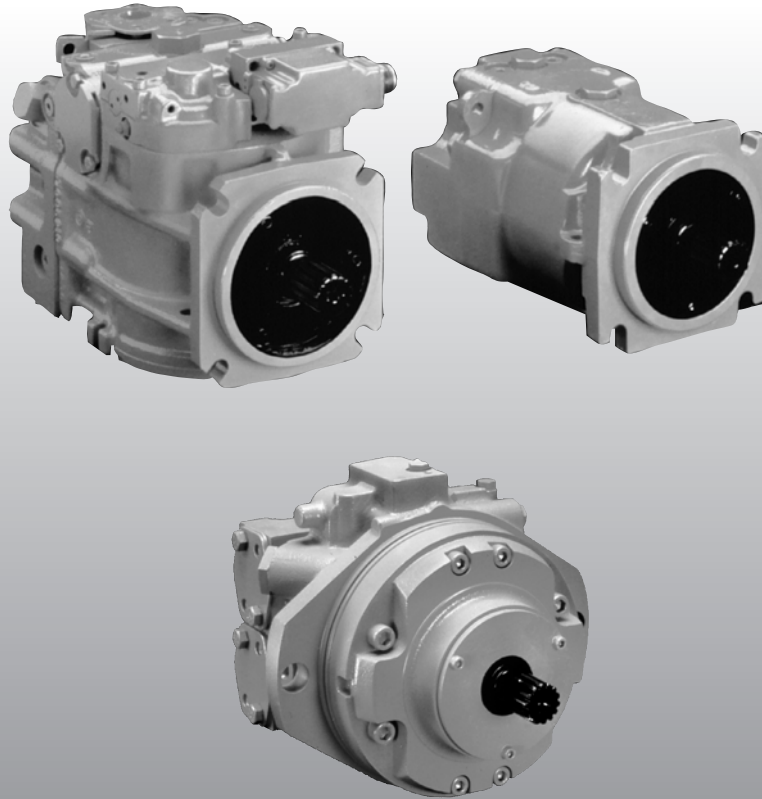




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## Series 90

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**Axial Piston**

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**Pumps and Motors**

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**Service Manual**

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## Introduction

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### Use of this Manual

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This manual includes information for the normal operation, maintenance, and servicing of the Series 90 family of hydrostatic pumps and motors.

The manual also includes the description of the units and their individual components, troubleshooting information, adjustment instructions, and minor repair procedures. Unit warranty obligations should not be affected if maintenance, adjustment, and minor repairs are performed according to the procedures described in this manual.

Many service and adjustment activities can be performed without removing the unit from the vehicle or machine. However, adequate access to the unit must be available, and the unit must be thoroughly cleaned before beginning maintenance, adjustment, or repair activities.

Since dirt and contamination are the greatest enemies of any type of hydraulic equipment, cleanliness requirements must be strictly adhered to. This is especially important when changing the system filter and during adjustment and repair activities.

For further information refer to Series 90 Technical Information. For information about fluid requirements refer to SAUER-SUNDSTRAND BLN 9887 or SDF (Id No. 697581).

A worldwide network of SAUER-SUNDSTRAND Authorized Service Centers is available should repairs be needed. Contact any SAUER-SUNDSTRAND Authorized Service Center for details. A list of all Service Centers can be found in bulletin BLN-2-400527, or in brochure SAW (Ident. No. 698266).

### Safety Precautions

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Observe the following safety precautions when using and servicing hydrostatic products.

#### Loss of Hydrostatic Braking Ability

---

**WARNING**

The loss of hydrostatic drive line power in any mode of operation (e.g., forward, reverse, or "neutral" mode) may cause the loss of hydrostatic braking capacity. A braking system, redundant to the hydrostatic transmission must, therefore, be provided which is adequate to stop and hold the system should the condition develop.

S00001E

#### Fluid under High Pressure

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**WARNING**

Use caution when dealing with hydraulic fluid under pressure. Escaping hydraulic fluid under pressure can have sufficient force to penetrate your skin causing serious injury. This fluid may also be hot enough to burn. Serious infection or reactions can develop if proper medical treatment is not administered immediately.

S000 003E

#### Disable Work Function

---

**WARNING**

Certain service procedures may require the vehicle/machine to be disabled (wheels raised off the ground, work function disconnected, etc.) while performing them in order to prevent injury to the technician and bystanders.

S000 005E

#### Flammable Cleaning Solvents

---

**WARNING**

Some cleaning solvents are flammable. To avoid possible fire, do not use cleaning solvents in an area where a source of ignition may be present.

S000 004E

**Contents**

<b>Introduction .....</b>	<b>2</b>
Use of this Manual .....	2
Safety Precautions .....	2
<b>Functional Description .....</b>	<b>5</b>
General Description and Cross Sectional Views .....	5
Variable Displacement Pumps .....	5
Fixed Displacement Motor .....	5
Variable Displacement Motor .....	6
The System Circuit .....	7
The Basic Closed Circuit .....	7
Case Drain and Heat Exchanger .....	7
Common Features of Pumps and Motors .....	8
End Caps and Shafts .....	8
Speed Sensors .....	8
Pump Features .....	9
Charge Pump .....	9
Charge Relief Valve .....	9
Multi-Function Valves .....	9
Pressure Limiter and High Pressure Relief Valves .....	10
System Check Valves .....	10
Bypass Valves .....	10
Displacement Limiters .....	11
Auxiliary Mounting Pads .....	11
Filtration Options .....	11
Pressure Override (POR) - 180 Frame Size Only .....	12
Pump Control Options .....	13
Manual Displacement Control (MDC) .....	13
Hydraulic Displacement Control (HDC) .....	13
Electric Displacement Control (EDC) .....	14
Automotive Control (FBA II B) .....	14
3-Position (FNR) Electric Control .....	14
Motor Features .....	15
Motor Loop Flushing Valve and Charge Relief Valve .....	15
Variable Motor Displacement Limiters .....	15
Variable Motor Controls .....	16
Hydraulic 2-Position Control .....	16
Electric 2-Position Control .....	16
<b>Technical Specifications .....</b>	<b>17</b>
General Specifications .....	17
Circuit Diagrams .....	17
Hydraulic Parameters .....	18
Size Specific Data .....	19
<b>Pressure Measurement .....</b>	<b>20</b>
Required Tools .....	20
Port Locations and Pressure Gauge Installation .....	20
Variable Pump .....	20
Fixed Motor .....	23
Variable Motor .....	24
<b>Initial Start-Up Procedure .....</b>	<b>25</b>
<b>Fluid and Filter Maintenance .....</b>	<b>26</b>
<b>Troubleshooting .....</b>	<b>27</b>
"NEUTRAL" Difficult or Impossible to Find .....	27
System Operating Hot .....	27
Transmission Operates Normally in One Direction Only .....	28
System Will Not Operate in Either Direction .....	28
Low Motor Output Torque .....	29
Improper Motor Output Speed .....	29
Excessive Noise and/or Vibration .....	30
System Response is Sluggish .....	30

<b>Inspections and Adjustments .....</b>	<b>31</b>
Pump Adjustments .....	31
Charge Pressure Relief Valve Adjustment .....	31
Multi-Function Valve Pressure Adjustment .....	33
Engaging the Bypass Function .....	35
Pressure Override (POR) Valve Pressure Adjustment (Option for 180 Frame Size) .....	36
Displacement Limiter Adjustment .....	37
Pump Control Adjustments .....	38
Standard Manual Displacement Control (MDC) Adjustment .....	38
Non-Linear Manual Displacement Control (MDC) .....	39
MDC Neutral Start Switch (NSS) Adjustments .....	40
Hydraulic Displacement Control (HDC) and Electric Displacement Control (EDC) Adjustment .....	46
Motor Adjustments .....	48
Charge Relief Valve Adjustment .....	48
Displacement Limiter Adjustment (MV) .....	49
Displacement Control Adjustments .....	49
Speed Sensor Adjustment .....	50
<b>Minor Repair Instructions .....</b>	<b>51</b>
Pump and Motor Minor Repair .....	53
Pump / Fitting Torques .....	53
Shaft Seal and Shaft Replacement .....	54
Pump Minor Repairs .....	56
Multi-Function Valve Cartridges .....	56
Pressure Override Valve (Option for 180 Frame Size) .....	57
Charge Relief Valve .....	57
Charge Pump - Remove .....	58
Installing the Charge Pump .....	60
Auxiliary Pad Installation .....	62
Auxiliary Pad Conversion .....	63
Filtration Options .....	64
Pump controls .....	65
Cover Plate .....	65
Manual Displacement Control (MDC) .....	66
Solenoid Override Valve for MDC .....	67
Solenoid Override Valve for MDC with Pressure Released Brake .....	67
Hydraulic and Electric Displacement Controls .....	68
Pressure Control Pilot (PCP) for Electric Displacement Control .....	68
3-Position (FNR) Electric Control .....	69
Displacement Control Components .....	69
Minor Repair - Motor .....	71
Loop Flushing and Charge Relief Valves .....	71
Variable Motor Displacement Limiters .....	73
Variable Motor Controls .....	74
Electrohydraulic 2-Position Control (Types NA, NB, NC, and ND) .....	74
Hydraulic 2-Position Control (Type PT) .....	74
Control Plugs .....	74
Variable Motor Control Orifices .....	75
Speed Sensor .....	77
<b>Exploded View Parts Drawings / Parts Lists .....</b>	<b>78</b>
Variable Pumps .....	78
Minor Repair Parts .....	78
Parts List .....	79
Variable Pump Controls .....	80
Control Parts List .....	81
Filter and Options .....	82
Parts List Filter and Options .....	83
Name Plates .....	83
Fixed Motor .....	84
Minor Repair Parts .....	84
Parts List .....	85
Name Plates .....	85
Variable Motor .....	86
Minor Repair Parts .....	86
Parts List .....	87
Name Plate .....	87



**Functional Description**

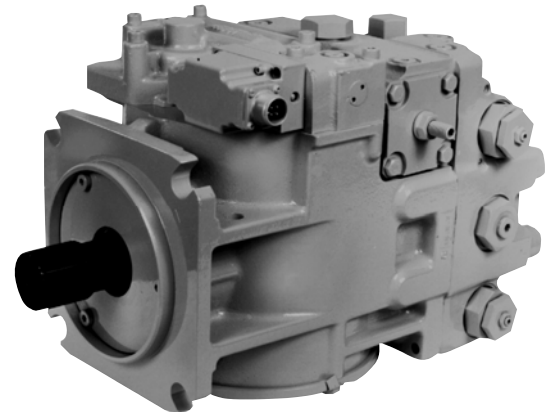
This section describes the operation of pumps, motors, and their various serviceable features. It is a useful reference for readers unfamiliar with the functioning of a specific system.

**General Description and Cross Sectional Views**

**Variable Displacement Pumps**

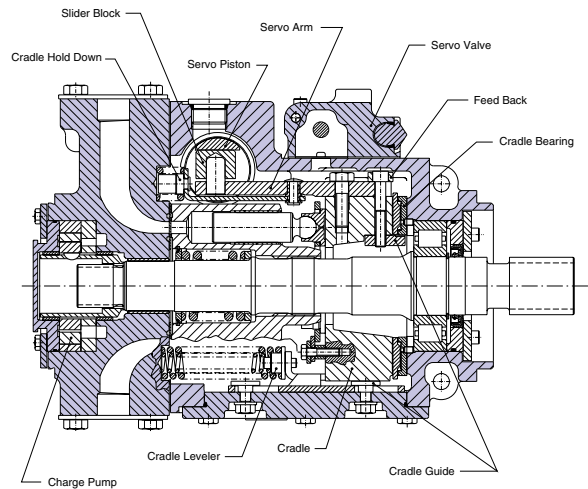
The Variable Displacement Pump (PV) is designed to convert an input torque into hydraulic power. The input shaft turns the pump cylinder which contains a ring of pistons. The pistons run against a tilted plate, called the swashplate. This causes the pistons to compress the hydraulic fluid which imparts the input energy into the hydraulic fluid. The high pressure fluid is then ported out to provide power to a remote function.

The swashplate angle can be varied by the control piston. Altering the swashplate angle varies the displacement of fluid in a given revolution of the input shaft.



F000 539

**Series 90 Variable Displacement Pump (PV)**

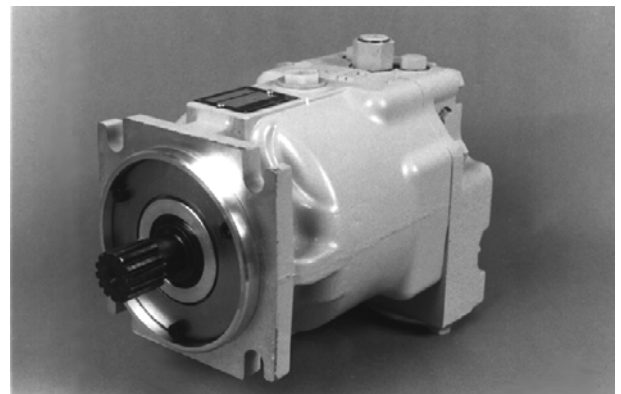


P001 413E

**Series 90 PV Cross Section**

**Fixed Displacement Motor**

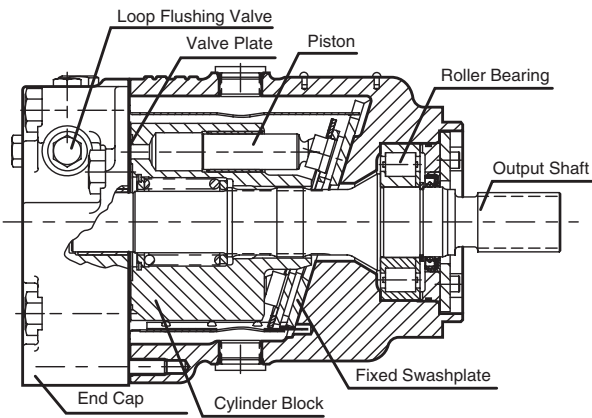
The Fixed Displacement Motor (MF) is designed to convert an input of hydraulic power into an output torque. It operates in the reverse manner of the pump. The high pressure hydraulic fluid enters through the input port. The fluid pressure builds behind the pistons causing them to move down the swashplate (the path of least resistance). As the piston returns up the swashplate again, the fluid is allowed to exit through the exit port. The spinning pistons are housed in a cylinder which is connected to the output shaft. The output torque can be applied to a mechanical function.



90000347

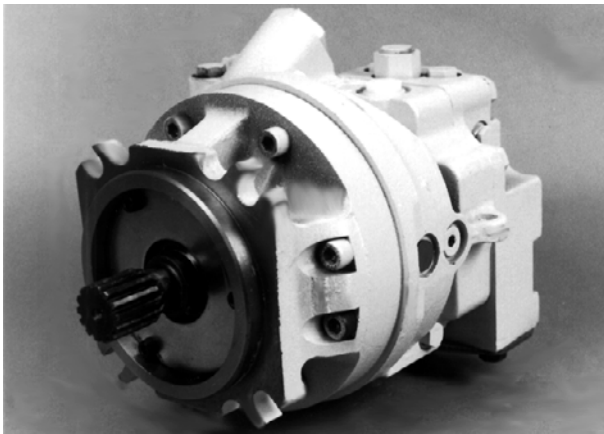
**Series 90 Fixed Displacement Motor (MF)**

In the Fixed Displacement Motor the "swashplate" is fixed, so any variation in motor speed and torque must be made by the input mechanism, i.e. the pump.



90000190E

**Series 90 MF Cross Section**

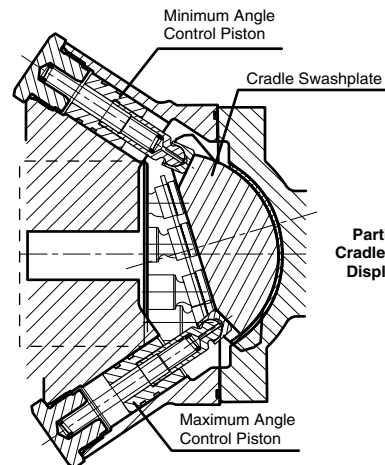
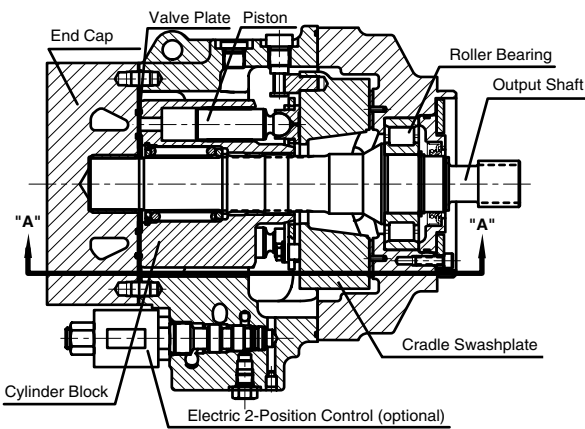


90000348

**Series 90 Variable Displacement Motor (MV)**

**Variable Displacement Motor**

The Variable Displacement Motor (MV) operates in the same manner as the fixed motor. However, its swashplate is not fixed; it can be switched between minimum and maximum angle to amplify torque or speed like the Variable Displacement Pump.

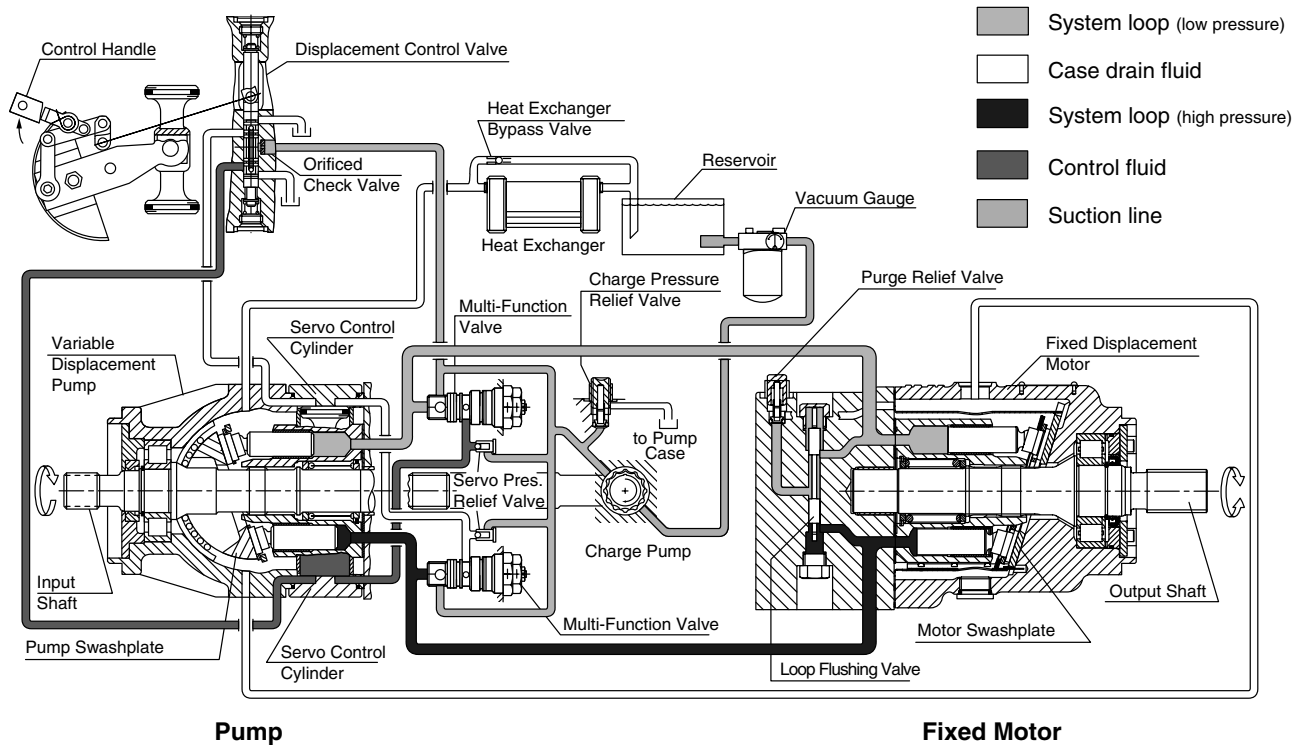


**Partial Section "A-A"  
Cradle Swashplate in Full  
Displacement Position**

**Series 90 MV Cross Section**

90000234E

**The System Circuit**



**Circuit Diagram for Series 90 PV and 90 MF**

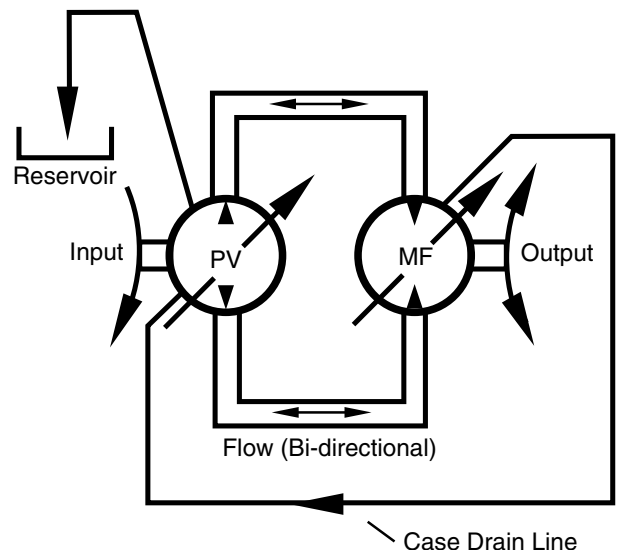
90000800E

**The Basic Closed Circuit**

The main ports of the pump are connected by hydraulic lines to the main ports of the motor. Fluid flows, in either direction, from the pump to the motor then back to the pump in this closed circuit. Either of the hydraulic lines can be under high pressure. In pumping mode the position of the pump swashplate determines which line is high pressure as well as the direction of fluid flow.

**Case Drain and Heat Exchanger**

The pump and motor require case drain lines to remove hot fluid from the system. The motor should be drained from its topmost drain port to ensure the case remains full of fluid. The motor case drain can then be connected to the lower drain port on the pump housing and out the top most port. A heat exchanger, with a bypass valve, is required to cool the case drain fluid before it returns to the reservoir.



**Basic Closed Circuit**

90000803E

**Common Features of Pumps and Motors**

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**End Caps and Shafts**

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Series 90 pumps and motors can be supplied with a variety of end caps and shafts to allow for almost any configuration. For pumps, end caps are available with system ports on either side ("side ports") or both ports on one side ("twin ports"). Motors have end caps with ports on the face of the end cap ("axial ports") or both ports on one side ("twin ports"). See the Series 90 Technical Information manuals (BLN-10029 and BLN-10030) or the Series 90 Price Book (BLN-2-40588) for information on available options.

**Removing the end cap will void the warranty on a Series 90 pump or motor.**

**Speed Sensors**

---

An optional speed sensor can be installed on Series 90 pumps and motors to provide unit speed information. The sensor reads a magnetic ring wrapped about the unit's cylinder. See the corresponding Section to locate, install and adjust the sensor.



**Speed Sensor**

90000810

**Pump Features**

**Charge Pump**

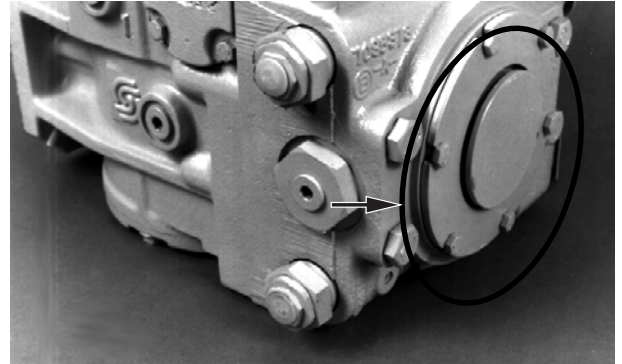
The charge pump is necessary to supply cool fluid to the system, to maintain positive pressure in the main system loop, to provide pressure to operate the control system, and to make up for internal leakage. Charge pressure must be at its specified pressure under all conditions of driving and braking to prevent damage to the transmission.

The charge pump is a fixed-displacement, gerotor type pump installed in the variable displacement pump and driven off the main pump shaft. Charge pressure is limited by a relief valve.

The standard charge pump will be satisfactory for most applications. However, if the charge pump sizes available for the given main pump size are not adequate, a gear pump may be mounted to the auxiliary mounting pad and supply the required additional charge flow.

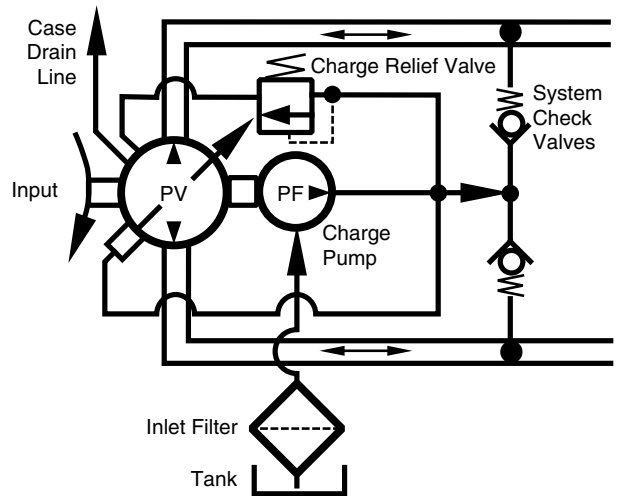
**Charge Relief Valve**

The charge relief valve on the pump serves to maintain charge pressure at a designated level. A direct-acting poppet valve relieves charge pressure whenever it surpasses a certain level. This level is nominally set referencing case pressure at 1500 rpm. This nominal setting assumes the pump is in neutral (zero flow); in forward or reverse charge pressure will be lower. The charge relief valve setting is specified on the model code of the pump.



90000243

**PV with Charge Pump**



90000804E

**Pump Charge System**

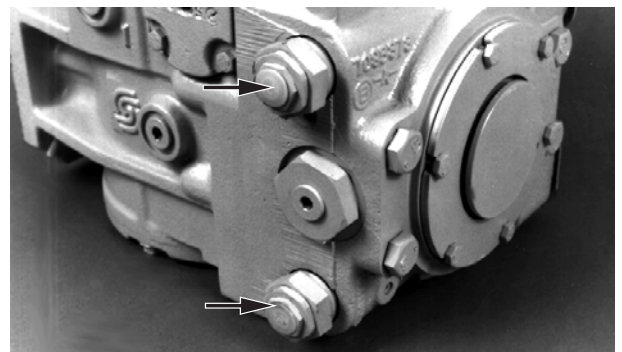
**Multi-Function Valves**

The multi-function valve incorporates  
 the system check valve,  
 the pressure limiter valve,  
 the high pressure relief valve and  
 the bypass valve

in a replaceable cartridge.

These functions are described separately. There are two multi-function valve cartridges in each Series 90 pump to handle functions in either direction. See corresponding Sections for adjustments and repairs.

NOTE: Some multi-function valves do not include a pressure limiter valve.



90000243

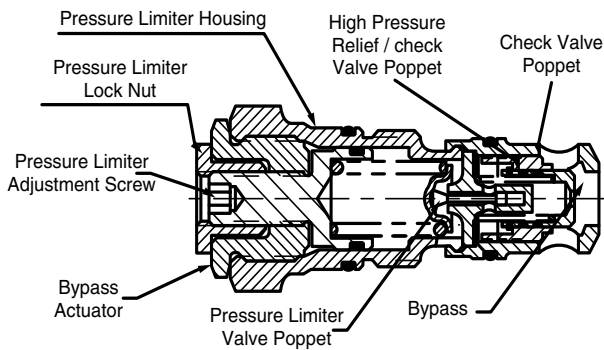
**Multi-Function Valve**

**Pressure Limiter and High Pressure Relief Valves**

Series 90 pumps are designed with a sequenced pressure limiting system and high pressure relief valves. When the preset pressure is reached, the pressure limiter system acts to rapidly destroke the pump so as to limit the system pressure. For unusually rapid load application, the high pressure relief valve acts to immediately limit system pressure by cross-porting system flow to the low pressure side of the loop. The pressure limiter valve acts as the pilot for the high pressure relief valve spool. The high pressure relief valve is sequenced to operate at approximately 35 bar (500 psi) above the level that initiates the pressure limiter valve.

Both the pressure limiter sensing valves and relief valves are built into the multi-function valves (see above).

NOTE: For some applications, such as dual path vehicles, the pressure limiter function may be defeated so that only the high pressure relief valve function remains.



**Cross Section of Multi-Function Valve**

90000806E

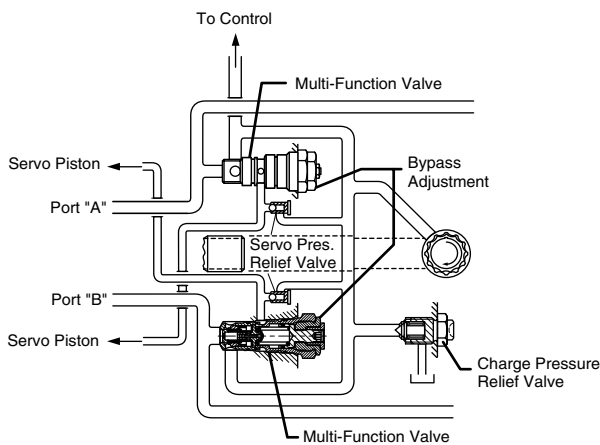
**System Check Valves**

The system check valves allow pressurized flow from the charge pump to enter the low pressure side of the loop whenever system pressure dips below a certain level. This is needed as the pump will generally lose system pressure due to leakage and other factors. Since the pump can operate in either direction, two system check valves are used to direct the charge supply into the low pressure lines. The system check valves are poppet valves located in the multi-function valve assembly.

**Bypass Valves**

The bypass valves ("tow") can be operated when it is desired to move the vehicle or mechanical function when the pump is not running. The valve is opened by manually resetting the valve position.

The bypass valves are built into the multi-function valves.



**Circuit Diagram showing Pressure Control Mechanism**

90000801E

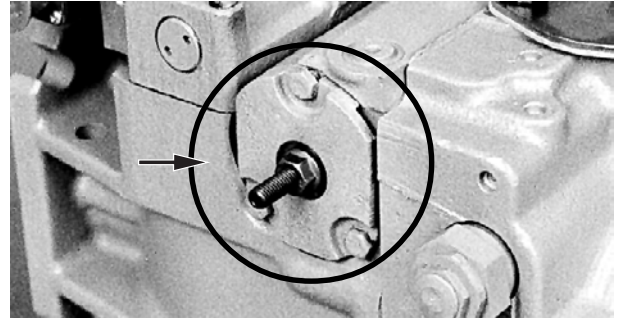


## Displacement Limiters

All Series 90 pumps are designed for optional mechanical displacement (stroke) limiters. The maximum displacement of the pump can be limited in either direction.

The setting can be set as low as 0° in either direction.

For instructions on adjustment see corresponding Section.

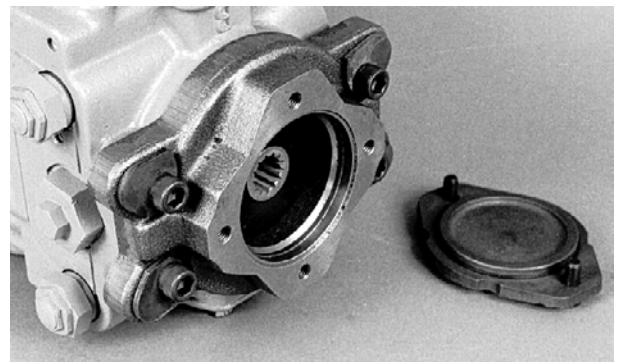


90000244

**PV with Displacement Limiters**

## Auxiliary Mounting Pads

Auxiliary mounting pads are available on all Series 90 pumps. SAE A through E mounts are available (availability varies by pump size). This pad is used for mounting auxiliary hydraulic pumps and for mounting additional Series 90 pumps to make tandem pumps. The pads allow for full through-torque capability.



