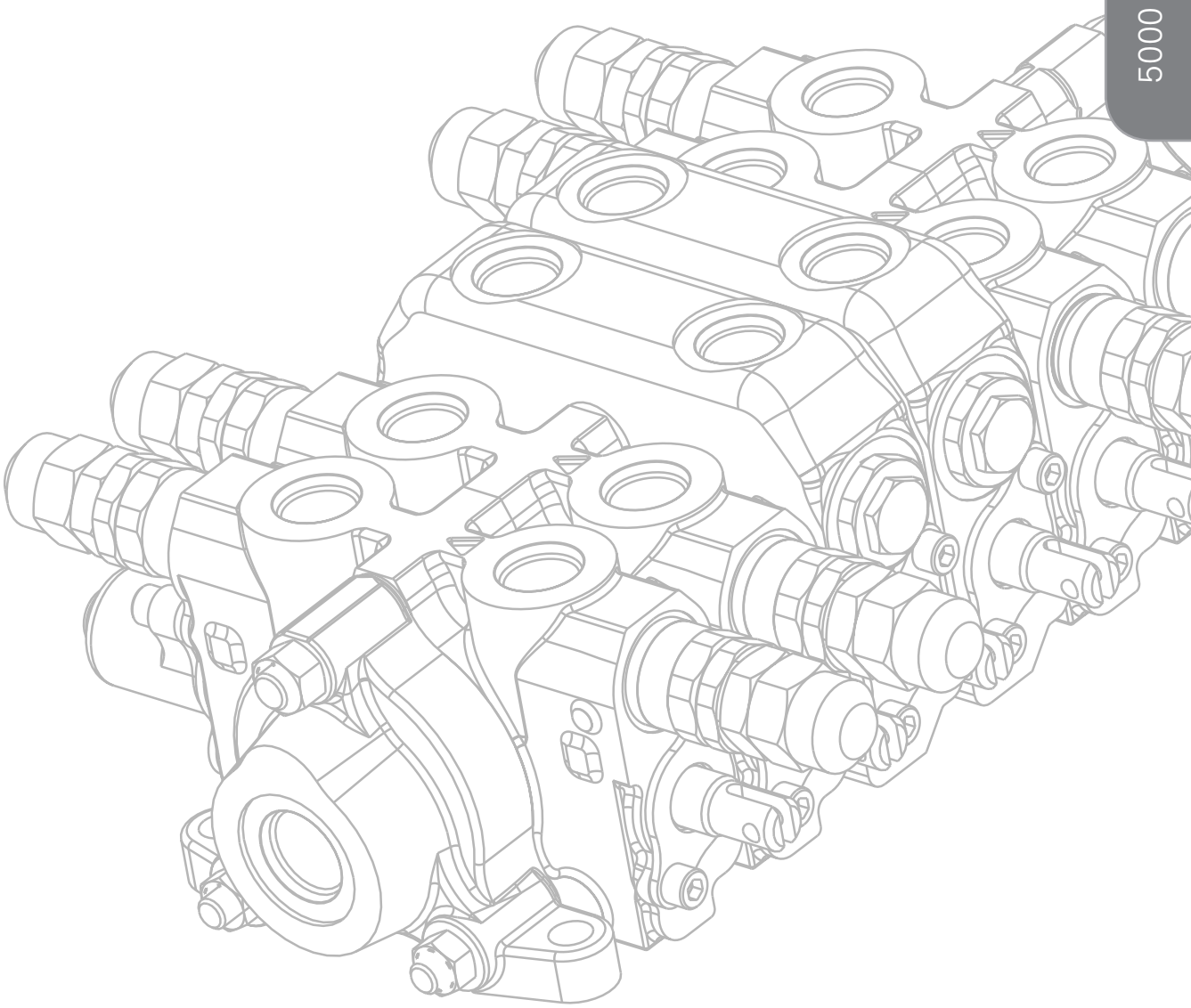
Service Manual

5000 VALVE SERIES

CONTROL FOCUSED • TECHNOLOGY DRIVEN



MODEL 5000
SECTIONAL VALVE

HUSCO INTERNATIONAL
control focused - technology driven

SSL-2000 REV 12/07

Technical Data

Flow rating (nominal)	20 gpm (75 lpm)
Operating Pressure*	3000 psi (207 bar) (Method of verifying rated fatigue pressure of the pressure containing envelope conforms to NFPA Recommended Std., NFPA/2.6.1 – 1974 Category 1/90)
Seals	Buna-N Standard Vitron Optional
Recommended Filtration	ISO 20/18/13
Maximum number of spool sections (any combination of) per valve assembly	11
Maximum outlet port/tank core (return) pressure	500 psi

*Higher pressure applications consult HUSCO

We reserve the right to amend these specifications at any time without notice. The only warranty applicable is our standard written warranty. We make no other warranty, expressed or implied.

Performance characteristics shown are typical of production units tested in the laboratory and are not necessarily representative of any one unit.

Section 1

Theory of Operation

Section 2

Trouble Shooting

Section 3

Repair

Section 4

Miscellaneous Information

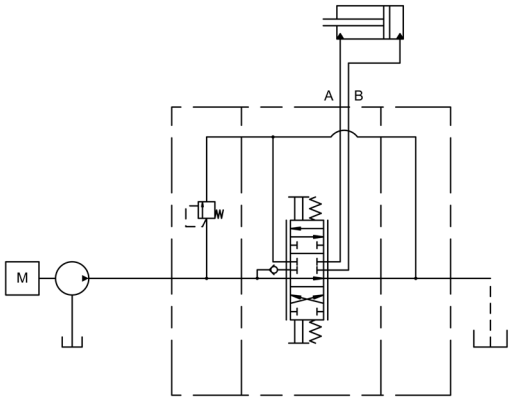
Section 1.1

System Types

Open-Center

In an open-center system, when all spools are in their neutral positions, a fixed-displacement pump directs full flow through the center passage of the valve and back to the reservoir. When one of the spools is shifted, flow is re-directed and made available for work by the desired section(s).

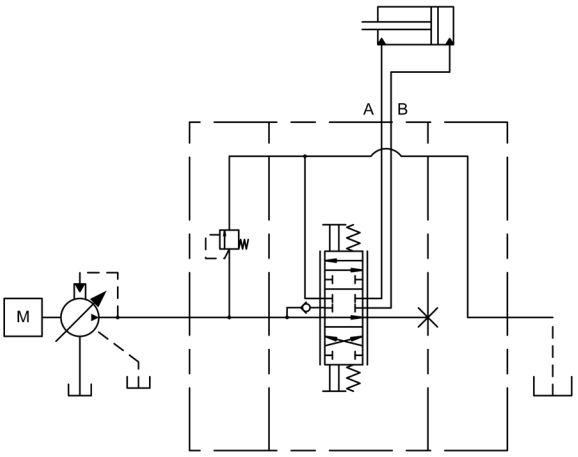
The advantages of an open-center system include simplicity of the system and lower component cost. The disadvantages include lower efficiency since the pump is continually providing full flow, as well as limited ability for the operator to control multiple functions at once.



Closed-Center

With the 5000 Series valve, closed-center functionality is attained by terminating the connection from the center passage to the reservoir. Since center passage flow is blocked when all spools are in their neutral positions, a variable displacement pump must be used. When one of the spools is shifted, flow is re-directed and made available for work by the desired section(s).

The advantages of closed-center operation with the 5000 Series valve include consistent start of metering and faster system response. The disadvantages include system complexity and cost due to the need for a variable-displacement pump, as well as the need for the pump to constantly remain at high pressure standby due to absence of a load-sense feedback from the valve.

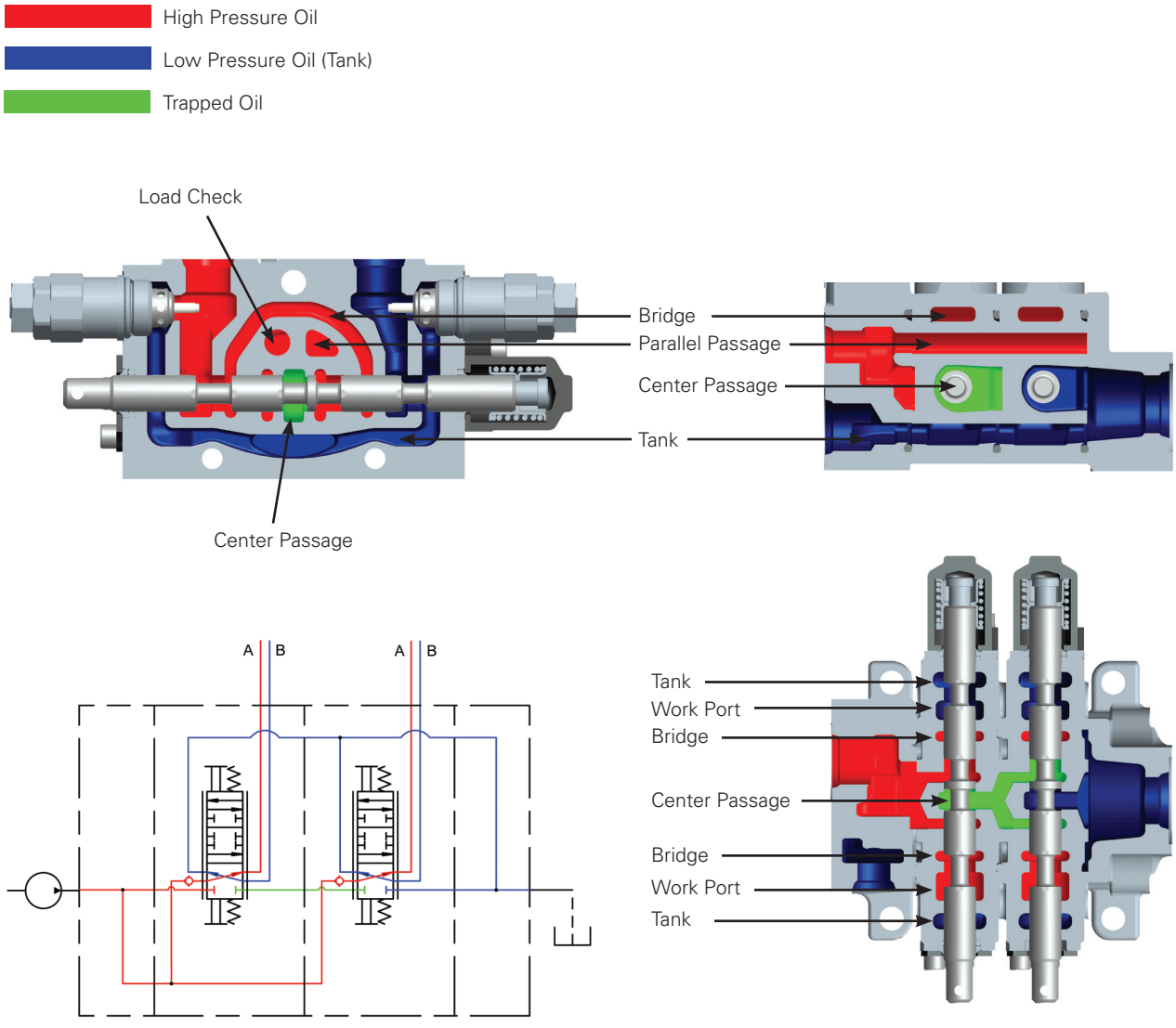


Parallel Circuit

In a parallel circuit, when two or more spools are fully shifted simultaneously, the spool in the upstream section (closer to the inlet) blocks the center passage and flow is made available to downstream sections of the valve through the parallel passage.

When actuating multiple spools simultaneously, flow will always follow the path of least resistance. This means that if two spools are fully shifted to operate two separate functions, the function with the lowest pressure will move first until the load is increased or the function is deadheaded. Then, pressure will increase to allow the next load to move.

Two functions can be operated simultaneously if the spool controlling the lowest pressure is partially shifted or metered. Metering divides the flow and allows pressure to build so both functions can be controlled at the same time.

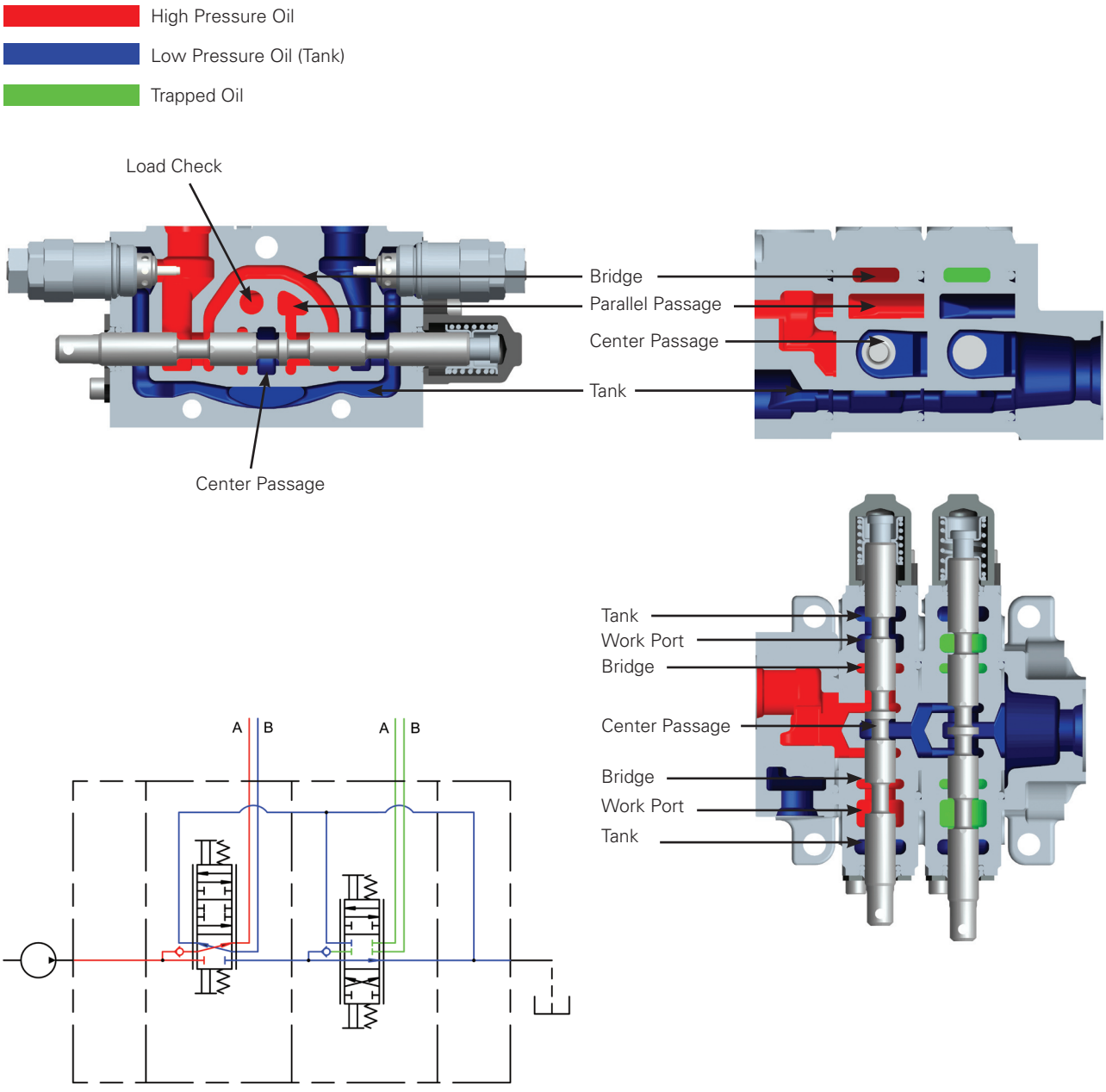


Conventional Circuit

Conventional circuits are also referred to as tandem or series-parallel circuits. A conventional circuit is similar to a parallel circuit except the parallel passages of each section are not connected, leaving only the center flow path to supply oil to sections.

