remove slight scratches on the piston, rod, or inner surface of the tube with very fine grit emery cloth. Use the emery cloth in a rotary motion to polish out and blend the scratch(es) into the surrounding surface.
2. Clean parts with trichlorethylene.
3. Check that the rod (6) is straight. If it is bent, install a new rod.

e. Side Tilt Carriage Cylinder Assembly

Note: Follow the general assembly instructions in *Section 9.12 c. General Cylinder Assembly.*

1. If necessary, press the self-align bearing (8, Fig. 9–75) into the cylinder tube eyelet. The bearing should protrude equally from each side of the eyelet.
2. Install the rod seal (9), wiper (10), backup ring (12) and O-ring (11) into the gland (5). Orient the parts as indicated in Fig. 9–75.

Note: The wiper lip should be toward the inner end of the gland and the rod seal toward the outer end of the gland. Use tools that will not damage the seal. If the backup ring is not flat on both sides, the side with the arc must be toward the O-ring.

3. Fasten the eye of the rod in a soft-jawed vise and put a padded support below and near the threaded end of the rod to help prevent damage to the rod.
4. Push the gland (5) onto the rod (6). If necessary, use a soft hammer to drive the gland onto the rod.
5. Install a new small O-ring (13) inside the rod end of the piston (4).
6. Install a new piston seal (14) on the piston (4).
7. Apply Loctite Primer "T" and Threadlocker #271 (red) to the threads of the piston nut (7) in accordance with Loctite instructions. Thread the piston nut onto the rod (6) and torque to 350 lb/ft (474,6 Nm).
8. Fasten the cylinder tube (2) in a soft-jawed vise or other acceptable holding equipment. **DO NOT** damage the tube (2).
9. Lubricate the piston (4), gland (5) and the inside of the tube (2) with clean, filtered hydraulic oil.

10. Apply a compression sleeve or other suitable tool to the gland in order to compress the O-ring (11). Carefully insert the rod (6) with all attachments straight into the tube (2). Use a pin spanner wrench to thread the gland into the tube. Remove the compression tool.

IMPORTANT: When sliding the rod and piston assembly in the tube, prevent the threaded end of the tube from damaging the piston seal (14). Keep the rod centered within the tube to help prevent binding.

11. Install new O-rings and backup rings on the pilot check valve (3). Lubricate the valve and rings with clean, filtered hydraulic oil. Install and torque to 30-35 lb/ft (40,7 to 47,5 Nm).
12. If necessary, install both grease fittings (15) into their threaded holes in the cylinder tube eyelet.
13. Test the side tilt cylinder at low operating pressure (100 psi, or 6,9 bar). Verify that the piston and rod move freely in both directions.
14. Increase the operating pressure to the maximum for the cylinder (1750 psi, or 120 bar). Verify that the piston and rod move freely in both directions.
15. Retract the piston fully and cap the hydraulic hose ports. Install the cylinder on the carriage. Lubricate the self-align bearing (8) via the grease fittings (15) with multi-purpose grease before operating the side tilt carriage on the vehicle.

f. Side Tilt Carriage Cylinder Installation

1. Install the side tilt carriage cylinder onto the side tilt carriage (1, Fig. 9–74). Secure the rod end to the side tilt carriage with the cylinder rod pin (7) and snap rings (11). Secure the tube end to the pivot base (5) with the cylinder base pin (6) and snap rings (11).
2. Lubricate the pivot pins with multi-purpose grease.

WARNING: Risk of severe personal injury. Before starting the engine, verify that all hydraulic connections are properly tightened and that all tools are removed from the vehicle.

3. Remove all plugs and caps from the hydraulic lines and securely tighten the lines to the cylinder.

WARNING: Avoid prolonged engine operation in closed areas with inadequate ventilation. Failure to properly ventilate exhaust fumes can result in death or severe personal injury.

4. Start the engine and remove any blocking from the carriage.
5. Tilt the side carriage five times through its full range or until operation of the side tilt carriage is normal (no jerks or spongy feel).
6. Shut the engine OFF. Check the hydraulic level and fill as required.

g. Side Tilt Carriage Cylinder Pressure Checking and Circuit Bleeding

1. Attach a 4000 psi (276 bar) gauge to the main control valve at the extend base port relief to test the swing carriage cylinder hydraulic system circuit pressure. The unit is equipped with test fittings from the factory. Pressure readings should be 3200 psi ± 100 psi (220,6 ± 7 bar).
2. Start with the side tilt carriage cylinder balanced; that is, with the carriage level and centered, not tilted.
3. Tilt the carriage fully left. Hold the joystick at full tilt left for several seconds, then tilt the carriage fully right and hold the joystick at full tilt right for several seconds. Observe the readings on the gauge during the carriage tilting operations.
4. Center and level the carriage. While levelling the carriage, check the pressure reading on the gauge.
5. Repeat steps 3 and 4 five times.

9.10.8 Steer Cylinders

The steer cylinders are secured to the axle assemblies. Steer cylinders are covered in the appropriate manufacturer's axle literature. Refer to *Section 5 Axles, Wheels and Tires* for further information.

9.11 TROUBLESHOOTING

This section provides an easy reference guide covering the most common problems that occur during operation of the hydraulic system.

Hydraulic System Troubleshooting

Problem	Cause	Remedy
1. Cannot lower elevated load.	1. Ruptured hoist or extend hose.	1. Lower load using Emergency Boom Lowering instructions in *Section 3 Boom*.
	2. Loss of engine power or hydraulic pump failure.	2. Lower load using Emergency Boom Lowering instructions in *Section 3 Boom*.
	3. Faulty components in hoist/lower circuit.	3. Lower load using Emergency Boom Lowering instructions in *Section 3 Boom*. Troubleshoot components; repair or replace.
	4. Failed selector valve solenoid.	4. Replace selector valve solenoid.
	5. Failed joystick pilot valve.	5. Replace joystick pilot valve assembly.
2. Cavitation and noise.	1. Fluid level in reservoir is low.	1. Add fluid. Refer to *Section 2 General Information, Specifications and Maintenance Instructions*.
	2. Filter/breather is clogged.	2. Clean or replace filter/breather.
	3. Air leaks in suction line.	3. With the engine running, apply a small amount of hydraulic fluid on each joint of the suction line and tighten any joint where fluid stopped the noise. Double clamp if necessary.
	4. Loose pump mounting hardware.	4. Torque the capscrews to 75 lb/ft (102 Nm).
	5. Loose pump sections.	5. Determine cause of looseness. Disassemble, clean, inspect, repair and replace parts as required. Torque pump capscrews to proper specification.
	6. Defective pump.	6. Repair or replace pump.
3. Ruptured hose.	1. Hose damaged due to tight bend(s) or twists.	1. Replace hose; install without tight bends or twists.
	2. Excessive pressure.	2. Check and adjust pressure to proper specification.
4. Hose cover separated from hose casing.	1. Hose twisted at fitting during installation.	1. Replace hose. Prevent hose from twisting or turning as fittings are tightened.
5. Hose fittings have damaged threads.	1. Connections were cross-threaded or over-tightened.	1. Replace hose. Install and torque properly.

Hydraulic System Troubleshooting

Problem	Cause	Remedy
6. Boom hoist or extend function slow or malfunctioning.	1. External fluid leakage at tubes, hoses or fittings. 2. Faulty relief valve setting. 3. Internal leakage in cylinders. 4. Internal leakage in main control valve. 5. Control valve not fully shifted. 6. Defective hydraulic pump. 7. Malfunctioning pilot valve. 8. Malfunctioning unloader valve.	1. Check and tighten connections. Repair or replace faulty hose(s). 2. Adjust pressure to proper setting. 3. Repair cylinders as required. 4. Repair control valve as required. 5. Repair control circuit. 6. Repair pump. 7. Check and replace as required. 8. Check and replace as required.
7. Boom hoist or extend function drifts.	1. Defective counterbalance valve or cylinder seals. 2. External fluid leakage at tubes, hoses or fittings. 3. Faulty relief valve setting. 4. Internal leakage in cylinders. 5. Internal leakage in main control valve. 6. Defective hydraulic pump.	1. Repair or replace counterbalance valve or seals as required. 2. Check and tighten connections. Repair or replace faulty hose(s). 3. Adjust pressure to proper setting. 4. Repair cylinders as required. 5. Repair control valve as required. 6. Repair pump.
8. Attachment tilt slow or malfunctioning.	1. Defective counterbalance valve or seals. 2. External fluid leakage at tubes, hoses or fittings. 3. Faulty relief valve setting. 4. Internal leakage in cylinders. 5. Internal leakage in main control valve. 6. Defective hydraulic pump. 7. Malfunctioning pilot valve. 8. Malfunctioning unloader valve.	1. Repair or replace counterbalance valve or seals as required. 2. Check and tighten connections. Repair or replace faulty hose(s). 3. Adjust pressure to proper setting or replace valve. 4. Repair cylinders as required. 5. Repair control valve as required. 6. Repair pump. 7. Check and replace as required. 8. Check and replace as required.
9. Attachment tilt drifts.	1. Defective attachment tilt or slave cylinder(s). 2. Defective counterbalance valves.	1. Repair or replace cylinder. 2. Repair or replace counterbalance valves.

Hydraulic System Troubleshooting

Problem	Cause	Remedy
10. Frame tilt slow or malfunctioning.	1. External fluid leakage at tubes, hoses or fittings. 2. Faulty relief valve setting. 3. Internal leakage in cylinders. 4. Internal leakage in main control valve. 5. Defective hydraulic pump. 6. Malfunctioning pilot valve. 7. Malfunctioning unloader valve.	1. Check and tighten connections. Repair or replace faulty hose(s). 2. Adjust pressure to proper setting or replace valve. 3. Repair cylinders as required. 4. Repair control valve as required. 5. Repair pump. 6. Check and replace as required. 7. Check and replace as required.
11. Frame tilt drifts.	1. Defective check valves or frame tilt cylinder.	1. Repair or replace check valves or frame tilt cylinder.
12. Service brakes grab.	1. Excessive hydraulic pressure.	1. Adjust pressure reducing valve.
13. Service brakes spongy.	1. Air in brake line. 2. Insufficient hydraulic pressure.	1. Bleed brake lines. 2. Check and/or adjust pressure reducing valve.
14. Service brakes fail to release.	1. Brake pedal binding. 2. Faulty brake valve.	1. Correct condition. 2. Replace brake valve.
15. Service brake failure.	1. Ruptured hydraulic hose. 2. Faulty brake valve. 3. Pressure reducing valve failure. 4. Insufficient pressure at auxiliary function manifold. 5. Defective brake discs or leakage within brake section of axle.	1. Replace hose. 2. Replace brake valve. 3. Replace pressure reducing valve. 4. Adjust pressure at auxiliary function manifold or replace pressure reducing valve cartridge. 5. Check manufacturer's information and specifications (refer to *Section 5 Axles, Wheels and Tires*).
16. Park lock brake fails to release.	1. Ruptured hydraulic hose. 2. Defective park lock switch. 3. Park lock solenoid valves fail to shift. 4. Defective park lock assembly in front axle.	1. Replace hose. 2. Replace park lock switch. 3. Check for proper operation of solenoids or valves. Check electrical schematic (*Section 10*) and test electrical circuit. 4. Repair park lock per manufacturer's information and specifications (refer to *Section 5 Axles, Wheels and Tires*).

Hydraulic System Troubleshooting

Problem	Cause	Remedy
17. Park lock brake fails to set.	1. Defective solenoids and/or valves.	1. Refer to the appropriate electrical schematic in *Section 10 Electrical System*. Check and/or replace solenoids and valves.
	2. Defective switch.	2. Check electrical schematic (*Section 10*) and test electrical circuit and switch. Repair wiring or replace switch as required.
	3. Defective or weak springs in park lock assembly of front axle.	3. Repair park lock assembly per manufacturer's information and specifications (refer to *Section 5 Axles, Wheels and Tires*).
18. Power steering fails completely.	1. Ruptured hydraulic hose.	1. Replace hose.
	2. Faulty steering unit.	2. Replace steering unit.
	3. Insufficient (low) hydraulic pressure.	3. Troubleshoot and correct cause of low pressure. Adjust steering relief valve.
	4. Unloader valve malfunction.	4. Check and replace as required.
19. No four-wheel or crab steering, or steering mode change does not occur.	1. Defective solenoid in steer select valve.	1. Repair steer select valve.
	2. Faulty steer select switch or wiring.	2. Repair or replace steer select switch or wiring.
	3. Broken spring in steer select valve.	3. Replace steer select valve.
20. Steering slow or sluggish.	1. Steer relief valve not set correctly.	1. Check and set relief valve to proper specification.
	2. Defective steer relief valve.	2. Install new cartridge or replace valve.
	3. Steering cylinder leakage.	3. Repair or replace steering cylinder. Refer to manufacturer's information and specifications (see *Section 5 Axles, Wheels and Tires*).
	4. Unloader valve malfunction.	4. Check and replace as required.
21. Front or rear wheels not parallel in two-wheel or four-wheel steering mode.	1. Wheels not properly indexed.	1. Index wheels per procedure in Owners/Operators Manual.
	2. Wheel misalignment.	2. Check and adjust wheels properly per manufacturer's information and specifications (see *Section 5 Axles, Wheels and Tires*).
	3. Internal steering unit leakage.	3. Replace steering unit.
	4. Defective steer select valve.	4. Check and repair or replace steer select valve.

Hydraulic System Troubleshooting

Problem	Cause	Remedy
22. Steering is "spongy" or noisy.	1. Air in steering lines.	1. Check and tighten loose connections. Operate steering lock-to-lock several times to purge air from system.
	2. Faulty steering unit.	2. Replace steering unit.
23. Auxiliary equipment operates slowly or malfunctions.	1. External fluid leakage.	1. Check and tighten connections; replace defective hoses, etc.
	2. Faulty relief valve setting.	2. Check and set relief valve to proper specification.
	3. Internal cylinder leakage.	3. Repair cylinder as required.
	4. Internal leakage in main or auxiliary control valve.	4. Repair control valve as required.
	5. Insufficient flow of oil.	5. Check flow and pressure from pump through entire auxiliary hydraulic circuit. Repair or replace parts as required.
	6. Pilot valve malfunction.	6. Check and replace as required.
24. Auxiliary equipment drifts or creeps.	1. Leakage in auxiliary cylinder.	1. Repair or replace cylinder or check valve.
25. Pump fails to deliver fluid to unloader valve.	1. Low hydraulic fluid in reservoir.	1. Check fluid level and add fluid as required.
	2. Hydraulic oil reservoir breather is dirty.	2. Clean or replace the breather.
	3. Suction strainer is clogged.	3. Clean suction strainer.
	4. Suction line is restricted or loose.	4. Clean or replace suction line and/or tighten if loose.
	5. Fluid viscosity is too heavy to allow pump to be primed.	5. Check working temperature and service as required. Change fluid to proper viscosity as required. Refer to *Section 2 General Information, Specifications and Maintenance*.
	6. Worn, broken or stuck parts within pump.	6. Troubleshoot and correct true cause of pump failure and repair or replace pump.
26. Cylinder fails to move when control valve is actuated.	1. Faulty hose.	1. Repair or replace hose.
	2. Insufficient flow of oil.	2. Check hydraulic pump.
	3. Damaged cylinder.	3. Repair or replace cylinder.
	4. Defective control valve.	4. Inspect and repair as required.
	5. Pilot selector malfunction.	5. Check and replace as required.
	6. Pilot valve malfunction.	6. Check and replace as required.

Hydraulic System Troubleshooting

Problem	Cause	Remedy
27. Cylinder movement is jerky.	1. Air trapped in cylinder or in hydraulic line. Low oil level in hydraulic oil reservoir.	1. Inspect fluid for foam or bubbles. Check and tighten connections. Bring hydraulic fluid up to operating temperature and cycle vehicle functions several times through full range of motion to remove (purge or “bleed”) air from system.
	2. Binding of cylinder rod or piston.	2. Repair or replace cylinder.
	3. Rod seal installed improperly.	3. Replace seal. Properly install new seal.
	4. Binding of bearing at base end or rod end.	4. Eliminate bind and repair or replace bearing and other components as required.
	5. Defective counterbalance cartridge (hoist/lower cylinder).	5. Replace counterbalance cartridges.
28. Cylinder movement is slow or sluggish; cycle times are slow.	1. Control valve not fully shifted.	1. Engage control valve fully. Check that valve pressures are set as specified and that applicable circuit hoses are not restricted, bent, kinked, damaged, etc.
	2. Internal leakage or binding within cylinder.	2. Repair or replace cylinder.
	3. Insufficient flow of oil.	3. Check flow throughout hydraulic circuit, starting at main pump.
	4. Unloader valve malfunction.	4. Check and replace as required.
	5. Pilot valve malfunction.	5. Check and replace as required.
29. Cylinder piston rod drifts or creeps.	1. Worn piston seals.	1. Install new seal kit.
	2. Tube is out-of-round.	2. Replace tube.
30. Main relief valve doesn’t hold pressure setting.	1. Spring is broken or worn (“has taken a set”).	1. Replace relief valve assembly.
	2. Poppet stuck due to dirt or deposits.	2. Replace relief valve assembly.

Hydraulic System Troubleshooting

Problem	Cause	Remedy
31. Directional control valve difficult to shift.	1. Broken internal parts.	1. Disassemble control valve and replace broken parts.
	2. Scored valve body bore, producing leakage between spool and body.	2. Inspect bore. Replace valve section if scored.
	3. Broken centering spring.	3. Replace spring.
32. Movement of joystick fails to cause spool in control valve to shift.	1. Faulty joystick, joystick switch, wiring, or solenoid valve.	1. Troubleshoot and repair as required. Refer to *Section 10 Electrical System*.
	2. Insufficient pressure to move spool.	2. Check pilot pressure.
	3. Check main control valve for stuck spool.	3. Replace as required.

Section 10
Electrical System

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Introduction

The electrical system produces, stores and distributes electricity in the operation of the vehicle.

An engine-driven, 65-amp alternator equipped with an internal, solid-state voltage regulator produces electricity. Current from the alternator charges the battery and powers electrical system components.

The battery provides power for starting the engine and supplements the output of the alternator during periods of peak demand.

The vehicle is equipped with two separate but connected wiring harnesses, an engine harness and a cab harness. A multiple or “bulkhead” connector at the end of each harness joins the two together.

Each wire within a harness has color-coded insulation and is marked with a number to aid in identifying and tracing each circuit and in making proper connections. Fuses and relays are included with the cab harness to help protect the electrical system and its components.

The wiring diagrams in this section indicate electrical circuits and components respective of their *approximate* location on the vehicle.

The information in this section has been developed from the perspective that all wires are connected and routed as they were when the vehicle left the factory. Take into account any disconnected or re-routed wires before beginning to diagnose a circuit. Refer to the wiring diagrams to test circuits for continuity or for shorts using a conventional test light, ohmmeter, multimeter or low-reading voltmeter.

The text discusses each circuit and component, as well as component function and replacement. A brief trouble-shooting table appears at the conclusion of this section. Keep in mind that the various systems on the vehicle include both electrical and hydraulic components; what at first may appear to be an electrical problem may turn out to be a hydraulic problem.

Legend for Cab Harness (S/N 8249 and before)

1. Cab Harness
2. Back-up Alarm
3. Hex-lock Elastic Nut, 1/4-20
4. Flat Washer, 1/4”
5. Boom Sensor
6. Service Brake Switch
7. Logic Board
8. Button-head Capscrew, #10-32 x 3/4
9. Well Nut, #10-32
10. Steer Select Switch
11. Switch Bezel
12. Operators Display Panel
13. Park Brake Switch
14. Round-head Wood Screw, #6 x 1/2”
15. Hourmeter
16. Machine Bushing Washer, 0.63” I.D.
17. Ignition Switch
18. Ignition Key
19. Fuse, 7.5 Amp
20. Fuse, 40 Amp
21. Fuse, 15 Amp (optional Perkins cold start only)
22. Sealed Relay, 12 Volt, 40 Amp
23. Slotted Pan-head Screw, #10-24 x 3/4”
24. Narrow Flat Washer, #10
25. Slotted Pan-head Screw, #10-24 x 5/8”
26. Hex-lock Elastic Nut, #10-24
27. Flat Washer, 1/4”
28. Lockwasher, 1/4”
29. Hex Nut, 1/4-20
30. Plastic Tie
31. Hex Jam Nut, M6-1 Cl4
32. Lockwasher, M6
33. Signal Horn
34. Tube Clip
35. Hex Locknut, 1/2-13
36. Attachment Tilt Mode Switch
37. Attachment Tilt Direction Harness

General Overview (Cab Harness)

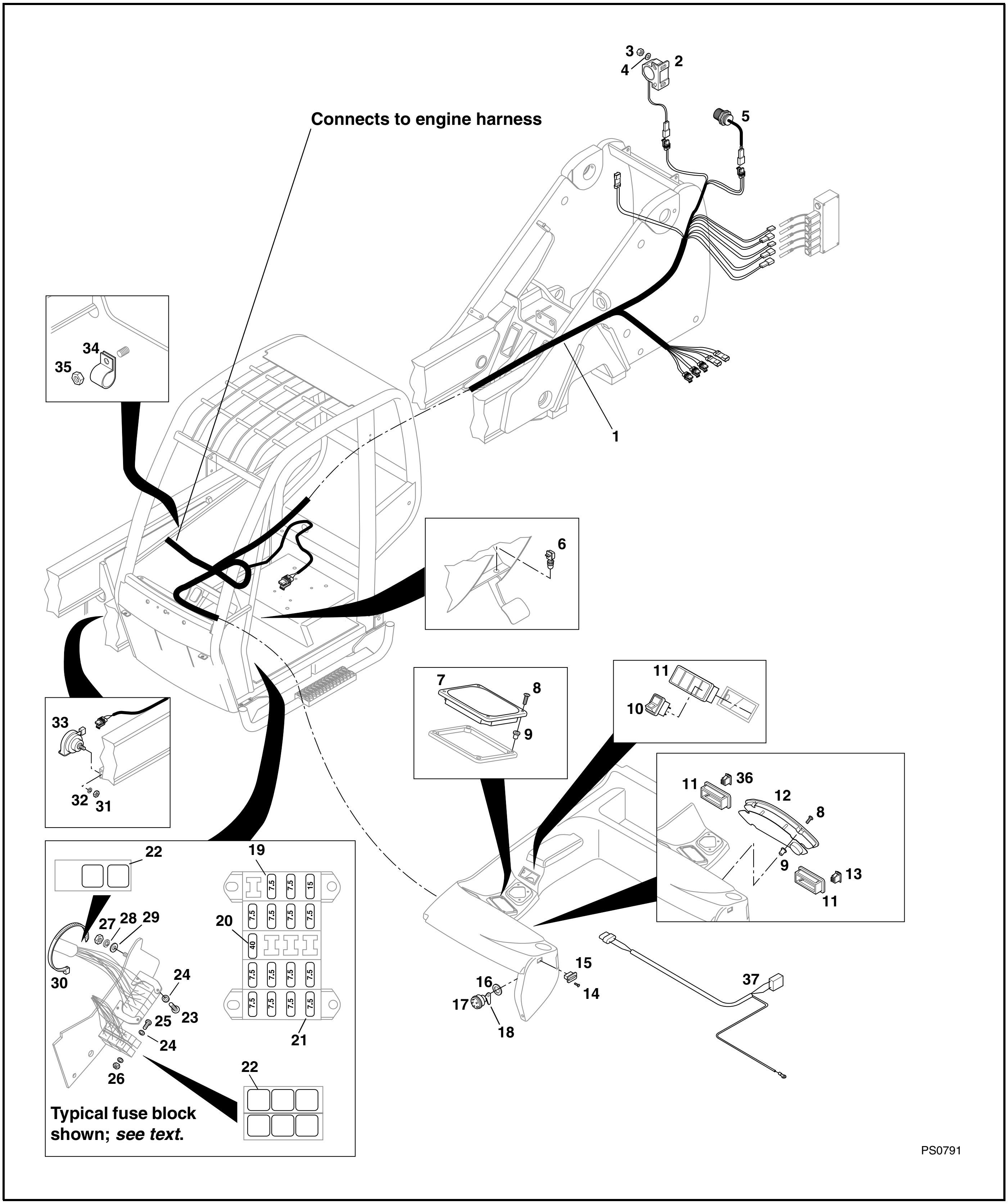


Figure 10-1. Typical cab harness (S/N 8249 and before; *see text*).

General Overview (Engine Harness)

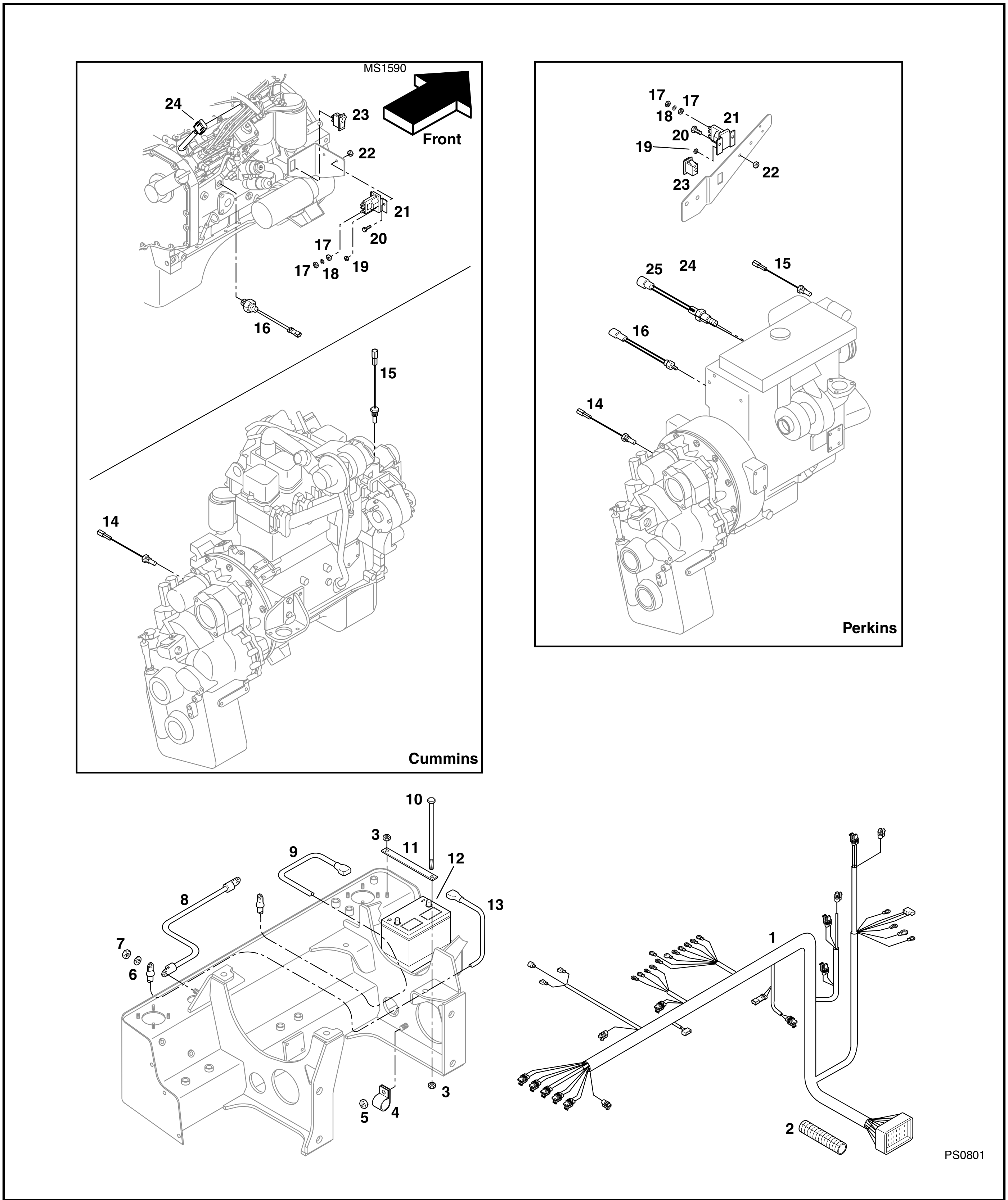


Figure 10–2. Engine harness.

Legend for Engine Harness

1. Engine Harness
2. Conduit, 3/4” diameter x 10” long
3. Hex-lock Elastic Nut, 3/8-16
4. Tube Clip
5. Hex-lock Elastic Nut, 1/2-13
6. Flat Washer, 3/8”
7. Hex Locknut
8. Battery Ground Cable
9. Positive (+) Battery Cable, w/protective cover
10. Hex-head Capscrew, 3/8-16 x 9-11/2”
11. Battery Hold-down Strip
12. Battery, 12 Volt, 1000 CCA
13. Negative (-) Battery Cable, w/protective cover
14. Transmission Temperature Switch, 250° F (121° C)
15. Engine Water Temperature Switch
16. Engine Oil Pressure Switch
17. Hex Nut, 1/4-20
18. Lockwasher, 1/2”
19. Hex Nut, #10-32
20. Hex-head Capscrew, 1/4-20 x 3/4”
21. Starter Relay
22. Hex-lock Elastic Nut, 1/4-20
23. Maintenance Reset Switch
24. Fuel Shut-off Solenoid
25. Perkins Cold-start Temperature Switch

10.1 SERVICE WARNINGS

General

WARNING: DO NOT disconnect any wiring without first stopping the engine, turning all electrical switches to the OFF position and disconnecting the battery ground cable from the battery.

WARNING: DO NOT cause a short circuit by connecting leads to incorrect terminals. Always identify a lead and its correct terminal. A short circuit or wrong connection creating reverse polarity will immediately and permanently ruin transistors and diodes within the electrical system.

WARNING: DO NOT momentarily or "flash" connect a terminal to check for current flow. No matter how brief the contact, the transistors may be ruined.

Battery

WARNING: Wear safety glasses when working near the battery.

WARNING: All lead-acid batteries generate hydrogen gas, which is highly flammable. If ignited by a spark or flame, the gas may explode violently, causing spraying of acid, fragmentation of the battery, and possible severe personal injuries, particularly to the eyes.

WARNING: Avoid battery acid. Battery acid can cause chemical burns or other serious injury. In case of contact with battery acid, flush immediately with water.

WARNING: Charge the battery in a well-ventilated area only. Always turn battery chargers OFF before connecting to or disconnecting from a battery.

WARNING: DO NOT disconnect the battery while the engine is running. This will cause a voltage surge in the alternator charging system that will immediately ruin the diodes or transistors.

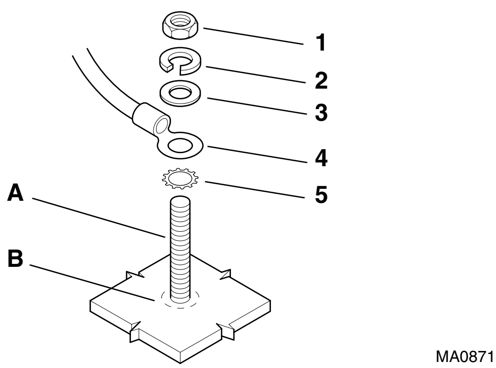
WARNING: DO NOT connect a battery into the system without checking for correct polarity and voltage.

10.2 SPECIFICATIONS

Electrical system specifications are listed in *Section 2 General Information, Specifications and Maintenance Instructions*.

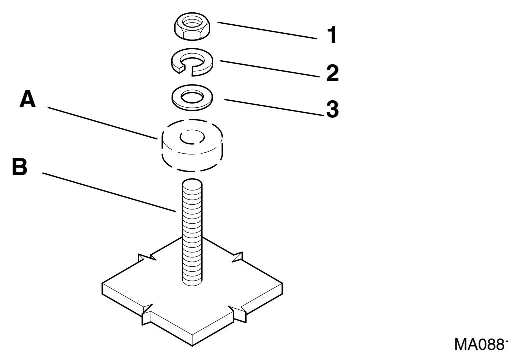
10.3 EFFECTIVE GROUND CONNECTIONS

Effective ground connections are essential to the efficient operation of electrical components. If an inadequate ground is suspected or determined, establishing another ground may be desired. Also, in the event a factory-authorized accessory is being installed, it is necessary to follow the proper sequence for providing an electrical ground. The sequence for installing or attaching a component to an electrical ground is shown in Figs. 10–3 and 10–4.



A. Stud, bolt or capscrew.
B. Eliminate paint, rust, etc. from the area around the base of the stud, equivalent to outside diameter of lockwasher (5).
1. Hex nut or lock nut
2. Tooth- or slot-type lockwasher
3. Flat washer
4. Electrical ground(s)
5. Tooth-type lockwasher

Figure 10–3. Recommended parts sequence for grounding an electrical wire.



A. Partial sectional view of part to be grounded.
B. Stud, bolt or capscrew.
1. Hex nut or lock nut
2. Tooth- or slot-type lockwasher, or locking nut with slotted type lockwasher
3. Flat washer

Figure 10–4. Recommended parts sequence for electrically grounding a component at a mechanical support.

10.4 WIRING HARNESSES

Wiring on the vehicle is contained within two separate wiring harnesses, an engine harness and a cab harness. There are several figures in this section that depict the different wiring harnesses.

A harness consists of black-nylon woven braiding, providing a protective cover to bundle numerous wiring groups, splices, terminals, connectors, and, where applicable, diodes. Each harness is identified with a Trak part number when the vehicle leaves the factory.

One engine harness has been used throughout the production history of this vehicle.

Note: There are currently three cab harnesses in use on this vehicle. The initial harness covered serial numbers 8249 and before. The addition of wiring for limited accessories on the next production harness covers serial numbers 8250 through 9398. The current harness covers serial numbers 9399 and after and includes additional wiring for all planned accessory items.

Check the cab wiring harness on the vehicle respective of the serial number information above to determine which harness the vehicle is equipped with.

Each wire is identified by a wire number on each end of the individual wire, and by the color and gauge size of the wire. The wire numbers and color codes are also identified on the appropriate electrical schematic. All circuits have been electrically tested for continuity, and all diodes have been tested for correct biasing. Where several individual connectors appear, the wiring leading to a particular connector can help identify the specific circuit. For some circuits, a colored band (tie wrap) is present, affixed to the connector wiring and used as a color-code indicator. For ease of identification, detailed illustrations of each type of connector also appear in this section.

If wiring ever needs to be replaced, use the correct gauge size wiring. NEVER replace a wire with a smaller gauge wire.

a. Removal and Replacement

Remove a wiring harness only if damaged or unusable. Install a new harness one terminal at a time as the old harness is removed. Label or tag the terminal locations of all wires, harness clips, tie wraps and conduit as the old harness is removed to allow correct installation of the new harness.

b. Disassembly

Disassembly of the wiring harness is not recommended due to the precise arrangement of wires and splice requirements. If it becomes necessary to replace wires, use the correct gauge size wiring, and NEVER replace a wire with a smaller gauge wire.

c. Cleaning and Drying

Clean a wire harness with a natural bristle brush and the same detergent used to clean the vehicle. Allow the harness to air dry. DO NOT allow surface temperatures to exceed 300° F (149° C).

d. Inspection and Repair

Replace a harness only if it is damaged or unusable. If a splice or repair must be made to a wire, always use rosin core solder to bond wires together. Use heat-shrink tubing or insulating electrical tape to cover all splices or bare wires.

e. Installation

The wiring harnesses are held securely in place by wire tie wraps, clips or other devices to help prevent chafing or wearing of the insulation and entanglement with moving parts. Sections of ribbed plastic conduit have been installed where wiring or harnesses pass through openings in the vehicle frame. Always install tie wraps, clips, conduit, etc., in their original locations to help prevent damage to the wiring or harnesses.

f. Wire Code and Color

The chart below indicates the wire code abbreviation and color as used on the electrical schematics.

WIRE CODE	COLOR
BLK	Black
BLU	Blue
BRN	Brown
DK BLU	Dark Blue
DK GRN	Dark Green
GRN	Green
GRY	Grey
LGT BLU	Light Blue
LGT GRN	Light Green
ORN	Orange
PNK	Pink
PUR	Purple
RED	Red
TAN	Tan
YEL	Yellow
WHT	White

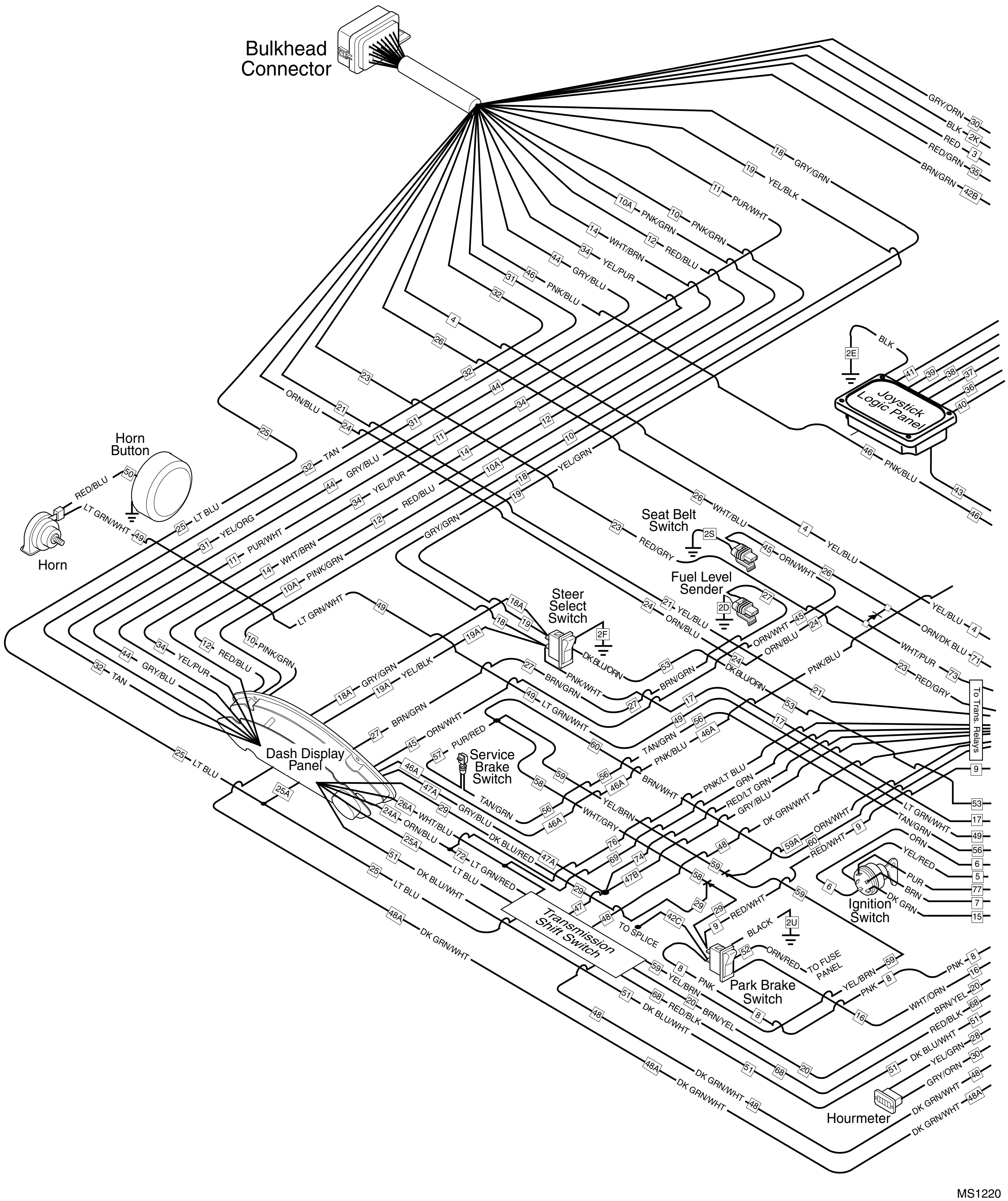


Figure 10-5. Cab wiring diagram (S/N 8249 and before), left side.

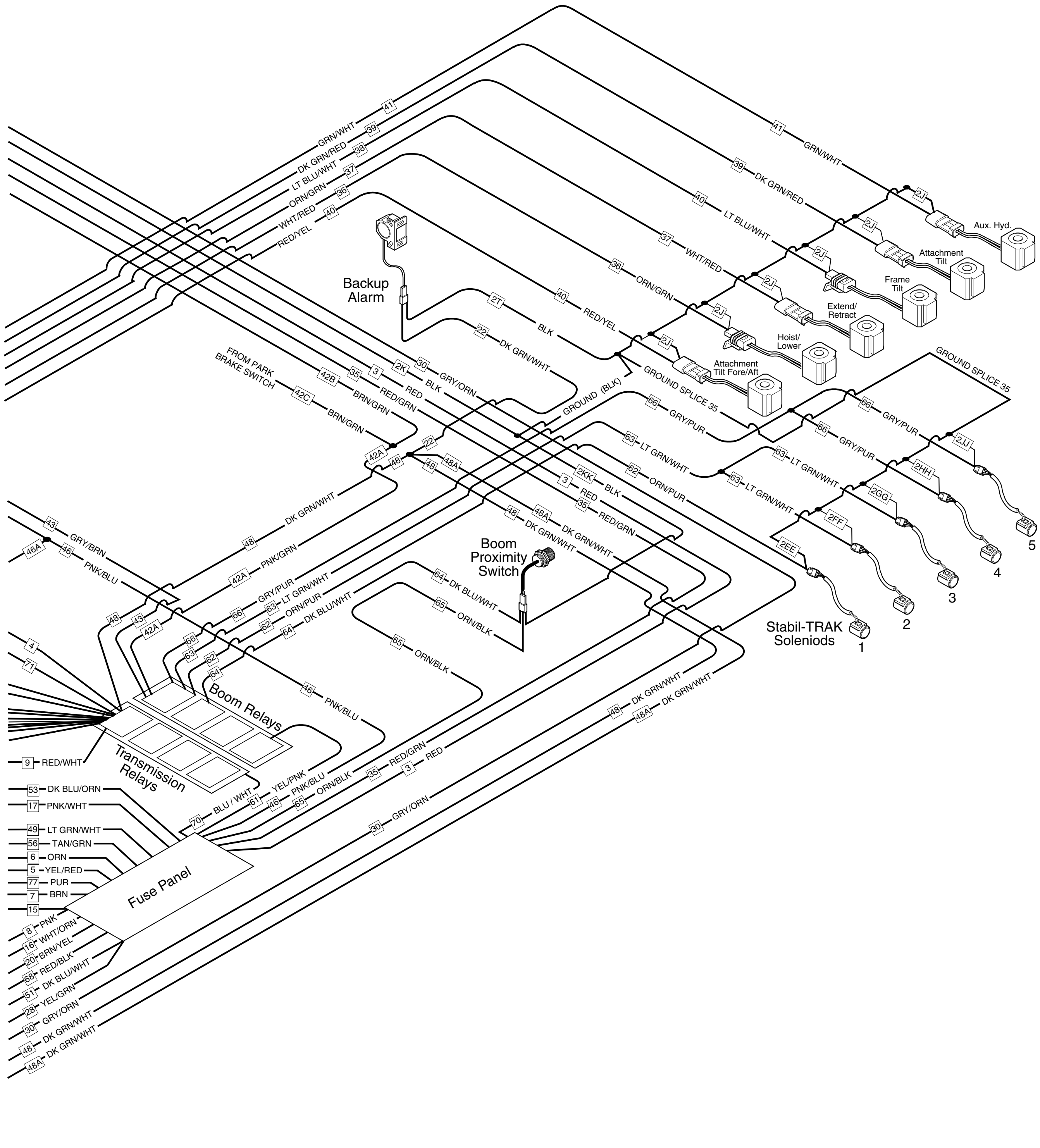


Figure 10-6. Cab wiring diagram (S/N 8249 and before), right side.