90000242

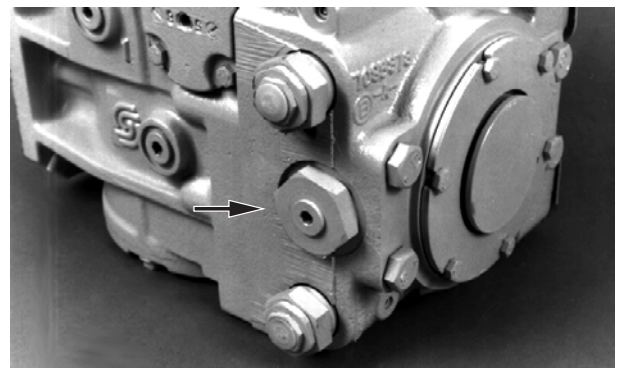
**PV with Auxiliary Mounting Pad**

## Filtration Options

All Series 90 pumps are available with provisions for either suction or charge pressure filtration (integral or remote mounted) to filter the fluid entering the charge circuit.

### Suction Filtration

The suction filter is placed in the circuit between the reservoir and the inlet to the charge pump. When suction filtration is used, a reducer fitting is placed in the charge pressure gauge port (M3). Filtration devices of this type are provided by the user.



90000243

**PV with Suction Filtration  
(No filtration device attached)**

### Charge Pressure Filtration

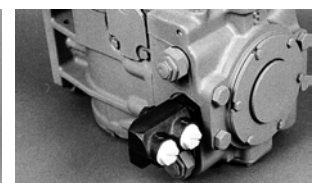
The pressure filter may be integrally mounted directly on the pump or a filter may be remotely mounted for ease of servicing.

A 125 µm screen, located in the reservoir or the charge inlet line, is recommended when using this filtration option.



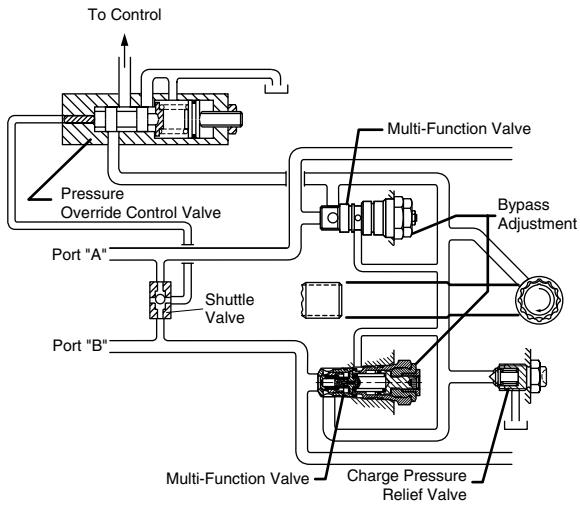
90000246

**PV with Integral Charge Pump**



90000247

**PV with Remote Charge Pump**



**POR-Valve (180 Frame Size only)**

90000802E

**Pressure Override (POR) - 180 Frame Size Only**

The pressure override valve (POR) modulates the control pressure to the displacement control to maintain a pump displacement which will produce a system pressure level less than or equal to the POR setting. For unusually rapid load application, the high pressure relief valve function of the multifunction valves is available to also limit the pressure level.

The pressure override consists of a three-way normally open valve which operates in series with the pump displacement control. Control supply pressure is normally ported through the pressure override valve to the displacement control valve for controlling the pump's displacement. If the system demands a pressure above the override setting, the POR valve will override the control by reducing the control pressure supplied to the displacement control. As the control pressure reduces, the internal forces tending to rotate the swashplate overcome the force of the servo pistons and allow the pump's displacement to decrease.



**Pump Control Options**

**Manual Displacement Control (MDC)**

The manual displacement control converts a mechanical input signal to a hydraulic signal using a spring-centered four-way servo valve. This valve ports hydraulic pressure to either side of a dual-acting servo piston. The servo piston rotates the cradle swashplate through an angular rotation of  $\pm 17^\circ$ , thus varying the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

The MDC is designed so the angular position of the pump swashplate is proportional to the rotation of the control input shaft.

**Non-Linear MDC**

The non-linear manual displacement control operates in the same manner as the regular MDC except that it is designed so the change in the angular position of the pump swashplate *progressively* increases as the control input shaft is rotated toward its maximum displacement position.

**Solenoid Override Valve for MDC**

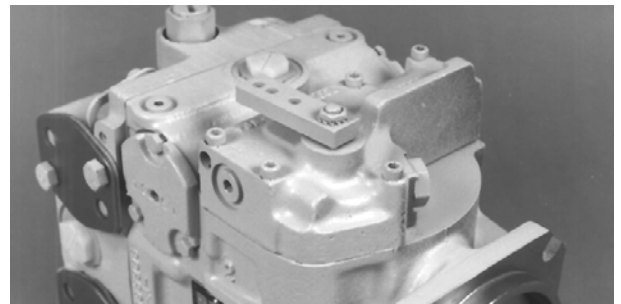
A solenoid override valve option (not shown here) is available for MDC. This safety feature will return the swashplate to zero displacement position when activated. The valve may be set in either a normally open or normally closed mode.

**Neutral Start Switch (NSS)**

The neutral start switch is an optional feature available with MDC. When connected properly with the vehicle's electrical system, the neutral start switch ensures that the prime mover can be started only when the control is in a neutral position.

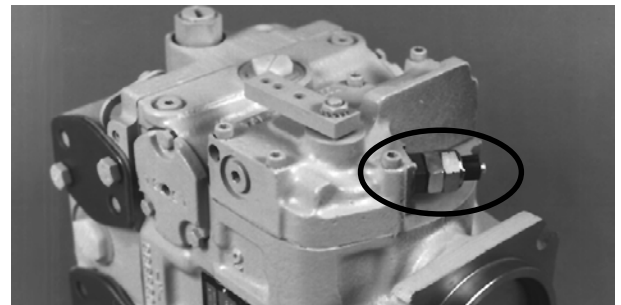
**Hydraulic Displacement Control (HDC)**

The hydraulic displacement control uses a hydraulic input signal to operate a spring-centered four-way servo valve. This valve ports hydraulic pressure to either side of a dual-acting servo piston. The servo piston rotates the cradle swashplate through an angular rotation of  $\pm 17^\circ$ , thus varying the pump's displacement from full displacement in one direction to full displacement in the opposite direction. The HDC is designed so the angular position of the pump swashplate is proportional to input pressure.



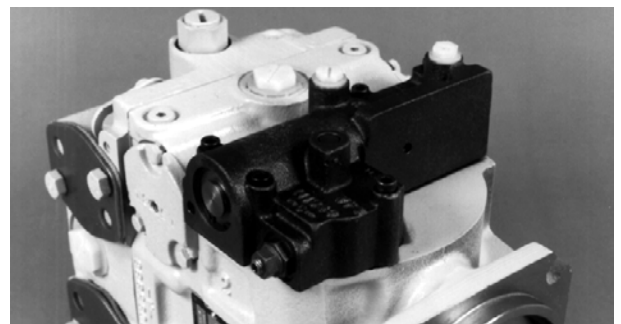
90000237

**PV with Manual Displacement Control**



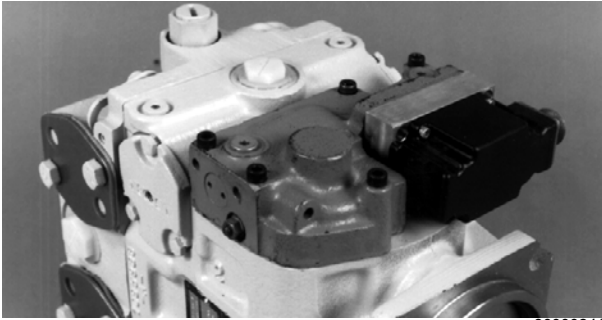
90000239

**PV with Manual Displacement Control and Neutral Start Switch**



90000240

**PV with Hydraulic Displacement Control**



90000241

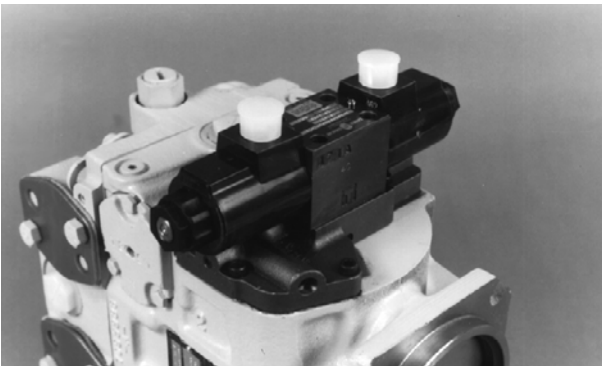
**PV with Electric Displacement Control****Electric Displacement Control (EDC)**

The electric displacement control is similar to the hydraulic displacement control with the input signal pressure controlled by a pressure control pilot (PCP) valve. The PCP valve converts a DC electrical input signal to a hydraulic signal which operates a spring-centered four-way servo valve. This valve ports hydraulic pressure to either side of a dual-acting servo piston. The servo piston rotates the cradle swashplate through an angular rotation of  $\pm 17^\circ$ , thus varying the pump's displacement from full displacement in one direction to full displacement in the opposite direction. The control is designed so the angular position of the swashplate is proportional to the EDC input.

**Automotive Control (FBA II B)**

Automotive Control allows a vehicle to be driven in a manner similar to an automobile with an automatic transmission.

The Automotive Control includes a three-position electric control to provide direction control.



90000354

**PV with 3-Position (FNR) Electric Control****3-Position (FNR) Electric Control**

This control utilizes a 12 or 24 VDC electrically operated spool valve to port pressure to either side of the pump displacement control piston. Energizing one of the solenoids will cause the pump to go to its maximum displacement in the corresponding direction.

All functions of the three-position (FNR) electric control are preset at the factory.

**Motor Features**

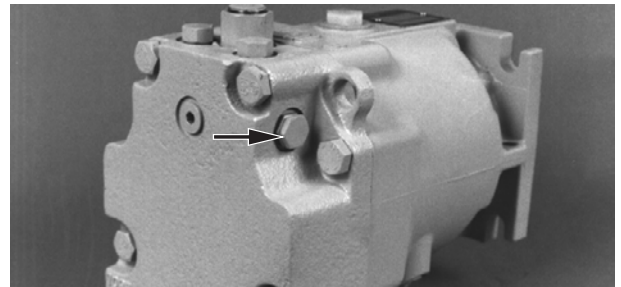
**Motor Loop Flushing Valve and Charge Relief Valve**

All Series 90 motors are designed to accommodate a loop flushing valve. The loop flushing valve is used in installations which require additional fluid to be removed from the main hydraulic circuit because of transmission cooling requirements, or unusual circuits requiring additional loop flushing to remove excessive contamination in the high pressure circuit.

A shuttle valve and charge relief valve are installed in the motor end cap to provide the loop flushing function. The shuttle valve provides a circuit between the low pressure side of the closed loop and the charge relief valve in the motor end cap.

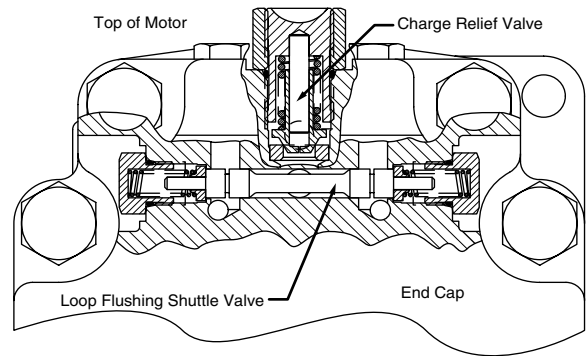
The motor charge relief valve regulates the charge pressure level only when there is a pressure differential in the main loop. The shuttle valve is spring centered to the closed position so that no high pressure fluid is lost from the circuit when reversing pressures.

For charge relief valve adjustment see corresponding Section.



90000248

**Loop Flushing Valve (MF)**



90000238E

**Motor Charge Relief Valve and Loop Flushing Shuttle Valve**

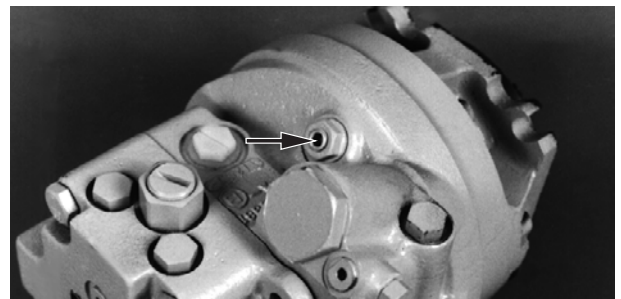
**Variable Motor Displacement Limiters**

All Series 90 variable motors include mechanical displacement (stroke) limiters. Both the maximum and minimum displacement of the motor can be limited.

The range of the settings is as follows:

	055 MV	075 MV
<b>Minimum Displacement</b>	19 - 40 cm <sup>3</sup> 1.2 - 2.4 in <sup>3</sup>	26 - 54 cm <sup>3</sup> 1.6 - 3.3 in <sup>3</sup>
<b>Maximum Displacement</b>	65 - 100 %	65 - 100 %

T002 251E

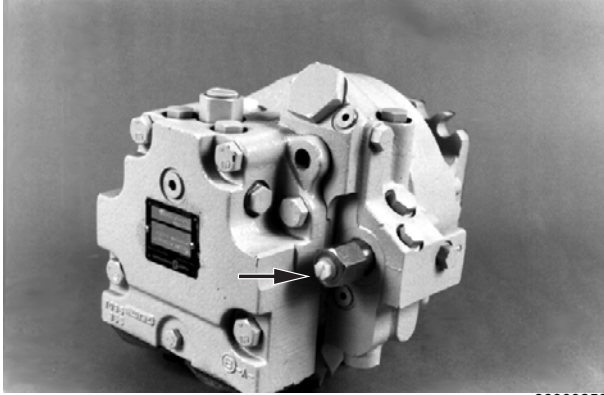


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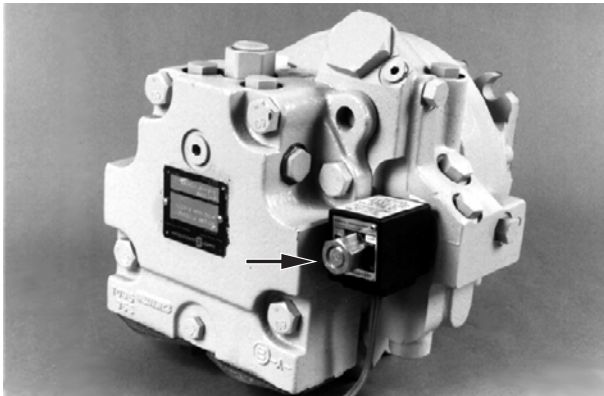
**MV Maximum Displacement Limiter  
(Minimum Displacement Limiters on opposite side)**

**Variable Motor Controls**

---

**MV with Hydraulic 2-Position Control****Hydraulic 2-Position Control**

This control utilizes a hydraulically operated three-way hydraulic valve to port system pressure to either of the motor displacement control pistons. The motor is normally held at its maximum displacement. Supplying pilot hydraulic pressure to the valve will cause the motor to go to its minimum displacement.

**MV with Electric 2-Position Control****Electric 2-Position Control**

This control utilizes an electric solenoid operated three-way hydraulic valve to port system pressure to either of the motor displacement control pistons. The motor is normally held at its maximum displacement. Energizing the solenoid will cause the motor to go to its minimum displacement.

Technical Specifications

General Specifications

Design

Variable Pumps and Motors: Axial piston pump of variable displacement, cradle swashplate design.

Fixed Motors: Axial piston motor with fixed displacement, fixed swashplate design.

Type of Mounting (per SAE J744)

SAE flange, Size "B", 2 bolts,  
SAE flange, Size "C and E", 4 bolts.

Cartridge flange, 2 bolts (for motor only).

Port Connections

(for details see chapter "Pressure Measurement")

Main pressure ports: SAE flange, Code 62,  
Remaining ports: SAE straight thread O-ring boss.

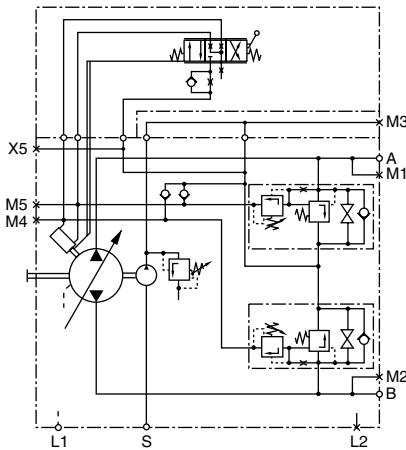
Direction of Rotation

Clockwise or counterclockwise (motors are bi-directional)

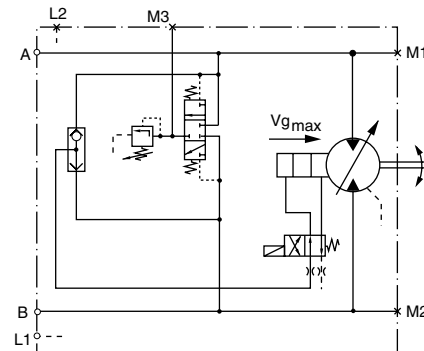
Recommended Installation Position

Pump installation recommended with control position on the top or side. Consult SAUER-SUNDSTRAND for non-conformance guidelines. The housing must always be filled with hydraulic fluid.

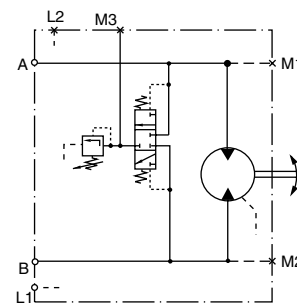
Circuit Diagrams



PV with Charge Pump and Manual Displacement Control



MV with Electrohydraulic 2-Position Control



MF

90000811  
90000812  
90000813

**Hydraulic Parameters**

System Pressure Range	bar	psi
Rated Pressure	420	6000
Maximum Pressure	480	6960
T002 252E		

Charge Pump Inlet Vacuum (on pumps only)	bar abs	in Hg
Minimum Vacuum (continuous)	0.7	10
Minimum Vacuum during Cold Start (Intermittent)	0.2	25
T002 253E		

Case Pressure	bar	psi
Maximum (Continuous)	3	44
Maximum during Cold Start (Intermittent)	5	73
T002 254E		

**Hydraulic Fluid**

Refer to SAUER-SUNDSTRAND BLN 9887 or SDF (Id No. 697581). Also refer to publication ATI-E 9101 for information relating to biogradable fluids.

Temperature Range <sup>1)</sup>		
	°C	[°F]
Minimum	-40	[-40]
Rated	104	[220]
Maximum	115	[240]
intermittent, cold start intermittent T002 006E		

<sup>1)</sup> At the hottest point, normally the case drain port.

Viscosity			
	mm <sup>2</sup> /s	[SUS]	
Minimum	7	[49]	intermittent
Recommended operating range	12-60	[70-278]	
Maximum	1600	[7500]	intermittent, cold start
T002 010E			

Cleanliness Level and $\beta_x$ -Ratio	
Required fluid cleanliness level	ISO 4406 Class 18/13
Recommended $\beta_x$ -ratio for suction filtration	$\beta_{35-45}=75$ ( $\beta_{10} \geq 2$ )
Recommended $\beta_x$ -ratio for charge pressure filtration	$\beta_{15-20}=75$ ( $\beta_{10} \geq 10$ )
Recommended inlet screen size for charge pressure filtration	100 $\mu$ m-125 $\mu$ m
T002 007E	

**Cleanliness**

Refer to SAUER-SUNDSTRAND Publications BLN 9887 or SDF (NO. 697581) and ATI-E 9201.

**Size Specific Data**
**Variable Displacement Pumps**

	Dimension	030 PV	042 PV	055 PV	075 PV	100 PV	130 PV	180 PV	250 PV
Displacement (maximum)	cm <sup>3</sup>	<b>30</b>	<b>42</b>	<b>55</b>	<b>75</b>	<b>100</b>	<b>130</b>	<b>180</b>	<b>250</b>
	in <sup>3</sup>	1.83	2.56	3.35	4.57	6.10	7.93	10.98	15.25
Minimum Speed	min <sup>-1</sup> (rpm)	500	500	500	500	500	500	500	500
Rated Speed	min <sup>-1</sup> (rpm)	4200	4200	3900	3600	3300	3100	2600	2300
Maximum Speed	min <sup>-1</sup> (rpm)	4600	4600	4250	3950	3650	3400	2850	2500
Maximum attainable Speed at max. Displacement	min <sup>-1</sup> (rpm)	5000	5000	4700	4300	4000	3700	3150	2750
Theoretical Torque at max. Displacement	Nm/bar	<b>0.48</b>	<b>0.67</b>	<b>0.88</b>	<b>1.19</b>	<b>1.59</b>	<b>2.07</b>	<b>2.87</b>	<b>3.97</b>
	lbf*in/1000 psi	290	380	530	730	870	1260	1750	2433
Weight (only base unit)	kg	<b>28</b>	<b>34</b>	<b>40</b>	<b>49</b>	<b>68</b>	<b>88</b>	<b>136</b>	<b>154</b>
	lb	62	75	88	108	150	195	300	340

T002 257E

**Fixed and Variable Displacement Motors**

	Einheit	030 MF	042 MF	055 MF	075 MF	100 MF	130 MF	055 MV	075 MV	
Displacement (maximum)	cm <sup>3</sup>	<b>30</b>	<b>42</b>	<b>55</b>	<b>75</b>	<b>100</b>	<b>130</b>	<b>55</b>	<b>75</b>	
	in <sup>3</sup>	1.83	2.56	3.35	4.57	6.10	7.93	3.35	4.57	
Displacement (minimum)	cm <sup>3</sup> in <sup>3</sup>	--	--	--	--	--	--	19	26	
Rated speed	at maximum displacement	min <sup>-1</sup> (rpm)	4200	4200	3900	3600	3300	3100	3900	3600
	at minimum displacement	min <sup>-1</sup> (rpm)	--	--	--	--	--	--	4600	4250
Maximum speed	at maximum displacement	min <sup>-1</sup> (rpm)	4600	4600	4250	3950	3650	3400	4250	3950
	at minimum displacement	min <sup>-1</sup> (rpm)	--	--	--	--	--	--	5100	4700
Max. attainable speed at max. displacement	min <sup>-1</sup> (rpm)	5000	5000	4700	4300	4000	3700	4700	4300	
Theoretical torque at max. displacement	Nm/bar	<b>0.48</b>	<b>0.67</b>	<b>0.88</b>	<b>1.19</b>	<b>1.59</b>	<b>2.07</b>	<b>0.88</b>	<b>1.19</b>	
	lbf*in/1000 psi	290	380	530	730	970	1260	530	730	
Maximum flow at max. displacement	l/min	<b>138</b>	<b>193</b>	<b>234</b>	<b>296</b>	<b>365</b>	<b>442</b>	<b>234</b>	<b>296</b>	
	gal/min	36.5	51	62	78	96	117	62	78	
Max. corner power	kW	<b>111</b>	<b>155</b>	<b>187</b>	<b>237</b>	<b>292</b>	<b>354</b>	224	282	
	hp	149	208	251	318	392	475	300	378	
Weight SAE-Flange	kg	<b>11</b>	<b>15</b>	<b>22</b>	<b>26</b>	<b>34</b>	<b>45</b>	<b>39</b>	<b>44</b>	
	lb	24	34	49	57	74	99	86	98	
Weight Cartridge Motor	kg	--	<b>21</b>	<b>26</b>	<b>33</b>	--	--	<b>40</b>	<b>46</b>	
	lb	--	46	57	72	--	--	88	101	

T002 258E

Refer to Series 90 technical information for definitions.



**Pressure Measurement**

**Required Tools**

The service procedures described in this manual for Series 90 pumps and motors can be performed using common mechanic's tools. Special tools, if required are shown.

Pressure gauges should be calibrated frequently to ensure accuracy. Snubbers are recommended to protect pressure gauges.

**Port Locations and Pressure Gauge Installation**

The following sections list the ports for each type of hydraulic unit. The recommended pressure gauge and fitting are also specified.

Outline drawings showing port locations follow the tables below.

**Variable Pump**

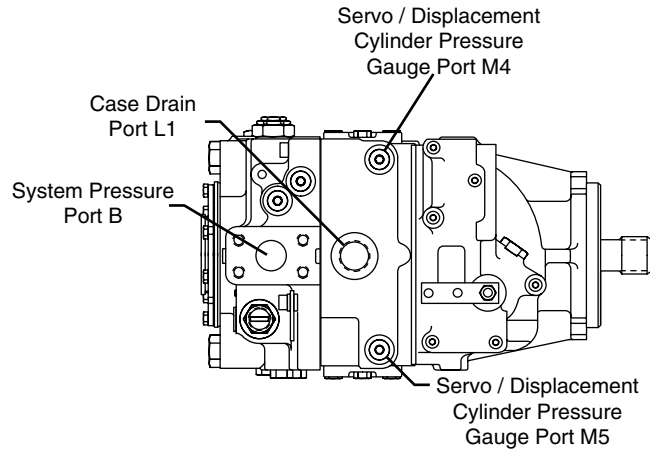
Port	Function	Gauge Size and Fitting
M1	System Pressure Port "A"	1000 bar or 10 000 psi 9/16-18 O-ring
M2	System Pressure Port "B"	1000 bar or 10 000 psi 9/16-18 O-ring fitting
M3 (M6)	Charge Pressure	50 bar or 1000 psi 9/16-18 O-ring
M4 M5	Servo Pressure	50 bar or 1000 psi 9/16-18 O-ring

T002 259E

Port	Function	Gauge Size and Fitting	
L1 L2	Case Pressure	10 bar or 100 psi	
		030 042	7/8-14 O-ring
		055 075 100	1-1/16-12 O-ring
		130	1-5/16-12 O-ring
		180 250	1-5/8-12 O-ring
X1 X2	HDC / EDC Control Pressure	50 bar or 1000 psi 7/16-20 O-ring or 9/16-18 O-ring	
X3	External Control Pressure	50 bar or 1000 psi 9/16-18 O-ring	
S	Charge Pump Inlet	Vacuum Gauge, Tee into Inlet Line	
		030 042	1-1/16-12 O-ring
		055 075	1-5/16-12 O-ring
		100 130 180	1-5/8-12 O-ring
		250	1-1/2 SAE-Split Flange

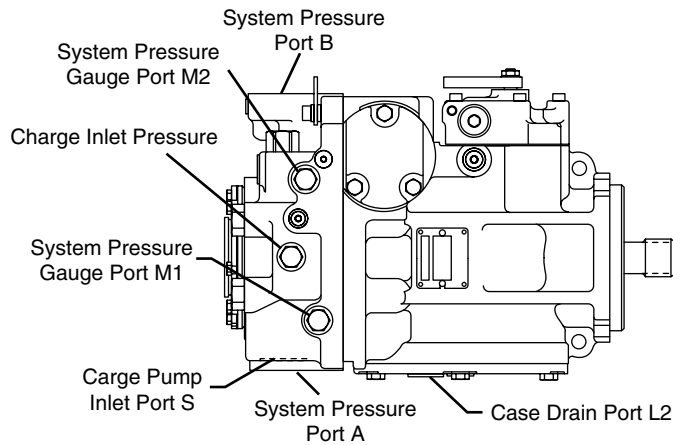
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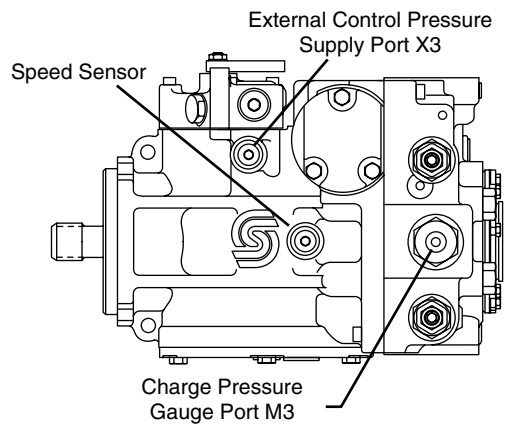


**Top View**

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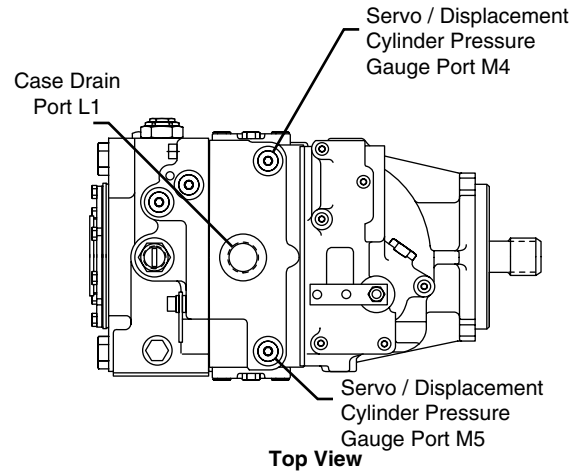
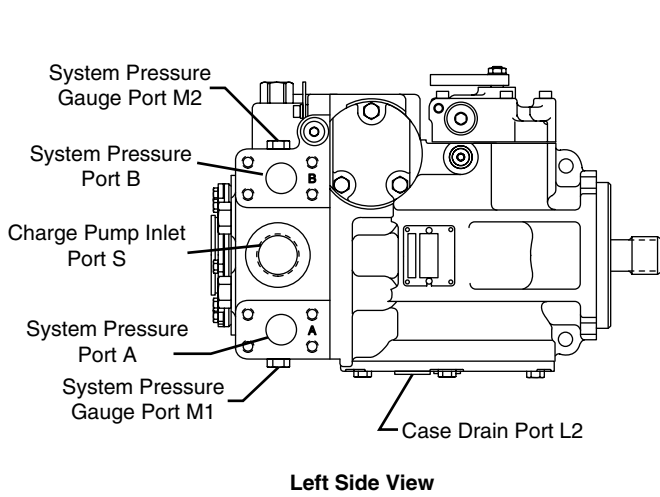
**Left Side View**



**Right Side View**

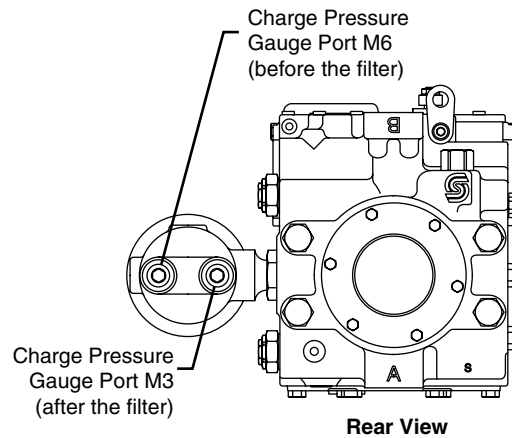
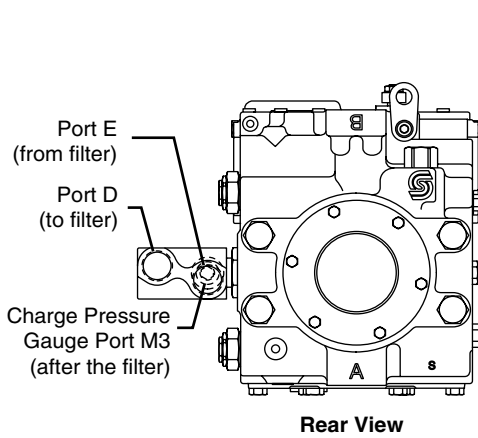
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90000816E

**PV with Side Port End Cap and Manual Displacement Control**



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90000820E

**PV with Twin Port End Cap and Manual Displacement Control**

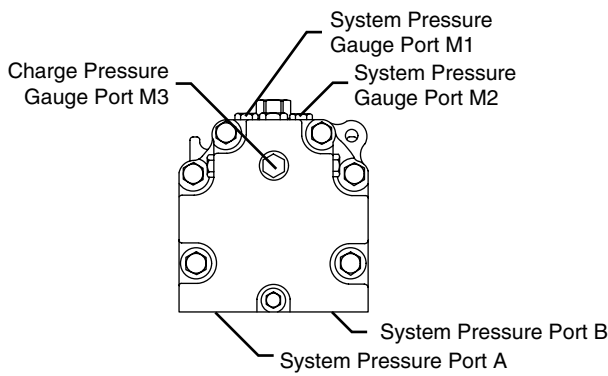


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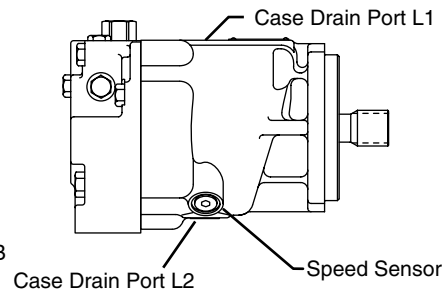
**Fixed Motor**

