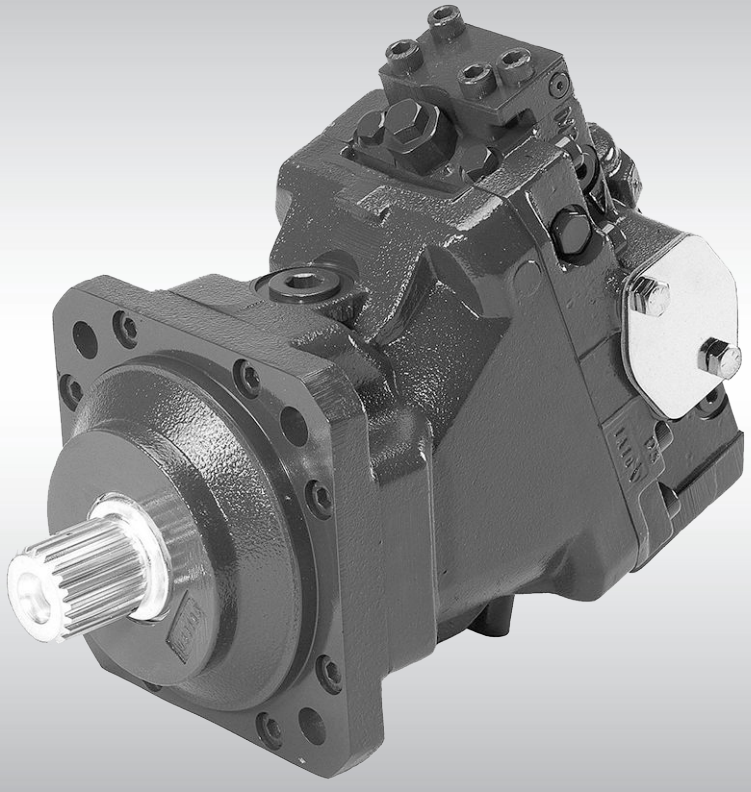
MAKING MODERN LIVING POSSIBLE

Service Manual

Bent Axis Motors

Series 51 Two Position Controls



Revision history

Table of revisions

Date	Changed	Rev
January 2015	Danfoss layout	CA
March 2009	Added TA, TH, TN, PC, PD	BA
February 2008	First edition	AA

Contents

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Introduction

Safety Precautions

Always consider safety precautions before beginning a service procedure. Protect yourself and others from injury. Take the following general precautions whenever servicing a hydraulic system.

Unintended Machine Movement

Warning

Unintended movement of the machine or mechanism may cause injury to the technician or bystanders. To protect against unintended movement, secure the machine or disable/disconnect the mechanism while servicing.

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.

Fluid Under Pressure

Warning

Escaping hydraulic fluid under pressure can have sufficient force to penetrate your skin causing serious injury and/or infection. This fluid may also be hot enough to cause burns. Use caution when dealing with hydraulic fluid under pressure. Relieve pressure in the system before removing hoses, fittings, gauges, or components. Never use your hand or any other body part to check for leaks in a pressurized line. Seek medical attention immediately if you are cut by hydraulic fluid.

Personal Safety

Warning

Protect yourself from injury. Use proper safety equipment, including safety glasses, at all times.

Hazardous Material

Warning

Hydraulic fluid contains hazardous material. Avoid prolonged contact with hydraulic fluid. Always dispose of used hydraulic fluid according to state and federal environmental regulations.

Introduction

Symbols used in Danfoss literature


WARNING may result in injury


CAUTION may result in damage to product or property


Reusable part


Non-reusable part, use a new part


Non-removable item


Option - either part may exist


Superseded - parts are not interchangeable


Measurement required


Flatness specification


Parallelism specification


External hex head


Internal hex head


Torx head


O-ring boss port


Tip, helpful suggestion


Lubricate with hydraulic fluid


Apply grease / petroleum jelly


Apply locking compound


Inspect for wear or damage


Clean area or part


Be careful not to scratch or damage


Note correct orientation


Mark orientation for reinstallation


Torque specification


Press in - press fit


Pull out with tool – press fit


Cover splines with installation sleeve


Pressure measurement/gauge location or specification

The symbols above appear in the illustrations and text of this manual. They are intended to communicate helpful information at the point where it is most useful to the reader. In most instances, the appearance of the symbol itself denotes its meaning. The legend above defines each symbol and explains its purpose.

Introduction

Overview

This manual includes information for the installation, maintenance, and minor repair of Series 51 two-position controls. It includes a description of each control, instructions for adjustment, and minor repair procedures.

General instructions

Keep it Clean

You can complete many repairs or adjustments without removing the unit from the machine, provided the unit is accessible and you can thoroughly clean it before beginning any procedures.

Cleanliness is a primary means of assuring satisfactory motor life on either new or repaired units. *Clean the outside of the motor thoroughly before disassembly*. Take care to avoid contamination of the system ports. Cleaning parts with a clean solvent wash and air drying is usually adequate.

As with any precision equipment, keep all parts free of foreign materials and chemicals. Protect all exposed sealing surfaces and open cavities from damage and foreign material. Cap all hoses after removal, and plug all open ports. Cover any unattended parts with a protective layer of plastic.

Inspect for System Contamination

Inspect the motor for signs of system contamination. If you find contamination, fully disassemble, clean and inspect all components of the motor.

Replace the O-rings and Gaskets

Replace all O-rings and gaskets. Discard them only after you make certain that you have the correct replacement parts. Lightly lubricate all O-rings with clean petroleum jelly before assembly.

Lubricate all Moving Parts

During reassembly, coat all moving parts with a film of clean hydraulic oil. This helps lubricate the surfaces during start-up.

For fluid quality requirements, refer to **520L0463** *Hydraulic Fluids and Lubricants, Technical Information*.

Torque Procedure

During reassembly, cross torque all retaining screws to the given value. Do not overtorque.

Operation

Two-position Controls

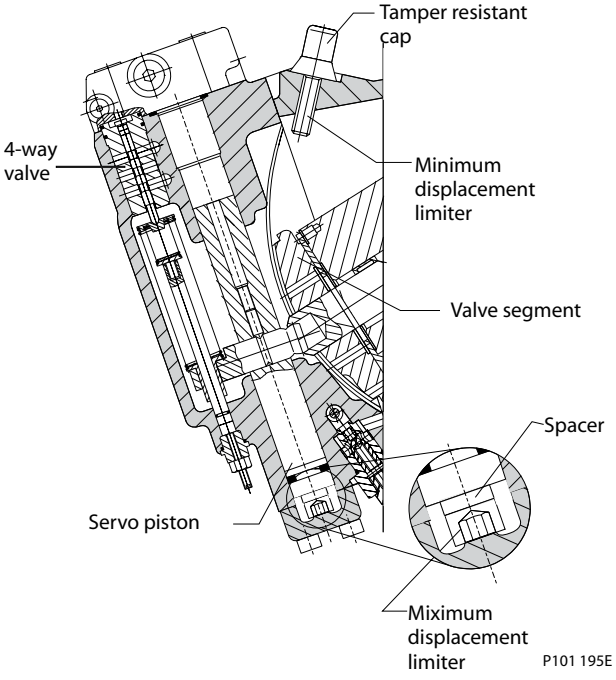
Two-position controls shift the motor to either maximum or minimum displacement. Control input may be hydraulic or electric. To change displacement, the control routes pilot pressure to one end of the servo piston while draining the other.

A 4-way valve integral to the motor's endcap routes the flow of oil in all two-position controls except N2, G1, G2 and PC. The 4-way valve consists of a spool and a logic sleeve. The control shifts the spool and ports pressure to one end of the servo and drains the other. Ports in the logic sleeve regulate the flow from the valve to the servo piston ends. The sleeve logic may be standard or reversed. The standard logic sleeve defaults the motor displacement to maximum and shifts to minimum displacement when the control operates. The reverse logic sleeve defaults the motor displacement to minimum and shifts to maximum displacement when the control operates.

With N2 controls, external valving pressurized and drains the servo piston ends. With G1, G2 controls, a two-position 4-way solenoid cartridge valve replaces the 4-way valve. The PC control feeds servo supply pressure directly to the minimum displacement end of the servo piston.

Optional orifices in the control and motor end cap modulate shift speed.

Series 51 servo mechanism



Control Options

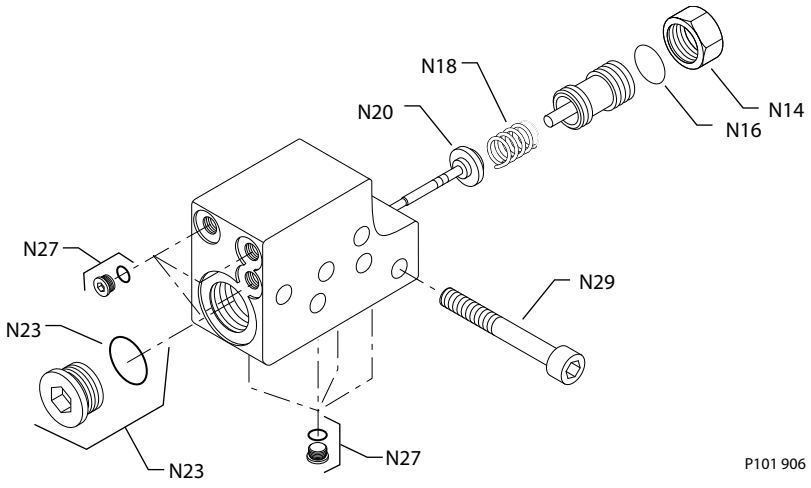
Pressure Compensator Override (PCOR) Option

The PCOR function allows the motor to match its displacement to the system load. The PCOR overrides the control command allowing the motor to increase displacement when system pressure reaches a set level due to load. This permits the motor to regulate system pressure by modulating the displacement of the rotating group. As displacement increases, so does available torque while output speed decreases and system pressure remains nearly constant at the PCOR setting.

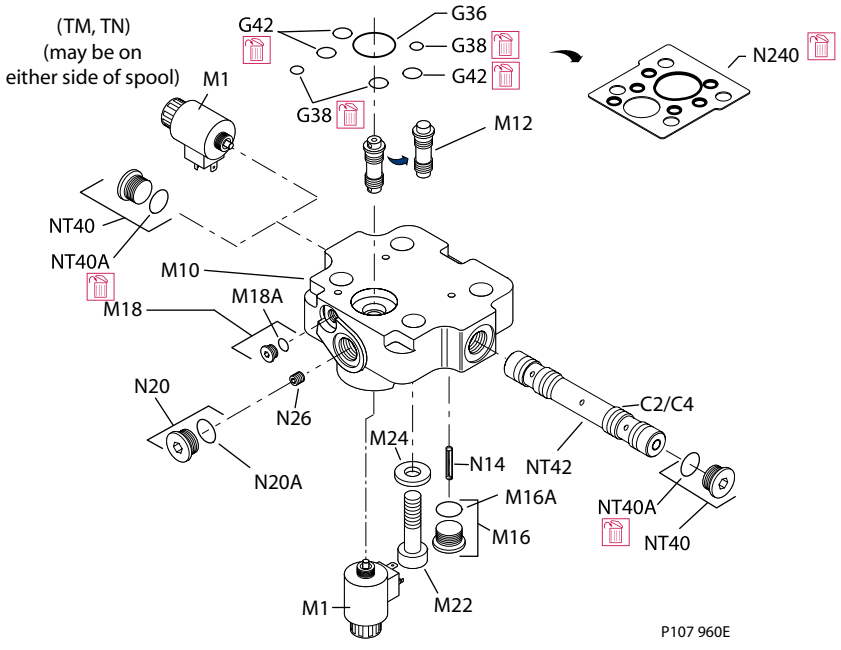
Operation

The PCOR setting pressure is adjustable from 130 to 370 bar [1890 to 5370 psi]. Optional orifices at locations T4, T5, T6, U6, or U7 regulate the speed of the PCOR operation.