10.4.1 Cab Harness, S/N 8249 and Before

Use this chart for vehicles with S/N 8249 and before.

WIRE No.	COLOR	GAUGE	FUNCTION
2B	BLK	16	Hourmeter to Ground Splice 40
2C	BLK	16	Shift Control Relays to Cab Ground Stud
2D	BLK	16	Fuel Level Sender to Ground Splice 50
2E	BLK	14	Joystick Logic Board to Ground Splice 40
2F	BLK	16	Steer Select Lamp (Terminal 7) to Ground Splice 40
2G	BLK	16	Display Panel to Ground Splice 40
2H	BLK	16	Display Panel to Ground Splice 40
2J	BLK	16	Boom Function Solenoids to Ground Splice 35
2K	BLK	10	Ground Splice 45 to Ground Splice 50
2S	BLK	16	Seat Belt Switch to Ground Splice 50
2T	BLK	16	Backup Alarm to Ground Splice 35
2U	BLK	16	Ground Splice 40 to Park Brake Lamp (Terminal 7)
2V	BLK	12	Ground Splice 40 to Cab Ground Stud
2Y	BLK	10	Ground Splice 35 to Ground Splice 50
2AA	BLK	10	Ground Splice 50 to Cab Ground Stud
2BB	BLK	10	Ground Jumper for Neutral Relay
2CC	BLK	16	Ground Splice 40 to Stabil-TRAK Relays
2EE	BLK	16	Ground Splice 35 to Stabil-TRAK Solenoid #3
2FF	BLK	16	Ground Splice 35 to Stabil-TRAK Solenoid #4A
2GG	BLK	16	Ground Splice 35 to Stabil-TRAK Solenoid #4B
2HH	BLK	16	Ground Splice 35 to Stabil-TRAK Solenoid #2A
2JJ	BLK	16	Ground Splice 35 to Stabil-TRAK Solenoid #2B
2KK	BLK	16	Ground Splice 35 to Boom Proximity Switch
2LL	BLK	16	Ground Splice 40 to Relay 1
2MM	BLK	16	Ground Splice 40 to Neutral Relay
3	RED	10	Starter (+) Power to (+) Grid (fuse panel bus)
4	YEL/BLU	16	Neutral Relay to Starter Relay
5	YEL/RED	14	Ignition Switch (Terminal 4) to 7.5-amp Fuses
6	ORN	10	Ignition Switch to 40-amp Main Fuse
7	BRN	10	Ignition Switch to (+) Grid (fuse panel bus)
8	PNK	16	7.5-amp Fuse to Park Brake Switch (Terminal 5)
9	RED/WHT	16	Park Brake Switch (Terminal 6) to Neutral Relay
10	PNK/GRN	16	Alternator Indicator Terminal to CUMMINS Indicator Logic
10A	PNK/GRN	16	Alternator Indicator Terminal to PERKINS Indicator Logic
11	PUR/WHT	16	Oil Pressure Logic to Oil Pressure Switch
12	RED/BLU	16	Engine Coolant Temperature Logic to Engine Coolant Temperature Switch
14	WHT/BRN	16	Hydraulic Oil Temperature Logic to Hydraulic Oil Temperature Switch
15	DK GRN	16	Ignition Switch to 7.5-amp Fuse for Shift Control
16	WHT/ORN	16	7.5-amp Fuse to Park Brake Switch (Terminal 2)
17	PNK/WHT	16	7.5-amp Fuse to Steer Select Switch (Terminal 2)
18	GRY/GRN	16	Steer Select Switch (Terminal 1) to Steer Select Solenoid (C)
18A	GRY/GRN	16	Steer Select Switch (Terminal 1) to Steer Select Logic
19	YEL/BLK	16	Steer Select Switch (Terminal 3) to Steer Select Solenoid (Terminal 4)
19A	YEL/BLK	16	Steer Select Switch (Terminal 3) to Steer Select Logic
20	BRN/YEL	14	7.5-amp Fuse to Shift Control Switch (Terminal 8)
21	YEL/BLU	16	Shift Control Relay to Reverse Clutch Solenoid
22	DK GRN/WHT	16	Splice 20 to Backup Alarm
23	RED/GRY	16	Shift Control Relay to Forward Clutch Solenoid
24	ORN/BLU	16	Transmission Shuttle Solenoid to Splice 8
24A	ORN/BLU	16	Splice 80 to Transmission Logic
25	LT BLU	16	Transmission Shift Control Switch to First Gear Clutch Solenoid
25A	LT BLU	16	First Clutch Shift Control to Transmission Logic

WIRE No.	COLOR	GAUGE	FUNCTION
26	WHT/BLU	16	Splice 12 to Second Gear Clutch Solenoid
26A	WHT/BLU	16	Second Clutch Shift Control to Transmission Logic
27	BRN/GRN	16	Fuel Gauge Logic to Fuel Level Sender
28	YEL/GRN	16	7.5-amp Fuse to Hourmeter Power (+) Terminal
29	DK BLU/RED	16	Park Brake Switch (Terminal 3) to Park Brake Logic
30	GRY/ORN	16	Oil Pressure Switch (Terminal B) to Hourmeter Ground (-) Terminal
31	YEL/ORN	16	Air Filter Logic to Air Filter Switch
32	TAN	16	Transmission Temperature Logic to Transmission Temperature Switch
34	YEL/PUR	16	Hydraulic Oil Filter Logic to Hydraulic Oil Pressure Switch
35	RED/GRN	16	Ignition Fuse to Fuel Shutoff Solenoid
36	ORN/GRN	14	Lift Solenoid to Logic Board
37	WHT/RED	14	Extend Solenoid to Logic Board
38	LT BLU/WHT	14	Frame Tilt Solenoid to Logic Board
39	DK GRN/RED	14	Attachment Tilt (side-to-side) Solenoid to Logic Board
40	RED/YEL	14	Auxiliary Hydraulics "1" to Logic Board
41	DK GRN/WHT	14	Auxiliary Hydraulics "2" to Logic Board
42A	PNK/GRN	16	Splice 10 to Shift Control Relays
42B	BRN/GRN	16	Splice 10 to Splice 15
42C	BRN/GRN	16	Splice 10 to Park Brake Switch (Terminal 1)
43	GRY/BRN	16	Joystick Logic (Terminal 7/A) to 7.5-amp Fuse
44	GRY/BLU	16	Maintenance Reset Switch to Bulkhead Connector to Maintenance Indicator
45	ORN/WHT	16	Seat Switch to Seat Belt Logic
46	PNK/BLU	10	Cold Start to 15-amp Fuse
46A	PNK/BLU	16	Cold Start to Logic Panel
47	GRY/BLU	16	Shift Control to Shift Control Relay (F)
47A	GRY/BLU	16	(F) Shift Control to Transmission Logic Indicator
48	DK GRN/WHT	16	Shift Control to Shift Control Relay (R)
48A	DK GRN/WHT	16	Shift Control to Shift Logic
49	LT GRN/WHT	16	7.5-amp Fuse to Horn (+) Power Terminal
50	RED/BLU	16	Horn (-) Terminal to Horn Button (on steering wheel)
51	DK BLU/WHT	16	7.5-amp Fuse to Indicator Panel Logic
52	ORN/RED	16	Park Brake Lamp (Terminal 8) to Fuse Panel
53	DK BLU/ORN	16	Steer Select Lamp (Terminal 8) to 7.5-amp Fuse
56	TAN/GRN	16	Service Brake Switch to Fuse Panel
57	PUR/RED	16	Service Brake Switch to Splice 5
58	WHT/GRY	16	Park Brake Splice to Splice 5
59	YEL/BRN	16	Transmission Shift Switch Out to NEUTRAL Splice to Splice 5
59A	ORN/WHT	16	Transmission Shift Switch Splice to NEUTRAL Relay
60	BRN/WHT	16	Splice 5 to Stabilizer Lock Relay
61	YEL/PNK	16	Boom Proximity Splice to Fuse Panel
62	ORN/PUR	16	Stabilizer Lock Relay to Stabilizer Valve (Coil 5)
63	LT GRN/WHT	16	Stabilizer Lock Relay to Stabilizer Valve (Coil 4)
64	DK BLU/WHT	16	Boom Proximity Switch to Boom Switch Relay
65	ORN/BLU	16	Boom Proximity Splice to Boom Switch Relay
66	GRY/PUR	16	Boom Switch Relay to Stabilizer Valve (Coil 2)
67	RED/GRN	16	Stabilizer Valve (Coil 3) to Stabil-TRAK Logic Input
68	RED/BLK	16	7.5-amp Fuse to Shift Control Switch Neutral
69	GRN	16	Shift Control Switch (Terminal 3) to Relay 1 (Terminal 85)
70	BLU/WHT	16	Fuse Panel 7.5-amp Fuse to Transmission Relay 1 (Terminal 30)
71	ORN/DK BLU	16	Relay 1 (Terminal 87) to Splice 12 to Transmission 2nd Gear Solenoid
72	LT GRN/RED	16	Shift Control to Shuttle Clutch Solenoid
73	WHT/PUR	16	Transmission Relay 3 (Terminal 87) to Splice 8
74	RED/LT GRN	16	Forward Splice to Transmission Relay 3 (Terminal 30)
75	WHT/BLU	16	Shift Control Switch to 2nd Gear Clutch Solenoid
76	PNK/LT BLU	16	4TH Gear (optional--if equipped) Splice to Transmission Relay 2 (Terminal 85)
77	PUR	10	Ignition Switch (Terminal 5) to 15-amp Fuse

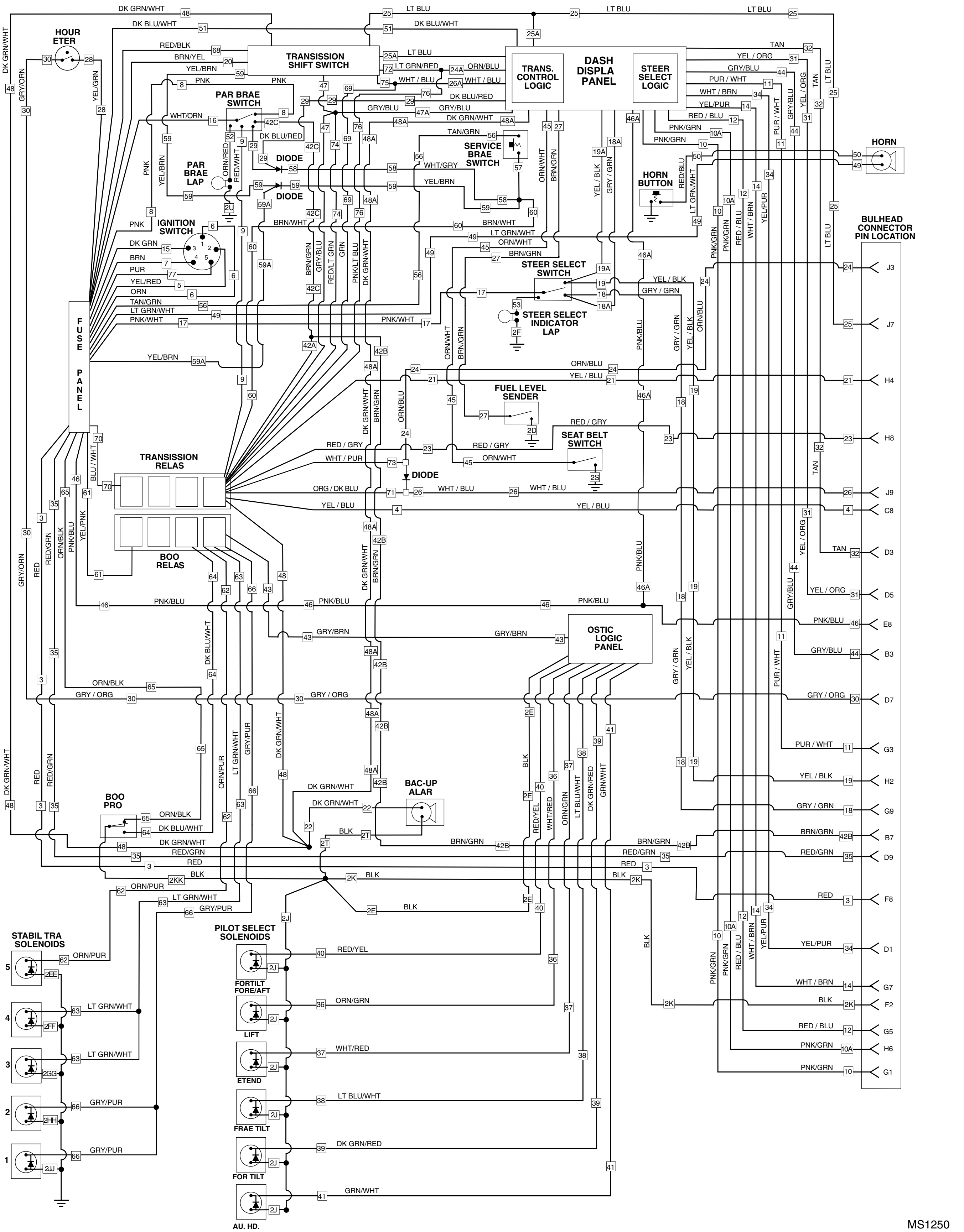


Figure 10-7. Cab wiring schematic, S/N 8249 and before.

Head-on views; wires exit at the rear of each component.

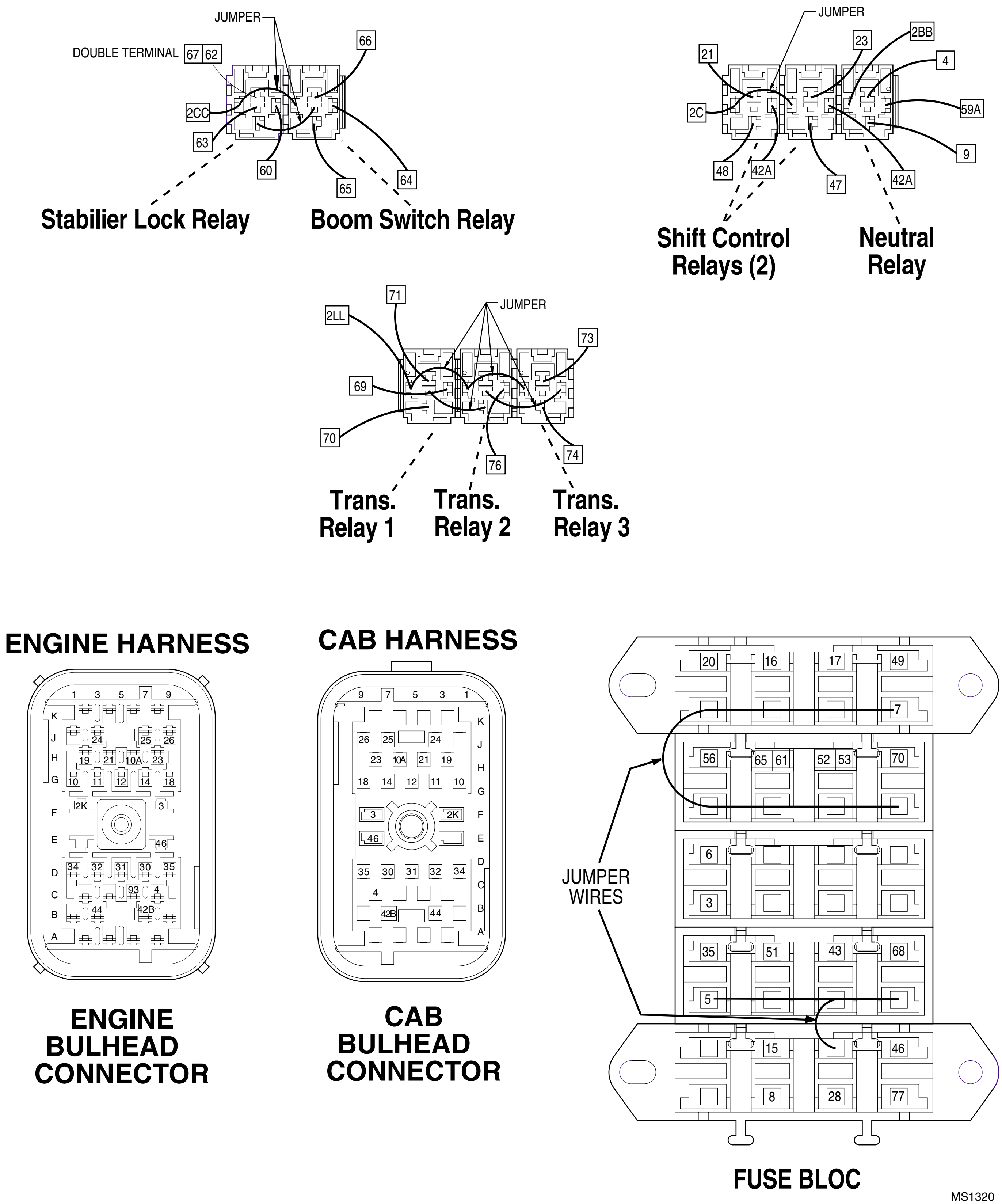


Figure 10–8. Cab harness relays, bulkhead connector and fuse panel, *S/N 8249 and before*.

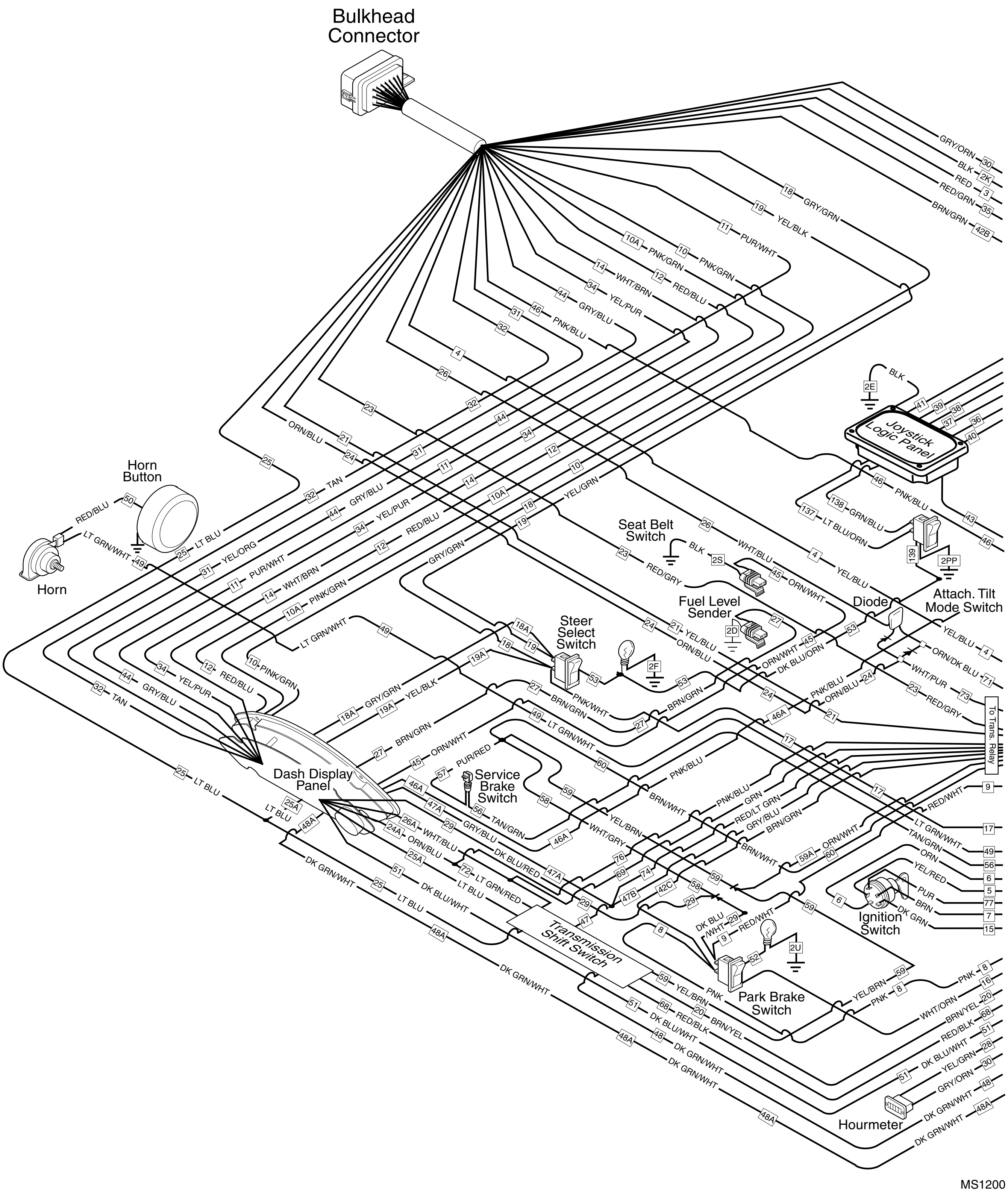


Figure 10–9. Cab wiring diagram, S/N 8250-9398, left side (*refer to the appropriate wire code chart*).

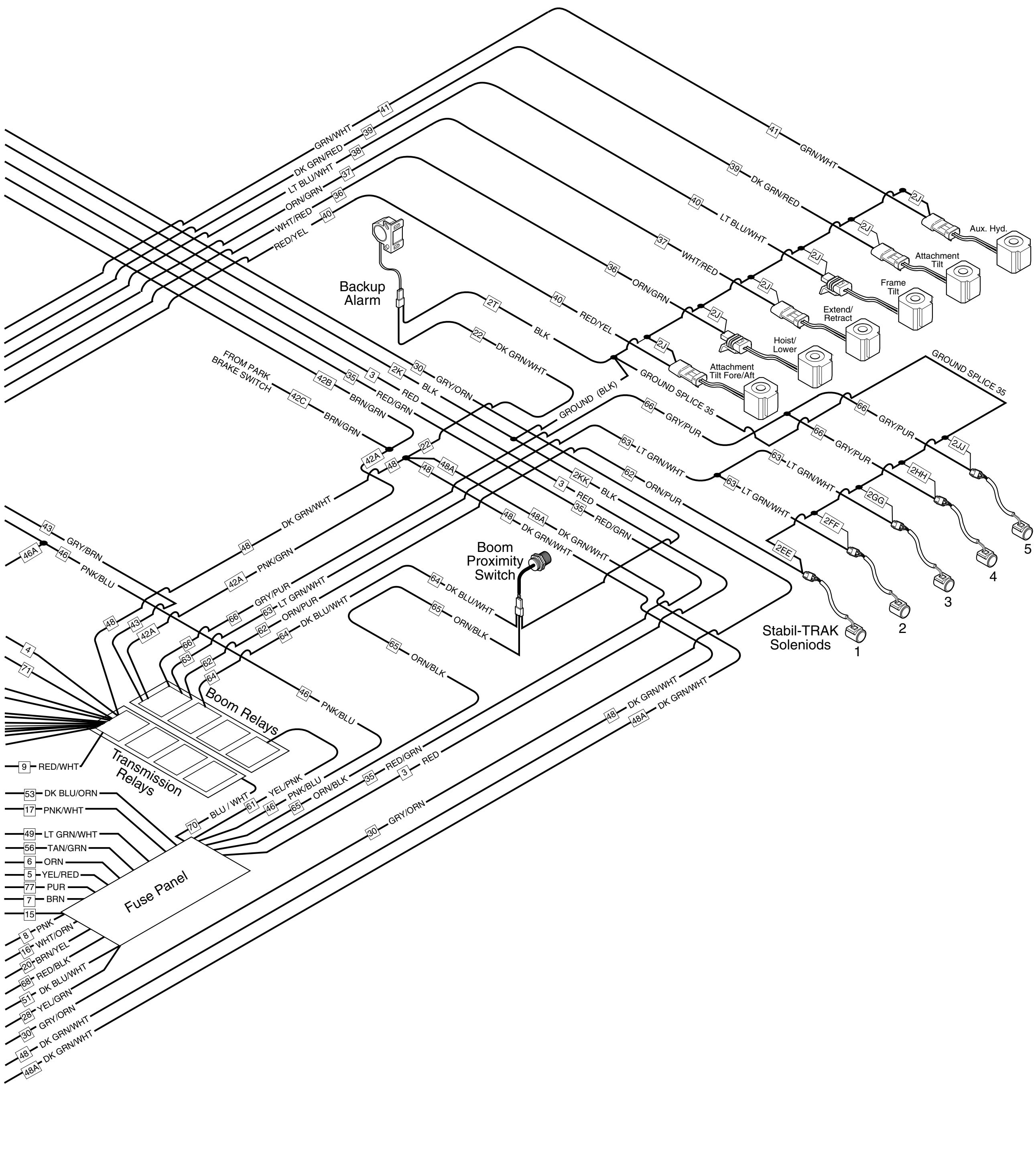


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Figure 10–10. Cab wiring diagram, S/N 8250-9398, right side (*refer to the appropriate wire code chart*).

10.4.2 Cab Harness, S/N 8250-9398

Use this chart for vehicles with S/N 8250-9398.

WIRE No.	COLOR	GAUGE	FUNCTION
2	BLK	16	Generic Ground
2B	BLK	16	Hourmeter to Ground Splice 40
2C	BLK	16	Shift Control Relays to Cab Ground Stud
2D	BLK	16	Fuel Level Sender to Ground Splice 50
2E	BLK	14	Joystick Logic Board to Ground Splice 40
2F	BLK	16	Steer Select Lamp (Terminal 7) to Ground Splice 40
2G	BLK	16	Display Panel to Ground Splice 40
2H	BLK	16	Display Panel to Ground Splice 40
2J	BLK	16	Boom Function Solenoids to Ground Splice 35
2K	BLK	10	Ground Splice 45 to Ground Splice 50
2S	BLK	16	Seat Belt Switch to Ground Splice 50
2T	BLK	16	Backup Alarm to Ground Splice 35
2U	BLK	16	Ground Splice 40 to Park Brake Lamp (Terminal 7)
2V	BLK	12	Ground Splice 40 to Cab Ground Stud
2Y	BLK	10	Ground Splice 35 to Ground Splice 50
2AA	BLK	10	Ground Splice 50 to Cab Ground Stud
2BB	BLK	10	Ground Jumper for Neutral Relay
2CC	BLK	16	Ground Splice 40 to Stabil-TRAK Relays
2EE	BLK	16	Ground Splice 35 to Stabil-TRAK Solenoid #5
2FF	BLK	16	Ground Splice 35 to Stabil-TRAK Solenoid #4
2GG	BLK	16	Ground Splice 35 to Stabil-TRAK Solenoid #3
2HH	BLK	16	Ground Splice 35 to Stabil-TRAK Solenoid #2
2JJ	BLK	16	Ground Splice 35 to Stabil-TRAK Solenoid #1
2KK	BLK	16	Ground Splice 35 to Boom Proximity Switch
2LL	BLK	16	Ground Splice 40 to Relay 1
2MM	BLK	16	Ground Splice 40 to Neutral Relay
3	RED	10	Starter (+) Power to (+) Grid (fuse panel bus)
4	YEL/BLU	16	Neutral Relay to Starter Relay
5	YEL/RED	14	Ignition Switch (Terminal 4) to 7.5-amp Fuses
6	ORN	10	Ignition Switch to 40-amp Main Fuse
7	BRN	10	Ignition Switch to (+) Grid (fuse panel bus)
8	PNK	16	7.5-amp Fuse to Park Brake Switch (Terminal 5)
9	RED/WHT	16	Park Brake Switch (Terminal 6) to Neutral Relay
10	PNK/GRN	16	Alternator Indicator Terminal to CUMMINS Indicator Logic
10A	PNK/GRN	16	Alternator Indicator Terminal to PERKINS Indicator Logic
11	PUR/WHT	16	Oil Pressure Logic to Oil Pressure Switch
12	RED/BLU	16	Engine Coolant Temperature Logic to Engine Coolant Temperature Switch
14	WHT/BRN	16	Hydraulic Oil Temperature Logic to Hydraulic Oil Temperature Switch
15	DK GRN	16	Ignition Switch to 7.5-amp Fuse for Shift Control
16	WHT/ORN	16	7.5-amp Fuse to Park Brake Switch (Terminal 2)
17	PNK/WHT	16	7.5-amp Fuse to Steer Select Switch (Terminal 2)
18	GRY/GRN	16	Steer Select Switch (Terminal 1) to Steer Select Solenoid (C)
18A	GRY/GRN	16	Steer Select Switch (Terminal 1) to Steer Select Logic
19	YEL/BLK	16	Steer Select Switch (Terminal 3) to Steer Select Solenoid (Terminal 4)
19A	YEL/BLK	16	Steer Select Switch (Terminal 3) to Steer Select Logic
20	BRN/YEL	14	7.5-amp Fuse to Shift Control Switch (Terminal 8)
21	YEL/BLU	16	Shift Control Relay to Reverse Clutch Solenoid
22	DK GRN/WHT	16	Splice 20 to Backup Alarm
23	RED/GRY	16	Shift Control Relay to Forward Clutch Solenoid
24	ORN/BLU	16	Transmission Shuttle Clutch Solenoid to Splice 8
24A	ORN/BLU	16	Splice 80 to Transmission Logic
25	LT BLU	16	Transmission Shift Control Switch to First Gear Clutch Solenoid

WIRE No.	COLOR	GAUGE	FUNCTION
25A	LT BLU	16	First Clutch Shift Control to Transmission Logic
26	WHT/BLU	16	Splice 12 to Second Gear Clutch Solenoid
26A	WHT/BLU	16	Second Clutch Shift Control to Transmission Logic
27	BRN/GRN	16	Fuel Gauge Logic to Fuel Level Sender
28	YEL/GRN	16	7.5-amp Fuse to Hourmeter Power (+) Terminal
29	DK BLU/RED	16	Park Brake Switch (Terminal 3) to Park Brake Logic
30	GRY/ORN	16	Oil Pressure Switch (Terminal B) to Hourmeter Ground (-) Terminal
31	YEL/ORN	16	Air Filter Logic to Air Filter Switch
32	TAN	16	Transmission Temperature Logic to Transmission Temperature Switch
34	YEL/PUR	16	Hydraulic Oil Filter Logic to Hydraulic Oil Pressure Switch
35	RED/GRN	16	Ignition Fuse to HOLD Lead Fuel Shutoff Solenoid
36	ORN/GRN	16	Lift Solenoid to Logic Board
37	WHT/RED	16	Extend Solenoid to Logic Board
38	LT BLU/WHT	16	Frame Tilt Solenoid to Logic Board
39	DK GRN/RED	16	Attachment Tilt (side-to-side) Solenoid to Logic Board
40	RED/YEL	16	Auxiliary Hydraulics "1" to Logic Board
41	DK GRN/WHT	16	Auxiliary Hydraulics "2" to Logic Board
42A	PNK/GRN	16	Splice 10 to Shift Control Relays
42B	BRN/GRN	16	Splice 10 to Splice 15
42C	BRN/GRN	16	Splice 10 to Park Brake Switch (Terminal 1)
43	GRY/BRN	16	Joystick Logic (Terminal 7/A) to 7.5-amp Fuse
44	GRY/BLU	16	Maintenance Reset Switch to Maintenance Internal Logic Indicator
45	ORN/WHT	16	Seat Switch to Seat Belt Logic
46	PNK/BLU	10	Cold Start to 15-amp Fuse
46A	PNK/BLU	16	Cold Start to Logic Panel
47	GRY/BLU	16	Shift Control to Shift Control Relay (F)
47A	GRY/BLU	16	(F) Shift Control to Transmission Logic Indicator
48	DK GRN/WHT	16	Shift Control to Shift Control Relay (R)
48A	DK GRN/WHT	16	Shift Control to Shift Logic
49	LT GRN/WHT	16	7.5-amp Fuse to Horn (+) Power Terminal
50	RED/BLU	16	Horn (-) Terminal to Horn Button (on steering wheel)
51	DK BLU/WHT	16	7.5-amp Fuse to Indicator Panel Logic
52	ORN/RED	16	Park Brake Lamp (Terminal 8) to Splice 200
53	DK BLU/ORN	16	Steer Select Lamp (Terminal 8) to Splice 200
56	TAN/GRN	12	Service Brake Switch to Fuse Panel
57	PUR/RED	16	Service Brake Switch to Splice 5
58	WHT/GRY	16	Park Brake Splice to Splice 5
59	YEL/BRN	16	Neutral Switch Out to Neutral Splice to Splice 5
59A	ORN/WHT	16	Neutral Switch Splice to Neutral Relay
60	BRN/WHT	16	Splice 5 to Stabilizer Lock Relay
61	YEL/PNK	16	Boom Proximity Splice to Fuse Panel
62	ORN/PUR	16	Stabilizer Lock Relay to Stabilizer Valve (Coil 5)
63	LT GRN/WHT	16	Stabilizer Lock Relay to Stabilizer Valve (Coil 2)
64	DK BLU/WHT	16	Boom Proximity Switch to Boom Switch Relay
65	ORN/BLU	16	Boom Proximity Splice to Boom Switch Relay
66	GRY/PUR	16	Boom Switch Relay to Stabilizer Valve (Coil 2)
67	RED/GRN	16	Stabilizer Valve (Coil 3) to Stabil-TRAK Logic Input
68	RED/BLK	16	7.5-amp Fuse to Shift Control Switch Neutral
69	GRN	16	Shift Control Switch (Terminal 3) to Relay 1 (Terminal 85)
70	BLU/WHT	16	Fuse Panel 7.5-amp Fuse to Transmission Relay 1 (Terminal 30)
71	ORN/DK BLU	16	Relay 1 (Terminal 87) to Splice 12 to 2 Solenoid
72	LT GRN/RED	16	Shift Control to Shuttle Clutch Solenoid
73	WHT/PUR	16	Transmission Relay 3 (Terminal 87) to Splice 8
74	RED/LT GRN	16	Forward Splice to Transmission Relay 3 (Terminal 30)
75	WHT/BLU	16	Shift Control Switch to "2ND" Clutch Solenoid

WIRE No.	COLOR	GAUGE	FUNCTION
76	PNK/BLU	16	4TH Gear (optional--if equipped) Splice to Transmission Relay 2 (Terminal 85)
77	PUR	10	Ignition Switch (Terminal 5) to 15-amp Fuse
92	TAN/PUR	16	Splice 200 to Lamp Fuse
93	LT BLU/PUR	16	Splice 110 to Cummins Cold Start Switch (optional)
137	LT BLU/ORN	16	Attachment Tilt Switch (Terminal 2) to +12V Logic
138	GRN/BLU	16	Attachment Tilt Switch (Terminal 3) to Signal
139	ORN/GRY	16	Attachment Tilt Switch (Terminal 8) to Splice 200

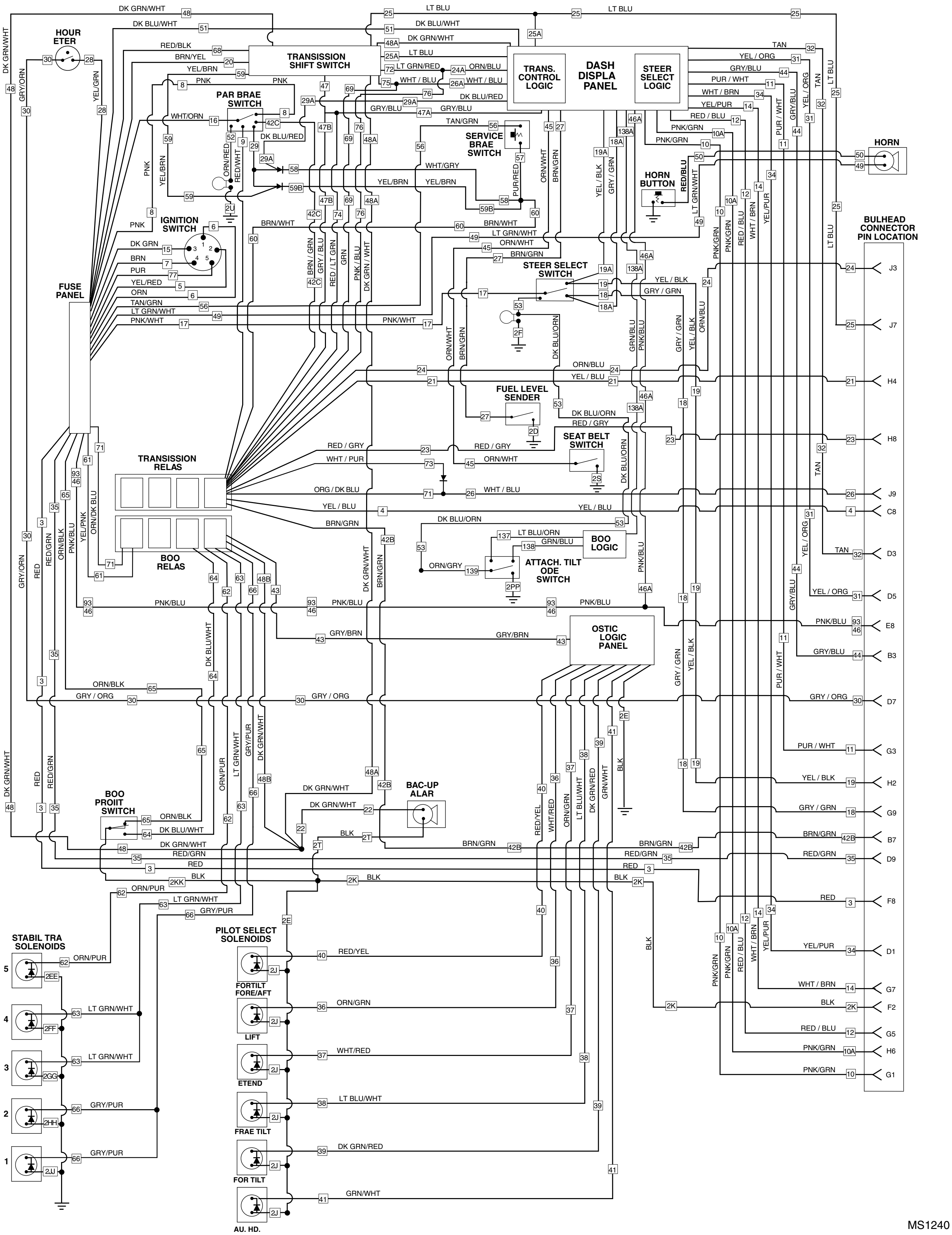

Figure 10–11. Cab wiring harness schematic, S/N 8250-9398 (*refer to the appropriate wire code chart*).

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<u>**Head-on views; wires exit at the rear of each component.**</u>

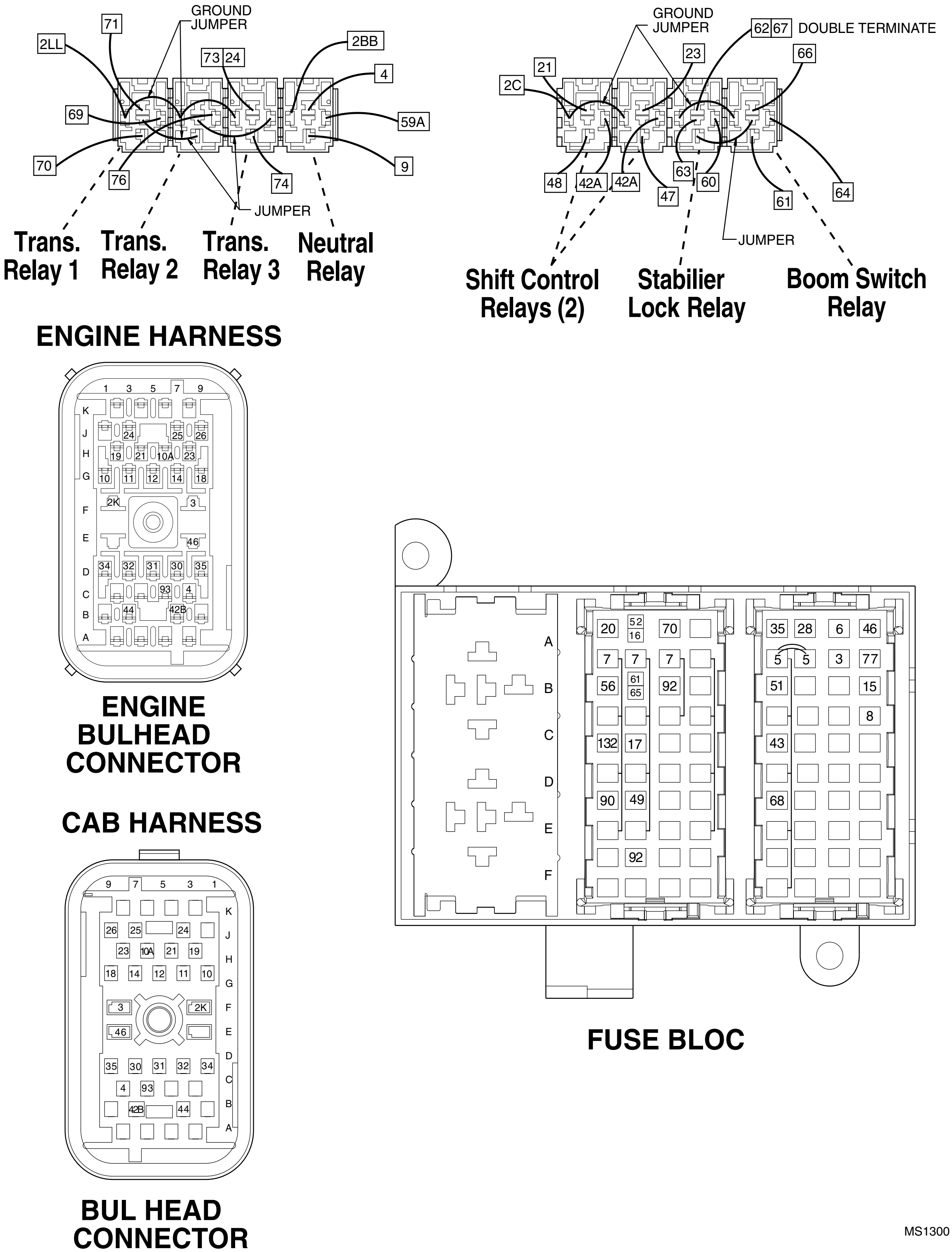


Figure 10–12. Cab harness relays, bulkhead connector and fuse panel, S/N 8250-9398.