Port	Function	Gauge Size and Fitting
<b>M1</b>	System Pressure Port "A"	1000 bar or 10 000 psi 9/16-18 O-ring
<b>M2</b>	System Pressure Port "B"	1000 bar or 10 000 psi 9/16-18 O-ring
<b>M3</b>	Charge Pressure	50 bar or 1000 psi 9/16-18 O-ring
T002 261E		

Port	Function	Gauge Size and Fitting	
<b>L1 L2</b>	Case Pressure)	10 bar or 500 psi	
		030 042 055	7/8-14 O-ring
		075 100 130	1-1/16-12 O-ring
		T002 262E	

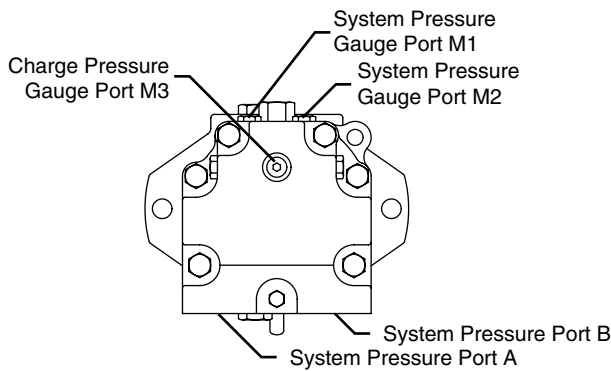


**Rear View**

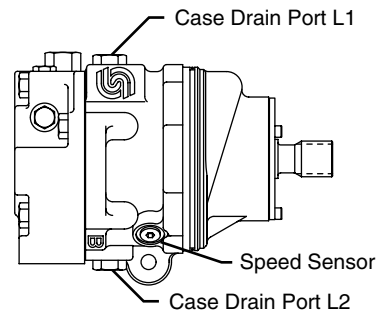


**Left Side View**

**MF with SAE Flange**



**Rear View**



**Left Side View**

**MF with Cartridge Flange**

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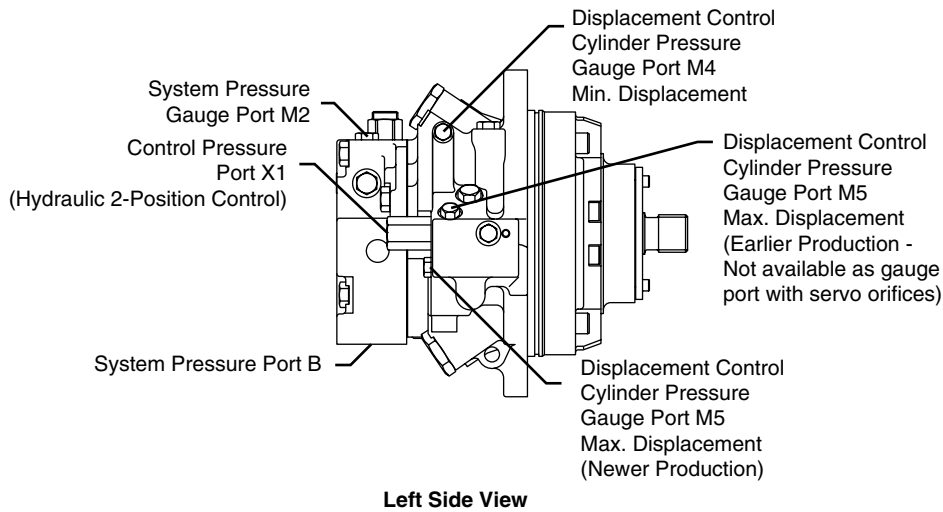
**Variable Motor**

Port	Function	Gauge Size and Fitting
<b>M1</b>	System Pressure Port "A"	1000 bar or 10 000 psi 9/16-18 O-ring
<b>M2</b>	System Pressure Port "B"	1000 bar or 10 000 psi 9/16-18 O-ring
<b>M3</b>	Charge Pressure	50 bar or 1000 psi 9/16-18 O-ring

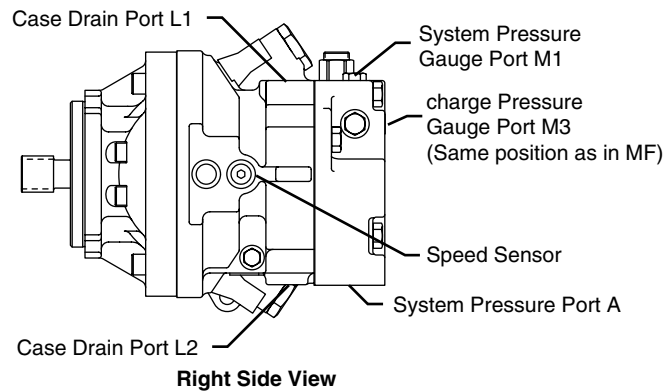
T002 263E

Port	Function	Gauge Size and Fitting
<b>M4</b>	Control Cylinder Pressure "Minimum Displacement"	1000 bar or 10 000 psi 7/16-20 O-ring
<b>M5</b>	Control Cylinder Pressure "Maximum Displacement"	1000 bar or 10 000 psi 7/16-20 O-ring
<b>L1</b> <b>L2</b>	Case Pressure	10 bar or 500 psi 1-1/16-12 O-ring

T002 264E



**MV with Cartridge Flange and Hydraulic 2-Position Control (SAE Flange Version Similar)**



90000823E

**MV with SAE Flange (Cartridge Flange Version Similar)**

## Initial Start-Up Procedure

---

The following start-up procedure should always be followed when starting-up a new Series 90 installation or when restarting an installation in which either the pump or motor had been removed.

**WARNING**

The following procedure may require the vehicle/machine to be disabled (wheels raised off the ground, work function disconnected, etc.) while performing the procedure in order to prevent injury to the technician and bystanders. Take necessary safety precautions before moving the vehicle/machine.

S000007E

Prior to installing the pump and/or motor, inspect the units for damage incurred during shipping and handling. Make certain all system components (reservoir, hoses, valves, fittings, heat exchanger, etc.) are clean prior to filling with fluid.

Fill the reservoir with recommended hydraulic fluid. This fluid should be passed through a 10 micron (nominal, no bypass) filter prior to entering the reservoir. The use of contaminated fluid will cause damage to the components, which may result in unexpected vehicle/machine movement. See the publications BLN-9887 and SDF 697581 for further related information.

The inlet line leading from the reservoir to the pump must be filled prior to start-up. Check inlet line for properly tightened fittings and make sure it is free of restrictions and air leaks.

**Be certain to fill the pump and/or motor housing with clean hydraulic fluid prior to start up.**

Fill the housing by pouring filtered oil into the upper case drain port.

Install a 50 bar (or 1000 psi) pressure gauge in the charge pressure gauge port to monitor the charge pressure during start-up.

It is recommended that the external control input signal (linkage for MDC, hydraulic lines for HDC, or electrical

connections for EDC) be disconnected at the pump control until after initial start-up. This will ensure that the pump remains in its neutral position.

**WARNING**

Do not start prime mover unless pump is in neutral position (0° swashplate angle). Take precautions to prevent machine movement in case pump is actuated during initial start up.

S000008E

“Jog” or slowly rotate prime mover until charge pressure starts to rise. Start the prime mover and run at the lowest possible RPM until charge pressure has been established. Excess air may be bled from the high pressure lines through the high pressure system gauge port.

Once charge pressure has been established, increase speed to normal operating RPM. Charge pressure should be as indicated in the pump model code. If charge pressure is inadequate, shut down and determine cause for improper pressure. Refer to Troubleshooting.

**WARNING**

Take necessary precautions that the motor shaft remains stationary during the adjustment procedure.

S000010E

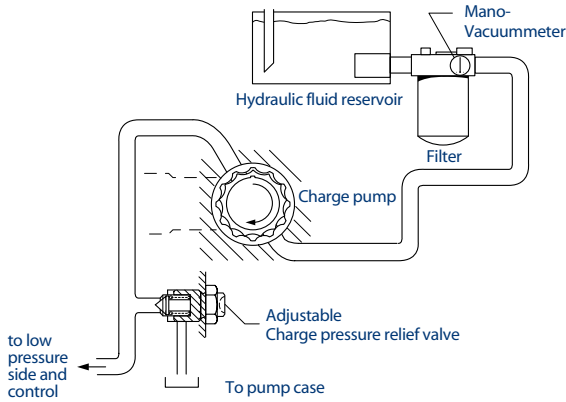
Shut down the prime mover and connect the external control input signal. Also reconnect the machine function if disconnected earlier. Start the prime mover, checking to be certain the pump remains in neutral. With the prime mover at normal operating speed, slowly check for forward and reverse machine operation.

Charge pressure may slightly decrease during forward or reverse operation. Continue to cycle slowly between forward and reverse for at least five minutes.

Shut down prime mover, remove gauges, and plug ports. Check reservoir level and add filtered fluid if needed.

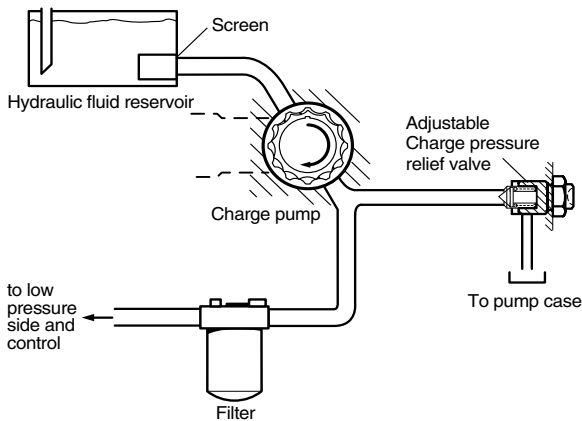
The transmission is now ready for operation.

**Fluid and Filter Maintenance**



P000 797E

**Suction Filtration Schematic**



P000 798E

**Charge Pressure Filtration Schematic  
(Partial flow)**

To ensure optimum service life of Series 90 products, regular maintenance of the fluid and filter must be performed. Contaminated fluid is the main cause of unit failure. Care should be taken to maintain fluid cleanliness while performing any service procedure.

Check the reservoir daily for proper fluid level, the presence of water (noted by a cloudy to milky appearance, or free water in bottom of reservoir), and rancid fluid odor (indicating excessive heat). If either of these conditions occur, change the fluid and filter immediately.

**It is recommended that the fluid and filter be changed per the vehicle/machine manufacturer's recommendations or at the following intervals:**

**First change**

**500** operating hours after start up

**second and subsequent changes**

every **2000** operating hours or once a year.

This recommendation applies for the most applications. High temperatures and pressures will result in accelerated fluid aging and an earlier fluid change may be required. At lower fluid loads longer change intervals are possible. Therefore we suggest to check the fluid with the manufacturer for suitability. This should be done at latest half way between fluid changes.

It may be necessary to change the fluid more frequently than the above intervals if the fluid becomes contaminated with foreign matter (dirt, water, grease, etc.) or if the fluid has been subjected to temperature levels greater than the recommended maximum. Never reuse fluid.

The filter should be changed whenever the fluid is changed or whenever the filter indicator shows that it is necessary to change the filter.

Cleanliness Level and $\beta_x$ -Ratio	
Required fluid cleanliness level	ISO 4406 Class 18/13
Recommended $\beta_x$ -ratio for suction filtration	$\beta_{35-45}=75$ ( $\beta_{10} \geq 2$ )
Recommended $\beta_x$ -ratio for charge pressure filtration	$\beta_{15-20}=75$ ( $\beta_{10} \geq 10$ )
Recommended inlet screen size for charge pressure filtration	100 $\mu\text{m}$ -125 $\mu\text{m}$

T002 007E

## Troubleshooting

This section provides general steps to follow if certain undesirable system conditions are observed. Follow the steps in a section until the problem is solved. Some of the items will be system specific. For areas covered in this manual, a section is referenced. **Always observe the safety precautions listed in the section "Introduction" and related to your specific equipment.**

### "NEUTRAL" Difficult or Impossible to Find

Check	Description	Action
1. Input to pump control.	Input to control module is operating improperly.	Check control input and repair or replace as necessary.
2. Pump displacement control.	Control linkages are not secure, control orifices are blocked, etc.	Adjust, repair, or replace control module as necessary.

If the above actions do not remedy the problem contact a SAUER-SUNDSTRAND Authorized Service Center.

### System Operating Hot

Check	Description	Action
1. Oil level in reservoir.	Insufficient hydraulic fluid will not meet cooling demands of system.	Fill reservoir to proper level.
2. Heat exchanger.	Heat exchanger not sufficiently cooling the system.	Check air flow and input air temperature for heat exchanger. Clean, repair or replace heat exchanger.
3. Charge pressure.	Low charge pressure will overwork system.	Measure charge pressure. Inspect and adjust or replace charge relief valve. Or repair leaky charge pump.
4. Charge pump inlet vacuum.	High inlet vacuum will overwork system. A dirty filter will increase the inlet vacuum. Inadequate line size will restrict flow.	Check charge inlet vacuum. If high, inspect inlet filter and replace as necessary. Check for adequate line size, length or other restrictions.
5. System relief pressure settings.	If the system relief settings are too low, the relief valves will be overworked.	Verify settings of pressure limiters and high pressure relief valves and adjust or replace multi-function valves as necessary.
6. For internal leakage in motor.	Leakage will reduce low side system pressure and overwork the system.	Monitor motor case flow without loop flushing in the circuit (use defeat spool). If flow is excessive, replace motor.
7. System pressure.	High system pressure will overheat system.	Measure system pressure. If pressure is high reduce loads.

If the above actions do not remedy the problem contact a SAUER-SUNDSTRAND Authorized Service Center.

**Transmission Operates Normally in One Direction Only**

Check	Description	Action
1. Input to pump control.	Input to control module is operating improperly.	Check control input and repair or replace as necessary.
2. Pump displacement control.	Control linkages are not secure, control orifices are blocked, etc.	Repair or replace control module as necessary.
3. Interchange system pressure limiters, high pressure relief valves, and system check valves.	Interchanging the multi-function valves will show if the problem is related to the valve functions contained in the multi-function valves.	Interchange multi-function valves. If the problem changes direction, repair or replace the valve on the side that does not operate.
4. Charge pressure.	If charge pressure decays in one direction the loop flushing valve may be "sticking" in one direction.	Measure charge pressure in forward and reverse. If pressure decays in one direction, inspect and repair the motor loop flushing valve.

If the above actions do not remedy the problem contact a SAUER-SUNDSTRAND Authorized Service Center.

**System Will Not Operate in Either Direction**

Check	Description	Action
1. Oil level in reservoir.	Insufficient hydraulic fluid to supply system loop.	Fill reservoir to proper level.
2. Input to pump control.	Input to control module is operating improperly.	Check control input and repair or replace as necessary.
3. Pump displacement control.	Control linkages are not secure, control orifices are blocked, etc.	Repair or replace control module as necessary.
4. Ensure bypass valve(s) are closed.	If bypass valve(s) is open, the system loop will be depressurized.	Close bypass valves. Replace multi-function valve if defective.
5. Charge pressure with pump in neutral.	Low charge pressure insufficient to re-charge system loop.	Measure charge pressure with the pump in neutral. If pressure is low, go to step 6; otherwise continue with step 5.
6. Charge pressure with pump in stroke.	Low charge pressure with the pump in stroke indicates a motor charge relief valve or system pressure relief valve may be improperly set.	Measure charge pressure with pump in stroke. If pressure is low, adjust or replace motor charge relief valve, otherwise go to step 9.
7. Pump charge relief valve.	A pump charge relief valve that is leaky or set too low will depressurize the system.	Adjust or replace pump charge relief valve as necessary.
8. Charge pump inlet filter.	A clogged filter will undersupply system loop.	Inspect filter and replace if necessary.
9. Charge pump.	A malfunctioning charge pump will provide insufficient charge flow.	Repair or replace the charge pump. If OK go to last step.



10. Pump displacement control.	Control linkages are not secure, control orifices are blocked, etc.	Repair or replace control module as necessary.
11. System pressure.	Low system pressure will not provide power necessary to move load.	Measure system pressure. Continue with next step.
12. System multi-function valves.	Defective multi-function valves will cause system pressure to be low.	Repair or replace multi-function valve(s).

If the above actions do not remedy the problem contact a SAUER-SUNDSTRAND Authorized Service Center.

### Low Motor Output Torque

Check	Description	Action
1. System pressure at motor.	Low system pressure at the motor will reduce torque.	Measure system pressure at motor. If pressure limiter setting is low, increase setting.
2. Variable motor stuck at minimum displacement.	Minimum motor displacement yields low output torque.	Check control supply pressure or repair displacement control. Check motor control orifices.
3. For internal leakage.	Internal leakage will reduce system pressure.	Check for leakage in O-rings, gaskets, and other fittings. Repair unit as required, or replace leaky unit.

If the above actions do not remedy the problem contact a SAUER-SUNDSTRAND Authorized Service Center.

### Improper Motor Output Speed

Check	Description	Action
1. Oil level in reservoir.	Insufficient hydraulic fluid will reduce motor speed.	Fill oil to proper level.
2. Pump output flow.	Incorrect outflow will affect output speed. Incorrect output flow indicates the swashplate is out of position.	Measure pump output and check for proper pump speed and see that the pump is in full stroke.
3. Variable motor displacement control.	If variable motor displacement control is not functioning correctly, variable motor swashplate may be in wrong position.	See if variable motor displacement control is responding. If not, repair or replace control.
4. For internal leakage.	Internal leakage will reduce system pressure.	Check for leakage in O-rings, gaskets, and other fittings. Repair unit as required, or replace leaky unit.

If the above actions do not remedy the problem contact a SAUER-SUNDSTRAND Authorized Service Center.

**Excessive Noise and/or Vibration**

Check	Description	Action
1. Oil in reservoir.	Insufficient hydraulic fluid will lead to cavitation.	Fill reservoir to proper level.
2. Air in system.	Air bubbles will lead to cavitation.	Look for foam in reservoir. Check for leaks on inlet side of system loop. Afterwards, let reservoir settle until bubbles are gone. Run system at low speed to move system fluid to reservoir. Repeat.
3. Pump inlet vacuum.	High inlet vacuum will create noise. A dirty filter will increase the inlet vacuum.	Inspect and replace filter as necessary. Check for proper suction line size.
4. Shaft couplings.	A loose shaft coupling will cause excessive noise.	Replace loose shaft coupling in charge pump or replace pump or motor.
5. Shaft alignment.	Unaligned shafts will create excessive frictional noise.	Align shafts.

If the above actions do not remedy the problem contact a SAUER-SUNDSTRAND Authorized Service Center.

**System Response is Sluggish**

Check	Description	Action
1. Oil level in reservoir.	Insufficient hydraulic fluid will reduce output pressure.	Fill reservoir to proper level.
2. Multi-function valves' pressure settings.	Incorrect pressure settings will affect system reaction time.	Adjust or replace multi-function valves.
3. Pump inlet vacuum.	High pump inlet vacuum will reduce system pressure.	Measure charge inlet vacuum. If high replace inlet filter.
4. Prime mover speed.	Low engine speed will reduce system performance.	Adjust engine speed.
5. Charge and control pressures.	Incorrect charge or control pressures will affect system performance.	Measure charge and control pressures and correct if necessary.
6. System internal leakage.	Internal leakage will reduce system pressure.	Check for leakage in O-rings, gaskets, and other fittings.

If the above actions do not remedy the problem contact a SAUER-SUNDSTRAND Authorized Service Center.

**Inspections and Adjustments**

This section offers instruction on how to perform inspections and adjustments on pump and motor components. Read through the entire related section before beginning a service activity. Refer to the corresponding section for location of gauge ports and suggested gauge size.

**Pump Adjustments**

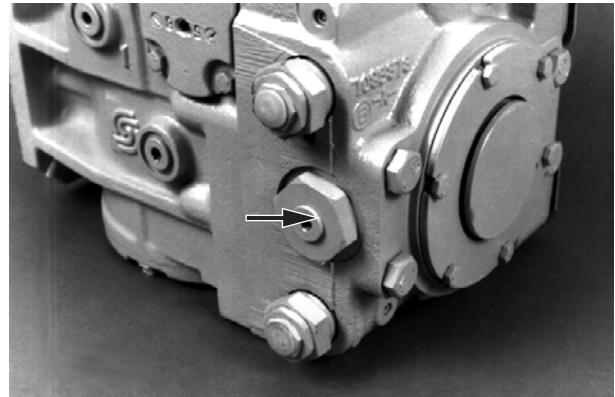
**Charge Pressure Relief Valve Adjustment**

The following procedure explains how to check and adjust the charge pressure relief valve.

**WARNING**

The following procedure may require the vehicle/machine to be disabled (wheels raised off the ground, work function disconnected, etc.) while performing the procedure in order to prevent injury to the technician and bystanders. Take necessary safety precautions before moving the vehicle/machine.

S000007E



**Charge Pressure Gauge Port (Reducer fitting shown - if filtration device attached)**

1. To measure pump charge pressure, install a pressure gauge in the pump charge pressure gauge port (M3). Also install a gauge to measure case pressure (tee into L1 or L2 or use servo gauge port). Operate the system with the pump in "neutral" (zero displacement) when measuring pump charge pressure.
2. The table shows the acceptable pump charge pressure range for some nominal charge relief valve settings (see sample model code at right). These pressures assume 1500 pump rpm and a reservoir temperature of 50°C (120°F), and are referenced to case pressure (see footnote on next page). Smaller displacement charge pumps will produce charge pressure readings in the lower portion of the range, while larger displacement charge pumps will produce readings in the higher portion of the range.

90L055 EA 1 N Nominal Charge Pressure  
 6 S 3 C6 C 03  
 HNN 35 35 **24**

**Model Code on Unit Name Plate ("24 bar")**

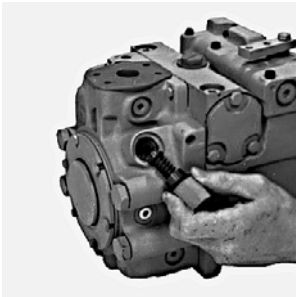
Model Code	Measured Charge Pressure *
20	18.1 bis 21.7 bar (262 to 315 psi)
24	22.0 bis 26.9 bar (319 to 390 psi)
28	25.8 bis 30.7 bar (374 to 445 psi)

T002 266E

\* This is the actual charge pressure port gauge reading minus the case pressure port gauge reading.

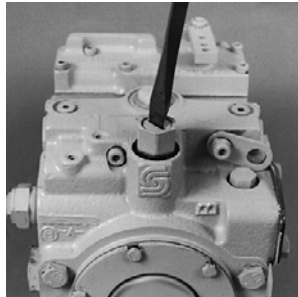
**Note:** These pressures assume a pump speed of 1450 - 1500 rpm. At higher pump input speeds (with higher charge flows) the charge pressure will rise over the rated setting.

\* This is the actual charge pressure port gauge reading minus the case pressure port gauge reading.



90000262

**Shim Adjustable Charge Pressure Relief Valve (Pump)**



90000264

**Screw Adjustable Charge Pressure Relief Valve (Pump)**

- Earlier production Series 90 pumps are equipped with a shim adjustable charge pressure relief valve. Shim kits are available from SAUER-SUNDSTRAND. Adjustment of charge pressure is accomplished by removing the plug [1 inch Hex] and changing the shim thickness behind the spring. The plug for this type of charge relief valve should be torqued to 68 Nm (50 lbf•ft).

Later production Series 90 pumps are equipped with an external screw adjustable charge pressure relief valve. Adjustment of the charge pressure is accomplished by loosening the lock nut -

Frame Size	Wrench Size
030 - 100	1-1/16 inch
130 - 250	1-5/8 inch
T002 267E	

and turning the adjustment plug with a large screwdriver or a 1/2 inch hex wrench.

Clockwise rotation of the plug increases the setting, and counterclockwise rotation decreases the setting (at a rate of approximately 3.9 bar (50 psi) per turn). The lock nut for this type of charge relief valve should be torqued to 52 Nm (39 lbf•ft).

- Once the desired charge pressure setting is achieved, remove the gauges.

**Multi-Function Valve Pressure Adjustment**

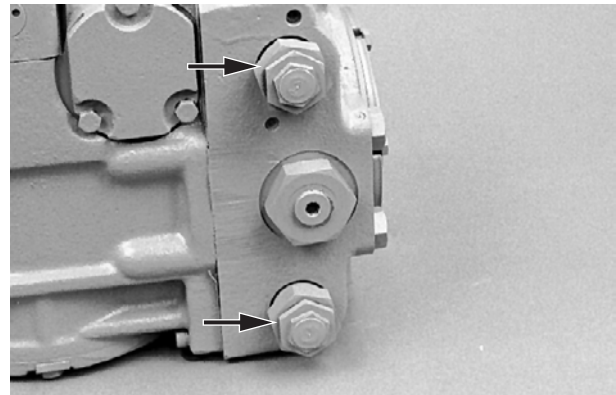
Adjustment of the pressure limiter setting and the high pressure relief valve setting is accomplished simultaneously. The latter is automatically set approximately 35 bar (500 psi) above the former.

In order to adjust the pressure limiter setting, the motor output shaft must be locked so it does not rotate. This may be accomplished by locking the vehicle's brakes or rigidly fixing the work function so it cannot rotate.

**WARNING**

**Take necessary precautions that the motor shaft remains stationary during the adjustment procedure.**

S000010E



90000258

**Multi-Function Valves on PV**

1. Install two 1000 bar (or 10 000 psi) pressure gauges in the high pressure gauge ports (M1 and M2). Install a 50 bar (or 1000 psi) pressure gauge in the pump charge pressure gauge port (M3).
2. Start the prime mover and operate at normal speed.
3. Loosen locking nut.

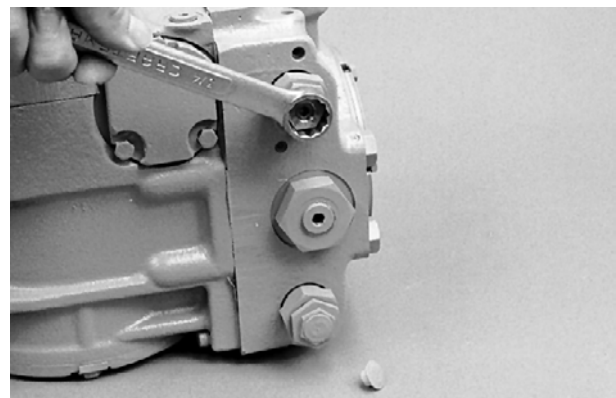
Frame Size	Wrench Size
early 042 - 100	10 mm
newer 030 - 100	19 mm
early 130	13 mm
130 - 250	24 mm

T002 268E

4. Insert a internal hex wrench into the pressure adjusting screw.

Frame Size	Internal Hex Wrench Size
early 042 - 100	3 mm
newer 030 - 100	5 mm
early 130	4 mm
130 - 250	8 mm

T002 269E



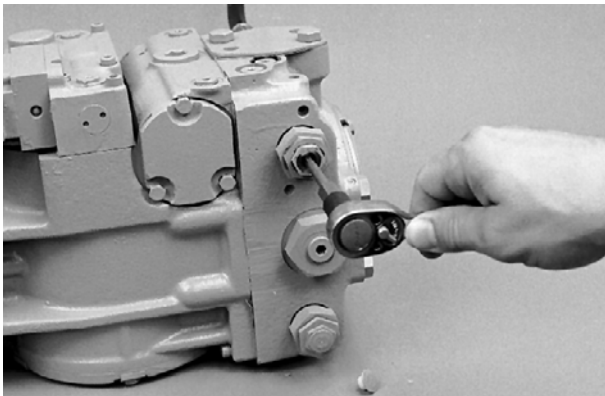
90000259

**Loosen Pressure Adjusting Screw Lock Nut**

Note: A plastic dust plug is installed in the adjusting screw on 030 and late 042 through 250 units.

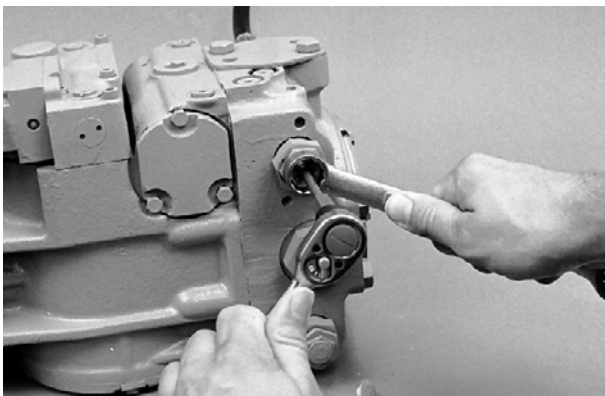
90L055 EA 1 N  
 6 S 3 C6 C 03  
 HNN 35 35 24

↑ ↑  
 Pressure Limiter Setting  
 Ports A and B (differential  
 pressure in 10s of bars,  
 e.g. "35" = 350 bar)



90000260

Rotate Pressure Adjusting Screw



90000261

Tighten Lock Nut

- The factory preset pressure limiter setting is shown on the model code as at right. It is referenced to charge pressure, so the pressure limiter setting is the difference between the high and low pressure sides of the system loop. Activate or move the control input so that pressure increases in the high pressure side of the closed circuit to the pressure limiter pressure setting. The pressure limiter setting is reached when the pressure stops increasing and remains steady at a given pressure level (as shown on the gauges).
- Return the pump to its "neutral" (zero flow) position and adjust the pressure limiter setting by rotating the pressure adjusting screw with the internal hex wrench.

Clockwise rotation of the pressure adjustment screw will increase the pressure setting, and counterclockwise rotation will decrease the pressure setting. Each complete rotation of the pressure adjusting screw changes the pressure as shown in the following table.

Frame Size	Approx Change per Rev of the Adjusting Screw
early 042 - 100	80 bar (1157 psi) per Rev
newer 030 - 100	90 bar (1300 psi) per Rev
130 - 250	80 bar (1157 psi) per Rev
T002 270E	

- To verify the actual pressure setting, actuate or move the control input so that the pump again develops pressure in the high pressure circuit to the newly adjusted pressure limiter pressure setting, and read the high pressure gauge. Then allow the pump to return to its "neutral" position. The pressure in the high pressure circuit should return to the charge pressure setting.
- While holding the pressure adjusting screw stationary, tighten the pressure adjusting screw lock.

Frame Size	Torque
early 042 - 100	3 Nm (26 lbf•in)
newer 030 - 100	20 Nm (15 lbf•ft)
130 - 250	40 Nm (30 lbf•ft)
T002 271E	

**Do not overtorque.**

- Shut down the prime mover, remove the gauges and install the gauge port plugs. Replace the plastic dust plugs (if used).

The same procedure is used for setting the pressure limit of the other multi-function valve, but the control input signal must be activated or moved in the opposite direction so that high pressure develops in the opposite side of the closed circuit.

## Engaging the Bypass Function

The bypass function is performed by the multi-function valve cartridges. The prime mover should be shut down when opening or closing the bypass valves.

The bypass valves on both of the multi-function valves must be opened to engaged the bypass function.

- Using a

Frame Size	Wrench Size
newer 030 - 100	1-1/16 inch
130 - 250	1-3/8 inch
T002 272E	

wrench on the middle sized hex of the multi-function valve cartridge, and a

Frame Size	Wrench Size
newer 030 - 100	1-1/4 inch
130 - 250	1-5/8 inch
T002 273E	

wrench on the large hex to prevent rotation of the cartridge assembly, rotate the middle hex three revolutions counterclockwise to open the bypass valve. **Do not rotate more than 3-1/2 revolutions, as additional rotation will permit external leakage.**

- For units with an MDC-type control, prior to moving the vehicle or otherwise causing the motor shaft to turn, move the control handle of the manual displacement control on the pump to the maximum full forward position. Hold the handle in this position during bypass valve operation.