When one spool is fully shifted, the center flow path is blocked in order to build pressure for the function it is actuating. Since the parallel passages are not connected, flow is not available for downstream functions when an upstream function is actuated. This gives the upstream function "priority."

To control multiple functions simultaneously, an operator can meter the upstream spool to pass flow through the center passage to downstream sections.



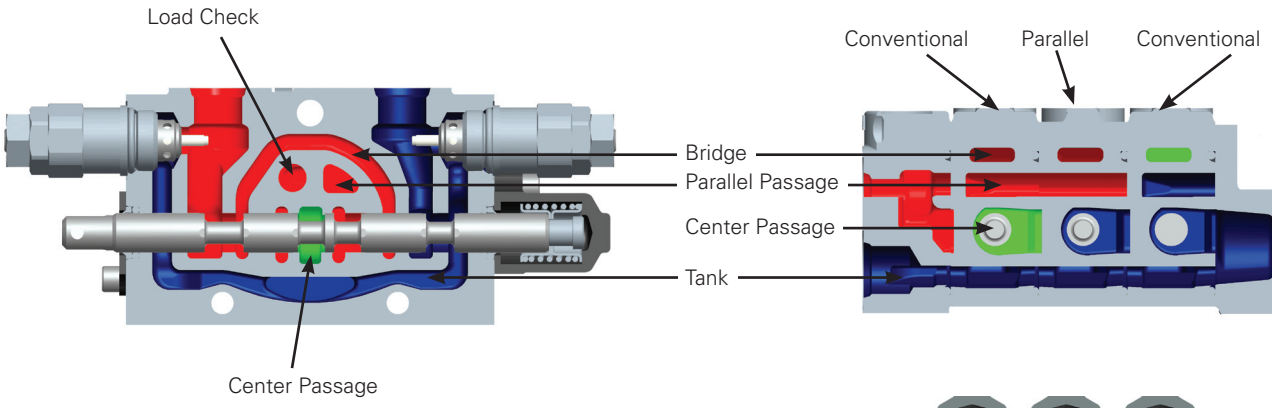
COMBINED CIRCUIT

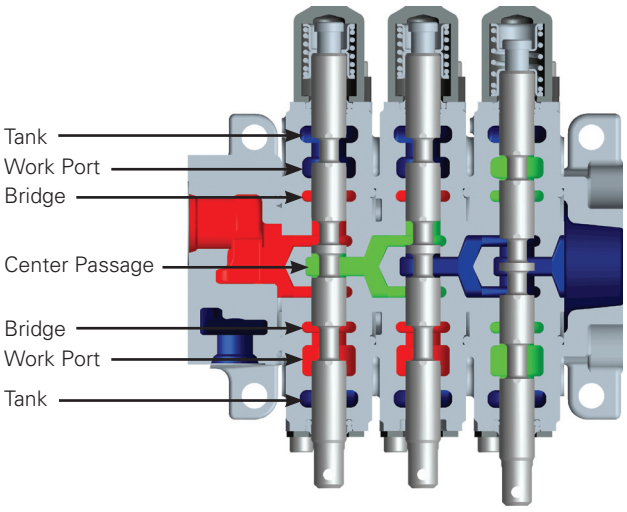
A valve assembly can be created with a combination of parallel and conventional circuits. When a conventional section is placed downstream of a parallel section, the parallel passages are not connected, and the two sections function as a conventional circuit. When a parallel section is placed downstream of a conventional section, the parallel passages are connected, and the two sections function as a parallel circuit. Various combinations of parallel and conventional sections can be configured to provide priority to one section of the valve relative to another.

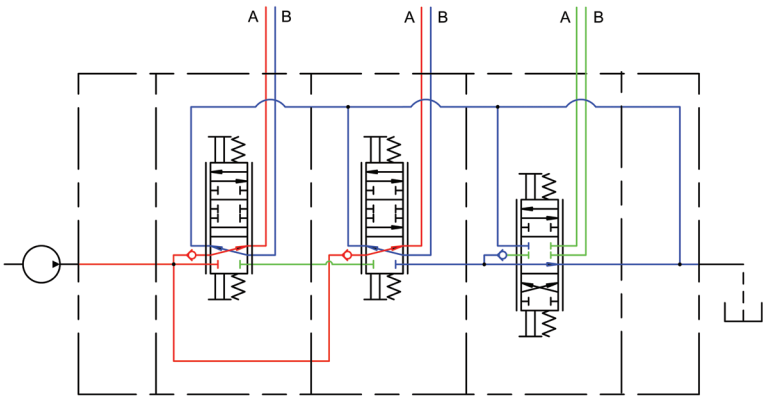
High Pressure Oil

Low Pressure Oil (Tank)

Trapped Oil







Series Circuit

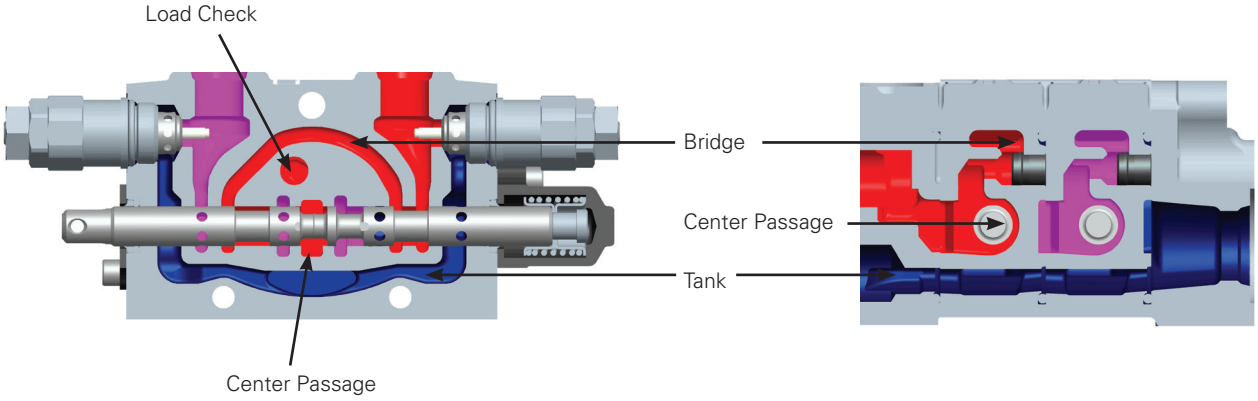
In a series circuit, pump flow is directed to each function in succession from the first function in the valve to the last. When multiple spools are fully shifted, all of the pump oil is routed to the first function. The exhaust oil returning from the first function is then routed back into the center flow path for use by the second function rather than being routed to tank. This allows an operator to simultaneously operate multiple functions with ease. It also permits use of a pump with a smaller flow capacity.

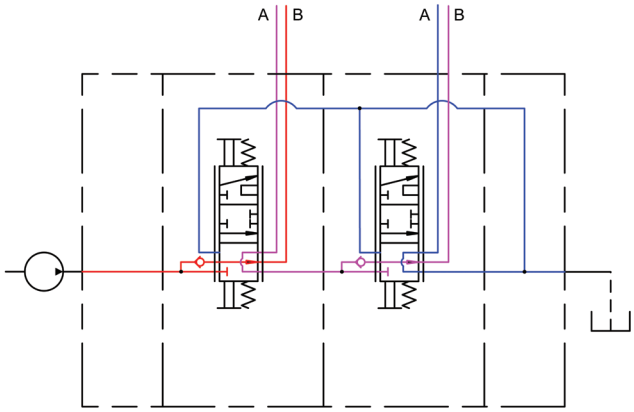
A disadvantage of the series circuit is that pressure is additive. This means that the pump and main relief valve will see a pressure resulting from the addition of all the loads in the system. Another disadvantage is a deadheaded function will stop flow to downstream functions, as exhaust oil will not be available to send to the neutral passage.

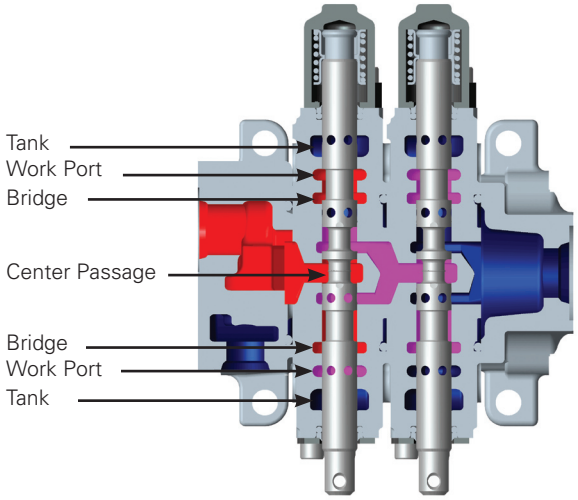
High Pressure Oil

Low Pressure Oil (Tank)

Return Oil (Series)





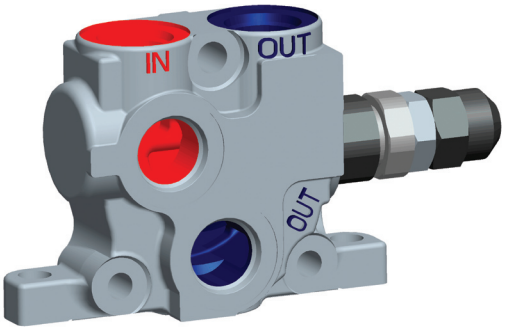


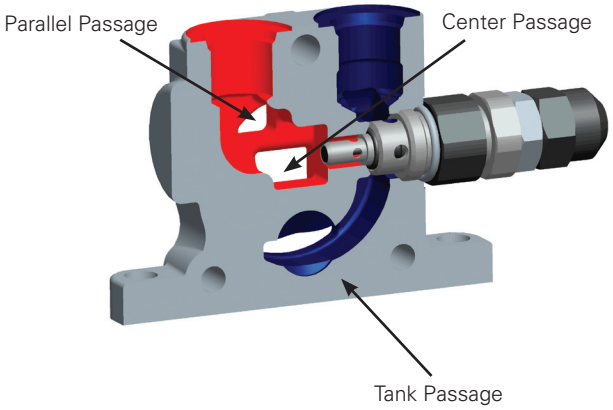
SECTION 1.3
INLETS & OUTLETS

END INLETS

End inlets contain a port(s) for supplying high-pressure pump flow to the valve. Some inlets, called "universal" inlets, also contain a port(s) for returning flow back to tank.

Ports used for inlet and outlet flow are located on the end and/or top of the inlet housing. All HUSCO inlets have IN and OUT cast into the inlet housing to differentiate between the types of ports. Inlets may also contain a relief valve cavity in which either a main relief valve or a shut-off plug is installed.

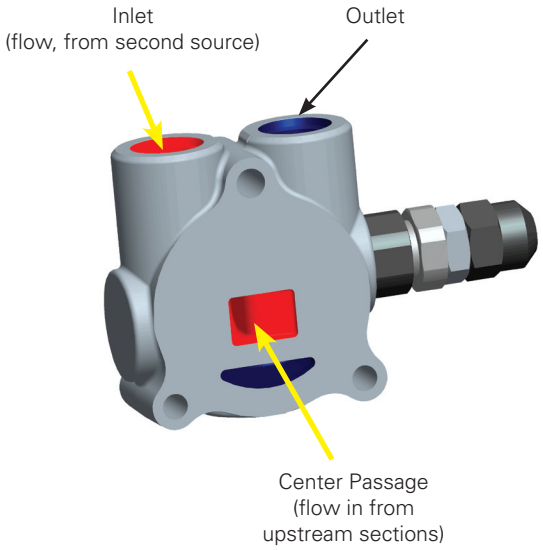


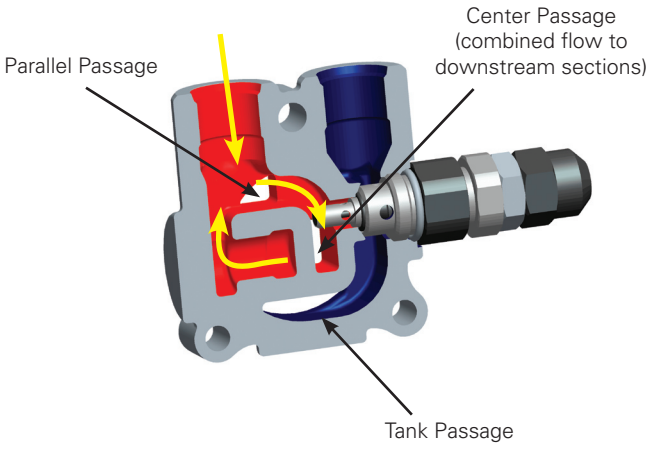


MID-INLETS

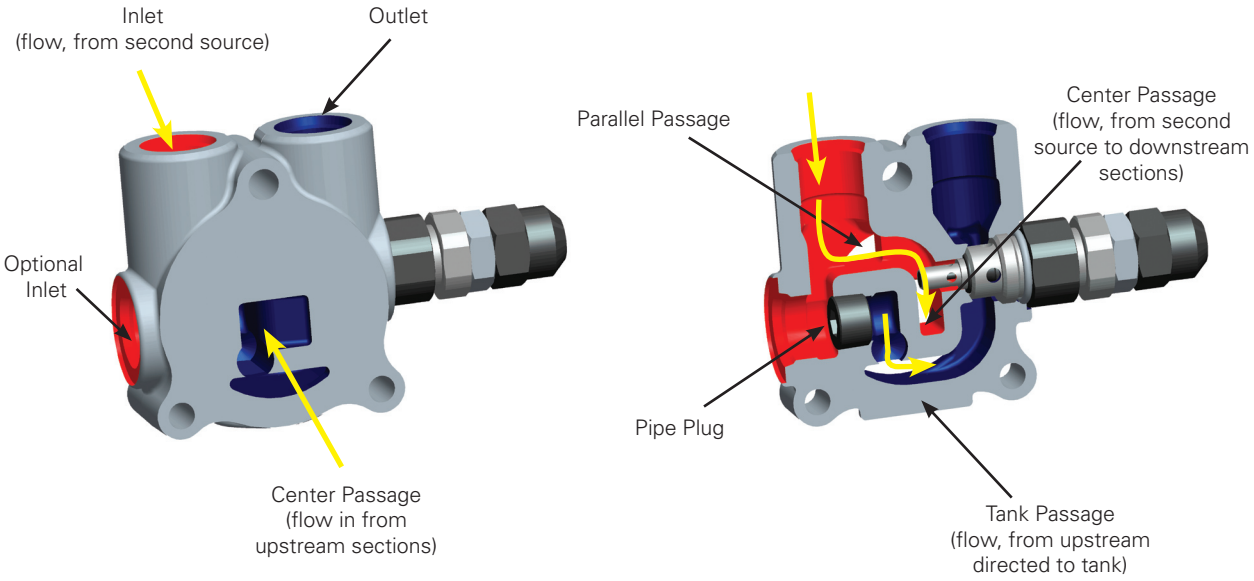
Mid-inlets are inserted between spool sections and enable flow to be supplied from a second source. Mid-inlets are similar to end-inlets in that they have inlet and outlet ports and also contain a cavity for a main relief valve or shut-off plug.