PCOR option



Example of T PCOR option*

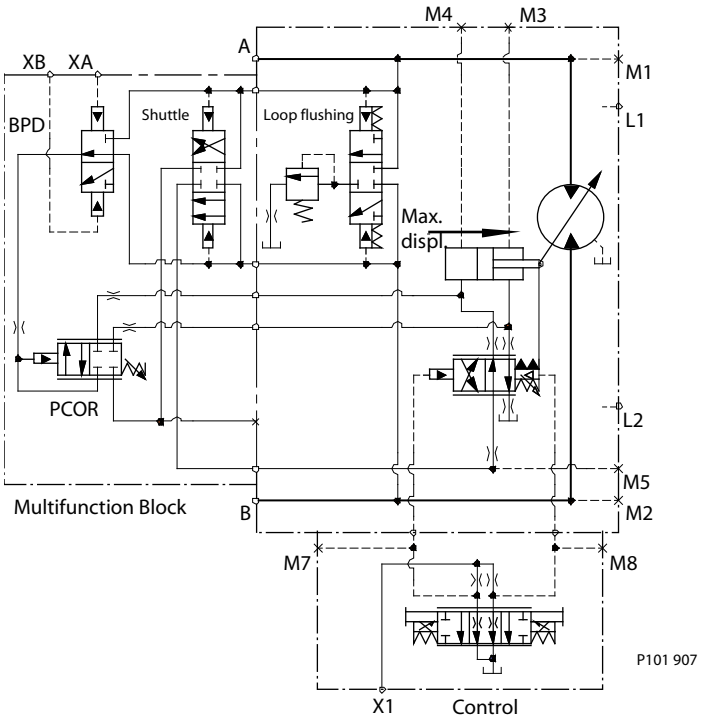


Brake Pressure Defeat (BPD)

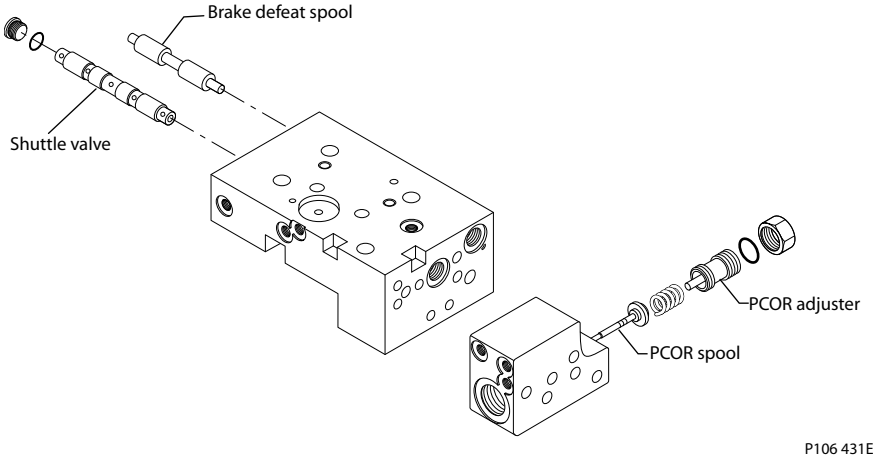
The PCOR function can be equipped with a brake pressure defeat option that defeats PCOR operation during dynamic braking. A spool in the multifunction block directs acceleration system pressure to the PCOR valve. During deceleration, braking pressure is blocked from the PCOR. This limits engine over-speeding while the vehicle is slowing down. The BPD spool requires an external signal to communicate motor rotation. This signal can be pressure to either port XA or XB, or it can be an electric signal to a solenoid.

Operation

EP, EQ electrohydraulic proportional control with pressure compensator and hydraulic brake pressure defeat.



BPD option



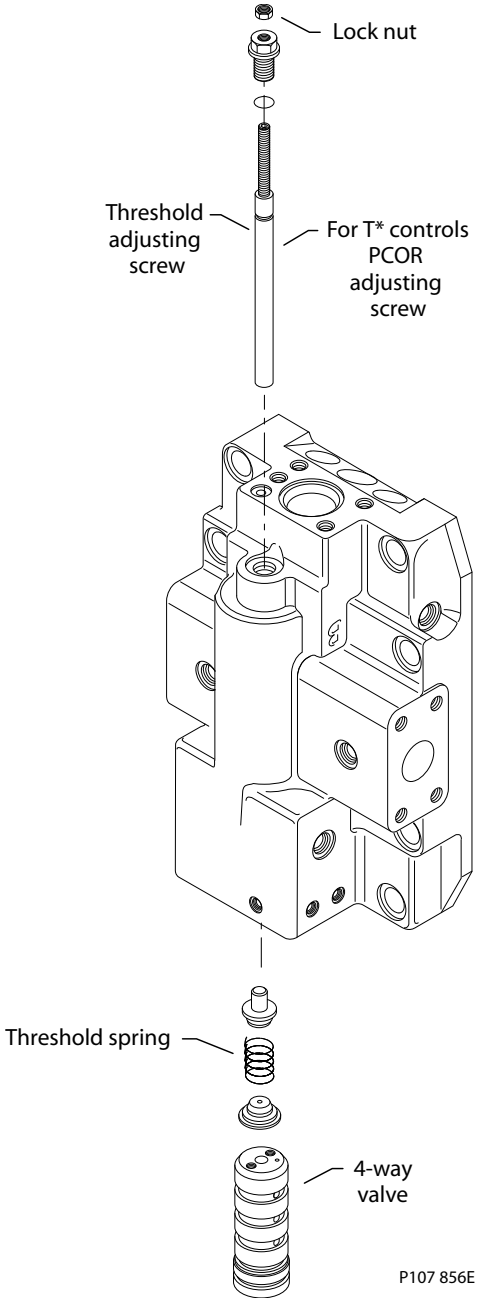
Operation

Threshold Spring

A threshold spring acts on the opposite end of the 4-way valve. Adjusting the threshold screw changes the pressure required to move the 4-way valve and start the change in displacement.

Optional orifices may be installed at several locations to regulate shift speed. Refer to the model code for your motor for details.

Threshold and ramp springs



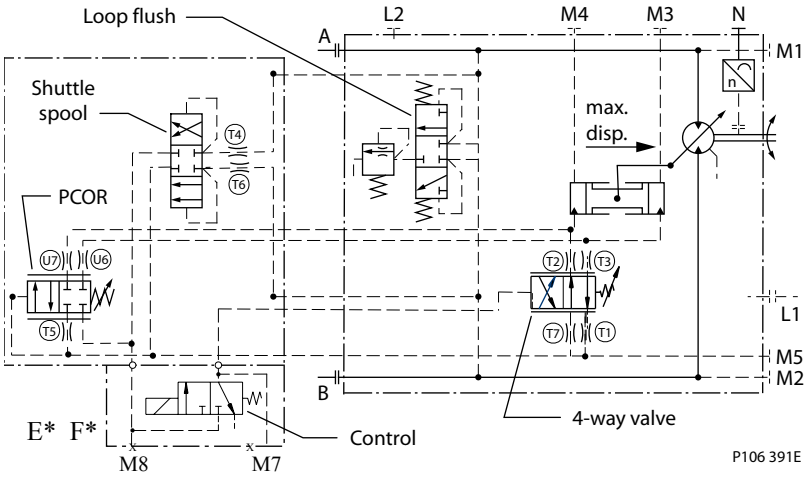
Multifunction Block

Some controls are used in conjunction with a multifunction block. The purpose of the multifunction block is to route high loop (system) pressure from port A or B to the 4-way valve for servo supply pressure, and to direct low loop pressure from port A or B to the control for pilot pressure. The spool that

Operation

resolves high pressure for servo supply and low pressure for control pilot also feeds these pressures to an optional Pressure Compensating Over-Ride (PCOR) valve.

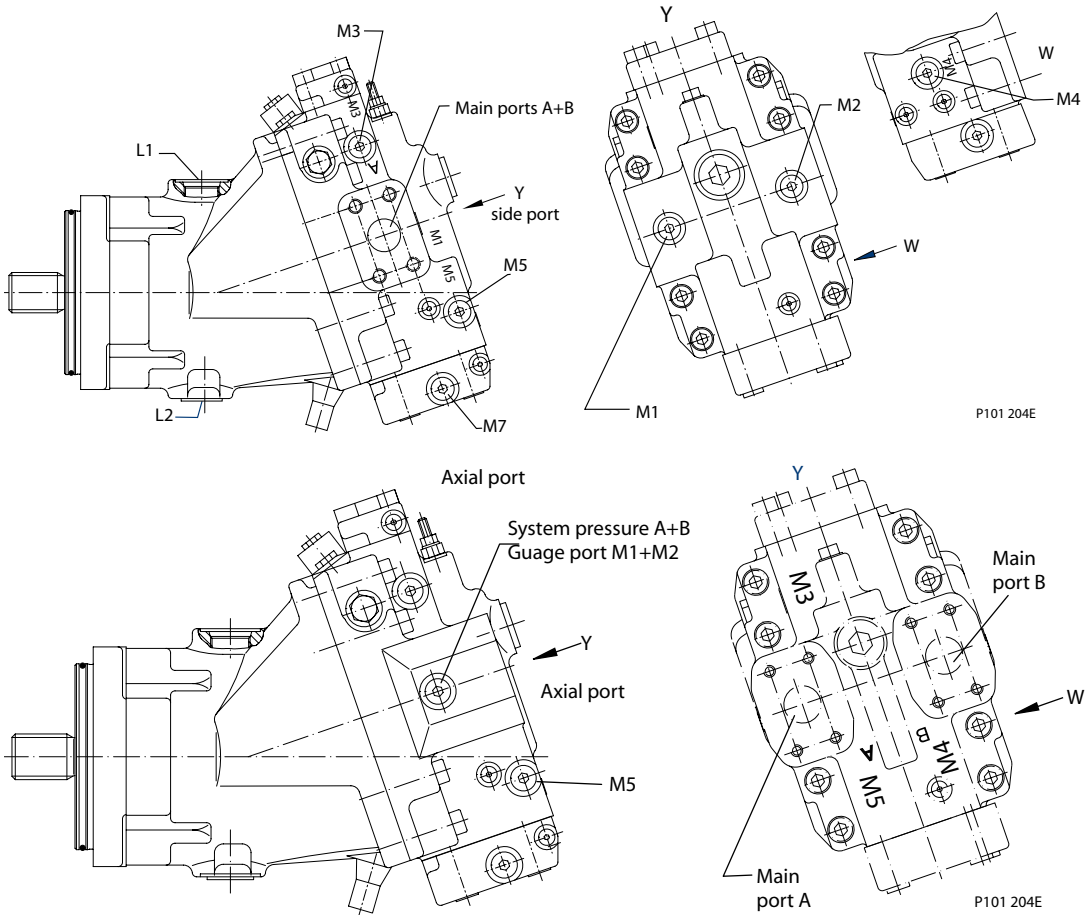
Multifunction block schematic



Pressure measurements

Port Locations and Gauge Installation

Series 51 motors

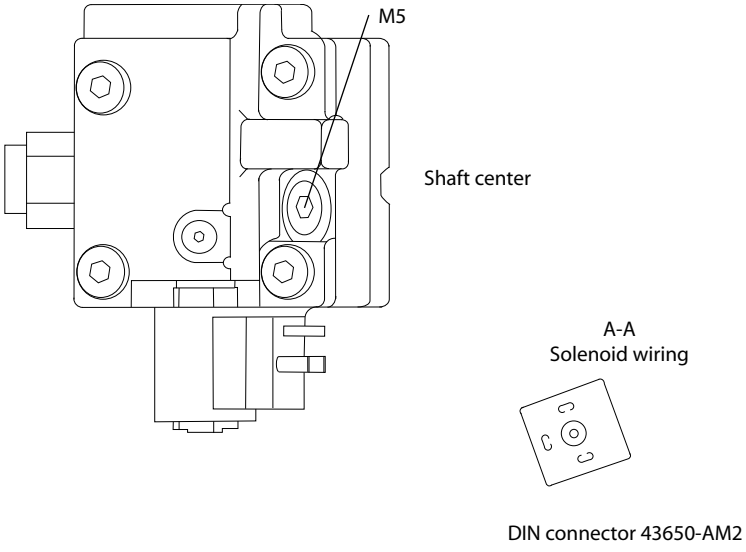


Legend

Abbreviation	Definition
L1	Case drain; (1-5/16-12UNF)
L2	Alternate case drain: (1-5/16-12UNF)
M1	Gauge port: system pressure A (9/16-18UNF)
M2	Gauge port: system pressure B (9/16-18UNF)
M3	Gauge port: servo pressure min. angle (9/16-18UNF)
M4, M5	Gauge port: servo pressure max. angle (9/16-18UNF)
M7	Control pressure port (9/16-18UNF)