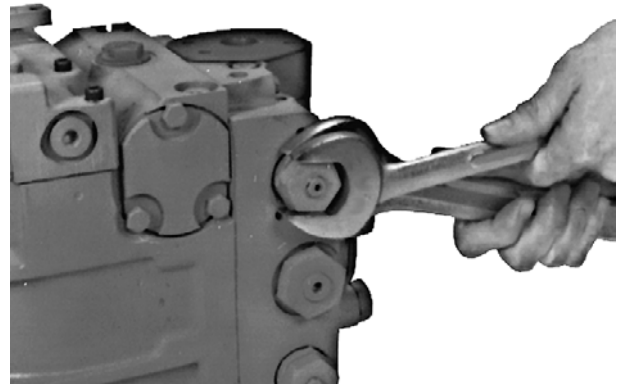
### Caution

**"Tow" at extremely low speeds and for short distances only.**

S000011E

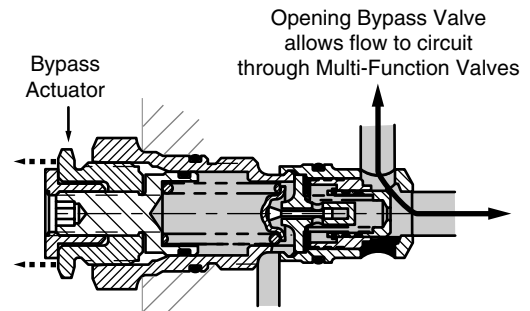
- To close the bypass valve, rotate the middle hex clockwise until it is seated. Then torque the middle hex.

Frame Size	Torque
newer 030 - 100	41 Nm (30 lbf•ft)
130 - 250	100 Nm (75 lbf•ft)
T002 274E	



90000266

**Loosening and Rotating Bypass Hex on Multi-Function Valve**



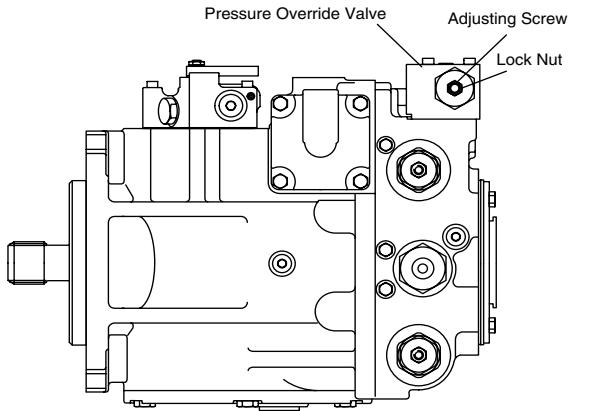
90000827E

**Multi-Function Valve with Bypass Function Engaged**



**Pressure Override (POR) Valve Pressure Adjustment (Option for 180 Frame Size)**

The Pressure Override Valve is explained in the corresponding section.



Right Side View

90000828E

Pressure Override Valve for 180 Frame Size

1. Install two 1000 bar (or 10 000 psi) pressure gauges in the high pressure gauge ports (M1 and M2). Install a 50 bar (or 1000 psi) pressure gauge in the pump charge pressure gauge port (M3).
2. Start the prime mover and operate at normal speed.
3. With the pump operating at approximately 20% displacement, load the work function and note the pressure as the POR valve operates (pump displacement reduces to "zero").
4. Adjustment of the pressure override setting is made by loosening the lock nut with a 9/16 inch hex wrench and turning the adjustment screw with a 3/16 inch internal hex wrench. The POR setting should be at least 50 bar (750 psi) below the high pressure relief valve setting of the multi-function valves for proper operation.
5. Following the adjustment, torque the lock nut to 43 Nm (32 lbf•ft).
6. Shut down the prime mover and remove the gauges and install the gauge port plugs.



## Displacement Limiter Adjustment

The maximum displacement can be limited in either direction.

1. Loosen the seal lock nut retaining the displacement limiter adjusting screw.

Frame Size	Wrench Size
030 - 100	13 mm
130	17 mm
180 - 250	19 mm

T002 275E

2. Rotate the adjusting screw.

Frame Size	Internal Hex Wrench Size
030 - 100	4 mm
130	5 mm
180 - 250	6 mm

T002 276E

Rotating the adjusting screw clockwise will decrease the maximum displacement of the pump while rotating the adjusting screw counterclockwise will increase the maximum displacement.

### Caution

Care should be taken in adjusting displacement limiters to avoid undesirable flow or speed conditions. The seal lock nut must be retorqued after every adjustment to prevent an unexpected change in operating conditions and to prevent external leakage during unit operation.

S000012E

3. After establishing the desired maximum displacement setting, tighten the lock nut on the adjusting screw as follows.

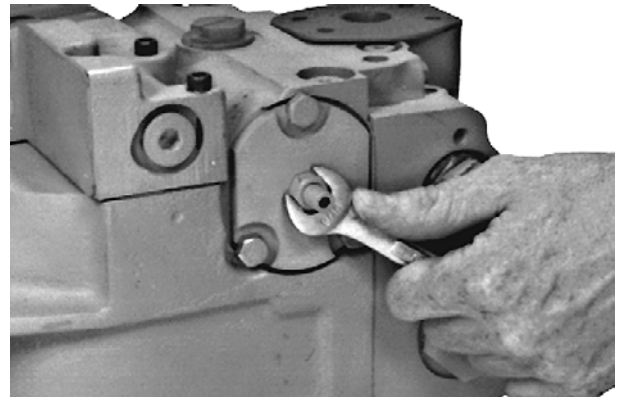
Frame Size	Torque
030 - 100	24 Nm (18 lbf•ft)
130	48 Nm (35 lbf•ft)
180 - 250	125 Nm (92 lbf•ft)

T002 278E

4. One turn of the adjusting screw will change the maximum displacement approximately as follows.

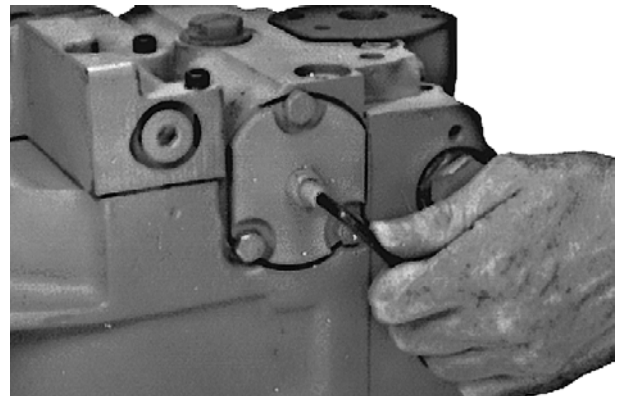
Frame Size	Approx Change in Disp per Rev of Adjusting Screw
030	2.8 cm <sup>3</sup> / Rev (0.17 in <sup>3</sup> / Rev)
042	3.5 cm <sup>3</sup> / Rev (0.21 in <sup>3</sup> / Rev)
055	4.2 cm <sup>3</sup> / Rev (0.26 in <sup>3</sup> / Rev)
075	5.1 cm <sup>3</sup> / Rev (0.31 in <sup>3</sup> / Rev)
100	6.2 cm <sup>3</sup> / Rev (0.38 in <sup>3</sup> / Rev)
130	8.8 cm <sup>3</sup> / Rev (0.53 in <sup>3</sup> / Rev)
180	12.5 cm <sup>3</sup> / Rev (0.76 in <sup>3</sup> / Rev)
250	17.3 cm <sup>3</sup> / Rev (1.06 in <sup>3</sup> / Rev)

T002 277E



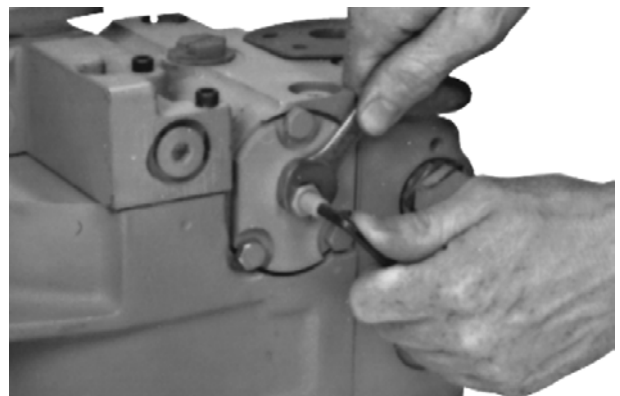
90000267

Loosen Displacement Limiter Lock Nut



90000268

Rotate Adjusting Screw



90000269

Tighten Lock Nut

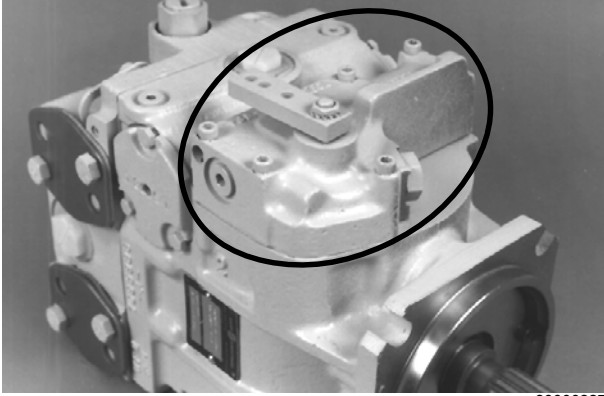
**Pump Control Adjustments**

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**Standard Manual Displacement Control (MDC) Adjustment**

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There are no adjustable elements in the manual displacement control. The control spool is held in its “neutral” position by centering springs and washers on each end of the spool. Since there is no centering spring on the control input shaft, the shaft will automatically assume the appropriate position when the control is installed on the pump.



90000237

**Variable Displacement Pump with Standard Manual  
Displacement Control**

## Non-Linear Manual Displacement Control (MDC)

A centering spring, located on the control input shaft, locates the control shaft in its “neutral” position. A bias spring on the control spool maintains a force on the spool and the control linkage to eliminate looseness (“free-play”) in the linkage.

The “neutral” adjustment is the only adjustment that can be made on the nonlinear manual displacement control. All other functions are preset at the factory.

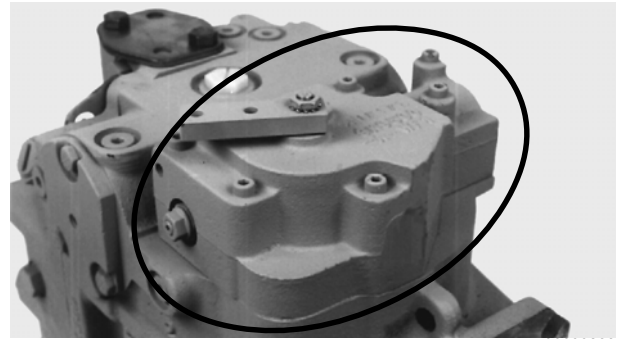
This adjustment must be made on a test stand or on the vehicle/machine with the prime mover operating.

### WARNING

The following procedure may require the vehicle/machine to be disabled (wheels raised off the ground, work function disconnected, etc.) while performing the procedure in order to prevent injury to the technician and bystanders. Take necessary safety precautions before moving the vehicle/machine.

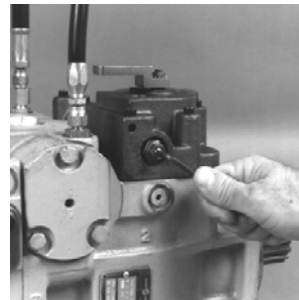
S000007E

1. Install two 50 bar (or 1000 psi) gauges in each of the displacement control cylinder gauge ports (M4 and M5). Disconnect the external control linkage from the control handle and make certain the control shaft is in its “neutral” position. Start the prime mover and operate at normal speed.
2. Loosen the lock nut on the neutral adjusting screw with a 13 mm hex wrench.
3. Using a 4 mm internal hex wrench, rotate the neutral adjusting screw clockwise until the pressure increases on one of the pressure gauges. Note the angular position of the wrench.
4. Rotate the adjusting screw counterclockwise until the pressure increases by an equal amount on the other gauge. Note the angular position of the wrench.
5. Rotate the adjusting screw clockwise half the distance between the locations noted above. The gauges should read the same pressure (case pressure), indicating that the control is in its “neutral” position.
6. Hold the adjusting screw stationary and tighten the lock nut to 13.5 Nm (10 lbf•ft). **Do not overtorque the nut.**
7. Once the neutral position is set, stop the prime mover, remove the gauges, and install the gauge port plugs. Reconnect the external control linkage.



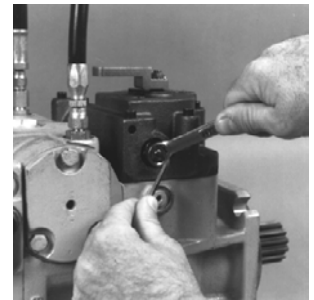
90000829

Variable Displacement Pump with Non-Linear Manual Displacement Control



90000357

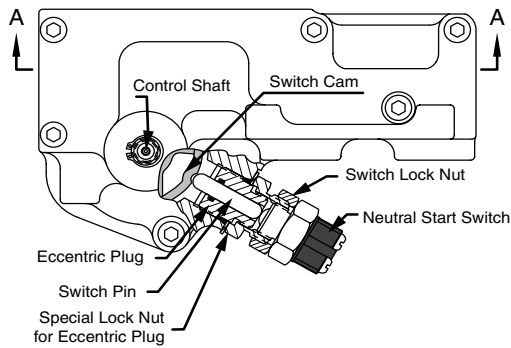
Rotate Neutral Adjusting Screw



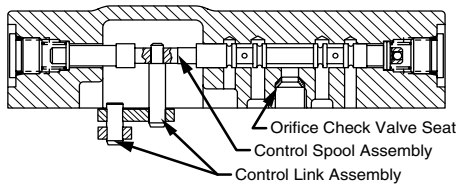
90000358

Tighten Neutral Adjusting Screw Lock Nut

**MDC Neutral Start Switch (NSS) Adjustments**



MDC with Neutral Start switch



View at Section A-A

90000830E

**Components of the Standard Manual Displacement Control with Neutral Start Switch**

The neutral start switch (NSS) provides a means to prevent the system prime mover from starting while the pump control handle and control input shaft are in a position which would command the pump to go “in-stroke” in either the “forward” or “reverse” direction.

When the control input shaft is in its “neutral” position, the inner end of the switch pin moves into a slot on the eccentric cam attached to the control shaft. This allows the spring loaded NSS to close, completing the electrical starting circuit for the prime mover.

When the control input shaft is NOT in its “neutral” position, the eccentric cam moves the switch pin out of the slot. This forces the NSS to open, breaking the electrical starting circuit for the prime mover.

The neutral start switch is threaded into the special lock nut for the eccentric plug.

Turning the NSS clockwise (CW) into the special nut will move the NSS closer to the switch cam on the control shaft, and will narrow the NSS deadband. Turning the NSS counterclockwise (CCW) out of the special nut will move the NSS farther from the switch cam on the control shaft, and will widen the NSS deadband.

The switch pin is located in an eccentric plug which is turned to move the center of the NSS deadband.

(continued)

The NSS must be adjusted to meet the following three requirements:

- i. The distance the control handle can be turned without opening the NSS is called the "NSS Deadband." The distance the control handle can be moved without moving the control spool enough to port hydraulic fluid to the pump displacement control cylinders is called the "Control Deadband." These deadbands **must** be centered in relation to each other.

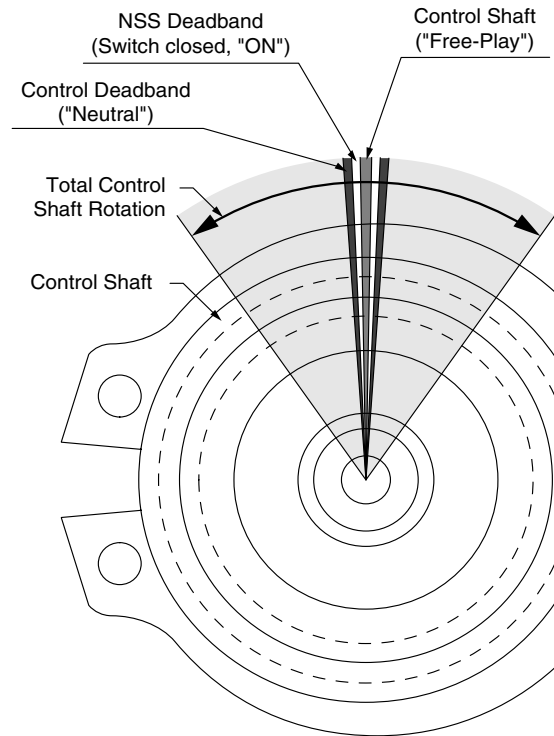
Since the position of the control deadband cannot be adjusted, the position of the NSS deadband must be adjusted to match it.

- ii. The NSS deadband must be wide enough so the NSS **will not** open within the loose area of control handle movement caused by normal operating clearances in the control linkage (control shaft "free-play").

By setting the NSS to open outside this area, the control spool springs or control shaft centering spring can always act to return the handle to "neutral" and re-close the NSS.

- iii. The NSS deadband must be narrow enough so the NSS **will** open before the unit builds 7 bar (100 psi) differential system pressure in either direction.

(continued)



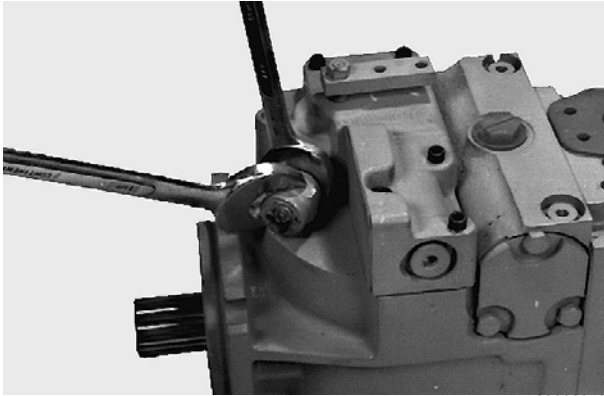
90000831E

Neutral Start Switch Adjustment Requirements

**NSS Deadband Adjustment (Conditions ii & iii)**

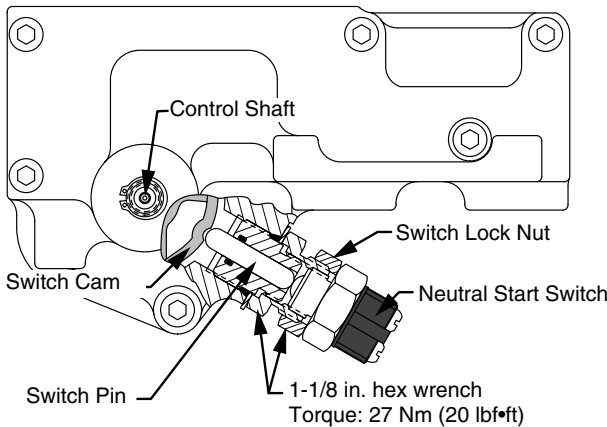
The NSS deadband must be wide enough so the NSS **will not** open within the control shaft “free-play” area, and it must be narrow enough so the NSS **will** open before the unit builds 7 bar (100 psi) differential system pressure in either direction.

1. Install two 1000 bar (10 000 psi) pressure gauges in the system pressure gauge ports M1 and M2.
2. Using two 1-1/8 inch wrenches, hold the neutral start switch from turning and loosen the locknut.
3. Disconnect the external control linkage and make certain the control shaft is in its “neutral” position.
4. Attach a continuity checker to the terminals of the switch. With the control shaft in its “neutral” position, turn the switch clockwise (CW) until electrical continuity is broken, then turn the switch counterclockwise (CCW) until electrical continuity is obtained. Turn the switch counterclockwise (CCW) an additional 1/4 turn (90°) after continuity has been obtained.
5. Hold the switch in place and tighten the locknut to 27 Nm (20 lbf•ft) torque.
6. With the continuity checker attached to the switch, rotate the control handle (or the control shaft) in each direction to assure continuity is broken when the control is not in the “neutral” position.
7. If continuity is obtained in “neutral” and satisfactorily interrupted in each direction, proceed to check the switch with the prime mover running. The switch must open **before** the unit builds 7 bar (100 psi) differential system pressure in either direction.  
  
If the switch opens **after** the unit builds system pressure in either direction, loosen the switch lock nut and turn the switch clockwise (CW) 1/12 turn (30°). Tighten the switch lock nut and recheck the switch operation. Repeat this procedure if necessary.
8. If continuity is not interrupted with an **equal** movement of the control handle in each direction, turn off prime mover, remove the pressure gauges, and continue with the next section.
9. If neutral start switch operation is satisfactory, turn off the prime mover, remove the pressure gauges, and reconnect the external control linkage.



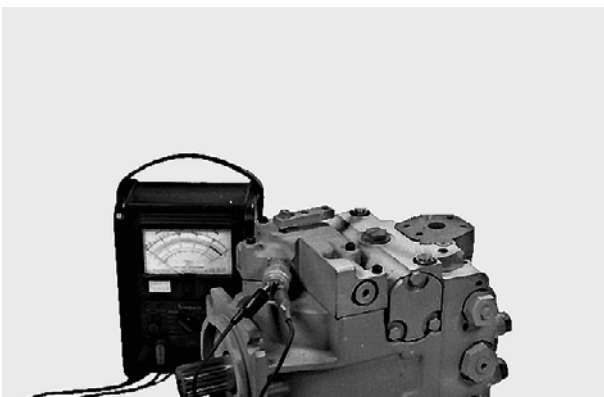
Loosening the NSS Lock Nut

90000253



NSS

90000832E



Checking Continuity of NSS (System Pressure Gauges installed on far side)

90000870



**Neutral Start Switch Eccentric Plug Adjustment (Condition i)**

The NSS deadband and the control deadband **must** be centered in relation to each other.

Since the position of the control deadband cannot be adjusted, the position of the NSS deadband must be adjusted to match it. The switch pin is located in an eccentric plug which is turned to move the center of the NSS deadband.

The MDC should be installed on the pump and be in its "neutral" position when adjusting the neutral start switch eccentric plug.

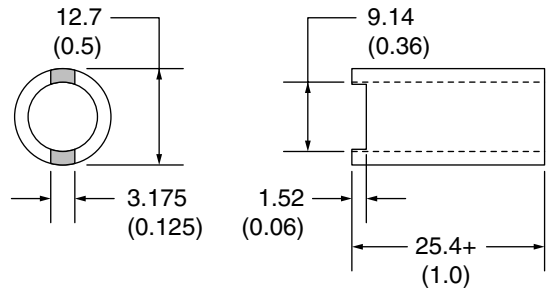
The accompanying drawing provides dimensions for an Eccentric Plug Adjustment Tool.

1. Hold the switch and eccentric plug from turning and use two 1-1/8 inch wrenches to loosen the locknut. Remove the neutral start switch.

**WARNING**

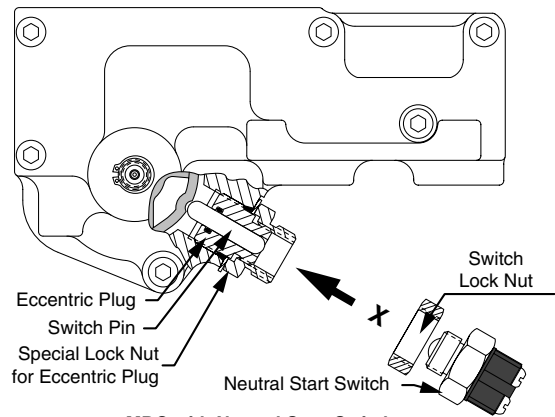
**Do not start the prime mover while the neutral start switch is removed from the control. Case pressure will force the pin out of the eccentric plug, causing oil loss.**

S000032E

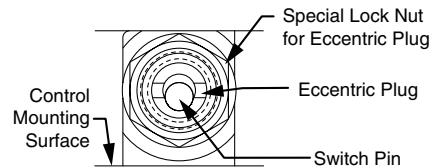


**Eccentric Plug Adjustment Tool**

90000834E



**MDC with Neutral Start Switch**



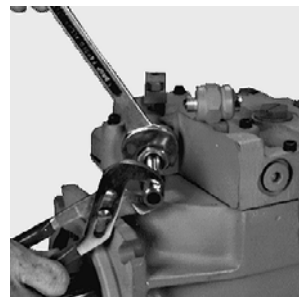
**View in Direction X  
(Switch and lock nut removed)**

90000833E

**NSS with Eccentric Plug**

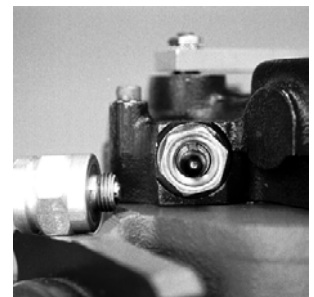
2. Note the slots on the eccentric plug for the adjustment tool. Hold the eccentric plug in place with the adjustment tool, and loosen the lock nut with a 1-1/8 inch wrench.

(continued)



90000256

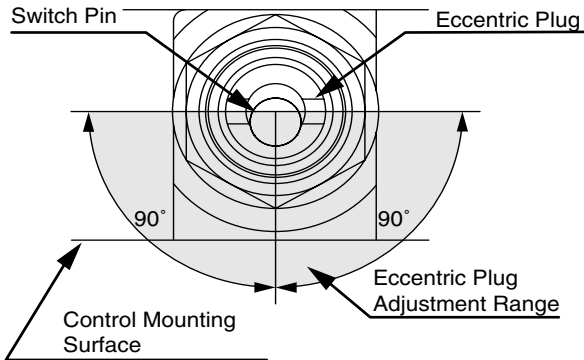
**Loosen Eccentric Lock Nut**



90000257

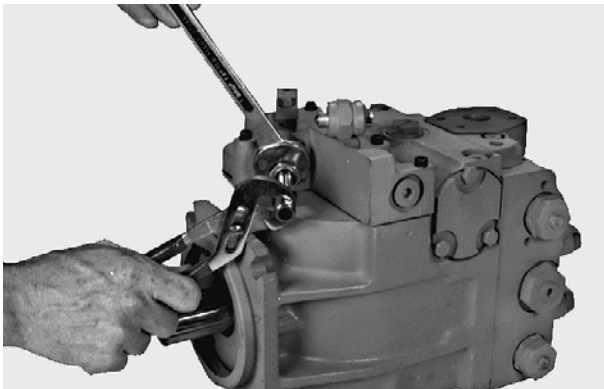
**NSS Removed**





Eccentric Plug Adjustment

90000835E



Adjust the Eccentric Plug

90000256

3. Position the eccentric plug so the switch pin is offset toward the control mounting surface. This will provide the best contact between the pin and the cam on the control shaft.
4. Hold the control shaft in its "neutral" position (in the center of the control shaft "free-play" area). Locate the switch pin in the slot of the switch cam by turning the eccentric plug while checking the pin position (depth) in the plug. When the pin engages the cam slot, the pin will be at its maximum depth in the plug. Hand tighten the plug lock nut to hold the eccentric plug in position.
5. Turn the control shaft an equal amount in either direction from "neutral." The switch pin should move out of the eccentric plug an equal distance when the control shaft is turned. Turn the eccentric plug to center the switch pin with the cam slot. Only a small amount of adjustment in either direction should be needed to center the pin.
6. While holding the eccentric plug in place, tighten the eccentric plug lock nut to 27 Nm (20 lbf•ft). Reinstall and adjust the switch as outlined in the previous section.

Note: The eccentric plug normally requires between 5-1/2 and 6-1/2 turns to install into the control housing .

**Caution**  
**Do not turn the eccentric plug into or out of the housing beyond specifications.**

S000014E

7. Once the switch is correctly adjusted, hold the switch in place and tighten the locknut to 27 Nm (20 lbf•ft) torque.

(continued)

### Checking Switch Continuity

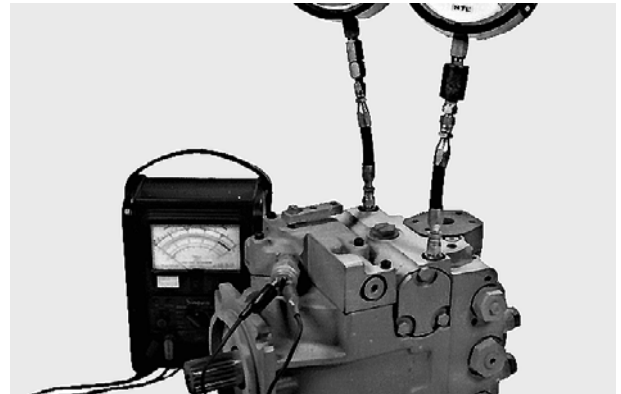
Recheck switch continuity to determine whether additional adjustment of the eccentric plug is necessary.

#### WARNING

The following procedure may require the vehicle/machine to be disabled (wheels raised off the ground, work function disconnected, etc.) while performing the procedure in order to prevent injury to the technician and bystanders. Take necessary safety precautions before moving the vehicle/machine.

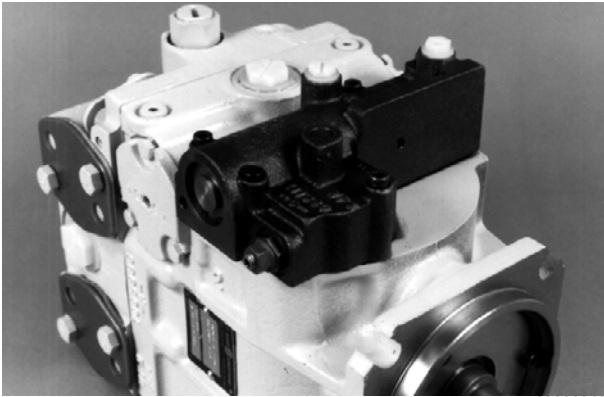
S000007E

1. Install two 50 bar (or 1000 psi) gauges in each of the displacement control cylinder gauge ports (M4 and M5). Attach a continuity checker to the terminals of the neutral start switch.
2. Energize the starter circuit, and start the prime mover.
3. While operating at normal speed and with the pump in its "neutral" (zero flow) position, note the pressure reading on the gauges. This reading should be noted as the base pressure.
4. Slowly move the control handle in one direction while observing the pressure gauges and the continuity checker. Continuity **must** be broken before the pressure on either gauge increases more than 1 bar (12 psi) from the base pressure obtained at "neutral."
5. Slowly move the control handle in the opposite direction. Again, continuity must be broken before the gauge pressure increases more than 1 bar (12 psi) from base pressure.
6. Continuity must again be verified when the control is returned to neutral.
7. If continuity is not broken at base pressure plus 0 to 1 bar (0 to 12 psi) in either direction, stop the prime mover and readjust the eccentric plug as described in the previous section. If the pressure difference is equal in each direction but greater than 1 bar (12 psi), loosen the switch locknut and turn the switch clockwise 1/12 turn (30°) to increase the sensitivity. Retighten the locknut and recheck pressure differences and continuity.
8. After verifying proper control and switch operation, stop the prime mover. Remove the continuity checker and pressure gauges. Reinstall the servo pressure port plugs and reconnect the electrical leads from the machine starter circuit to the neutral start switch. Install and adjust, if necessary, the external control linkage.



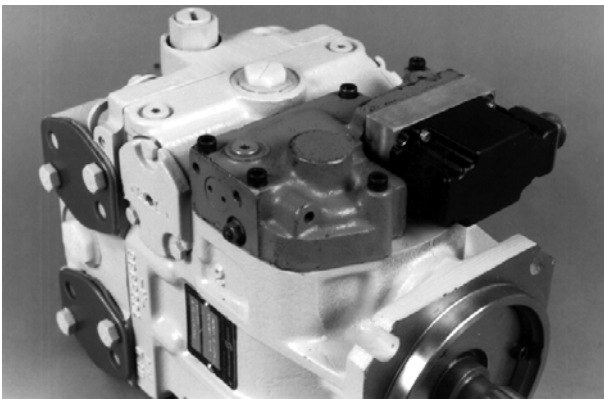
90000255

**Checking Continuity of NSS  
(Gauges installed in Servo Gauge Ports)**



PV with Hydraulic Displacement Control

90000240



PV with Electric Displacement Control

90000241

### Hydraulic Displacement Control (HDC) and Electric Displacement Control (EDC) Adjustment

The “neutral” adjustment is the only adjustment that can be made on hydraulic and electric displacement controls. All other functions are preset at the factory.