There are two types of mid-inlets: flow combiners and flow separators. In a flow combiner, flow from the second source combines with flow through the center passage of the upstream sections. The sum of the flows is then supplied to downstream sections.



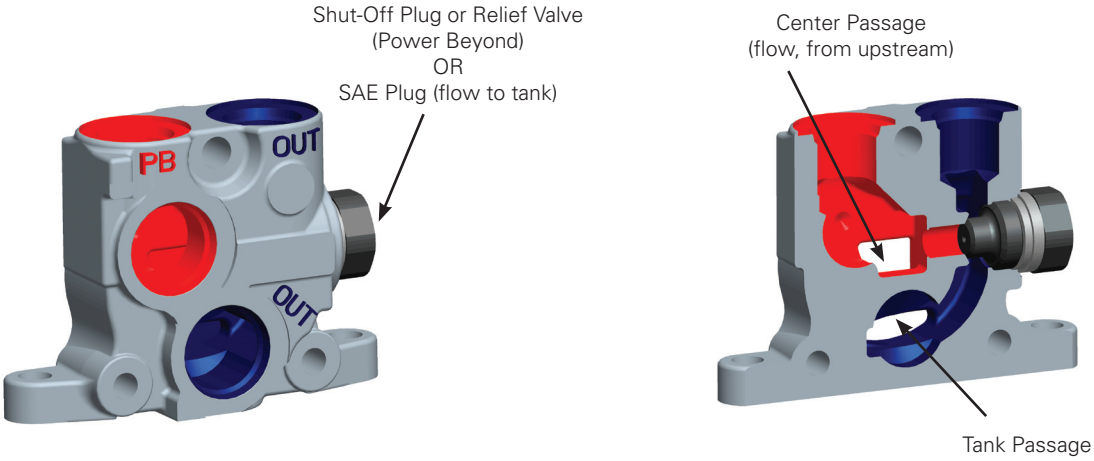


A flow separator directs center passage flow from upstream sections to tank. Sections downstream of the flow separator only receive supply flow provided by the mid-inlet flow source.



Outlets

Depending on the type, an outlet can serve as a simple turnaround, an outlet to tank, and/or a power beyond. They can also be plugged to convert an open-center valve to closed-center operation.

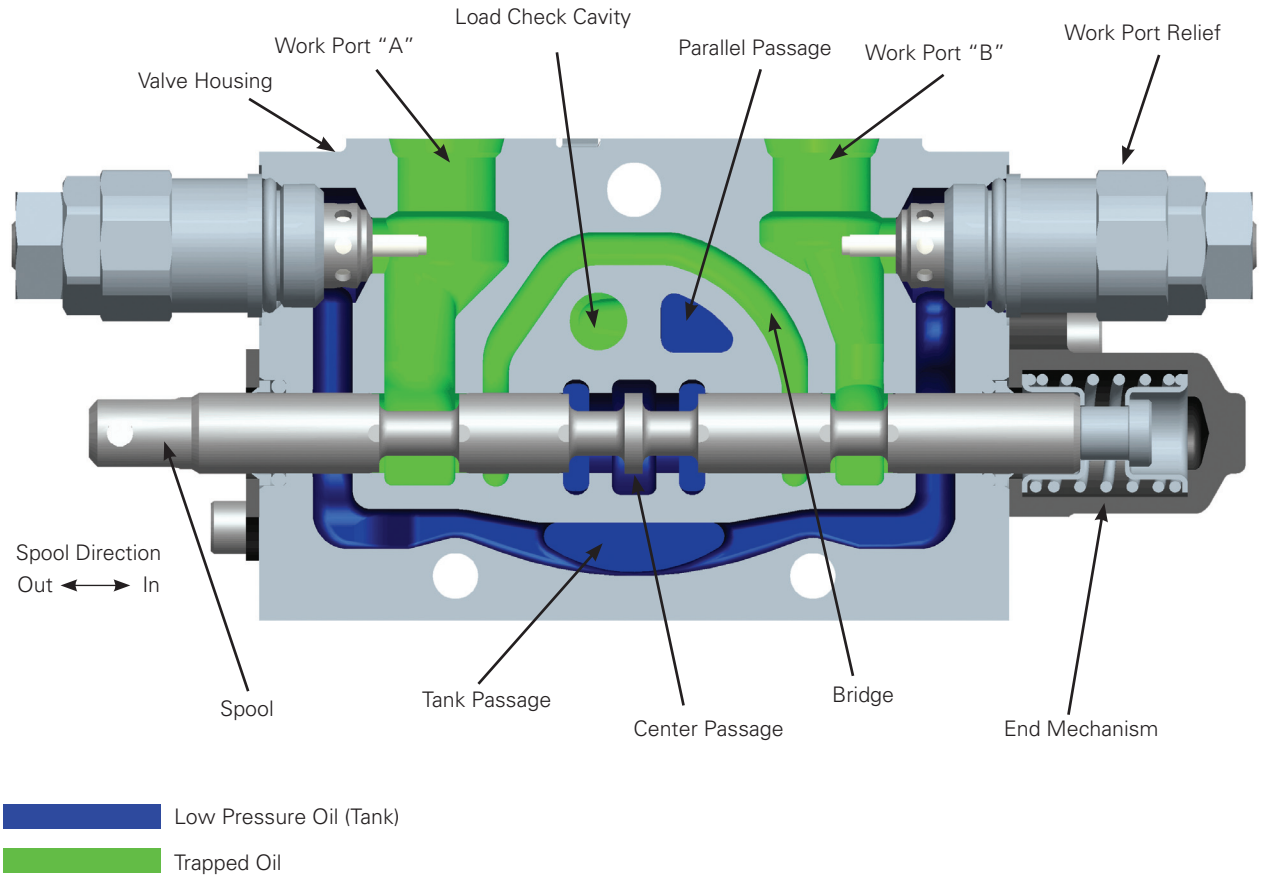


To convert to closed-center operation, plug all Power Beyond ports and block the flow path from the center passage to the tank passage.

Section 1.4

Spool Types

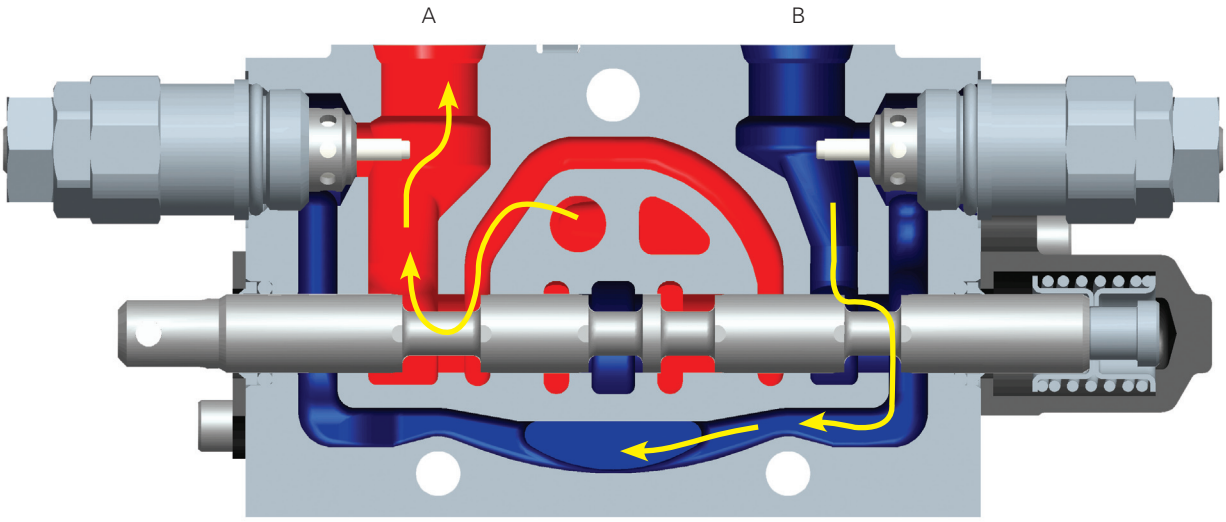
Common spool section components and passages. The section below shows a cylinder spool in the neutral position.

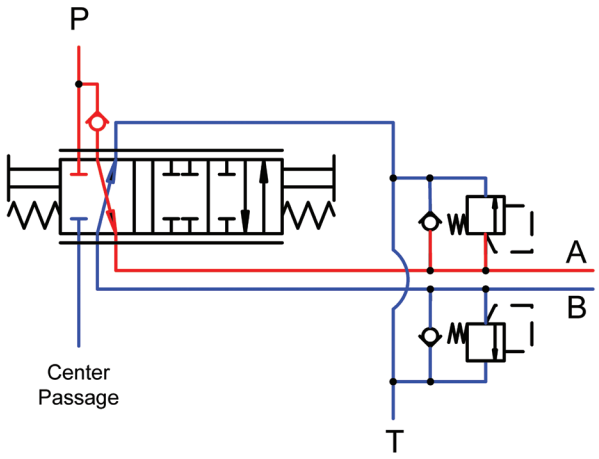


Cylinder Spools

When a cylinder spool is in the neutral position, the center passage is open and both work ports are blocked.

When a cylinder spool is shifted in, the center passage is blocked and high-pressure oil is directed from the parallel passage, through the bridge, and into Work Port "A." In parallel and conventional sections, return oil from Work Port "B" is directed to the tank passage.

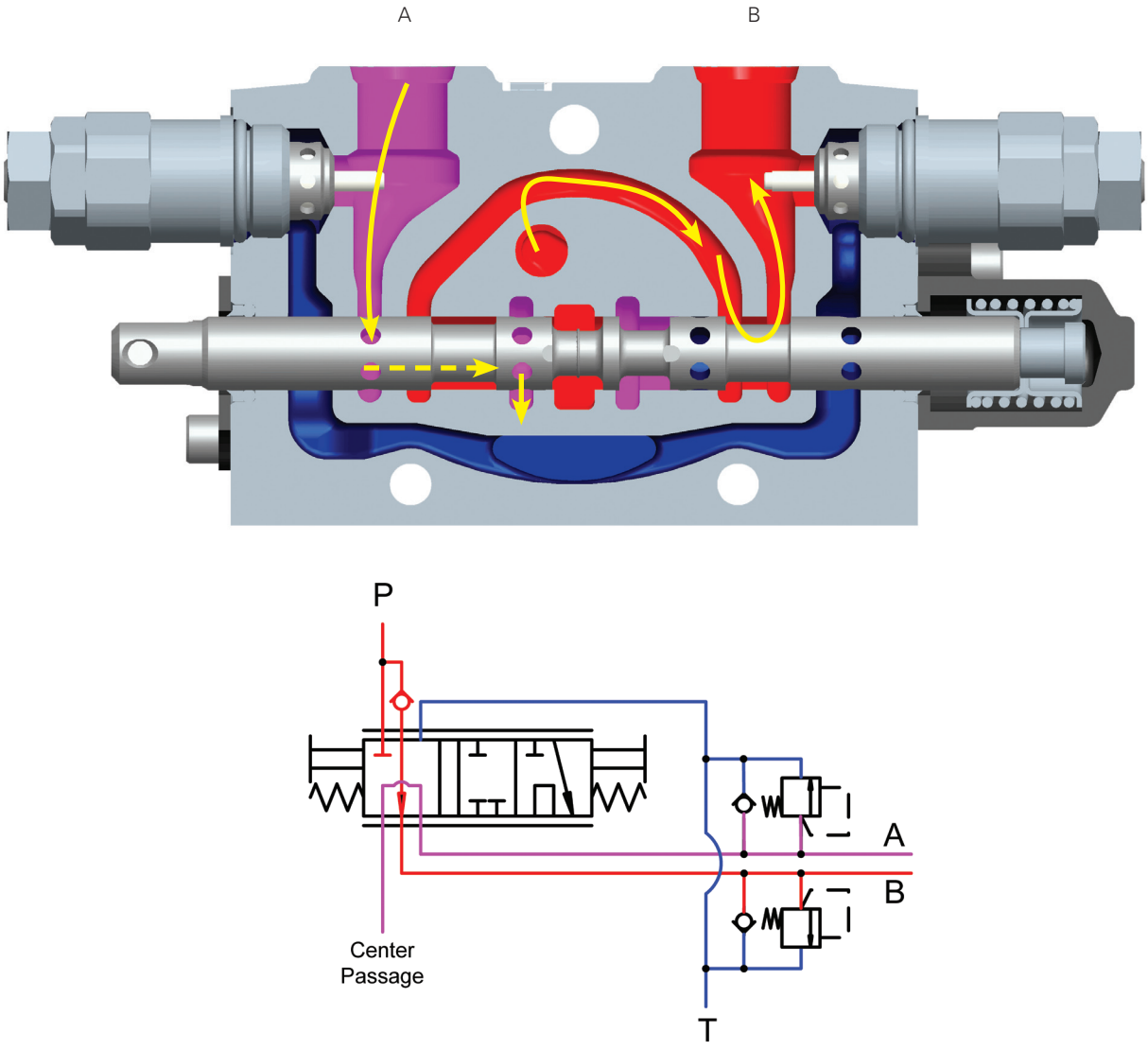




High Pressure Oil

Low Pressure Oil (Tank)

In a series section with the spool shifted in, return oil from Work Port "A" is directed back into the center passage for use in downstream sections.