Pressure measurements

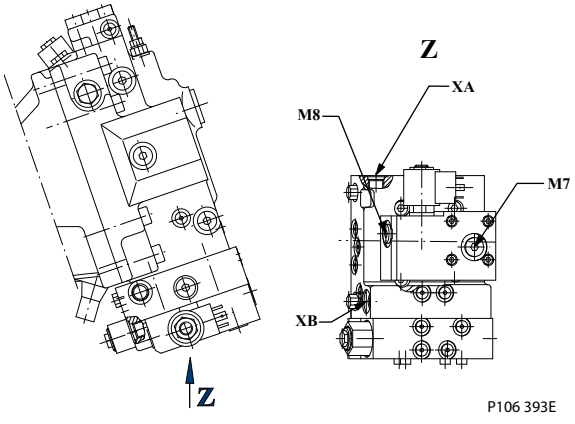
G1, G2 controls



Legend

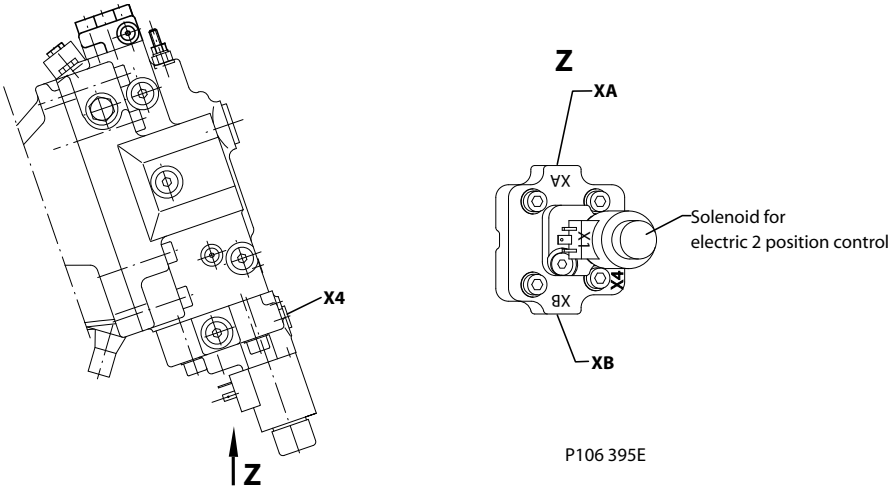
Abbreviation	Definition
M5	Gauge port: servo pressure max. angle (9/16-18UNF)

E1/E2, F1/F2. H1/H2, and K1/K2 controls



Pressure measurements

Gauge ports with U1/U2 controls and T1, T2, T3, T4, TA, and TH controls



P106 395E

Legend

Abbreviation	Definition
M7, M8	Gauge port control pressure (9/16-18UNF)
X (A, B, and 1)	Control pressure port (9/16-18UNF)

Adjustments

Threshold Setting

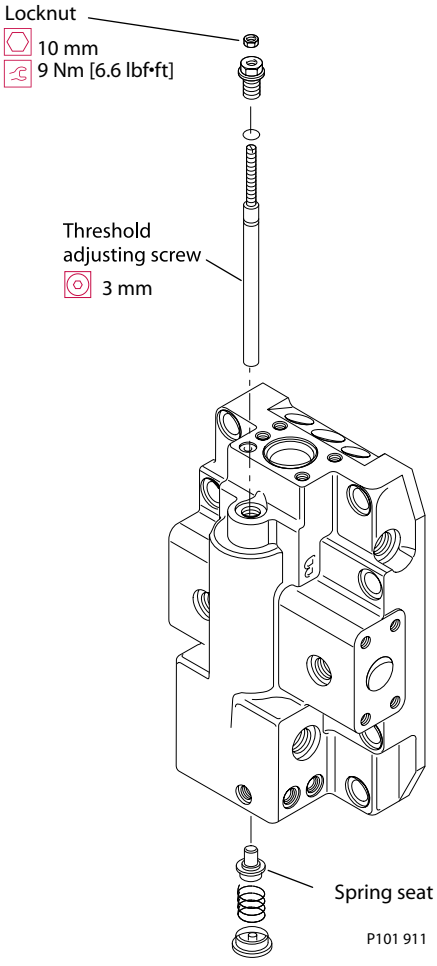
Adjusting Threshold Setting

Threshold on two-position controls is 3 bar [44 psi], except on T* controls.

1. Using a 10 mm wrench loosen the locknut on the adjustment screw.
2. Turn adjusting screw out till it stops. Then turn in five turns.
3. While holding the position of the adjustment screw:
   - tighten the locknut
   - using a 10 mm wrench torque the locknut to 9 N•m [6.6 lbf•ft].

For T* controls the threshold screw adjusts the the PCOR setting.

Locknut and threshold



PCOR Setting

PCOR Adjustment

To measure and adjust the start pressure setting for the PCOR function:

1. Install a 600 bar [10000 psi] gauge at port M, M2 or M5 to read high system pressure.

Adjustments

2. Install a 600 bar [10000 psi] gauge at port M3 to read minimum servo pressure.
3. Safely prevent the motor shaft from moving by:
   - applying the park brake, apply an extreme load, or
   - positioning the machine against an immovable object, or
   - use other means to hold the machine.
4. Start the prime mover. Operate at medium speed.
5. Stroke the pump very slowly to gradually increase the system pressure.

   An alternate method to slowly increase the system pressure is to use the pump's pressure limiter (PL) valve. Lower the PL setting below the PCOR setting. Stroke the pump to about one-fourth displacement. Raise the PL setting slowly to increase system pressure until pressure at the M3 port drops down. System pressure at this point is the PCOR setting. Adjust the PL back to its proper setting after checking the PCOR setting.
6. Increase system pressure until pressure at port M3 drops down, system pressure at this point is the PCOR setting.

Checking PCOR Setting on a Test Stand

Increase system pressure until the system flow begins to increase (+8 l/min [2 US gal/min]). System pressure at this point is the PCOR setting.

System pressure may increase rapidly when flow increases.

Adjusting the PCOR Setting

For PCOR valves mounted on a multiblock, use a 1-1/16 inch wrench to loosen the lock nut on the adjusting screw. Using a large screw driver or a 13 mm wrench turn the adjusting screw clockwise to increase pressure setting or counter clockwise to decrease pressure setting. One turn of the adjusting screw changes the setting approximately 69 bar [1000 psi].

For controls using the threshold adjusting screw for PCOR adjustment, use a 10 mm wrench to loosen the locknut. Using a 3 mm wrench turn the adjusting screw clockwise to increase pressure or counter clockwise to decrease pressure setting. One turn of the adjusting screw changes the setting approximately 55 bar [800 psi].

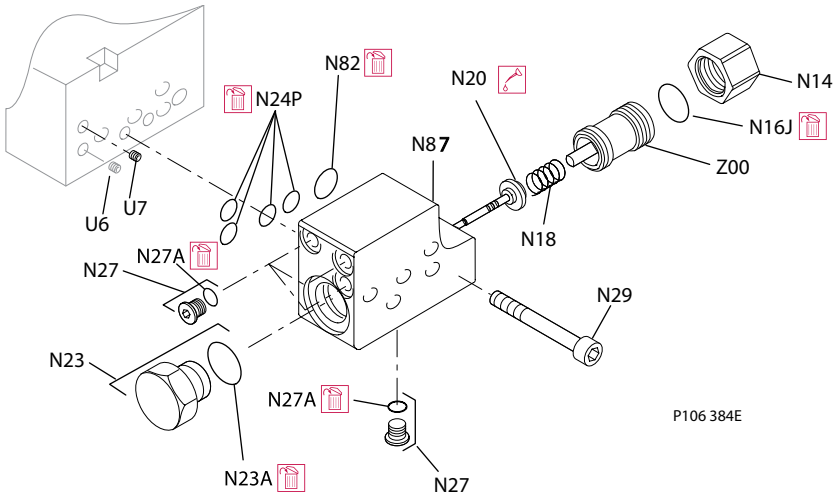
Pressure Compensator Override (PCOR)

Repair

Disassembly

1. Remove plugs (N27). Remove and discard O-rings (N27A).
2. Using a 1 inch hex wrench, remove plug (N23). Remove and discard O-ring (N23A).
3. Remove locknut (N14).
4. Remove adjustment plug (Z00). Remove and discard O-ring (N16J).
5. Remove spring (N18).
6. Remove spool and spring guide assembly (N20).
7. Remove screws (N29).
8. Remove and discard O-rings (N24P, N82).
9. If present, remove orifices (U6, U7).

PCOR



Tool size and torque

Item	Wrench size	Torque
N27	1/8 inch internal hex	7 N•m [4 lbf•ft]
N23	1 inch	40 N•m [30 lbf•ft]
U6, U7	3 mm internal hex	6 N•m [4 lbf•ft]
N29	5 mm internal hex	16 N•m [12 lbf•ft]
N14	1-5/16 inch	N/A

Inspection

Clean and inspect components for damage or foreign material. Replace damaged parts.

Assembly

1. If previously removed, use a 3mm internal hex wrench to install orifices (U6, U7). Torque to 6 N•m [4 lbf•ft].
2. Using petroleum jelly to retain them, install new interface O-rings (N24P, N82).
3. Position PCOR on multiblock. Install screws (N29). Torque using a 5 mm internal hex wrench to 16 N•m [12 lbf•ft].

Pressure Compensator Override (PCOR)

4. Lubricate and install spool and spring guide assembly (N20).
5. Install spring (N18) to cavity.
6. Lubricate and install new O-ring (N16J). Install adjustment plug (Z00).
7. Using a 1-1/16 inch hex wrench, install locknut (N14). Do not torque until after PCOR adjustment. Refer to page 17 for instructions.
8. Lubricate and install a new O-ring (N23A). Using a 1 inch hex wrench, install plug (N23). Torque to 40 N•m [30 lbf•ft].
9. Lubricate and install new O-rings (N27A). Using a 1/8 inch internal hex wrench, install and torque plugs (N27) to 7 N•m [4 lbf•ft].