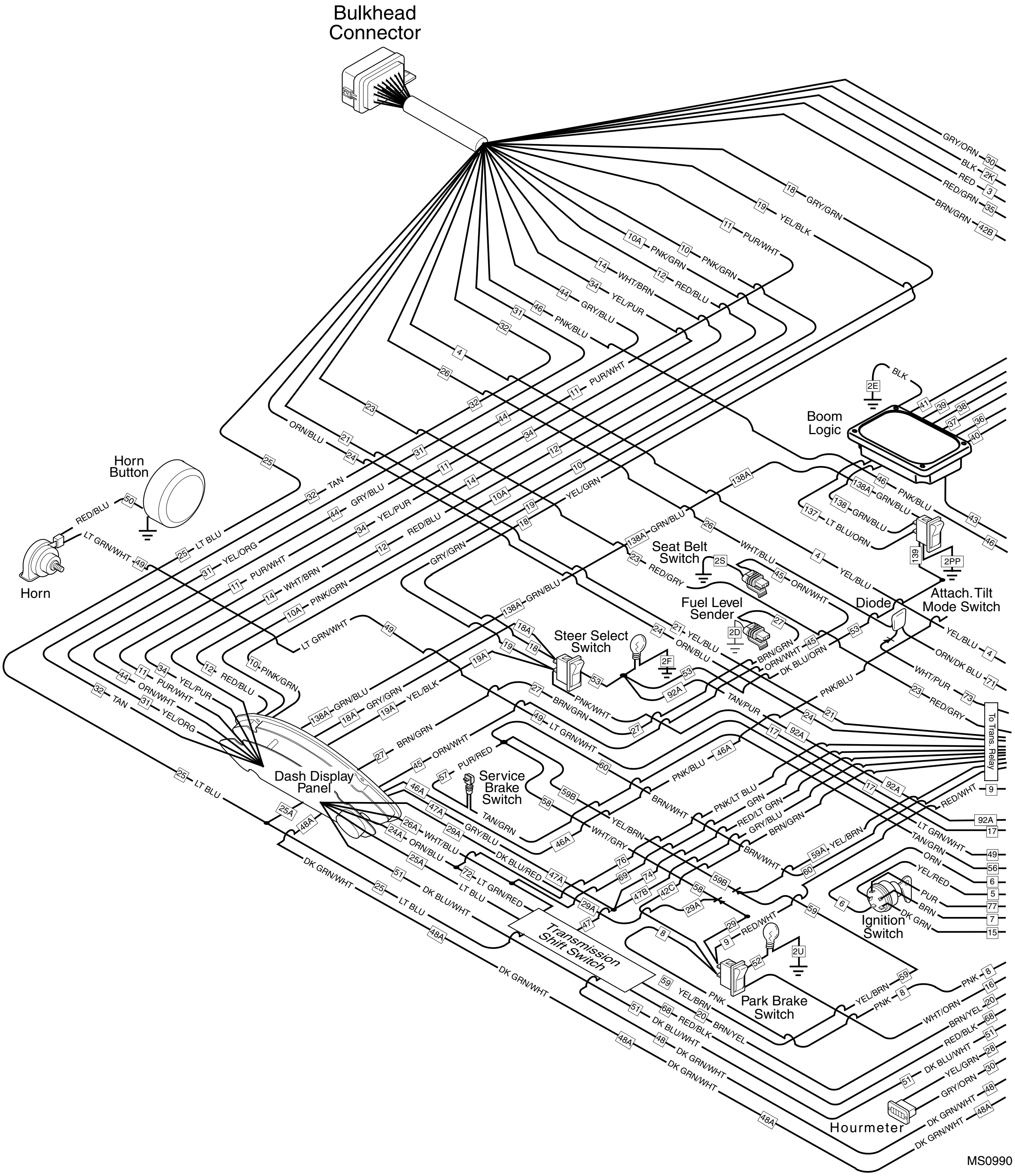


Figure 10–13. Cab wiring harness diagram, S/N 9399 and after, left side (*refer to the appropriate wire code chart*).

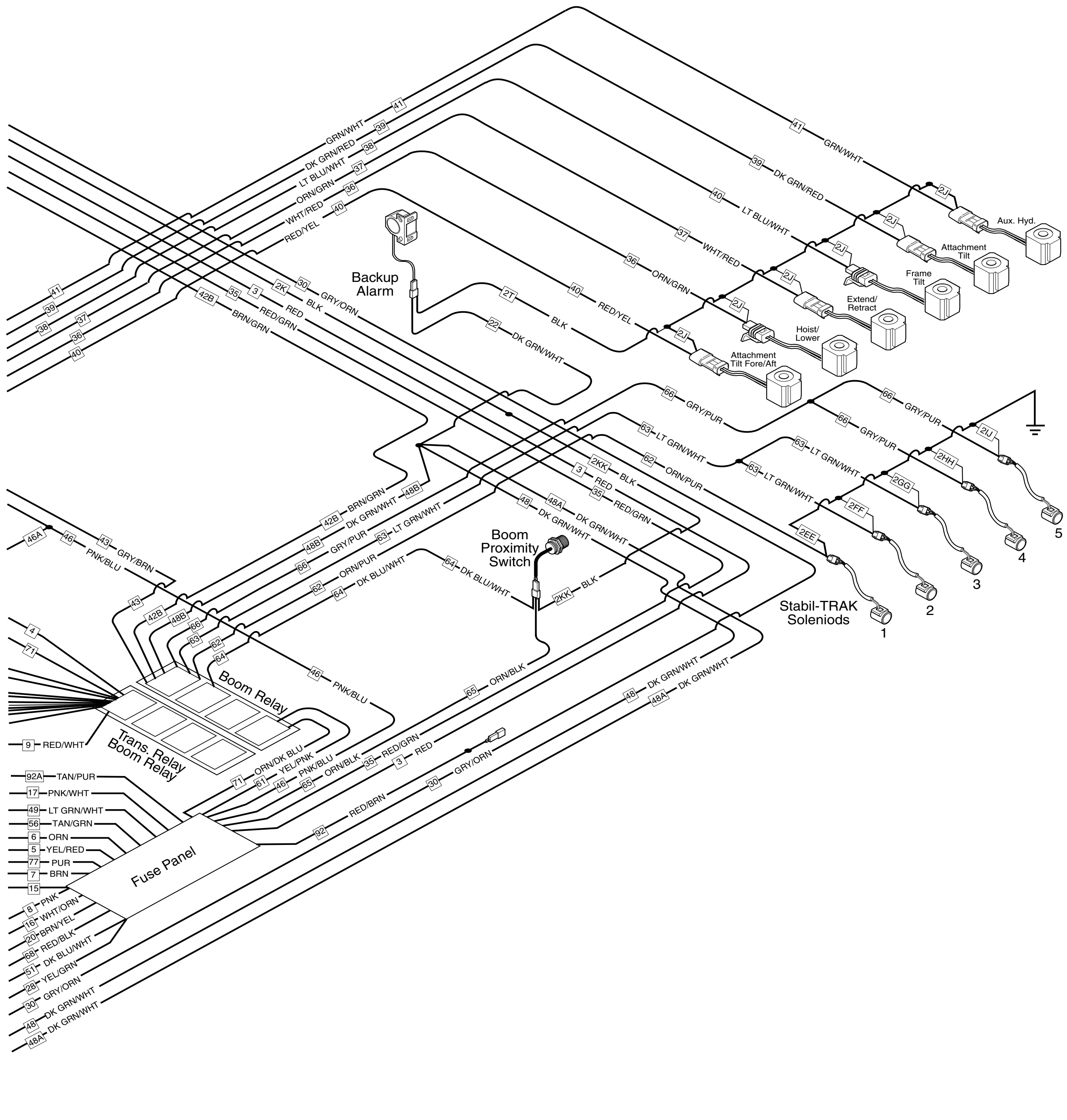


Figure 10–14. Cab wiring harness diagram, S/N 9399 and after, right side (*refer to the appropriate wire code chart*).

10.4.3 Cab Harness, S/N 9399 and After

Use this chart for vehicles with S/N 9399 and after.

WIRE No.	COLOR	GAUGE	FUNCTION
2	BLK	16	Generic Ground
2B	BLK	16	Hourmeter to Ground Splice 40
2C	BLK	16	Shift Control Relays to Cab Ground Stud
2D	BLK	16	Fuel Level Sender to Ground Splice 50
2E	BLK	14	Joystick Logic Board to Ground Splice 40
2F	BLK	16	Steer Select Lamp (Terminal 7) to Ground Splice 40
2G	BLK	16	Display Panel to Ground Splice 40
2H	BLK	16	Display Panel to Ground Splice 40
2J	BLK	16	Boom Function Solenoids to Ground Splice 35
2K	BLK	10	Ground Splice 45 to Ground Splice 50
2S	BLK	16	Seat Belt Switch to Ground Splice 50
2T	BLK	16	Backup Alarm to Ground Splice 35
2U	BLK	16	Ground Splice 40 to Park Brake Lamp (Terminal 7)
2V	BLK	12	Ground Splice 40 to Cab Ground Stud
2Y	BLK	10	Ground Splice 35 to Ground Splice 50
2AA	BLK	10	Ground Splice 50 to Cab Ground Stud
2BB	BLK	10	Ground Jumper for Neutral Relay
2CC	BLK	16	Ground Splice 40 to Stabil-TRAK Relays
2EE	BLK	16	Ground Splice 35 to Stabil-TRAK Solenoid #5
2FF	BLK	16	Ground Splice 35 to Stabil-TRAK Solenoid #4
2GG	BLK	16	Ground Splice 35 to Stabil-TRAK Solenoid #3
2HH	BLK	16	Ground Splice 35 to Stabil-TRAK Solenoid #2
2JJ	BLK	16	Ground Splice 35 to Stabil-TRAK Solenoid #1
2KK	BLK	16	Ground Splice 35 to Boom Proximity Switch
2LL	BLK	16	Ground Splice 40 to Relay 1
2MM	BLK	16	Ground Splice 40 to Neutral Relay
3	RED	10	Starter (+) Power to (+) Grid (fuse panel bus)
4	YEL/BLU	16	Neutral Relay (Terminal 87) to Starter Relay (coil positive terminal)
5	YEL/RED	14	Ignition Switch (Terminal 2) to Switched Grid (fuse panel bus)
6	ORN	10	Ignition Switch to 30-amp Main Fuse
7	BRN	10	Ignition Switch (Terminal 4) to (+) Grid (fuse panel bus)
7A	BRN/WHT	10	Closed Cab Relay (Terminal 85) to Splice 65
8	PNK	16	7.5-amp Fuse to Park Brake Switch (Terminal 5)
9	RED/WHT	16	Park Brake Switch (Terminal 6) to Neutral Relay (Terminal 30)
10	PNK/GRN	16	Alternator Indicator Terminal to CUMMINS Input (10GY/D)
10A	PNK/GRN	16	Alternator Indicator Terminal to PERKINS Input (10GY/F)
11	PUR/WHT	16	Oil Pressure Input (Terminal 10/C) to Oil Pressure Switch (Terminal A)
12	RED/BLU	16	Water Temperature Logic (10/B) to Water Temperature Switch
14	WHT/BRN	16	Hydraulic Oil Temperature Logic (10GY/A) to Hydraulic Oil Temperature Switch
15	DK GRN	16	Ignition Switch (Terminal 3) to 7.5-amp Fuse
16	WHT/ORN	16	7.5-amp Fuse to Park Brake Switch (Terminal 2)
17	PNK/WHT	16	7.5-amp Fuse to Steer Select Switch (Terminal 2)
18	GRY/GRN	16	Steer Select Switch (Terminal 1) to Steer Select Solenoid (Terminal 4)
19	YEL/BLK	16	Steer Select Switch (Terminal 3) to Steer Select Solenoid (Terminal 4)
19A	YEL/BLK	16	Steer Select Switch (Terminal 3) to Steer Select Logic (Terminal 6/E)
20	BRN/YEL	14	7.5-amp Fuse to Shift Control Switch (Terminal 8)
21	YEL/BLU	16	Reverse Relay (Terminal 87) to Reverse Clutch Solenoid
22	DK GRN/WHT	16	Splice 20 to Reverse Alarm
23	RED/GRY	16	Forward Relay (Terminal 87) to Forward Clutch Solenoid
24	ORN/BLU	16	Transmission Relay 3 (Terminal 87) to Shuttle Clutch Solenoid
24A	ORN/BLU	16	Splice 80 to Fourth Gear (optional--if equipped) Input (Terminal 6/C)
25	LT BLU	16	Transmission Shift Control Switch (through Splice 60) to 1st Clutch Solenoid

WIRE No.	COLOR	GAUGE	FUNCTION
25A	LT BLU	16	Splice 60 to First Gear Input (Terminal 6/A dash indicator)
26	WHT/BLU	16	Diode to Second Gear Clutch Solenoid
26A	WHT/BLU	16	Splice 70 to Second Gear Input (Terminal 6/B)
27	BRN/GRN	16	Fuel Gauge Input (Terminal 10/A) to Fuel Level Sender
28	YEL/GRN	16	7.5-amp Fuse to Hourmeter Power (+) Terminal
29	DK BLU/RED	16	Park Brake Switch (Terminal 3) to Diode
29A	DK BLU/RED	16	Diode to Park Brake Input (Terminal 10GY/E)
30	GRY/ORN	16	Oil Pressure Switch (Terminal B) to Hourmeter Ground (-) Terminal
31	YEL/ORN	16	Air Filter Input (10GY/C) to Air Filter Switch
32	TAN	16	Transmission Temperature Input (10/E) to Transmission Temperature Switch
34	YEL/PUR	16	Hydraulic Oil Filter Input (10GY/B) to Hydraulic Oil Pressure Switch
35	RED/GRN	16	Ignition Fuse to HOLD Lead Fuel Shutoff Solenoid (A)
36	ORN/GRN	16	Lift Solenoid to Logic Board (7/E)
37	WHT/RED	16	Extend Solenoid to Logic Board (7/G)
38	LT BLU/WHT	16	Frame Tilt Solenoid to Logic Board (7/C)
39	DK GRN/RED	16	Attachment Tilt (side-to-side) Solenoid to Logic Board (7/F)
40	RED/YEL	16	Attachment Tilt (fore/aft) to Logic Board (7/D)
41	DK GRN/WHT	16	Auxiliary Hydraulics to Logic Board (3/C)
42A	PNK/GRN	16	Splice 10 to Shift Control Relays
42B	BRN/GRN	16	Splice 10 to Park Brake Solenoids
42C	BRN/GRN	16	Splice 10 to Park Brake Switch (Terminal 1)
43	GRY/BRN	16	Joystick Logic (Terminal 7/A) to 7.5-amp Fuse
44	GRY/BLU	16	Maintenance Reset Switch to Maintenance Input (Terminal 10/J)
45	ORN/WHT	16	Seat Switch to Seat Belt Input (Terminal 10/K)
46	PNK/BLU	10	Cold Start to 15-amp Fuse
46A	PNK/BLU	16	Cold Start to Logic Panel
47	GRY/BLU	16	Shift Control Switch (Terminal 1) to Splice 30
47A	GRY/BLU	16	Splice 30 to Forward Input (Terminal 4/C)
47B	GRY/BLU	16	Splice 30 to Forward Relay (Terminal 30)
48	DK GRN/WHT	16	Shift Control Switch (Terminal 7) to Splice 20
48A	DK GRN/WHT	16	Splice 30 to Reverse Input (Terminal 4/A)
48B	DK GRN/WHT	16	Splice 30 to Reverse Relay (Terminal 30)
49	LT GRN/WHT	16	7.5-amp Fuse to Horn (+) Power Terminal
50	RED/BLU	16	Horn (-) Terminal to Horn Button
51	DK BLU/WHT	16	7.5-amp Fuse to Indicator Panel Input (B/B)
52	ORN/RED	16	Park Brake Lamp (Terminal 8) to Fuse Panel
53	DK BLU/ORN	16	Steer Select Lamp (Terminal 8) to Splice 200
56	TAN/GRN	12	Service Brake Switch to Fuse Panel
57	PUR/RED	16	Service Brake Switch to Diode
57A	PUR/RED	16	Service Brake Switch to Stop Lights Connector
57B	PUR/RED	16	Diode to Splice 5
58	WHT/GRY	16	Diode to Splice 5
59	YEL/BRN	16	Shift Control Switch (Terminal 5) to Diode
59A	ORN/WHT	16	Neutral Relay (Terminal 85) to Diode
59B	YEL/BRN	16	Diode to Splice 5
60	BRN/WHT	16	Splice 5 to Stabilizer Lock Relay (Terminal 85)
61	YEL/PNK	16	Boom Switch Relay (Terminal 30) to Fuse Panel
62	ORN/PUR	16	Stabilizer Lock Relay (Terminal 87) to Stabilizer Valve (3)
63	LT GRN/WHT	16	Stabilizer Lock Relay (Terminal 87A) to Stabilizer Valve (4)
64	DK BLU/WHT	16	Boom Switch Relay (Terminal 8) to Boom Proximity Switch (B)
65	ORN/BLU	16	7.5-amp Fuse to Boom Switch Relay
66	GRY/PUR	16	Boom Switch Relay (Terminal 8) to Stabilizer Valve (2)
67	RED/GRN	16	Stabilizer Lock Relay (Terminal 87) to Stabil-TRAK Input (10/J)
68	RED/BLK	16	7.5-amp Fuse to Shift Control Switch (Terminal 6)
69	GRN	16	Splice 70 to Transmission Relay 1 (Terminal 85)

WIRE No.	COLOR	GAUGE	FUNCTION
70	BLU/WHT	16	Fuse Panel 7.5-amp Fuse to Transmission Relay 1 (Terminal 30)
71	ORN/DK BLU	16	Relay 1 (Terminal 87) to Diode
72	LT GRN/RED	16	Boom Switch Relay (Terminal 87) to Stabilizer Valve (Solenoid 2)
73	WHT/PUR	16	Transmission Relay 3 (Terminal 87) to Diode
74	RED/LT GRN	16	Splice 30 to Transmission Relay 3 (Terminal 30)
75	WHT/BLU	16	Shift Control Switch (Terminal 3) to Splice 70
76	PNK/BLU	16	Splice 80 to Transmission Relay 2 (Terminal 85)
77	PUR	10	Ignition Switch (Terminal 5) to 15-amp Fuse
92	TAN/PUR	16	Female Metri-Pack Connector (for Auxiliary Hydraulics) to 7.5-amp Fuse
92A	TAN/PUR	16	Splice 200 to Female Metri-Pack Connector (for Auxiliary Hydraulics)
93	LT BLU/PUR	16	Splice 110 to Cummins Cold Start Switch (optional)
113	PUR/BLU	16	Splice 200 to 2-way Connector (Cavity A)
123	ORN/BLK	16	Splice 20 to Back-up Lights Input Connector (Cavity B)
124	DK BLU/GRY	10	Door Window Power to Fuse Panel (see Fig. 10–16)
132	BRN/YEL	16	Accessory Power to Light Switch Input (see Fig. 10–16)
134	TAN/WHT	14	Fuse Panel to Light Module Power (see Fig. 10–16)
134A	TAN/WHT	14	Fuse Panel to Light Module Power (see Fig. 10–16)
135	BLU/YEL	10	Fuse Panel to Starter (+) Terminal (see Fig. 10–16)
136	LT GRN/RED	10	Power Relay to Starter (+) Terminal (see Fig. 10–16)
137	LT BLU/ORN	16	Attachment Tilt Switch (Terminal 2) to +12V Logic
138	GRN/BLU	16	Attachment Tilt Switch (Terminal 3) to Signal
138A	GRN/BLU	16	Attachment Tilt Switch (Terminal 3) to Dash (10/H)
139	ORN/GRY	16	Attachment Tilt Switch (Terminal 8) to Splice 200
140	RED/GRY	10	Fuse Panel to Starter (+) Terminal (see Fig. 10–16)
141	RED/BLU	10	Fuse Panel to Power Relay (see Fig. 10–16)
142	YEL/GRN	10	Fuse Panel to Blower Switch (+) Connection (Cavity C) (see Fig. 10–16)
143	ORN/YEL	16	7.5-amp C.B. to Connector (Cavity A) (see Fig. 10–16)
149	YEL/ORN	14	Connector (Cavity B) to 7.5-amp C.B. Fuse (see Fig. 10–16)
150	GRY/PNK	16	Splice 200X to Closed Cab Connector (see Fig. 10–19)
150A	GRY/PNK	16	One-way Female Connector to Closed Cab Lamp Connector (see Fig. 10–19)
153	GRY/YEL	16	One-way 56-series Connector to 7.5-amp C.B. Rear Wiper Fuse (see Fig. 10–19)
164	LT GRN/PNK	10	Fuse to Window Switch (Terminal 2) Connector (Cavity E) (see Fig. 10–19)

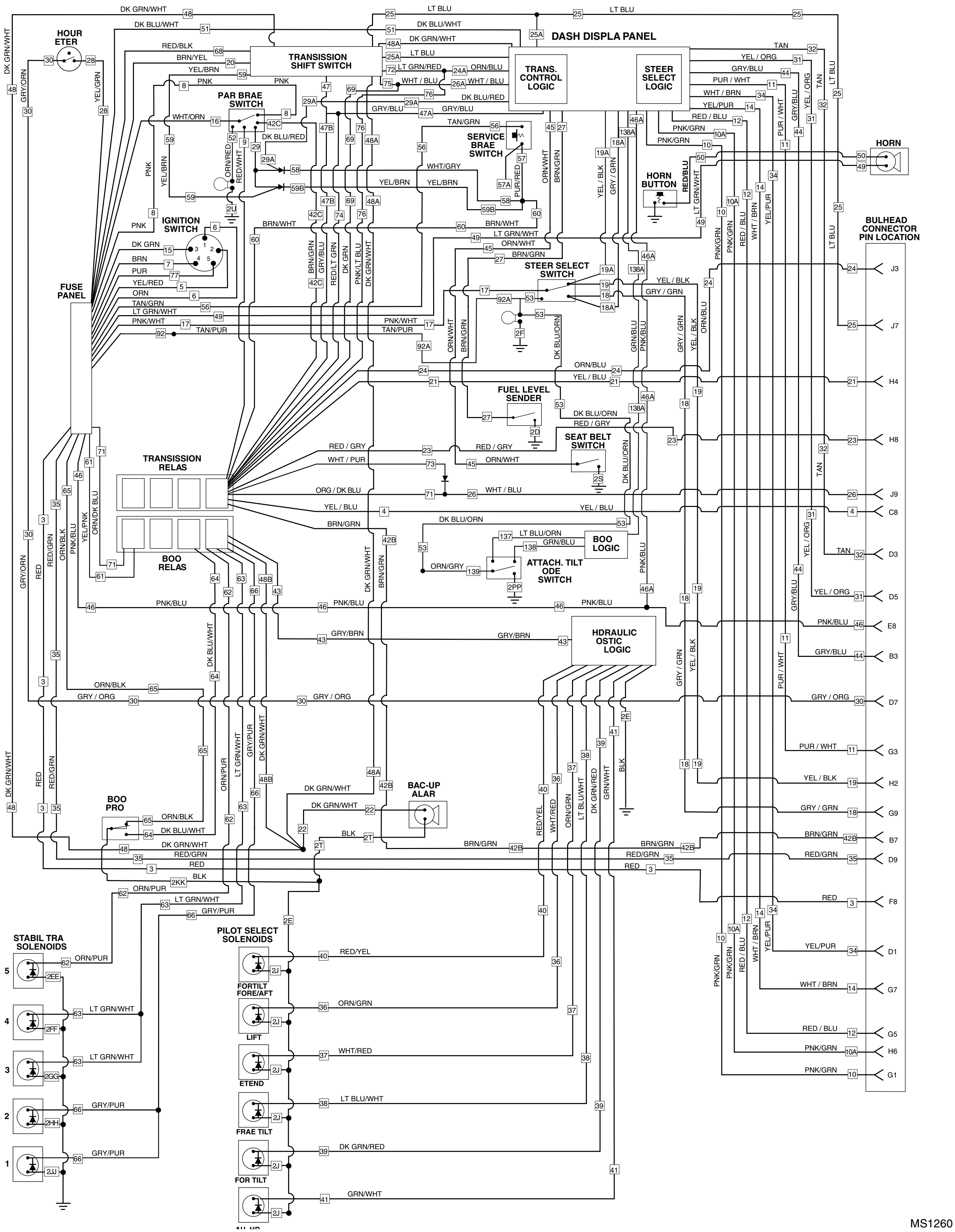


Figure 10–15. Cab wiring harness schematic, S/N 9399 and after (*refer to the appropriate wire code chart*).

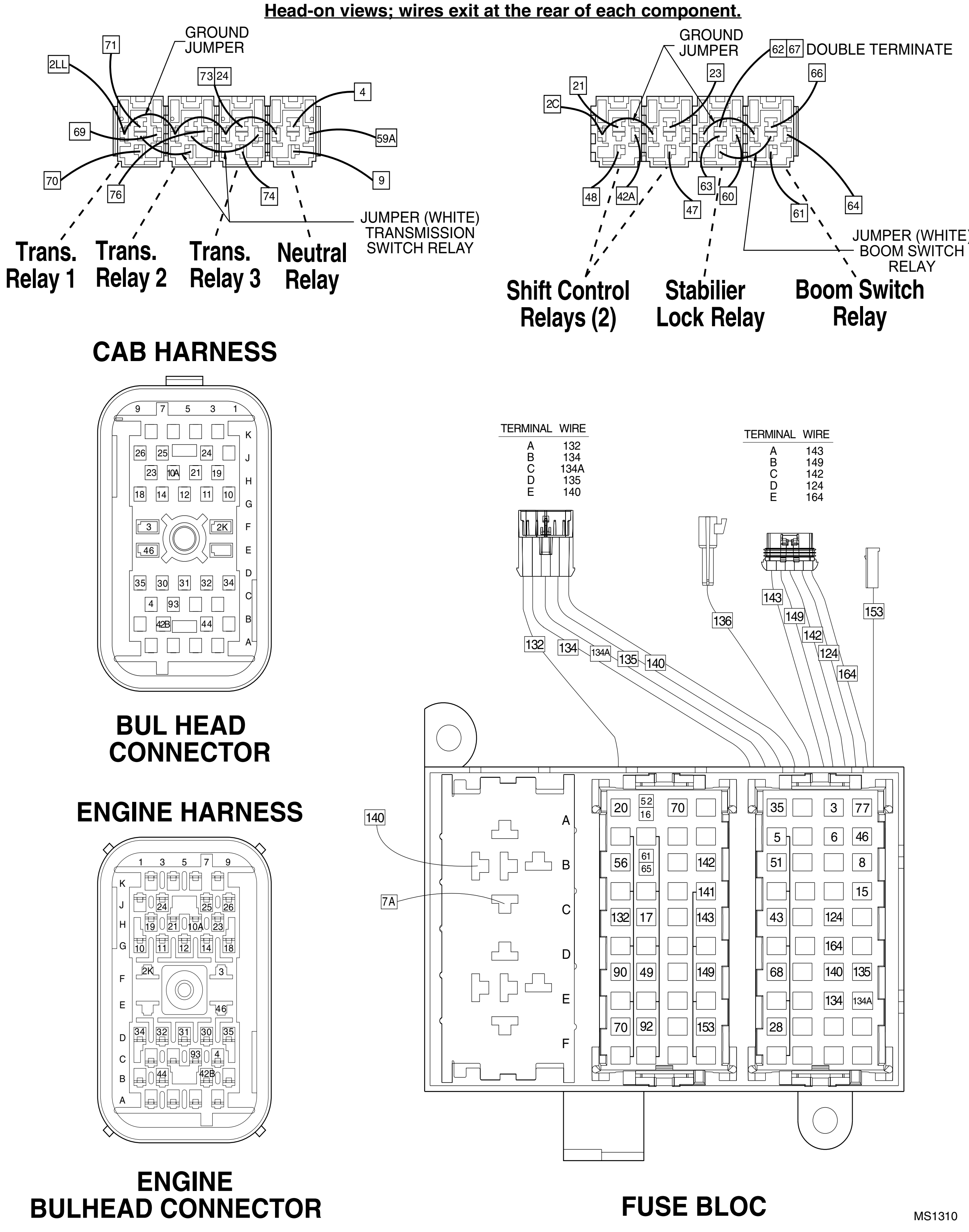


Figure 10–16. Cab harness relays, bulkhead connector and fuse panel, *S/N 9399 and after.*

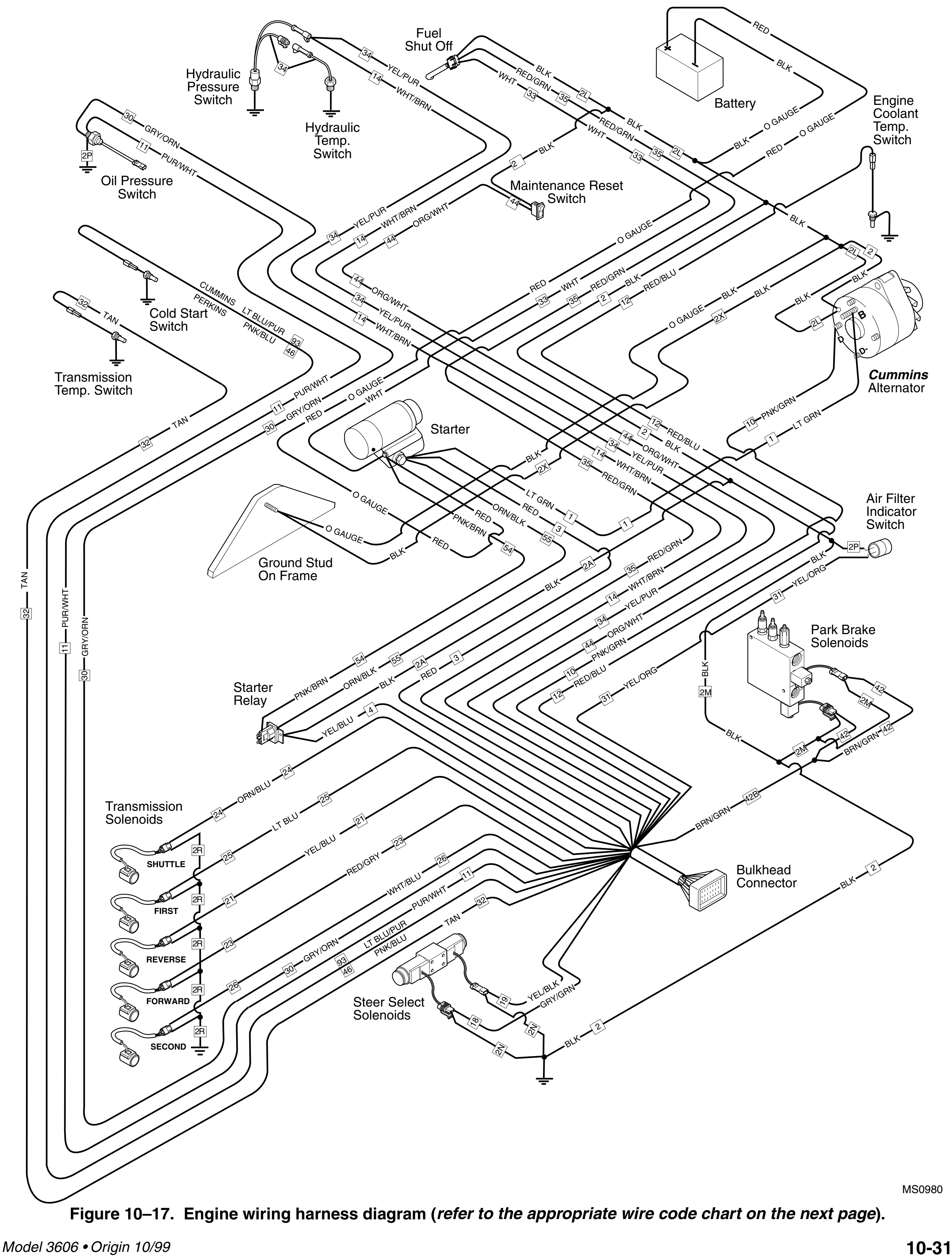


Figure 10–17. Engine wiring harness diagram (*refer to the appropriate wire code chart on the next page*).

10.4.4 Engine Harness

Use the chart below for the engine harness diagram (Fig. 10–17) and engine harness schematic (Fig. 10–18).

WIRE No.	COLOR	GAUGE	FUNCTION
1	LGT GRN	10	Power, Starter to Alternator (Cummins)
1A	LT GRN/BLK	10	Power, Starter to Alternator (Perkins)
1B	LT GRN/BLK	10	Power, Starter to Alternator (Perkins)
2	BLK	10	Main Ground Alternator to Ground Splice 45
2A	BLK	16	Starter Relay to Ground Splice 45
2K	BLK	10	Ground Splice 45 to Ground Splice 50 (in cab harness)
2L	BLK	12	Fuel Shutoff Solenoid to Alternator Bolt (housing ground)
2M	BLK	16	Park Brake Solenoids to Ground Splice 45
2N	BLK	16	Steer Select Solenoids to Ground Splice 45
2P	BLK	16	Air Filter to Ground Splice 45
2Q	BLK	16	Maintenance Reset Switch to Ground Splice 45
2R	BLK	16	Transmission Shift Solenoids to Ground Splice 45
2X	BLK	10	Ground Splice 45 to Ground Stud
3	RED	10	Power, Starter to (+) Grid (fuse panel bus)
4	YEL/BLK	16	Transmission Shift Switch to Starter Relay
10	PNK/GRN	16	Alternator Indicator to Alternator Indicator Logic (Cummins-operators display panel)
10A	PNK/GRN	16	Alternator Indicator to Alternator Indicator Logic (Perkins-operators display panel)
11	PUR/WHT	16	Oil Pressure Logic (operators display panel) to Oil Pressure Switch
12	RED/BLU	16	Water Temperature Logic (operators display panel) to Water Temperature Switch
14	WHT/BRN	16	Hydraulic Oil Temperature Logic (operators display panel) to Hydraulic Oil Temperature Switch
18	GRY/GRN	16	Steer Select Switch to Steer Select Solenoid (terminal C)
19	YEL/BLK	16	Steer Select Switch to Steer Select Solenoid (terminal 4)
21	YEL/BLU	16	Shift Control Relay to Reverse Clutch Solenoid
23	RD/GRY	16	Shift Control Relay to Reverse Clutch Solenoid
24	ORN/BLU	16	Shift Control to Shuttle Clutch Solenoid
26	WHT/BLU	16	Shift Control to '2nd' Clutch Solenoid
30	GRY/ORN	16	Oil Pressure Switch (terminal B) to Hourmeter (-)
31	YEL/ORN	16	Air Filter Logic to Air Filter Switch
32	TAN	16	Transmission Temperature Logic (display indicator) to Transmission Temperature Switch
33	WHT	12	Fuel Shutoff Solenoid to Starter Motor
34	YEL/PUR	16	Hydraulic Filter Logic (display indicator) to Hydraulic Oil PSI Switch
35	RED/GRN	16	Ignition Fuse to Fuel Shutoff Solenoid
42	BRN/GRN	16	Splice 15 to Park Brake Solenoids
42B	BRN/GRN	16	Splice 10 to Splice 15
44	GRY/BLU	16	Maintenance Reset Switch to Bulkhead Connector to Maintenance Indicator (display panel)
46	PNK/BLU	10	Cold Start to 15-amp Fuse
54	PNK/BRN	10	Starter Relay to Starter Power
55	ORN/BLK	10	Starter Relay to Starter Power
93	LT BLU/PUR	16	Splice 110 to Cold Start Control (optional)

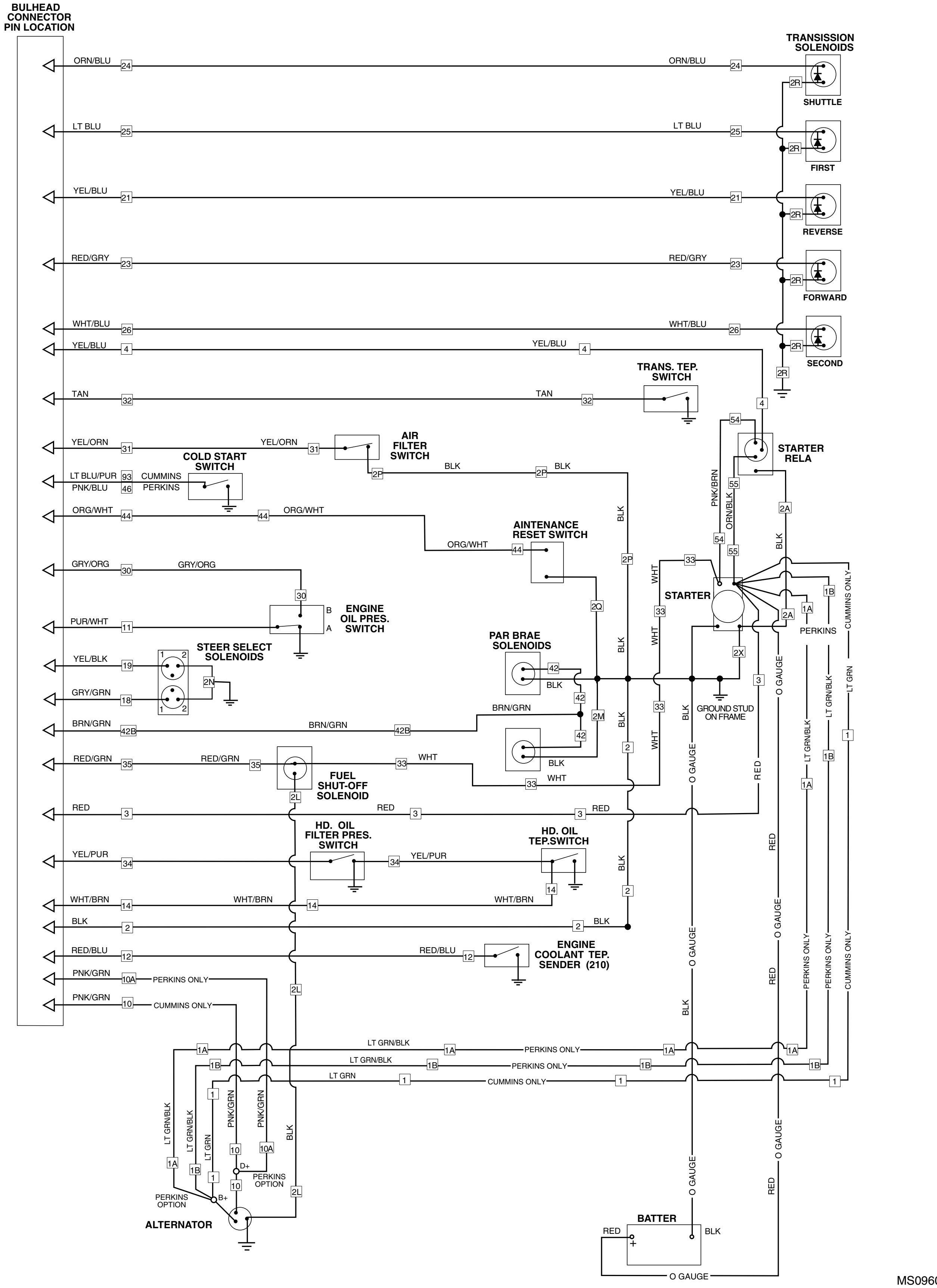


Figure 10–18. Engine wiring harness schematic (*refer to the appropriate wire code chart*).

10.4.5 Closed Cab Harness (Option)

A closed cab option was being finalized shortly before completion of this manual. Use the wiring schematic below (Fig. 10–19 and Fig. 10–20) as needed when troubleshooting closed cab electrical problems.

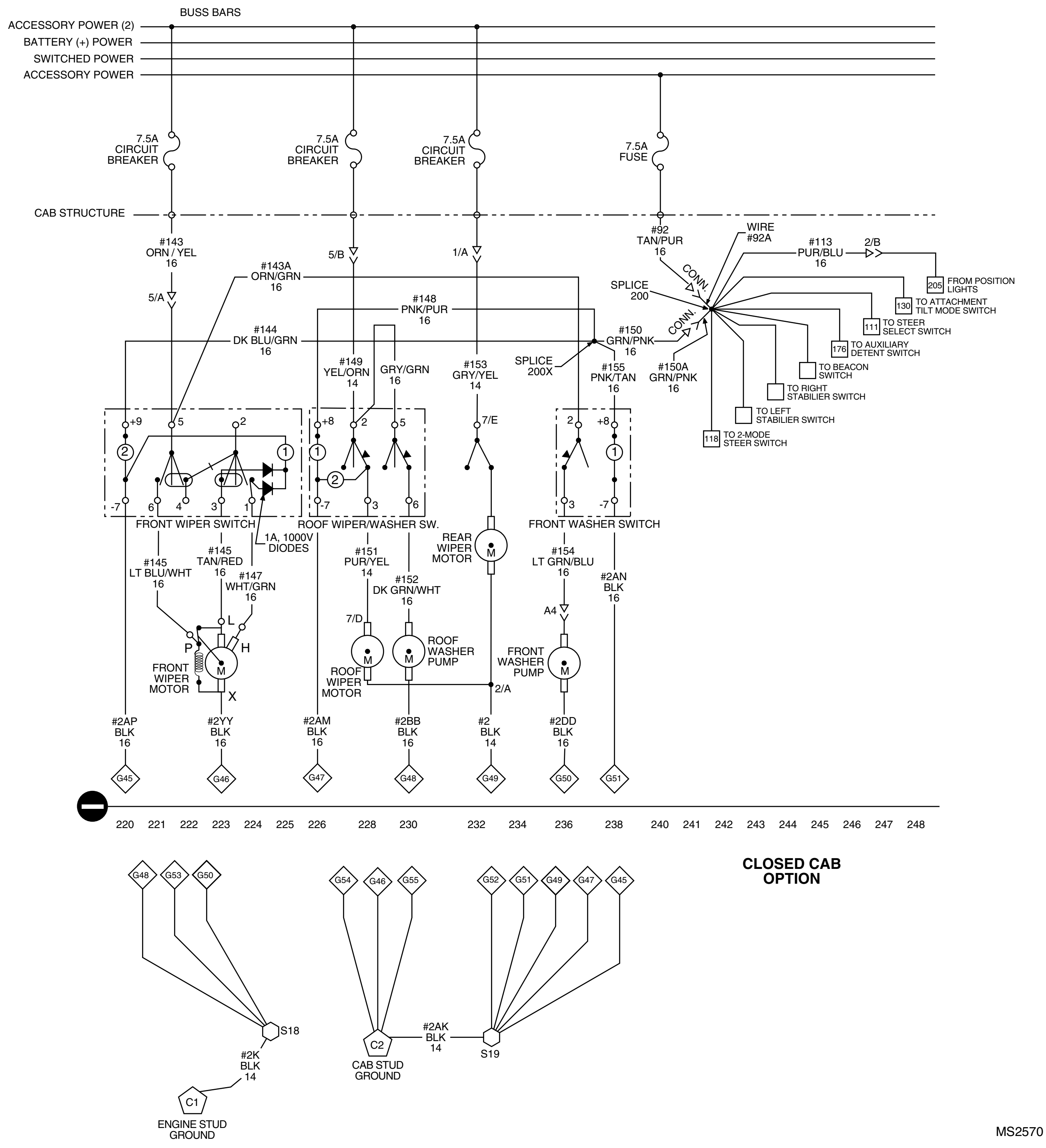


Figure 10–19. Enclosed cab option electrical schematic, left side.