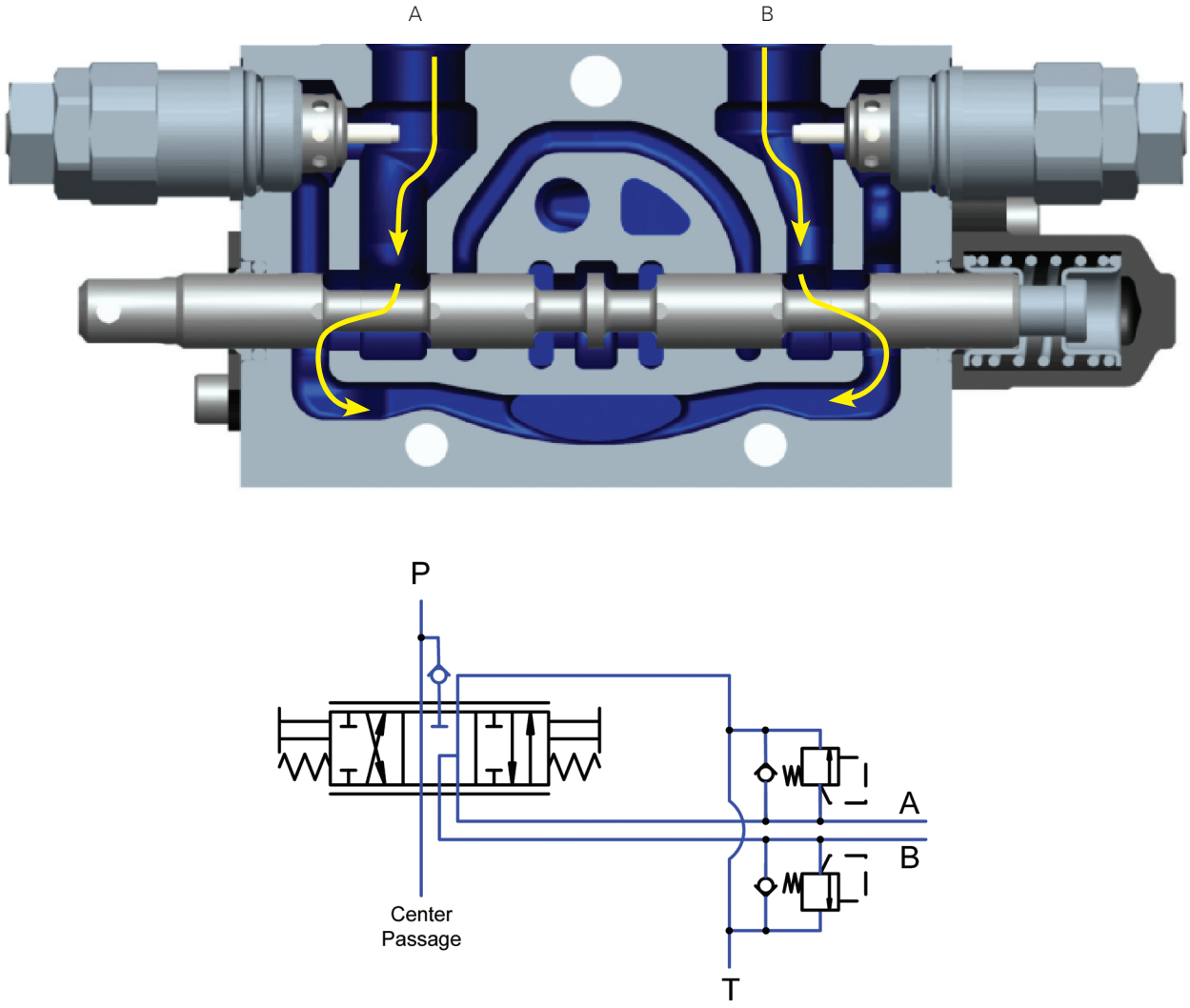
High Pressure Oil

Low Pressure Oil (Tank)

Return Oil (Series)

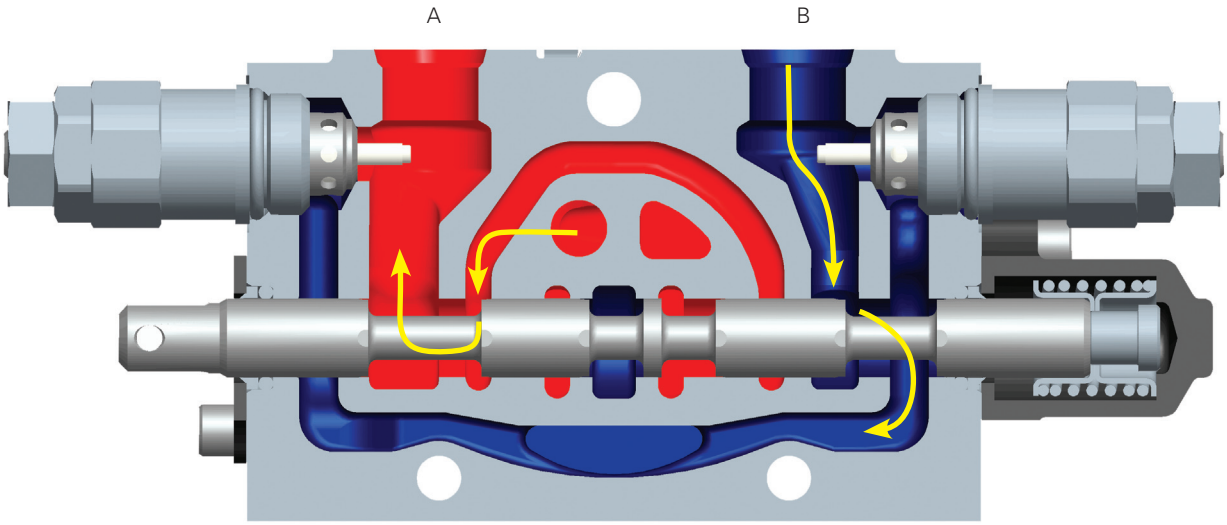
Motor Spools

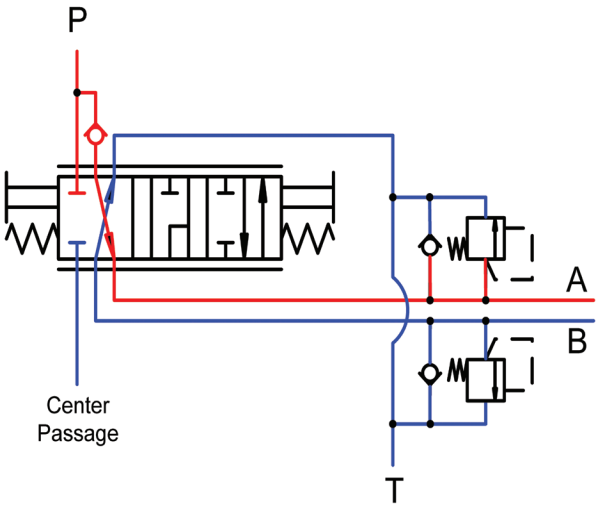
When a motor spool is in the neutral position, the center passage is open, and the work ports are connected to the tank passage.



Low Pressure Oil (Tank)

When the spool is shifted in, high pressure oil is supplied to work port "A," and the connection to tank is terminated. Work port "B" remains connected to the tank passage.



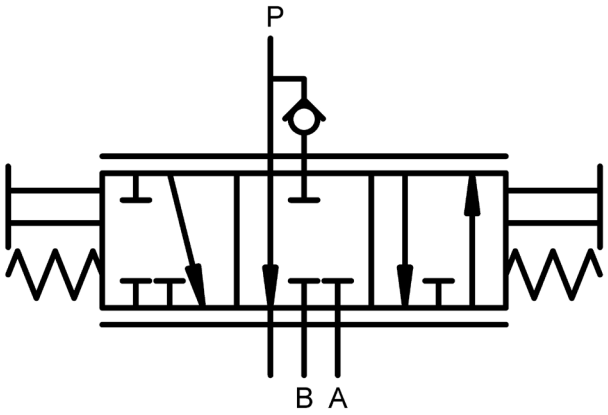


High Pressure Oil

Low Pressure Oil (Tank)

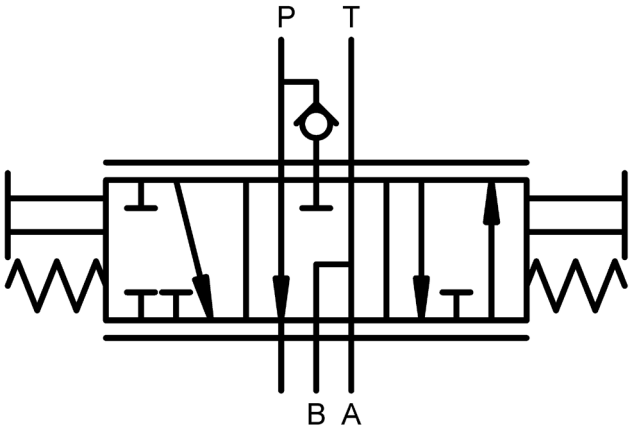
3-Way, 3-Position Cylinder Spool

Spool is used to control a single-acting cylinder. Pressurized flow is only available to one work port. Flow to this work port is blocked when the spool is in the neutral position. The second work port is externally plugged.



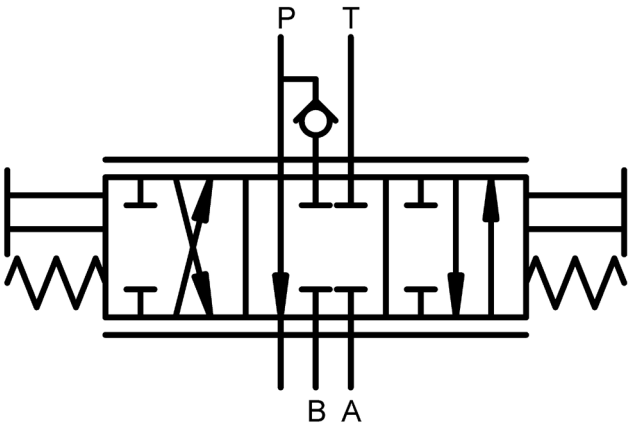
3-Way, 3-Position Motor Spool

Spool is used to control a non-reversible motor function. Pressurized flow is only available to one work port. This work port is connected to the tank passage when the spool is in the neutral position. The second work port is externally plugged.



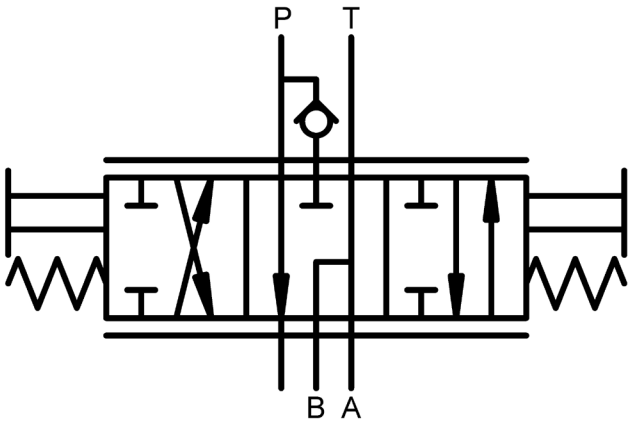
4-Way, 3-Position Cylinder Spool

Spool is used to control a double-acting cylinder or bi-directional motor. Pressurized flow is available to both work ports. When the spool is shifted, one work port is supplied with pressurized oil flow and the other is connected to the tank passage. Oil flow to both work ports is blocked when the spool is in the neutral position.



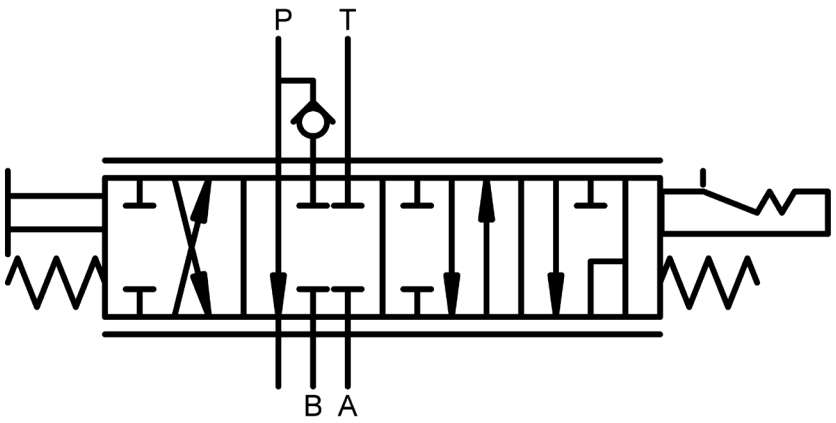
4-Way, 3-Position Motor Spool

Spool is used to control a reversible motor function. Pressurized oil flow is available to both work ports. With the spool in the neutral position, both work ports are connected to the tank passage. When the spool is shifted, one work port is supplied with pressurized oil flow and the other remains connected to the tank passage.



4-Way, 4-Position Float Spool

Function is very similar to a 4-way, 3-position cylinder spool. The 4-way, 4-position cylinder spool is used to control double-acting cylinders, except for the fourth "float" position that connects both work ports to the tank passage.

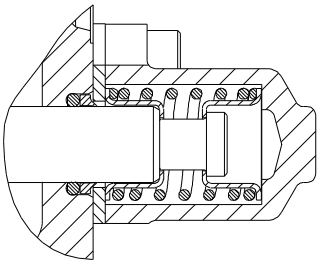


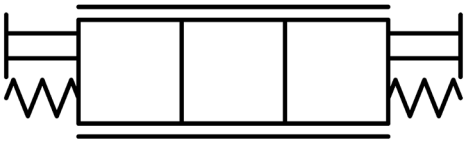
Section 1.5

End Mechanisms

3-Position Spring-Centered

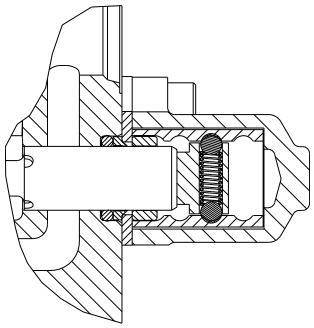
End mechanism accommodates three spool positions – "in," "neutral," and "out." The centering spring returns spool to neutral from the "in" and "out" positions.

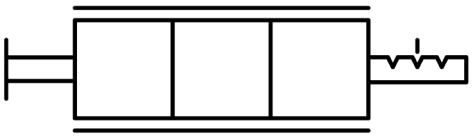




3-Position Detent

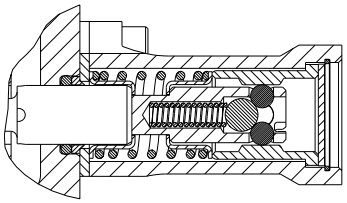
End mechanism holds the spool in place in each of the three spool positions – "in," "neutral," and "out."

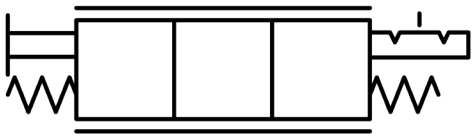




3-Position Detent "In" & "Out"

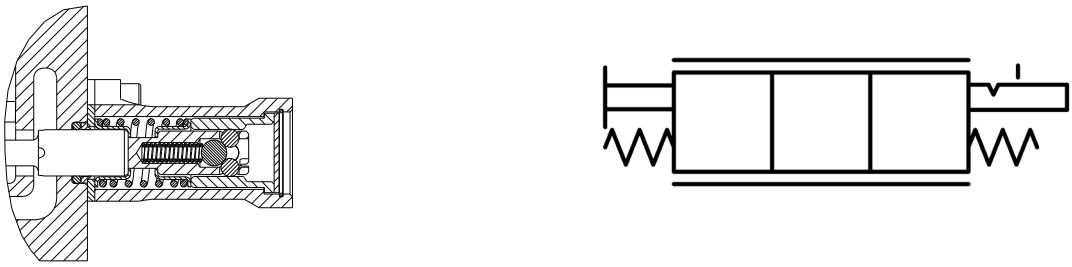
End mechanism is similar to a 3-Position Spring-Centered except the detent mechanism holds the spool in place when shifted into the "in" or "out" positions. The centering spring returns the spool to neutral when the detent is released.





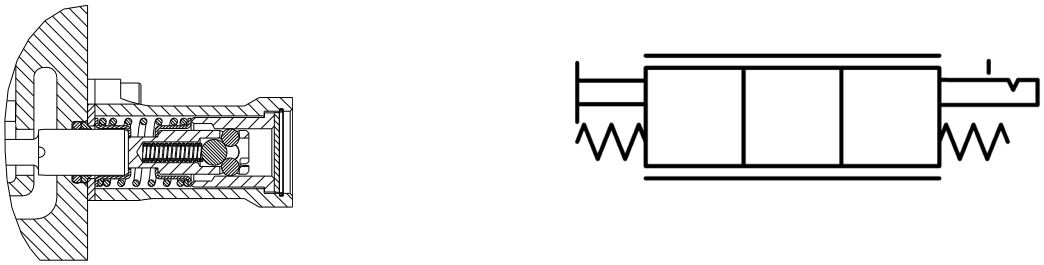
3-Position Detent "In"

The detent mechanism holds the spool in place when shifted into the "in" position. The centering spring returns the spool to neutral from the "out" position.