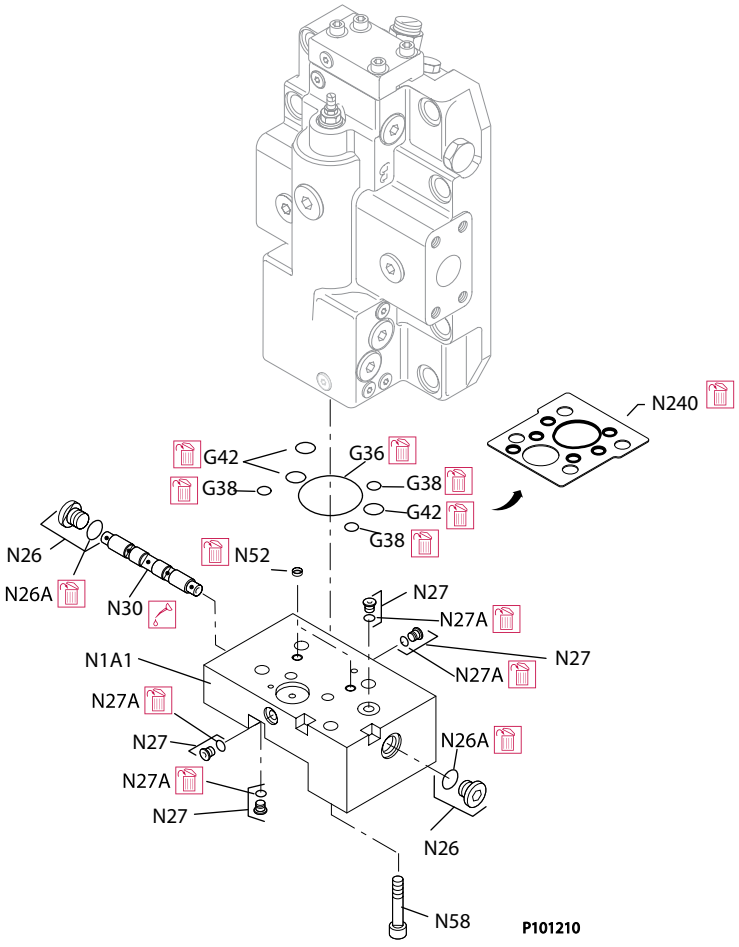
Multifunction Block

Repair

Disassembly

1. Using a ¼ inch internal hex wrench, remove plugs (N26). Remove and discard O-rings (N26A).
2. Remove the double resolver spool (N30).
3. Using a 1/8 inch internal hex wrench, remove plugs (N27). Remove and discard O-rings (N27A).
4. Remove screws (N58).
5. Remove the multifunction block (N1A1).
6. Remove and discard the O-rings (G36, G38, G42) or gasket (N240).
7. If present, remove and discard screens (N52).

E, F* control*



Tool size and torque

Item	Wrench size	Torque
N27	1/8 inch internal hex	7 N•m [4 lbf•ft]
N26	1/4 inch internal hex	37 N•m [28 lbf•ft]
N58 (80, 110)	8 mm internal hex	78 N•m [58 lbf•ft]

Multifunction Block

Tool size and torque (continued)

Item	Wrench size	Torque
N58 (160, 250)	10 mm internal hex	110 N•m [81 lbf•ft]

Inspection

Clean and inspect components for damage or foreign material. Replace damaged parts.

Assembly

1. Lubricate and install new O-rings (N27A). Install plugs (N27) using a 1/8 inch internal hex wrench. Torque to 7 N•m [4 lbf•ft].
2. Using petroleum jelly to retain them, install new interface O-rings (G36, G38, G42) or gasket (N240).
3. Position the multifunction block on the endcap. Install screws (N58). Torque screws as shown in the table.
4. Lubricate and install the double-resolver spool (N30). Spool is symmetrical, either end first.
5. Lubricate and install new O-rings (N26A). Using a 1/4 inch internal hex wrench, install plugs (N26). Torque to 37 N•m [28 lbf•ft].

T1, T2, T3, T4, TA, TH, TM, TN

Operation

TA Control

The TA control does not have two-position operation, it is Pressure Compensating Over-Ride (PCOR) operation only. It uses a sensing piston (M12) to shift the 4-way valve when system pressure reaches the PCOR setting. The 4-way valve then ports high system pressure to the servo piston, shifting the motor toward maximum displacement. The 4-way sleeve is reverse logic: the motor is biased to minimum displacement. The sensing piston has different area lands that allow high system pressure between the lands to push the 4-way valve against the threshold spring. The PCOR function threshold setting is adjustable from 110 to 370 bar [1595 to 5365 psi].

TH Control

The TH control is a hydraulic two-position override with the PCOR function as described above. This control holds the motor at maximum displacement when an external signal of 10 to 35 bar [145 to 507 psi] is applied to the X1 port.

The non-signal pressure at the X1 port must be equal to the motor's case pressure or else the PCOR setting will be altered.

T1, T2, T3, T4 Control

The Tl, T2, T3, T4 controls are electric, two-position override with the PCOR function discussed earlier. These controls hold the motor displacement at maximum when an external electric signal is applied. The solenoid is available in four configurations: 12V (T1) or 24V (T2) with DIN 4360 connectors and 12V (T3) or 24V (T4) with Jet jr. Timer connector with Zener commutating diode.

TM, TN Controls

The TM and TN controls are electric two-position with a proportional PCOR solenoid. Full current to the solenoid holds the motor at maximum displacement. Lesser current varies the PCOR setting, no current equals full PCOR setting. This coil is available in two configurations; 12V (TM) or 24V (TN) with jet Jr. Timer connector with Zener commutating diode. These controls also have an electric Brake Pressure Defeat (BPD) spool. An electric solenoid shifts the BPD spool when energized. This coil is available in two configurations; 12V (E7- F7) or 24V (E8 - F8) with Jet jr. Timer connector with Zener commutating diode.

Logic for this option is:

- E7 or E8 at XB port energized = system pressure A to PCOR only,
- F7 or F8 at XA port energized = system pressure B to PCOR only.

See TA option for the PCOR operation in T* controls.

N Module Option Codes

Overview

Module N of the motor's order code indicates circuit options affecting features such as BPD and PCOR. These are explained below. The pressure required to shift the motor varies with system pressure and by frame size.

C0/C3 3

The C0 or C3 order code requires an external hydraulic signal into port XA or XB while draining the opposite port. Signal pressure into port XA shifts the spool so only system pressure A is fed to the 4-way valve for servo supply and to the sensing piston. Signal pressure into port XB shifts the spool so only system pressure B is fed to the 4-way valve for servo supply and to the sensing piston. The C0 code is for internal servo supply and the C3 code is for external servo supply with a plug at U5.

T1, T2, T3, T4, TA, TH, TM, TN

C2/C4

The C2 or C4 order ode uses no BPD option: PCOR function operates when either system pressure is high. The BPD spool resolves high pressure and routes it to the 4-way valve for servo supply and to the sensing piston. The C2 code is for internal servo supply and the C4 code is for external servo supply with a plug at U5.

C7/C8

The C7 or C8 order code uses no BPD option. An external signal pressure, applied to port X4, manages the PCOR function. The N26 plug in the control housing blocks the passage connecting internal system pressure to the sensing piston. The sensing piston operates only from the external pressure at the X4 port. The C7code is for internal servo supply and the C8 code is for external servo supply with a plug at U5.

L5/L6

The L5 order code defeats the PCOR function on system pressure A. The BPD spool is pinned in one position, allowing PCOR function only when system port B is high.

R5/R6

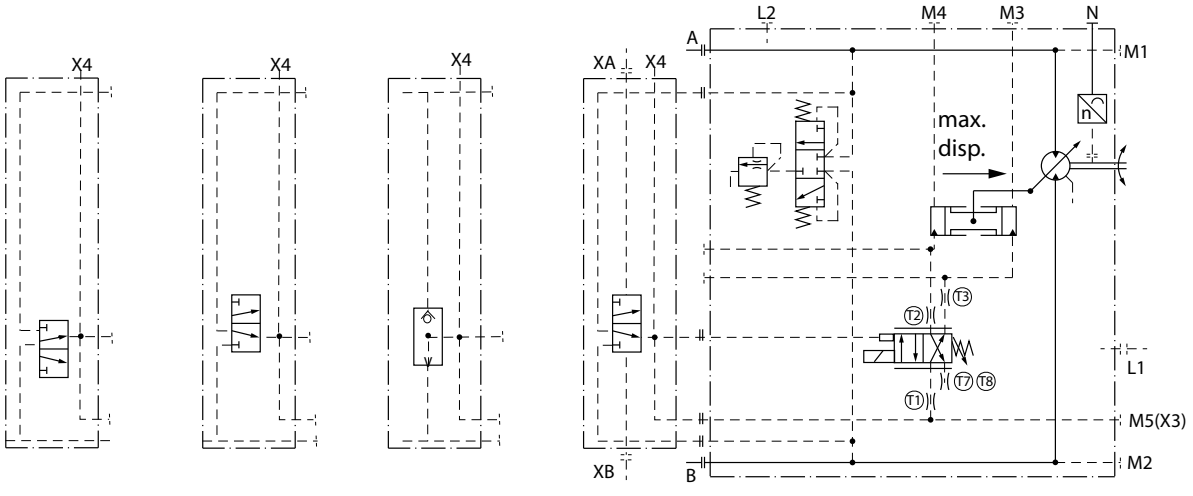
The R5 order code defeats the PCOR function on system pressure B. The BPD spool is pinned in one position, allowing PCOR function only when system port A is high.

E7, E8, F7, F8

These options include an electrically operated BPD spool . An electric solenoid shifts the BPD spool when energized. This coil is available in two configurations; 12V (E7/F7) or 24 V (E8/F8) with Jet jr. Timer connector with Zener commutating diode.