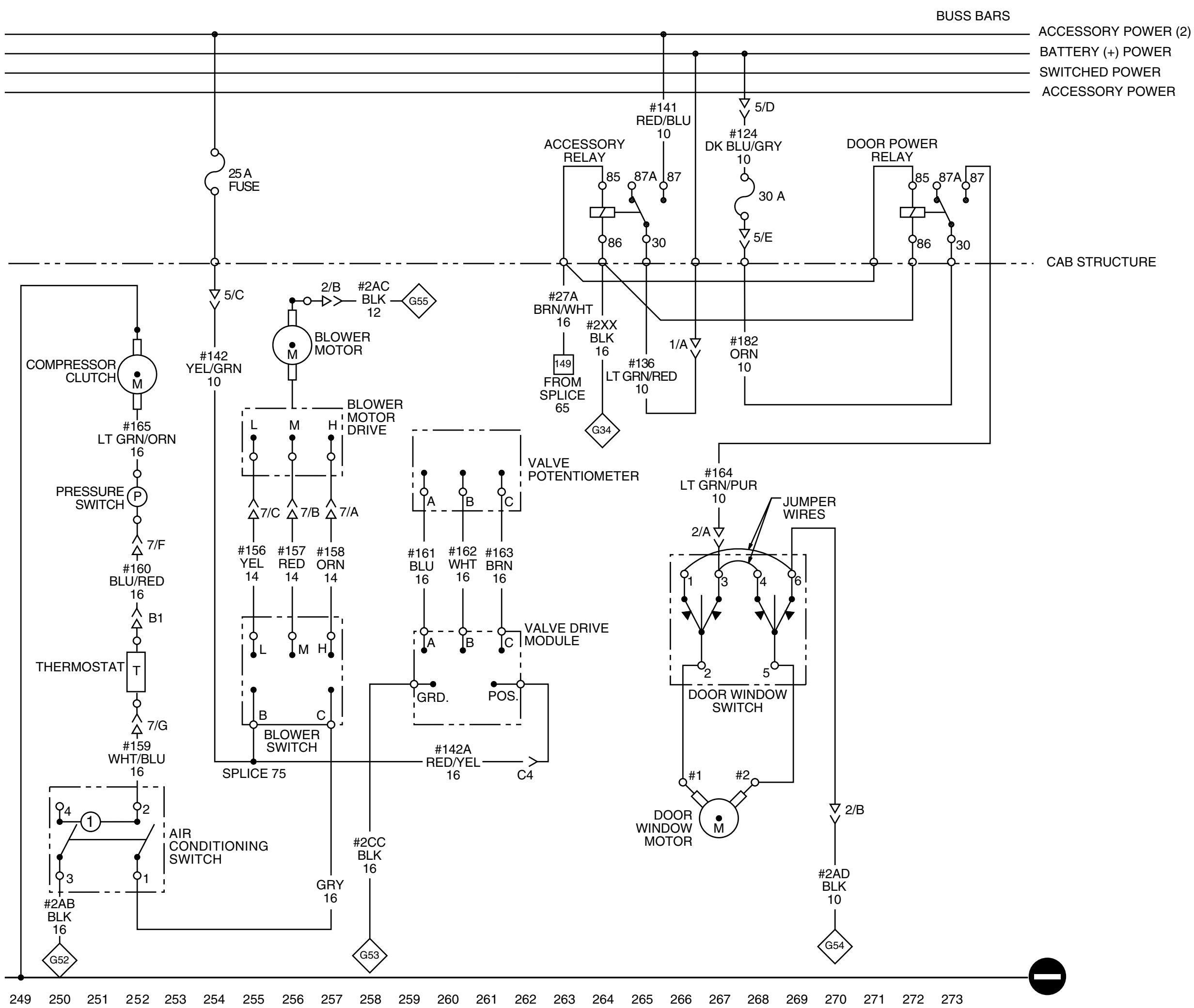


Figure 10–20. Enclosed cab option electrical schematic, right side.

10.5 FUSES AND RELAYS

Fuses and relays help to protect the electrical system. In general, a blown fuse is a symptom of another electrical problem. Address the true problem, not just the symptom. Simply replacing the fuse often will not solve the problem. Blown fuses are usually due to simple causes, including loose or corroded connections, or a defective relay. There are two main causes of blown fuses; a shorted or grounded wire in the applicable circuit, or a defective electrical component. Visually check the condition of the fuse, wires, connections and components in the involved circuit before replacing a fuse. Check the circuit for shorts, grounding, or defective electrical components. Keep in mind that many parts in the electrical system work with components of the hydraulic system; a careful inspection of the related hydraulic components may help in solving problems.

For access to the fuse and relay panel, remove the four screws securing the lower dash panel (Fig. 10–21) to the cab. The fuses and relays are mounted under the lower left side of the operators console (Fig. 10–22).

The fuse and relay panels are part of the cab harness. Check illustrations Fig. 10–24 (S/N 8249 and before), Fig. 10–26 (S/N 8250-9398), and Fig. 10–27 (S/N 9399 and after) on the following pages to determine which type of fuse and relay panel is being addressed.

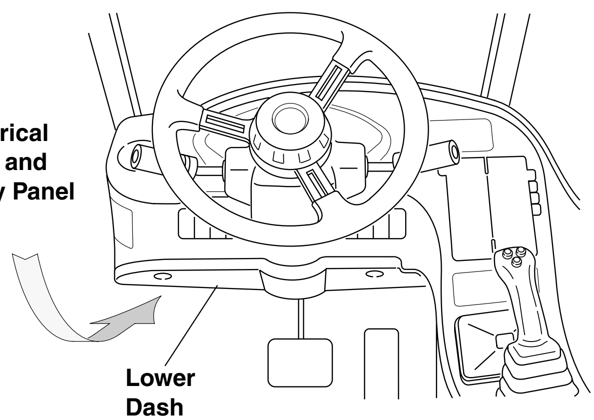


Figure 10–21. Remove the lower dash panel to gain access to the electrical fuse and relay panel.

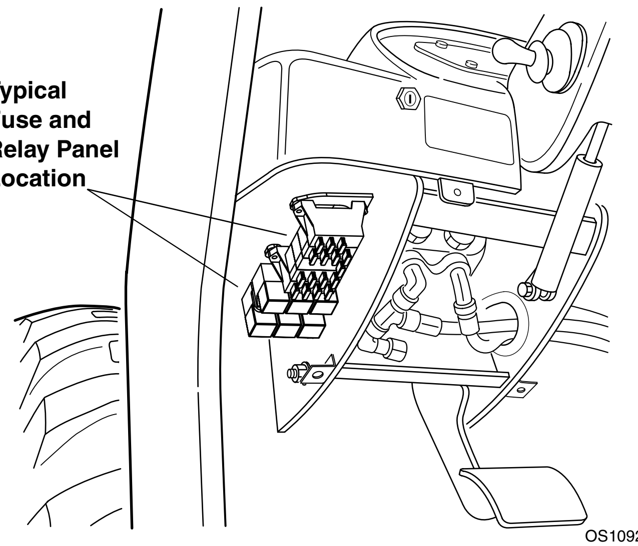


Figure 10–22. The fuse and relay panel is mounted under the lower left side of the operators console behind the lower dash panel (typical).

10.5.1 Fuse and Relay Replacement

Shut off the engine and disconnect the negative (-) battery cable at the negative (-) battery terminal (Fig. 10–23) before checking the electrical system. Use an ohmmeter to check the resistance of wires and components.

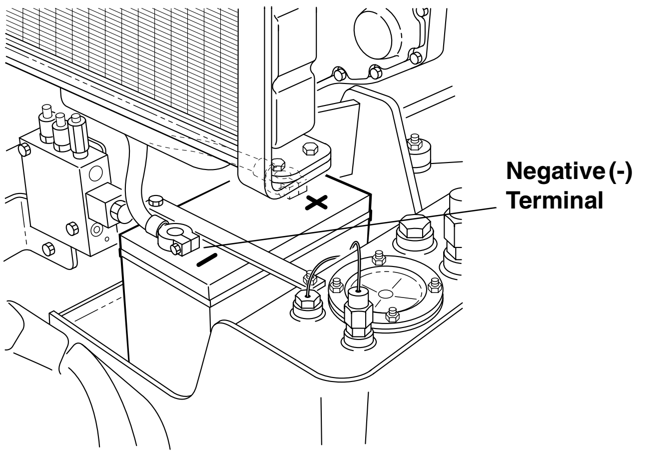


Figure 10–23. Disconnect the negative (-) battery cable.

Different fuse and relay panels exist. Vehicles with serial number 8249 and before use the fuse and relay panel shown in Fig. 10–24. Vehicles with serial number 8250 through 9398 use the fuse and relay panel shown in Fig. 10–26. Vehicles with serial number 9399 and after use the fuse and relay panel shown in Fig. 10–27.

Before checking a malfunctioning electrical circuit, examine the applicable wiring diagram to help identify the components involved. Noting whether other components, including hydraulic system components, related to the circuit are functioning properly can often aid in identifying problems. When several components or circuits fail at one time, the problem is probably related to a poor ground connection, because several circuits may share that same connection. Examine the appropriate ground connection(s) and make sure a contact capable of conducting full voltage is available.

10.6 ENGINE START CIRCUIT

When the ignition key switch (Fig. 10–25) is turned to START the engine with the transmission in NEUTRAL (N), the starting circuit activates the starter relay, starter solenoid, and fuel run solenoid. The fuel run solenoid opens a valve that supplies fuel to the injection pump.

The starting circuit functions as follows:

1. Current from the battery flows through the positive (+) battery cable to the starter solenoid.
2. Current then flows to the fuse box, through the main fuse, to terminal "1" of the ignition switch.

Vehicles Stamped with *S/N 8249 and Before*

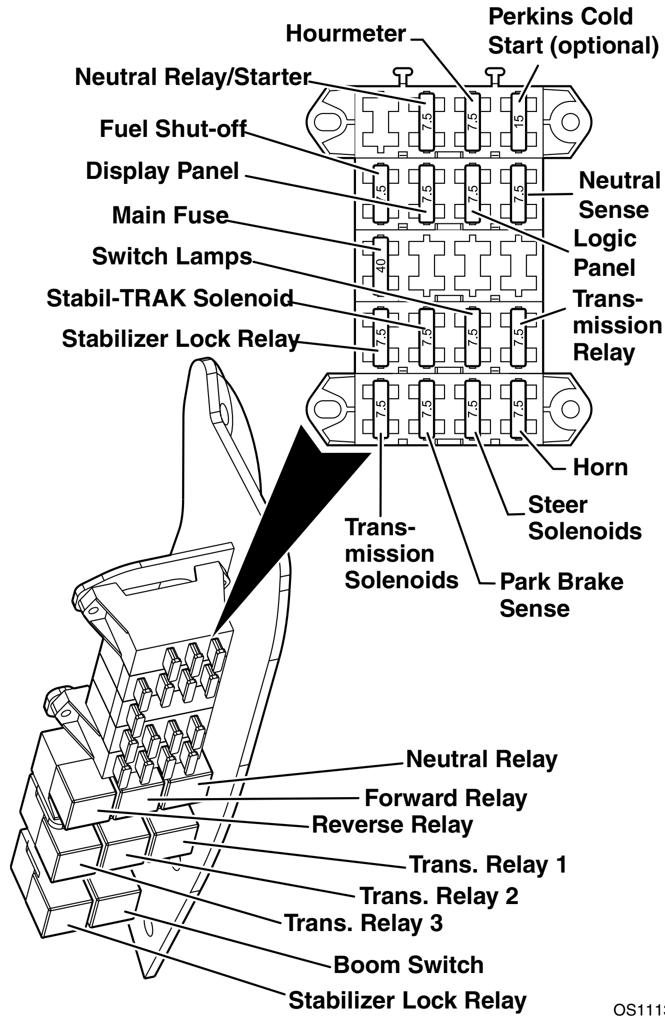


Figure 10–24. Vehicles with *S/N 8249 and before* use the fuse and relay panel shown above.

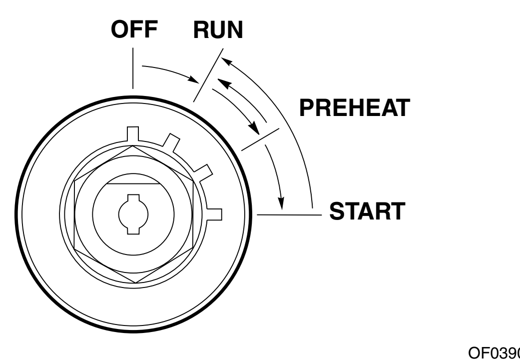


Figure 10–25. Ignition key switch positions.

3. When the key is turned to the START position (Fig. 10–25), current flows through contacts in the ignition switch to the park brake switch.

<u>Vehicles Stamped with S/N 8250 *through 9398*</u>

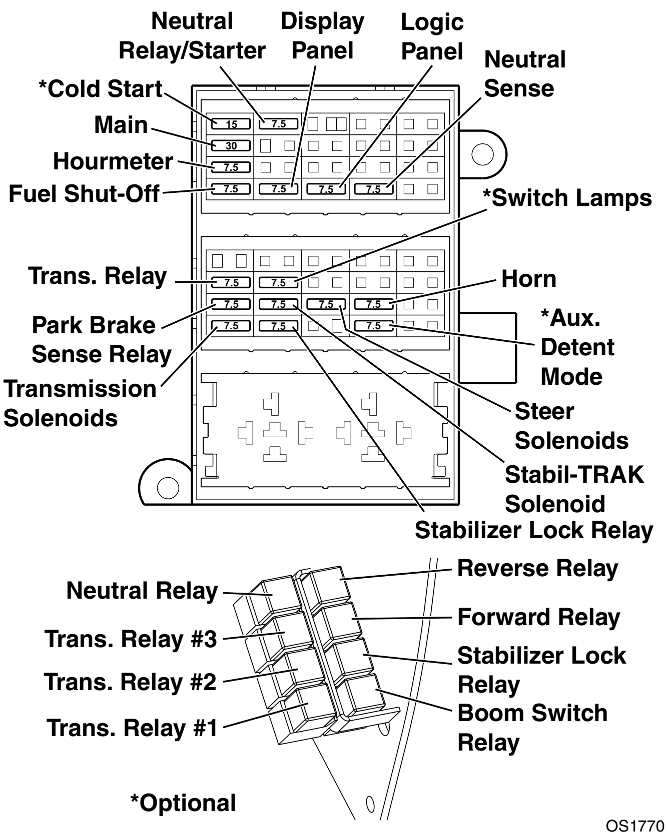


Figure 10–26. Vehicles with *<u>serial number 8250 through 9398</u>* use the fuse and relay panel shown here.

<u>Vehicles Stamped with S/N 9399 *and After*</u>

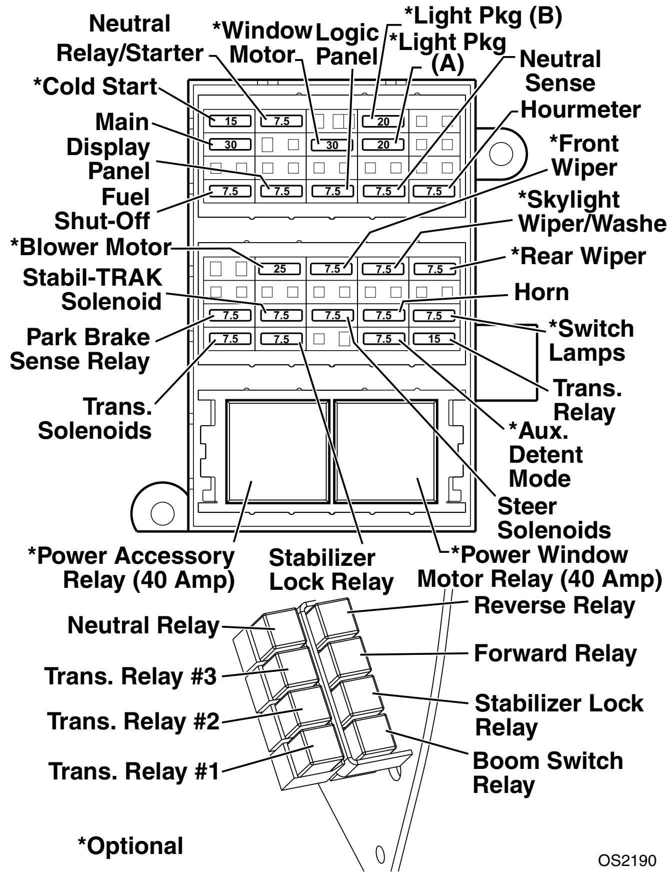


Figure 10–27. Vehicles with *<u>serial number 9399 and after</u>* use the fuse and relay panel shown here.

4. If the park brake is set, current flows through contacts in the brake switch to the neutral start circuit.
5. If the transmission select lever is in NEUTRAL (N), current flows through the neutral start circuit to energize the coil of the starter relay. The relay closes internal contacts that allow current to flow to the starter solenoid and starter.
6. The starter solenoid engages a gear on the starter pinion shaft to mesh with the flywheel, and the starter pinion and gear begin to spin, in turn rotating the flywheel, crankshaft and related components within the engine.
7. When the ignition key switch was initially turned, the fuel run solenoid opened a valve to supply to the fuel injection pump. As the starter rotated the engine components, the fuel injection pump and related lines and injectors supplied fuel to the cylinders.
8. When the pistons compress injected fuel, ignition occurs, the engine starts and the starter pinion retracts.
9. As the engine runs it operates an alternator that recharges the battery used during the starting cycle.
10. When the ignition key switch is released after starting the engine, the key switch returns to a neutral position where it directs current to the fuse panel that distributes electrical current for the operation of vehicle controls, including the joystick, gauges and other equipment.

PERKINS COLD START OPTION ONLY: When starting in a cold environment (when temperatures are at or below freezing), turning the ignition key switch (Fig. 10–25) to the PREHEAT position between RUN and START for a few moments (usually 15-20 seconds, or up to 30 seconds during extreme cold) before starting will supply current to a thermo-start plug in the intake manifold. The plug ignites a fuel-air mixture in the intake manifold to facilitate cold weather starting.

10.6.1 Testing the Starter on the Engine

If the starter does not engage when the ignition key is turned, check the following:

1. The main fuse may be blown, requiring replacement. Check for the cause of the blown fuse.
2. There may be a defect in the ignition switch, ignition wiring, or starter solenoid.
3. Check battery condition. Clean the battery posts and the connectors at each end of the battery cables. Also check the ground cable behind the starter mounting bolt and the frame ground stud, just above the hydraulic oil reservoir fill cap.
4. Check for broken wiring and damaged insulation on the wiring. Replace all broken or damaged wiring.
5. Check all connections at the starter solenoid, key switch, and wiring harness plugs. Clean and tighten all connections.
6. If the starter still does not operate after these checks have been performed, check the starting circuit.

Starter Circuit Checks

1. Check wires and connections for looseness, corrosion, damage, etc.
2. If a "whirring" noise is heard, but the engine does not turn over, the starter is spinning but not engaging the flywheel. The starter drive or solenoid that pushes the drive forward to engage the flywheel may be defective. Missing or damaged teeth on the flywheel can also prevent the starter from cranking the engine.
3. If the starter only "clicks", it may indicate that the battery is discharged, or that there is a loose or corroded battery cable connection. Check the battery state of charge and battery condition first, then check the cables and cable connections.

10.6.2 Starter

The starter (Fig. 10–29) is located on the left side of the engine (the right side of the vehicle), just inboard of the hydraulic oil reservoir.

The starter operates when the attached starter solenoid engages a gear on the starter pinion shaft to mesh with the flywheel, and the starter pinion and gear begin to spin, in turn rotating the flywheel, crankshaft and related components within the engine.

The starter is grounded indirectly via the negative (-) battery. The cable is routed from the battery to the main ground stud, located on a triangular weldment (Fig. 10–29) above the hydraulic reservoir. Other ground wires are connected to this stud, including the starter ground cable, secured to the engine by one of the starter mounting bolts.

a. Starter Removal

Remove the starter only if it fails. To remove the starter:

1. Disconnect the negative (-) battery cable at its battery terminal (Fig. 10–28).

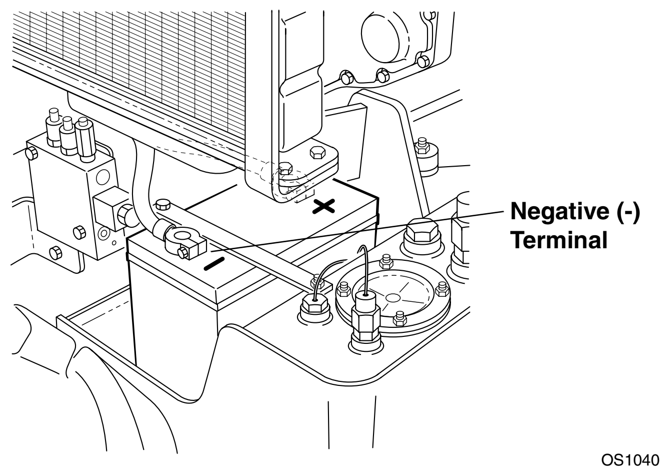


Figure 10–28. Disconnect the negative (-) battery cable.

2. Label and disconnect the positive (+) battery cable and other wiring from the starter solenoid. Note how the wires are installed for ease of installation later.
3. Loosen, but DO NOT remove, the three hex fasteners securing the starter to the flywheel housing. Support the starter securely, as it is relatively heavy and will fall if not supported.
4. Support the starter and remove the fasteners securing the starter to the engine. Remove the negative (-) ground cable from its starter mounting bolt (Fig. 10–28).
5. Remove the starter from the vehicle.

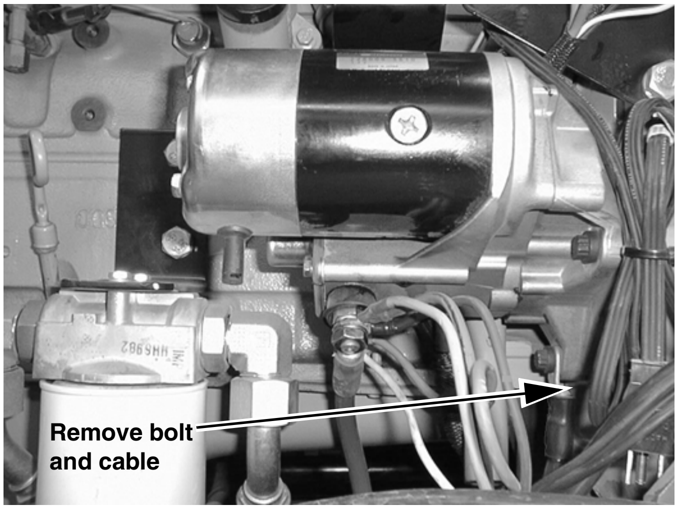


Figure 10-29. Disconnect the ground cable (from the chassis ground stud) at the starter mounting bolt (Cummins engine shown).

b. Starter Cleaning and Drying

1. While the starter is out, wipe away any grease or dirt that has accumulated around the starter mounting opening.
2. If reinstalling the starter, clean the exterior of the starter with an approved solvent. DO NOT submerse the starter or allow the solvent to contact the starter bushings.
3. Dry the starter with a clean, lint-free cloth.

c. Starter Periodic Maintenance

A starter requires no routine maintenance beyond the occasional inspection of the electrical connections, which must be clean and tight. The starter is not serviceable; replace a defective starter with a new unit.

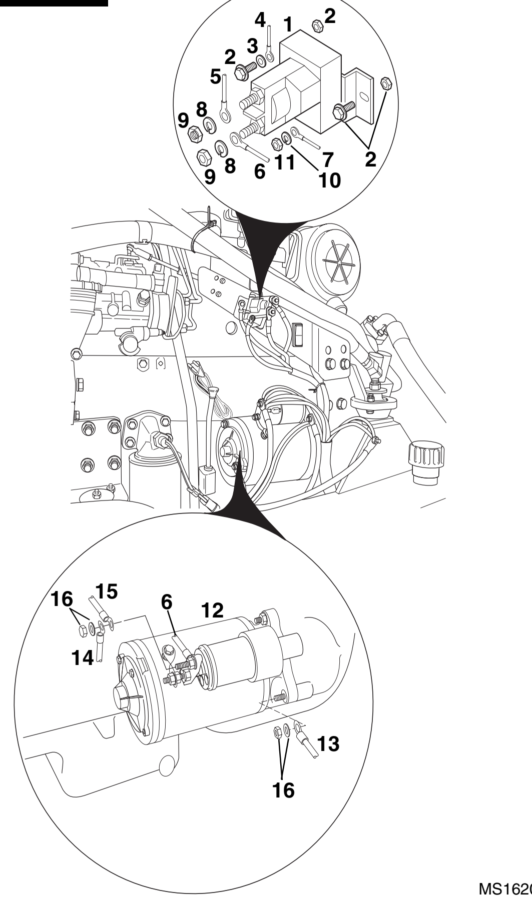
d. Starter Installation

1. Position the starter in its mounting opening on the flywheel housing. Position the ground cable over the correct starter mounting fastener boss. Secure the starter with three hex fasteners. Torque hex nuts to 3.4 lb/ft (4,6 Nm) and torque hex-head capscrews to 32 lb/ft (43 Nm).
2. Connect all the wires to the starter solenoid.
3. Connect the positive (+) battery cable to the positive battery terminal and the negative (-) battery cable to the negative battery terminal.

10.6.3 Starter Relay

The starter relay (Figs. 10-30 and 10-31) is a non-serviceable part and must be replaced if defective. The starter relay consists of a movable contact, not unlike a solenoid, with a fixed coil in a weatherproof case.

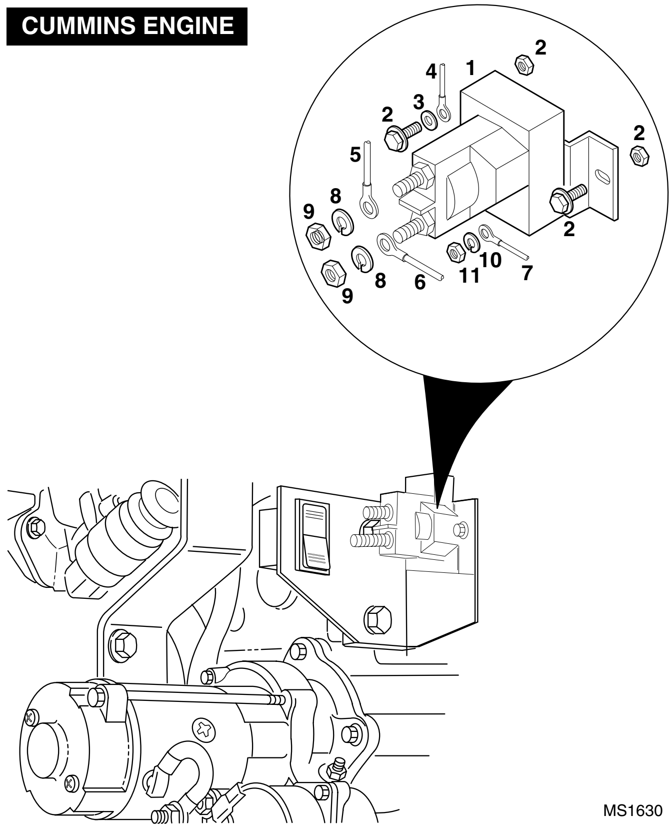
PERKINS ENGINE



1. Starter Relay
2. Mounting Hardware
3. Flat Washer
4. Wire #2A BLK Ground
5. Wire #55 ORG/BLK Ignition Wire
6. Wire #54 PNK/BRN to Starter
7. Wire #4 YEL/BLU Transmission Neutral Switch to Starter Relay
8. Lockwashers
9. Hex Nuts
10. "Small" Lockwashers
11. "Small" Hex Nuts
12. Starter
13. Ground (-) Cable
14. Positive (+) Battery Cable
15. Wire #10 GRN Starter to Alternator (B+) Terminal
16. Attaching Hardware

Figure 10-30. Perkins starter relay.

CUMMINS ENGINE



1. Starter Relay
2. Mounting Hardware
3. Flat Washer
4. Wire #2A BLK Ground
5. Wire #55 ORG/BLK Ignition Wire
6. Wire #54 PNK/BRN to Starter
7. Wire #4 YEL/BLU Transmission Neutral Switch to Starter Relay
8. Lockwashers
9. Hex Nuts
10. “Small” Lockwashers
11. “Small” Hex Nuts

Figure 10–31. Cummins starter relay.

The relay is internally grounded and is equipped with two large terminals and one small terminal. The two large terminals are for connection between the battery and the starter. The small terminal is located on the lower side of the relay is for connection to the ignition key switch.

Turning the ignition key switch with the transmission in NEUTRAL (N) allows current to flow through the relay coil via terminal to the ground point on the casing. The flow of current energizes the coil, forming a magnetic field that attracts a movable contact. When the contacts fully close, current from the battery is allowed to flow to the starter through the relay.

When the ignition switch is released, the flow of current to the coil is stopped. The magnetic field is broken, and the return spring opens the contacts, stopping current flow from the battery to the starter.

a. Starter Relay Removal

1. Disconnect the negative (-) battery cable at the battery.
2. Remove the hex nut (9), lockwasher (8) and the orange/black wire #55 (5) from the relay.
3. Remove hex nut (9), lockwasher (8) and the pink and brown wire #54 (item 6) from the relay terminal stud.
4. Remove small hex nut (11), small lockwasher (10) and the yellow and blue wire #4 (item 7) from the relay terminal stud.
5. Remove the two 1/4-20 x 3/4 hex-head capscrews, (2) 1/4-20 hex-lock elastic nuts securing the starter relay to the mount bracket. Remove the flat washer (3) the black ground wire #2A (4) from one of the capscrews.
6. Remove the relay from the vehicle.

The starter relay is a non-serviceable part and must be replaced if defective.

b. Starter Relay Inspection and Testing

Inspect the general condition of the starter relay casing and terminals. Replace the relay if it is cracked or damaged in any way.

To test the operation of the starter relay, connect a 12-volt DC positive lead to the positive terminal (the “top” terminal). Connect the negative lead to the mounting bracket, listening for a “click” sound as the contacts close. Replace the relay if the contacts do not close.

c. Starter Relay Installation

1. Position the black ground wire #2A (4) on a 1/4-20 x 3/4 hex-head capscrew (2). Insert the capscrew through the left mount hole on the starter relay (1). Secure the relay to the relay mount plate with the other 1/4-20 x 3/4 hex-head capscrew and two 1/4-20 hex-lock elastic nuts. Torque to 9 lb/ft (12 Nm).
2. Install the yellow/blue wire #4 (7) onto the relay terminal stud. Secure with the small lockwasher (10) and small hex nut (11).
3. Install the pink/brown wire #54 (6) onto the relay terminal stud. Secure with lockwasher (8) and hex nut (9).
4. Install the orange/black wire #55 (5) onto the relay terminal stud. Secure with lockwasher (8) and hex nut (9).
5. Connect the negative (-) battery cable at the battery.

10.7 CHARGING CIRCUIT

The charging circuit consists of the battery and a belt-driven alternator with an internal voltage regulator. These components work together to provide electrical power for the vehicle, including the starting system, operators display panel, horn, solenoids, back-up alarm, joystick, logic panel and all accessories. Examine the appropriate wiring diagrams and schematics earlier in this section to understand the wiring circuits involved.

Current flows from the positive post of the battery to the BATT terminal on the starter motor.

When the ignition switch is in the RUN position, current flows from the instrument cluster terminal to the alternator D+ terminal, and is used to excite the field windings and the alternator begins emitting a charge. Current flows from the alternator B+ terminal to the starter motor B terminal, then through the positive (+) battery cable to the battery. The circuit in the instrument panel connects to the battery positive terminal through the fuse panel and detects field voltages in excess of 16 volts or system voltages less than 2 to 4 volts less than battery voltage. Either of these conditions will cause the warning light in the operators display panel to illuminate.

The warning indicator (A, Fig. 10–32), a battery-shaped icon on the operators display panel, illuminates for three seconds when the engine is started and will remain illuminated if the engine is not running. The warning indicator illuminates when the battery is at a low state of charge, and when the alternator is no longer able to charge the battery.

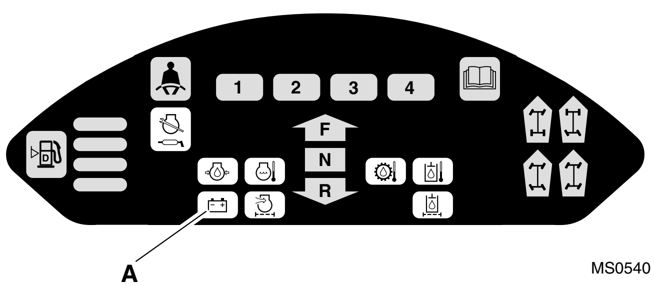


Figure 10–32. The battery warning indicator (A) is located on the operators display panel.

The negative (-) post of the battery is connected to the main chassis ground, a stud located on a triangular weldment at the hydraulic reservoir. Other ground leads routed directly from the main chassis ground are provided to the alternator, fuel shutoff switch, maintenance reset switch and spliced within the wiring harness to other electrical system grounds.

The alternator includes an internal voltage regulator that limits alternator voltage to a pre-set value and helps prevent circuit overloads, power surges, etc. during peak-voltage output.

Beyond inspecting the fan belt every 1,000 hours of engine operation, there is no periodic maintenance required for the charging circuit. When inspecting the fan belt, also check the electrical wiring and connectors.

Under normal conditions the alternator will have no problem keeping the battery charged. The only condition in which the battery may cause a problem is when it has been completely discharged for an extended period of time. In this condition, the alternator may be unable to recharge the battery, and a battery charger will be required for recharging.

Before using a battery charger, an attempt can be made to recharge the battery by jump starting the vehicle (refer to *Section 2.12.15 Battery*, sub-paragraph *C. Jump Starting*). Allow the engine to run, which enables the alternator to charge the battery.

> **WARNING: DO NOT** charge a frozen battery. A frozen battery may explode and cause serious personal injury. Allow the battery to thaw before “jump starting” the vehicle or connecting a battery charger.

If the alternator charging warning indicator illuminates, perform the following checks:

1. Check the battery cable connections at the battery and verify that they are clean and tight.
2. Check the external alternator wiring and connections and verify that they are in good condition.
3. Check the fan belt condition and tension (refer to *Section 2.12.8 Engine Fan Belt*).
4. Verify that the alternator mounting hardware is tight.
5. Run the engine and check the alternator for noise. A loose drive pulley, loose mounting hardware, worn or dirty internal alternator bearings, a defective stator or defective diodes can cause noise. Replace a worn or defective alternator.

10.7.1 Alternator

There are two types of 65-amp alternators used. Vehicles equipped with Perkins engines use a Perkins alternator. Vehicles equipped with Cummins engines use a Bosch alternator.

PERKINS ENGINE

a. Perkins Alternator Removal

1. Disconnect the negative (-) battery cable (Fig. 10–33) at the negative (-) battery terminal.

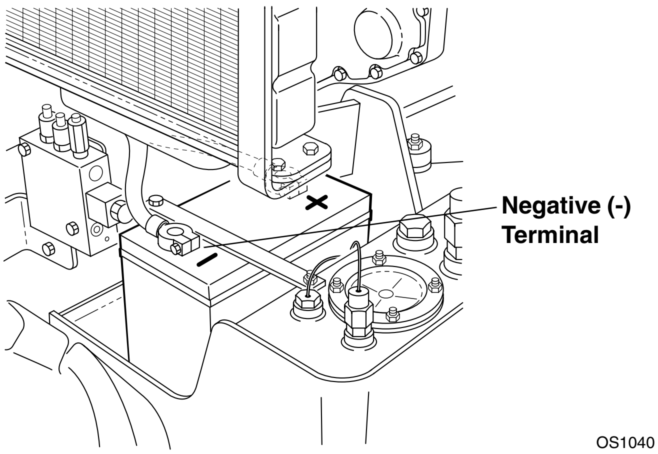


Figure 10–33. Disconnect the negative (-) battery cable at the negative (-) battery terminal.

2. Label all wiring at the rear of the alternator. Disconnect the three-wire plug at the rear of the alternator.
3. Label or tag the alternator wires. Remove the nut securing the two ground wires to the alternator. Move the three-wire plug and the two ground wires out of the way.

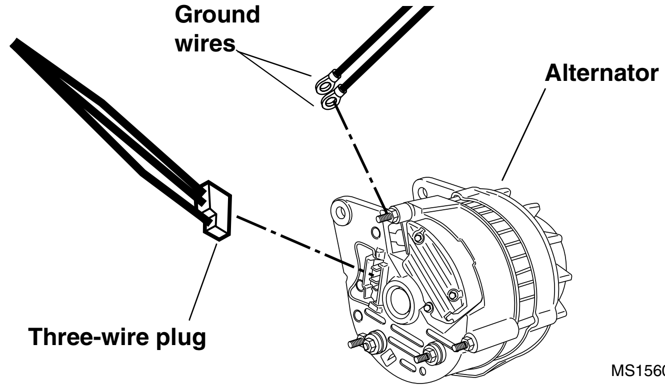
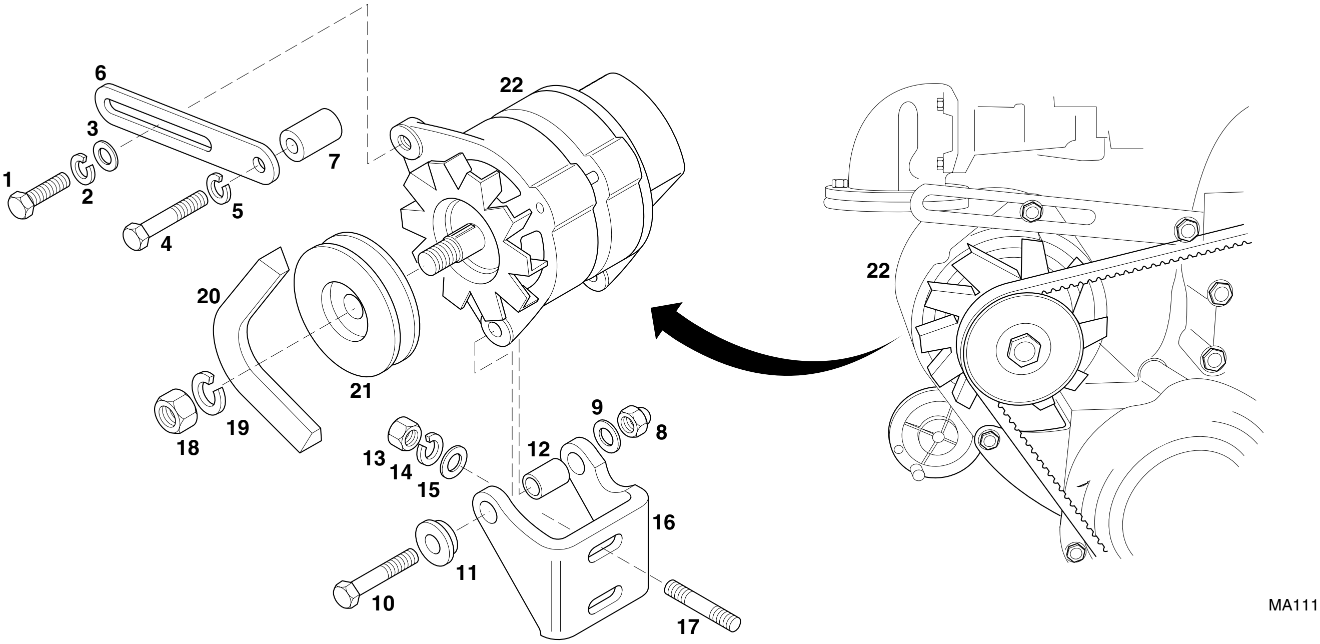


Figure 10–34. Label and disconnect the alternator wire connector and both ground wires.

4. Loosen the upper hex-head capscrew (1, Fig. 10–35) and lower hex-head capscrew (10) slightly. In order to loosen the lower screw (10), a wrench may need to hold the self-locking nut (8) in position. Rotate the alternator toward the engine and move the fan belt (20) out of the way.
5. Remove the screw (1), lockwasher (2), and flat washer (3) securing the lever (6) to the tapped hole in the alternator (22).
6. Remove the screw (4), lockwasher (5), lever (6) and spacer (7) from the tapped hole in the engine block.
7. While supporting the alternator (22) so it does not fall, remove the self-locking nut (8), washer (9), screw (10), and two sleeves (11 and 12). Remove the alternator from the vehicle.
8. If required, remove the hex nut (13), lockwasher (14), flat washer (15) bracket (16) and stud (17).
9. If required, remove hex nut (18), lockwasher (19), belt (20), and pulley (21).

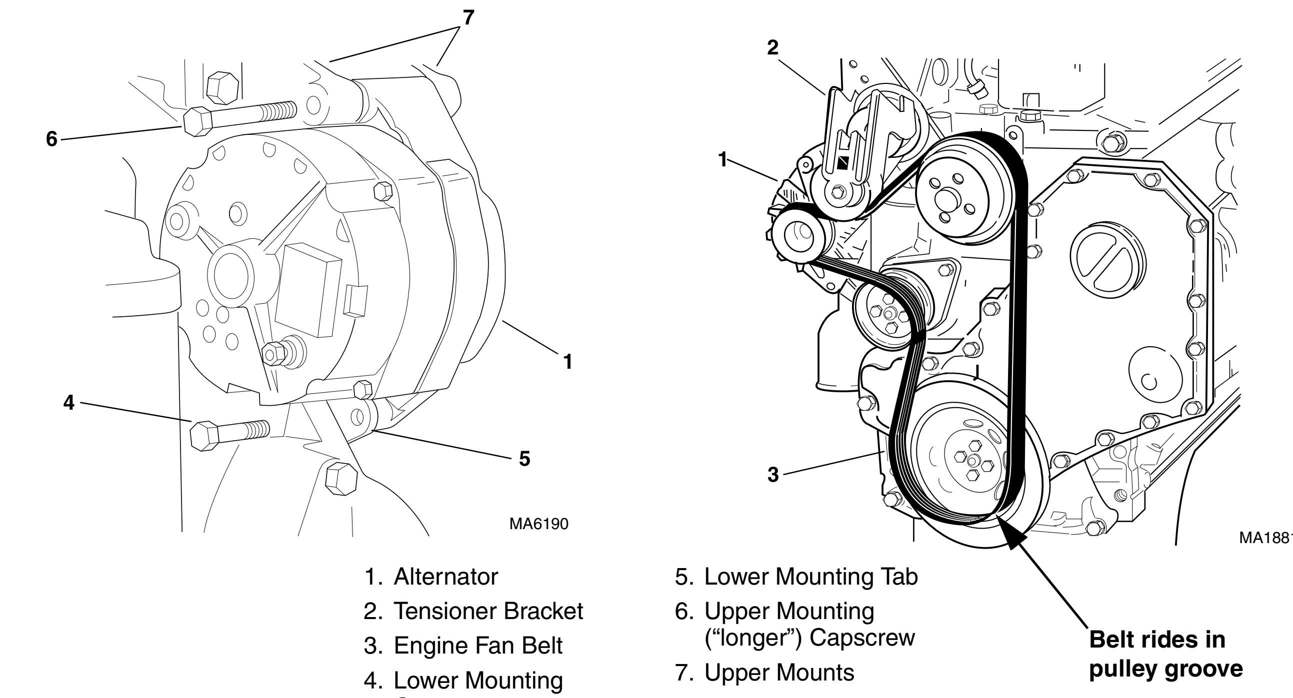


1. Screw	5. Lockwasher	9. Washer	13. Nut	17. Stud	21. Belt Pulley
2. Lockwasher	6. Lever	10. Screw	14. Washer	18. Hex Nut	22. Alternator
3. Washer	7. Spacer	11. Sleeve	15. Washer	19. Washer	
4. Bolt	8. Self-locking Nut	12. Sleeve	16. Bracket	20. Belt	

Figure 10–35. Perkins alternator mounting detail.

b. Perkins Alternator Installation

1. If required, install pulley (21, Fig. 10–35), belt (20), lockwasher (19), and hex nut (18).
2. If required, install the stud (17), bracket (16), flat washer (15), lockwasher (14), and hex nut (13).
3. Slide the sleeve (11) over the hex-head capscrew (10) and position these parts in the mounting hole on the front of the bracket (16).
4. Position the alternator (22) so that its front lower mount hole is aligned in the bracket (16), and begin to push the screw (10) through the front lower mount hole. Position sleeve (12) so that the screw (10) goes through it, through the alternator rear lower mount hole, and out the rear of the bracket (16). Install the washer (9) and self-locking nut (8) onto the screw (10) but DO NOT tighten at this time.
5. Install the spacer (7), lever (6), lockwasher (5), and screw (4), and thread the screw (4) into the tapped hole in the engine block.
6. Install the flat washer (3), lockwasher (2) and screw (1) securing the lever (6) to the tapped hole in the alternator (22).
7. Rotate the alternator toward the engine and place the fan belt (20) into position. In order to tighten the lower screw (10), use a wrench to hold the self-locking nut (8). Rotate the alternator with the fan belt away from the engine and tighten the upper hex-head capscrew (1) and lower hex-head capscrew (10) securely.
8. Check for proper fan belt deflection (refer to *Section 2.12.8 Engine Fan Belt*).
9. At the ground stud on the back of the alternator, install the two alternator ground wires and secure with a hex nut.
10. Connect the three-wire plug at the rear of the alternator.
11. Connect the negative (-) battery cable (Fig. 10–33) to the negative (-) battery terminal.