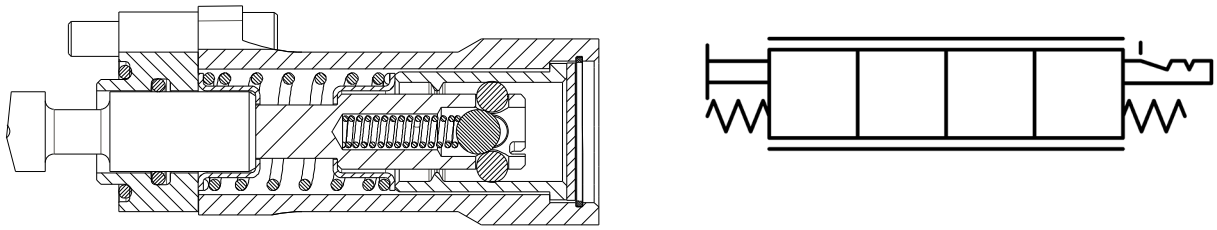
3-Position Detent "Out"

Function is opposite of 3-Position Detented "In." The detent mechanism holds the spool in place when shifted into the "out" position. The centering spring returns the spool to neutral from the "in" position.



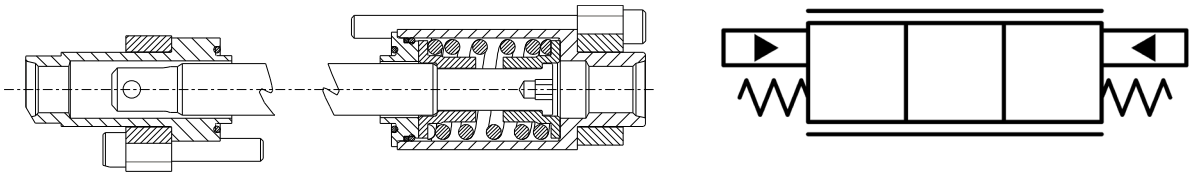
4-Position Spring-Centered Detent Float

End mechanism accommodates four spool positions – "in," "neutral," "out" and "float." The centering spring returns the spool to neutral from the "in" and "out" positions. When the spool is shifted through a "feel" position into the fourth position, the detent mechanism holds the spool in a "float" position.



3-Position Spring-Centered Hydraulic Pilot

Similar to a 3-Position Spring-Centered end mechanism except the spool is actuated using pilot pressure on the ends of the spools in place of a manual lever. Spool movement is proportional to the pilot pressure applied to the end of the spool.



3-Position Spring-Centered Solenoid Operated

Similar to a 3-Position Spring-Centered end mechanism except the spool is actuated using solenoids on each end of the spool in place of a manual lever. Spool movement is subject to current being applied ON or OFF without proportional control at intermediate spool positions.

Automatic Kick-Out

The Automatic Kick-Out mechanism combines a spring-centered end mechanism with a spool detented "in" and "out" mechanism that releases the spool to the center position at a pre-set pressure.

SECTION 1.6

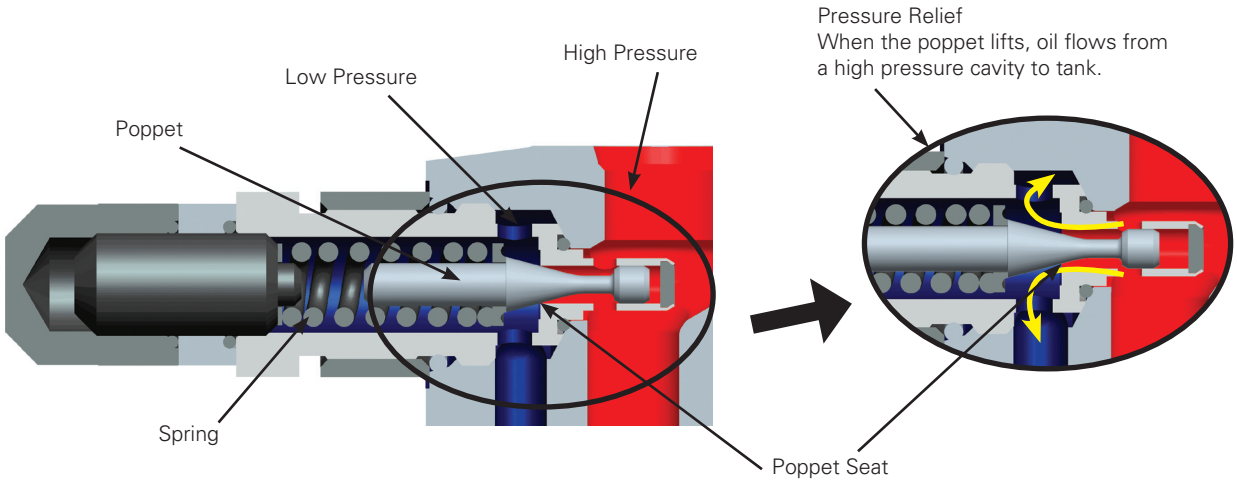
RELIEF VALVES

A relief valve is a normally closed device that opens to "relieve" pressure at a pre-determined setting.

The basic function of a relief valve is that it is a ball or poppet held into place by a spring. When hydraulic pressure overcomes the force of the spring, the relief opens and directs oil to tank.

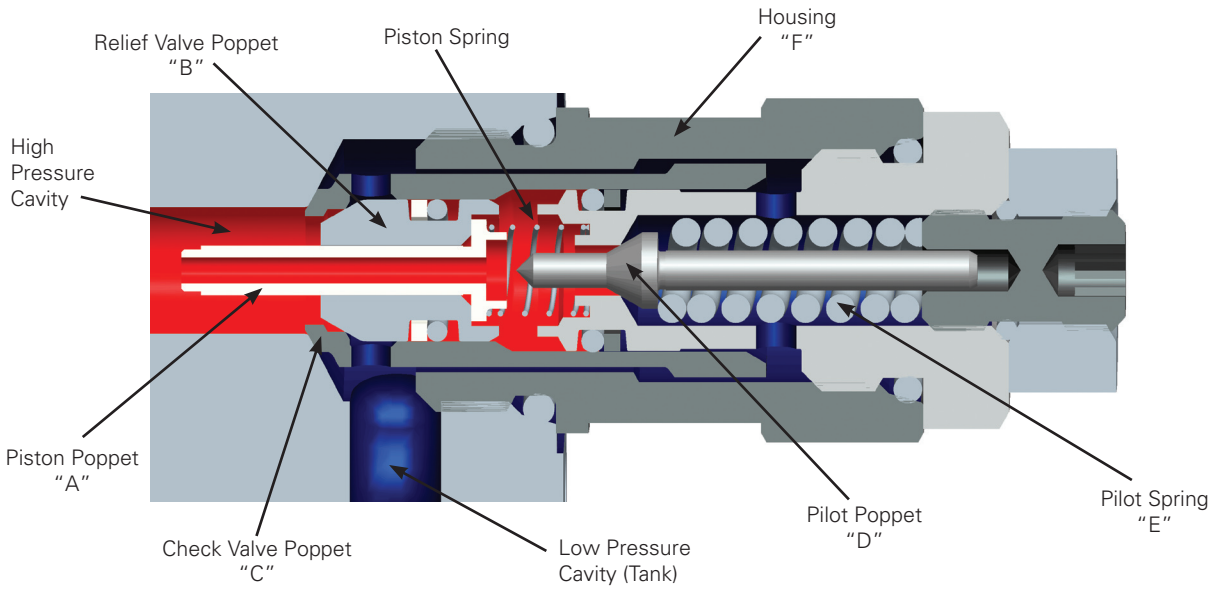
DIRECT-ACTING RELIEF VALVE

A direct-acting relief valve consists of a poppet held into place by a spring. When crack pressure is reached, the poppet lifts off of its seat, and the spring begins to compress, allowing oil to flow from the high pressure cavity to tank. The simple design of a direct-acting relief makes it more resistant to contamination. A disadvantage is limited flow capacity. As flow increases, additional force is required to further compress the spring. The result is a continual rise in system pressure and increasing pressure loss across the relief valve.

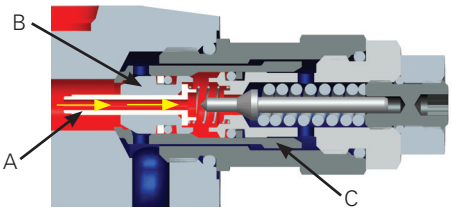


PILOT-OPERATED RELIEF VALVE

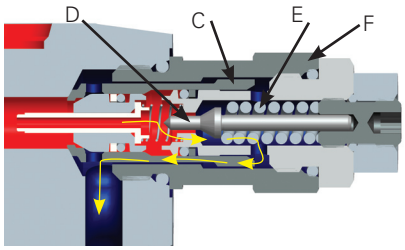
A pilot-operated relief provides higher performance with respect to a direct-acting relief. First, it accommodates higher flow by minimizing system pressure rise and pressure loss as relief flow increases. Second, it can act as an anti-cavitation check valve. The disadvantage of a pilot-operated relief is that its complex design makes it more susceptible to contamination.



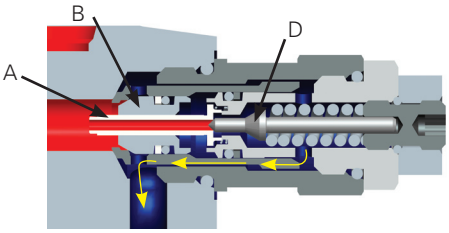
Oil enters the relief through the center passage in Piston Poppet "A." The difference in pressurized areas on each end of Relief Valve Poppet "B" and Check Valve Poppet "C" keep both poppets tightly seated.



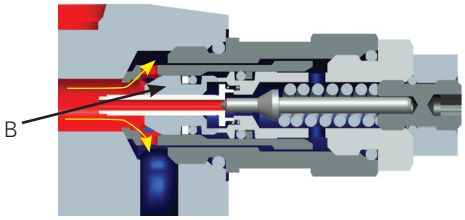
At crack pressure, high pressure oil unseats Pilot Poppet "D" causing Pilot Spring "E" to compress. Oil flows around "D," through the space between Check Valve Poppet "C" and Housing "F" and on to tank.



As Pilot Poppet "D" opens, the pressure drops in the cavity behind Relief Valve Poppet "B." High pressure oil then forces Piston Poppet "A" to seat against "D," terminating flow to the area behind "B." Pressure inside the relief valve drops as oil drains to tank.

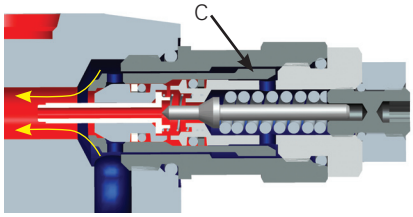


The imbalance of pressure between the inside of the relief valve and the High Pressure Cavity forces Relief Valve Poppet "B" to open and relieve oil directly to tank. Once this occurs, pressure rise is minimal.



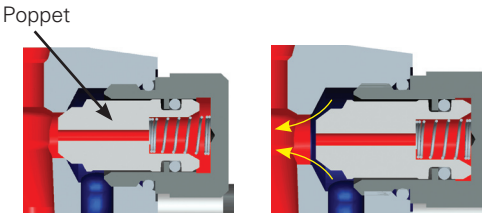
Pilot-Operated Relief – Anti-Cavitation Function

A standard pilot-operated relief also acts as an anti-cavitation check valve. When a low pressure exists in the High Pressure Cavity relative to the Low Pressure Cavity, the pressure imbalance unseats Check Valve Poppet "C," and oil is supplied to the High Pressure Cavity.



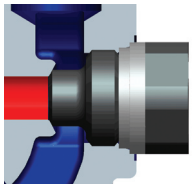
Anti-Cavitation Check Valve

Under normal conditions, the difference in pressurized areas on each end of the Poppet keep it firmly seated. When a low pressure exists in the High Pressure Cavity relative to tank, a force imbalance results that unseats the poppet and supplies oil from tank.



Shut-Off Plug

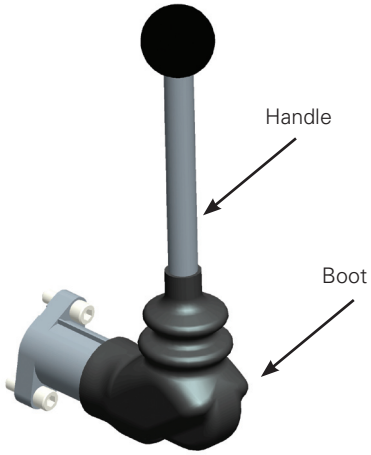
A shut-off plug is used to plug a cavity when a relief valve or anti-cavitation check valve is not required.



SECTION 1.7
LEVER KITS

FIXED POSITION

Single-spool lever whose handle orientation is non-adjustable. Changing the handle orientation requires use of a different handle and boot.

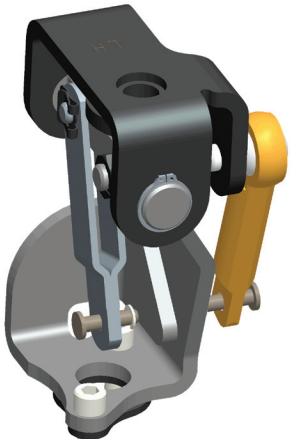


INFINITE POSITION

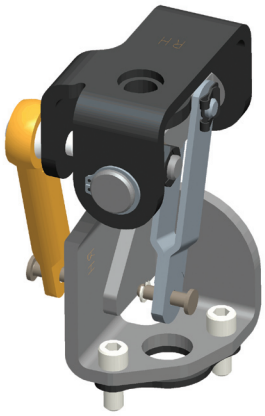
Single-spool lever whose handle orientation is "infinitely" adjustable. Changing the handle orientation is accomplished by loosening the handle, rotating it to a new position relative to the hub and re-tightening.

MECHANICAL JOYSTICK

Dual-axis joystick that provides control of two spools simultaneously. Two versions, RH and LH, are available depending on the required handle movements.