Schematic Diagrams

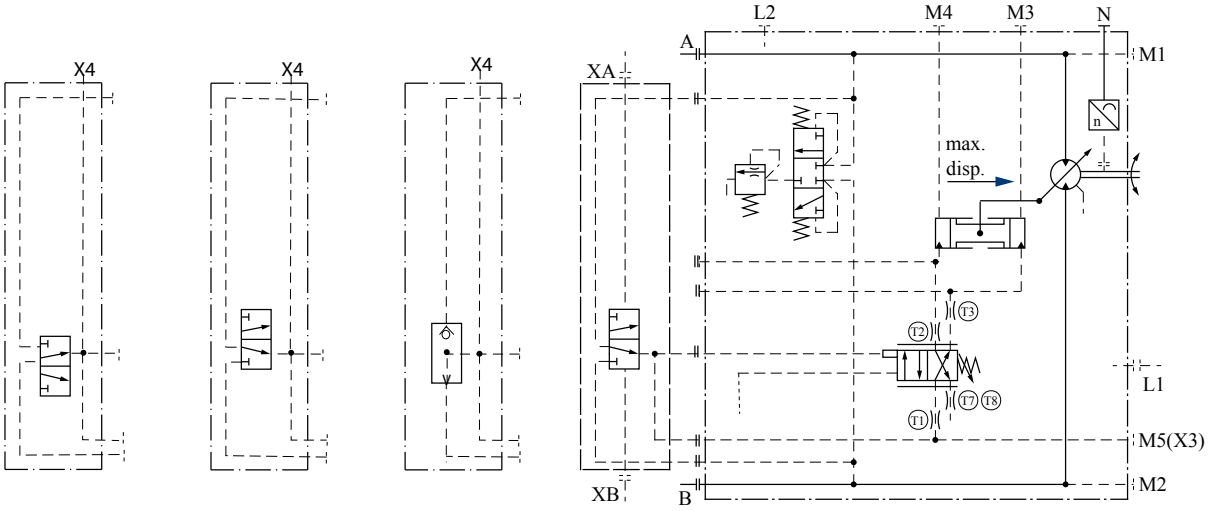
T1/ T2/ T3/ T4 schematic



T1/2/3/4 - R5/R6 T1/2/3/4 - L5/L6 T1/2/3/4 - C2/C4 T1/2/3/4 - C0/C3 P106 358E

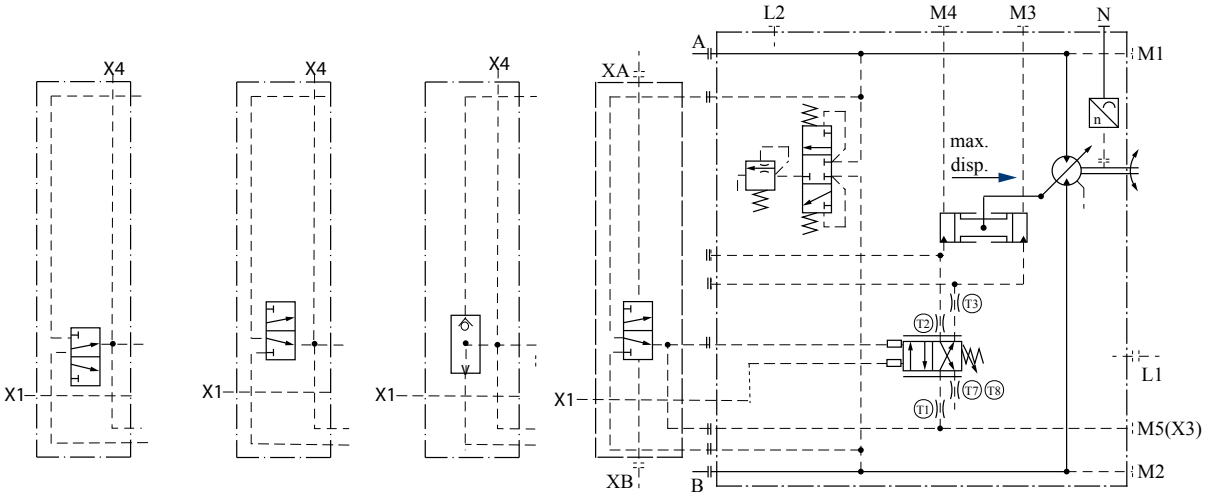
T1, T2, T3, T4, TA, TH, TM, TN

TA schematic



TA - R5/R6 TA - L5/L6 TA - C2/C4 TA - C0/C3 P106 360E

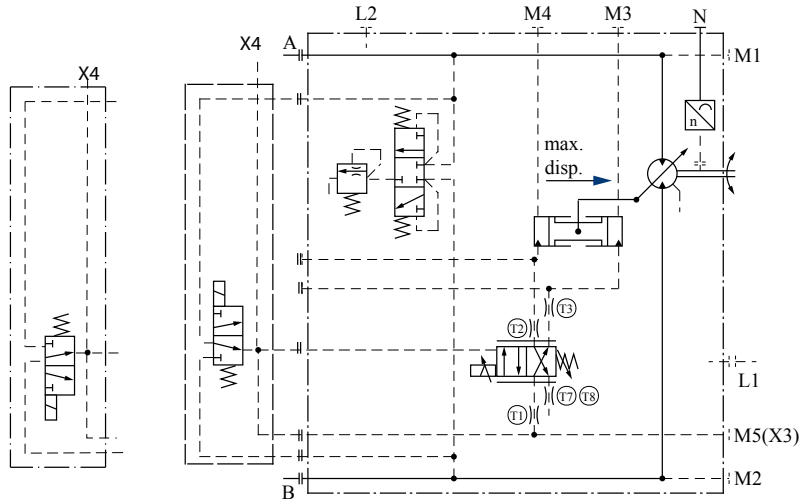
TH schematic



TH - R5/R6 TH - L5/L6 TH - C2/C4 TH - C0/C3 P106 359E

T1, T2, T3, T4, TA, TH, TM, TN

TM/TN schematic



TM-E 7 (12V)
TN-E 8 (24V)

TM-F 7 (12V)
TN-F 8 (24V)

P107 827E

Repair

Removing Solenoid(s)

T1/T2/T3/T4 controls

Solenoid(s) (M1) available as complete assembly only. Do not remove the solenoid(s) unless you intend to replace them.

If replacing the solenoid(s) (M1), remove plastic nut, remove coil, and use a thin 3/4 inch wrench to remove solenoid.

Disassembly

T1/T2/T3/T4/TA/TH/TM/TN controls

1. Using a 1/4 inch internal hex wrench, remove plugs (NT40). Remove and discard O-rings (NT40A).
2. Using a 1/4 inch internal hex wrench, remove plug (M16). Remove and discard O-ring (M16A).

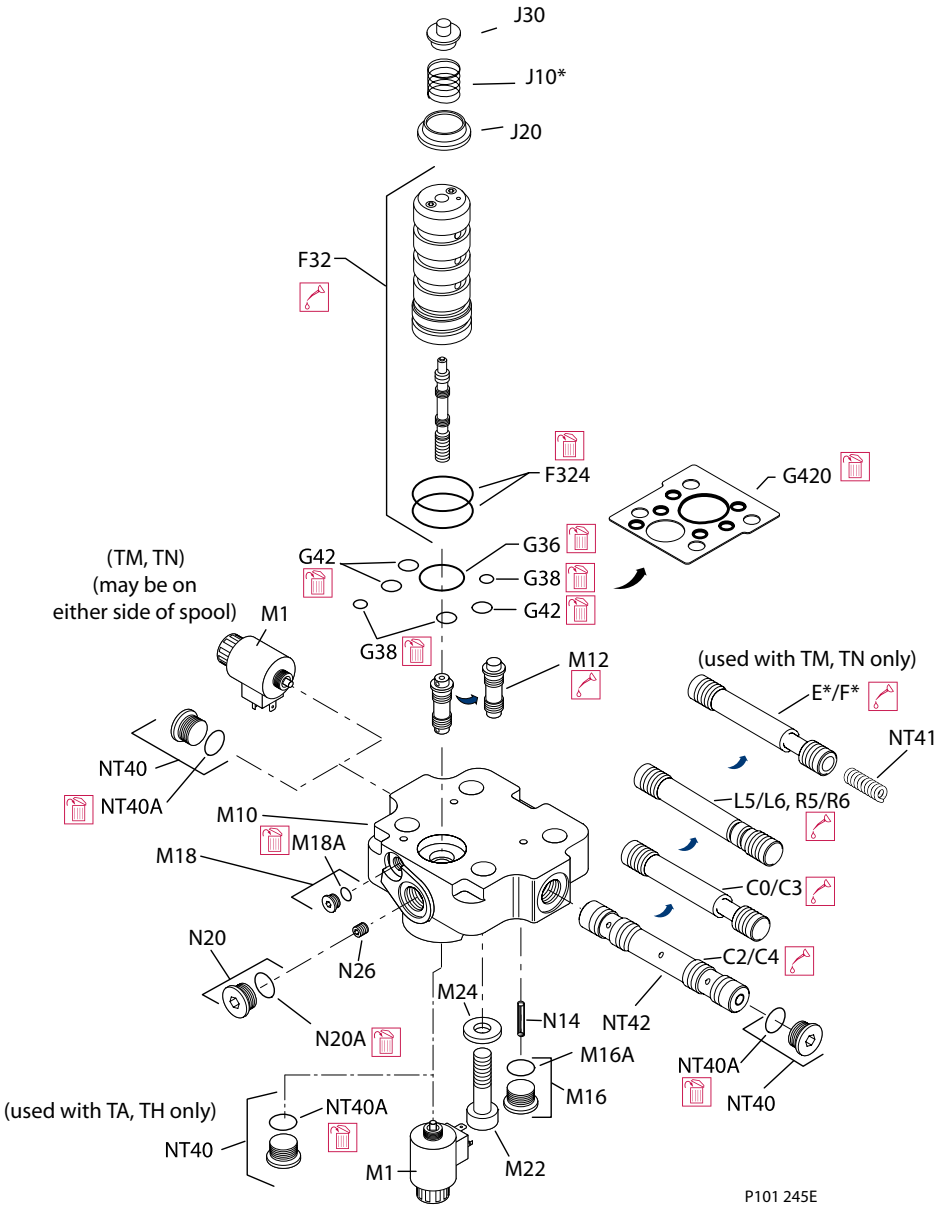
   TA controls have a steel plug and TH controls have a plastic plug at (M1).
3. If present, remove pin (N14). Remove shuttle spool (NT42).
4. Using a 1/8 inch internal hex, remove plug (M18). Discard O-ring (M18A).
5. Remove plug (N20). Remove and discard O-ring (N20A).
6. Using a 3 mm internal hex, remove plug (N26), if present.
7. Remove screws (M22) and spacers (M24), if present.
8. Remove the control housing (M10). Discard O-rings (G38, G42, G36) or gasket (G240).
9. Remove the 4-way valve assembly (F32). Discard O-rings (F324).

   Read Series 51 and 51-1 Bent Axis Motors Service Manual **11008567** for minor repair instructions for the 4-way valve, threshold spring, and ramp spring components, if repair is necessary.
10. Remove spring (J10*) and spring seats (J30, J20).

T1, T2, T3, T4, TA, TH, TM, TN

11. Remove piston (M12).

Module disassembly



Legend

Item	Wrench size	Torque
M22 (80, 110)	8 mm internal hex	78 N•m [58 lbf•ft]
M22 (160, 1250)	10 mm internal hex	110 N•m [81 lbf•ft]

Item	Wrench size	Torque
M16, N20, NT40	1/4 internal hex	37 N•m [28 lbf•ft]
N26	3 mm internal hex	**1.** 7 N•m [2.7 lbf•ft]

T1, T2, T3, T4, TA, TH, TM, TN

Item	Wrench size	Torque
M18	1/8 internal hex	6 N•m [4.5 lbf•ft]

Inspection

1. Clean and inspect the housing and spools for wear, damage or foreign material.
2. Check internal passages for contamination and clean them if necessary.

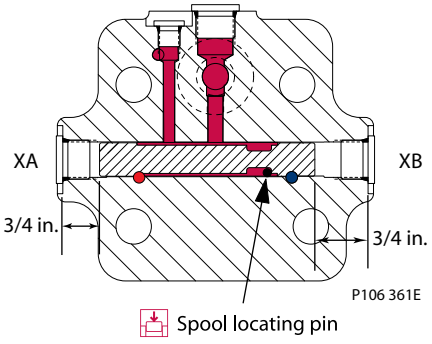
   Position motor with shaft horizontally and control surface up to allow easier assembly of all components.

Assembly

1. Install spring seat (J30), spring (J10*), and seat (J20).
2. Lubricate and install O-rings (F324).
3. Install the 4-way valve assembly (F32).
4. Using petroleum jelly, lubricate and install O-rings (G38, G42, G36), or install gasket (G420).
5. Install spool (M12).
6. Position control housing (M10) on motor.
7. Install spacers (M24), if used, and screws (M22). Torque screws per table on page 2
8. If present, install plug (N26) using a 3 mm internal hex. Torque to 9 N•m [7 lbf•ft].
9. Lubricate and Install new O-ring (M18A). Install plug (M18). Using a 1/8 internal hex, torque to 6 N•m [4.5 lbf•ft].
10. Lubricate and Install new O-ring (N20A). Install plug (N20). Using a 1/4 internal hex, torque to 37 N•m [28 lbf•ft].
11. Lubricate and install shuttle spool (NT42).
12. Install pin (N14), if used. Refer to drawing and table below for spool position.
13. Install spring (NT41) if used (E7/E8/F7/F8 spool only).
14. Lubricate and Install new O-rings (NT40A, M16A). Install plugs (NT40, M16). Using a 1/4 inch internal hex, torque plugs to 37 N•m [28 lbf•ft].

TH control uses a plastic plug for (M1). TA control uses a steel plug for (M1).

Spool and pin location



Option	Spool (NT42) location	Pin (N14)
C2/C4	loose in bore	No
C0/C3	Center of the bore	Yes
L5/L6	3/4 inch from XA end	Yes
R5/R6	3/4 inch from XB end	Yes

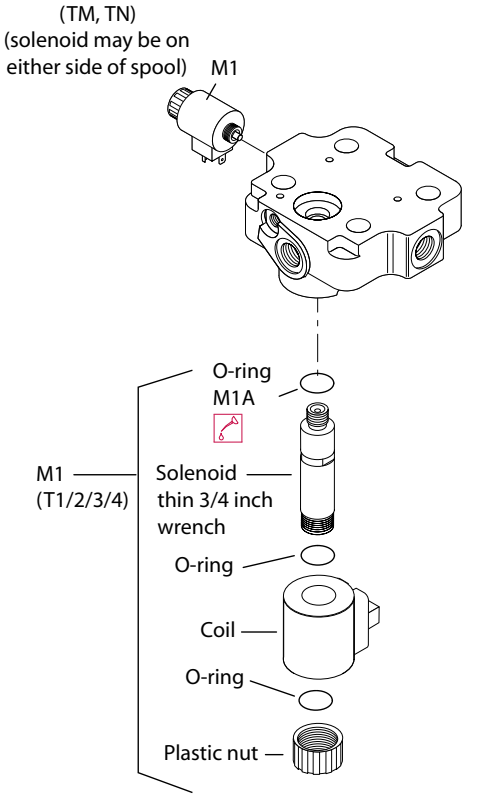
T1, T2, T3, T4, TA, TH, TM, TN

Solenoid Assembly

T1/T2/T3/T4 controls

1. Lubricate and install O-ring (M1A). Install solenoid stem.
2. Using a thin 3/4 inch wrench on the flats provided, torque to 47 N•m [35 lbf•ft].
3. Install coil with O-rings.
4. Install plastic nut. Tighten by hand.