1. Alternator
2. Tensioner Bracket
3. Engine Fan Belt
4. Lower Mounting Capscrew
5. Lower Mounting Tab
6. Upper Mounting ("longer") Capscrew
7. Upper Mounts

Figure 10–36. Cummins alternator mounting detail.

CUMMINS ENGINE

a. Cummins Engine Bosch Alternator Removal

1. Disconnect the negative (-) battery cable (Fig. 10–37) at the negative (-) battery terminal.

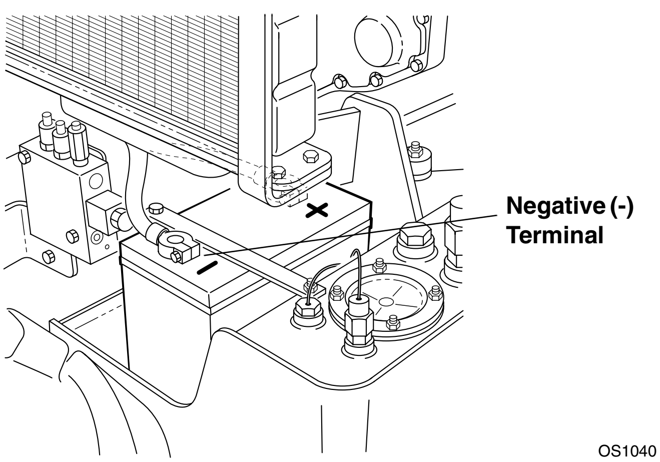


Figure 10–37. Disconnect the negative (-) battery cable at the negative (-) battery terminal.

2. Install a 1/2" square drive ratchet into the square hole in the tensioner bracket (2, Fig. 10–36). Turn the ratchet to lift the bracket and remove the engine fan belt (3).
3. Label and remove all wiring from the rear of the alternator.
4. Remove the lower mounting capscrew (4) securing the alternator to the lower mounting tab (5) on the engine.
5. While supporting the alternator with one hand, remove the upper ("longer") mounting capscrew (6) from the upper alternator mounts (7). Remove the alternator from the vehicle.

b. Cummins Engine Bosch Alternator Installation

1. Position the alternator (1, Fig. 10–36) between the upper mounts (7) on the engine bracket. Align the holes and insert the upper ("longer") mounting capscrew (6) through the rear mount and alternator. Thread the longer capscrew into the alternator front mount. DO NOT tighten completely at this time.
2. Align the lower alternator mount hole with the lower mounting tab (5) on the engine and insert the lower mounting capscrew (4). Tighten the lower capscrew (4) and upper capscrew (6) securely.
3. At the rear of the alternator, reattach all wires to their proper terminals.

4. Use a 1/2" square drive ratchet to raise the tensioner bracket (2). Properly route the fan belt (3) onto the alternator and engine pulleys. Check the tensioner pulley to verify that it is pivoting freely to provide the proper tension on the belt. Check for proper fan belt deflection (refer to *Section 2.12.8 Engine Fan Belt*).
5. Connect the negative (-) battery cable (Fig. 10–37) to the negative (-) battery terminal.

10.7.2 Battery

WARNING: All lead-acid batteries generate hydrogen gas, which is highly flammable. If ignited by a spark or flame, the gas may explode violently, causing spraying of acid, fragmentation of the battery, and possible severe personal injuries. Wear safety glasses when working near batteries. In case of contact with acid, flush immediately with water.

A single, lead-acid type, 12-volt, negative (-) ground, maintenance-free battery rated at 1000 cold-cranking amps is used in this vehicle. Refer to *Section 2.12.15 Battery* for general information.

a. Battery Description

The battery supplies power to the starter and ignition system to crank the engine, and provides extra power when the electrical load requirements of the vehicle exceed the supply from the charging system in the event of an alternator or charging-system failure. The battery also acts as a voltage stabilizer in the electrical system, smoothing out or reducing temporarily high voltage.

With the correct battery cables properly attached, and with the battery properly mounted, the battery does not require periodic maintenance.

When starting the engine, allow the starter to crank for a maximum of 15 seconds only, then wait a minimum of two minutes to help avoid burning out the starter. Also, DO NOT let the engine idle excessively, as low engine RPM can also lead to battery discharge.

Keep the battery from freezing by maintaining a full charge. A completely discharged battery will freeze at 18° F (8° C).

Due to the maintenance-free design, water never has to be added to the battery, so there are no filler caps. Each battery is sealed, except for small vent holes in the cover. The vent holes allow gas and pressure produced in the battery during charging to escape. The special chemical composition inside the battery reduces gassing to a very small amount at normal charging voltages. The special chemistry also greatly reduces the possibility of overcharge damage.

The vents require keeping the battery in an upright position to help prevent electrolyte leakage. Tipping the battery beyond a 45° angle in any direction can allow a small amount of electrolyte to leak out the vent hole.

DO NOT exceed this 45° angle when carrying or installing a battery.

The battery has top-post terminals. Keep the terminals clean, and securely tighten clean cable clamps onto the posts. Grease or special spray sealers may be applied over the connections.

b. Visual Inspection of the Battery

Inspect for damage such as a cracked or broken case or cover that could permit loss of electrolyte. If obvious physical damage is noted, replace the battery. Handle the battery with care. Determine the cause of damage and correct as needed before installing the new battery.

c. Battery Load Test

1. Disconnect both the negative (-) battery cable (first), and the positive (+) battery cable from the battery. Make sure that the negative and positive battery terminal posts are clean to help assure a good electrical connection.
2. Attach voltmeter and battery load tester clamps to the battery terminal posts.
3. Remove the surface charge from any battery that has just been charged (by a battery charger or by the vehicle alternator). DO NOT remove the surface charge from a battery that has been in storage. To remove the surface charge, apply a 300-ampere load across the terminals for 15 seconds. Then turn off the load and wait for 15 seconds to allow the battery to recover and normalize.
4. Battery temperature should be estimated by touch and also by the surrounding temperature it was exposed to during the preceding few hours before testing. Select the nearest estimated temperature from the chart below and determine the minimum voltage that must be maintained while the battery supplies a specified electrical load.
5. Apply a 260-ampere load test to check the charge acceptance of the battery. Observe the voltage after 15 seconds with the load connected, then turn off the load.
6. If voltage is at or above the value determined in step 4, the battery is good and may be returned to service.
7. If voltage is below the value determined in step 4, check the charge acceptance of the battery one more time before discarding it. If the voltage continues to read below the value determined in step 4, replace the battery.

Note: The accuracy of this test procedure depends on closely following the load, time and temperature specifications.

Relation of Battery Temperature to Minimum Voltage

TEMPERATURE	MINIMUM VOLTAGE
70° F (21° C) and above	9.6
50° F (10° C)	9.4
30° F (-1° C)	9.1
15° F (-10° C)	8.8
0° F (-18° C)	Below 0° F (-18° C)

d. Battery Charging

Charge rates between 3 and 50 amperes are generally satisfactory as long as spewing of electrolyte does not occur, or the battery does not feel excessively hot [over 125° F (52° C)]. Battery temperature can be estimated by touching or feeling the battery case. If spewing of electrolyte occurs or temperature exceeds 125° F (52° C), commonly referred to as "boiling" the battery, the charging rate must be reduced or temporarily halted to permit cooling. Failure to do so will destroy the battery.

When charging a battery, keep this point in mind:

• *Battery charging* consists of a charge current *in amperes* for a period of time *in hours*. Thus, a 25-ampere charging rate for 2 hours would result in a 50-ampere hour charge to the battery.

The time required for a charge will vary due to the following conditions:

• ***Size of battery:*** For example, a completely discharged, large, heavy-duty battery requires more than twice the recharging as a completely discharged small passenger car battery.

• ***Temperature:*** For example, more time will be required to charge a battery at 0° F than at 80° F. When a fast charger is connected to a cold battery, the current accepted by the battery will be very low at first, then in time the battery will accept a higher rate as the battery warms.

• ***State of Charge:*** A completely discharged battery requires more than twice as much charge as a half-charged battery. Because the electrolyte is nearly pure water and therefore a poor conductor in a completely discharged battery, the current accepted is very low at first. Later, as the charging current causes the electrolyte acid content to increase, the charging current will likewise increase.

• ***Charger Capacity:*** A charger that can only supply 5 amperes will require a much longer period of charging than a charger that can supply 30 amperes or more.

e. Battery Troubleshooting

If a battery has tested satisfactorily but then fails to perform satisfactorily for no apparent reason, the following items are among the more popular factors that may help understand the cause:

1. Vehicle accessories left on, causing battery discharge.
2. Charging system defect, such as slipping fan belt, high wiring resistance, or faulty alternator.
3. A vehicle electrical load exceeds alternator output capacity (common with the addition of electrical accessories such as radio equipment, lights, air conditioning, or window defogging/de-misting devices).
4. Electrical system defects, such as shorted wires.
5. Extended slow speed driving with many accessories on, and excessive engine idling (both cases do not allow engine RPM to reach a sufficient speed to enable alternator output to sufficiently charge the battery).
6. Loose or poor battery cable-to-post connections, previous improper charging of a run-down battery, or loose battery hold-down hardware.
7. High resistance connections or defects in the starting system.
8. Failure to disconnect the battery before long periods of vehicle storage. Small current drains of vehicle accessories that are connected all the time can also discharge the battery in a six- to eight-week period. A battery left in a discharged condition for a prolonged period of time is subject to freezing and can become difficult to recharge.

f. Jump Starting with an Auxiliary (“booster”) Battery

Note: Use this information in addition to that found under *C. Jump Starting* in *Section 2.12.15 Battery*.

Both the auxiliary or “booster” battery and the discharged battery should be treated carefully when using jumper cables. Follow the following procedure exactly, and DO NOT cause sparks to occur:

1. Engage the park lock of the booster vehicle and place its transmission in NEUTRAL (N). DO NOT allow both vehicles to touch each other in any manner, as this could establish a ground connection and counteract the jump-starting process.

WARNING: Any other procedure than that outlined in these instructions could result in:
- Personal injury caused by electrolyte spewing out of the top vent holes on the battery.
- Personal injury or property damage due to battery explosion;
- Damage to the starting systems of both vehicles.

2. Continue with the jump starting instructions found under *C. Jump Starting in Section 2.12.15 Battery*.

g. Battery Removal

1. Disconnect the negative (-) battery cable from the battery (Fig. 10-38). Disconnect the positive (+) battery cable from the battery.
2. Remove the battery retaining ("hold-down") strap hardware and the retaining strap (Fig. 10-38).
3. Carefully remove the battery from the vehicle.

Note: The best time to clean the battery compartment is when the battery is removed from the vehicle.

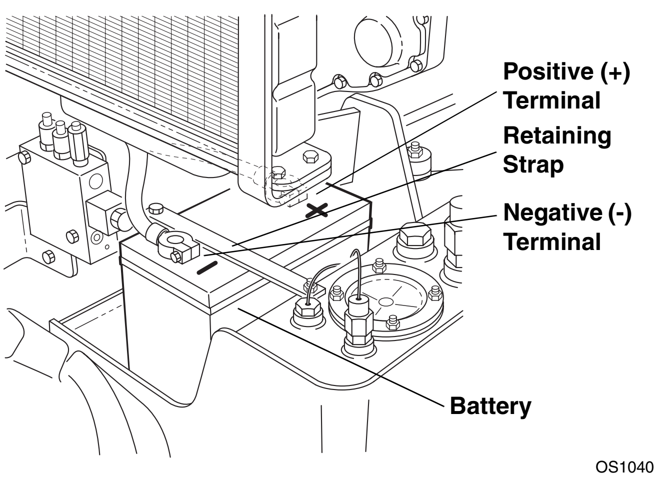


Figure 10-38. Disconnect the negative (-) and positive (+) battery terminals.

h. Battery Removal

1. Disconnect the negative (-) battery cable from the battery (Fig. 10-38). Disconnect the positive (+) battery cable from the battery.
2. Remove the rear engine cover (Fig. 10-39), the battery retaining ("hold-down") strap hardware, the retaining strap (Fig. 10-38) and the battery.

Note: The best time to clean the battery compartment is when the battery is removed from the vehicle.

i. Battery Inspection, Cleaning and Drying

1. Periodically inspect the battery for accumulation of dirt or corrosion on the battery, terminals, cable ends, and battery retaining hardware. Also check that the battery case and cover is not cracked or leaking, and that the terminal posts are not broken or loose.
2. Prepare a mixture of baking soda and water and obtain a non-metallic scrub brush. Dip the brush in the mixture and scrub the battery and cable terminals. Also clean the battery mounting area on the vehicle frame before replacing the battery.
3. Dry the battery with a clean, lint-free cloth.

j. Battery Installation

1. Carefully place the battery (Fig. 10-38) in the battery compartment.
2. Install the battery retaining ("hold-down") strap and the retaining strap hardware. Attach the strap properly to help prevent the battery from shifting, moving and vibrating. Vibration is harmful to a battery. DO NOT overtighten the fasteners.
3. Install the rear engine cover (Fig. 10-39).
4. Connect the positive (+) cable to the positive battery terminal post.
5. Connect the negative (-) cable to the negative battery terminal post.

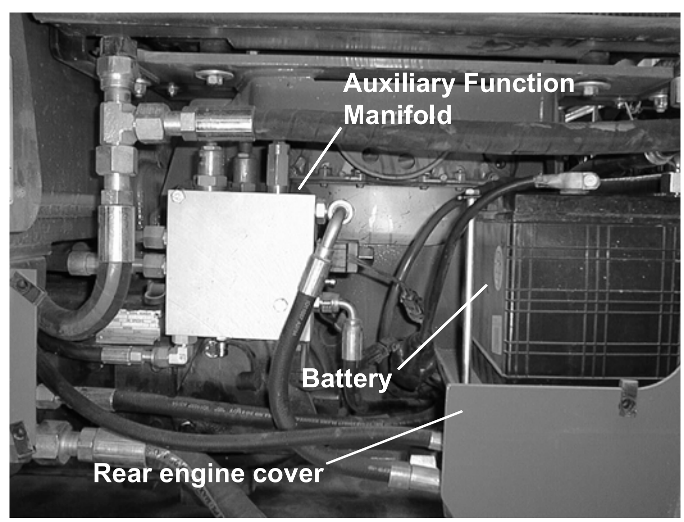


Figure 10-39. The rear engine cover is located to the rear of the battery.

10.8 ELECTRICAL SYSTEM COMPONENTS

Electrical components include warning devices such as the indicators in the operators display panel, horn, back-up alarm, and other components such as the joystick, logic panel, various solenoids and all accessories.

Examine the appropriate wiring diagrams and schematics earlier in this section to help understand the wiring circuits involved.

10.8.1 Warning Devices

Vehicle warning devices include the horn, instrument panel warning lights, and the back-up alarm.

a. Horn

The horn (Fig. 10–40) is mounted forward of the cab on the vehicle frame.

The horn sounds when the momentary-contact horn button on the center of the steering wheel is pressed. Removal of the horn button is discussed in *Section 4.2.4 Controls* of this manual.

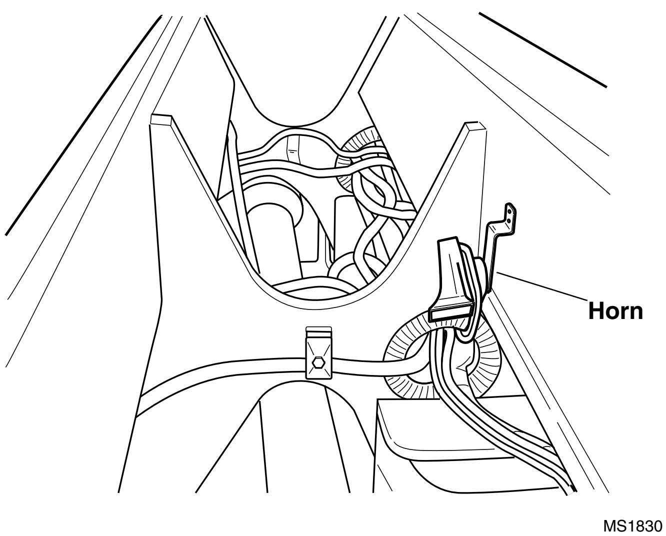


Figure 10–40. Horn location.

The horn sound is produced by a solenoid-actuated diaphragm in the horn that develops a resonating air column in the horn trumpet, which is shaped to project the sound. If the horn doesn't sound when the horn button is pressed, check that the fuse is not blown.

Check for corrosion on the horn mounting that may be preventing a solid ground, and check for a loose horn wire. Test the horn switch for continuity when the horn button is pressed.

If the problem is still not located, remove the horn from the frame and test it using short, heavy-gauge wires connected to a fused or otherwise protected 6-amp minimum output, 12-volt DC power supply.

b. Warning Indicator Lights (in operators display panel)

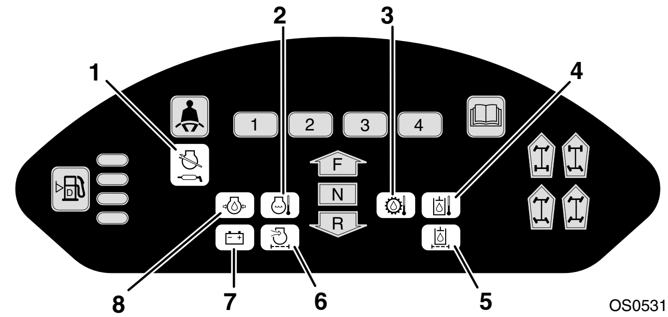


Figure 10–41. Typical operators display panel warning indicator lights.

There are eight subdued or "hidden" warning indicator lights (described below) present in the operators display panel (Fig. 10–41). These warning indicators illuminate during critical circumstances.

IMPORTANT: All eight warning indicator lights demand immediate attention and vehicle service. In many cases, the vehicle should be shut down as soon as practical to help prevent serious mechanical failure. Appropriate service procedures for each circuit, as applicable, appear elsewhere in this section of the manual.

1. Engine Maintenance/Vehicle Lubrication Indicator

This light (item 1, Fig. 10–41) illuminates every 250 hours of engine operation to remind the operator that important maintenance operations are required. After the engine is serviced (engine oil and engine oil filter changed), the indicator can be reset by pressing and holding the reset switch (Fig. 10–42), then turning the ignition switch to the RUN position. The indicator light will illuminate during power-up and will cease to illuminate when it is reset. The reset switch can then be released. Should there be a problem with the indicator and it does not cease to illuminate after servicing the engine and conducting the reset steps above, check the involved circuit and the reset switch itself for continuity and shorts. Replace a defective switch. If the problem is determined to exist in the operators display panel, replace the panel with a new unit.

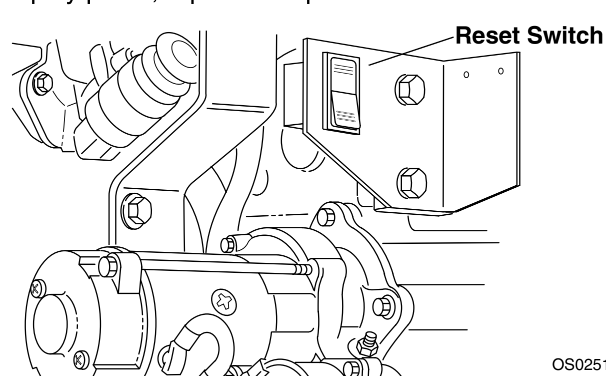


Figure 10–42. Typical maintenance reset switch.

2. Engine Coolant Temperature Warning Indicator

This indicator (item 2, Fig. 10–41) is illuminated when the engine coolant temperature is above 210° F (85° C). An audible alarm will sound, and the engine must be shut down as soon as practical to help avoid engine damage.

3. Transmission Temperature Warning Indicator

This indicator (item 3, Fig. 10–41) illuminates when the transmission fluid temperature exceeds 250° F (107° C). An audible alarm will also sound, and the vehicle should be stopped and the engine allowed to idle at high idle for five minutes. If the light and alarm do not cease after five minutes, the engine must be shut down to help avoid transmission damage.

4. Hydraulic Oil Temperature Warning Indicator

This warning light (item 4, Fig. 10–41) will activate when the hydraulic oil temperature is above 195° F (76° C). The vehicle should be stopped and the engine allowed to idle at high idle for five minutes. If the light continues to illuminate after five minutes, the engine must be shut down to help avoid damage in the hydraulic system.

5. Hydraulic Oil Filter Restriction Warning Indicator

This warning light (item 5, Fig. 10–41) will activate when a restricted hydraulic oil system filter is detected. The vehicle should be stopped and the engine allowed to idle at high idle for five minutes. If the light remains illuminated or begins to flicker on and off at high idle, replace the hydraulic oil filter (see *Section 9 Hydraulic System* for further information).

6. Engine Air Filter Restriction Warning Indicator

This warning light (item 6, Fig. 10–41) will activate when a restricted engine air filter is detected. The vehicle should be stopped and the engine allowed to idle at high idle for five minutes. If the light remains illuminated or begins to flicker on and off at high idle, replace the engine air filter (see *Section 8A Perkins Engine* or *Section 8B Cummins Engine* for information on replacing the air filter).

7. Alternator Charging Warning Indicator

This light (item 7, Fig. 10–41) illuminates when the charging system is not working properly. Check and service the alternator and battery as required.

8. Engine Oil Pressure Warning Indicator

This indicator (item 8, Fig. 10–41) illuminates and an audible alarm sounds after 15 seconds if the engine is not started. This is normal. When the ignition key switch is turned to the OFF position, the indicator is reset. Should the light and alarm begin during engine operation, the engine oil pressure is too low. The engine must be shut down as soon as practical to help avoid engine damage.

c. Back-Up Alarm

The back-up alarm (Fig. 10–43) is located at the rear of the vehicle, under the rear cover, mounted on the top left side of the frame.

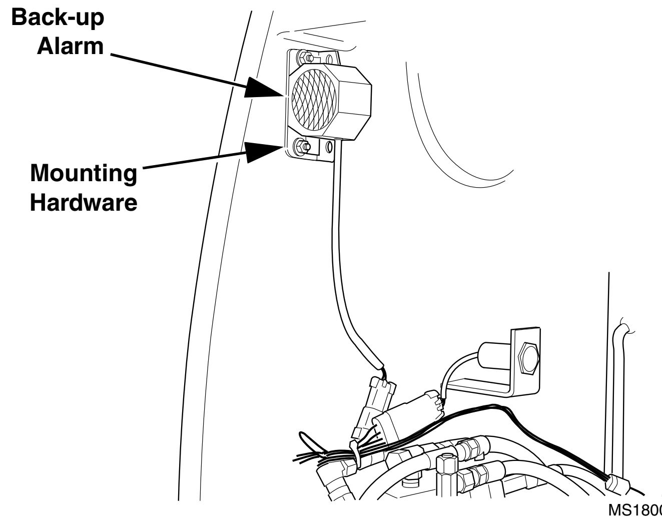


Figure 10–43. Back-up alarm location.

When the transmission shift control switch (travel select lever) is shifted to the reverse position, the back-up alarm will automatically sound. Place the travel select lever in reverse to test the back-up alarm. The back-up alarm must not sound when the travel select lever is in NEUTRAL (N) or FORWARD (F). Also, with the ignition key switch in the RUN position, the back-up alarm will sound when the travel select lever is shifted into the REVERSE (R) position.

The back-up alarm is energized via current from the transmission shift control switch, part of the travel select lever mounted within the steering column. See the appropriate wiring schematic and diagram in this section to help understand the back-up alarm circuit. See *Section 4.2.4 Controls* for information on removing and replacing the transmission shift control switch.

Back-up Alarm Removal

1. Disconnect the negative (-) battery cable at the negative battery terminal (Fig. 10–44).

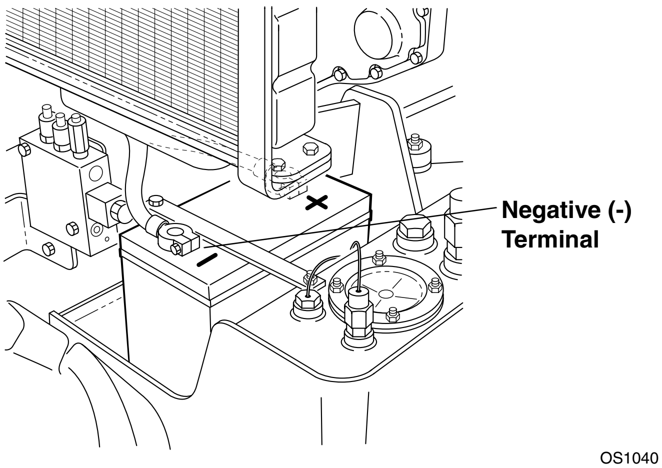


Figure 10–44. Disconnect the negative (-) battery cable at the negative (-) battery terminal.

2. Label and disconnect the wiring from the back-up alarm.
3. Two nuts and lockwashers secure the back-up alarm to weldstuds on the vehicle frame. Remove the nuts and washers and remove the alarm from the vehicle.

Disassembly

DO NOT disassemble the back-up alarm. Replace a defective or faulty alarm with a new one.

Inspection and Replacement

Inspect the wiring harness connector and alarm terminals for continuity and shorting. Replace a defective or faulty alarm with a new one.

Installation and Testing

1. Position the back-up alarm (Fig. 10–43) on its mounting studs and secure with two 1/4-20 hex-lock elastic nuts and 1/4” lockwashers.
2. Connect the wiring harness connector lead to the back-up alarm.
3. Connect the negative (-) battery cable to its battery terminal (Fig. 10–44).
4. Test the alarm by turning the ignition key switch to the RUN position and shifting the travel select lever into the reverse position.

10.8.2 Operators Display Panel

There are two types of operators display panels in existence (Fig. 10–45) at the time this manual was published.

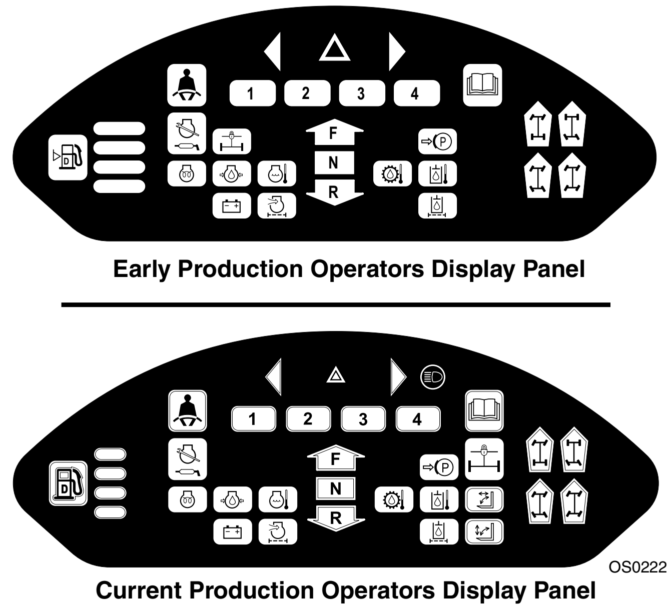


Figure 10–45. There are two types of operators display panels.

The information under this heading deals mainly with the description and function of each indicator in the operators display panel. Appropriate service procedures for each circuit, as applicable, appear elsewhere in this section of the manual.

The operators display panel is of solid-state, printed circuit design and contains five wiring terminals or plugs, two printed-circuit boards mounted piggy-back style with standoffs, and a display panel that provides overall monitoring of vehicle functions and status. Due to the complex design and solid-state circuitry, the panel is non-serviceable. Electro-static discharge and moisture are two of the main reasons for malfunction. Prevent the panel from coming into contact with static or other electrical sources. When washing the vehicle, keep spray away from the operators display panel. Replace a defective, malfunctioning or faulty panel with a new unit.

The operators display panel provides important information in a “user friendly” design with easily-recognizable graphic and alpha-numeric indicators. The panel provides information the operator needs on vehicle and engine functions.

When testing circuits connected to the dash, disconnect the harness connector and test the *harness* side only.

a. Power-Up Lights

When the ignition key switch is turned to power up the vehicle, all lights in the display panel will illuminate for three seconds as a test function. During this time, an audible alarm will also sound.

The Fasten Seat Belt and Read Manual symbols (Fig. 10–46) will remain illuminated for five to seven seconds (repeated whenever the seat belt switch senses that pressure is removed from the seat), reminding the operator to fasten the seat belt and to review the *Owners/Operators Manual* if there are any questions about safe and proper operation of the vehicle (a manual should be kept in the storage compartment beneath the seat at all times).

Normal Operating Lights

After the engine starts, the operators display panel (Fig. 10–46) provides information via the following indicators:

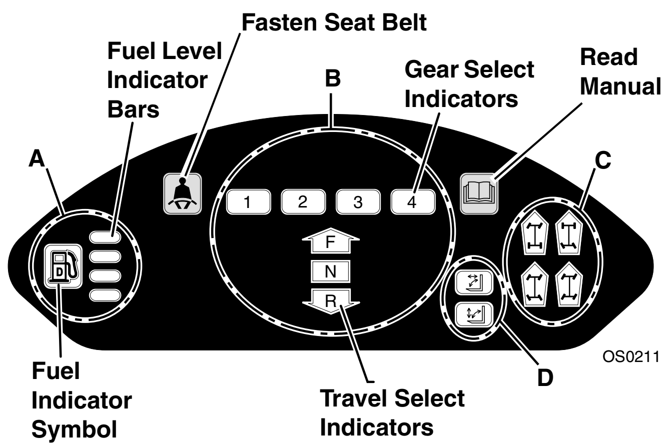


Figure 10–46. The operators display panel indicators illuminate when the vehicle is started.

A. Fuel Level Indicator Bars

Each of the fuel level indicator bars (Fig. 10–46) represents approximately 1/4 tank. The vehicle must be parked on a firm, level surface to ensure an accurate fuel level reading. The fuel level indicator bars will be illuminated with a low-light green hue, easily apparent for night visibility and in low-light conditions. When approximately 1/8 tank is reached, the last fuel level indicator bar will stop illuminating, and the fuel level indicator symbol, a graphic of a fuel dispensing pump, will change from green to orange. When the fuel level indicator symbol changes from green to orange, refuel the tank.

B. Travel and Gear Select Indicators

These illuminate to show the direction the travel select lever is in (F for FORWARD, N for NEUTRAL, and R for REVERSE) and the gear presently engaged.

C. Steering Mode Indicators

The steering mode indicators (Fig. 10–46) illuminate to show which of the steering modes (front-wheel, crab, or four-wheel steering) is presently engaged.

D. Attachment Tilt Mode Indicator

One of the two attachment tilt mode indicators will illuminate to show which mode (extend/retract or raise/lower) is presently engaged.

Function Indicator Lights

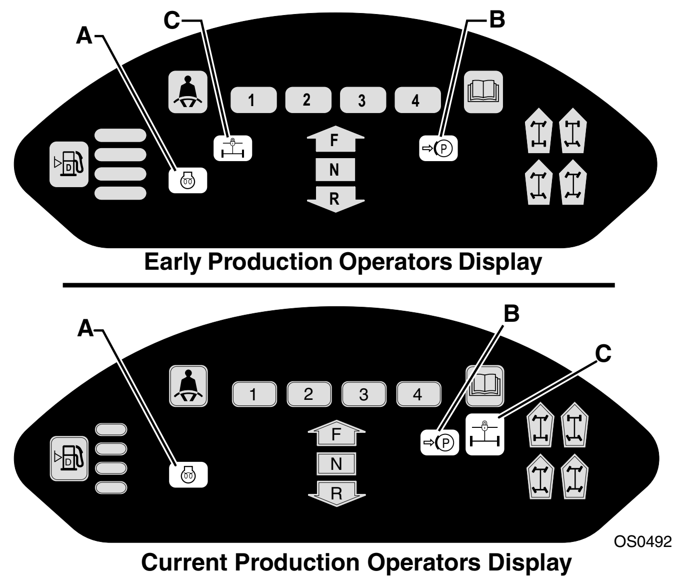


Figure 10–47. Function indicator lights.

There are three subdued or "hidden" function indicator lights (Fig. 10–47) in the display panel that illuminate only when a specific function is activated. They are:

A. Engine Preheat Indicator (Perkins engines only)

This light flashes when the ignition key is held in the PREHEAT position (Fig. 10–48). After 30 seconds, the light will glow steadily, indicating the engine is warm enough to start.

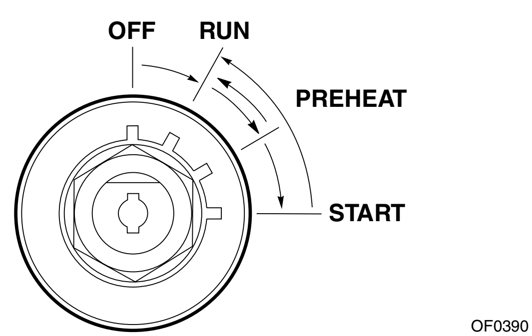


Figure 10–48. Ignition key switch positions.

B. Parking Brake Indicator

This illuminates any time the parking brake switch is applied and the ignition switch is in the RUN position.

C. Stabil-TRAK Indicator

This light illuminates when the Stabil-TRAK system is activated.

b. Operators Display Panel Removal

IMPORTANT: Static electricity can cause damage to the operators display panel. Avoid any manner of touching (hands, tools, etc.) the printed circuit boards and terminals. Disconnect the negative (-) battery cable at its battery terminal before beginning this procedure. Failure to comply can result in damage to the operators display panel and malfunction of the instruments and indicator lights.

1. Disconnect the negative (-) battery cable at its battery terminal (Fig. 10–49).

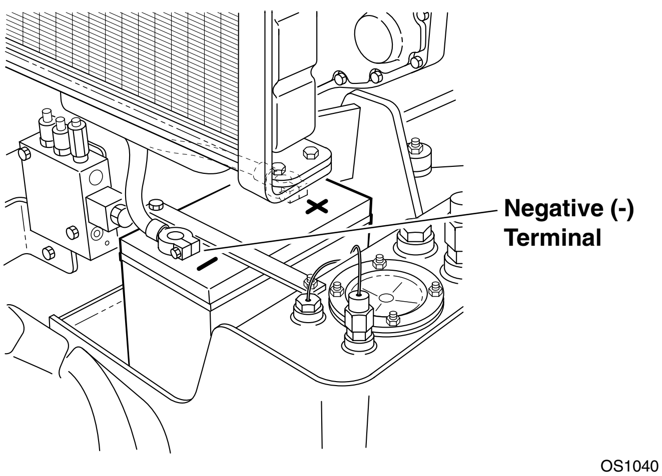


Figure 10–49. Disconnect the negative (-) battery cable at the negative (-) battery terminal.

2. Remove the four internal-hex fasteners (Fig. 10–50) securing the operators display panel to the dashboard housing.
3. Disengage the five quick-disconnect plug terminals at the rear of the operators display panel. Remove the panel from the vehicle.

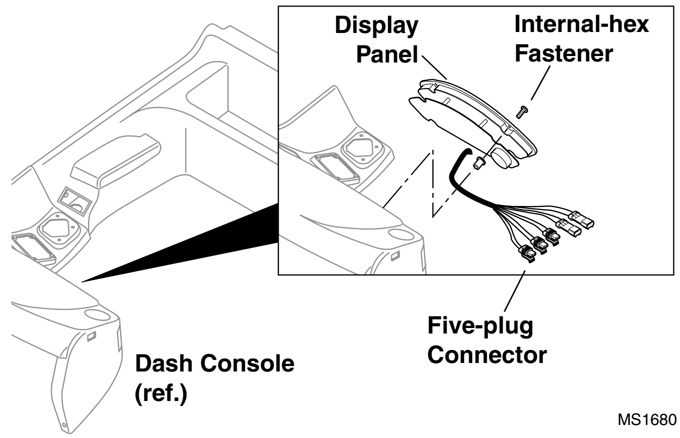


Figure 10–50. The operators display panel connects to the cab wiring harness via five plug terminals.

c. Installation

1. Connect the five quick-disconnect plug terminals at the rear of the operators display panel (Fig. 10–50). Install the panel by positioning it into the dashboard housing and aligning the four fastener mounting holes.
2. Install the four internal-hex fasteners securing the operators display panel to the dashboard housing.
3. Connect the negative (-) battery cable to the negative battery terminal (Fig. 10–49).
4. Turn the ignition switch key to the RUN position (Fig. 10–51) and observe that all operators display panel functions are operative per the following diagnostic test:

Operators Display Panel Test

Check the following as the key is switched into the "RUN" position (Fig. 10–51):

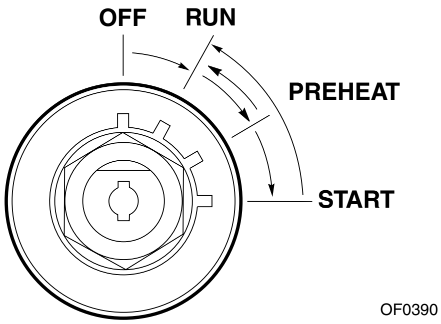


Figure 10–51. Ignition key switch positions.

1. All lights must illuminate for a minimum of 3 seconds.
2. An audible alarm must sound for a minimum of 3 seconds.
3. "Seat belt" light and “Read Manual” light and must remain on for 5 to 7 seconds, with operator seated.
4. "Seat belt" light and "Read manual" light must illuminate when operator is removed from seat.
5. Warning lights and alarm must be OFF for an additional 15 to 20 seconds.
6. Engine oil pressure light and alarm will turn ON in 15 seconds if engine is not running.
7. One of three travel direction lights (F, N, or R) must always remain ON.
8. 1 of 4 gear selection lights must always remain ON "1, 2, 3, 4" (*4-speed transmission only*).
   OR
   1 of 3 gear selection lights must always remain on "1, 2, 3" (*3-speed transmission only*).
9. 1 of 3 steering mode lights must always remain ON.
10. The appropriate fuel level indicator lights must always remain ON.

Note: 4 green bars = a full tank; 1 green bar = 1/4 tank, and at 1/8 tank, no green bars illuminate and the fuel dispensing pump symbol illuminates in orange.

10.8.3 Switches and Solenoids

a. Ignition Key Switch

The ignition key switch (Fig. 10–52) is located on the lower left side of the dash. It is a key-operated switch used to start the engine and to run the vehicle. Only on Perkins engines equipped with the optional cold start feature (refer to *Thermo-Start Plug* in this section), the ignition switch preheat function will allow the thermo-start plug to ignite the air/fuel mixture in the intake manifold, making the engine easier to start in cold weather.

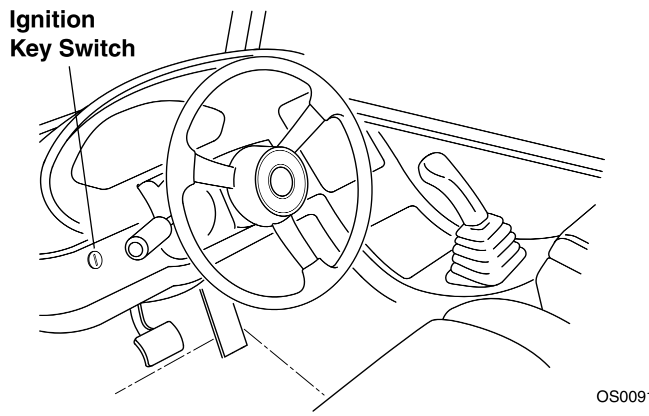


Figure 10–52. Ignition key switch location.

When the key is inserted into the ignition key switch, the switch can be turned clockwise from the OFF position (Fig. 10–51) to the RUN, PREHEAT (Perkins-only option), and START positions. The PREHEAT and the START positions are spring-loaded to return the switch to the RUN position; these two switch positions must be manually held in place for cold-weather starting (Perkins-only option) and for normal starting.

OFF Position

The entire electrical system is shut down, with power at the ignition switch and the starter solenoid only.

RUN Position

All controls and indicators are operable.

PREHEAT position (Perkins-only option)

Preheats air in the induction manifold for cold-weather starting (refer to Thermo-Start Plug in this section). When starting in cold weather, momentarily hold the key in the PREHEAT position before turning it to the START position.

START Position

When the park brake switch is ON and the transmission is in NEUTRAL (N), turning the ignition switch to the START position engages the starter to start the engine.

If the key binds in the switch, check the key for defects and the switch for foreign objects. Clean or remove foreign material from the key as required. Check that the key is not bent or excessively worn; replace a bent or worn key with a new key. Apply powdered graphite to the key and insert and withdraw the key from the switch several times to distribute the graphite into the switch lock mechanism.

During freezing temperatures, if the ignition switch fails to turn, or does not allow the key to be inserted, warm the switch with a heat gun (blow dryer), or use liquid lock deicer to help evaporate frozen moisture from within the switch.

IMPORTANT: Only use graphite or a liquid lock deicer within the switch. Replace a defective switch.

Ignition Switch Removal

1. Disconnect the negative (-) battery cable at the negative battery terminal (Fig. 10–49).
2. Remove the hex nut securing the ignition switch to the dash.
3. Reach up and under the dash to work the ignition switch and wiring out of the mounting hole.
4. Label the wires on the ignition switch. Disconnect the wires from the switch and remove the switch from the vehicle.

Disassembly

DO NOT disassemble the ignition switch. Replace a defective switch with a new one.

Inspection and Replacement

The key should insert and turn freely in the switch. If the key binds in the switch, check the key for defects and the switch for foreign objects. Clean or remove foreign material from the key as required. Check that the key is not bent or excessively worn; replace a bent or worn key with a new key. Apply powdered graphite to the key and insert and withdraw the key from the switch several times to distribute the graphite into the switch lock mechanism.

IMPORTANT: Only use graphite or a liquid lock deicer within the switch. Replace a defective switch.

Refer to the SWITCH POSITION table below. Using an ohmmeter or a continuity tester, check for continuity. Replace the switch if it fails to test according to the table.

SWITCH POSITION

Switch Terminals	OFF	RUN	PREHEAT	START
1. BAT		X	X	X
2. IGN		X	X	X
3. START				X
4. ACC		X		
5. PREHEAT			X	X

Ignition Switch Installation

1. Connect the wires according to the labels applied during removal. Follow the ignition key switch wiring diagram (Fig. 10–53) as required.

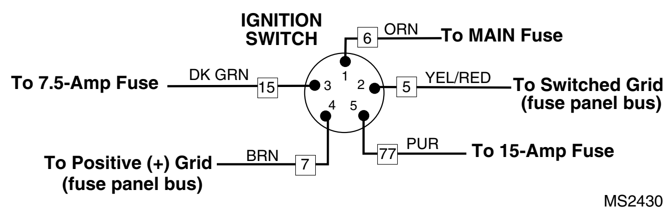


Figure 10–53. Ignition key switch wiring diagram.

2. Reach up and under the dash to work the ignition switch and wiring into the ignition switch-mounting hole on the left side of the dash (Fig. 10–52).
3. Align the ignition switch so that when it is in the OFF position (Fig. 10–54), the key slot is positioned vertically (straight up and down). Install the hex nut securing the ignition switch to the dash. DO NOT overtighten.

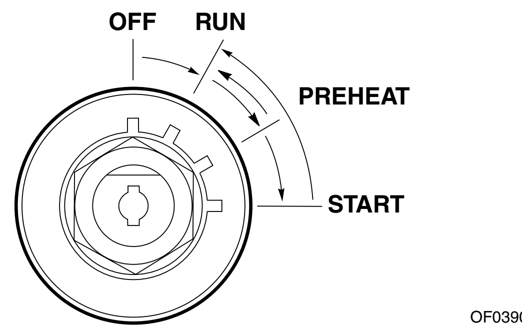


Figure 10–54. Ignition key switch positions.