Left-Hand (LH)



Right-Hand (RH)

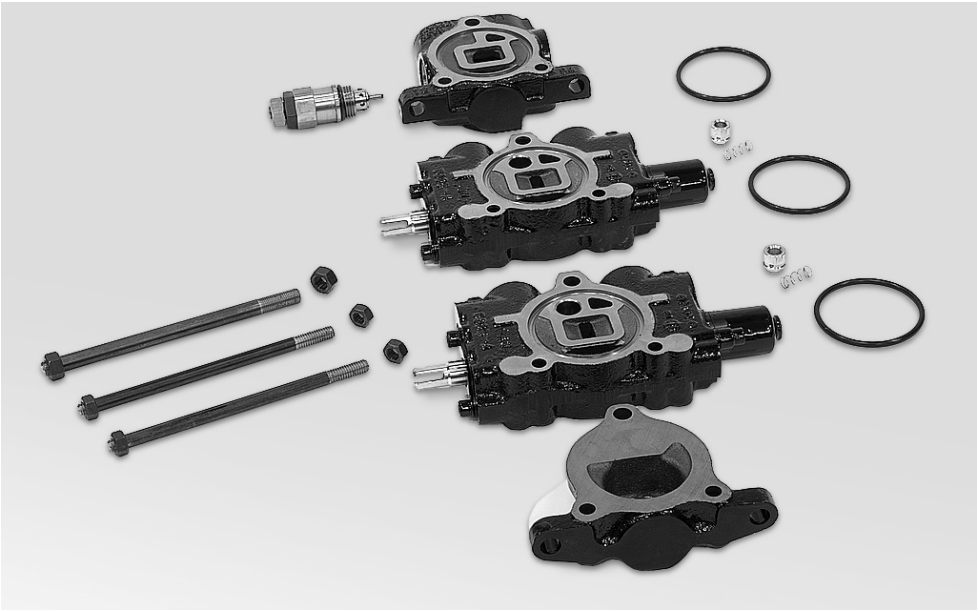
Trouble	Potential Cause(s)	Potential Fix
External Leakage – Past Spool Seals	Dirt / contamination.	Replace O-ring and wiper.
	Worn / damaged O-ring.	Replace O-ring and wiper.
	Loose seal plate.	Tighten seal plate screws.
	Excessive back pressure, blocked or restricted return passage to reservoir.	Check / replace hydraulic return line filter.
		Check for kinked or pinched return hose.
External Leakage – Between Sections	Insufficient tie rod torque.	Tighten to proper torque value.
	Pinched or damaged section O-ring.	Disassemble valve stack and replace pinched or damaged O-ring.
	Check valve spring pinched between sections.	Disassemble valve stack and replace check valve spring. Also inspect for damage to housing surface. If damaged, replace the entire spool section.
External Leakage – Past Relief Valve	Relief valve not properly torqued into cavity.	Tighten to proper torque value.
	Adjust screw / jam nut not properly torqued.	Tighten to proper torque value.
	Damaged or worn O-ring.	Replace O-ring and wiper.
	Damaged cavity / housing.	Replace spool section.
Does Not Build Pressure (Main and / or Workport)	Incorrect hydraulic connections to control valve.	Check to ensure pump supply and tank return hoses are properly connected to valve inlet (P) and outlet (T) ports.
	Internal leakage due to casting/housing defect.	Replace spool section.
	Relief valve out of adjustment.	Readjust relief valve.
	Relief valve jam nut / adjust screw loose.	Readjust relief valve and tighten jam nut.
	Relief valve over / under torqued into cavity.	Tighten to proper torque value.
	Relief valve stuck open due to contamination.	Disassemble and clean or replace.
	Anti-void valve stuck open due to contamination.	Disassemble and clean or replace.
	Damaged or worn relief valve / anti-void.	Replace relief valve / anti-void.
Function Speed Slow	Spool not fully shifted.	Inspect and fix worn or damaged handle linkage.
		Inspect and fix damaged spool end-mechanism parts.
		Insufficient pilot pressure (pilot operated spool section).
	Contamination in main or workport relief valve.	Disassemble and clean or replace relief valve assembly.
	Contamination in anti-void valve.	Disassemble and clean or replace anti-void assembly.
Spool Metering Jerky / Inconsistent	Handle linkage is dirty or damaged.	Clean / inspect handle linkage. Repair or replace worn or damaged components.
	Handle linkage not properly aligned with spools.	Adjust linkage to ensure that binding or interference does not exit when actuating the valve assembly.
	Spool is binding in valve housing.	Remove spool assembly from valve body. Inspect for physical signs of spool damage or excessive wear. Clean and reassemble or replace damaged spool section.

Trouble	Potential Cause(s)	Potential Fix
Spool Sticks / Does Not Return to Center	Handle linkage is dirty or damaged.	Clean / inspect handle linkage. Repair or replace worn or damaged components.
	Handle linkage not properly aligned with spools.	Adjust linkage to ensure that binding or interference does not exist when actuating the valve assembly.
	Dirty hydraulic oil.	Change oil / replace hydraulic filter(s).
	Foreign material between spool and valve housing.	Remove spool assembly from valve body. Inspect for physical signs of spool damage or excessive wear. Clean and reassemble, or replace damaged spool section
	Bent spool.	Replace spool section.
	Damaged spring cap.	Disassemble and replace worn or damaged parts.
	Damaged spool section housing.	Replace spool section.
	Incorrect or broken centering spring.	Disassemble and replace worn or damaged parts.
	Valve stack incorrectly assembled / torqued.	Reassemble valve in correct order / tighten tie rods using correct installation torque.
	Valve stack not correctly mounted / installed.	Ensure that only 3 mounting points are being used.
Spool Does Not Stay In Detented Position	Detent end-mechanism incorrectly assembled.	Reassemble detent assembly in correct order.
	Broken detent spring.	Disassemble and replace worn or damaged parts.
	Worn / damaged detent sleeve.	Disassemble and replace worn or damaged parts.
	Auto kick-out pressure setting too low.	Readjust pressure / kick-out setting.
	Dirt / contamination in detent end-mechanism.	Disassemble and clean.
Does Not Hold Load / Excessive Cyl. Drift	Cylinder damaged / leaking hose or fittings.	Disassemble and replace worn or damaged parts.
	Spool not fully centered in neutral position.	Clean / inspect handle linkage. Repair or replace worn or damaged components.
		Remove spool assembly from valve body. Inspect for physical signs of spool damage or excessive wear. Clean and reassemblle, or replace damaged spool section.
	Leakage past workport relief or anti-void valve.	Disassemble and clean or replace relief valve / anti-void assembly.
		Check the relief valve pressure setting and readjust if it is not within the recommended pressure range.
	Damaged relief valve or anti-void cavity (seat).	Replace spool section.
	Worn spool section.	Replace spool section.
Load / Cylinder Experiences Momentary "Droop" or Drift	Missing or damaged check valve poppet.	Disassemble valve stack and inspect for missing or damaged check valve poppet / spring – replace worn or damaged parts.
Relief Valve Setting Too Low / Too High	Relief valve incorrectly adjusted.	Check the relief valve pressure setting and readjust if it is not within the recommended pressure range.
	Contamination.	Disassemble and clean or replace relief valve.
	Pressure adjust screw loose / jam nut not properly torqued.	Readjust relief valve and tighten jam nut.
	Relief valve not properly torqued into housing.	Ensure proper installation torque.
	Damaged or worn relief valve.	Replace relief valve.

Section 3.1

5000 Series Build & Torque

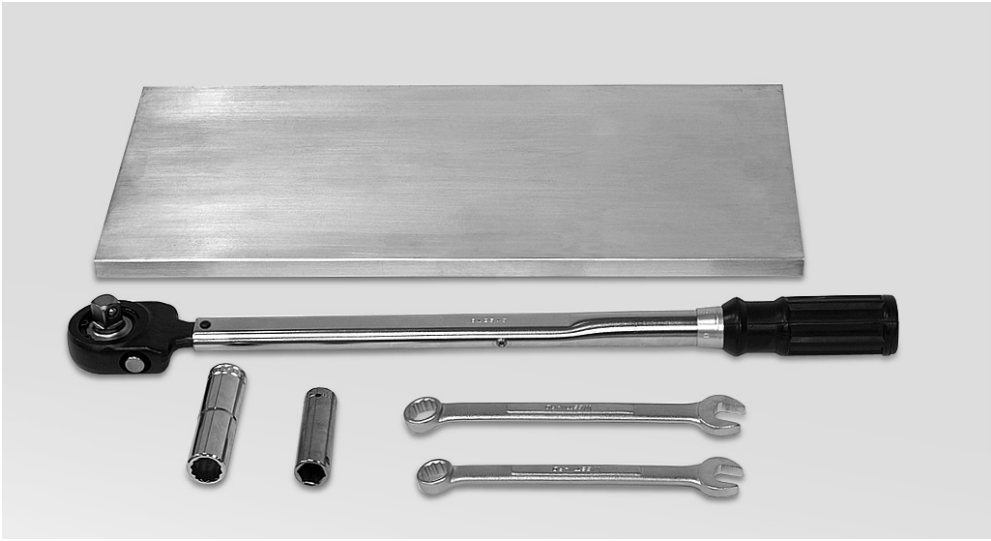
Lay out valve components on a clean, flat working surface. The inlet assembly will include an o-ring, and the spool section(s) will include an o-ring; load check poppet and load check spring.



🛠 Tools required for basic valve assembly include:

- ½" and 9/16" open-end or box type wrenches
- Torque wrench
- ½" and 9/16" thin wall sockets

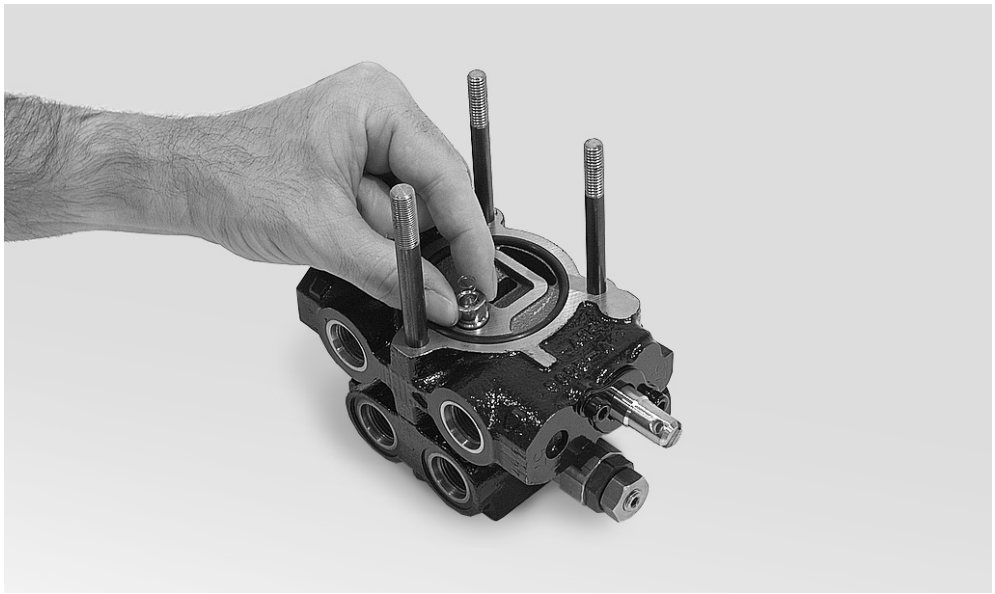
Note: If work space where valve is to be serviced does not have a smooth, level working surface, a metal plate should be used to ensure proper valve section alignment.



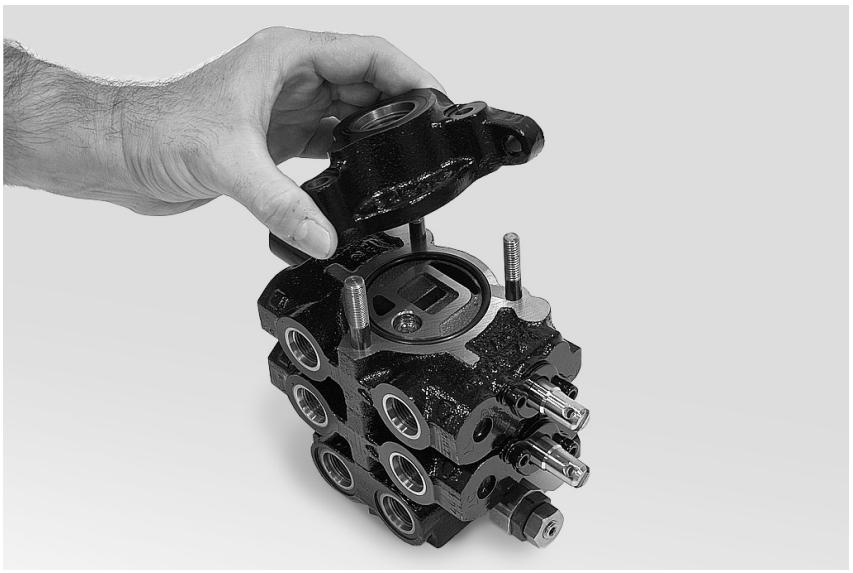
Thread tie rod nuts onto the short threaded end of each of the individual tie rods with the nuts threaded up the entire length of the threads.

Insert tie rods through tie rod holes of inlet housing, lay inlet on end with tie rods pointing up and install o-ring into groove. Special care must be taken to ensure o-ring has been completely installed in groove.

Place first spool section over inlet section with o-ring groove facing upward and install o-ring into groove. Special care must be taken to ensure o-ring has been completely installed in groove. Install load check poppet into load check cavity as shown (nose-first into cavity). Once load check poppet has been properly installed, place load check spring in hollow cavity inside check poppet.

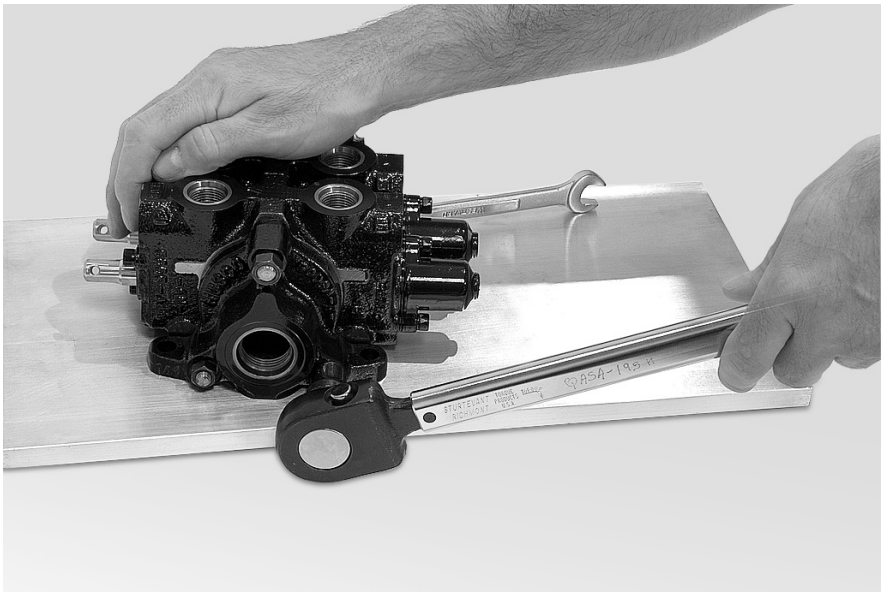


Repeat this procedure for additional spool sections. Special care must be taken to ensure o-ring and / or load check spring are not pinched between sections during assembly. Lastly, position the outlet section over the last spool section as shown.

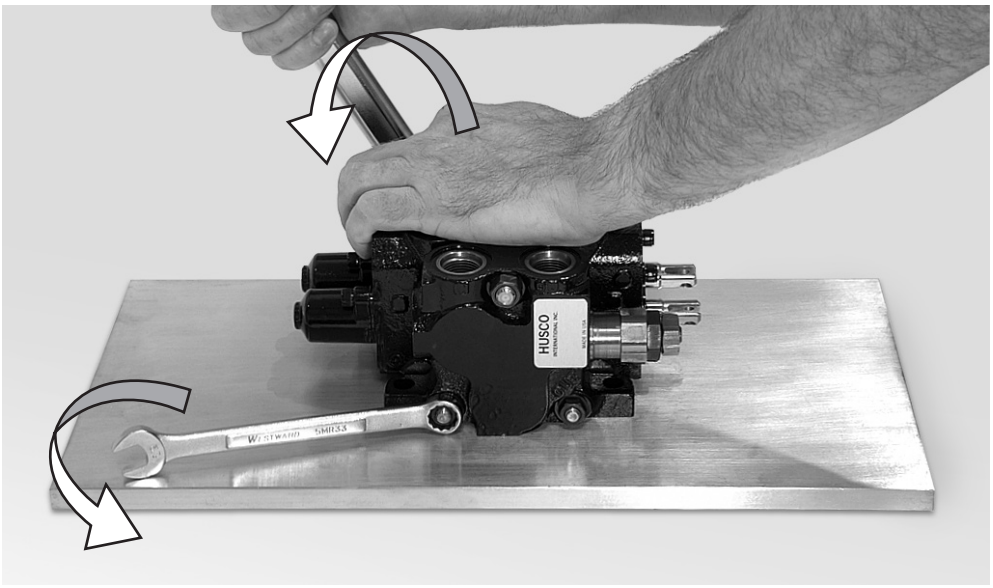


After hand-tightening all three tie rod nuts, position the valve assembly with the mounting feet on a smooth and flat working surface. To ensure proper alignment of entire valve assembly, apply a downward pressure to the inlet and outlet sections prior to torquing tie rod nuts.