This adjustment must be made on a test stand or on the vehicle/machine with the prime mover operating.

The neutral adjustment is performed by adjusting a neutral adjusting shaft (earlier production EDCs) or a neutral adjusting screw (HDCs and current production EDCs).

#### WARNING

The following procedure may require the vehicle/machine to be disabled (wheels raised off the ground, work function disconnected, etc.) while performing the procedure in order to prevent injury to the technician and bystanders. Take necessary safety precautions before moving the vehicle/machine.

S000007E

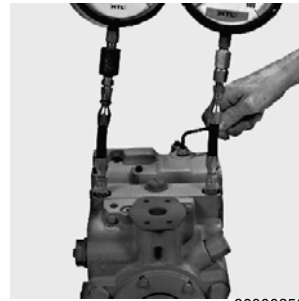


Install Gauges in Displacement Control Cylinder Gauge Ports

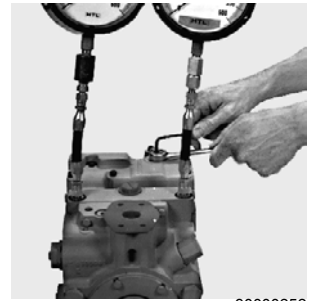
90000249

1. Install two 50 bar (or 1000 psi) gauges in each of the two displacement control cylinder gauge ports (M4 and M5). Disconnect the external control input (hydraulic or electronic) from the control. Start the prime mover and operate at normal speed.
2. Loosen the lock nut with a 17 mm hex wrench for the neutral adjusting shaft or with a 10 mm or 13 mm hex wrench for the neutral adjusting screw.

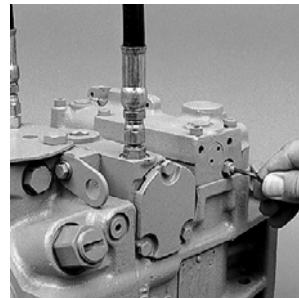
3. Using a 5 mm internal hex wrench for the neutral adjusting shaft or a 3 mm or 4 mm internal hex wrench for the neutral adjusting screw, rotate clockwise until the pressure increases in one of the pressure gauges. Note the angular position of the wrench. Then rotate the neutral adjusting shaft or screw counterclockwise until the pressure increases by an equal amount on the other gauge. Again note the angular position of the wrench.
4. Rotate the neutral shaft or adjusting screw clockwise half the distance between the locations noted above. The gauges should read the same pressure (case pressure), indicating that the control is in its “neutral” position.
5. Hold the neutral adjusting shaft or screw stationary. Tighten the neutral shaft lock nut (early production controls) to 22 Nm (195 lbf•in.). Tighten the neutral adjusting screw lock nut (later production controls) to 7 Nm (62 lbf•in.) for the 6 mm screw or 13.5 Nm (120 lbf•in.) for the 8 mm screw. **Do not overtorque the nut.**
6. Once the neutral position is set, stop the prime mover, remove the gauges, and install the gauge port plugs. Reconnect the external control input.



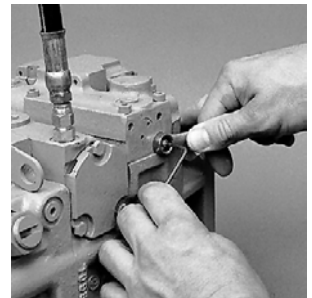
90000250  
**Rotate Neutral Adjusting Shaft (Early production)**



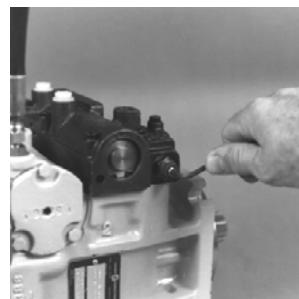
90000252  
**Tighten Neutral Adjusting Shaft Lock Nut (Early production)**



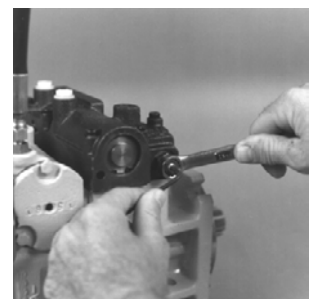
90000251  
**Rotate Neutral Adjusting Screw (Later production)**



90000318  
**Tighten Neutral Adjusting Screw Lock Nut (Later production)**

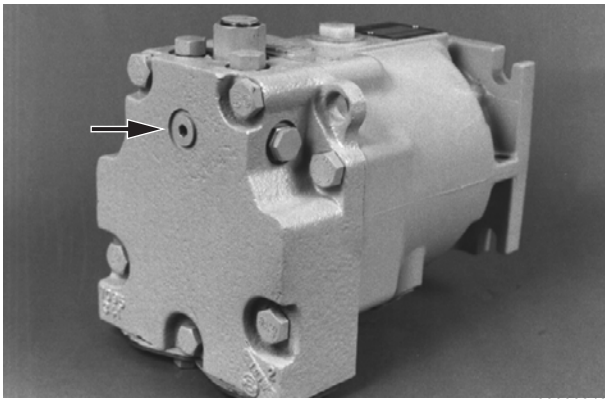


90000355  
**Rotate Neutral Adjusting Shaft (Current production HDC)**



90000356  
**Tighten Neutral Adjusting Shaft Lock Nut (Current production HDC)**

Motor Adjustments



90000248

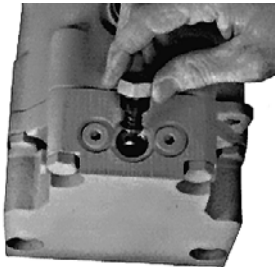
Charge Pressure Gauge Port (MF)

90M055 NC 0 N Nominal charge Pressure Setting  
 8 N 0 C6 W 00  
 NNN 00 00 24

Model Code	Motor Charge Pressure (±1.4 bar [±20 psi])
10	8.1 bar (117 psi)
18	16.1 bar (233 psi)
20	18.1 bar (262 psi)
24	22.1 bar (320 psi)
28	26.1 bar (378 psi)
30	30.0 bar (435 psi)

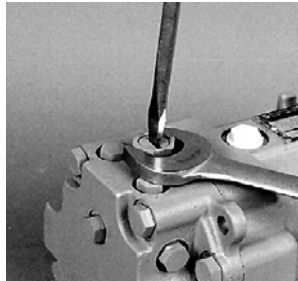
T002 279E

Model Code at the Name Plate (24 bar)



90000263

Shim Adjustable Charge Pressure Relief Valve (Motor)



90000343

Screw Adjustable Charge Pressure Relief Valve (Motor)

Charge Relief Valve Adjustment

- To measure motor charge pressure, install a 50 bar (or 1000 psi) pressure gauge in the motor charge pressure gauge port (M3). Size 30 and 42 don't have the M3 gauge port. Install pressure gauge in the motor system pressure gauge port. For this kind of measurement add 1 bar (14.5 psi) to the nominal values shown in the table. Also install a gauge to measure case pressure. Operate the system with the pump in stroke (forward or reverse) when measuring motor charge pressure.
- The following table shows acceptable motor charge pressures for some nominal charge relief valve settings (see model code at right). These pressures assume a reservoir temperature of 50°C (120°F). They are referenced to case pressure and assume a one pump/one motor system.
- Earlier production Series 90 motors are equipped with a shim adjustable charge relief valve. Shim kits are available as service items. Adjustment of the charge pressure is accomplished by removing the plug (7/8 inch hex) and changing the shim thickness behind the spring. The plug for this type charge relief port should be torqued to 68 Nm (50 lbf•ft).

Later production Series 90 motors are equipped with an external screw adjustable charge relief valve. Adjustment of charge pressure is accomplished by loosening the lock nut,

Frame Size	Wrench Size
030 - 130	1-1/16 inch

T002 293E

and turning the adjustment plug with a large screwdriver or a 1/2 inch hex wrench. Clockwise rotation of the plug increases the setting, and counterclockwise rotation decreases the setting (at a rate of approximately 5.4 bar [78 psi] per turn). The lock nut for this type charge relief valve should be torqued to 52 Nm (38 lbf•ft).

- Once the desired charge pressure setting is achieved, remove the gauges.



## Displacement Limiter Adjustment (MV)

Both the maximum and minimum displacement may be limited.

1. Remove the tamper resistant cap from the displacement limiter screw. Loosen the seal lock nut retaining the displacement limiter adjusting screw with a 19 mm wrench.

**Caution**

The displacement limiters act as travel stops for the swashplate. Do not turn the limiter screws counterclockwise beyond the point of contact with the swashplate for either the maximum or minimum displacement position.

S000015E

2. All adjustments can only be done when the motor is running and the pump is in neutral position. Steer the respective displacement limiter by the control.

Rotate the adjusting screw with a 6 mm internal hex wrench. Rotating the maximum displacement adjusting screw clockwise will decrease the maximum displacement of the motor. Rotating the minimum displacement adjusting screw clockwise will increase the minimum displacement of the motor.

**Caution**

Care should be taken in adjusting displacement limiters to avoid undesirable flow or speed conditions. See corresponding section for speed and pressure limits.

The seal lock nut must be retorqued after every adjustment to prevent an unexpected change in operating conditions and to prevent external leakage during unit operation.

S000016E

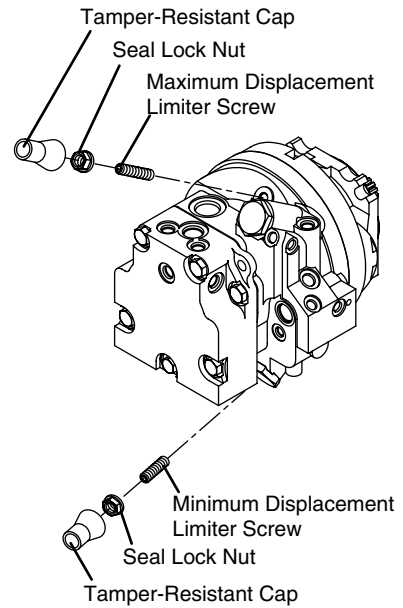
3. After establishing the desired displacement setting, tighten the lock nut on the adjusting screw to 54 Nm (40 lbf•ft). Install a new tamper resistant cap.
4. One turn of the adjusting screw will change the maximum or minimum displacement according to the following chart.

Frame Size	Approx Change in Disp per Rev of Adjusting Screw
055	5.6 cm <sup>3</sup> / Rev (0.34 in <sup>3</sup> / Rev)
075	7.1 cm <sup>3</sup> / Rev (0.43 in <sup>3</sup> / Rev)

T002 280E

## Displacement Control Adjustments

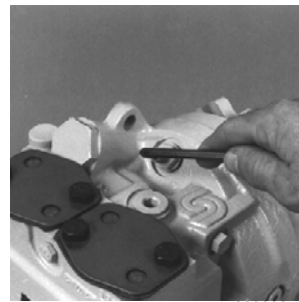
All variable motor displacement control settings do not require adjusting.



SAE Flange Version shown (Cartridge Version similar)

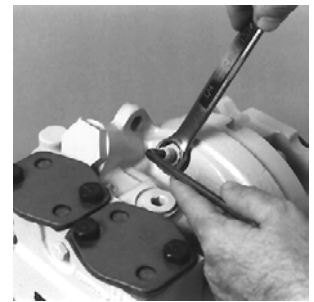
90000837E

### MV Displacement Limiters



90000359

Rotate Adjusting Screw for Minimum Displacement Limiter



90000360

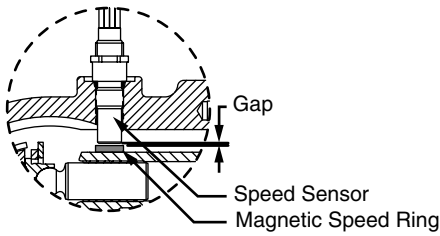
Tighten Lock Nut for Minimum Displacement Limiter



90000352

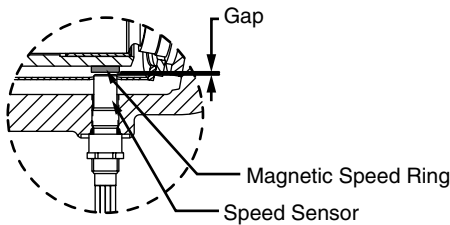
Maximum Displacement Limiter

Speed Sensor Adjustment



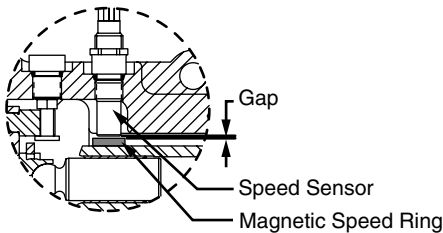
90000838E

Cross Section View of Speed Sensor in Variable Pump



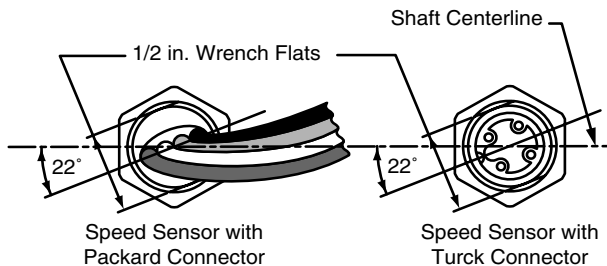
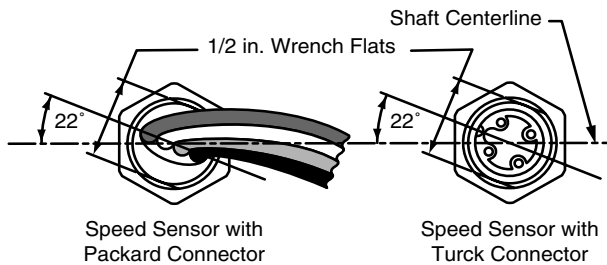
90000839E

Cross Section View of Speed Sensor in fixed Motor



90000840E

Cross Section View of Speed Sensor in Variable Motor



90000841E

Positioning Speed Sensor relative to Pump or Motor Shaft

When installing or adjusting the speed sensor on a pump or motor, it must be set at a specific distance from the speed ring on the unit's cylinder. To locate the position of the speed sensor on the unit or description see the corresponding section.

1. Loosen the sensor lock nut with an 1-1/16 inch hex wrench.
2. Turn the sensor clockwise (CW) by hand until it contacts the speed ring.
3. Turn the sensor counterclockwise (CCW) 1/2 turn (180°) to establish the nominal gap of 0.71 mm (0.028 inch).
4. Then turn the sensor clockwise (CW) until the wrench flats on sensor body are positioned at a 22° angle to the pump shaft center line.

Note: Many adjustable wrenches have a 22° handle offset.

5. The final sensor position should be between 1/2 (180°) and 1/4 turn (90°) counterclockwise (CCW) from the point where the sensor contacts the speed ring.
6. Hold sensor in position with a 1/2 inch hex wrench while tightening the lock nut to 13 Nm (10 lbf•ft).



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## Minor Repair Instructions

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Minor repairs may be performed, following the procedures in this section, without voiding the unit warranty. Although specific models are shown, these procedures apply to all series and types of units in the Series 90 Family.

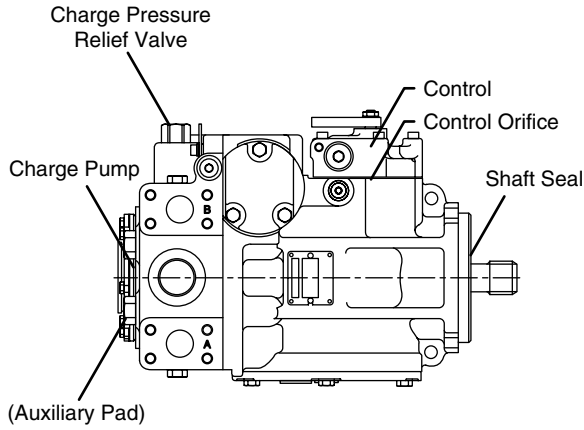
Cleanliness is a primary means of ensuring satisfactory transmission life, on either new or repaired units. Cleaning parts by using a solvent wash and air drying is adequate, providing clean solvent is used. As with any precision equipment, the internal mechanism and related

items must be kept free of foreign materials and chemicals.

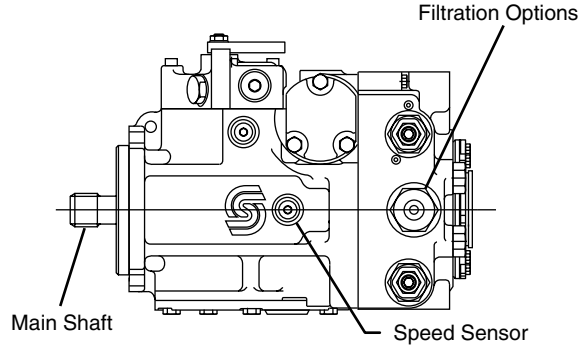
Protect all exposed sealing surfaces and open cavities from damage and foreign material.

It is recommended that all gaskets and O-rings be replaced when servicing. All gasket sealing surfaces must be cleaned prior to installing new gaskets. Lightly lubricate all O-rings with clean petroleum jelly prior to assembly.

**Hydrostatic Unit Outlines for Minor Repair Reference**



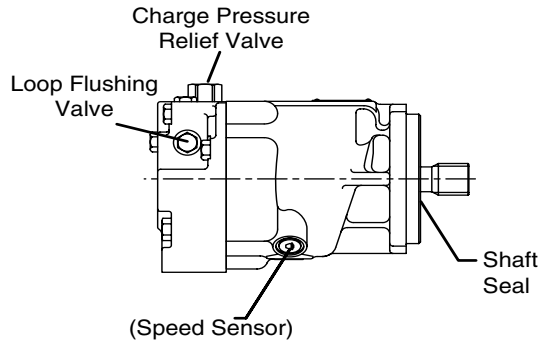
**Left Side View**



**Right Side View**

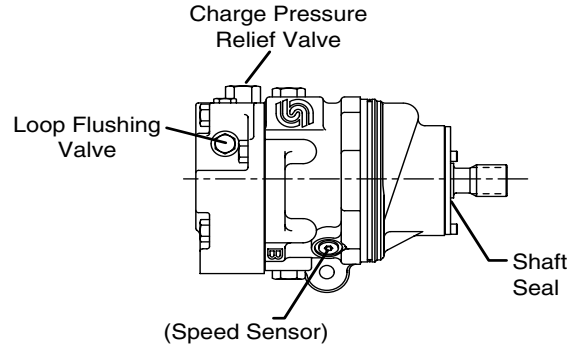
90000843E

**SAE-Flange PV**



**Left Side View**

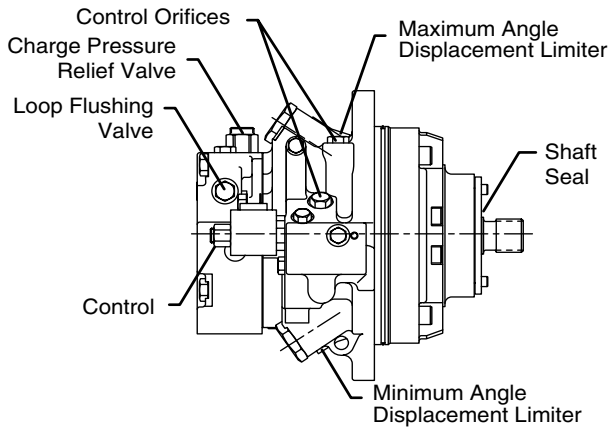
**SAE Flange MF**



**Left Side View**

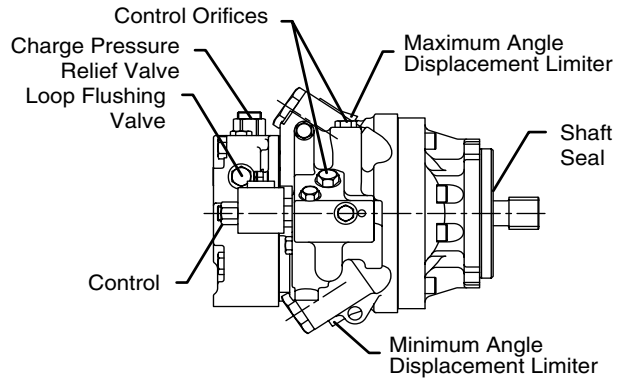
**Cartridge Flange MF**

90000844E



**Left Side View**

**Cartridge Flange MV**



**Left Side View**

**SAE Flange MV**

90000845E

**Pump and Motor Minor Repair**

**Pump / Fitting Torques**

If any plugs or fittings are removed from the pump or motor during servicing, they should be torqued as indicated in the accompanying table.

Always install new O-rings before reinstalling the plugs or fittings.

**Caution**

**Plugs or fittings installed into aluminum housings should always be torqued to the lower values specified for internal hex plugs of the same size.**

S000017E

Description	Torque
7/16-20 O-ring 9/16 inch Hex Wrench	20 Nm (15 lbf•ft)
7/16-20 O-ring 3/16 inch Internal Hex Wrench	12 Nm (9 lbf•ft)
9/16-18 O-ring 1 1/16 inch Hex Wrench	37 Nm (27 lbf•ft)
9/16-18 O-ring 1/4 inch Internal Hex Wrench	23 Nm (17 lbf•ft)
3/4-16 O-ring 7/8 inch Hex Wrench	68 Nm (50 lbf•ft)
3/4-16 O-ring 5/16 inch Internal Hex Wrench	68 Nm (50 lbf•ft)
7/8-14 O-ring 1 inch Hex Wrench	95 Nm (70 lbf•ft)
7/8-14 O-ring 3/8 inch Internal Hex Wrench	68 Nm (50 lbf•ft)
1-1/16-12 O-ring 1 1/4 inch Hex Wrench	163 Nm (120 lbf•ft)
1-1/16-12 O-ring 9/16 inch Internal Hex Wrench	115 Nm (85 lbf•ft)
1-5/16-12 O-ring 1-1/2 inch Hex Wrench	190 Nm (140 lbf•ft)
1-5/16-12 O-ring 5/8 inch Internal Hex Wrench	129 Nm (95 lbf•ft)
1-5/8-12 O-ring 1-7/8 inch Hex Wrench	224 Nm (165 lbf•ft)
T002 281E	

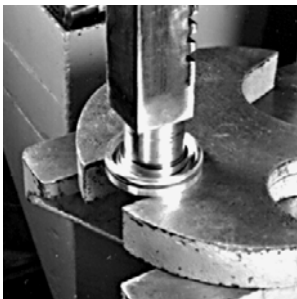
Shaft Seal and Shaft Replacement



90000270  
Remove Screws Holding Retainer Plate and Seal Carrier



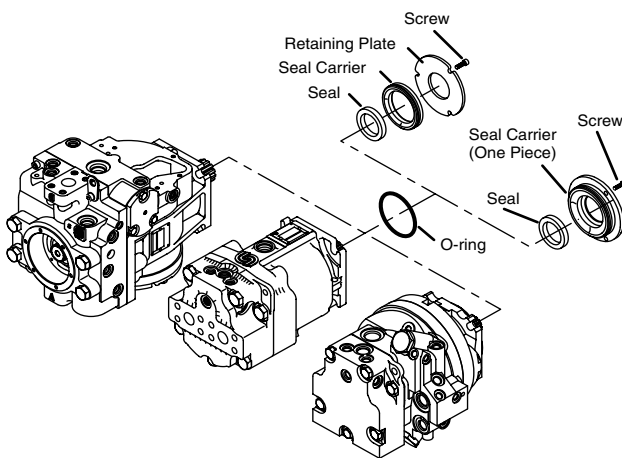
90000271  
Remove Seal Carrier



90000272  
Press Out Old Seal



90000273  
New Seal Installed in Carrier



Series 90 Shaft Seal Components

90000846E

Lip type shaft seals are used on Series 90 pumps and motors. These seals and/or the shafts can be replaced without major disassembly of the unit. However, replacement usually requires removal of the pump or motor from the machine.

1. Position the pump with the shaft facing up.

Note: If the unit is positioned horizontally when the shaft is removed, the cylinder block could move out of place, making shaft installation difficult.

2. Remove the three or four screws holding the retainer plate and seal carrier to the housing, using a 10 mm hex wrench (030 and 042 units), a 5 mm internal hex wrench (055 through 100 units), or a 6 mm internal hex wrench (130 through 250 units). Remove the retainer plate.

Note: Certain earlier production units use a one piece retainer plate and seal carrier.

3. After removing the screws, the spring force on the shaft may move the seal carrier out of its bore by approximately 5 mm (1/4 inch). If the seal carrier does not move from its bore after removing the screws, pry it from its bore as shown and/or lightly tap the end of the shaft with a soft mallet.

4. Remove the O-ring from the seal carrier.

5. Place seal carrier and seal in an arbor press and press out old seal.

6. Inspect the seal carrier, the new seal and the O-ring for any damage or nicks.

7. Using the arbor press, press the new seal into seal carrier. Be careful not to damage the seal.

Note: The outside diameter of the seal may be lightly coated with a sealant (such as Loctite High Performance Sealant #59231) prior to installation. This aids in preventing leaks caused by damage to the seal bore in the seal carrier.

- Inspect the sealing area on the shaft for rust, wear, or contamination.

**If the shaft is not being replaced proceed to step 12.**

- Remove shaft and roller bearing assembly from pump or motor. The bearing assembly can be transferred to the new shaft.
- Remove the retaining ring that secures roller bearing assembly with a snap ring pliers. Remove the roller bearing assembly.
- Place roller bearing assembly on new shaft and secure with the retaining ring.
- Wrap spline or key end of shaft with plastic film to prevent damage to the sealing lip on the seal during installation.
- Prior to assembly, lubricate the O-ring on the O.D. of the seal carrier and the I.D. of the seal with clean petroleum jelly.
- Assemble the seal carrier and seal over the shaft and into the housing bore. Install the retainer plate (if used).
- Install the screws and torque like the tables.

Pumps

Frame Size	Torque Pumps
030 - 042	12 Nm (9 lbf•ft)
055 - 100	16 Nm (12 lbf•ft)
130 - 250	32 Nm (24 lbf•ft)

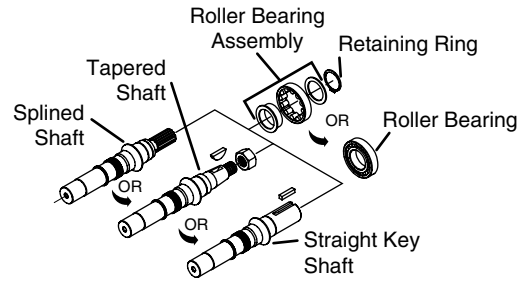
T002 282E

Motors

Frame Size	Torque Motors
030 - 100	9.5 Nm (7 lbf•ft)
130	22.5 Nm (16.6 lbf•ft)

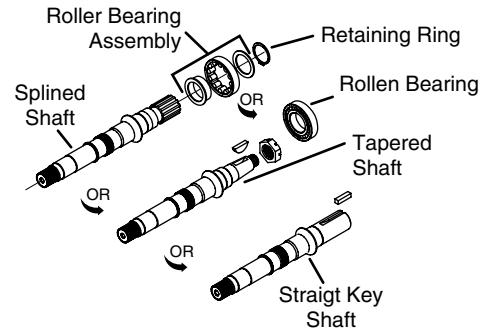
T002 283E

Note: Torque the screws in a sequenced pattern then recheck.



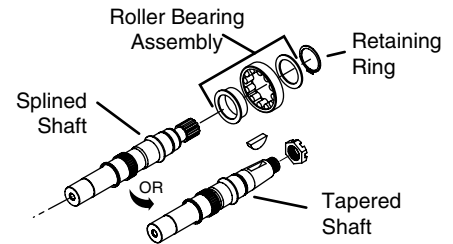
90000866E

Fixed Motor Shaft Configuration



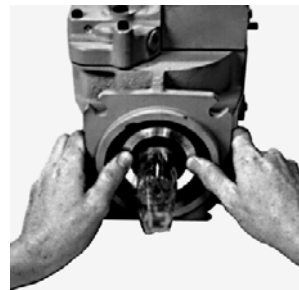
90000867E

Variable Pump Shaft Configuration



90000868E

Variable Motor Shaft Configuration



90000274

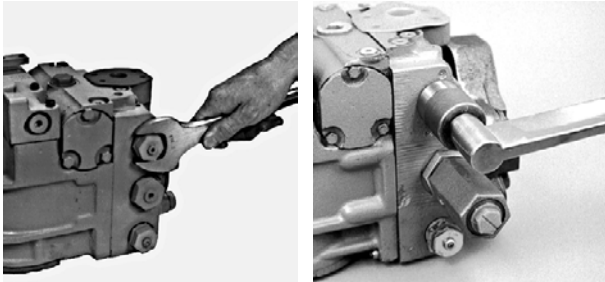
Install Seal Carrier



90000275

Torque Retainer Screw

Pump Minor Repairs

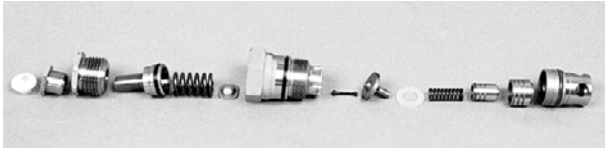


90000276  
Remove Multi-Function Valve Cartridge

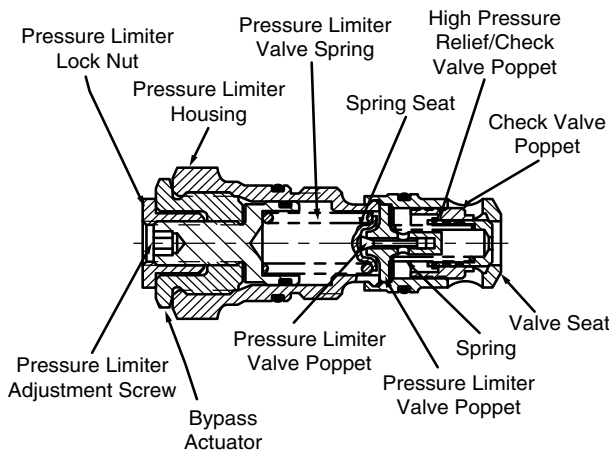
90000277  
Install and Torque Cartridge



90000278  
Multi-Function Valve Cartridge Components (Earlier production)



90000279  
Multi-Function Valve Cartridge Components (Later production)



90000869E  
Multi-Function Valve Cartridge Sectional View

Multi-Function Valve Cartridges

1. The multi-function valve cartridge is removed with a hex wrench on the largest hex on the cartridge.

Frame Size	Wrench Size
030 - 100	1-1/4 inch
130 - 250	1-5/8 inch
T002 284E	

2. Inspect cartridge for damage to parts and O-rings.

The multi-function valve cartridge may be disassembled for cleaning. However, if the pressure limiter housing assembly is disassembled, the pressure settings must be readjusted. Usually, if there is contamination problem, it will be in the valve seat assembly. If it is not necessary to clean the interior of the cartridge, proceed to step 7.

Note: Multi-function valve components are not sold separately as service parts (except O-rings).

3. On early versions of the multi-function valves, the valve seat assembly is held by a retaining ring. Remove retaining ring with a snap ring pliers.

On late versions, the valve seat section is pressed over a lip. Place the cartridge in a vise and pry the lower section off with an appropriate tool. Maintain sufficient control to prevent the contents from flying loose.

4. Remove pressure limiter lock nut and bypass actuator.
5. Unscrew the pressure limiter adjustment screw from the bypass actuator. Clean and inspect all disassembled parts.
6. Reassemble with new, lightly lubricated O-rings by reversing the above procedure. For early versions assemble with the retaining ring. For late versions, place the cartridge in a vise and press on lower assembly.

**Caution**  
The pressure settings must be readjusted after disassembling the pressure limiter housing of the multi-function valve cartridge.

S000018E

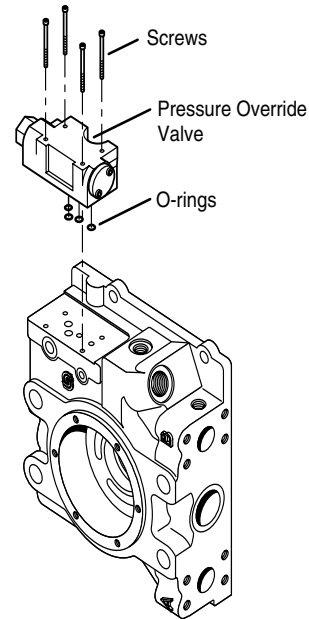
7. Install cartridge in multi-function valve cavity and torque.