Solenoid assembly



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N2 Controls

Operation

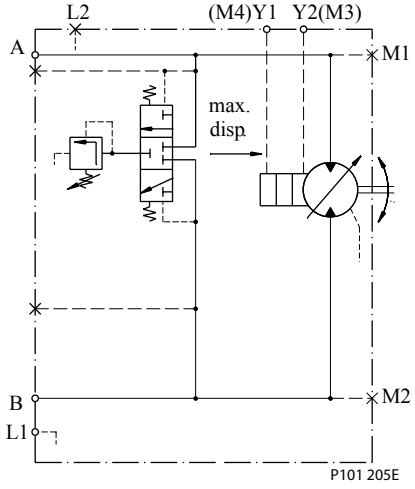
Functional Description

The N2 control consists of a cover plate mounted on the motor's endcap, a seal plug in place of the four-way valve, and passage plugs at locations T1, T2, and T3.

The servo piston is powered externally. You may use orifices in the signal lines to control shift speeds.

The N2 control has no servo supply and no PCOR options.

Schematic diagram



Control logic

Displacement	Signal	
	Y1 (M4)	Y2 (M3)
Maximum	High	Drained
Minimum	Drained	High

Repair

Disassembly

1. Remove screws (M14).
2. Remove cover plate (M1).
3. Remove and discard O-rings (G36, G38, G42) or gasket (N240).
4. Remove plug (M10). An M8 threaded hole is provided in the plug for a puller screw.
5. Remove and discard O-ring (M12).
6. If necessary, remove plug (M18) using a 13mm hex wrench. Remove and discard seal washer (M16).
7. Using a 3 mm internal hex wrench, remove plugs (G30). Remove and discard O-rings (G30A).
8. Using a 3 mm internal hex wrench, remove orifices (T2, T3) if present. Tag orifices for reassembly.
9. Using a 1/4 inch internal hex wrench, remove plug (G12). Remove and discard O-ring (G12A).
10. Using a 3 mm internal hex wrench, remove orifice (T1) if present. Tag orifice for reassembly.

N2 Controls

Inspection

Clean and inspect components for damage or foreign material. Replace damaged parts as necessary.

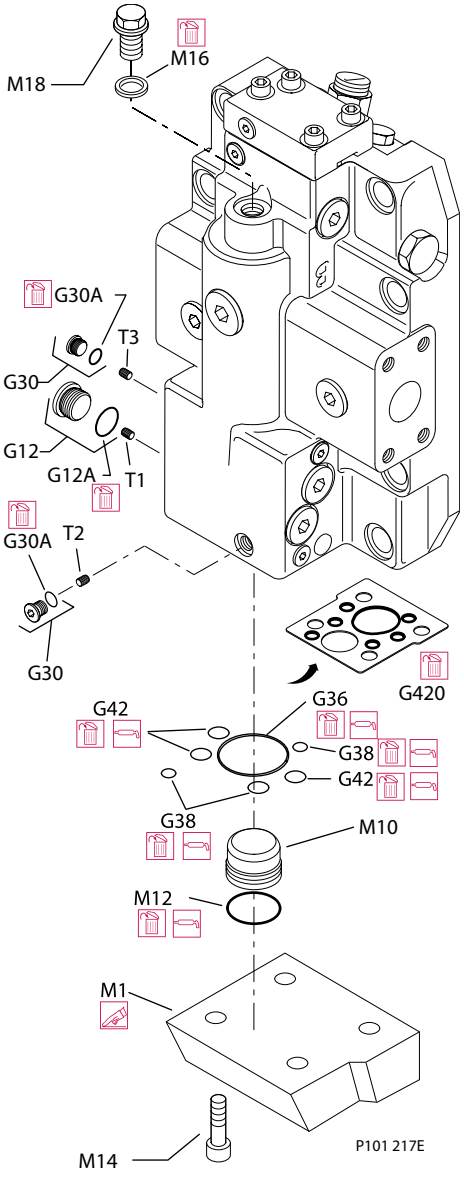
Assembly

1. Lubricate and install new O-ring (M12) to plug (M10).
2. Install the plug (M10) to the four-way valve cavity in the end cap.
3. Using petroleum jelly to retain them, install new interface O-rings (G36, G38, G42) on the end cap, or install gasket (G420).
4. Install cover plate (M1).
5. Install screws (M14). Torque as shown in the table.
6. If previously removed, install a new seal washer (M16) on plug (M18). Using a 13mm hex wrench, torque to 18 N•m [13.3 lbf•ft].
7. Using a 3 mm internal hex wrench, install orifices (T1, T2, T3) if used. Torque to 6 N•m [4 lbf•ft].
8. Lubricate and install new O-rings (G30A) onto plugs (G30). Using a 3 mm internal hex wrench, install plugs. Torque to 9 N•m [7 lbf•ft].

N2 Controls

9. Lubricate and install new O-ring (G12A) onto plug (G12). Using a 1/4 inch internal hex wrench, install plug. Torque to 37 N•m [28 lbf•ft]..

N2 Control



Wrench size and torque

Item	Frame	Wrench size	Torque
M14	80, 110	8 mm internal hex	78 N•m [58 lbf•ft]
M14	160, 250	10 mm internal hex	110 N•m [81 lbf•ft]

E1, E2, F1, F2 Controls

Operation

Functional Description

The E* and F* two-position controls consist of a ported housing containing a cartridge style, 3-way, two-position, solenoid valve. The control housing mounts to the multifunction block containing the double-resolver spool.

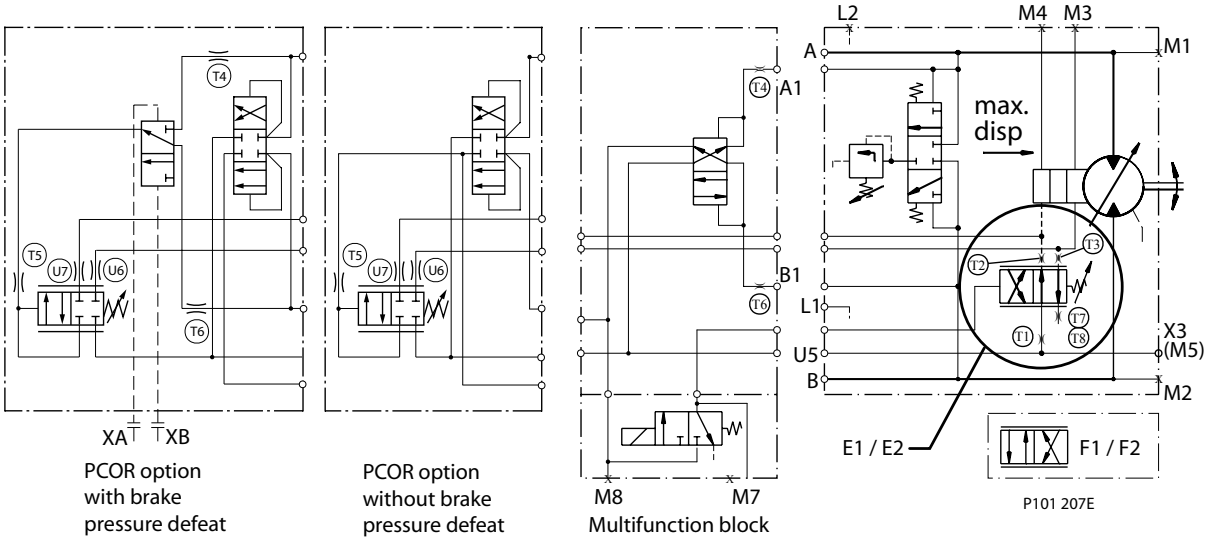
The resolver spool takes high pressure (system A or system B) and routes it to the four-way valve as servo supply, and sends low-loop pressure to the solenoid valve to operate the four-way valve. The solenoid valve, when energized, sends pilot pressure (low loop pressure) to the end of the four-way valve, to shift the motor's displacement.

E* controls use the standard logic sleeve. F* controls use the reverse logic sleeve. Optional orifices T1, T2, T3, T7, and T8 control shift speeds. This table shows control logic, input voltage, and connector options for each control type. E* and F* controls have the option of PCOR.

Control logic, voltage, and connector type

Type		Sol. on	Sol. off	Volts	Connector
E	1	min.	max.	12	DIN 46350
	2	min.	max.	24	DIN 46350
	5	min.	max.	12	Packard
F	1	max.	min.	12	DIN 46350
	2	max.	min.	24	DIN 46350

Schematic diagram



Repair

Disassembly

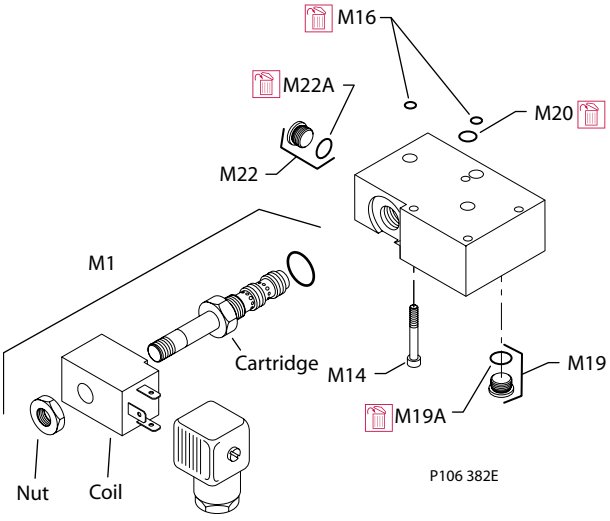
Solenoid valve (M1) is available as a complete assembly only.

1. Using a 7/8 inch wrench, remove the cartridge (M1) from the control housing.

E1, E2, F1, F2 Controls

2. Using a ¼ inch internal hex wrench, remove plugs (M22, M19). Remove and discard O-rings (M22A, M19A).
3. Using a 4 mm internal hex wrench, remove screws (M14).
4. Remove the control housing from the multifunction block.
5. Remove and discard O-rings (M16, M20).

E, F* control*



Tool sizes and torques

Item	Wrench size	Torque
M14	4 mm internal hex	6 N•m [4 lbf•ft]
M22, M19	1/4 inch internal hex	37 N•m [28 lbf•ft]
M1 nut	3/4 wrench	6 N•m [4 lbf•ft]
M1 cartridge	7/8 wrench	78 N•m [58 lbf•ft]

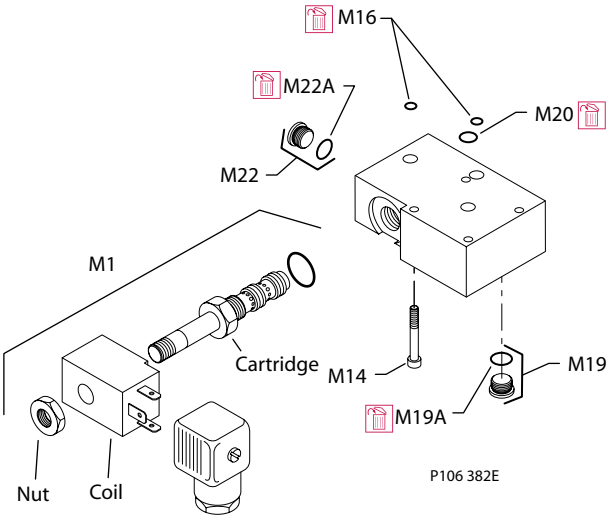
Assembly

1. Using petroleum jelly to retain them, install new interface O-rings (M16, M20).
2. Position the control housing on the multifunction block. Install screws (M14). Using a 4 mm internal hex wrench, torque to 6 N•m [4 lbf•ft].
3. Lubricate and install new O-rings (M19A, M22A). Install plugs (M19, M22). Using a 1/4 inch internal hex wrench, torque to 37 N•m [28 lbf•ft].
4. Lubricate the O-rings and install a new solenoid cartridge (M1). Using a 7/8 inch hex wrench, torque to 30 N•m [22 lbf•ft]. Do not overtorque.
5. Install the coil to the cartridge stem.