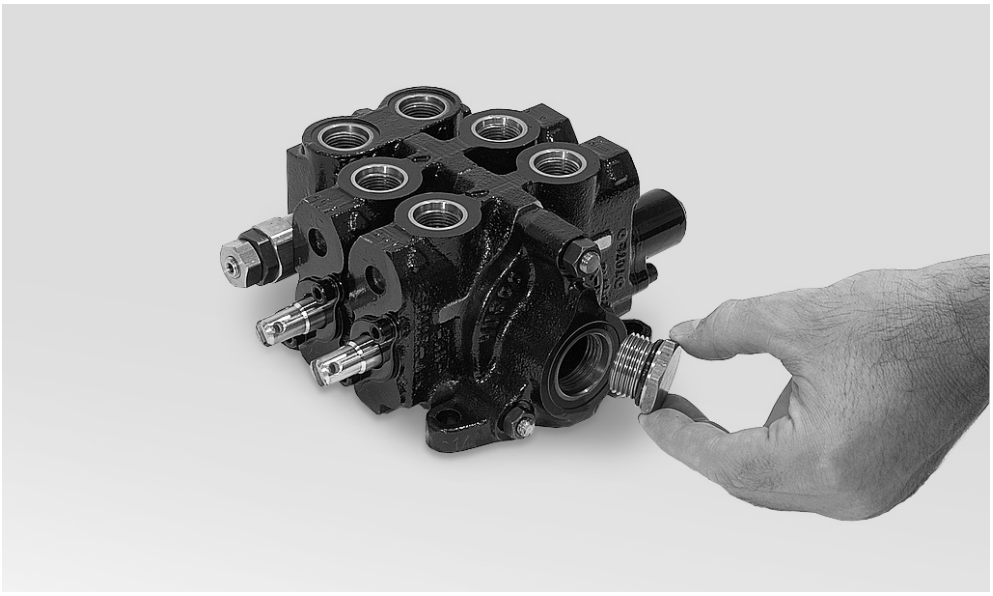
When torquing tie rod nuts, the lower (2) tie rod nuts should be torqued first at 18±2 ft-lbs. (24.4±2.7 N-m), followed by torquing of the upper tie rod at 33±3.5 ft-lbs. (44.7±4.7 N-m). During the torquing operation, place one hand on top of valve assembly (to keep all mounting feet in contact with working surface), while the other hand applies force to torque wrench.



A noteworthy technique is to position the open-end or box type wrench over the nut so rotation during torquing operation is prevented by wrench making contact with working surface.



Install auxiliary valves and plugs and torque to proper specifications.



Section 3.2

Guidelines for Handling Spools

Spools are fitted to housings with a very small clearance, and caution is required to prevent bending or raised material on the OD of the spool during field repairs.

- Avoid dropping spools on hard surfaces.
- Brass, copper or aluminum "soft jaws" must be used when clamping a spool in a vise.
- Collets for standard spool sizes are available from HUSCO for holding spools outside of the valve during repair procedures.

Section 3.3

Spool Seal Field Replacements

Recommended Method

A) Number the spools and housings with a paint pen so they can be reinstalled into the same bore. Number the spool on the tang / clevis ends to avoid contaminating the seals.

B) Remove the spool and end mechanism from the bore.

C) Remove the seal, wiper and seal plate from the tang / clevis end of the spool.
A dental pick can be used to remove the wiper and o-ring. Use caution to avoid damaging the seal counter bore.

D) Remove the end mechanism from the cap end of the spool. Handle spools and end mechanism components with care to keep them clean and free of damage (Reference "Spool Handling" instruction).

E) Remove all foreign material from the spool and seal counter bores.

F) Lubricate the seal counter bores on the cap and tang / clevis ends of the housing.

G) Re-assemble the cap end of the spool with the new seals per the applicable end mechanism repair instruction.

H) Re-install the spool and end mechanism into the bore.

I) Install the new seal and wiper onto the tang / clevis end of the spool using the seal plate to push them in prior to completing the seal plate cap screw installation and torque.

Alternate Method

A) Remove the seal, wiper and seal plate from the tang / clevis end of the spool.
A dental pick can be used to remove the wiper and o-ring, using caution to avoid damaging the seal counter bores.

B) Install a steel rod through the spool tang / clevis holes to prevent the spools from turning during end mechanism disassembly and re-assembly.

C) Remove the end mechanisms from the cap end of the spool.

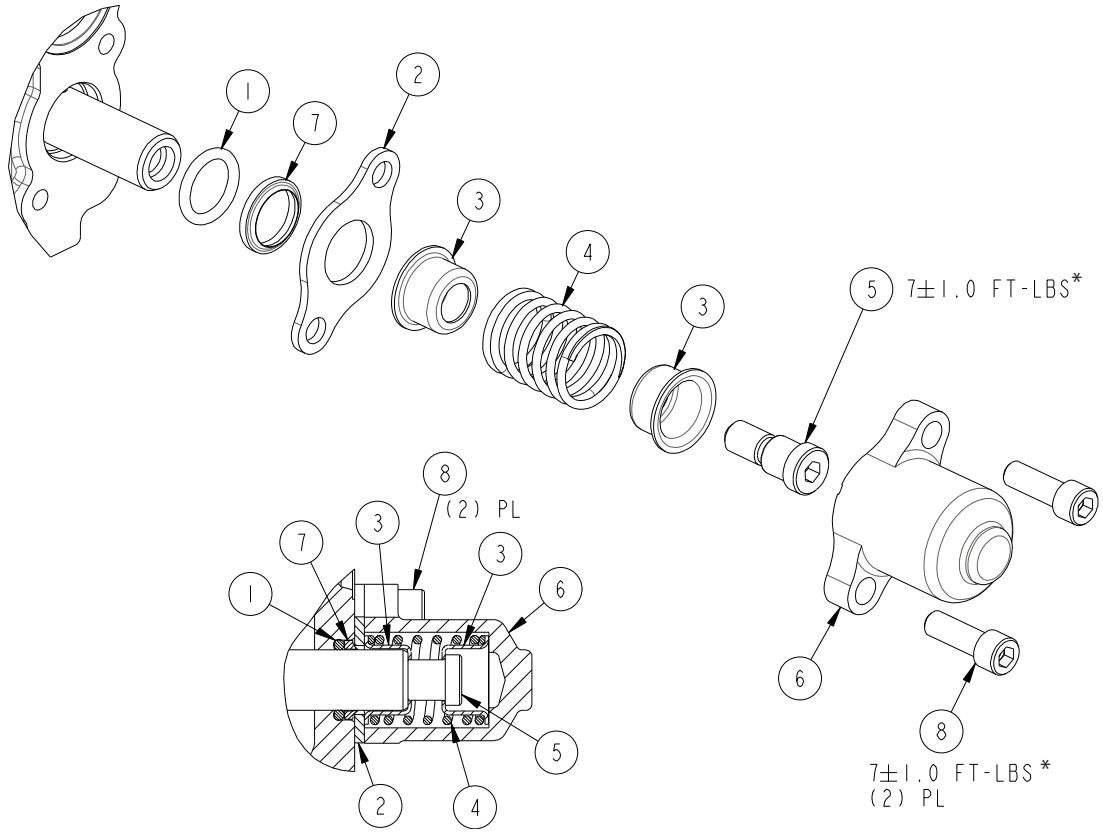
D) Remove all foreign material from the spool and seal counter bores.

E) Lubricate the seal counter bores on the cap and tang / clevis ends of the housing.

F) Re-assemble the cap end of the spool with the new seals per the applicable end mechanism repair instruction.

G) Install the new seal and wiper onto the tang / clevis end of the spool using the seal plate to push them in prior to completing the seal plate cap screw installation and torque.

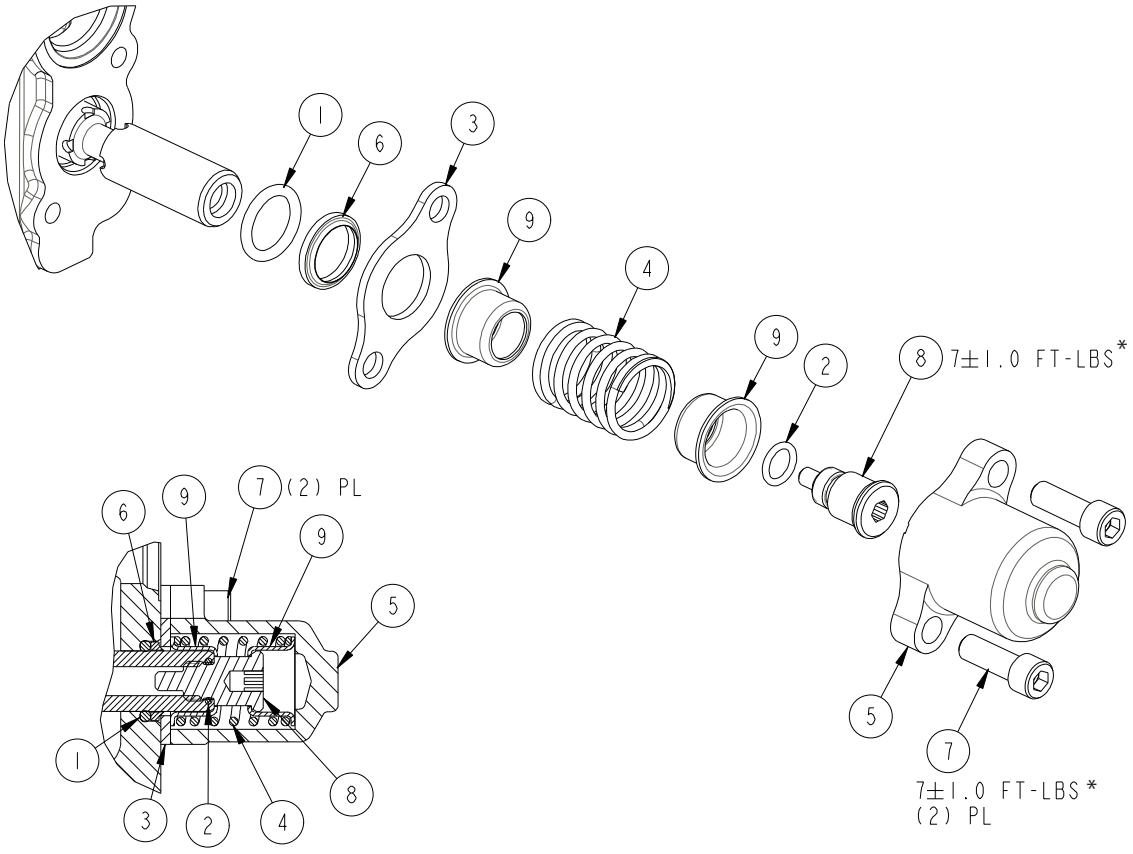
3-Position Spring Return 'SC' to Neutral End Mechanism for Solid Spools



Ref No.	Part No.	Description	Quantity
	B10-100	End Mechanism Kit for 3-Position SC – Solid Spools	
1	130	O-Ring AS568A-113 70 duro Nitrile	1
2	5012	Plate-Seal	1
3	5013	Spring Seat	2
4	5014	Spring	1
5	5015	Spool End ① 🛠 3/16 Allen	1
6	5028	Cap-Spool	1
7	5029	Wiper	1
8	5035	Cap Screw-Soc. Hd. 1/4-20 x .75" 🛠 3/16 Allen	2

① Clean threads and apply Loctite® 242 (Blue) thread locking adhesive prior to installation.
* 7±1.0 ft-lbs. = 9.5±1.4 N-m

3-Position Spring Return 'SC' to Neutral End Mechanism for Hollow Spools

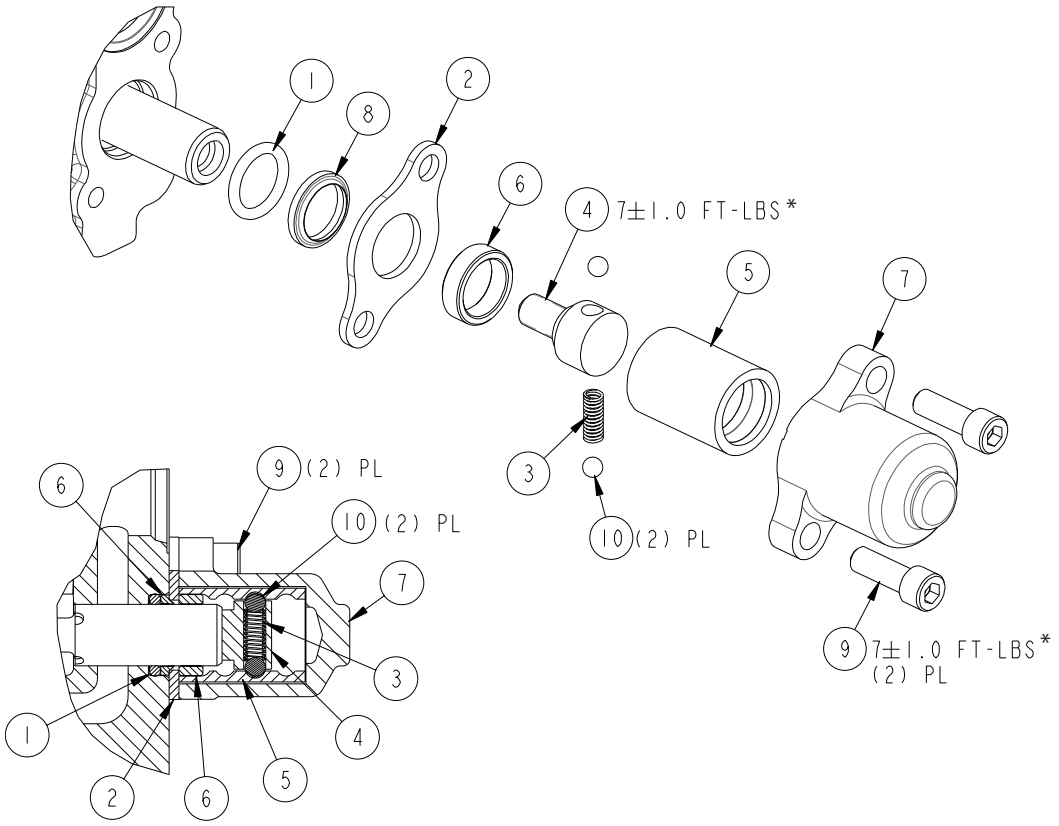


Ref No.	Part No.	Description	Quantity
	B10-103	End Mechanism Kit for 3-Position SC – Series Spools	
1	130	O-Ring AS568A-113 70 duro Nitrile	1
2	4623	O-Ring AS568A-903 90 duro Nitrile	1
3	5012	Plate-Seal	1
4	5014	Spring	1
5	5028	Cap-Spool	1
6	5029	Wiper	1
7	5035	Cap Screw-Soc.Hd. 1/4-20 x .75" 3/16 Allen	2
8	51983	Spool End ① 3/16 Allen	1
9	5264	Spring Seat	2

① Clean threads and apply Loctite® 242 (Blue) thread locking adhesive prior to installation. (avoid contact with o-ring)