4. Connect the negative (-) battery cable at the negative battery terminal (Fig. 10–55).

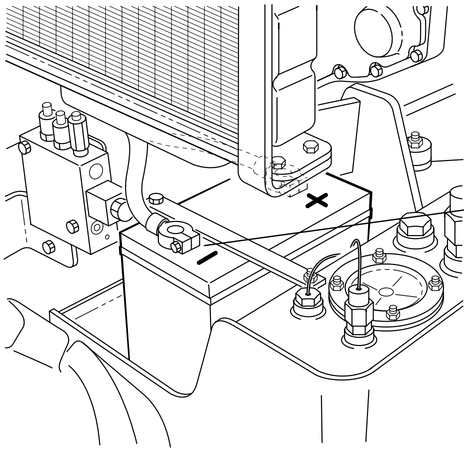


Figure 10–55. Connect the negative (-) battery cable to the negative (-) battery terminal.

b. Transmission Neutral Start Feature

The transmission neutral start feature is a safety feature designed to prevent the engine from starting with the transmission in FORWARD (F) or REVERSE (R).

Shifting into NEUTRAL (N) activates the neutral relay (in the relay and fuse panel). When the travel select lever is in NEUTRAL (N), electrical power flows to the starter relay, allowing the starter to engage and start the engine.

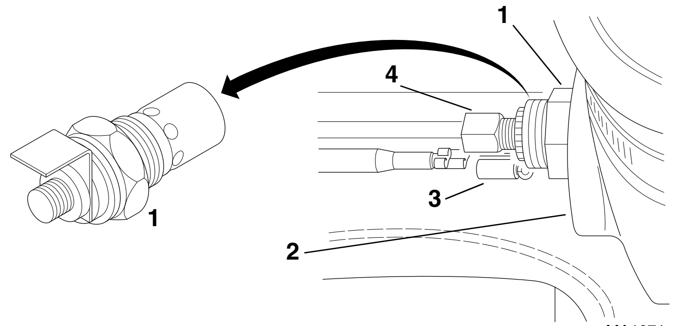
Test the transmission neutral start circuit as follows:

- The starter MUST NOT operate with the travel select lever in FORWARD or REVERSE
- The starter MUST NOT operate when the park lock is OFF (disengaged)
- The starter MUST operate with the travel select lever in NEUTRAL

If the starter fails to turn the engine with the travel select lever in NEUTRAL (N) and the ignition switch in the START position, refer to *Section 10.9 Electrical System Troubleshooting*. The neutral position contacts in the shift switch are non-repairable. Replace the switch if defective.

10.8.4 Thermo-Start Plug (optional for Perkins engines only)

The thermo-start plug (Fig. 10–56) is located in the Perkins engine intake manifold, plumbed into the fuel line.



1. Thermo-start Plug
2. Intake Manifold
3. Electrical Terminal
4. Fuel Line Fitting

Figure 10–56. The thermo-start plug is located in the Perkins engine intake manifold.

The thermo-start plug is activated by the PREHEAT ignition key switch position (Fig. 10–54). The PREHEAT cold-starting aid should be used when the temperature is below 32° F (0° C), but not below 10 ° F (-12°C) if 10W30 engine oil is used in the crankcase. Consult the appropriate Perkins engine manual for other variables.

When the ignition key switch (Fig. 10–54) is turned to the PREHEAT position, an air/fuel mixture in the intake manifold is ignited to help make cold-weather starting easier.

For specific cold starting instructions, see the *Owners/ Operators Manual* for this vehicle.

WARNING: Ether, starting fluid, or high-energy fuels should not be used with the PREHEAT system. An explosion may cause serious injury or engine damage.

The engine is fitted with an efficient cold-starting aid and no responsibility can be accepted for any damage caused by unauthorized starting aids.

If the engine is difficult to start or fails to start and the thermo-start plug is suspected, check the electrical connection at the plug. If the electrical connection is not suspect, check that fuel is indeed reaching the thermo-start plug by unscrewing the fuel line fitting at the plug. If fuel is present, the plug itself may not be working correctly. This can be checked by removing the air cleaner and watching the cold starting aid while the equipment is used. When the ignition key switch is turned to the PREHEAT position, the element should become red hot, and when the ignition key switch is placed in the START position and the starter engages the engine, ignition of the fuel should occur.

a. Thermo-Start Plug Removal

1. Label and disconnect the thermo-start wiring lead at the thermo-start plug electrical connector.
2. Disconnect the fuel line.
3. Remove the thermo-start plug by unthreading it from the intake manifold.

b. Disassembly

DO NOT disassemble the thermo-start plug. Replace a defective plug with a new one.

c. Cleaning and Drying

DO NOT submerge the thermo-start plug. Clean the exterior of the plug in an approved solvent. Dry the plug with a clean, lint-free cloth.

d. Inspection and replacement

Examine the fuel line and the thermo-start plug mounting bore in the intake manifold for any contamination and clean as required.

Test the thermo-start plug coil using short, heavy-gauge wires connected to a fused or otherwise protected 6-amp minimum output, 12-volt DC power supply. If the coil fails to heat, replace the thermo-start plug with a new one.

e. Thermo-start Plug Installation

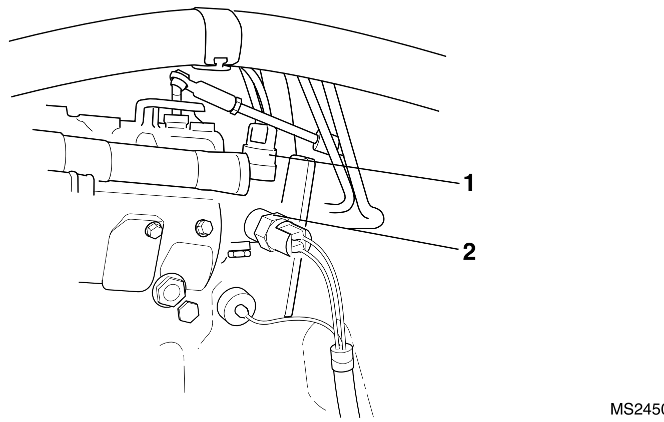
1. Thread the thermo-start plug (Fig. 10–56) into its mounting bore in the intake manifold.
2. Connect the fuel line to the thermo-start plug.
3. Connect the wiring lead to the thermo-start plug terminal.

10.8.5 Fuel Run Solenoid

The fuel run solenoids a valve that lets fuel enter the injection pump when the ignition switch is turned to the START or RUN positions. The fuel run solenoid is located as follows:

PERKINS ENGINE

On the side of the fuel injection pump (2, Fig. 10–57).

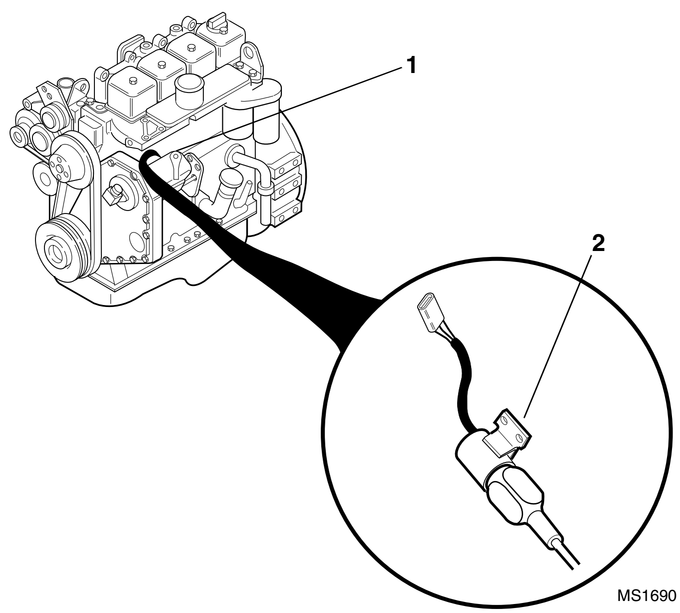


1. Fuel Injector Pump
2. Fuel-run Solenoid

Figure 10–57. Perkins engine fuel-run solenoid.

CUMMINS ENGINE

On the rear of the fuel injection pump, connected to mechanical linkage (2, Fig. 10–58).



1. Fuel Injector Pump
2. Fuel-run Solenoid

Figure 10–58. Cummins engine fuel-run solenoid.

a. Fuel Run Solenoid Removal

1. Disconnect the negative (-) battery cable at the negative battery terminal (Fig. 10–59).

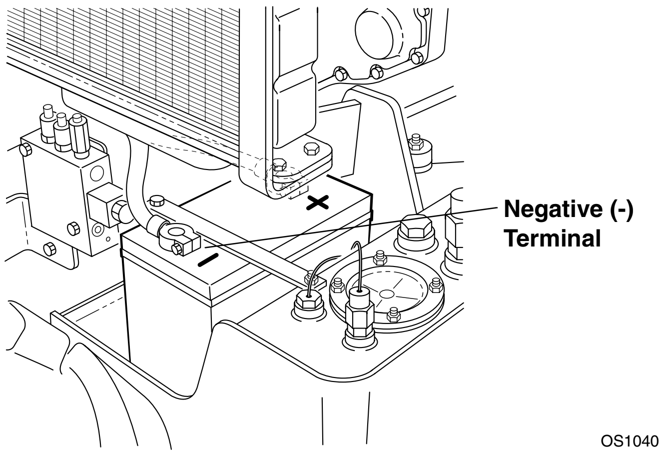


Figure 10–59. Disconnect the negative (-) battery cable at the negative (-) battery terminal.

2. Disconnect the wiring connector at the fuel run solenoid lead, then remove the fuel run solenoid from the fuel injector pump.
3. *For Perkins engines:* Use a wrench to remove the solenoid.
   For Cummins engines: Remove the two bolts securing the solenoid to the mounting plate. Remove the nut holding the linkage to the arm on the fuel injection pump. Save the hardware for later re-use.

b. Fuel Run Solenoid Disassembly

DO NOT disassemble a fuel run solenoid. Replace a defective fuel run solenoid with a new one.

c. Fuel Run Solenoid Inspection and Replacement

Use a 12-volt DC source and ground to test the solenoid. Energize the solenoid and watch for the plunger to retract. If the plunger does not retract, replace the fuel run solenoid with a new one.

d. Fuel Run Solenoid Installation

1. Clean the exterior of the fuel injector pump.
2. *For Perkins engines:* Install a new O-ring on the fuel run solenoid (2, Fig. 10–57). Install the fuel run solenoid onto the fuel injector pump (1). Use a wrench to install the solenoid. DO NOT overtighten.

   For Cummins engines: Using the hardware removed earlier, install the nut holding the linkage to the arm on the fuel injection pump (2, Fig. 10–58). Install the two bolts to secure the solenoid to the mounting plate.
3. Connect the wiring connector at the fuel run solenoid lead.
4. Connect the negative (-) battery cable to the negative battery terminal (Fig. 10–59).
5. Clear personnel and any obstructions from the area around the vehicle.
6. Start the engine.
7. If the engine starts, the fuel run solenoid is functioning.
8. If the engine fails to start, the fuel run solenoid may have a poor ground connection. Visually check the wiring at the fuel run solenoid leads and/or check for continuity with a voltmeter as required.
9. Check for fuel and/or oil leakage around the solenoid.

10.8.6 Hydraulic Oil Filter Pressure Switch

The hydraulic oil filter pressure switch (Fig. 10–60) is threaded into a fitting welded at the top rear of the hydraulic oil reservoir.

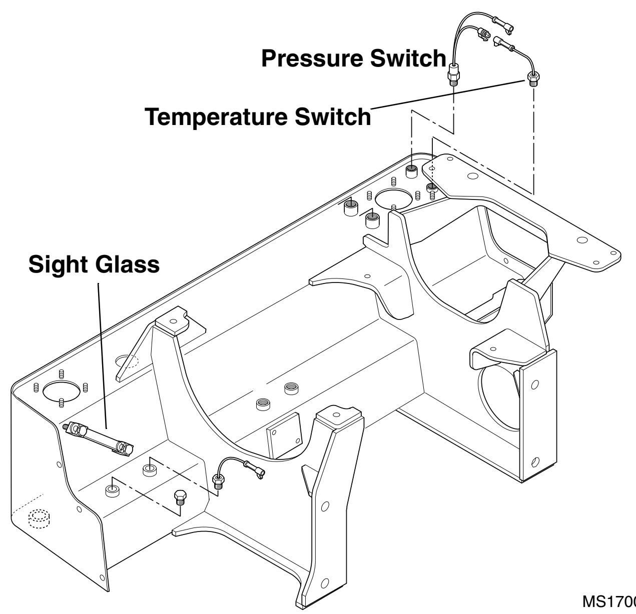


Figure 10–60. Location of the hydraulic oil filter pressure switch, hydraulic temperature switch, and hydraulic oil sight glass.

The switch is connected to the wiring harness and to the hydraulic oil temperature switch. When the 25 psi (1,7 kPa) hydraulic oil system filter is clogged or restricted and the internal pressure of the filter rises to 25 psi (1,7 kPa), the switch closes and the hydraulic oil filter restriction indicator illuminates on the operators display panel. The vehicle should be stopped and the engine revved at high idle for five minutes. If the light remains illuminated or begins to flicker on and off at high idle, shut down the engine and inspect the hydraulic system.

Examine the fluid in the hydraulic oil sight glass (Fig. 10–61) to check whether there is a sufficient amount of fluid in the system (the oil level should be at the bottom of the sight glass with all hydraulic cylinders retracted) and whether the fluid is contaminated. Replace the hydraulic oil filter as required.

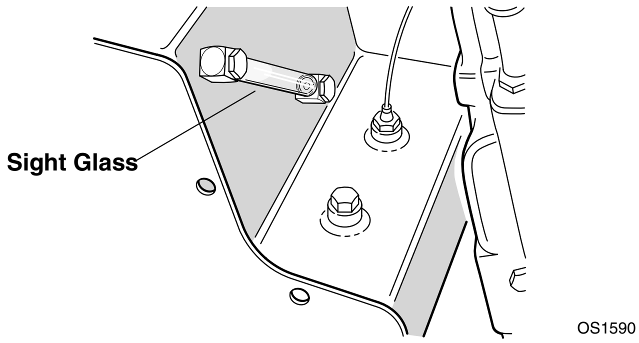


Figure 10–61. Examine the fluid in the hydraulic oil sight glass.

a. Hydraulic Oil Filter Pressure Switch Removal

1. Disconnect the negative (-) battery cable at the negative battery terminal (Fig. 10–62).

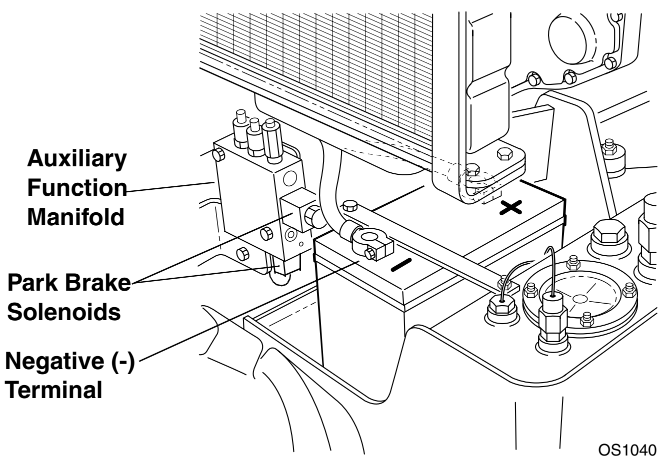


Figure 10–62. Disconnect the negative (-) battery cable at the negative (-) battery terminal.

2. Label and disconnect the hydraulic oil filter pressure switch wiring connectors.
3. Unthread the switch from the hydraulic reservoir.

b. Disassembly

DO NOT disassemble the hydraulic oil filter pressure switch. Replace a defective or faulty switch with a new one.

c. Cleaning and Drying

DO NOT submerge the hydraulic oil filter pressure switch. Clean only with an approved solvent and dry with a clean, lint-free cloth.

d. Inspection and Replacement

Inspect switch wiring for continuity and shorting. Replace a defective or faulty switch with a new one.

e. Installation and Testing

1. Thread the hydraulic oil filter pressure switch into its welded fitting on the hydraulic reservoir. Tighten securely.
2. Connect the switch wiring connector leads for the wiring harness and for the hydraulic oil temperature switch.
3. Connect the negative (-) battery cable to its battery terminal (Fig. 10–62).
4. Clear the area around the vehicle of personnel and any obstructions to vehicle travel.
5. Start the engine, check for hydraulic fluid leaking at the hydraulic oil filter pressure switch, and allow the hydraulic fluid to reach operating temperature.
6. Cycle the boom several times and check whether the hydraulic oil filter restriction indicator illuminates on the operators display panel.

10.8.7 Hydraulic Oil Temperature Switch

The hydraulic oil temperature switch (Fig. 10–60) is threaded into a welded fitting at the top rear of the hydraulic oil reservoir, inboard from the hydraulic oil filter pressure switch. The hydraulic oil temperature switch is connected to the hydraulic oil filter pressure switch, and through it to the wiring harness and operators display panel. When the hydraulic oil temperature is above 195° F (76° C), the hydraulic oil temperature warning indicator on the operators display panel illuminates. The vehicle should be stopped and the engine allowed to idle at high idle for five minutes. If the warning indicator continues to illuminate after five minutes, the engine must be shut down to help avoid damage in the hydraulic system. Examine the fluid in the hydraulic oil sight glass (Fig. 10–61) to check whether there is a sufficient amount of fluid in the system (the oil level should be at the bottom of the sight glass with all hydraulic cylinders retracted) and whether the fluid is contaminated. Replace the hydraulic oil filter as required. Explore other causes for excessive temperature, such as high air temperature, plugged oil cooler or lines, loose fan belt, plugged radiator, etc.

a. Hydraulic Oil Temperature Switch Removal

1. Disconnect the negative (-) battery cable at the negative battery terminal (Fig. 10–62).
2. Label and disconnect the switch wiring connector from the hydraulic oil filter pressure switch lead.
3. Unthread the switch from the hydraulic reservoir.

b. Hydraulic Oil Temperature Switch Disassembly

DO NOT disassemble the hydraulic oil temperature switch. Replace a defective or faulty switch with a new one.

c. Hydraulic Oil Temperature Switch Cleaning and Drying

DO NOT submerge the hydraulic oil temperature switch. Clean only with an approved solvent and dry with a clean, lint-free cloth.

d. Hydraulic Oil Temperature Switch Inspection and Replacement

Inspect switch wiring for continuity and shorting. Replace a defective or faulty switch with a new one.

e. Installation and Testing

1. Thread the switch (Fig. 10–60) into its welded fitting on the hydraulic reservoir. Tighten securely.
2. Connect the switch wiring connector lead for the hydraulic oil pressure switch.
3. Connect the negative (-) battery cable to its battery terminal (Fig. 10–62).
4. Clear the area around the vehicle of personnel and any obstructions to vehicle travel.
5. Start the engine, check for hydraulic fluid leaking at the hydraulic oil temperature switch, and allow the hydraulic fluid to reach operating temperature. Cycle the boom several times and check whether the hydraulic oil temperature warning indicator illuminates on the operators display panel.

10.8.8 Parking Brake Switch

The parking brake switch (Fig. 10–63) is located on the dash to the left of the steering column and is pressed or "snapped" into a rectangular switch bezel. The parking brake switch is a two-position toggle switch; the two positions are engaged and disengaged (Fig. 10–64). The parking brake switch must be ENGAGED to permit engine starting. The parking brake may be used to stop in an EMERGENCY situation; however, notify the operator to use caution as the stop will be abrupt and the operator and the load may be jolted forward unexpectedly.

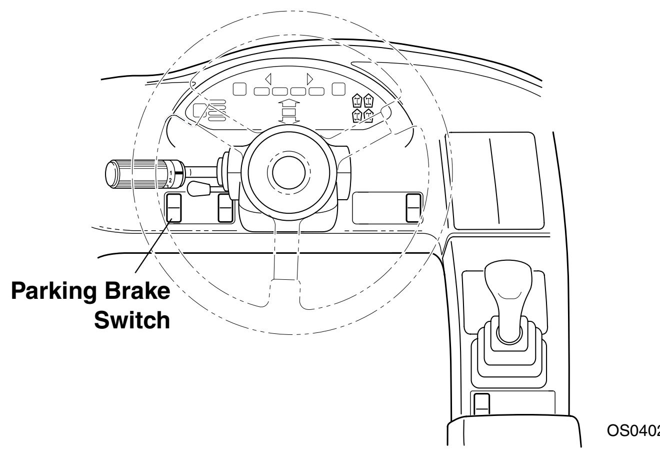


Figure 10–63. Location of various operational controls.

When engaged, the parking brake switch completes the parking brake circuit. The park brake solenoids on the auxiliary function valve (Fig. 10–62) are normally de-energized, allowing the park brake to engage. When the park brake solenoids are energized, the park brake is disengaged. The system is designed so that, when electrical power is OFF the park brake is engaged.

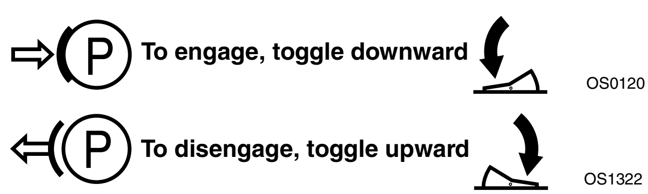


Figure 10–64. The parking brake switch has two positions, engaged and disengaged.

a. Parking Brake Switch Removal

1. Disconnect the negative (-) battery cable at the negative battery terminal (Fig. 10–62).
2. Carefully pry the parking brake switch and wiring out of the mounting hole in the switch bezel (Fig. 10–63).
3. Label and disconnect the wiring from the parking brake switch. Remove the switch from the vehicle.

b. Parking Brake Switch Disassembly

DO NOT disassemble the parking brake switch. Replace a defective or faulty switch with a new one.

c. Parking Brake Switch Inspection and Replacement

Inspect the switch terminals for continuity and shorting in both the engaged and disengaged positions. Replace a defective or faulty switch with a new one.

d. Parking Brake Switch Installation and Testing

1. Route the wiring from the dash through the bezel, then connect the wiring to the parking brake switch as labeled during switch removal.
2. Properly position the "P" on the switch, then press or "snap" the switch into place in the bezel.
3. Connect the negative (-) battery cable to its battery terminal (Fig. 10–65).
4. Clear the area around the vehicle of personnel and any obstructions to vehicle travel.
5. Start the engine, engage the park lock switch, place the travel select lever in FORWARD (F) or REVERSE (R) and second gear and apply full throttle. The vehicle should remain motionless in both FORWARD and REVERSE positions.

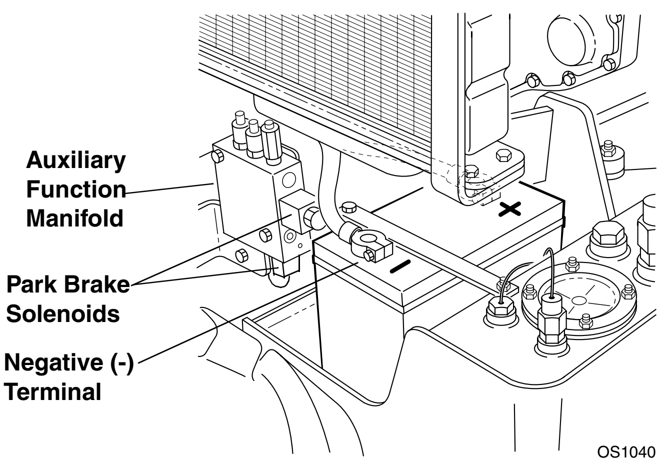


Figure 10–65. Connect the negative (-) battery cable at the negative (-) battery terminal.

6. To test for proper parking brake switch disengagement, firmly depress the service brake pedal, disengage the park lock switch, place the travel select lever in either forward or reverse and in first gear, and slowly press the throttle pedal while releasing the service brake pedal. The park brake should release and the vehicle should travel freely.

Note: The park brake indicator on the operators display panel must illuminate when the park brake switch is engaged, and not illuminate when the park brake switch is disengaged.

10.8.9 Service Brake Switch

The service brake switch (Fig. 10–66) is located above the service brake pedal, inserted through a mount hole in the cab crossmember weldment and connected to a wiring harness lead. A nut threads onto the service brake switch to secure it to the crossmember.

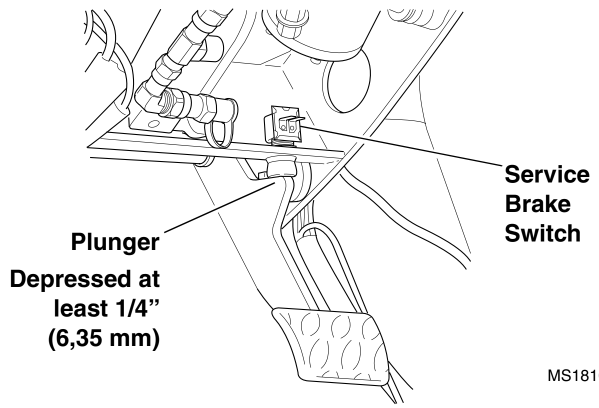


Figure 10–66. The service brake switch is located above the service brake pedal.

The service brake switch is a spring-loaded switch that senses movement along the service brake pedal arm. When the brake pedal is pressed and the brake pedal arm begins to move through its arc, the spring within the switch allows internal contacts to close an electrical connection. The service brake switch circuit is also spliced into the park brake and Stabil-TRAK circuits.

Service Brake Switch Replacement

If the service brake switch (Fig. 10–66) is suspect, remove the switch. Remove the jam nut, then dislodge the switch from the crossmember and unplug the harness connector. Remove the switch from the vehicle and test the switch for continuity and shorting. Replace a defective or faulty switch with a new one.

When installing a switch, make sure that the brake pedal does not actuate the brakes, and that the rubber cap on the switch is securely threaded onto the mounting stem. Adjust the jam nut so that the switch plunger is pushed up into the switch is at least 1/4” (6,35 mm).

Service Brake Switch Adjustment

The service brake switch may be adjusted as required by loosening the jam nut and positioning the switch so that the brake switch does not activate until the pedal arm moves a minimum of 1/8” (3,2mm). Tighten the jam nut after adjusting the position of the switch in relation to pedal travel.

10.8.10 Transmission Shift Control Switch (Travel Select Lever)

The transmission shift control switch (travel select lever) is located on the left side of the steering column. The switch has three positions (Fig. 10–67): FORWARD (F, all the way up), NEUTRAL (N, center position), and REVERSE (R, all the way down). The switch or lever must be in the NEUTRAL (N) position to permit engine starting.

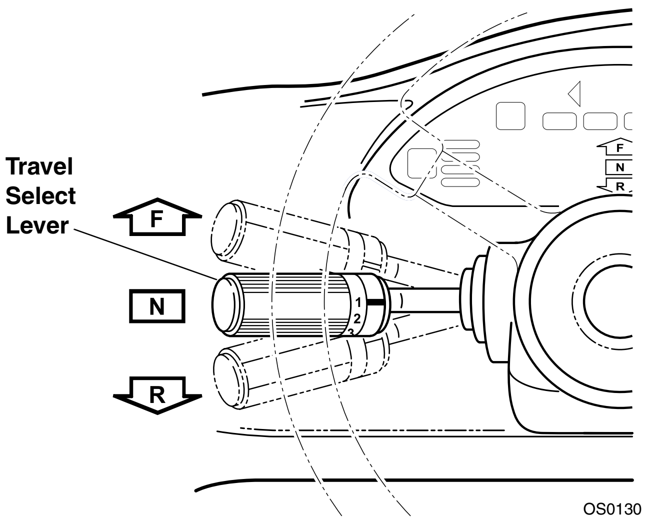


Figure 10–67. The travel select lever has three positions.

Moving the lever opens and closes electrical contacts in the switch, allowing electricity to flow to the appropriate relays and on to the transmission shift solenoids.

Travel selections are changed by grasping the lever, pulling it toward the steering wheel, then UP or DOWN to the desired selection, FORWARD (F) or REVERSE (R).

When the switch is shifted to the REVERSE (R) position, the back-up alarm will automatically sound.

Refer to *Section 4.2.5 Transmission Shift Control Switch Removal* and *Transmission Shift Control Switch Installation* for removal and installation instructions.

Gear Select Lever (switch)

The gear select lever (Fig. 10–68) is part of the transmission shift control switch (travel select lever). The lever has a twist-grip handle with four positions, although only three may be used, depending on the engine the vehicle is equipped with and on the direction the transmission shift lever (gear select lever) has engaged.

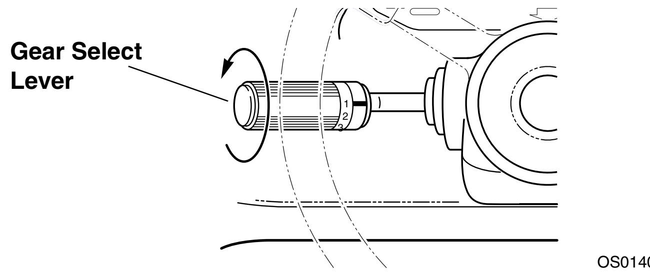


Figure 10–68. The gear select lever permits transmission gear selection (shifting).

Vehicles equipped with the Perkins naturally aspirated (non-turbo) engine have three (3) forward gears and three (3) reverse gears. Placing the gear select lever into the fourth position when in forward will have no effect on vehicle speed.

Vehicles equipped with either the Perkins turbo-charged engine or Cummins turbo-charged engine have four (4) forward gears and three (3) reverse gears.

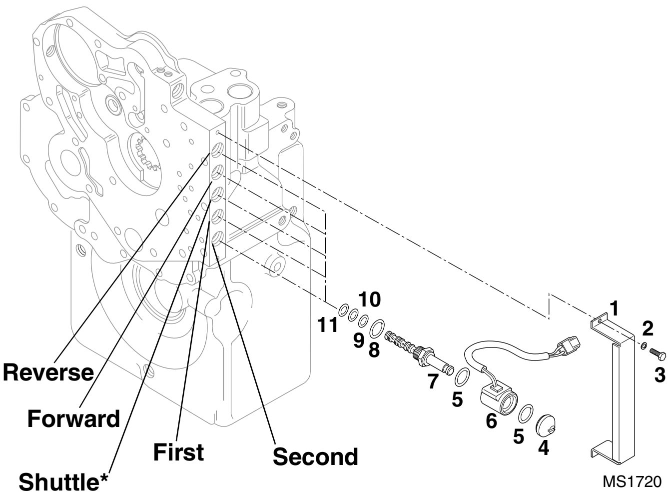
First gear is used for the highest torque and pulling power, and the higher-numbered gears are for increasing vehicle travel speed.

Refer to *Section 4.2.5 Transmission Shift Control Switch Removal* and *Transmission Shift Control Switch Installation* for removal and installation instructions.

Refer to the *Owners/Operators Manual* for this vehicle for information on how travel direction and gear select control should be indicated on the operators display panel.

10.8.11 Transmission Solenoid Valves

The transmission is shifted via spool-type solenoid cartridge assemblies (Fig. 10–69) or valves. While each 12-volt solenoid coil at the transmission is the same, the wiring to the solenoids is different and connected so that the various transmission clutches can be actuated via input from the transmission shift control switch (travel select lever) and gear select switch.



(*not on Perkins naturally-aspirated 3-speed)

1. Protective Cover
2. Lockwasher
3. Screw
4. Retainer Nut
5. Coil O-ring
6. Solenoid Coil
7. Cartridge Valve
8. O-ring
9. O-ring
10. O-ring
11. O-ring

Figure 10–69. Transmission shift solenoids are easily replaced.

So that the solenoids can be properly connected, the transmission solenoid valve wiring is identified by color-coded plastic bands as described in the chart below.

Solenoid	Color Code Indicator
2nd Clutch	GREEN
Reverse Clutch	BROWN
Forward Clutch	BLUE
Shuttle Clutch	LIGHT BROWN
1st Clutch	YELLOW

Note: Replacement solenoids will not have colored bands.

If the transmission is not shifting properly and a faulty or defective transmission shift solenoid is suspected, remove and test the solenoid. Replace a defective or faulty unit with a new one.

a. Transmission Solenoid Valve Removal

1. Disconnect the negative (-) battery cable at the negative battery terminal (Fig. 10–70).

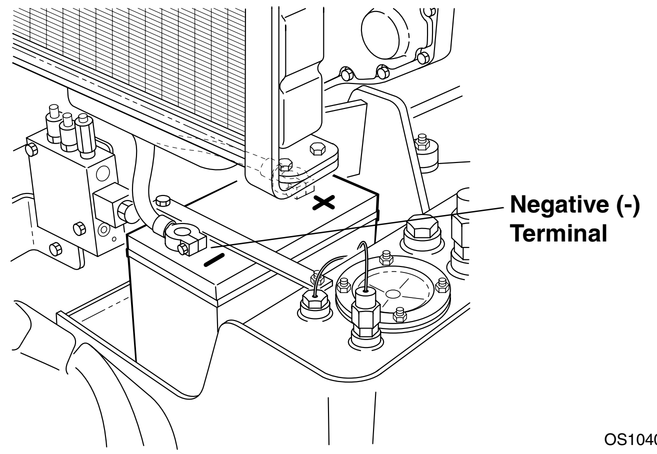


Figure 10–70. Disconnect the negative (-) battery cable at the negative (-) battery terminal.

2. Remove the cover screws (3, Fig. 10–69), lockwashers (2) and protective cover (1) secured over the transmission solenoid cartridge valves (7).
3. Remove the valve cartridge retainer nut (4) securing the 12-volt solenoid coil (6) to the transmission.
4. Remove the 12-volt solenoid coil (6). An O-ring (5) is on each side of the 12-volt solenoid coil. Remove both O-rings. Always replace used O-rings with new O-rings. Label the connections if removing more than one solenoid valve.
5. Carefully withdraw the 4-way cartridge valve assembly and count to make sure all four O-rings (8, 9, 10, and 11) come with it.

Note: Always replace used O-rings with new O-rings.

6. Inspect the cartridge valve for nicks, cut O-rings, and debris or foreign material.

b. Transmission Solenoid Valve Disassembly

DO NOT further disassemble the transmission solenoid. Replace a defective or faulty unit with a new one.

c. Transmission Solenoid Valve Inspection, Testing and Replacement

Inspect the solenoid wiring and connector plug. Test for continuity and shorting. The solenoid should have 7.5 to 10 ohms of resistance when testing with an ohm/volt meter. Replace a defective or faulty solenoid valve.

d. Transmission Solenoid Valve Installation

1. Carefully install the four-way cartridge valve assembly with four new O-rings (8, 9, 10 and 11, Fig. 10–69) into the transmission. Always replace used O-rings with new O-rings.
2. Install an O-ring (5) on each side of the 12-volt solenoid coil (6). Always replace used O-rings with new O-rings. Install the 12-volt solenoid coil onto the cartridge valve (7).
3. Install the valve cartridge retainer nut (4) securing the 12-volt solenoid coil to the transmission.
4. Install the protective cover (1), lockwashers (2) and cover screws (3) over the transmission solenoid valves.
5. Refer to the chart listed earlier under *10.8.11 Transmission Solenoid Valves*. Connect the transmission solenoid valve(s) with the proper wiring connector(s).
6. Connect the negative (-) battery cable to the negative battery terminal (Fig. 10–70).
7. Test the operation of the transmission. Put the transmission through its entire range of gears (speeds) in both FORWARD (F) and REVERSE (R) and check that the transmission also shifts into NEUTRAL (N).
8. Verify that each function works properly, that the transmission does not engage when in NEUTRAL (N) and that the proper indicators illuminate on the operators display panel.

For further transmission information, refer to *Section 7 Transmission* and to the *Clark-Hurth T 12000* transmission service manual.

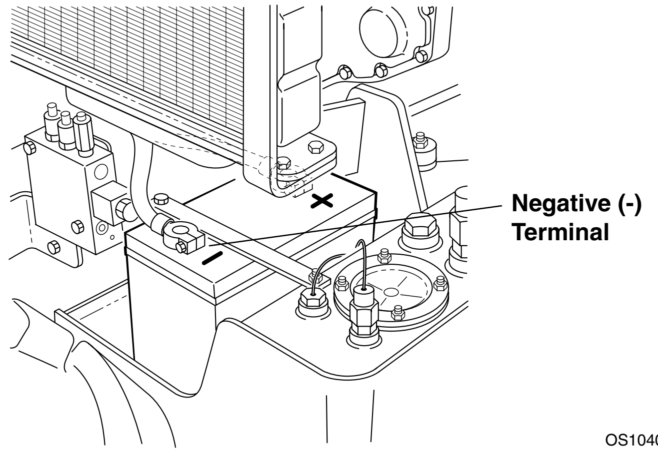


Figure 10–71. Disconnect the negative (-) battery cable at the negative (-) battery terminal.

10.8.12 Attachment Tilt Mode Switch

The attachment tilt mode switch (Fig. 10–72) is located on the dash to the right of the steering column.

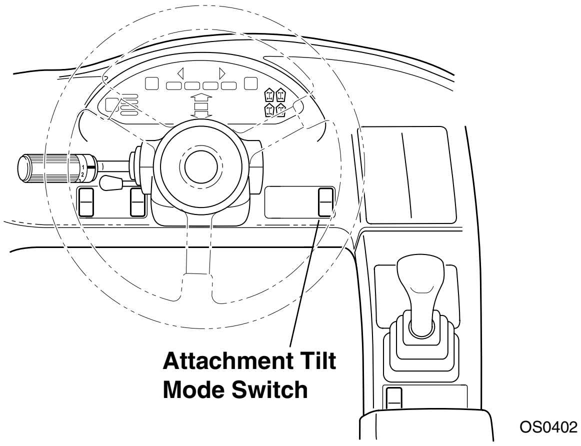


Figure 10–72. Switch location.

The switch is pressed or "snapped" into a rectangular switch bezel. The attachment tilt mode switch is a two-position switch that allows the operator to chose between the boom lift/lower function and the extend/retract function accompanying the attachment tilt capability. For detailed information, see *10.8.14 Joystick* and the *Owners/Operators Manual* for this vehicle.

a. Attachment Tilt Mode Switch Removal

1. Disconnect the negative (-) battery cable at the negative battery terminal (Fig. 10–71).
2. Carefully pry the attachment tilt mode (Fig. 10–72) switch and wiring out of the mounting hole in the switch bezel.
3. Label and disconnect the wiring from the attachment tilt mode switch. Note and mark the "top" of the switch in relation to the switch wiring terminals, and remove the switch from the vehicle.

b. Attachment Tilt Mode Switch Disassembly

DO NOT disassemble the attachment tilt mode switch. Replace a defective or faulty switch with a new one.

c. Attachment Tilt Mode Switch Inspection and Replacement

Inspect the switch terminals for continuity and shorting in all three switch positions. Replace a defective or faulty switch with a new one.

d. Attachment Tilt Mode Switch Installation and Testing

1. Route the wiring through the dash and switch bezel (Fig. 10–73), then connect the wiring to the attachment tilt mode switch as labeled during switch removal.

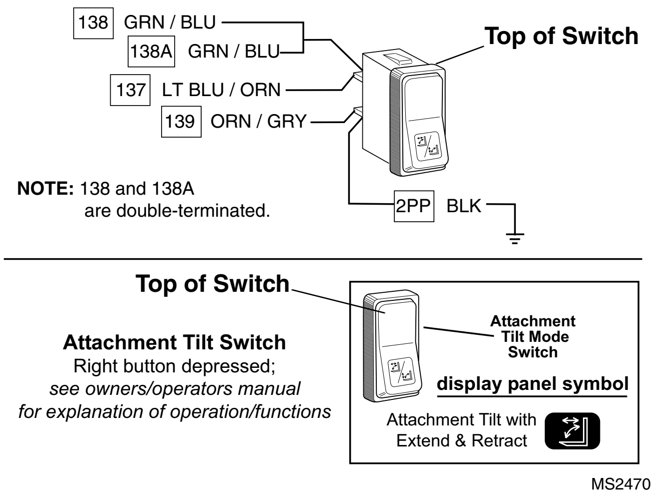


Figure 10–73. Attachment tilt mode switch wiring and installation position.

2. Properly position the "top" of the switch (Fig. 10–73), then press or "snap" the switch into place in the bezel.
3. Connect the negative (-) battery cable to its battery terminal (Fig. 10–71).
4. Clear the area around the vehicle of personnel and any obstructions to vehicle travel.
5. Start the engine, and check the operation of the attachment tilt mode switch functions with the switch in both positions.

10.8.13 Joystick

The multi-function joystick (Fig. 10–74) controls boom movement, attachment tilt, vehicle frame tilt, and optional auxiliary hydraulics.

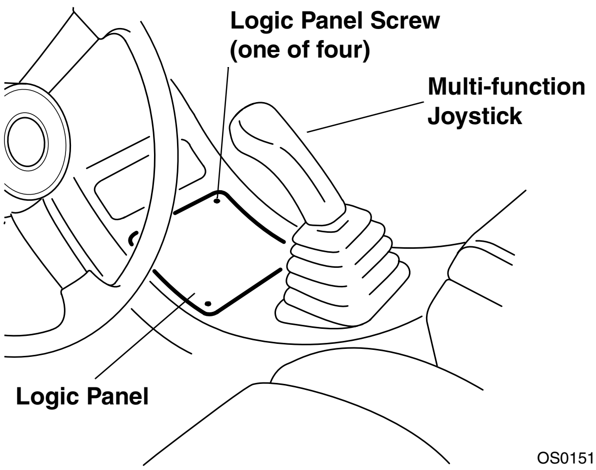


Figure 10–74. Joystick and logic panel locations.

The joystick is equipped with several momentary switches ("buttons") that enable the joystick to operate in four specific modes. The mode available per selection is displayed on a logic panel located just forward of the joystick. The logic panel will illuminate an indicator for the specific mode that corresponds with the movement of the joystick and the button(s) selected.

Two functions can be accomplished at the same time by moving the joystick in between quadrants. For example, moving the stick forward will lower the boom, and moving the stick to the left will retract the boom; moving the joystick forward and to the left will both lower and retract the boom at the same time.

The speed of movement relates to the amount of joystick movement away from the center position. The overall speed of movement also depends directly on engine rpm.

IMPORTANT: When the joystick is in an off-center position, the mode will change immediately upon releasing any button.

Joystick mode operation can be checked according to the joystick operation instructions found in the *Owners/Operators Manual* for this vehicle. Operational checks will indicate whether the system is working properly. If a designated function does not occur as described, check both the electrical and hydraulic circuit involved to determine the cause.