E1, E2, F1, F2 Controls

6. Install the coil nut. Using a 3/4 inch hex wrench, torque to 6 N•m [4 lbf•ft]. Do not overtorque.

E, F* control*



Tool sizes and torques

Item	Wrench size	Torque
M14	4 mm internal hex	6 N•m [4 lbf•ft]
M22, M19	1/4 inch internal hex	37 N•m [28 lbf•ft]
M1 nut	3/4 wrench	6 N•m [4 lbf•ft]
M1 cartridge	7/8 wrench	78 N•m [58 lbf•ft]

G1, G2, G7

Operation

Functional Description

The G* two-position controls consist of a ported housing that contains a four-way, 2-position, solenoid operated cartridge valve. A seal plug is installed in the four-way valve cavity in the motor's endcap. The control contains a loop-flushing shuttle valve and relief valve. The loop-flushing and four-way valve components normally found in the motor's endcap are not used with G* controls. A special endcap is used with the G* controls.

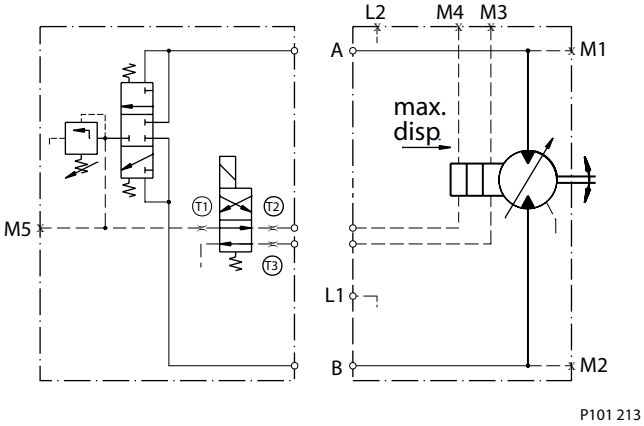
The loop-flushing shuttle valve resolves which port, system A or system B, is at a lower pressure. It then routes low-loop pressure to the loop-flushing relief valve and to the solenoid operated cartridge valve. The loop-flushing relief valve allows fluid to pass out of the working loop into the motor's case for cooling and contamination removal.

When energized, the solenoid valve routes low loop pressure to the minimum displacement end of the servo piston while draining the maximum displacement end to motor case, shifting the motor to minimum displacement. When de-energized, the valve routes low loop pressure to the maximum displacement end of the servo, while draining the minimum displacement end. Orifices at locations T1, T2, and T3 control shift speed.

G controls solenoid details*

Type		Sol. on	Sol.off	Volts	Connector
G	1	min.	max.	12	DIN 46350
	2	min.	max.	24	DIN 46350
	7	min.	max.	12	Jet Junior Timer

Schematic diagram



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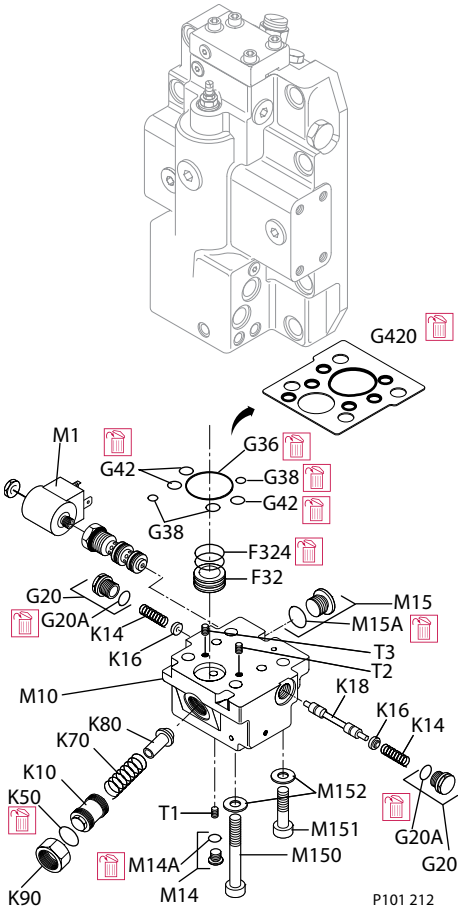
Repair

Solenoid (M1) is available as a complete assembly only. Do not remove the valve unless you plan to replace it.

G1, G2, G7

G control*



Tool sizes and torques

Item	Wrench size	Torque
M15	1/8 inch internal hex	9 N•m [7 lbf•ft]
M14	1/4 inch internal hex	37 N•m [28 lbf•ft]
G20	1-1/16 inch hex	37 N•m [28 lbf•ft]
T1, T2, T3	3 mm internal hex	6 N•m [4 lbf•ft]
K90	1-1/16 inch hex	52 N•m [38 lbf•ft]
M1 coil nut	3/4 hex wrench	6 N•m [4 lbf•ft]
M1 cartridge	7/8 hex wrench	78 N•m [58 lbf•ft]
M150/151 (80, 110)	8 mm internal hex	78 N•m [58 lbf•ft]
M150/151 (160, 250)	10 mm internal hex	110 N•m [81 lbf•ft]

Disassembly

1. Using a 1-1/16 inch wrench, remove the loop-flushing relief valve locknut (K90).
2. Using a 13 mm wrench, remove the adjustment plug (K10). Remove and discard the O-ring (K50) from the plug.
3. Remove spring (K70), and poppet (K80).

G1, G2, G7

4. Remove two plugs (G20). Remove and discard O-rings (G20A).
5. Remove loop-flushing springs (K14), seats (K16), and spool (K18).
6. Using a 3/4 inch wrench, remove coil nut and coil from solenoid valve (M1).
7. Using a 7/8 inch wrench, remove solenoid valve (M1).
8. Using a 1/8 inch internal hex wrench, remove plug (M15). Remove and discard O-ring (M15A).
9. Remove screws (M150, M151) and washers (M152). Remove control (M10).
10. Remove and discard O-rings (G38, G42, G36) or gasket (G420).
11. Remove plug (F32). There is a 6 mm threaded hole in the seal plug for a puller screw. Remove and discard O-rings (F324).
12. Using a 1/4 inch internal hex wrench, remove plug (M14). Remove and discard O-ring (M14A).
13. Using a 3 mm internal hex wrench, remove orifice (T1).

Inspection

Clean and inspect components for damage or foreign material. Replace damaged parts as necessary.

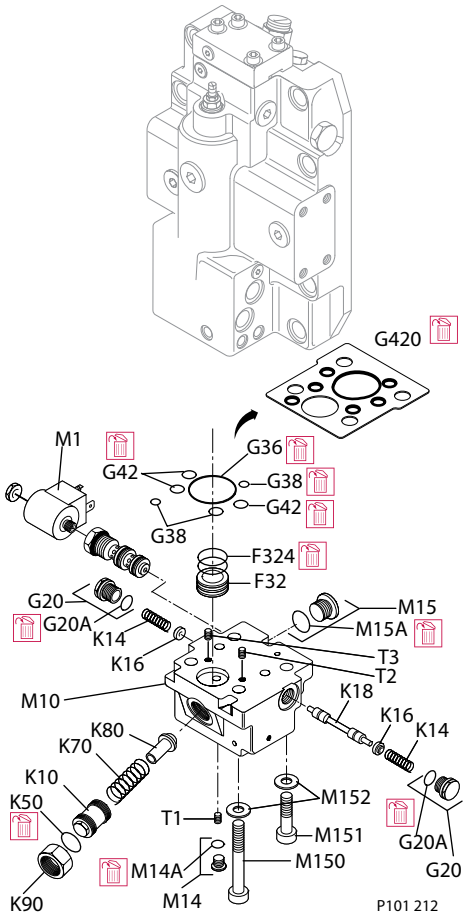
Assembly

1. Using a 3 mm internal hex wrench, install orifice (T1). Torque to 6 N•m [4 lbf•ft].
2. Lubricate and install new O-rings (F324). Install plug (F32).
3. Using petroleum jelly to retain them, install new O-rings (G36, 38, 42) or install gasket (G420).
4. Position control on endcap.
5. Install washers (M152) on to the retaining screws (M150 and M151). Install the screws and torque as shown in the table.
6. Lubricate and install new O-ring (M14A). Using a 1/4 inch internal hex wrench, install plug (M14). Torque to 37 N•m [28 lbf•ft].
7. Lubricate and install new O-ring (M15A). Using a 1/8 inch internal hex wrench, install plug (M15). Torque to 9 N•m [7 lbf•ft].
8. Lubricate and install loop-flushing spool (K18), spring seats (K16), and springs (K14).
9. Lubricate and install new O-rings (G20A). Using an 11/16 inch hex wrench, install plugs (G20). Torque to 37 N•m [28 lbf•ft].
10. Install poppet (K80) and spring (K70).
11. Lubricate and install a new O-ring (K50) on adjustment plug (K10). Install the plug.
12. Using a 1-1/16 inch hex wrench, install locknut (K90). Do not torque the locknut until after adjustment.
13. Lubricate O-rings on valve (M1). Using a 7/8 inch hex wrench, install the cartridge and torque to 30 N•m [22 lbf•ft]. Do not overtorque.
14. Install the coil onto the cartridge stem. Install the coil nut using a 3/4 inch hex wrench, torque to 6 N•m [4 lbf•ft]. Do not overtorque.

After assembly, adjust the loop-flushing relief valve. Refer to **11008567** *Series 51 and 51-1 Basic Service Manual* for adjustment procedure.

G1, G2, G7

G control*



Tool sizes and torques

Item	Wrench size	Torque
M15	1/8 inch internal hex	9 N•m [7 lbf•ft]
M14	1/4 inch internal hex	37 N•m [28 lbf•ft]
G20	1-1/16 inch hex	37 N•m [28 lbf•ft]
T1, T2, T3	3 mm internal hex	6 N•m [4 lbf•ft]
K90	1-1/16 inch hex	52 N•m [38 lbf•ft]
M1 coil nut	3/4 hex wrench	6 N•m [4 lbf•ft]
M1 cartridge	7/8 hex wrench	78 N•m [58 lbf•ft]
M150/151 (80, 110)	8 mm internal hex	78 N•m [58 lbf•ft]
M150/151 (160, 250)	10 mm internal hex	110 N•m [81 lbf•ft]

U1, U2

Operation

Functional Description

The U* two-position controls consist of a ported housing containing a shuttle spool and a solenoid. The shuttle spool resolves which port, system A or system B, is at higher pressure, routing that high pressure to the four-way valve to power the servo piston. The solenoid actuates the four-way valve causing the motor to shift displacement. The sensing piston functions only as a push-rod in this control.