Frame Size	Torque
030 - 100	89 Nm (66 lbf•ft)
130 - 250	210 Nm (155 lbf•ft)
T002 285E	

**Do not overtorque the multi-function valve cartridge.**

## Pressure Override Valve (Option for 180 Frame Size)

1. Remove the four screws attaching the pressure override valve to the pump end cap with a 5 mm internal hex wrench. Remove the O-rings.
2. Inspect valve for damage to parts.
3. Install new O-rings. Install the valve onto the pump end cap and torque the screws to 16 Nm (12 lbf•ft).



## Charge Relief Valve

The pump charge relief valve may be shim adjustable (early models) or screw adjustable (late models).

1. Remove the shim adjustable charge relief valve plug with a 1 inch hex wrench.

Before removing the screw adjustable relief valve plug, mark the plug, lock nut, and housing so as to approximately maintain the original adjustment when assembling. Remove the screw adjustable charge relief valve plug by loosening the lock nut with a wrench.

Frame Size	Wrench Size
030 - 100	1-1/16 inch
130 - 250	1-5/8 inch

T002 286E

Unscrew the plug with a large screwdriver or 1/2 inch hex wrench.

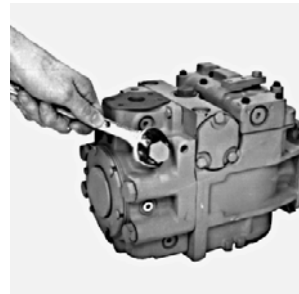
2. Remove the spring and relief valve poppet.
3. Inspect the poppet and mating seat in the end cap for damage or foreign material.

When inspecting shim adjustable valves, do not alter the shims or interchange parts with another valve.

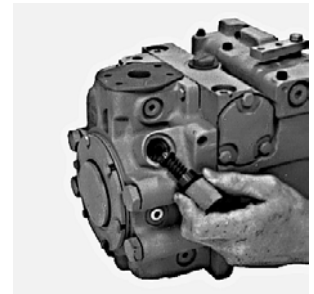
4. Install the poppet and spring. For shim adjustable valves, install the plug and torque to 68 Nm (50 lbf•ft). For screw adjustable valves, install the plug with its lock nut, aligning the marks made at disassembly, and torque the lock nut to 52 Nm (38 lbf•ft).

Check the charge pressure and adjust, if necessary.

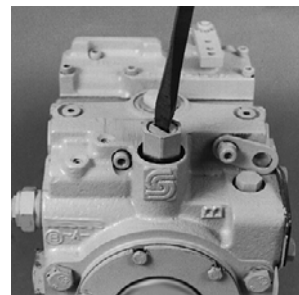
90000870E  
**Pressure Override Valve Components**



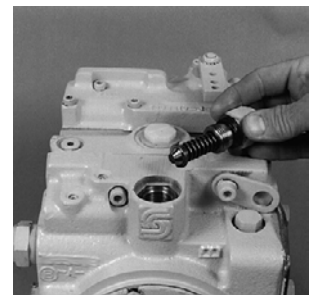
90000280  
**Remove Charge Relief Valve (Shim adjustable)**



90000262  
**Shim Adjustable Charge Relief Valve**



90000264  
**Remove Charge Relief Valve (Screw adjustable)**



90000265  
**Screw Adjustable Charge Relief Valve**



**Charge Pump - Remove**

The following procedure shows how to remove and install a charge pump.

1. For pumps with an auxiliary mounting pad, remove the four screws holding the pad to the end cap and remove the pad. Refer to the Auxiliary Mounting Pad Installation instructions (next section) for details.

Note: At earlier production frame size 75 pumps with twin ports secure the end cap to the pump housing with a clamp to avoid gasket damage.



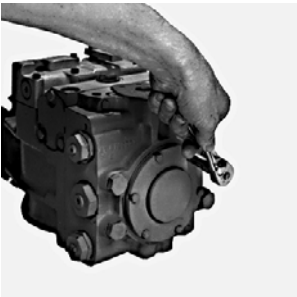
90000281

**Remove Auxiliary Pad Adapter Screws**



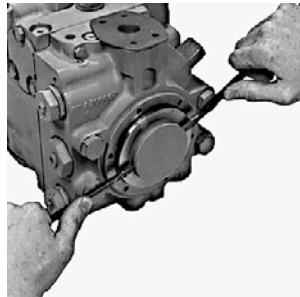
90000303

**Remove Auxiliary Pad Adapter**



90000282

**Remove Retainer Screws**



90000284

**Remove Charge Pump Cover**

**Caution**  
 Do not allow the force of the cylinder block spring and swashplate leveler springs to separate the end cap from the pump housing. Gasket damage and external leakage may result.

S000019E

2. Remove the six screws holding the charge pump cover retainer.

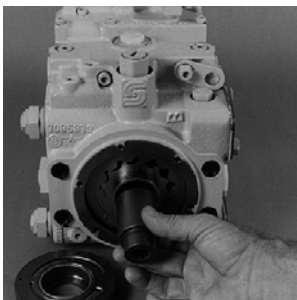
Frame Size	Wrench Size
030 - 100	10 mm
130 - 250	13 mm
T002 287E	

3. Remove the retainer and the charge pump cover. For pumps with an auxiliary mounting pad, remove the auxiliary drive coupling. Note the orientation of the gerotor.
4. Remove the charge pump shaft and charge pump drive key.
5. Remove the spacer plate(s), if present (intermediate production pumps only).

Remove the charge pump outer port plate, if present (early and intermediate production pumps).

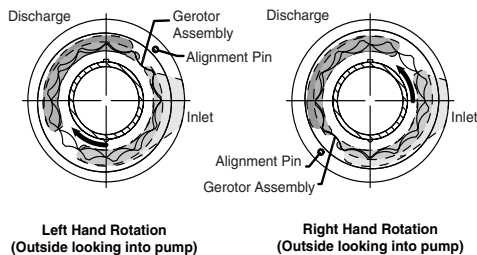
Remove the charge pump gerotor assembly.

6. Remove the outer eccentric ring and alignment pin.
7. Remove the inner port plate.
8. Inspect all parts for abnormal wear or damage.



90000297

**Remove Drive Coupling**



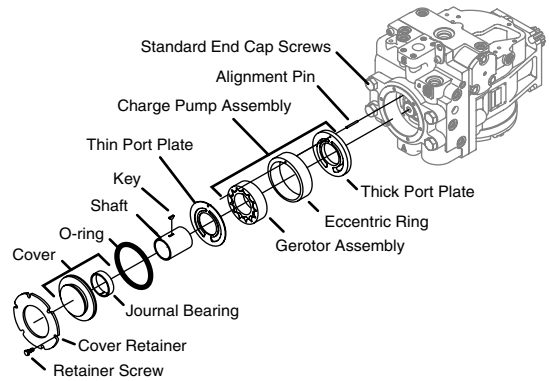
**Orienting Alignment Pin**

90000871E

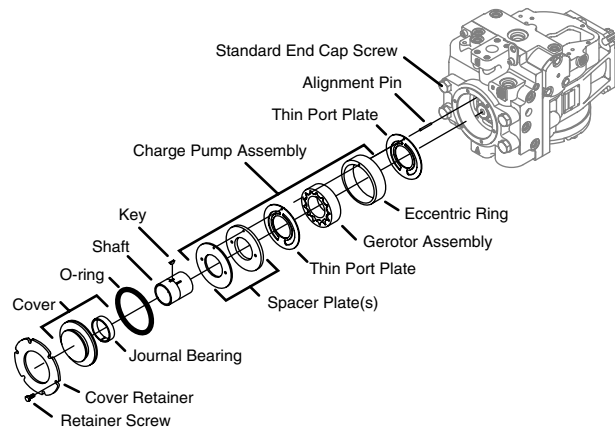
Note: If a different displacement charge pump is being installed, the gerotor assembly, gerotor outer eccentric ring, and inner port plate (early and late production pumps) or outer spacer plate(s) (intermediate production pumps) must be replaced together. If different thickness port plates are used in an early production charge pump assembly, the thicker plate is the inner port plate (installed next to the pump end cap).

Each charge pump assembly includes a different quantity / types of port plates and spacer plates.

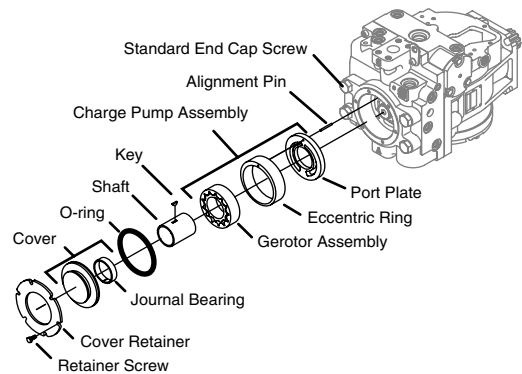
The charge pump kit "No Charge Pump" includes a spacer.



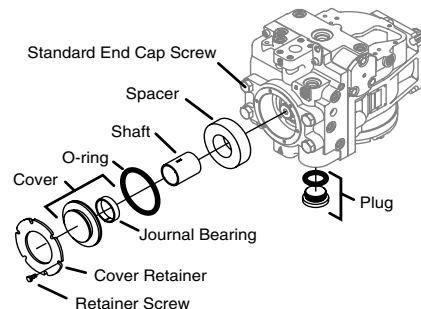
**Charge Pump Components (Early Production)** 90000872E



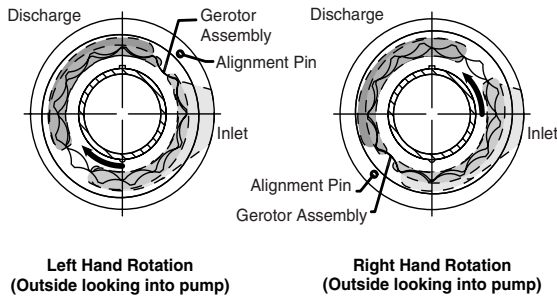
**Charge Pump Components (Intermediate Production)** 90000873E



**Charge Pump Components (Late Production)** 90000874E



**"No Charge Pump" Components** 90000875E



Orienting Alignment Pin

90000871E

### Installing the Charge Pump

Be sure to install the charge pump in the proper orientation. If unsure of charge pump rotation, refer to the model code.

Note: The charge pump **rotation** is determined by the orientation of the gerotor assembly outer eccentric ring and the location of the alignment pin in the end cap.

Do not mix charge pump piece parts from different production periods. Always install as a complete assembly.

1. Install the inner port plate and the gerotor assembly outer ring.
2. Install the alignment pin to properly orient the port plates and outer eccentric ring for corresponding pump rotation.
3. Prior to installation, apply a small quantity of petroleum jelly to the I.D., O.D., and side faces of the gerotor assembly to provide initial lubrication.
4. Install the gerotor assembly.
5. Install the outer port plate (early production and intermediate production pumps only).
6. Install the spacer plate, if present (intermediate production pumps).
7. Install the charge pump drive key into the charge pump shaft and retain with petroleum jelly.



Install Inner Port Plate

90000285



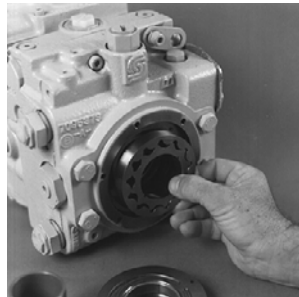
Install Gerotor Assembly Outer Ring

90000286



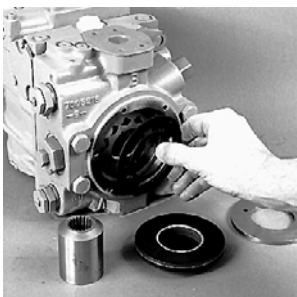
Install Alignment Pin

90000287



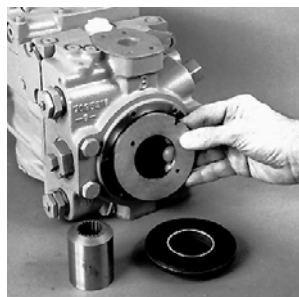
Install Gerotor Assembly

90000288



Install Outer Port Plate (Early and intermediate production only)

90000289



Install Spacer Plate (Intermediate production only)

90000290

Note: Intermediate production 75 cc and 100 cc pumps use the same charge pump drive shaft. Two keyways are provided in the drive shaft for the charge pumps used in these units. The rear keyway (with identifier groove) is used in 75 cc pumps. The front keyway (closest to the internally splined end of the shaft) is used in 100 cc pumps.

8. Install the charge pump shaft. The internally splined end of the shaft must engage the main pump shaft.

Note: The outside diameter of the internally splined end of some early production charge pump shafts was chamfered. Early production end caps may not be machined to accept a non-chamfered shaft. Always use a chamfered charge pump shaft in pumps with the early end cap.

9. For pumps with an auxiliary mounting pad, install the auxiliary drive coupling.
10. Install a new O-ring onto the non-auxiliary pad charge pump cover. (If an auxiliary pad is installed, an O-ring is not used on the cover.)
11. Carefully remove the alignment pin from the charge pump parts. Install the pin in its hole in the charge pump cover (see previous page for correct orientation) and retain with petroleum jelly. Install the cover (with alignment pin) into the end cap and aligned charge pump parts. (Take care not to damage the cover O-ring, if used.)

**Caution**

In order to avoid loss of charge pressure in pumps with an auxiliary mounting pad, always install the charge pump cover with the pad drain hole located on the same side of the end cap as the charge inlet port. Refer to the section „Auxiliary Pad Installation“ for details.

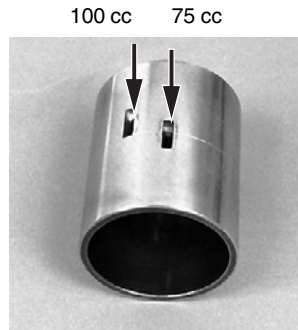
S000 020E

12. Install the charge pump cover retainer and the six hex screws and torque the screws.

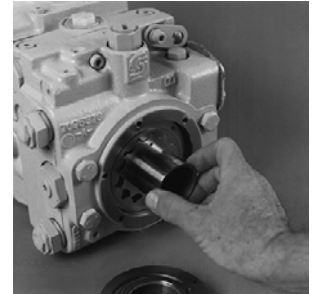
Frame Size	Torque
030 - 100	13.5 Nm (10 lbf•ft)
130 - 250	32 Nm (24 lbf•ft)

T002 288E

13. For pumps with auxiliary mounting pads, install the O-ring and auxiliary mounting pad adaptor onto the end cap. Refer to the corresponding section for instructions on auxiliary pad installation.



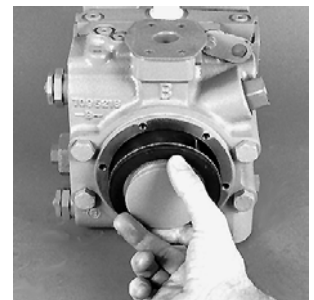
100 cc 75 cc  
90000291  
**Keyways in Charge Pump Shaft (Intermediate Production 075 and 100)**



90000292  
**Install Charge Pump Shaft**



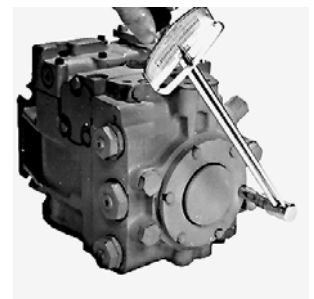
90000293  
**Alignment Pin Installed in Cover**



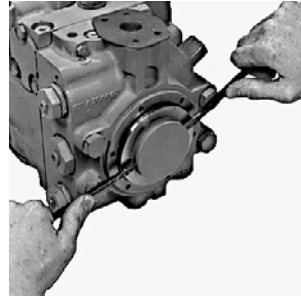
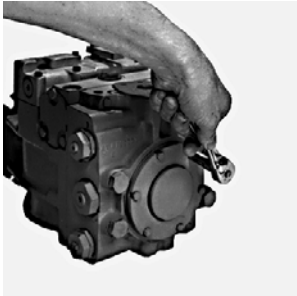
90000294  
**Install Charge Pump Cover**



90000283  
**Install Cover Retainer**

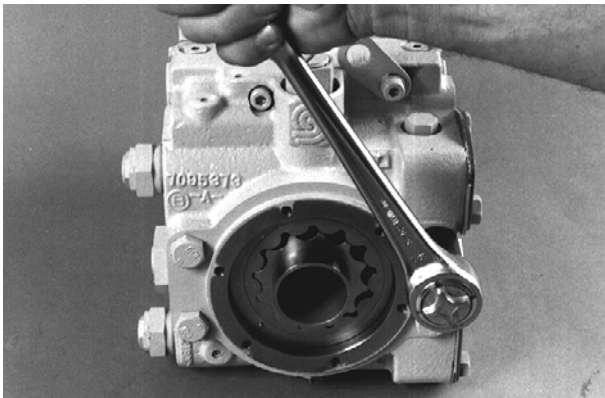


90000295  
**Torque Retainer Screws**

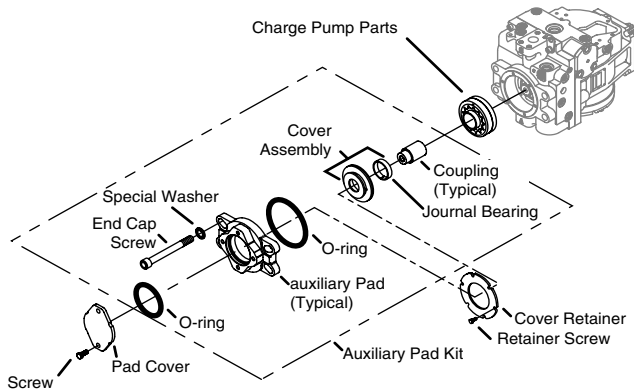


90000282  
Remove Screws and Retainer

90000284  
Remove Charge Pump Cover



90000296  
Remove Large End Cap Screws



90000876E  
Auxiliary Pad Components (Typical)

**Auxiliary Pad Installation**

1. Remove the six screws holding the charge pump cover retainer. Remove the retainer.

Frame Size	Wrench Size
030 - 100	10 mm
130 - 250	13 mm
T002 287E	

2. Remove the charge pump cover and its O-ring.

Note: The original charge pump cover will not be used when installing the auxiliary pad.

3. Remove the four large screws which fasten the end cap to the pump housing.

Frame Size	Wrench Sizes	
	Internal Hex	External Hex
030 - early 042	8 mm	
late 042	10 mm	
055		19 mm
075 - 100		24 mm
100 - 130	14 mm	
180 - 250	17 mm	
T002 289E		

Note: At earlier production frame size 75 pumps with twin ports secure the end cap to the pump housing with a clamp to avoid gasket damage.

**Caution**  
Do not allow the force of the cylinder block spring and swashplate leveler springs to separate the end cap from the pump housing. Gasket damage and external leakage may result.  
S000019E

4. Take care to assure the surfaces are clean and free of any foreign material or paint prior to installing the auxiliary pad.
5. Install the auxiliary drive coupling onto the pump drive shaft spline (auxiliary drive spline must be toward the rear of the pump).



- Carefully remove the alignment pin from the charge pump parts. Install the pin in its hole in the new charge pump cover (with hole for the auxiliary coupling) and retain with petroleum jelly. Install the new charge pump cover with alignment pin into the end cap and the aligned charge pump parts.

**Caution**

In order to avoid loss of charge pressure in pumps with an auxiliary mounting pad, always install the charge pump cover with the pad drain hole located on the same side of the end cap as the charge inlet port. Refer to the section "Auxiliary Pad Installation" for details.

S000 020E

- Install the charge pump cover retainer and the six hex screws and torque the screws.

Frame Size	Torque
030 - 100	13.5 Nm (10 lbf•ft)
130 - 250	32 Nm (24 lbf•ft)

T002 288E

- Install O-ring on end cap pilot.
- Install the auxiliary mounting pad adapter on external pilot on rear of end cap.
- Install four new large screws and washers through the mounting pad and end cap into the housing. Torque per the accompanying table.

Frame Size	Torque
030 - early 042	58 Nm (43 lbf•ft)
late 042	122 Nm (90 lbf•ft)
055	122 Nm (90 lbf•ft)
075 - 100	256 Nm (189 lbf•ft)
100 - 130	298 Nm (220 lbf•ft)
180 - 250	580 Nm (429 lbf•ft)

T002 290E

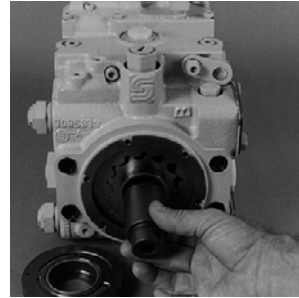
- Install the O-ring and flange cover or auxiliary pump.

### Auxiliary Pad Conversion

To convert an auxiliary mounting pad to a different size mounting pad, use the above procedure with the following additions:

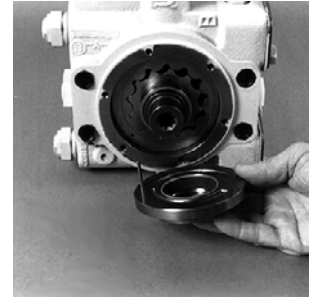
After removing the charge pump cover (step 2), remove the old auxiliary drive coupling.

After removing the four end cap retaining screws, remove the old auxiliary mounting pad adapter.



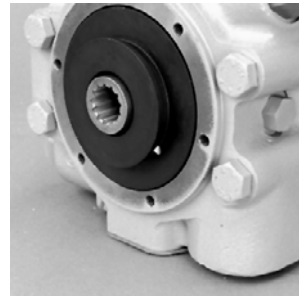
Install Drive Coupling

90000297



Install Alignment Pin in Cover (CCW rotation shown)

90000298



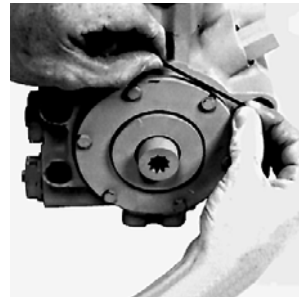
Install New Charge Pump Cover

90000299



Install Screws and Cover Retainer

90000300



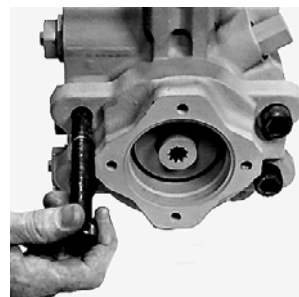
Install O-ring on End Cap Pilot

90000302



Install Auxiliary Pad Adapter

90000303



Install Auxiliary Pad Adapter Screws

90000281



Torque Pad Adapter Screws

90000305

**Filtration Options**

**Suction Filtration Installation**

1. Install the hydraulic fitting to connect the external suction filter to the charge pump inlet port.
2. The reducer fitting (placed on the charge pressure gauge port) is installed as follows.

Frame Size	Wrench Size	Torque
030 - 042	1-1/4 inch	70 Nm (52 lbf•ft)
055 - 130	1-1/2 inch	122 Nm (90 lbf•ft)
180 - 250	1-1/2 inch	156 Nm (115 lbf•ft)
T002 291E		

The gauge port plug takes a 1/4 inch internal hex wrench and is torqued to 27 Nm (20 lbf•ft).

**Remote Charge Pressure Filtration or Integral Charge Pressure Filtration**

Install either of these two filtration devices as follows.

1. Remove the reducer fitting, located at charge pressure gauge port, from pump end cap (this part will not be used).
2. Install the filter manifold or filter head into the port. The hydraulic tube should enter its mating bore in the pump end cap with a low force.
3. After rotating the filter manifold or filter head clockwise so that the threads engage with the threads in the end cap, continue to rotate it clockwise between 6 and 7 revolutions. Face manifold or head to the desired position.

**Caution**  
 Failure to install the filter manifold or filter head to a sufficient depth in the end cap will result in insufficient engagement of the tube in the end cap bore. This may allow unfiltered oil to bypass the filter and enter the charge system.

S000021E

4. While holding the filter manifold or filter head in the desired position, tighten the swivel lock nut.

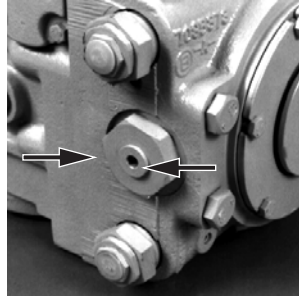
Frame Size	Wrench Size	Torque
030 - 042	1-3/8 inch	70 Nm (52 lbf•ft)
055 - 130	1-5/8 inch	122 Nm (90 lbf•ft)
180 - 250	1-5/8 inch	156 Nm (115 lbf•ft)
T002 292E		

5. After installing the integral pressure filter head assembly, install the filter canister per the instructions on the filter canister.



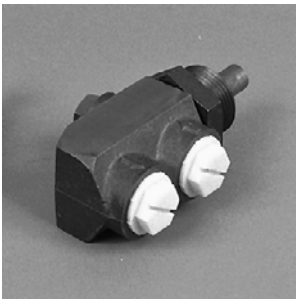
Charge Pump Inlet

90000310



Reducer Fitting and Gauge Port Plug

90000243



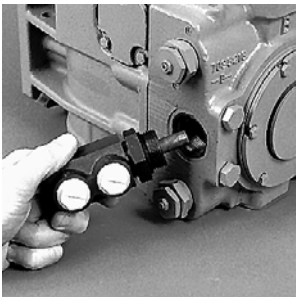
remote Pressure Filter Manifold

90000311



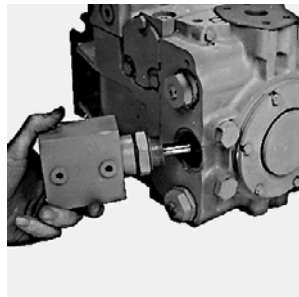
Integral Pressure Filter Head

90000314



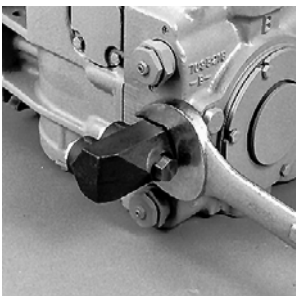
Install Remote Pressure Filter Manifold

90000312



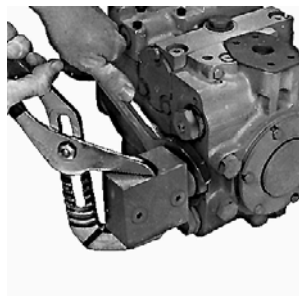
Install Integral Pressure Filter Head

90000315



Tighten Remote Pressure Filter Manifold Lock Nut

90000313



Tighten Integral Pressure Filter Head Lock Nut

90000316



**Pump controls**

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**Cover Plate**

1. Thoroughly clean external surfaces prior to removal of cover plate.
2. Using a 5 mm internal hex wrench, remove the eight cover plate mounting screws. Remove the cover plate and gasket from housing.

**Caution**

**Protect exposed surfaces and cavities from damage and foreign material.**

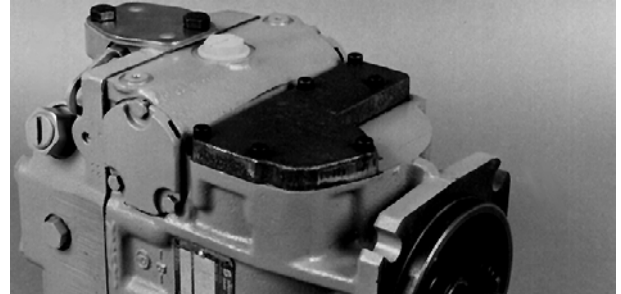
S000022E

3. In preparation for installing the cover plate, place a new gasket on the housing. Place the cover plate into position and install the screws. Torque the screws to 16 Nm (12 lbf•ft).

**NOTE**

**A sealing washer must be installed under the head of any mounting screws that are installed into "thru" holes in the housing.**

S000023E

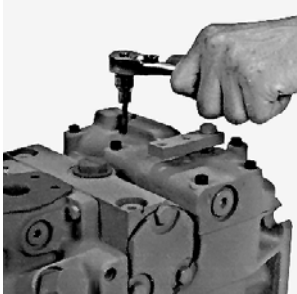
**Pump with Cover Plate**

90000361

**Manual Displacement Control (MDC)**

1. Thoroughly clean external surfaces prior to removal of control.
2. Using a 5 mm internal hex wrench, remove the eight control mounting screws. Remove the control (with orifice check valve and spring) and control gasket from housing.

**Caution**  
**Protect exposed surfaces and cavities from damage and foreign material.**  
 S000022E



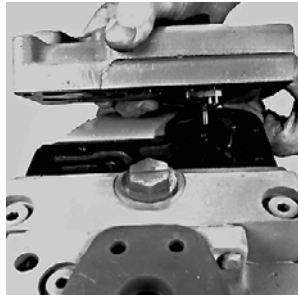
90000319  
**Remove Mounting Screws**



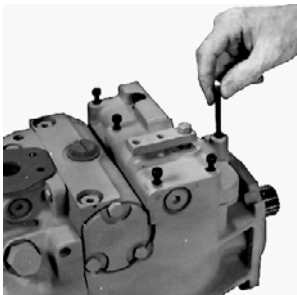
90000320  
**Remove Control**



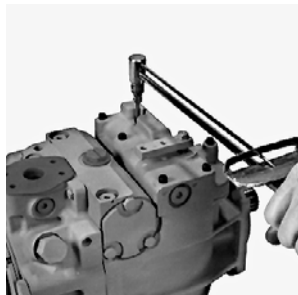
90000321  
**Inner Face of Control**



90000322  
**Assemble Control to Linkage**



90000323  
**Assemble Control to Pump**



90000324  
**Torque Mounting Screws**

3. In preparation for installing the control, place a new gasket on the housing. Inspect to assure that the control orifice check valve and spring are in their proper position in the control.
4. While setting the control into position, engage the pin on the control linkage into the mating hole in the link attached to the swashplate.
5. With the control in position, move control lever both directions to check proper engagement of control linkage pin. Proper engagement will be indicated by centering torque as the lever is moved from center. Non-engagement of control linkage pin is indicated by lack of centering torque as the lever is moved. In case of non-engagement remove the control and repeat the above procedure.
6. Align the control gasket and install the screws. Torque the screws to 16 Nm (12 lbf•ft).

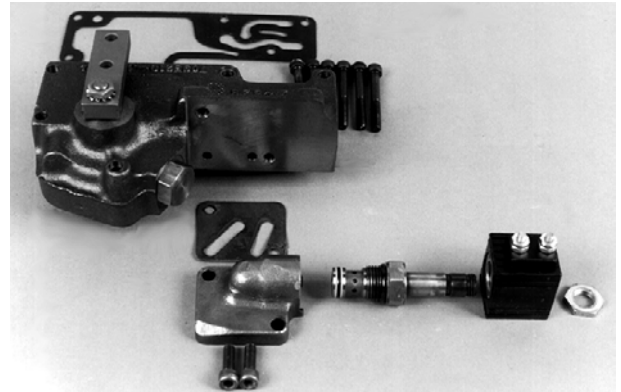
**NOTE**  
**A sealing washer must be installed under the head of any mounting screws that are installed into "thru" holes in the housing.**  
 S000023E

7. If the control is equipped with a neutral start switch, refer to the "MDC Neutral Start Switch Adjustment" instructions.

**WARNING**  
**The neutral start switch "neutral" must be readjusted after reassembling the MDC module.**  
 S000 024E

### Solenoid Override Valve for MDC

1. Thoroughly clean external surfaces prior to removal of valve.
2. Using a 5 mm internal hex wrench, remove the two screws and remove solenoid manifold from housing. Remove the old gasket.
3. The solenoid may be removed from the valve by removing the nut with a 3/4 inch hex wrench. The solenoid valve may be removed from the manifold with a 7/8 inch hex wrench.
4. When installing the solenoid valve into the manifold, the valve should be torqued to  $24 \pm 2.4 \text{ Nm}$  ( $17.7 \pm 1.8 \text{ lbf}\cdot\text{ft}$ ). When installing the solenoid onto the valve, torque the nut to  $6 \text{ Nm}$  ( $53 \pm 12 \text{ lbf}\cdot\text{in}$ ).
5. In preparation for installing the solenoid manifold, place a new gasket on the control housing. Install the manifold onto the control housing, align the gasket, and install the screws. Torque the screws to  $13.5 \text{ Nm}$  ( $10 \text{ lbf}\cdot\text{ft}$ ).