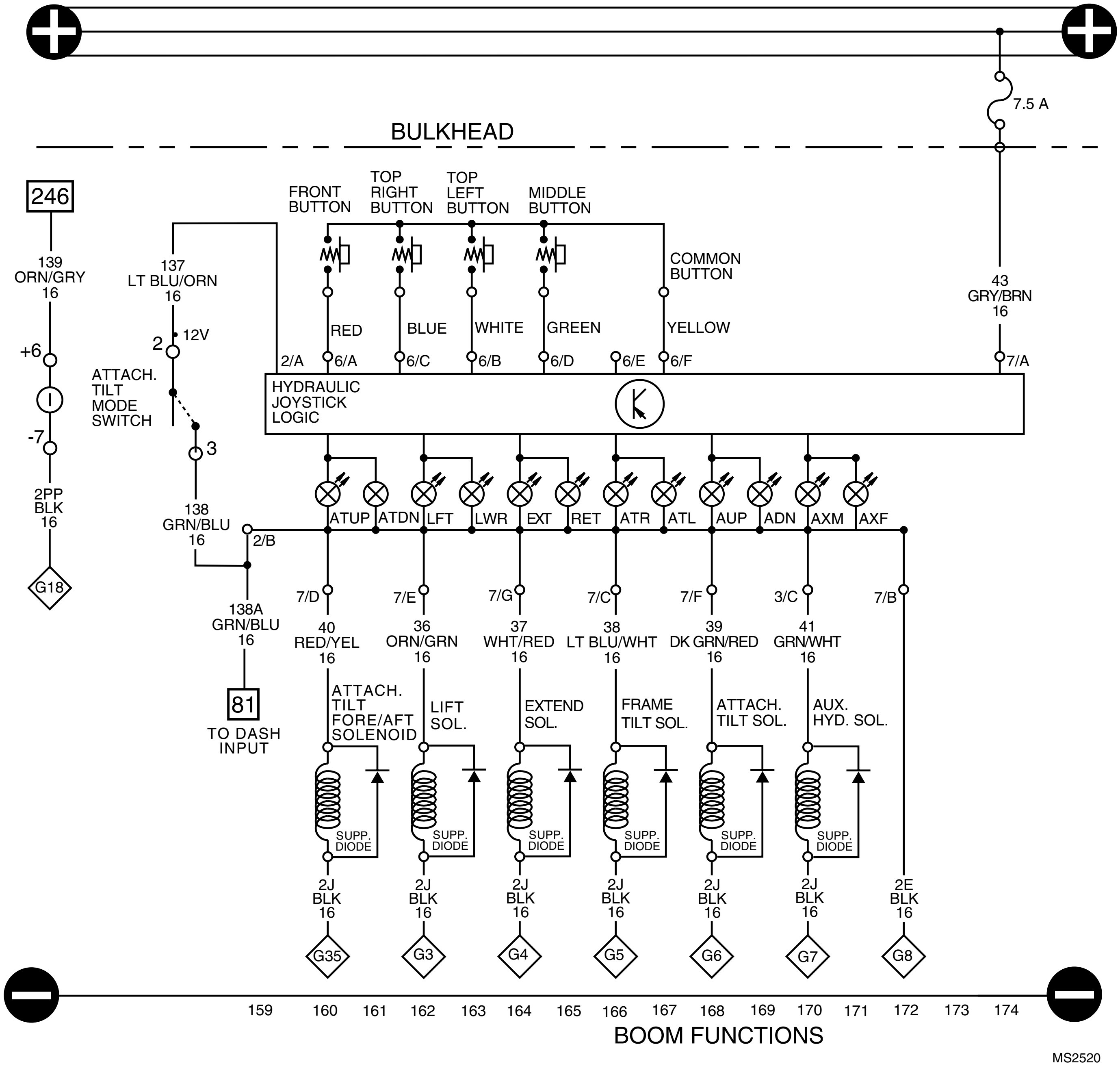


Figure 10–75. Logic panel and joystick wiring schematic.

a. Joystick Button Testing

1. Remove the four button-head capscrews (Fig. 10–76) securing the logic panel to the side console.

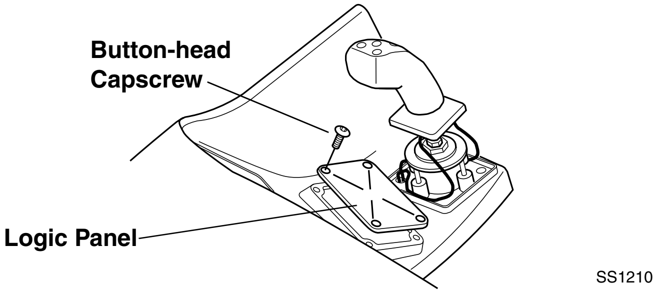


Figure 10–76. Logic panel mounting detail.

2. Carefully pry the panel up away from the console and locate the six-wire connector that comes from the joystick (Fig. 10–77).

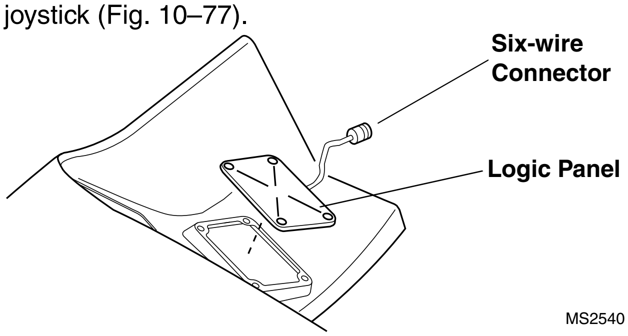


Figure 10–77. Logic panel to joystick wire connector.

3. Inspect the wiring and connector plug for obvious signs of shorts, damage, etc.
4. Disconnect the harness half. Test only the joystick half.
5. Using an ohm/volt meter, test for continuity in the joystick button switches when they are depressed. The wiring should have zero (0) ohms of resistance when testing with an ohm/volt meter. Using the chart below and the wiring schematic in Fig. 10–75, test each joystick button switch for proper functioning.

Joystick Wire Color / Function Chart

YELLOW	Common Wire
GREEN	Middle Button
WHITE	Top Left
BLUE	Top Right Button
RED	Front Button

Battery positive (+) is accessed via wire 43, the fused GRY/BRN 16-gauge wire. The ground wire, 2E, is a black (BLK) 16-gauge wire.

b. Joystick Function Solenoid Valves

Joystick commands are actuated both electrically and hydraulically via a set of solenoid-operated control valves mounted in an array at the pilot select manifold (Fig. 10–78). The pilot select manifold is located inside the rear cover on the left side of the frame.

As the solenoid coils are energized/de-energized, the cartridge valves work to open and close oil passages (Fig. 10–79), thereby directing hydraulic fluid flow to the proper hydraulic circuit for the function selected.

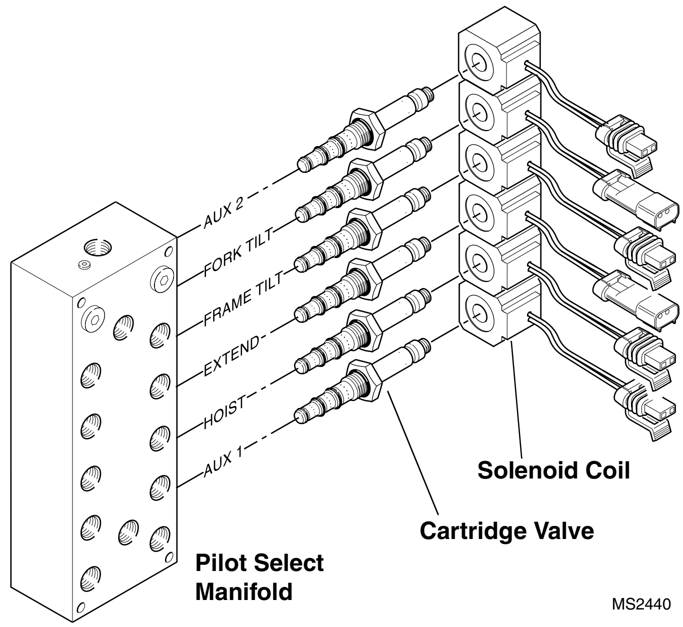


Figure 10–78. Pilot select manifold.

Solenoid Coil and Cartridge Valve Replacement

If a solenoid coil (Fig. 10–79) is suspected of malfunctioning, disconnect the coil wiring lead and test the coil. Also inspect the valve cartridge, O-rings, and the other hydraulic and electrical components in the circuit to accurately determine the cause of the problem.

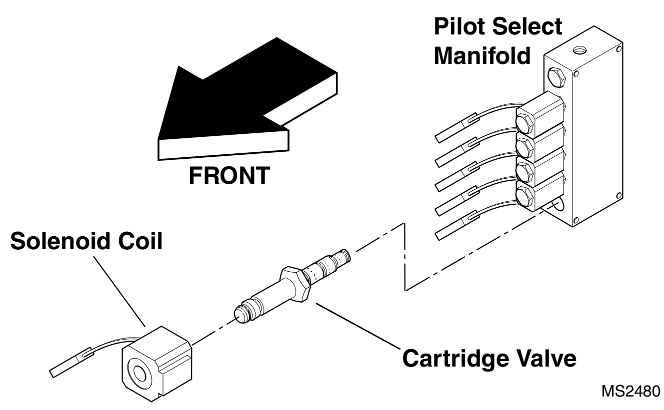


Figure 10–79. Solenoid and cartridge valve detail.

10.8.14 Logic Board Panel

The logic board or side console panel (Fig. 10-80; see also Fig. 10-76 and Fig. 10-77) is secured to the right side dash panel, in front of the joystick. The panel consists of a solid-state printed circuit board and various indicators that illuminate per joystick, attachment tilt, and auxiliary hydraulics selections.

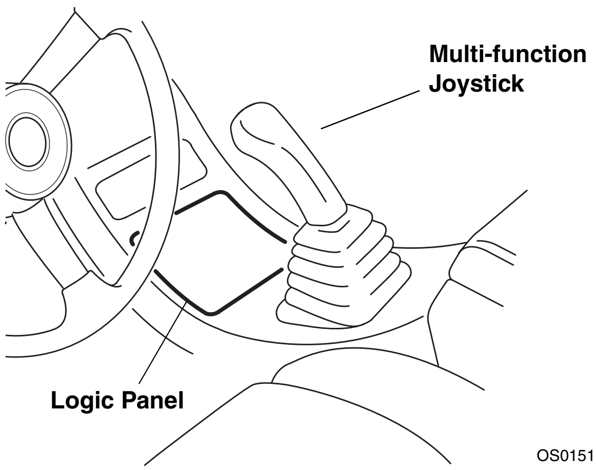


Figure 10-80. Joystick and logic panel locations.

The logic board panel is of solid-state, printed circuit design and contains a wiring terminal or plug (Fig. 10-76 and Fig. 10-77), a printed-circuit board and a display panel that provides monitoring of joystick, attachment tilt and auxiliary hydraulics functions and status.

Due to the complex design and solid-state circuitry, the panel is non-serviceable. Electro-static discharge is one of the main reasons for panel malfunction. Prevent the panel from coming into contact with static or other electrical sources. When washing the vehicle, keep spray away from the logic board panel. Replace a defective, malfunctioning or faulty panel with a new unit.

The logic board panel provides important information in a "user-friendly" design with easily-recognizable graphic and arrow indicators. The panel provides information the operator needs on joystick, attachment tilt and auxiliary hydraulics functions at any given time.

The panel (Fig. 10-76 and Fig. 10-77) is mounted with four button-head capscrews and well nuts for easy replacement.

10.8.15 Boom Sensor (Proximity Switch)

The boom sensor (Fig. 10-81) is a proximity switch located inside the rear cover on the top left of the frame. When energized, the sensor creates a magnetic field and detects the presence of the boom, as the boom is raised or lowered past the sensor. Depending on conditions (including boom raised above or below 40 degrees, park or service brakes ON or OFF, Stabil-TRAK engaged or not, etc.), the boom sensor and its electrical circuitry will either allow or disallow certain hydraulic functions.

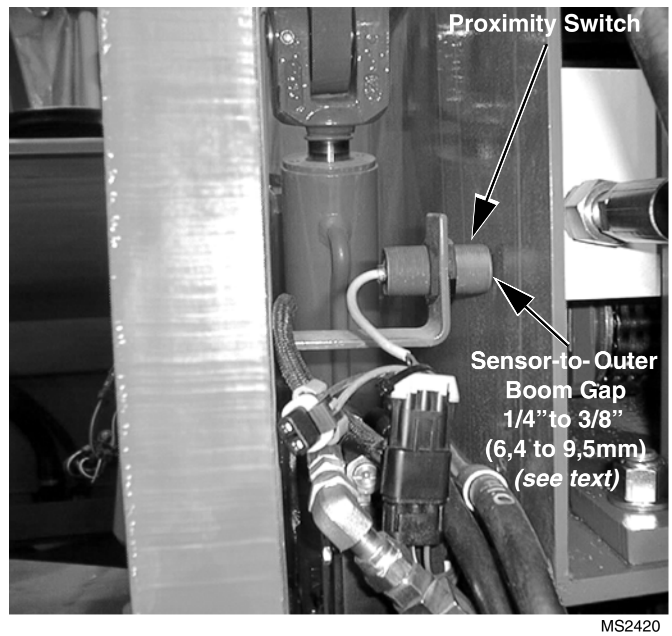


Figure 10-81. Boom proximity switch location.

Boom Sensor Replacement and Adjustment

The sensor is easily removed by disconnecting the wire lead from the wiring harness connector, removing the sensor mounting nut, and removing the sensor from the vehicle.

To install and adjust a boom sensor:

1. Place the sensor into the mounting bracket as shown in Fig. 10-81.
2. Adjust the sensor to achieve a 1/4" to 3/8" (6,4 to 9,5 mm) gap between the sensor and the boom.
3. Connect the wiring harness lead, then tighten the sensor mounting nut to 36-inch pounds (4 Nm).
4. Operate the boom through its full range of motion; the boom must NEVER touch the sensor.
5. Check the function of the Stabil-TRAK system as described in *Section 10.8.16 Stabil-TRAK System*.

10.8.16 Stabil-TRAK System

The patented Stabil-TRAK system works to stabilize the vehicle under various conditions. The *Owners/Operators Manual* for this vehicle contains basic Stabil-TRAK information; a copy of the *Owners/Operators Manual* should always be in the storage compartment beneath the operators seat.

The operators display panel Stabil-TRAK indicator (C, Fig. 10–47, page 10-48) goes ON when the Stabil-TRAK system is activated.

The stabilizing system operates via interface among the boom proximity switch, the park, service brake and travel select lever switches, and five solenoid-operated valves on the Stabil-TRAK cylinder manifold.

The front axle frame tilt cylinder is also involved in the Stabil-TRAK system, but only in a passive role as hydraulic fluid is cycled to accommodate Stabil-TRAK system operation.

In general, if there is a problem with the Stabil-TRAK system beyond common electrical troubles, the involved electrical and hydraulic circuits should each be checked and the exact source of the problem diagnosed before any parts are replaced. Refer to *Section 9 Hydraulic System* in this manual for more information.

The Stabil-TRAK or rear axle lock system can only be activated when the boom angle is greater than forty degrees (40°). Any one, any two or all three of the following selections will activate the system:

- Engaging the parking brake switch
- Placing the travel select lever in NEUTRAL (N)
- Depressing and holding the service brake

a. Understanding the Stabil-TRAK system

The following describes the three basic modes of the patented Stabil-TRAK system. The vehicle may operate in any one of these three modes.

Free Pivot Mode

(Fig. 10–82)

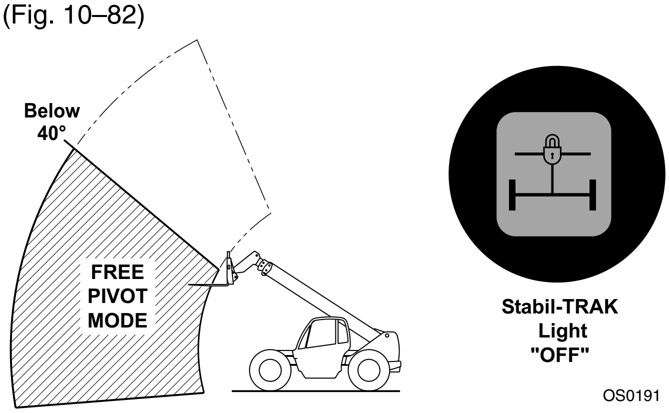


Figure 10–82. Stabil-TRAK system free pivot mode.

With the boom <u>below</u> 40°, the Stabil-TRAK system is in the free pivot mode and the rear axle is allowed to pivot freely. The frame sway control will function normally.

Locked Mode

(Fig. 10–83)

With the boom above 40° <u>and</u> by activating one or more of the following functions listed below, the Stabil-TRAK system is in the locked mode and the rear axle is locked so it is rigid with the frame.

- engaging the parking brake switch
- placing the travel select lever in NEUTRAL (N)
- depressing and holding the service brake pedal

The frame sway control will function slower than normal in this mode.

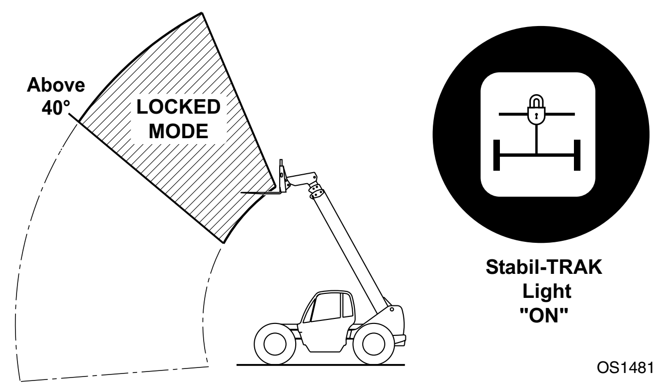


Figure 10–83. Stabil-TRAK system locked mode.

Final Positioning Mode

(Fig. 10–84)

With the boom <u>above</u> 40°, the Stabil-TRAK system is now in the final positioning mode. In this mode the rear axle is unlocked and is allowed to pivot, but will respond <u>SLOWLY</u> to changes in terrain.

The frame sway control function will function normally in this mode.

IMPORTANT: Regularly check that this system is functioning properly. Refer to the Stabil-Trak System Test Procedures.

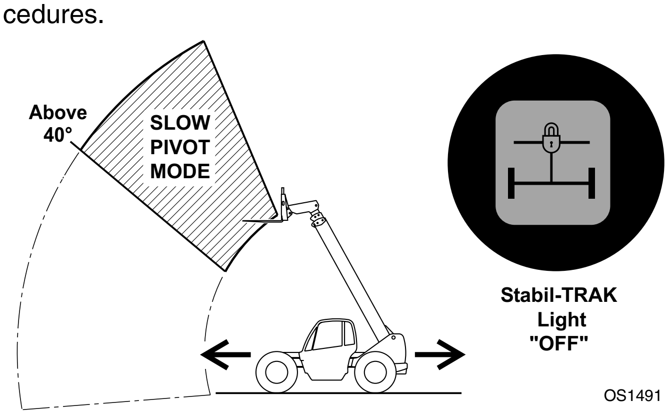


Figure 10–84. Stabil-TRAK system final positioning mode.

Stabil-TRAK System Test

IMPORTANT: The operator must know that the Stabil-TRAK system is active and functioning properly.

!	**DANGER:** Vehicle tipover can result in death or serious injury. **DO NOT** use the vehicle if the Stabil-TRAK system is not functioning properly.

To test the function of the Stabil-TRAK system, read the Stabil-TRAK system test instructions and follow steps 1 through 9 of the Stabil-TRAK system test procedure.

Stabil-TRAK System Test Instructions

- Test the Stabil-TRAK system with the vehicle on a level surface.
- Remove any attachment from the quick attach before performing the test.
- Perform the test with the boom fully retracted. DO NOT extend the boom at any time during the test.
- DO NOT raise the boom above 60° for steps 3 through 6.
- DO NOT raise the boom above 45° for steps 7 through 9.
- Follow steps 1 through 9 of the Stabil-TRAK system test procedure exactly as written.

IMPORTANT: If the Stabil-TRAK light goes OFF and the front left tire lowers to the ground at any time during steps 4 through 7, the test was not performed properly or the Stabil-TRAK system is not functioning properly. Carefully repeat the steps starting with step 1. If the Stabil-TRAK light goes OFF and the front left tire lowers to the ground consistently during steps 4 through 7, the Stabil-TRAK system is not functioning properly and the test should be stopped immediately. DO NOT use the vehicle if the Stabil-TRAK system is not functioning properly. Repair the system immediately.

!	**WARNING: DO NOT** operate this vehicle unless you are in the seat with the seat belt fastened around you. Death or serious injury could result if the belt is not securely fastened.

Stabil-TRAK System Test Procedures

1. Fasten seat belt and place the vehicle on a level surface with 0° sway, no load on the forks, boom fully retracted and horizontal. Check to be sure the Stabil-TRAK light is OFF. See Fig. 10–47 on page 10-48 for the location of the light in the display panel.
2. Locate an 8 inch (203,2 cm) wood or cement block in front of the left front tire and drive the vehicle up on the block. Use the frame sway control to level the vehicle back to 0°.
3. With the service brake pedal depressed, the parking brake switch OFF, move the travel select lever to the NEUTRAL (N) position and raise the boom to exactly 60°. The Stabil-TRAK light should come ON when the boom angle is at about 40° and remain ON.

IMPORTANT: Perform steps 4 through 9 with the engine rpm at idle.

4. While the service brake pedal is depressed, move the travel select lever to the REVERSE (R) position. Ease your foot off the service brake pedal and increase the engine RPM slightly if necessary just enough to back the vehicle off the block, while keeping the service brake pedal partially depressed so the Stabil-TRAK light remains ON. The rear axle should remain locked while backing off the block and the left front tire should remain off the ground.
5. While keeping the service brake pedal depressed, move the travel select lever to the NEUTRAL (N) position and take your foot off the service brake pedal. The rear axle should remain locked, the Stabil-TRAK light should remain ON, and the left front tire should remain off the ground.
6. With the travel select lever in the NEUTRAL (N) position, engage the parking brake switch and move the travel select lever to the FORWARD position. The rear axle should remain locked, the Stabil-TRAK light should remain ON, and the left front tire should remain off the ground.
7. With the parking brake switch ON, move the travel select lever to the NEUTRAL (N) position, and lower the boom to exactly 45°. Use the frame sway control to tilt the vehicle no more than 5° to the left and then no more than 5° to the right. The vehicle should sway slowly to the left and then to the right. The Stabil-TRAK light should remain ON, and the left front tire should remain off the ground. The left front tire should not raise or lower when swaying. Leave the vehicle swayed to the right 1° to 2°.

8. Depress the service brake pedal. Disengage the parking brake switch and move the travel select lever to the REVERSE (R) position. Release the service brake pedal to deactivate the Stabil-TRAK system and the Stabil-TRAK light should go OFF. The left front tire should return to the ground while the vehicle travels in reverse. Depress the service brake pedal to stop the vehicle.
9. With the service brake pedal depressed, boom angle at exactly 45°, move the range select lever to third (3) and the travel select lever to FORWARD (F). Release the service brake pedal to deactivate the Stabil-TRAK system and the Stabil-TRAK light should go OFF. Slowly drive the vehicle forward against the block to stop the vehicle from moving forward. With the left front tire against the block, frame sway the vehicle no more than 5° in both directions (left and right) while checking that the front tires remain on the ground. It is normal for the left front tire to raise slightly when swaying to the left and for the right front tire to raise slightly when swaying to the right, but the tires should immediately lower when the frame sway function is stopped. The tires should not come completely off the ground during this step. Frame sway the vehicle back to 0°. Depress the service brake pedal, shift the travel select lever to NEUTRAL (N) and lower the boom.

If steps 1 through 9 prove positive, the Stabil-TRAK system is functioning properly and the vehicle can be returned to service. if any of these steps indicate that the Stabil-TRAK system is not functioning properly, repair the system immediately.

b. Stabil-TRAK Solenoid Valves

There are five Stabil-TRAK solenoid valves (Fig. 10–85) attached to the Stabil-TRAK cylinder manifold, anchored at the left side of the rear axle. Individual solenoid valves may be replaced as required.

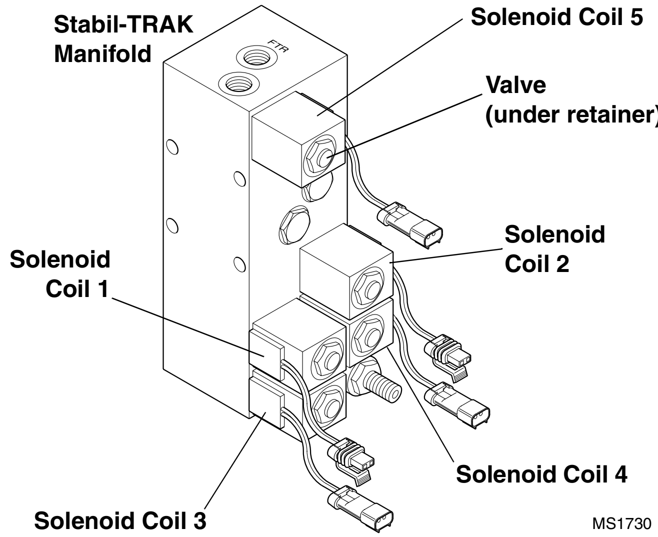


Figure 10–85. Stabil-TRAK manifold.

Stabil-TRAK Solenoid Valve Replacement

If a solenoid valve (Fig. 10–85) is suspected of malfunctioning, disconnect the coil wiring lead and test the coil. Also inspect the valve cartridge, O-rings, and the other hydraulic and electrical components in the circuit to accurately determine the cause of the problem.

10.8.17 Steering

Certain steering functions are dependent upon electrical operations, described below. Consult the *Owners/Operators Manual* for further information related to steering.

Four Wheel Steer Indexing

If the vehicle does not drive “straight,” the steering could not be synchronized or “out of phase.” Perform the *Four Wheel Steer Indexing* procedure to synchronize the steering.

Four Wheel Steer Indexing Procedure

1. With the steering select switch (Fig. 10–87) in the four wheel steer position, turn the steering wheel fully left.
2. While holding the steering wheel fully left, toggle the steer select switch to the front wheel steer position.
3. Steer the front wheels back to center.
4. Toggle the steer select switch back to four wheel steer position.
5. Turn the steering wheel fully left.
6. Toggle the steering select switch back to the front wheel steering position.
7. Steer the front wheels fully left.
8. Toggle the switch to the four wheel steer position and return to center.

The vehicle should now be properly indexed in four wheel steering. If the steering is still not synchronized, repeat the procedure.

a. Steering Select Switch

The steering select switch (Fig. 10–86 and Fig. 10–87) is located on the right console to the rear of the joystick below the armrest. It is a three-position switch that is pressed or “snapped” into a rectangular switch bezel.

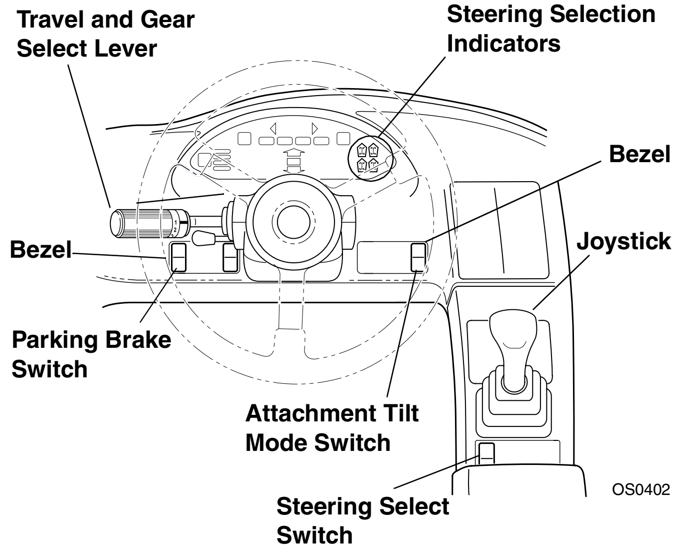


Figure 10–86. Location of various operational controls.

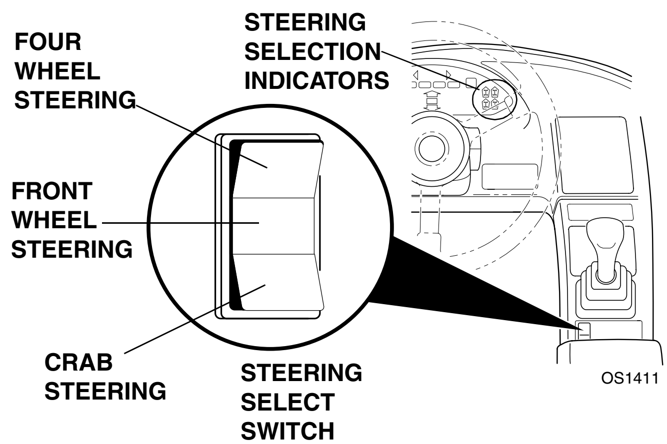


Figure 10–87. Steering select switch.

This three-position switch is a single-pole, double throw toggle switch that has three positions (Fig. 10–87 and Fig. 10–88). It has a multiple-connector plug on its underside that connects to the cab wiring harness. Wiring from the plug connects the switch with power from the fuse panel bus bar, and to the operators display panel and the steering select solenoids on the vehicle.

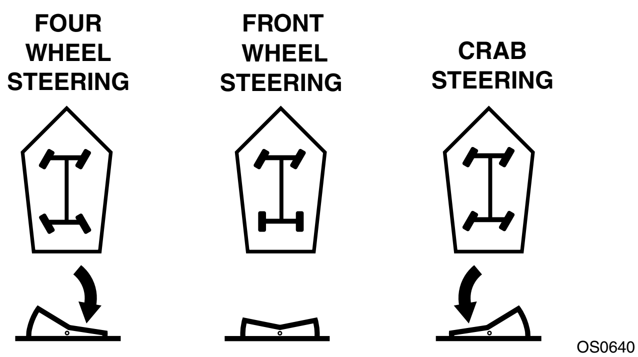


Figure 10–88. The steer select switch has three positions.

Steering select indicators on the right side of the operators display panel illuminate per the switch selected mode, and the steering select solenoids are energized or de-energized accordingly to provide the type of steering selected. The switch allows four-wheel steering (the rear wheels turn opposite the front wheels), two-wheel steering (the front wheels only), or crab steering (the rear wheels turn in the same direction as the front wheels).

b. Steering modes and conditions:

• **Four-wheel steer mode:** (Fig. 10–89) With the steering select switch in the forward most position, the following conditions must be met:

1. Four-wheel steer mode light (only) must be illuminated on the operators display panel (Fig. 10–86).

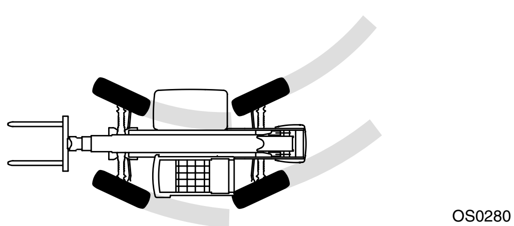


Figure 10–89. Four wheel steering.

2. Front wheels must steer in the direction that the steering wheel is turned.
3. Rear wheels must steer in the opposite direction from which the steering wheel is turned.

• **Two-wheel steer mode:** (Fig. 10–90) With the steering select switch in the centered position, the following conditions must be met:

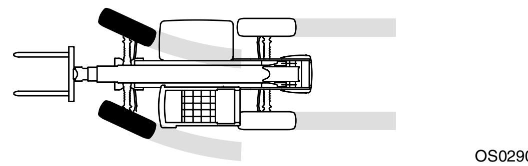


Figure 10–90. Two wheel steering.

1. Front-wheel steer mode light (only) must be illuminated on the operators display panel (Fig. 10–86).
2. Front wheels must steer in the direction that the steering wheel is turned.
3. Rear wheels must remain in a fixed forward position and not move.

• **Crab-steer mode:** (Fig. 10–91) With the steering select switch in the rear most position, the following conditions must be met:

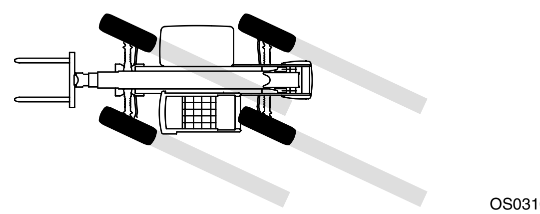


Figure 10–91. Crab steering.

1. Crab-steer mode light (only) must be illuminated on the operators display panel (Fig. 10–86).
2. Front wheels must steer in the direction that the steering wheel is turned.
3. Rear wheels must steer in the direction that the steering wheel is turned.

c. Steering Select Switch Removal

1. Disconnect the negative (-) battery cable at the negative battery terminal (Fig. 10–92).

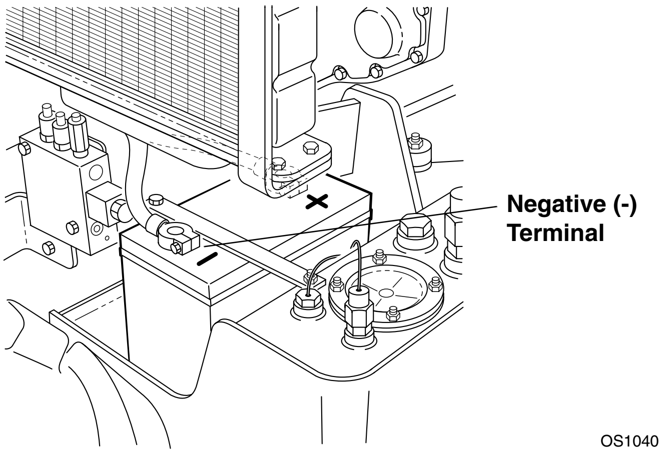


Figure 10–92. The negative (-) battery terminal.

1. Carefully pry the switch (Fig. 10–93) and wiring out of the mounting hole in the switch bezel.

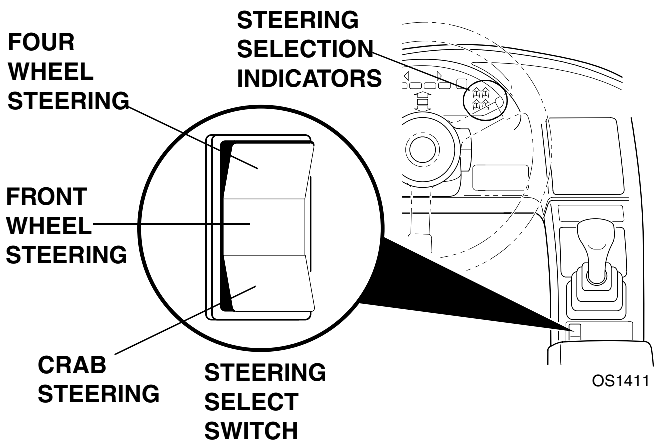


Figure 10–93. Steering select switch.

2. Label and disconnect the wiring from the switch. Note and mark the "front" or top of the switch in relation to the switch wiring terminals, and remove the switch from the vehicle.

d. Steering Select Switch Disassembly, Inspection and Replacement

DO NOT disassemble the switch. Replace a defective or faulty switch with a new one. Inspect the switch and the wiring harness connector terminals for continuity and shorting in all three switch positions. Inspect the switch terminals for continuity in the "up" and "down" positions and for shorting in the "middle" position. Replace a defective or faulty switch with a new one.

e. Steering Select Switch Installation and Testing

1. Route the wiring through the dash and switch bezel, then connect the wiring (Fig. 10–94) to the switch as labeled during switch removal (the eight-pin connector only goes on one way).
2. Properly position the “front” and top of the switch as noted during removal, then press or “snap” the switch into place in the bezel.

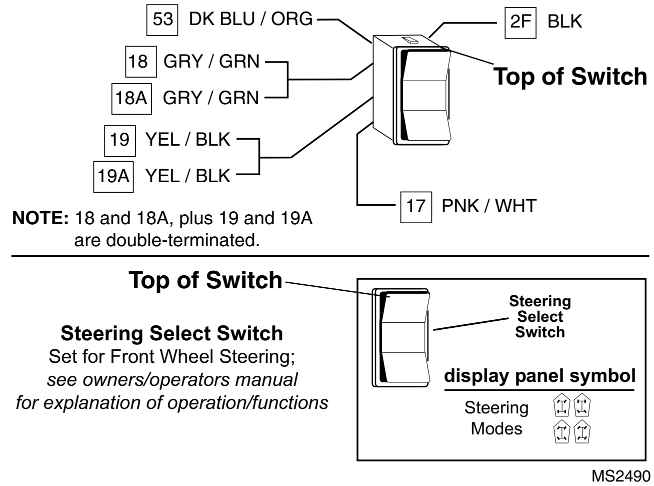


Figure 10–94. Steering select switch wiring and installation position.

3. Connect the negative (-) battery cable to its battery terminal (Fig. 10–92).
4. Clear the area around the vehicle of personnel and any obstructions to vehicle travel.
5. Start the engine, and check the operation of the steering select switch functions with the switch in all three positions.

10.8.18 Steer Select Valve

The steer select valve (Fig. 10–95), is secured to the steer select manifold and frame with four capscrews and O-rings near the hydraulic fluid reservoir.

It contains two solenoids that direct hydraulic fluid through hoses and ultimately help operate the steering. The valve is a direct dual-solenoid operated, spool-type directional control valve. The steer select valve controls the start, stop and direction of hydraulic fluid flow to the steering cylinders mounted on each axle.The valve consists of a housing (2, Fig. 10–96), two solenoids (3), a control spool (4), and two return springs (5).

In the de-energized state, the spool (4) is held by the return springs (5) in the center position. The spool is shifted through the action of the two wet-pin type solenoids (3).

The force of an acting solenoid works against the push pin (6) on the end of the spool (4). The spool is shifted from its normal position to the end position for selected flow. The selected flow pattern is covered in *Section 9 Hydraulic System*.

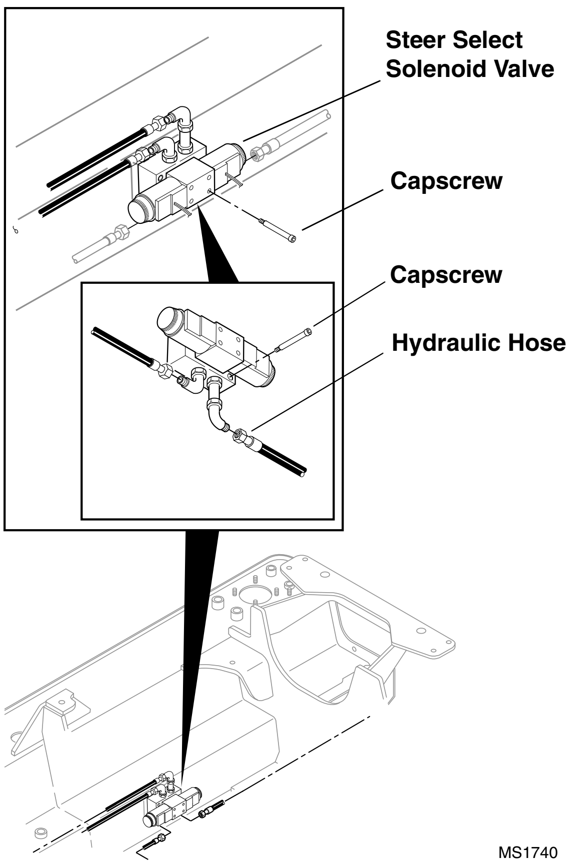
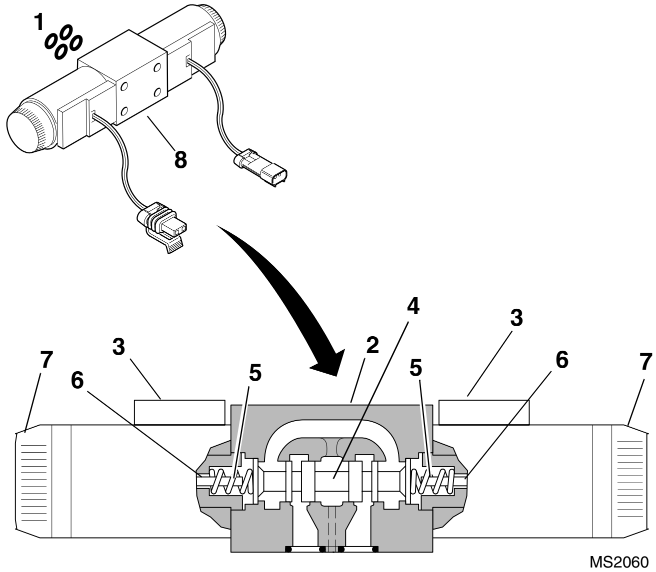


Figure 10–95. Steer select valve location and mounting.



1. O-rings
2. Housing
3. Solenoids (2)
4. Control Spool
5. Return Springs
6. Push Pin
7. Manual Override
8. Solenoid-operated Valve

Figure 10–96. Steer select valve detail.

When the solenoid is de-energized, the control spool (4, Fig. 10–96) is returned to its normal condition by the centering springs (5).

Check the steer select valve solenoids for proper operation and check the wiring for continuity or shorts. When energized/de-energized, the solenoid should move and/or an audible “click” should be heard; check for the presence of voltage with a voltmeter. Replace a defective or faulty steer select valve with a new unit. Refer to *Section 10.9 Electrical System Troubleshooting*.

10.8.19 Engine Low Oil Pressure Sender

The engine oil pressure sender is located on the engine block (Cummins, Fig. 10–97, and Perkins, Fig. 10–98) and is connected via the engine wiring harness, bulkhead connector and cab wiring harness to the operators display panel (Fig. 10–99).

CUMMINS ENGINE

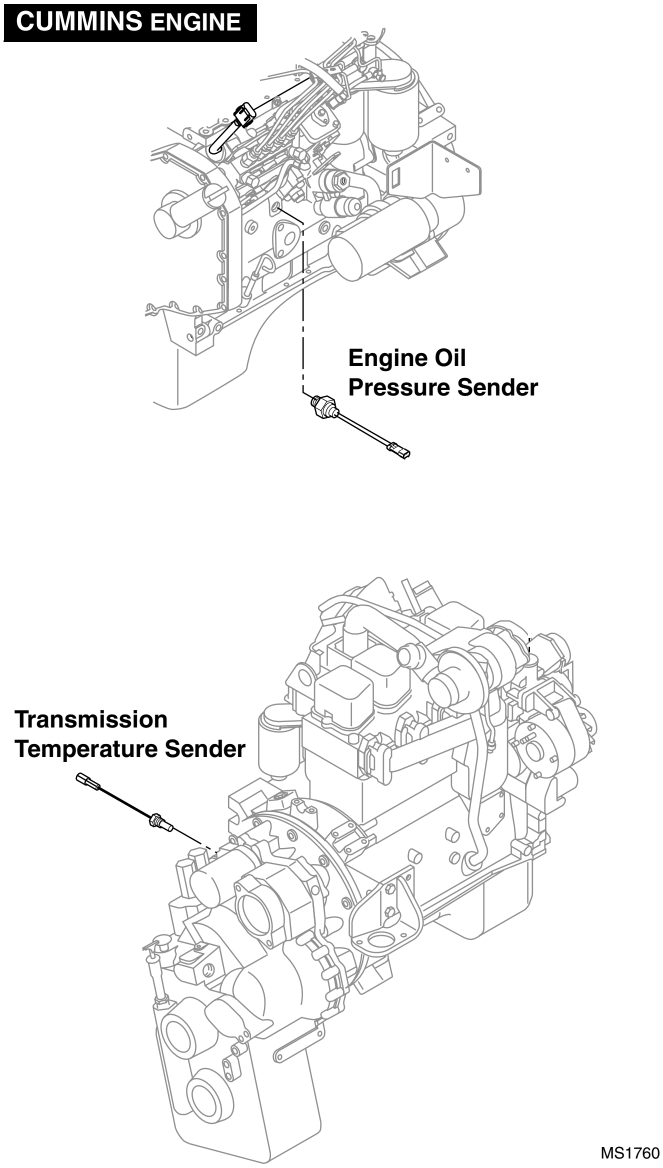


Figure 10–97. Cummins engine/transmission senders.