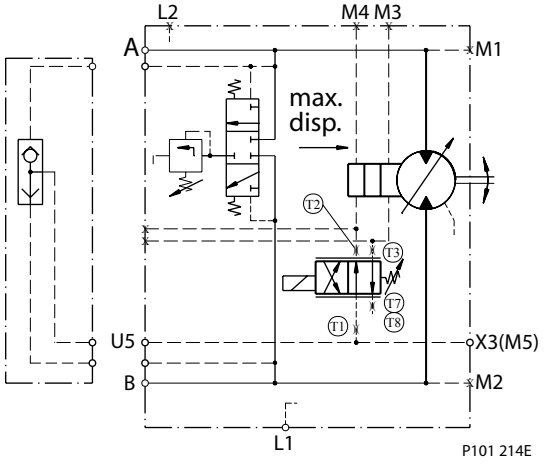
The motor defaults to minimum displacement, shifting to maximum when the solenoid operates. Optional orifices at locations T1, T2, T3, T7, and T8 control shift speeds.

This table shows control logic, input voltage, and connector options for each control type.

Control logic, input voltage and connector options

Type		SOL on	SOL off	Volts	Connector
U	1	max.	min.	12v	DIN 46350
	2	max.	min.	24 v	DIN 46250

Schematic diagram



The PCOR option is not available with U1/U2 controls.

Repair

Disassembly

1. Using a 1/4 inch internal hex wrench, remove plugs (M16, N20, NT40). Remove and discard O-rings (M16A, 20A, NT40A).
2. Remove shuttle spool (NT42).
3. Using a 3mm internal hex wrench, remove plug (N26).
4. Using a 1/8 inch internal hex wrench, remove plug (M18). Remove and discard O-ring (M18A).
5. Remove coil nut and coil from solenoid (M1).
6. Using a thin 3/4 inch hex wrench, remove cartridge (M1) from control. Keep the pushrod in the cartridge.
7. Remove screws (M22) and washers (M24).
8. Remove control housing (M10). Remove and discard O-rings (G36, G38, G42) or gasket (G420).

U1, U2

9. Remove piston (M12).
10. Remove the 4-way valve assembly (F32). Discard O-rings (F324).

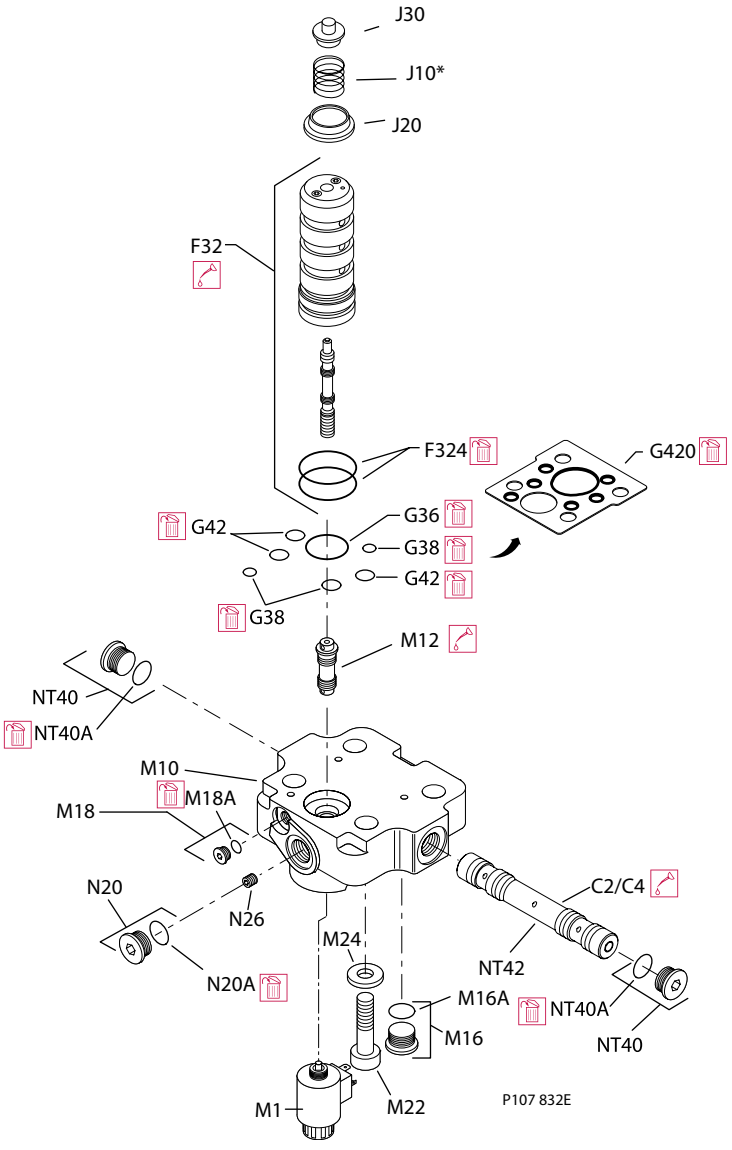
Caution

Read *Series 51 and 51-1 Bent Axis Motors Service Manual* **11008567** for minor repair instructions for the 4-way valve, threshold spring, and ramp spring components, if repair is necessary.

11. Remove spring (J10*) and spring seats (J30, J20).

Solenoid (M1) is available as a complete assembly only.

U control*



Tool size and torque

Item	Wrench size	Torque
M22 (80, 110)	8 mm internal hex	78 N•m [58 lbf•ft]

U1, U2

Tool size and torque (continued)

Item	Wrench size	Torque
M22 (160, 1250)	10 mm internal hex	110 N•m [81 lbf•ft]
M16, N20, NT40	1/4 inch internal hex	37 N•m [28 lbf•ft]
N26	3 mm internal hex	1. 7 N•m [2.7 lbf•ft]
M18	1/8 inch internal hex	78 N•m [58 lbf•ft]
M1 cartridge	3/4 inch hex	47 N•m [35 lbf•ft]

Inspection

Clean and inspect components for damage or foreign material. Replace damaged parts as necessary.

Assembly

Refer to the illustration on the previous page.

1. Position motor with control surface up for easier assembly.
2. Install spring seat (J30), spring (J10*), and seat (J20).
3. Lubricate and install O-rings (F324) to four-way valve.
4. Lubricate and install the 4-way valve assembly (F32).
5. Lubricate and install piston (M12).
6. Using petroleum jelly to retain them, lubricate and install O-rings (G38, G42, G36), or install gasket (G420).
7. Position control on endcap.
8. Install washers (M24) and screws (M22). Torque as shown in the table on the previous page.
9. Using a 3 mm internal hex wrench, install the plug (N26) to the control housing. Torque to 6 N•m [4 lbf•ft].
10. Lubricate the shuttle spool (NT42) and install into the cavity in the control housing.
11. Lubricate and install new O-rings (M16A, N20A, NT40A). Install plugs (M16, N20, NT40) using a 1/4 inch internal hex wrench. Torque to 37 N•m [28 lbf•ft].
12. Lubricate and install new O-ring (M18A). Install plug (M18) using a 1/8 inch internal hex wrench. Torque to 9 N•m [7 lbf•ft].
13. Install new cartridge (M1) with pushrod. Using a thin 3/4 inch hex wrench, torque to 47 N•m [35 lbf•ft].
14. Install coil (M1) to the cartridge stem. Hand-tighten the coil nut.

PC, PD

Operation

Functional Description

PC Control

The PC control consists of a multifunction block with PCOR valve attached. The multifunction block contains the servo supply spool. It resolves high loop pressure for servo supply, and routes the high loop pressure to the PCOR valve. At the same time it connects the low loop pressure to the PCOR.

The PC control uses a ported plug in place of the 4-way valve that connects the servo supply pressure to the minimum displacement end of the servo piston. It drains the maximum displacement end to case through orifice T7.

System pressure operates the PCOR valve. When system pressure reaches the PC threshold pressure, the PCOR spool shifts, routing system pressure to the maximum displacement end of the servo piston, saturating the T7 orifice, while draining the minimum displacement end to low loop. Optional orifices at locations T1, T2, T3, T5, T7, U6 and U7 control shift speed. Brake pressure defeat option is not available with the PC control.

PD Control

The PD control consists of a multifunction block with PCOR valve attached. The multifunction block contains the servo supply spool that resolves high loop pressure, routing it to the 4-way valve for servo supply, and to the PCOR valve.

The motor defaults to minimum displacement, shifting to maximum when directed by an external hydraulic signal applied to port X1. This signal acts on the 4-way valve. When the signal pressure overcomes the threshold spring force, the valve shifts.

External pressure in the range of 5 to 12 bar [72.5 to 174 psi] is required at port X1 to shift the motor to maximum displacement. The threshold setting is adjustable within this range.

Pressure from an external source, applied to port X4 operates the PCOR valve. When this external pressure reaches the PCOR setting, the PCOR spool shifts. This routes high system pressure to the maximum displacement end of the servo piston while the minimum displacement end drains through the 4-way valve out of X1.

Port X4 requires external pressure in the range of 130 to 370 bar [1890 to 5370 psi] to operate the PCOR valve and shift the motor to maximum displacement. The PCOR threshold pressure setting is adjustable within this range. Optional orificesT1, T2, T3, T7, T8, and U7 control shift speed. The PD control does not have brake pressure defeat option.

Adjustment

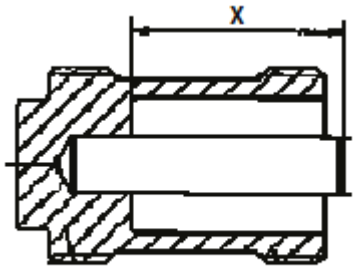
PC, PD PCOR Adjuster Stop-pin

A stop-pin is installed in the PCOR adjuster to prevent over-travel of the PCOR valve spool. If the spool is allowed to over-travel, due to high system pressure, it will close off flow to the servo piston. This would keep the PCOR from shifting the motor toward maximum displacement and regulating the system pressure.

The stop-pin must protrude from the spring seat (dimension X, shown) 24 mm [0.94 inch] for PCOR settings of 110 to 260 bar [1600 to 3750 psi] or 19 mm [0.74 inch] for PCOR settings of 270 to 370 bar [3900 to 5370 psi].

PC, PD

Stop pin dimension



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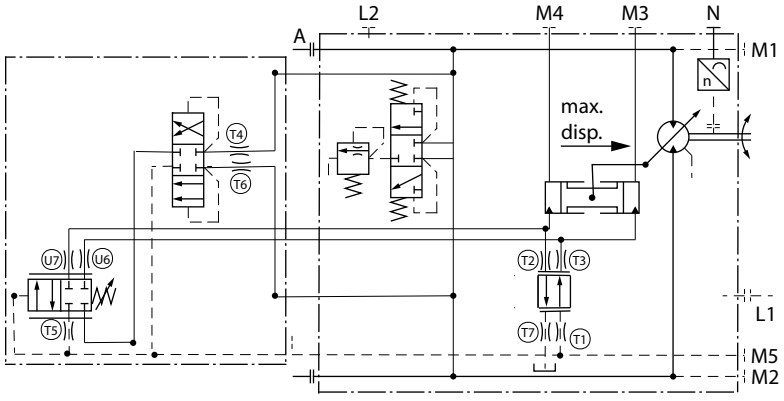
Repair

Refer to *Pressure Compensator Override (PCOR)* on page 18, and *Multifunction Block* on page 20, earlier in this book for repair instructions.

Schematic Diagrams

PC schematic



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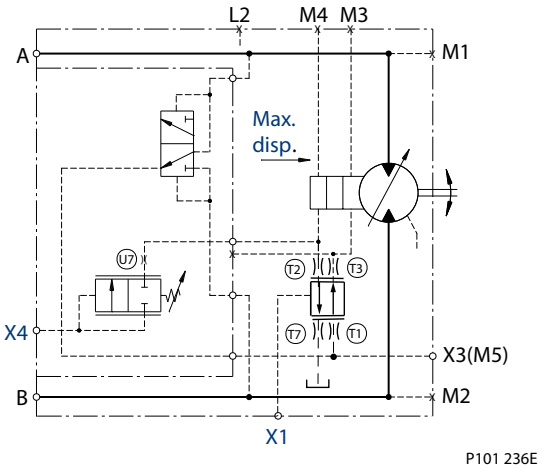
PC, PD

PD schematic



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