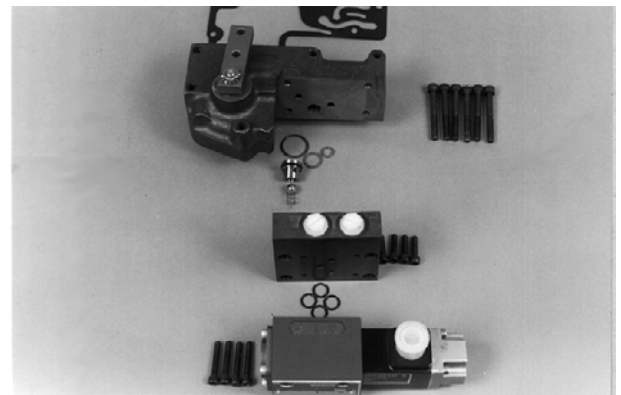


Components of Solenoid Override for MDC

90000363

### Solenoid Override Valve for MDC with Pressure Released Brake

1. Thoroughly clean external surfaces prior to removal of valve.
2. Using a 4 mm internal hex wrench, remove the four solenoid valve mounting screws. Remove the solenoid valve (with O-rings) from the adapter plate.
3. Using a 4 mm internal hex wrench, remove the four adapter plate mounting screws. Remove the adapter plate and O-rings from the control housing.
4. Remove the check valve seat and O-ring from the control side of the adapter plate. Remove the check ball and spring.
5. Install a new O-ring on the check valve seat and reassemble the check valve spring, ball, and seat into the adapter plate.
6. Install new O-rings on the adapter plate. Place the adapter plate into position and install the screws. Torque the screws to  $5.4 \text{ Nm}$  ( $48 \text{ lbf}\cdot\text{in}$ ).
7. Install new O-rings onto the solenoid valve assembly and install the solenoid valve onto the adapter plate. Install the screws and torque to  $5.4 \text{ Nm}$  ( $48 \text{ lbf}\cdot\text{in}$ ).



Components of Solenoid Override with Brake Pressure Defeat for MDC

90000364

**Hydraulic and Electric Displacement Controls**

1. Thoroughly clean external surfaces prior to removal of control.
2. Using a 5 mm internal hex wrench, remove the eight control mounting screws. Remove the control (with orifice check valve and spring) and control gasket from housing.

**Caution**  
**Protect exposed surfaces and cavities from damage and foreign material.**  
 S000022E

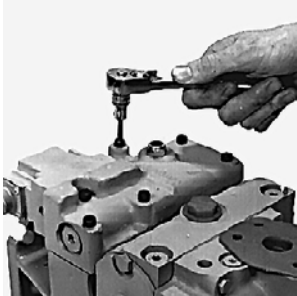
3. In preparation for installing the control, place a new gasket on the housing. Inspect to ensure that the control orifice check valve and spring are in their proper position in the control.
4. While setting the control into position, engage the pin on the control linkage into the mating hole in the link attached to the swashplate.
5. With the control in position, move control assembly left and right to check engagement of pin in the link. Proper engagement will be indicated by an increasing resistance as the control is moved away from center position. Non-engagement of pin will be indicated by lack of spring force. In case of non-engagement, remove control and repeat the above procedure.
6. Align the control gasket and install the screws. Torque the screws to 16 Nm (12 lbf•ft).

**Caution**  
**A sealing washer must be installed under the head of any mounting screws that are installed into "thru" holes in the housing.**  
 S000 023E

**Pressure Control Pilot (PCP) for Electric Displacement Control**

1. Thoroughly clean external surfaces of control.
2. Using a 4 mm internal hex wrench, remove the four screws and remove the PCP.
3. Check surfaces for nicks or damage. Clean internal screens.
4. Install new O-rings in PCP Housing. Place PCP against EDC housing and install the screws. Torque to 5.4 Nm (48 lbf•in).

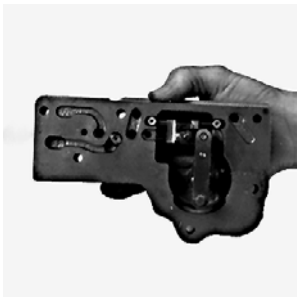
**Note:** Do not remove black plastic cover from the aluminum plate. This is not a serviceable item and will void the product warranty.



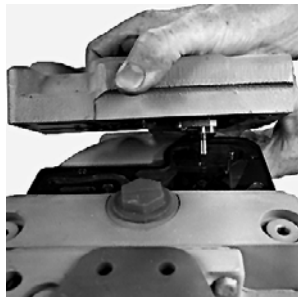
90000325  
**Remove Mounting Screws**



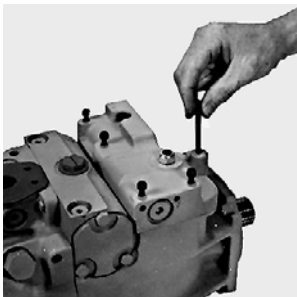
90000326  
**Remove Control**



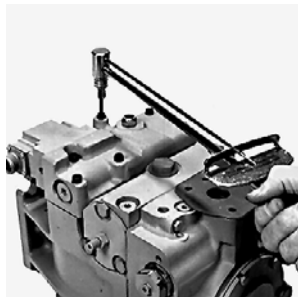
90000327  
**Inner Face of Control**



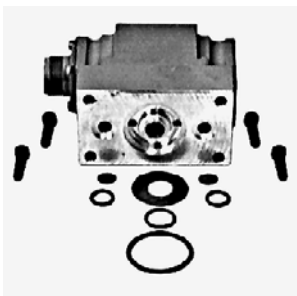
90000328  
**Assemble Control to Linkage**



90000329  
**Install Mounting Screws**



90000330  
**Torque Mounting Screws**



90000332  
**PCP Components**



90000334  
**Torque PCP Valve Screws**

## 3-Position (FNR) Electric Control

1. Thoroughly clean external surfaces prior to removal of control.
2. Using a 4 mm internal hex wrench, remove the four solenoid valve mounting screws. Remove the solenoid valve (with O-rings and orifice) from the adapter plate.
3. Using a 5 mm internal hex wrench, remove the eight adapter plate mounting screws. Remove the adapter plate and gasket from housing.

### Caution

**Protect exposed surfaces and cavities from damage and foreign material.**

S000022E

4. Inspect the orifice installed between the valve and adapter plate. This orifice **MUST** be installed in the case drain passage for proper pressure limiter operation.
5. In preparation for installing the adapter plate, place a new gasket on the housing. Place the adapter plate into position and install the screws. Torque the screws to 16 Nm (12 lbf•ft).

### NOTE

**A sealing washer must be installed under the head of any mounting screws that are installed into „thru“ holes in the housing.**

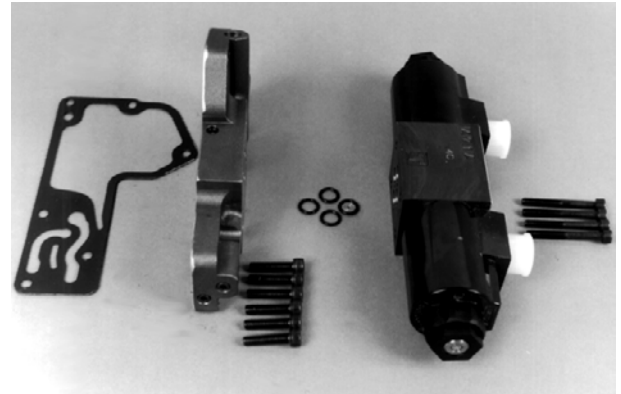
S000023E

6. Install new O-rings and the orifice onto the solenoid valve assembly and install the solenoid valve onto the adapter plate. Install the screws and torque to 5.4 Nm (48 lbf•in).

## Displacement Control Components

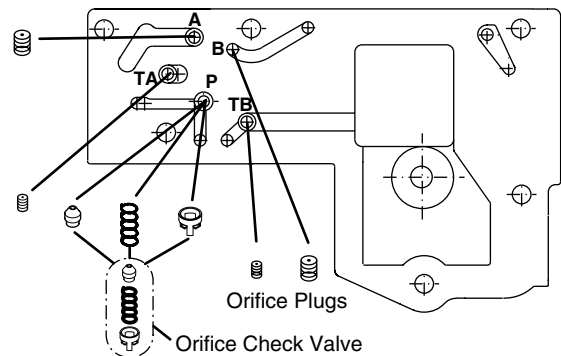
### Displacement Control Orifices

1. Remove the control assembly as described in the instructions for the specific displacement control.
2. Orifice plugs may be located in the control assembly, at the pump housing face surface. Remove the orifice plugs with a 4 mm internal hex wrench. Note the location of each plug, do not interchange plugs. Torque the orifice plugs to 3 Nm (26 lbf•in).
3. Assemble the control onto the pump. Refer to the instructions for the specific control.



3-Position Electric Control Components

90000362

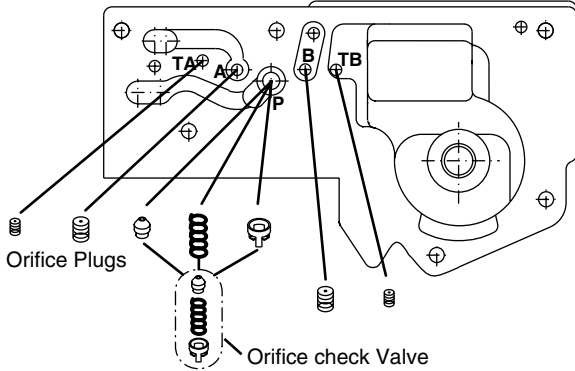


Underside of an HDC/EDC Module Showing Orifice Locations

90000849E

**Displacement Control Orifice Check Valve**

1. Remove the control assembly as described in the instructions for the specific displacement control.
2. The orifice check valve is located in the control assembly, at the surface of the pump housing face. Remove the spring retainer and spring from the orifice check valve cavity and then remove the orifice check valve.
3. Install the desired orifice check valve in the cavity and then install the spring and spring retainer to hold the orifice check valve in position.
4. Assemble the control onto the pump. Refer to the instructions for the specific control.



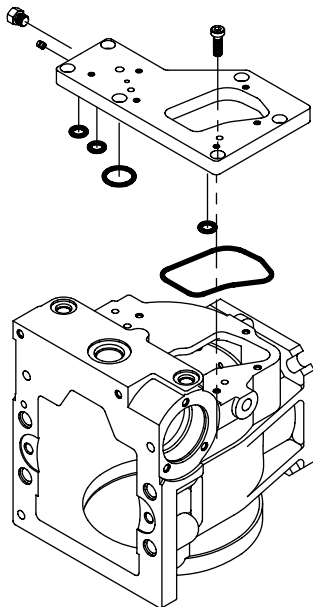
90000848E

**Underside of an MDC Module Showing Orifice Locations**

**Displacement Control Adapter Plate (Early production 130 Pumps only)**

The screws fastening the control adapter plate to the housing have retaining compound on the threads. They are removed with a 6 mm internal hex wrench.

When installing the adapter plate, ensure the O-rings are in the proper position and torque the screws to 32 Nm (24 lbf•ft).



90000847

**Displacement Control Adapter Plate (Early production 130cc Pumps only)**

**Displacement Control Filter Screens**

If the pump is equipped with control filter screens in the pump housing (late production), they should be pressed into position (with the rounded edge of the filter screens facing the control until they are flush to 2.0 mm (0.08 inch) below the surface of the housing).



**Minor Repair - Motor**

**Loop Flushing and Charge Relief Valves**

**Loop Flushing Valve**

1. Using an 1-1/16 inch wrench, remove the hex plugs and O-rings from both sides of the valve. Remove the springs, shoulder washers, and flushing valve shuttle spool. Note orientation of the washers. Remove the flushing valve spool.
2. Inspect parts for damage or foreign material.

Note: Early production motors used a small diameter shuttle valve spool. Late production motors use a larger diameter spool.

3. Install flushing valve spool in end cap, then install the shoulder washers (with shoulders facing "out") and springs on each end of the spool. Install the hex plugs with O-rings, and torque to 41 Nm (30 lbf•ft) on 030 through 100 motors or 68 Nm (50 lbf•ft) on 130 motors.

**Motor Charge Relief Valve**

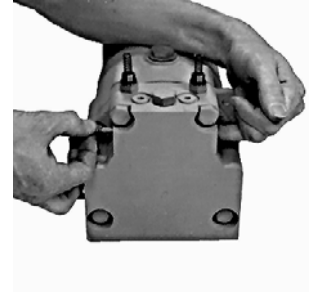
1. Remove the shim adjustable charge relief valve plug with a 7/8 inch hex wrench.

Before removing the screw adjustable relief valve plug, mark the plug, lock nut, and housing so as to be able to maintain the original adjustment when assembling. Remove the screw adjustable charge relief valve plug by loosening the lock nut with a 1-1/16 inch hex wrench for 030 through 100 units, or a 1-5/8 inch hex wrench for 130 units, and unscrewing the plug with a large screwdriver or 1/2 inch hex wrench.

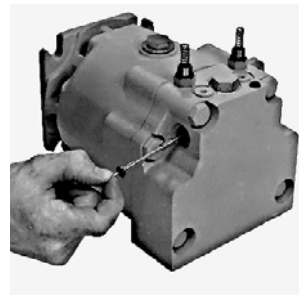
2. Remove the spring and valve poppet.
3. Inspect the poppet and mating seat in the end cap for damage or foreign material. When inspecting shim adjustable valves, do not alter the shims or interchange parts with another valve.



90000338  
**Remove Plugs Springs**



90000339  
**Remove Flushing Shuttle Spool**



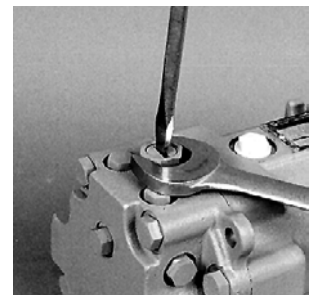
90000340  
**Install Flushing Shuttle Spool**



90000341  
**Torque Plugs**

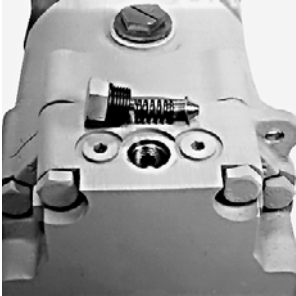


90000342  
**Remove Shim Charge Relief Valve**



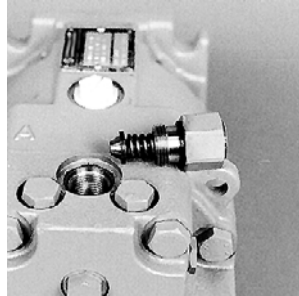
90000343  
**Remove Screw Charge Relief Valve**





90000344

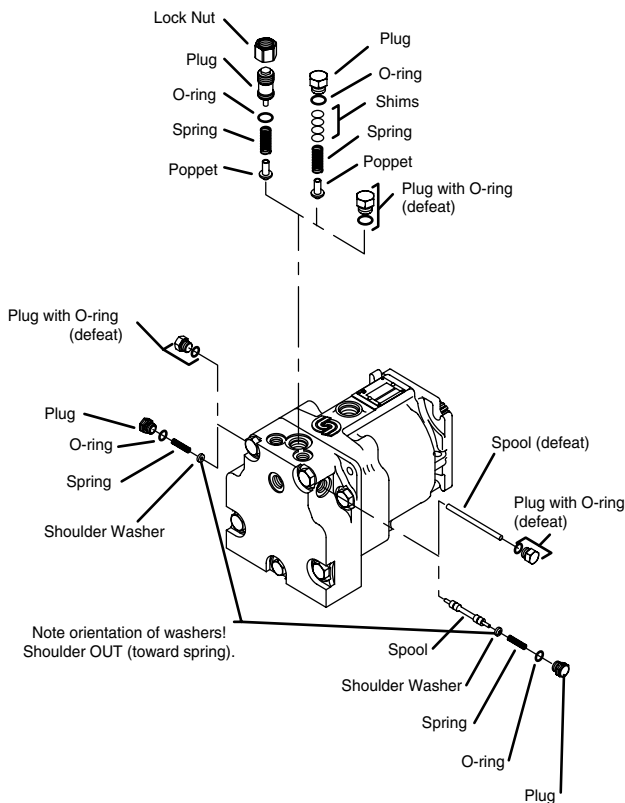
**Shim Adjustable Charge Relief Valve**



90000345

**Screw Adjustable Charge Relief Valve**

4. Install the poppet and spring. For shim adjustable valves, install the plug and torque to 68 Nm (50 lbf•ft). For screw adjustable valves, install the plug with its lock nut, aligning the marks made at disassembly, and torque the lock nut to 52 Nm (38 lbf•ft).
5. Check and adjust the charge pressure.



90000850E

**Motor charge Relief Valve and Loop Flushing Valve Parts**

**Defeating the Loop Flushing Valve**

1. Remove loop flushing valve components (these parts will not be used).
2. Install defeating spool into spool bore in end cap.
3. Install hex plugs provided and torque to 41 Nm (30 lbf•ft).
4. Remove charge relief valve components (these parts are not necessary).
5. Replace with the hex plug provided and torque to 41 Nm (30 lbf•ft).

**Variable Motor Displacement Limiters**

1. Remove the tamper-resistant cap from the displacement limiter. Measure and note the length of the adjustment screw up to the seal lock nut. Using a 19 mm hex wrench, loosen the seal lock nut and remove the nut. Remove the limiter screw from the motor housing with a 6 mm internal hex wrench.
2. Install the limiter screw with the noted length between adjustment screw and the seal lock nut. Do not install a new tamper-resistant cap until the limiter has been adjusted.
3. Final adjustment of the displacement limiters should be performed on a test stand.

**Do not turn the limiter screws counterclockwise beyond their initial adjustment positions.**

**Caution**

Care should be taken in adjusting displacement limiters to avoid undesirable speed conditions. The seal lock nut must be retorqued after every adjustment to prevent an unexpected change in operating conditions and to prevent external leakage during unit operation.

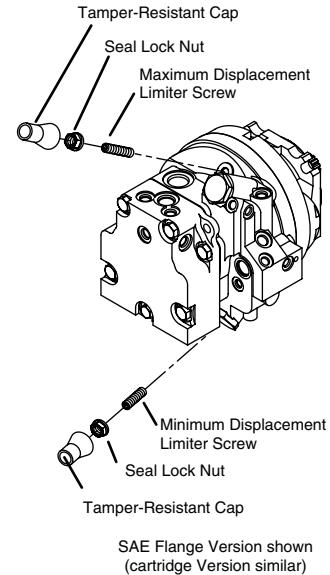
S000026E

One full turn of the displacement limiter adjustment screw will change the displacement as follows:

Frame Size	Approx Change in Disp per Rev of Adjusting Screw
055	5.6 cm <sup>3</sup> / Rev (0.34 in <sup>3</sup> / Rev)
075	7.1 cm <sup>3</sup> / Rev (0.43 in <sup>3</sup> / Rev)

T002 295E

4. Following the final adjustment, install new tamper resistant caps.



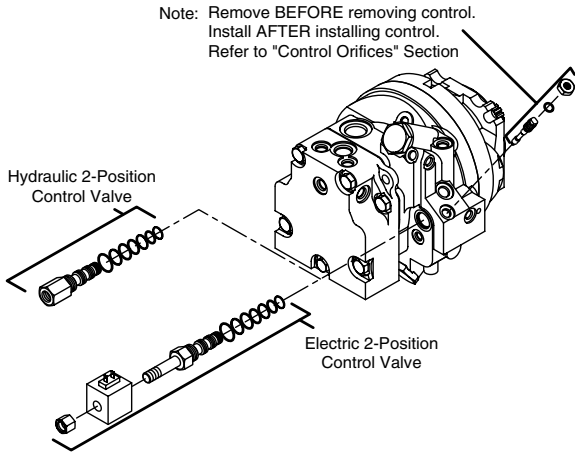
**MV Displacement Limiters**

90000851E

Variable Motor Controls

**Electrohydraulic 2-Position Control (Types NA, NB, NC, and ND)**

1. Thoroughly clean external surfaces prior to removal of the control.
2. Disconnect the external electrical signal connection.
3. Remove the hex nut and solenoid from the control valve.
4. Remove the orifice check valve for the maximum angle control cylinder, if equipped.
5. Remove the control valve from the motor housing.
6. Remove O-rings from the valve.
7. Install new O-rings on the control valve.
8. Install the valve into the motor housing and torque to 47 Nm (35 lbf•ft). **Do not overtorque the control valve.** Over-torquing may result in the valve spool sticking.
9. Install the solenoid onto the valve and torque the hex nut to 5 Nm (44 lbf•in). **Do not overtorque the nut.**
10. If previously removed, reinstall the orifice check valve. Reconnect the external signal connection.



MV Control components

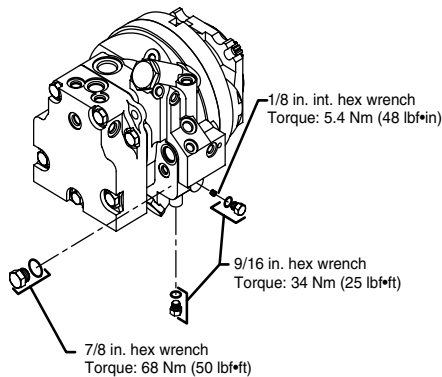
90000852E

**Hydraulic 2-Position Control (Type PT)**

Follow the steps above, except that in step 2 a hydraulic signal line will be disconnected, and steps 3 and 9 are not applicable.

**Control Plugs**

Remove the control plugs from the housings of earlier production motors, if necessary. Install new O-rings, reinstall, and torque.



MV Control Plugs

90000853E

**Variable Motor Control Orifices**

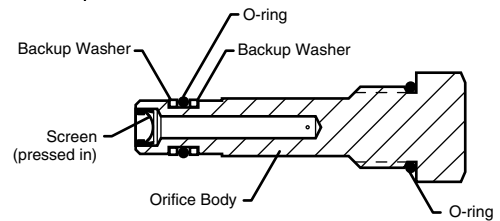
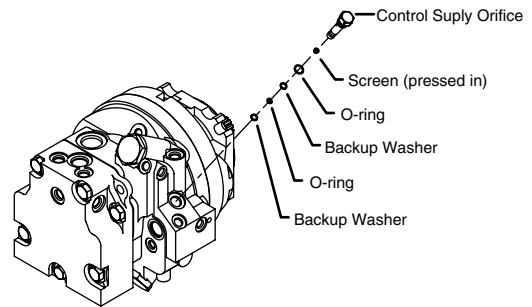
**Control Supply Orifice**

1. Remove the control supply orifice from the motor housing with an 1-1/16 inch hex wrench.
2. Remove the O-rings and the backup washers. Check that the filter screen is secure in the orifice body and that the screen and the orifice are not plugged.
3. Install new backup washers and O-rings onto the orifice body. Install the orifice into the motor housing and torque to 37 Nm (27 lbf•ft).

**Caution**

**Do not interchange the control supply orifice with the minimum displacement orifice (next section).**

S000 027E



**Cross-section View of Control Supply Orifice Assembly**

90000854E

**MV Control Supply Orifice**

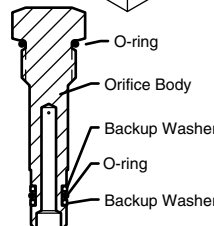
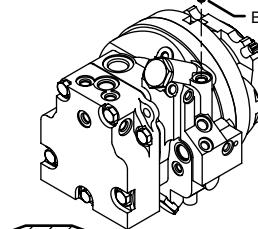
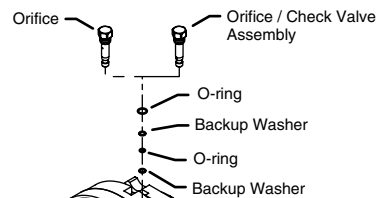
**Minimum Displacement Cylinder Orifice or Orifice Check Valve**

1. Remove the minimum displacement cylinder drain orifice or the orifice check valve from the motor housing with an 1-1/16 inch hex wrench.
2. Remove the O-rings and the backup washers. Check that the orifice is not plugged. Check that the check valve seat is secure in the body and that the check ball is free.
3. Install new backup washers and O-rings onto the orifice body. Install the orifice into the motor housing and torque to 37 Nm (27 lbf•ft).

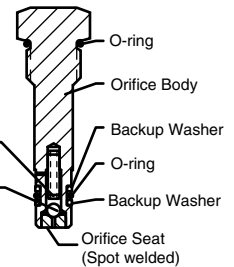
**Caution**

**Do not interchange the control supply orifice (previous section) with the minimum displacement orifice.**

S000 028E



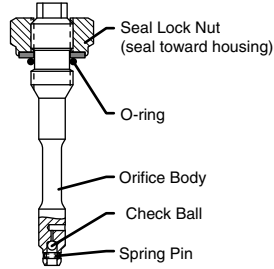
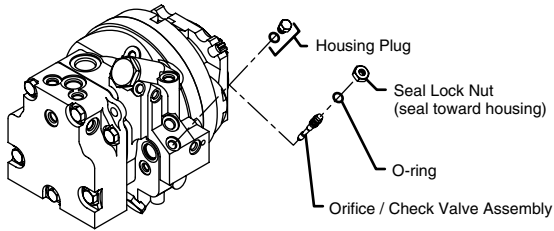
**Cross-Section View of Orifice Assembly**



**Cross-Section View of Orifice / Check Valve Assembly**

90000855E

**MV Minimum Displacement Orifice**



Cross-Section View of Orifice / Check Valve Assembly

**Maximum Displacement Cylinder Orifice Check Valve**

1. Remove the seal lock nut with a 3/4 inch hex wrench. Remove the maximum displacement cylinder orifice check valve from the motor housing with a 1/4 inch end wrench. Remove the O-ring. The check ball in the valve must be free.
2. Reinstall the check valve and torque to 15 Nm (11 lbf•ft). Install a new O-ring. Install the seal lock nut with the seal toward the motor housing.

**Hold the check valve from turning while torquing the seal lock nut to 34 Nm (25 lbf•ft).**

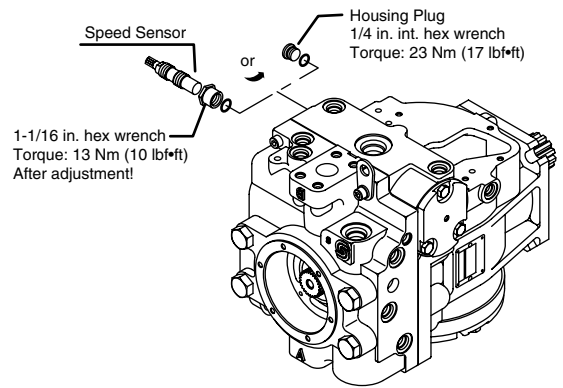
3. If no orifice check valve is installed, the housing plug may be removed with a 9/16 inch hex wrench. Always install a new O-ring. Reinstall the plug and torque to 20 Nm (15 lbf•ft).

MV Maximum Displacement Orifice

90000856E

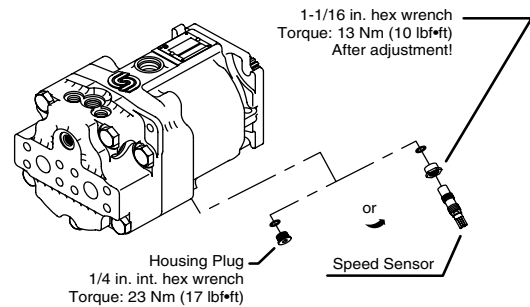
**Speed Sensor**

1. Remove the speed sensor by disconnecting the electrical connector, loosening the lock nut, and unscrewing the speed sensor from the pump or motor housing.
2. Always install a new O-ring before installing the sensor.
3. Reinstall the speed sensor (with lock nut and O-ring) into the housing. Adjust the gap between the sensor and the magnetic speed ring as instructed in Section "Speed Sensor Adjustment" and torque the sensor lock nut.
4. If a speed sensor is not installed, the housing plug should be torqued as indicated in the accompanying figure.