PERKINS ENGINE

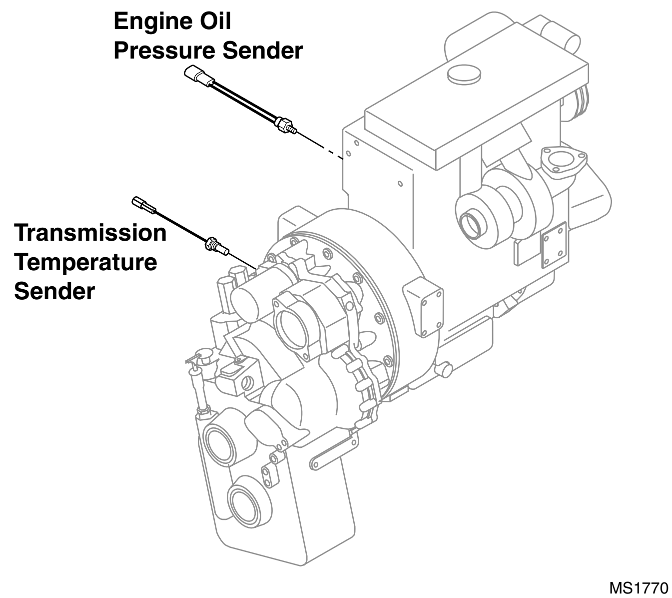


Figure 10–98. Perkins engine/transmission senders.

The operators display panel indicator (E, Fig. 10–99) illuminates when engine oil pressure is too low to properly lubricate the engine. The warning indicator illuminates when oil pressure is below 8.7 psi (0,6 bar) and an audible alarm will also sound. When the engine has attained normal oil pressure, the sender opens and the operators display panel indicator and alarm turn OFF.

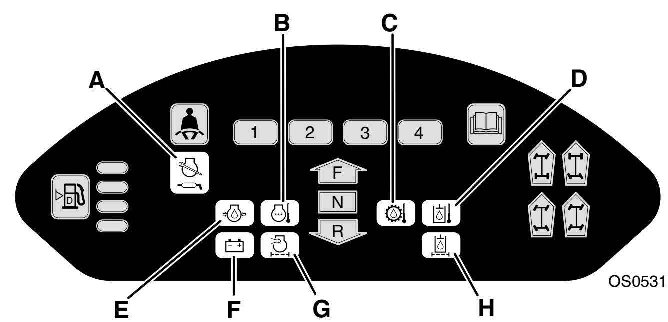


Figure 10–99. Operators display panel indicators.

a. Engine Oil Pressure Sender Removal

1. Disconnect the negative (-) battery cable at the negative battery terminal (Fig. 10–100).
2. Unplug the wiring harness connector from the sender.
3. The sender is threaded into the engine block. Remove the sender.

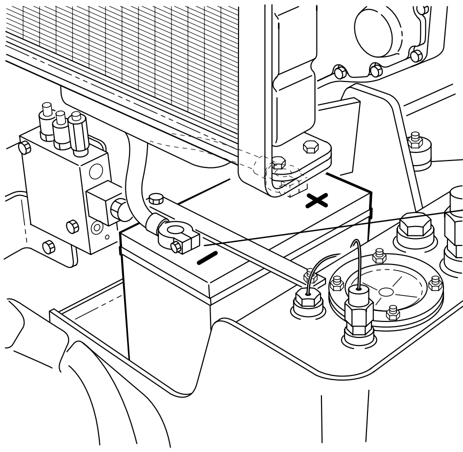


Figure 10–100. Disconnect the negative (-) battery cable at the negative (-) battery terminal.

b. Engine Oil Pressure Sender Disassembly

DO NOT disassemble the sender. Replace a defective or faulty sender with a new one.

c. Engine Oil Pressure Sender Inspection and Replacement

Inspect the sender and the wiring harness connector terminals for continuity. Replace a defective or faulty sender with a new one.

d. Engine Oil Pressure Sender Installation and Testing

1. Thread the sender (Cummins, Fig. 10–101 or Perkins, Fig. 10–98) into the engine block snugly, then connect the wiring harness connector lead to the sender.
2. Connect the negative (-) battery cable to its battery terminal (Fig. 10–100).
3. Start the engine, allow it to reach operating temperature, and observe the operators display panel for sender indication. If the sender is not defective, the problem could be elsewhere; possibly in a shorted wire, improper-running engine, defective display, etc.

10.8.20 Transmission High Temperature Sender

The transmission high temperature sender (Cummins, Fig. 10–101 or Perkins, Fig. 10–98) is threaded into the transmission housing and is connected via the engine wiring harness, bulkhead connector and cab wiring harness to the operators display panel (Fig. 10–99).

When the transmission fluid temperature rises above 250° F (107° C), the sender heats up, closing contacts within the sending unit. The operators display panel indicator (C, Fig. 10–99) illuminates and an audible alarm will sound. When the transmission temperature is below 250° F (107° C), the contacts within the sending unit open and the operators display panel indicator and alarm turn OFF.

a. Transmission High Temperature Sender Removal

1. Disconnect the negative (-) battery cable at the negative battery terminal (Fig. 10–100).
2. Unplug the wiring harness connector from the sender (Cummins, Fig. 10–101 or Perkins, Fig. 10–98).
3. The sender is threaded into the transmission housing or case. Remove the sender.

b. Transmission High Temperature Sender Disassembly

DO NOT disassemble the sender. Replace a defective or faulty sender with a new one.

c. Transmission High Temperature Sender Inspection and Replacement

Inspect the sender and the wiring harness connector terminals for continuity. Replace a defective or faulty sender with a new one.

d. Transmission High Temperature Sender Installation and Testing

1. Thread the sender (Cummins, Fig. 10–101 or Perkins, Fig. 10–98) into the transmission housing snugly, then connect the wiring harness connector lead to the sender.
2. Connect the negative (-) battery cable to its battery terminal (Fig. 10–100).
3. Start the engine, allow all systems to reach operating temperature, and observe the operators display panel for sender indication. If the sender is not defective, the problem could be elsewhere; possibly in a shorted wire, clogged or defective transmission cooler, defective display, etc.

10.8.21 Engine Coolant High Temperature Sender

The engine coolant high temperature sender (Cummins, Fig. 10–101 or Perkins, Fig. 10–98) is threaded into the engine block and is connected via the engine wiring harness, bulkhead connector and cab wiring harness to the operators display panel.

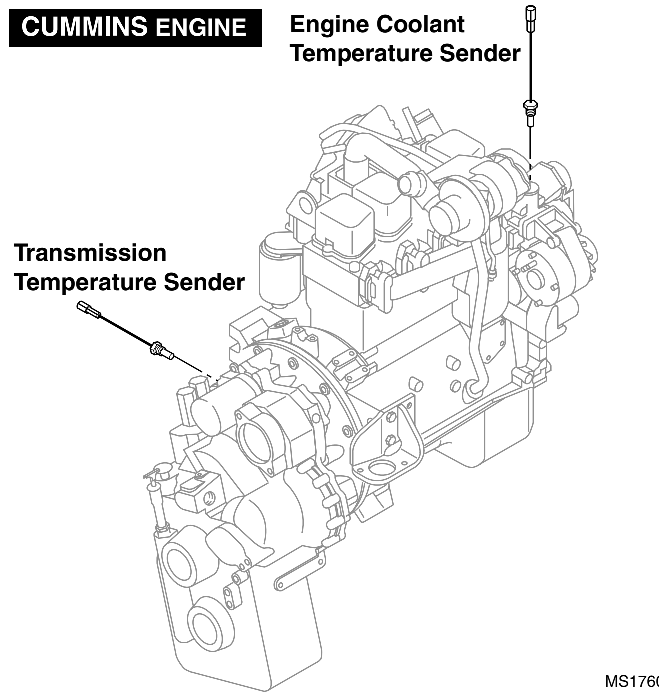


Figure 10–101. Cummins engine/transmission senders.

When the engine coolant temperature exceeds normal limits and rises above 210° F (85° C), the sender heats up, closing contacts within the sending unit. The operators display panel indicator (B, Fig. 10–103) illuminates and an audible alarm will sound. When the engine coolant temperature is below 210° F (85° C), the contacts within the sending unit open and the operators display panel indicator and alarm turn OFF.

PERKINS ENGINE

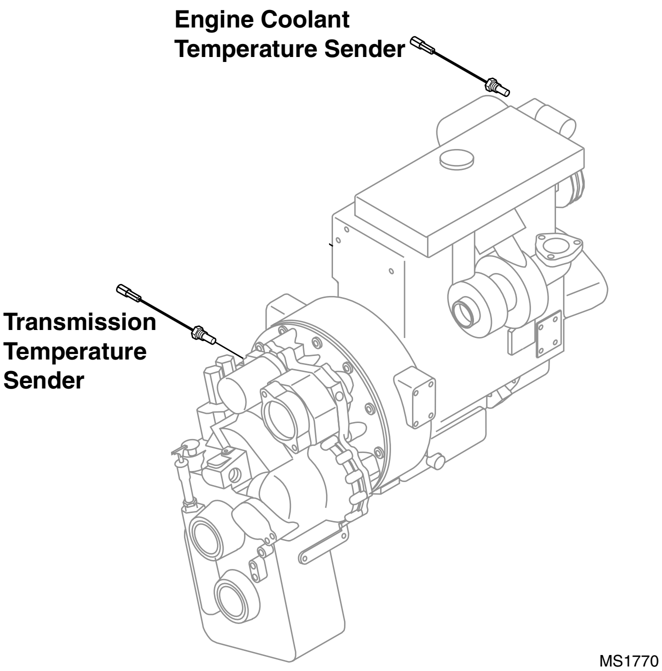


Figure 10–102. Perkins engine/transmission senders.

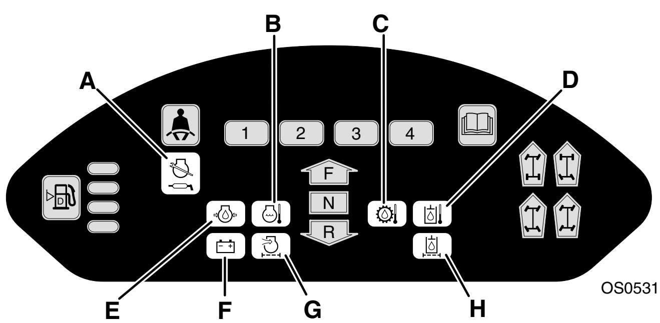


Figure 10–103. Operators display panel indicators.

a. Engine Coolant High Temperature Sender Removal

1. Disconnect the negative (-) battery cable at the negative battery terminal (Fig. 10–104).
2. Unplug the wiring harness connector from the sender (Fig. 10–101 or 10–102).
3. The sender is threaded into the engine block. Remove the sender.

b. Engine Coolant High Temperature Sender Disassembly

DO NOT disassemble the sender. Replace a defective or faulty sender with a new one.

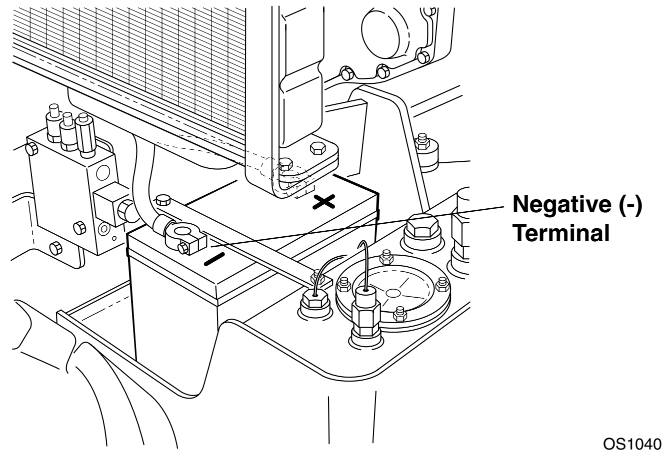


Figure 10–104. Disconnect the negative (-) battery cable at the negative (-) battery terminal.

c. Engine Coolant High Temperature Sender Inspection and Replacement

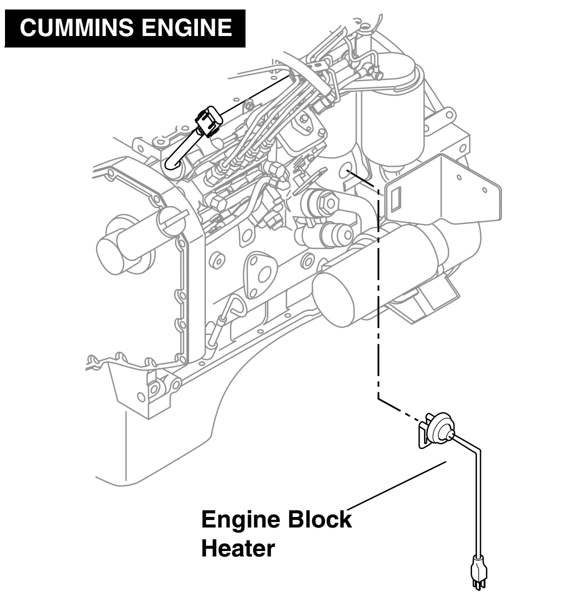
Inspect the sender and the wiring harness connector terminals for continuity. Replace a defective or faulty sender with a new one.

d. Engine Coolant High Temperature Sender Installation and Testing

1. Thread the sender (Fig. 10–101 or 10–102) into the engine block snugly, then connect the wiring harness connector lead to the sender.
2. Connect the negative (-) battery cable to the negative (-) battery terminal (Fig. 10–104).
3. Start the engine, allow it to reach operating temperature, and observe the operators display panel for sender indication. If the sender is not defective, the problem could be elsewhere; possibly in a shorted wire, improper-running engine, improper coolant, obstructed or faulty radiator, water pump, loose fan belt, defective display etc.

10.8.22 Engine Block Heater (*option*)

Some engines are equipped with an optional engine block heater (Fig. 10–105) that can be plugged into a standard 110/120V ac grounded outlet to heat the engine coolant. When temperatures are below 10° F (-12° C), the block heater should be used.



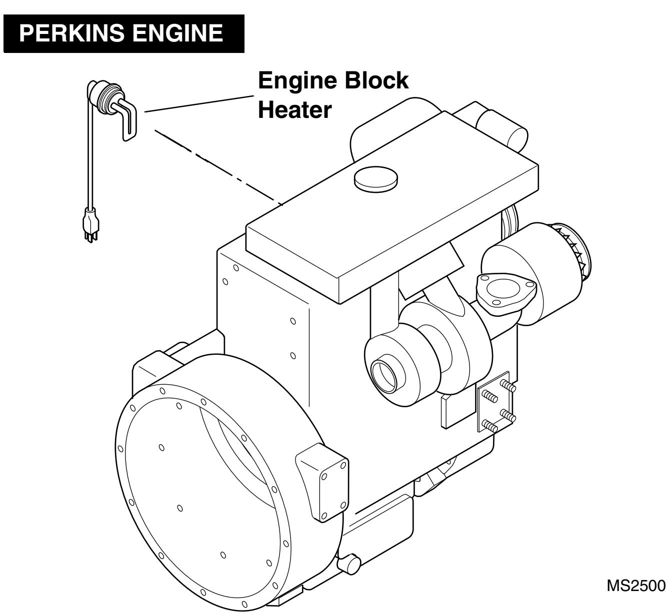


Figure 10–105. Some engines are equipped with an optional engine block heater.

For further information, consult the appropriate engine manual or the nearest engine distributor.

10.8.23 Fuel Level Indicator and Fuel Level Sender

The fuel level indicators on the left side of the operators display panel (Fig. 10–106) work in conjunction with the fuel level sender (Fig. 10–107, next page).

The submerged, coil-type fuel sender is secured to the fuel tank beneath the cab and is connected via the engine wiring harness, bulkhead connector and cab wiring harness to the operators display panel.

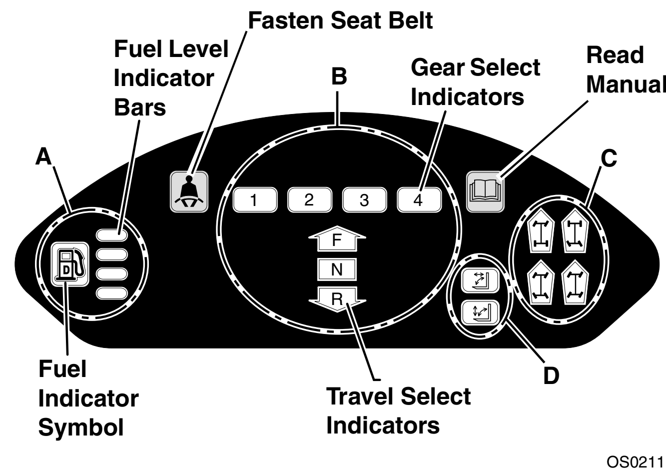


Figure 10–106. Operators display panel indicators.

The operators display panel fuel level indicator bars on the left of the operators display panel illuminate to show the approximate fuel level in 1/4 tank increments. The fuel level indicator bars will be illuminated with a low-light green hue, easily apparent for night visibility and in low-light conditions. When approximately 1/8 tank is reached, the last fuel level indicator bar will stop illuminating, and the fuel level indicator symbol will change from green to orange. When the fuel level indicator symbol changes from green to orange, refuel the tank.

The fuel level sender wiring harness connector can be accessed from beneath the cab without removing the cab. The cab must be removed to access the fuel tank and fuel sender. See *Section 4 Cab, Covers and Mirrors* in this manual for cab and fuel tank removal instructions.

The fuel level sender (Fig. 10–107) consists of a resistance, float-type fuel level sender mounted in the top of the fuel tank, and the wiring connecting it with the fuel indicators in the operators display panel.

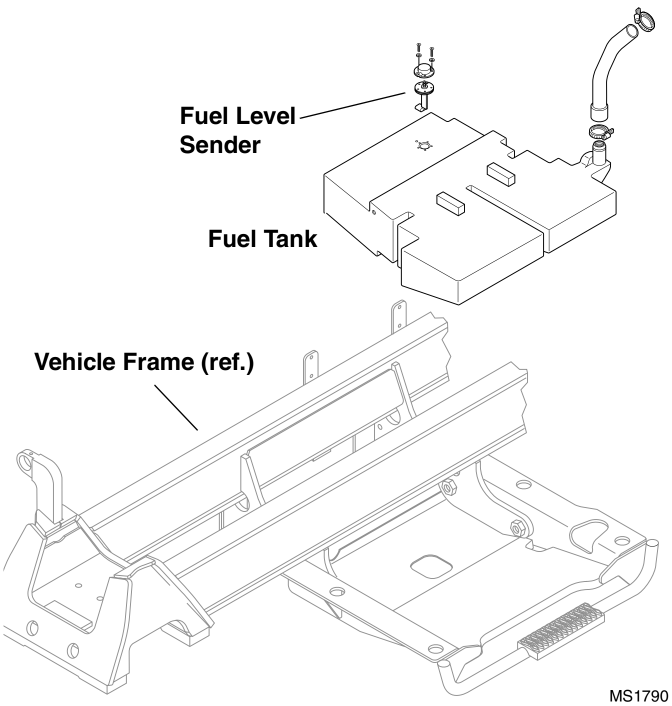


Figure 10–107. Fuel level sender.

The resistance of the fuel sender is 33.5 ohms for a full tank of fuel and 240 ohms for an empty tank. The fuel level indicator bars in the operators display panel receive a signal sensed within the electronic circuitry of the operators display panel. Examine the fuel level sender circuit in the appropriate wiring diagram and schematic earlier in this section.

Battery voltage is applied to the circuit and the circuit divides at the fuel level indicator bars. One path continues to ground through the operators display panel and fuel level indicator connector plug. Another electrical path goes to ground through the variable resistor of the fuel level sender.

When the fuel level reaches approximately 1/8 of a tank, the resistance of the sender increases. This in turn changes the operators display panel, causing the green fuel level indicator bars to turn OFF, and resulting in the orange fuel indicator symbol (shaped like a standard fuel pump) to turn ON.

When the tank is more than 1/8 full, the sender resistance is lower. On the operators display panel, the green fuel level indicator bars illuminate according to the amount of resistance supplied.

a. Fuel Level Indicator Testing

1. With approximately eight gallons (30,4 liters) of fuel in the fuel tank (Fig. 10–107), the bottom fuel level indicator bar should illuminate, indicating approximately 1/4 tank of fuel.
2. The fuel level sender wiring harness connector can be accessed from beneath the cab without removing the cab. Beneath the cab, disconnect the fuel level sender wiring harness connector. Connect a jumper wire across the two wires in the harness connector.
3. From the operators position, turn the ignition key switch to the RUN position (Fig. 10–108). DO NOT start the engine. Observe the fuel level indicator bars on the operators display panel. The reading must be at the FULL mark, with all four bars illuminated after the engine start-up bulb test is completed.

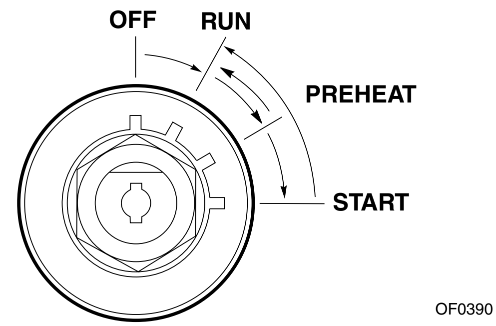


Figure 10–108. Ignition key switch positions.

4. Turn the ignition key switch to the OFF position. The bars should turn OFF.

The cab must be partially removed to access the fuel tank and fuel sender. See *Section 4 Cab, Covers and Mirrors* in this manual for cab and fuel tank removal instructions.

b. Fuel Level Circuit Tests

If the fuel level indicators are suspected of giving a false reading, perform the following checks:

1. Check for loose or defective wiring, faulty ground connections, and corrosion on the fuel tank sender and wiring lead.
2. If the fuel level indicator bars do not illuminate after the engine start-up bulb test is completed and when the ignition key switch is turned to the RUN position, use a test lamp to determine whether current is flowing from the ignition switch to the fuel level indicator wiring connector behind the operators display panel (the panel can be unfastened and raised slightly to do this).
3. If the fuel level indicator bars do not illuminate, check the fuel tank for fuel.

4. If the fuel level indicators do not illuminate, and a faulty or defective fuel sender in the fuel tank has been ruled out, and wiring and connectors have been checked and ruled out, the operators display panel is defective and must be replaced in its entirety.
5. Check that the ignition terminal has current, and that the fuse in the fuse panel is not blown.
6. Check for broken, shorted, frayed, disconnected or damaged wiring between the fuel level indicator wiring at the operators display panel, fuse and relay panel, ignition key switch, and from the fuel sender on the fuel tank through the wiring in the cab.
7. Check the fuel level sender. The resistance of the fuel sender is 33.5 ohms for a full tank of fuel and 240 ohms for an empty tank. A defective fuel level sender in the fuel tank may also prevent the fuel level indicator bars from illuminating.

Excessive fuel level indicator bar “fluctuation” may be caused by loose wire connections or a defective fuel sender in the fuel tank.

A full tank reading at all times may occur if the wiring to the fuel sender in the tank is broken, if the sender is not properly grounded, or if the sender is defective.

If the fuel level indicator bars indicate inaccurately, the fuel sender in the tank may be defective or there may be low voltage at the fuel level indicator connector to the operators display panel.

If the fuel level indicator bars fluctuate when other electrical items are used, there may be a defective, corroded or improper ground. Check the cab harness ground stud under the dash, the engine to chassis ground, and the negative (-) battery cable and ground stud cable near the hydraulic reservoir fill cap under the engine cover.

The cab must be partially removed to access the fuel tank. See *Section 4 Cab, Covers and Mirrors* in this manual for cab and fuel tank removal instructions.

10.8.24 Hourmeter

The hourmeter (Fig. 10–109) is a non-repairable instrument that records hours of vehicle engine operation in tenth of an hour increments and is located on the left outside edge of the dash console. The hourmeter is an analog device, similar to an odometer, and will display 99,999.9 hours before resetting to zero.If trouble is suspected, time the hourmeter for six minutes to verify that a tenth of an hour has been recorded. The meter is secured to the dashboard with two screws; there are two wires at the rear of the meter; one is connected to a sensor on the engine, the other provides grounding.

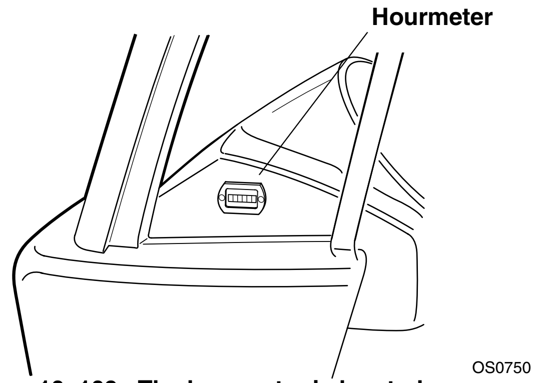


Figure 10–109. The hourmeter is located on the left outside edge of the dash console.

a. Hourmeter Removal

Note: For vehicles with the optional closed cab, the front console must be removed (see *Section 4 Cab, Covers and Mirrors*) to access the hourmeter.

1. Disconnect the negative (-) battery cable at the battery (Fig. 10–110).
2. Remove the two screws securing the hourmeter to the dash console (Fig. 10–109). Gently begin removing the hourmeter from the dashboard until the two wires are visible. Note or label the wires respective of their colors and locations. Disconnect (unplug) both wire terminals at the rear of the hourmeter.

b. Hourmeter Installation

1. Attach both wire terminals at the rear of the meter. The black wire attaches to the forward terminal; the green wire attaches to the rear terminal.
2. Insert the meter into the opening in the left side of the dash console (Fig. 10–109). Secure with two screws.
3. Reconnect the negative (-) battery cable (Fig. 10–110). Start the engine. Observe the hourmeter for function with the engine running to verify operation. Time the hourmeter for six minutes to verify that a tenth of an hour has been recorded.

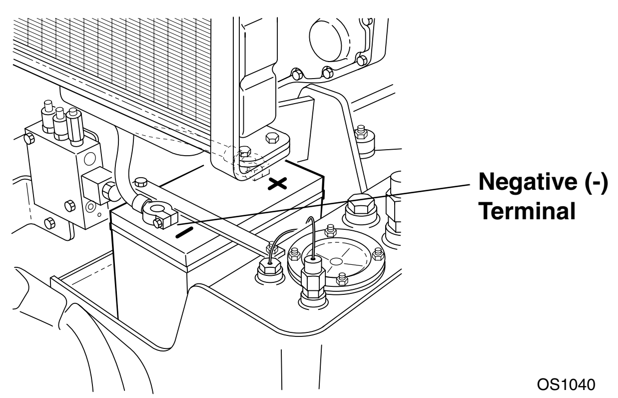


Figure 10–110. The negative (-) battery terminal.

10.9 ELECTRICAL SYSTEM TROUBLESHOOTING

This section provides an easy reference guide covering the most common problems that occur in the electrical system.

Electrical System Troubleshooting

Problem	Possible Cause	Remedy
1. HORN doesn't sound when horn button is pressed.	1. No voltage at horn; broken wire or blown fuse.	1. Replace wiring and fuse as required.
	2. Corroded electrical ground at horn mounting.	2. Repair electrical ground.
	3. Loose or broken wiring.	3. Repair or replace wiring.
	4. Defective horn switch.	4. Test horn switch for continuity with horn button pressed; replace switch if open.
	5. Defective horn.	5. Remove horn from vehicle and test horn using short, heavy-gauge wires connected to a fused or otherwise protected 6-amp, 12-volt DC power supply
2. Horn sounds continuously although horn button is not being pressed.	1. Stuck horn button.	1. Free horn button; inspect and eliminate cause of sticking.
	2. Defective horn switch	2. Test horn switch for continuity without pressing horn button; replace switch if closed.
	3. Short circuit in wiring.	3. Determine and repair cause of short circuit
3. BACKUP ALARM doesn't sound with travel select lever in REVERSE (R).	1. No voltage at backup alarm; broken wire.	1. Check for voltage at backup alarm wire leads; determine and repair cause of broken wiring as required.
	2. Short circuit in wiring.	2. Determine and repair cause of short circuit.
	3. Defective travel select switch.	3. Test travel select switch for continuity; replace as required.
4. Backup alarm sounds with travel select lever in NEUTRAL (N) and/or FORWARD (F).	1. Short circuit in wiring.	1. Determine and repair cause of short circuit.
	2. Defective travel select switch.	2. Test travel select switch for continuity; replace as required.
5. OPERATORS DISPLAY PANEL warning indicator lights do not illuminate. ***• During lamp test?*** ***• During operation?***	1. No voltage at panel; loose or broken wiring or blown fuse.	1. Replace wiring and fuse as required.
	2. Defective operators display panel.	2. Replace operators display panel.
6. Operators display panel indicators illuminate continuously with ignition key switch in the RUN position (*after lamp test*).	1. Short circuit in wiring.	1. Determine and repair the cause of the short circuit.
	2. Defective operators display panel	2. Replace operators display panel

Electrical System Troubleshooting

Problem	Possible Cause	Remedy
7. LOSS OF ELECTRICAL POWER for some but not all vehicle operations.	1. No voltage at these circuits, caused by a broken wire or switch, or a blown fuse.	1. Repair wiring, switch and fuse as required.
8. FUSE continuously blows.	1. Check the system for shorts, loose grounds, defective or corroded electrical components.	1. Repair or replace as required.
9. Overheating and burnout of wiring and electrical components.	1. Incorrect fuse for circuit or fuse is bypassed with a jumper. **IMPORTANT:** NEVER connect a jumper between fuse terminals without providing an equivalent protective device in the jumper.	1. Use correct fuse. Correct the cause of the overload and replace damaged wiring, components and fuses as required.
10. Starting System/GENERAL **Engine will not crank and starter relay or starter solenoid does not engage.** **Note:** Refer to the Perkins or Cummins engine troubleshooting information in *Section 8A* or *Section 8B*.	1. Transmission is in FORWARD (F) or REVERSE (R). 2. Battery is discharged. 3. Inoperative ignition switch, relay or solenoid. 4. Starting circuit is open or has high resistance. 5. Neutral relay is open or shorted.	1. Shift travel select lever into NEUTRAL (N). 2. Check battery and charge or replace battery. 3. Check circuitry and repair or replace faulty components. 4. Check circuit connections and repair or replace faulty wiring. 5. Check and replace as necessary.
11. Starter relay closes and solenoid engages but engine will not crank.	1. Battery is discharged. 2. Defective starter motor connections or loose battery connections. 3. Starter motor is faulty. 4. Relay or solenoid contacts are burned. 5. Engine is seized, crankshaft cannot rotate.	1. Check battery and charge or replace. 2. Check, clean and tighten connections. 3. Inspect, repair or replace. 4. Replace relay or solenoid. 5. Repair or replace engine or transmission as required.
12. Starting motor turns but does not crank engine.	1. Defective starter solenoid or pinion. 2. Defective solenoid or pinion drive. 3. Defective flywheel ring gear.	1. Inspect and repair or replace. 2. Inspect and repair or replace. 3. Inspect and replace.
13. Engine cranks slowly.	1. Battery output is low. 2. Excessive resistance in the starting circuit. 3. Defective starter motor.	1. Check battery and charge or replace. 2. Check circuit connections and repair or replace faulty wiring. 3. Inspect and repair or renew.

Electrical System Troubleshooting

Problem	Possible Cause	Remedy
14. Engine turns over but does not start. **Note:** Refer to the Perkins or Cummins engine trouble-shooting information in *Section 8A* or *Section 8B*.	1. Fuel tank is empty.	1. Fill fuel tank.
	2. Faulty injection pump or fuel run solenoid.	2. Test for fuel at injection pump. Test the electrical circuit and the solenoid. Check that 12 volts are present at the fuel run solenoid. Check wiring for defects and repair as required.
15. Starter doesn't operate or doesn't operate correctly.	1. Discharged battery.	1. See corrections for problem of discharged battery.
	2. Bad connections, wires, cables or other components in the start circuit.	2. See troubleshooting the starting system/GENERAL.
	3. Wrong engine oil (viscosity too thick) for cold weather operation.	3. Refer to appropriate engine section and see lubrication instructions in *Section 2 General Information, Specifications and Maintenance* of this manual.
	4. Worn teeth on the starter drive pinion or the flywheel ring gear.	4. Remove the starter to check the teeth. Repair or replace as necessary.
	5. Starter fasteners are loose.	5. Tighten the fasteners.
16. STARTER MOTOR RELAY No voltage at the starter solenoid when the ignition key switch is in the START position.	1. Starter relay is not energized due to broken wiring or a blown fuse.	1. Replace wiring or fuse.
17. Starter operates continuously without ignition key switch in the START position.	1. Starter relay is stuck in the closed position.	1. Replace the starter relay.
18. THERMO-START Intake manifold remains cold after ignition key switch is momentarily turned to the PREHEAT position.	1. Discharged battery.	1. Charge battery only if electrolyte is not frozen. If electrolyte is frozen, remove the battery from the vehicle, completely thaw it and then attempt to charge the battery.
	2. Broken wiring or blown fuse.	2. Replace switch, wiring or fuse.
	3. Loose connections.	3. Tighten connections.
	4. Clogged or bent fuel line to the thermo-start plug.	4. Clean or replace the fuel line.
	5. Defective thermo-start plug.	5. Replace the thermo-start plug.
	6. Defective ignition switch.	6. Remove and test the ignition key switch in all positions. Replace a faulty switch.

Electrical System Troubleshooting

Problem	Possible Cause	Remedy
19. Intake manifold remains abnormally hot during normal engine operation.	1. Thermo-start plug is ON continuously due to a defective ignition switch or a short circuit in the wiring. 2. Thermo-start plug leaks fuel into intake manifold.	1. Remove and test the ignition key switch in all positions. Replace a defective switch. 2. Replace thermo-start plug.
20. Charging System/GENERAL VISUAL CHECK	1. Check for loose or corroded connections. 2. Check the condition and adjustment of the alternator belt. 3. Check the condition of the battery.	1. Repair as required. 2. Install a new belt if necessary. 3. Refer to *Section 10.7.2 Battery.*
21. ALTERNATOR Noisy Alternator.	1. Damaged or worn drive belt. 2. Worn alternator bearings or shaft.	1. Install new drive belt. 2. Install new alternator.
22. BATTERY Battery doesn't perform satisfactorily.	1. Damaged or defective battery.	1. Test battery; refer to *Section 10.7.2 Battery.*
23. Discharged battery.	1. Short circuit in battery cell(s). 2. Loose or dirty battery cable connections. 3. Electrical draw on battery. 4. Dirty battery top. 5. Low output or no output from alternator. 6. High resistance in the positive (+) battery cable. 7. High resistance in the negative (-) battery cable.	1. Conduct battery load test. 2. Clean and tighten connections. 3. Test and correct draw on battery. 4. Clean the top of the battery. 5. Test the alternator. 6. Check the positive cable. 7. Check the negative cable.
24. Switches and Solenoids IGNITION KEY SWITCH Key binds in switch.	1. Sticky, dirty, or bent key.	1. Clean, remove sticky substance or dirt, burrs, etc. from key and sprinkle powdered graphite on key. Insert, turn and withdraw several times from ignition switch. **IMPORTANT:** Use only graphite or a liquid lock deicer within the lock.
25. Key cannot enter switch or be turned once inside.	1. Defective switch. 2. Ice has formed in switch.	1. Replace the switch. 2. Warm the switch with warm air or use liquid lock deicer to thaw the lock.
26. Ignition switch fails to function in one or more positions.	1. Loose or broken wiring or blown fuse. 2. Trouble in the starting circuit. 3. Defective ignition key switch.	1. Replace wiring and fuse. 2. Refer to starting circuit troubleshooting. 3. Test and repair or replace the ignition key switch.

Electrical System Troubleshooting

Problem	Possible Cause	Remedy
27. With key in the START position, engine does not crank.	1. Travel select lever is in forward (F) or reverse (R).	1. Move the travel select lever to NEUTRAL (N).
28. Engine runs momentarily then stops.	1. Defective fuel run solenoid.	1. Refer to Step 30, Fuel Run Solenoid troubleshooting.
Note: Refer to the Perkins or Cummins engine troubleshooting information in *Section 8A* or *Section 8B*.	2. Fuel tank is empty.	2. Fill fuel tank.
	3. Defective fuel injection pump.	3. Check that pump operates properly per the appropriate engine section of this manual.
	4. Clogged or dirty fuel filter.	4. Replace fuel filter.
	5. Excessive water in fuel.	5. Drain water separator or replace water filter.
29. NEUTRAL START SWITCH Starter fails to crank engine with travel select lever in NEUTRAL (N), parking brake switch engaged and ignition key switch in START position.	1. Check for problems in the transmission shift switch or wiring.	1. Check the transmission shift switch wiring and fuse.
	2. Check transmission shift switch for proper operation, continuity, shorts, etc.	2. Replace a defective switch or relay.
30. FUEL RUN SOLENOID Ignition switch cranks engine in START position but engine doesn't operate when key returns to RUN position.	1. Fuel run solenoid.	1. Test for voltage at fuel run solenoid with ignition key switch in RUN position.
	2. Fuel tank is empty.	2. Fill fuel tank.
	3. Defective injection pump.	3. Replace pump. See the appropriate engine troubleshooting section.
31. PARKING BRAKE SWITCH When switched to disengaged position, park brake switch fails to disengage park brake.	1. Blown fuse.	1. Replace fuse.
	2. Defective park brake solenoid.	2. Test solenoids and circuits; test for continuity with park brake switch in both positions; check park brake solenoid operation. Repair circuits or replace switch and/or solenoids as required.
	3. Defective park brake switch.	3. Replace.
	4. Hydraulic problem.	4. Refer to *Section 9 Hydraulic System*.
32. BACK-UP ALARM Backup alarm doesn't sound with travel select lever in REVERSE (R).	1. No voltage at backup alarm; broken wiring or blown fuse.	1. Test alarm and ground circuit; check for voltage at alarm. Repair wiring or replace fuse as required.
	2. Defective alarm.	2. Test alarm and ground circuit.
	3. Defective travel select lever.	3. Test travel select lever for continuity and circuit for shorts. Replace travel select lever if defective.

Electrical System Troubleshooting

Problem	Possible Cause	Remedy
33. Backup alarm sounds with travel select in NEUTRAL (N) and FORWARD (F).	1. Short circuit in wiring. 2. Defective travel select lever.	1. Determine and repair cause of short circuit. 2. Test travel select lever for continuity and circuit for shorts. Replace travel select lever if defective.
34. STEER SELECT SWITCH **Steer select switch fails to select mode or selects incorrect steering mode.**	1. Blown fuse. 2. Short circuit or broken wire. 3. Defective steer select switch. 4. Defective steer select solenoid.	1. Replace fuse. Check circuit for cause of blown fuse. 2. Repair short, repair or replace wire. 3. Remove steer select switch and check for continuity in each position. Replace switch if defective. 4. Test for correct operation. Replace if defective.
35. HOURMETER **Hourmeter doesn't operate.**	1. No voltage at meter terminals. 2. Defective wiring and/or ground.	1. Check for proper voltage at hourmeter terminals with engine running. Required voltage is 9 to 36-volts DC. If voltage is present, replace hourmeter. 2. Repair wiring and repair ground.
36. WARNING INDICATORS **(on operators display panel)** **Indicators fail to illuminate *after* engine start up lamp test.**	1. Defective sender switch(es). 2. Defective operators display panel.	1. Test sender and/or circuit. Replace sender switch(es). 2. Replace panel.
37. All warning indicators on the operators display panel illuminate continuously when the ignition key switch is in the RUN position *after* engine start up lamp test.	1. Short circuit in wiring. 2. Defective panel.	1. Determine and repair the short. 2. Test panel ground circuit.
38. ENGINE OIL PRESSURE SWITCH **Oil pressure indicator continuously illuminates when engine is running.**	1. If the oil level and oil pressure are sufficient, check for shorts to ground between the operators display terminal and the engine oil pressure sender switch on the engine block.	1. If there are no shorts to ground, install a new engine oil pressure switch.
39. Oil pressure indicator does not illuminate after lamp test, engine not running for twenty seconds.	1. Wiring broken or disconnected. 2. Defective oil sender switch (switch is closed when engine is not running).	1. Check wiring and circuit continuity. Repair break(s) in circuit as required. 2. Install a new engine oil pressure sender switch.

Electrical System Troubleshooting

Problem	Possible Cause	Remedy
40. ENGINECOOLANT TEMPERATURE SWITCH Engine coolant temperature warning indicator on operators display panel fails to illuminate when engine is overheated.	1. Defective engine coolant temperature sender. 2. Defective wiring.	1. Check and test sender. Test electrical circuit to sender. 2. Test circuit for continuity and repair as required.
41. Engine coolant temperature warning indicator illuminates when engine is not overheated (indicator lights during lamp test on engine start up for five seconds; if sender wiring is disconnected, operators display indicator will light).	1. Short circuit in wiring. 2. Defective engine coolant temperature sender.	1. Disconnect the wiring harness connector at the engine coolant temperature sender switch on the engine block. If the indicator goes out, install a new engine coolant temperature sender switch on the engine block. 2. If the indicator continues to illuminate, check the wire lead at the display panel and at the ignition switch for a short to ground. Repair a short circuit or replace the sender.
42. BATTERY/ALTERNATOR CHARGING WARNING INDICATOR Charging indicator fails to illuminate when alternator is not producing voltage (but does illuminate during engine start-up lamp test).	1. Defective alternator or wiring.	1. Test and/or replace alternator and wiring
43. TRANSMISSION Temperature Warning Indicator Transmission temperature warning indicator fails to illuminate when transmission is overheated.	1. Circuit wiring is disconnected or defective. 2. Transmission temperature sender switch on transmission is defective.	1. Check wiring, test circuit and repair as required. 2. Replace switch.

Electrical System Troubleshooting

Problem	Possible Cause	Remedy
44. Transmission temperature warning indicator illuminates during vehicle operation when transmission is not overheated (indicator illuminates normally during engine start-up lamp test).	1. Wiring is shorting to ground.	1. If the indicator continues to illuminate, check the wiring from the operators display panel to the ignition key switch, fuse panel and sender for a short to ground. If a short is detected, test the circuit and repair the short.
	2. Defective transmission temperature sender.	2. Disconnect wiring connector at the transmission temperature sender switch on the transmission. If the wiring checks out o.k. and the transmission temperature warning indicator continues to illuminate, install a new transmission temperature sender switch. If the problem persists, replace the operators display panel. Test and replace the sender as required.
45. FUEL LEVEL INDICATOR BARS No indication.	1. No current in circuit because of broken or disconnected lead.	1. Check wiring and repair or replace as required. Follow wiring from sender on fuel tank beneath cab to fuse panel, ignition key switch and operators display panel terminal for fuel level indicator bars.
	2. Bad ground connection.	2. Repair ground.
	3. Defective fuel level sender at fuel tank.	3. Check for proper resistance; see *Section 10.8.25 Fuel Level Indicator and Fuel Level Sender*.
	4. Defective operators display panel.	4. Replace panel.
46. Excessive fuel level indicator bar fluctuation (not caused by frame tilt function, travel over rough terrain, etc.).	1. Loose wire connections.	1. Tighten connections at fuel level sender.
	2. Defective fuel level sender at fuel tank.	2. Test. If bad, replace sender.
47. FULL reading at all times.	1. Wire #27 BRN/GRN to sender is shorted to ground.	1. Repair short.
	2. Defective fuel level sender at fuel tank.	2. Test. Replace if defective.
48. Fuel level indicator bars indicate inaccurately.	1. Defective fuel level sender in tank.	1. Replace fuel level sender in tank.
	2. Low voltage at fuel level sender (should read 33.5 ohms for a full tank of fuel and 240 ohms for an empty tank).	2. Check ohm reading. Determine and correct cause of low voltage.

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