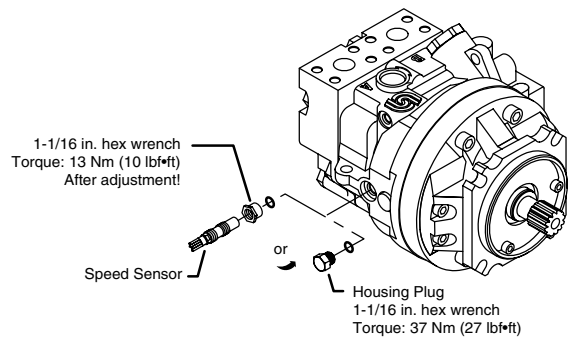
90000857E

**Typical Location of Speed Sensor - PV**



90000858E

**Typical Location of Speed Sensor - MF**



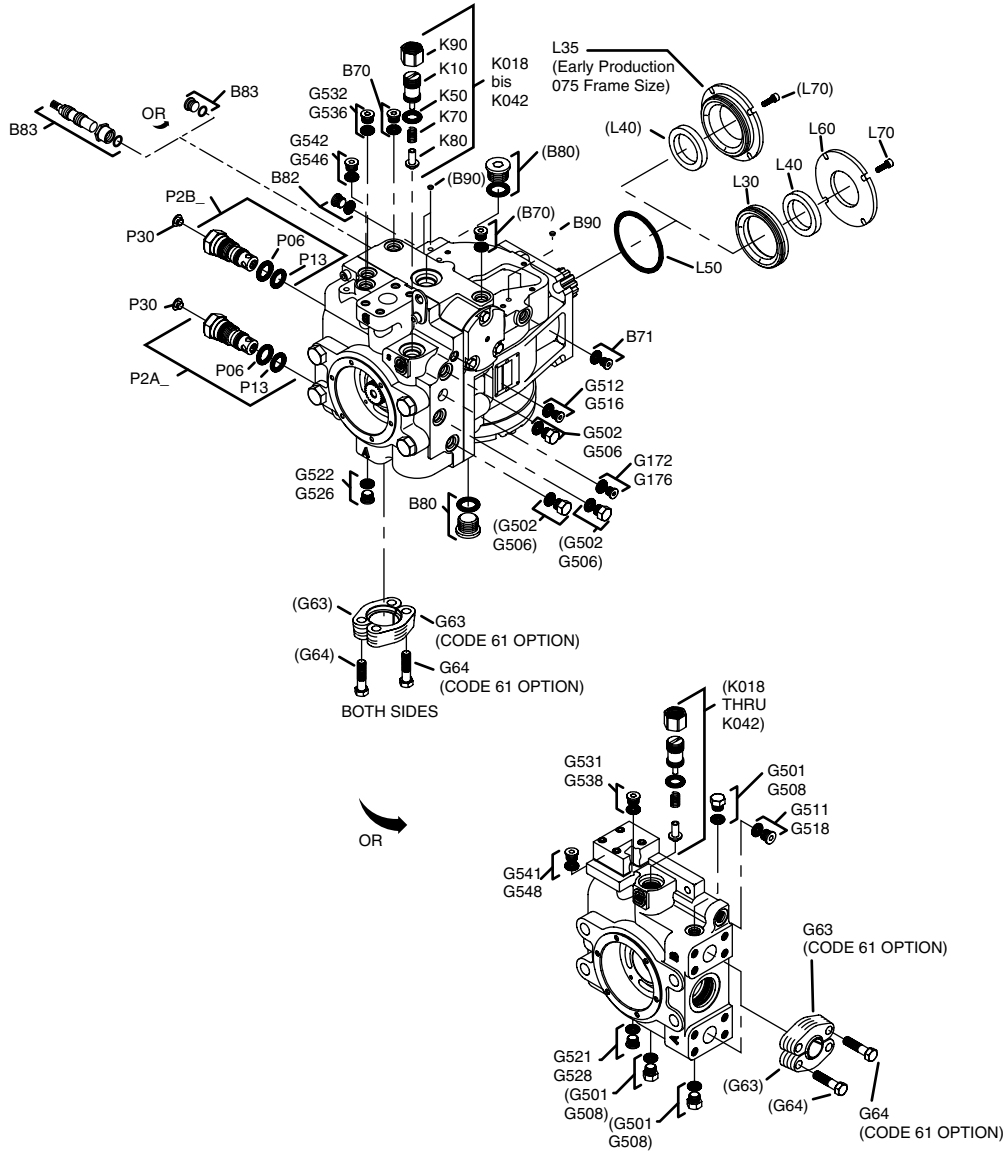
90000859E

**Typical Location of Speed Sensor - MV**

**Exploded View Parts Drawings / Parts Lists**

**Variable Pumps**

**Minor Repair Parts**

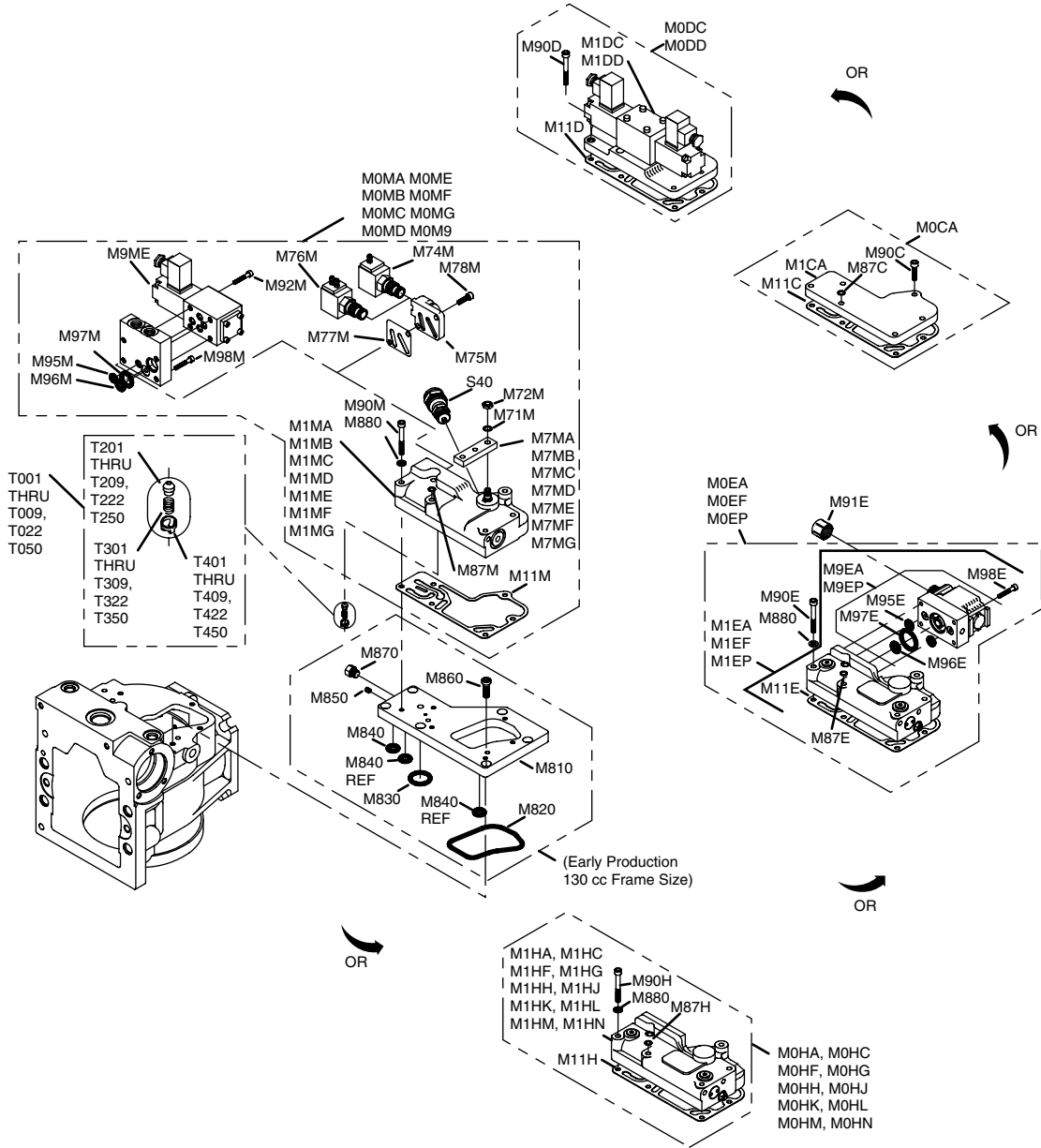




**Parts List**

Item	Description	Qty	Item	Description	Qty
B70	Plug	2	G532	Plug	1
B71	Plug	1	G536	O-ring	1
B80	Plug	1	G538	O-ring	1
B82	Plug	1	G541	Plug	1
B90	Filter screen	3	G542	Plug	1
			G546	O-ring	1
G63	Split flange clamp	4	G548	O-ring	1
G64	Plug	4			
G172	Plug	1	K10	Plug assembly	1
G176	O-ring	1	K50	O-ring	1
G501	Plug	3	K70	Spring	1
G502	Plug	3	K80	Poppet	1
G506	O-ring	3	K90	Nut	1
G508	O-ring	3			
G511	Plug	1	L30	Seal carrier	1
G512	Plug	1	L35	Seal carrier	1
G516	O-ring	1	L40	Lip seal	1
G518	O-ring	1	L50	O-ring	1
G521	Plug	1	L60	Retainer	1
G522	Plug	1	L70	Screw	3
G526	O-ring	1			
G528	O-ring	1	L8	Key	1
G531	Plug	1	L9	Slotted nut	1

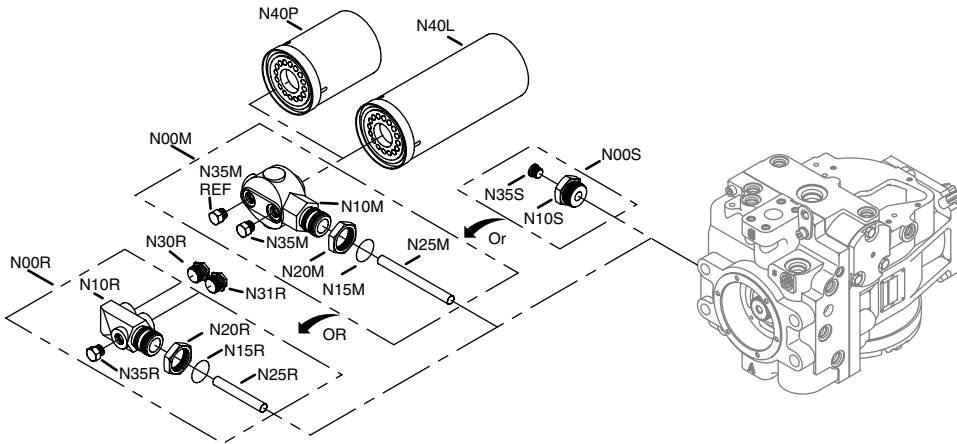
**Variable Pump Controls**



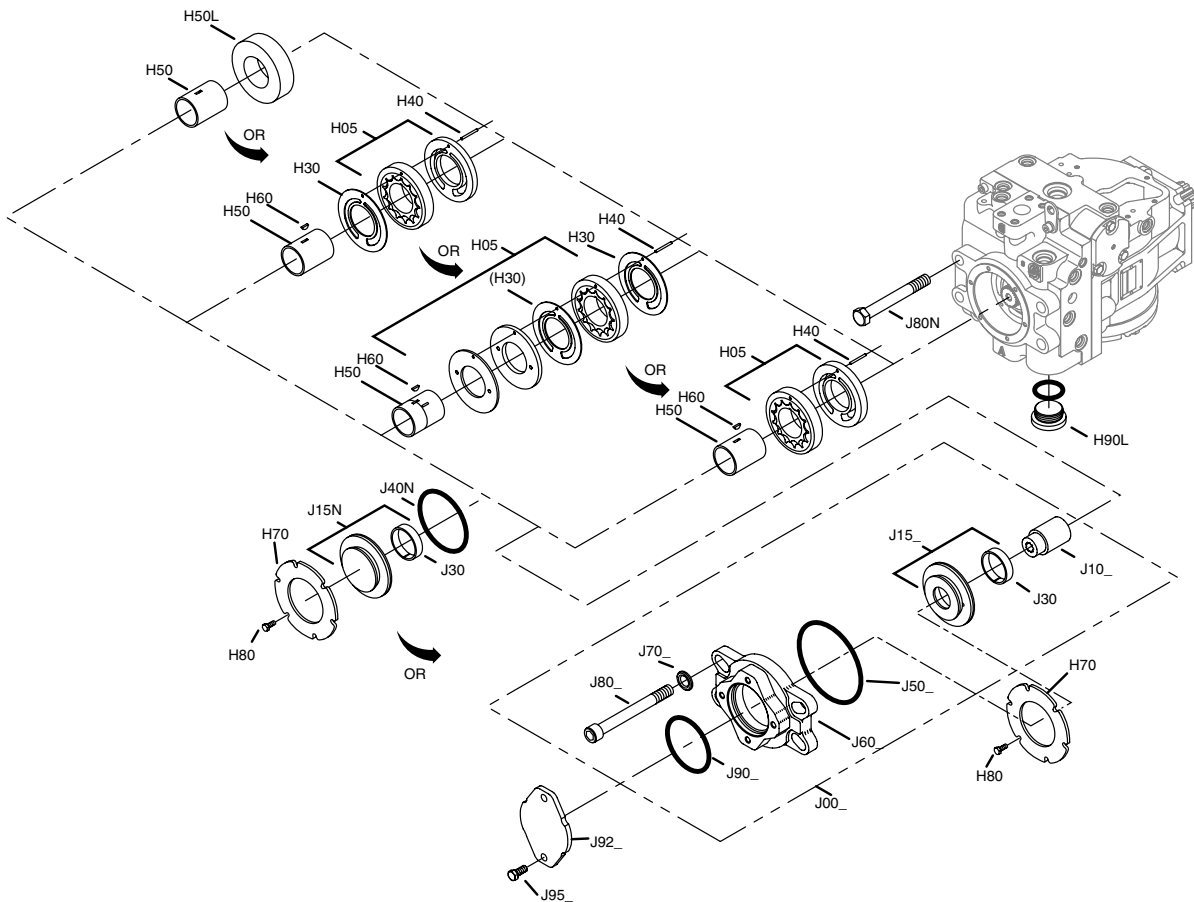
**Control Parts List**

Item	Description	Qty	Item	Description	Qty
M0CA	Cover plate kit	1	M71M	Washer	1
M1CA	Cover plate	1	M72M	Nut	1
M11C	Control gasket	1	M80	Control gasket	1
M11D	Control gasket	1	M87M	Washer, seal (042)	1
M87C	Washer, seal (042)	1	M90M	Screw	6
M90C	Screw	6	S40	Neutral start switch kit	1
M0DC	Control kit, 3-position FNR 12V	1	M0MC	Control MDC w/ sol. valve	1
M0DD	Control kit, 3-position FNR 24V	1	M7M	Control handle	1
M1DC	Control, 3-position FNR 12V	1	M71M	Washer	1
M1DD	Control, 3-position FNR 24V	1	M72M	Nut	1
M80	Control gasket	1	M74M	Solenoid valve	1
M87D	Washer, seal (042)	1	M75M	Control manifold	1
M90D	Screw	6	M77M	Manifold gasket	1
M0EA	Control kit, EDC with MS connector	1	M78M	Screw	2
M0EP	Control kit, EDC with Packard connector	1	M80	Control gasket	1
M1EA	Control, EDC with MS-connector	1	M87M	Washer, seal (042)	1
M1EP	Control, EDC with Packard-connector	1	M90M	Screw	6
M9EA	PCP type 3 oil filled (MS)	1	M0MD	Control MDC w/ sol. valve and neutral start switch	1
M9EA	PCP type 3 oil filled (Packard)	1	M7M	Control handle	1
M80	Control gasket	1	M71M	Washer	1
M87E	Washer, seal (042)	1	M72M	Nut	1
M90E	Screw	6	M75M	Control manifold	1
M91E	Plastic cap (MS)	1	M76M	Solenoid valve	1
M95E	O-ring	2	M77M	Manifold gasket	1
M96E	O-ring	1	M78M	Screw	2
M97E	O-ring	1	M80	Control gasket	1
M98E	Screw	4	M87M	Washer, seal (042)	1
M1MA	Servovalve kit	1	M90M	Screw	6
M0HA	Control kit, hydraulic, HDC	1	S40	Neutral start switch	1
M0HC	Control kit, hydraulic, HDC	1	M810	Adapter plate - Control (130 cc)	1
M1HA	Control, hydraulic, HDC	1	M820	O-ring (130 cc)	1
M1HC	Control, hydraulic, HDC	1	M830	O-ring (130 cc)	1
M11H	Control gasket	1	M840	O-ring (130 cc)	2
M80	Control gasket	1	M850	Plug (130 cc)	1
M87H	Washer, seal (042)	1	M860	Screw (130 cc)	6
M90H	Screw	6	M870	Plug (130 cc)	1
M0MA	Control MDC w/o neutral start switch	1	M9ME	4/2 Way valve	1
M7M	Control handle	1	M92M	Screw	4
M71M	Washer	1	M95M	O-ring	1
M72M	Nut	1	M96M	O-ring	1
M80	Control gasket	1	M97M	O-ring	1
M87M	Washer, seal (042)	1	M98M	Screw	4
M90M	Screw	6	T001-9	Control orifice kit	1
M0MB	Control MDC w/ neutral start switch	1	T201-9	Orificed check valve	1
M7M	Control handle	1	T301-9	Spring	1
			T401-9	Spring retainer	1

**Filter and Options**



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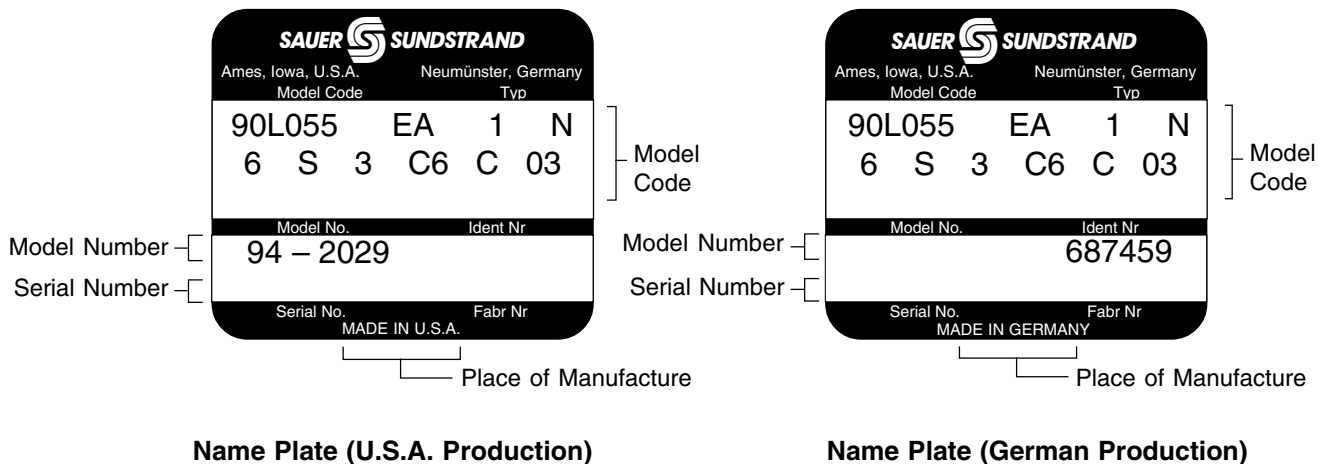


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Parts List Filter and Options

Item	Description	Qty	Item	Description	Qty
H05B-H	Kit - Charge pump	1	J80A-V	Screw	4
H50L	Spacer (No charge pump)	1	J80N	Screw	4
H30	Port plate	2	J90A-V	O-ring	1
H40	Pin	1	J92A-V	Cover plate	1
H50	Charge pump shaft	1	J95A-V	Screw	2/4
H60	Key	1	N00M	Filtration manifold kit (Int)	1
H70	Retaining plate	1	N10M	Manifold	1
H80	Screw	6	N15M	O-ring	2
H90L	Plug	1	N20M	Nut	1
J00A	Aux. mtg. SAE A flange	1	N25M	Tube	1
J00B	Aux. mtg. SAE B flange	1	N35M	Plug	2
J00C	Aux. mtg. SAE C flange	1	N40L	Filter	1
J00D	Aux. mtg. SAE D flange	1	N40P	Filter	1
J00T	Aux. mtg. SAE A flange (11 T)	1	N00R	Filtration manifold kit (Rmt)	1
J00V	Aux. mtg. SAE B-B flange	1	N10R	Manifold	1
J00N	Aux. mtg. flange - none	1	N15R	O-ring	1
J10A-V	Coupling	1	N20R	Nut	1
J15	Charge pump cover assembly	1	N25R	Tube	1
J15N	Charge pump cover assembly	1	N30R	Plastic plug	2
J30	Bushing	1	N35R	Plug	1
J50A-V	O-ring	1	N00S	Filtration kit (Suction Flt)	1
J60A/T	Flange adaptor SAE A	1	N10S	Reducer fitting (Suction Flt)	1
J60B/V	Flange adaptor SAE B	1	N35S	Plug	1
J60C	Flange adaptor SAE C	1			
J60D	Flange adaptor SAE D	1			
J70A-V	Washer	4			

Name Plates

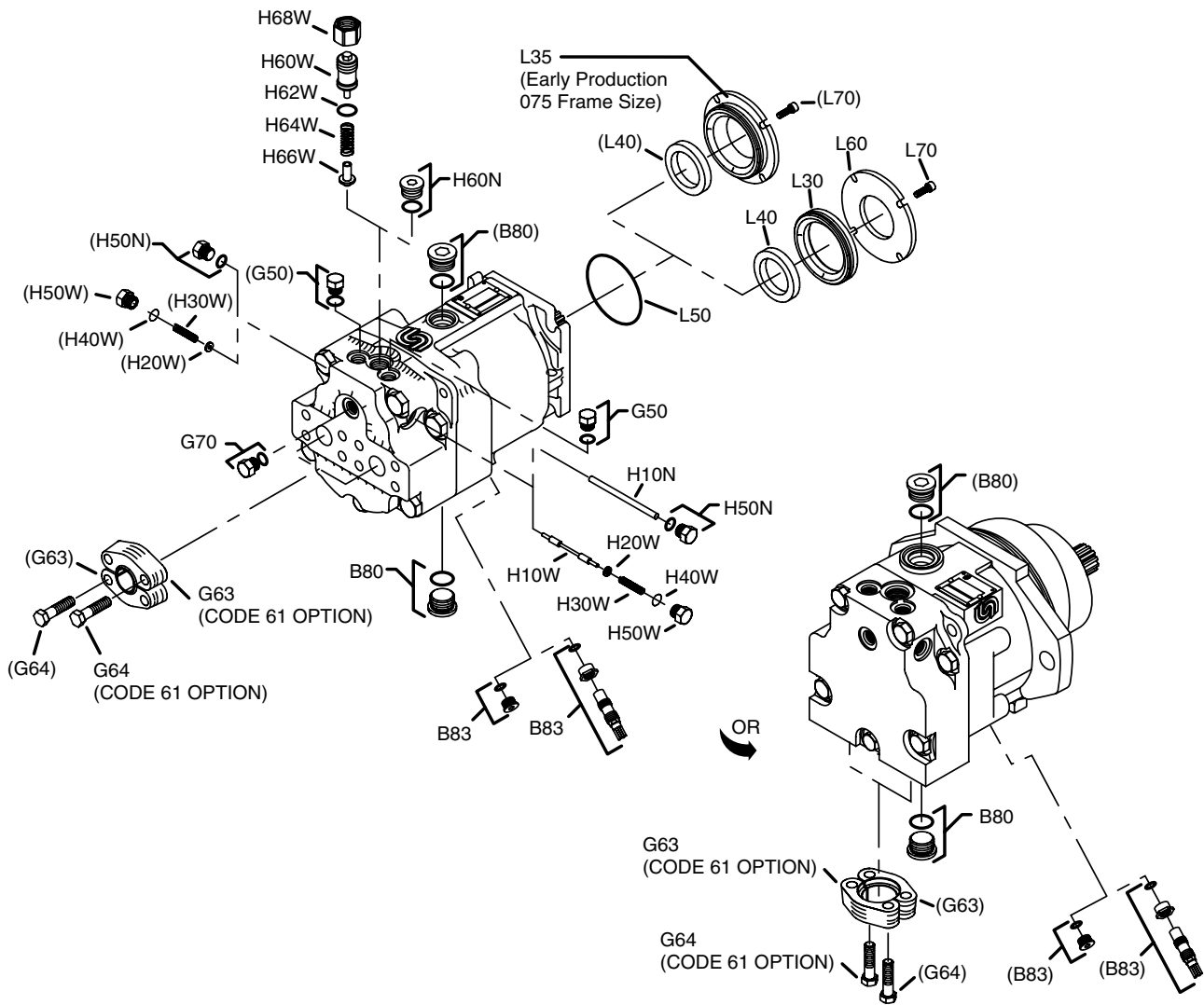


Name Plate (U.S.A. Production)

Name Plate (German Production)

**Fixed Motor**

**Minor Repair Parts**

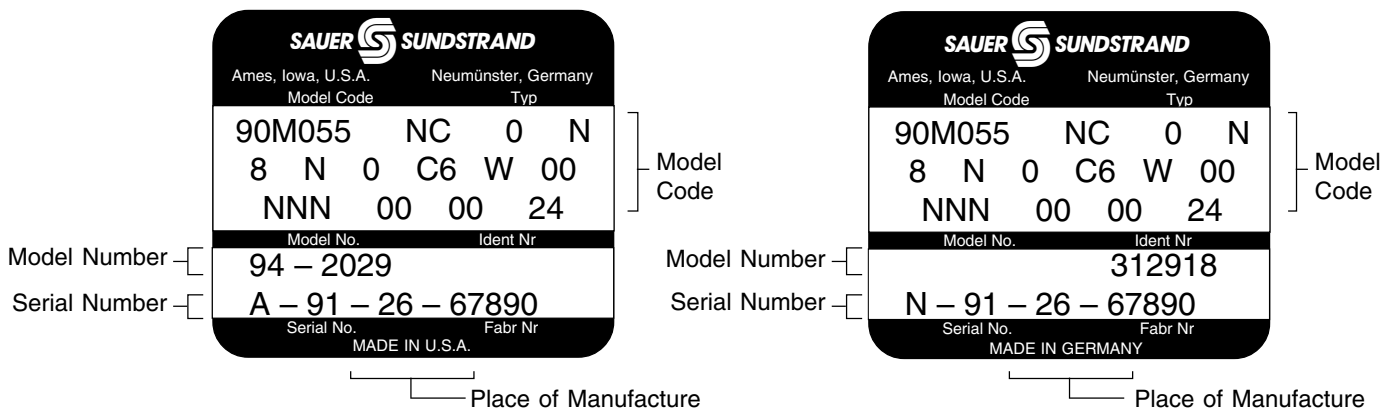




Parts List

Item	Description	Qty	Item	Description	Qty
B80	Plug	2	H50W	Plug	2
B83	Plug	1	H60W	Charge relief valve plug	1
B83	Speed sensor	1	H62W	O-ring	1
G50	Plug	2	H64W	Spring	1
G70	Plug	1	H66W	Charge relief poppet	1
G63	Split flange screw	4	H68W	Lock nut	1
G64	Screw - Shipping Cover	4	L30	Seal carrier	1
H10N	Loop flushing spool - defeat	1	L35	Seal carrier	1
H50N	Plug	2	L40	Lip seal	1
H10W	Shuttle valve spool	1	L50	O-ring	1
H20W	Spring guide	2	L60	Retainer	1
H30W	Spring	2	L70	Screw	3
H40W	O-ring	2	L8	Key	1
			L9	Slotted nut	1

Name Plates

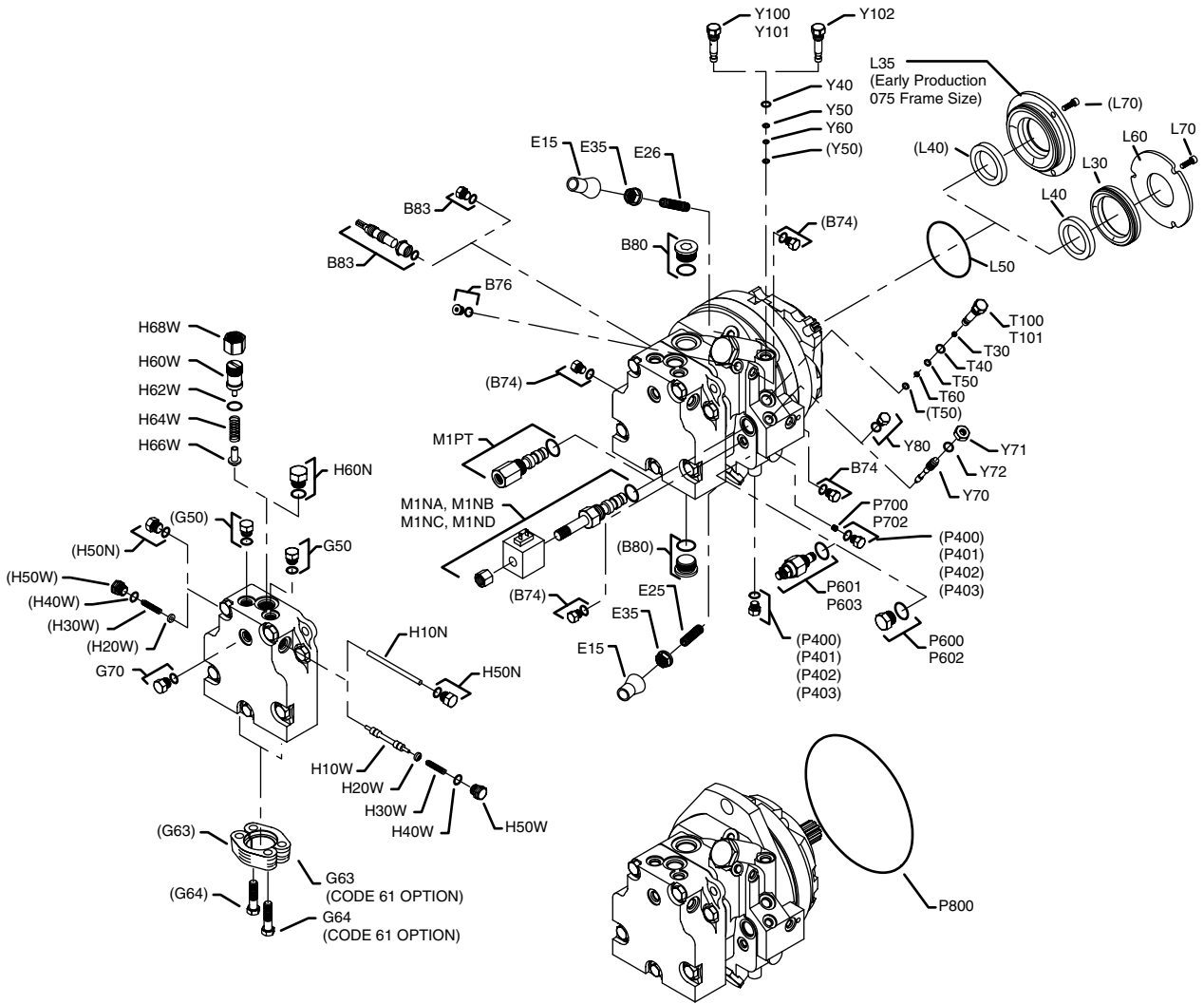


Name Plate (U.S.A. Production)

Name Plate (German Production)

**Variable Motor**

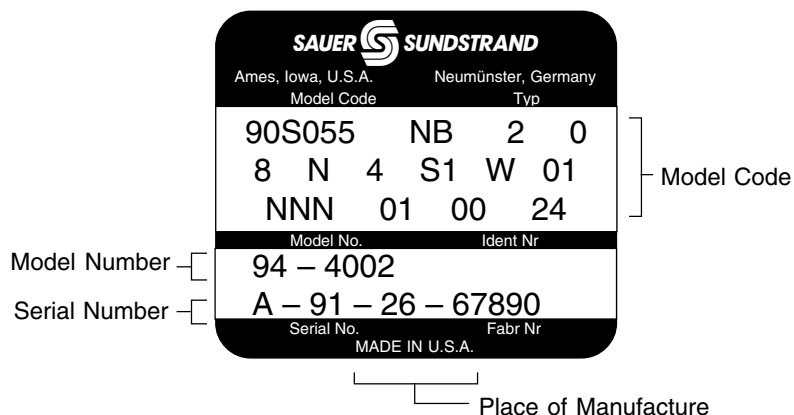
**Minor Repair Parts**



**Parts List**

Item	Description	Qty	Item	Description	Qty
B74	Plug	4	L30	Seal carrier	1
B76	Plug	1	L35	Seal carrier	1
B80	Plug	2	L40	Lip seal	1
B83	Plug	1	L50	O-ring	1
B83	Speed sensor	1	L60	Retainer	1
			L70	Screw	3
E15	Cap	1	M1N	Control valve - electric	1
E25	Set screw	1	M1P	Control valve - hydraulic	1
E35	Nut - Seal Lock	1			
G50	Plug	2	P400	Plug	2
G63	Split flange clamp	4	P600	Plug	1
G64	Shipping cover screw	4	P601	PCOR-Valve	1
			P700	Special plug	1
G70	Plug	1	P800	O-ring	1
H10N	Loop flushing spool - defeat	1	T30	Filter screen	1
H50N	Plug	2	T40	O-ring	1
H60N	Plug	1	T50	Backup ring	2
			T60	O-ring	1
H10W	Shuttle valve spool	1	T100	Orifice plug	1
H20W	Spring guide	2			
H30W	Spring	2	Y40	O-ring	1
H40W	O-ring	2	Y50	Backup ring	2
H50W	Plug	2	Y60	O-ring	1
H60W	Charge relief valve plug	1	Y70	Orifice check valve	1
H62W	O-ring	1	Y71	Nut - Seal Lock	1
H64W	Spring	1	Y72	O-ring	1
H66W	Charge relief poppet	1	Y80	Plug	1
H68W	Lock nut	1	Y100	Orifice plug	1
			Y102	Orifice check valve	1
L8	Key	1			
L9	Slotted nut	1			

**Name Plate**



**Name Plate (U.S.A. Production)**

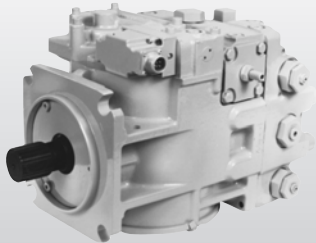
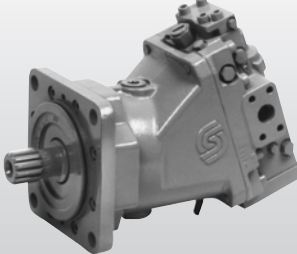

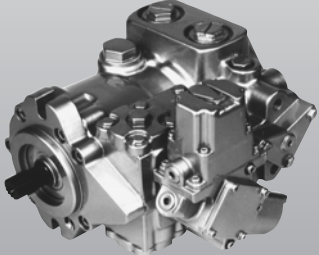
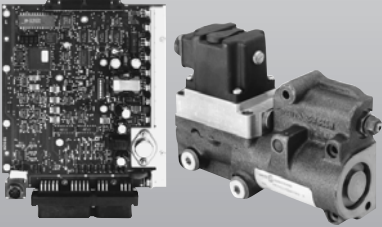
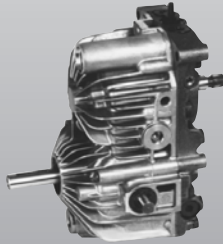

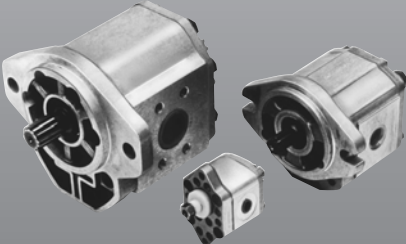

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