* 7±1.0 ft-lbs. = 9.5±1.4 N-m

3-Position Detent End Mechanism for Solid Spools

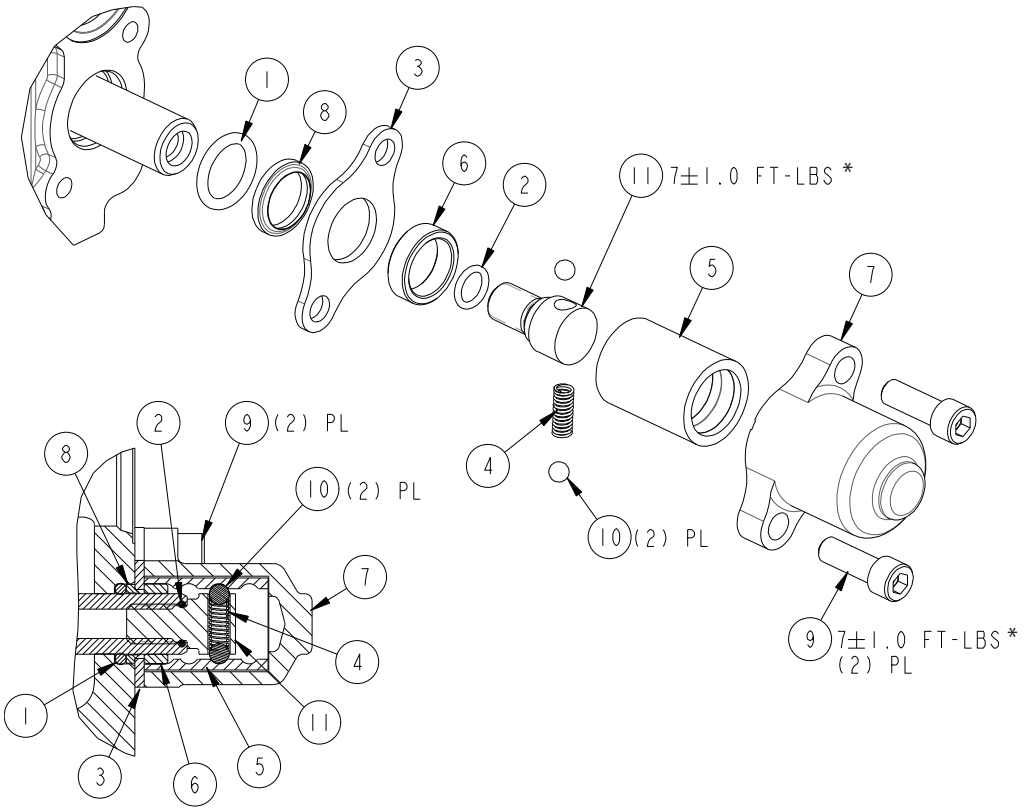


Ref No.	Part No.	Description	Quantity
	B11-100	End Mechanism Kit for 3-Position Detent – Solid Spools	
1	130	O-Ring AS568A-113 70 duro Nitrile	1
2	5012	Plate-Seal	1
3	5023	Spring ②	1
4	5024	Spool End-Detent Pin ① 🛠 3/16 dia rod	1
5	5025	Sleeve-Detent	1
6	5026	Spacer	1
7	5028	Cap-Spool	1
8	5029	Wiper	1
9	5035	Cap Screw-Soc. Hd. ¼-20 x .75" 🛠 3/16 Allen	2
10	5049	Ball 3/16" grade 200 type 440 stainless steel ②	2

① Clean threads and apply Loctite® 242 (Blue) thread locking adhesive prior to installation.
② Lubricate with a high quality lithium based grease prior to installation.
* 7±1.0 ft-lbs. = 9.5±1.4 N-m

Section 3.4 Assembling End Mechanisms

3-Position Detent End Mechanism for Hollow Spools

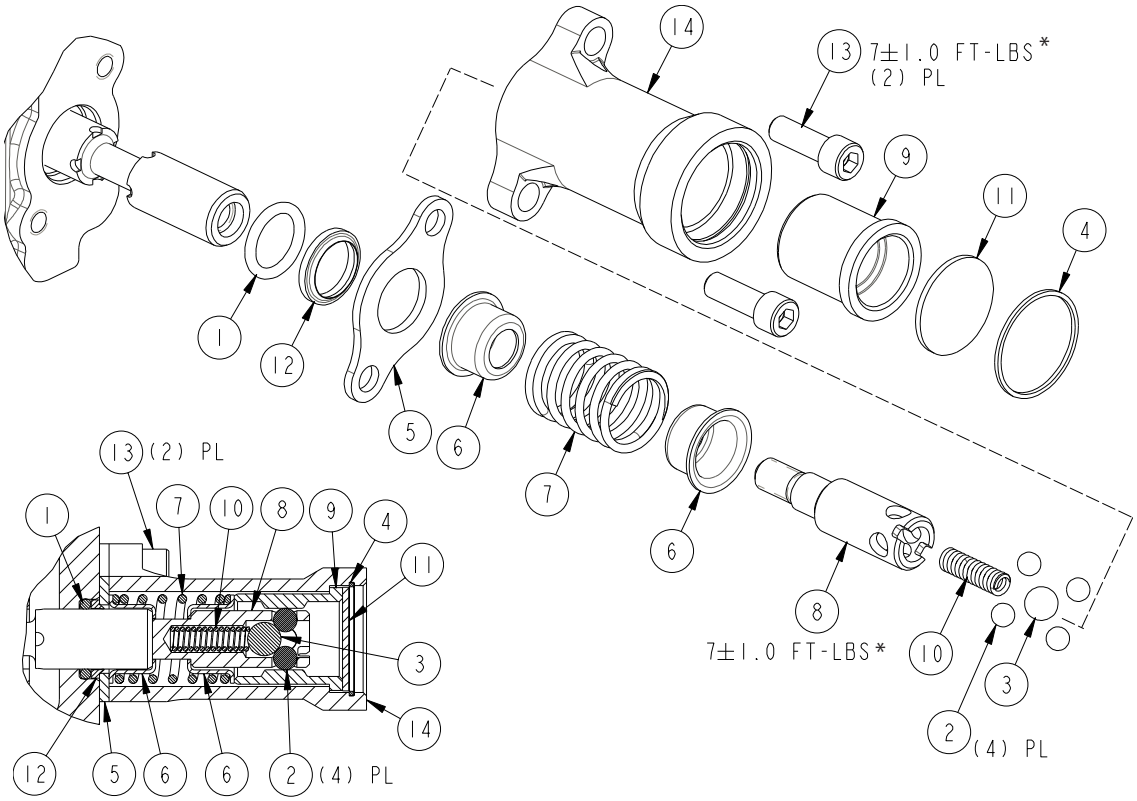


Ref No.	Part No.	Description	Quantity
	B11-119	End Mechanism Kit for 3-Position Detent – Series Spools	
1	130	O-Ring AS568A-113 70 duro Nitrile	1
2	4623	O-Ring AS568A-903 90 duro Nitrile	1
3	5012	Plate-Seal	1
4	5023	Spring	1
5	5025	Sleeve-Detent	1
6	5026	Spacer	1
7	5028	Cap-Spool	1
8	5029	Wiper	1
9	5035	Cap Screw-Soc.Hd. ¼-20 x .75" 🛠 3/16 Allen	2
10	5049	Ball grade 200 type 440 stainless steel	2
11	52272	Spool End-Detent Pin ① 🛠 3/16 dia rod	1

① Clean threads and apply Loctite® 242 (Blue) thread locking adhesive prior to installation (avoid contact with o-ring)

* 7±1.0 ft-lbs. = 9.5±1.4 N-m

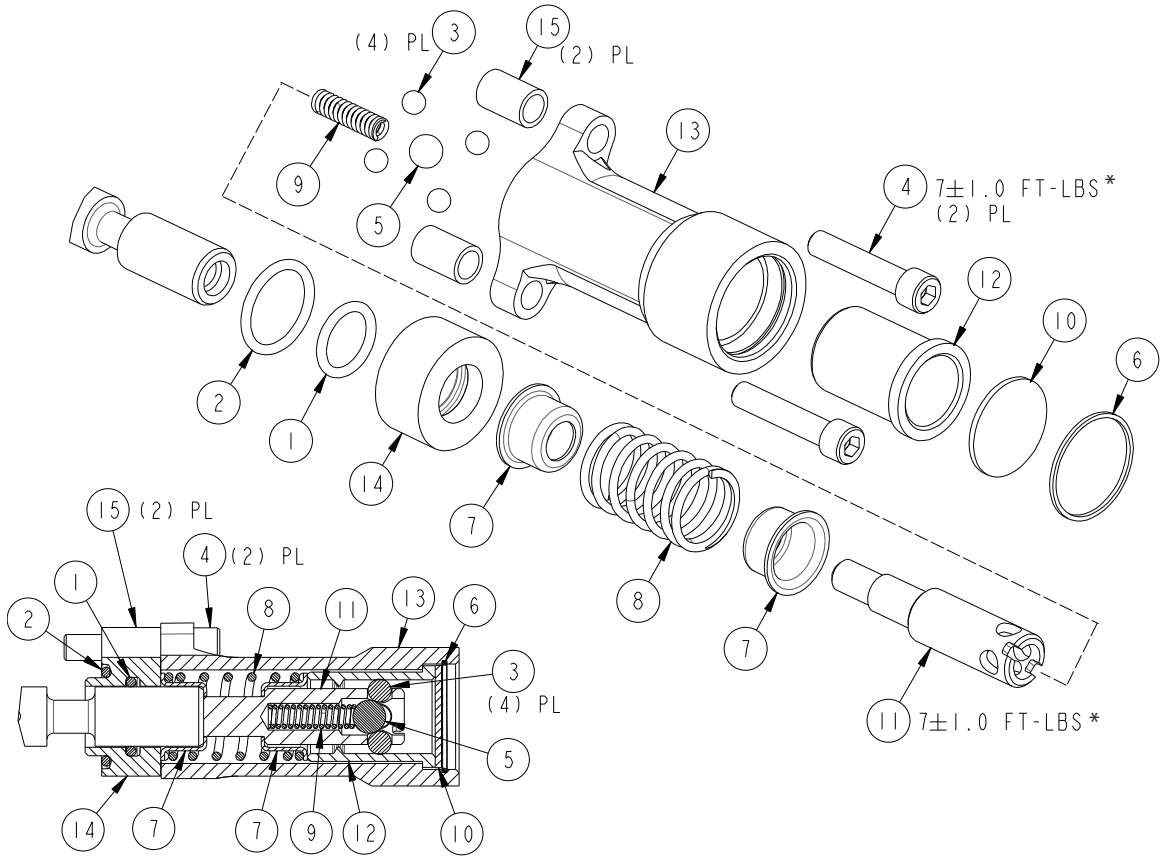
3-Position Spring Centered Detent End Mechanism for Solid Spools



Ref No.	Part No.	Description	Quantity
	B11-101, B11-102 & B11-103	End Mechanism Kit for 3-Position Spring-Centered Detent – Solid Spools	
1	130	O-Ring AS568A-113 70 duro Nitrile	1
2	3272	Ball 7/32 grade 200 type 440 stainless steel	4
3	3658	Ball 5/16 grade 200 type 440 stainless steel	1
4	3738	Retaining Ring-Int. Spirolox RRT 100	1
5	5012	Plate-Seal	1
6	5013	Spring Seat	2
7	5014	Spring	1
8	5016	Spool End-Detent Pin ① 🛠 .125" x .50" slot	1
9	5283 5163 5017	Sleeve - Detent "IN" Sleeve - Detent "OUT" Sleeve - Detent "IN" & "OUT"	1
10	5018	Spring	1
11	5019	Spacer	1
12	5029	Wiper	1
13	5035	Cap Screw-Soc. Hd. 1/4-20 x .75" 🛠 3/16 Allen	2
14	5048	Cap-Spool	1

① Clean threads and apply Loctite® 242 (Blue) thread locking adhesive prior to installation.
» Refer to **Installation of a Detent End Mechanism** for recommended installation procedure.
* 7±1.0 ft-lbs. = 9.5±1.4 N-m

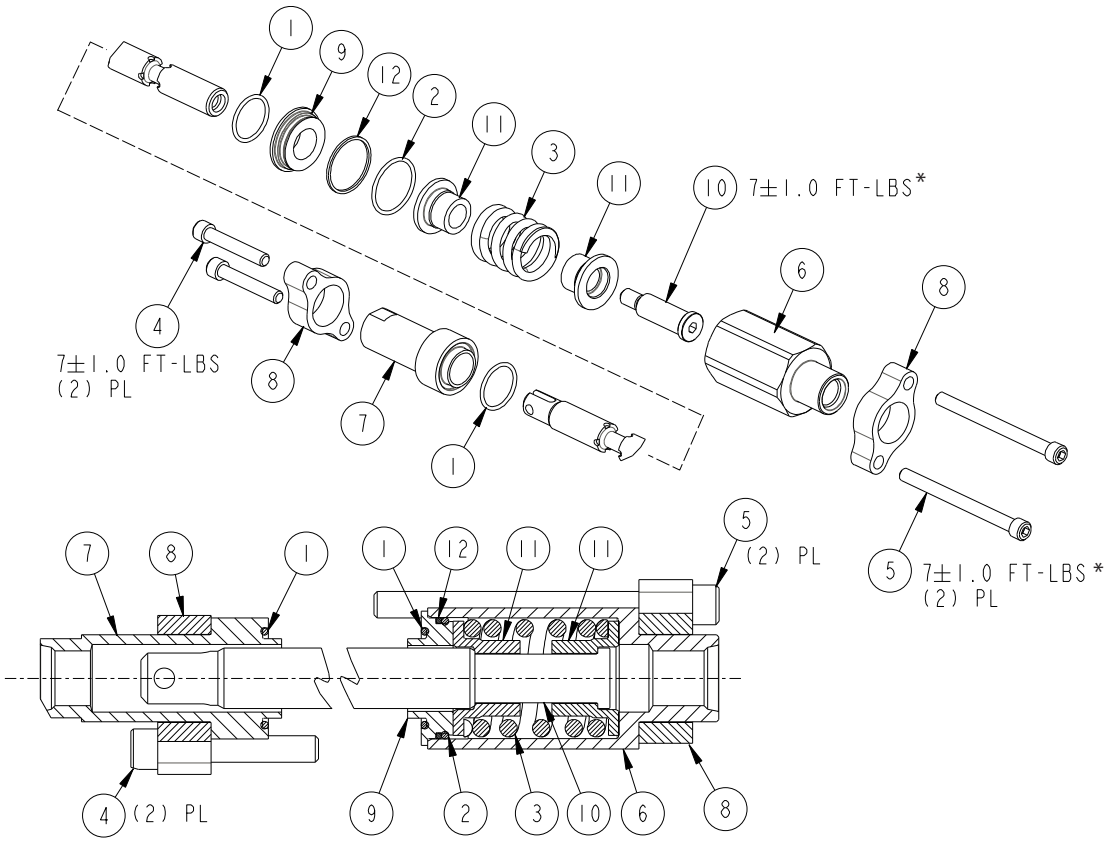
4-Position Spring-Centered Detent in Float End Mechanism for Solid Spools



Ref No.	Part No.	Description	Quantity
	B11-105	End Mechanism Kit for 4-Position Spring-Centered with Detent in Float – Solid Spools	
1	130	O-Ring AS568A-113 70 duro Nitrile	1
2	1490	O-Ring AS568A-116 70 duro Nitrile	1
3	3272	Ball 7/32 grade 200 type 440 stainless steel	4
4	3424	Cap Screw-Soc.Hd. 1/4-20 x 1.25" 🛠 3/16 Allen	2
5	3658	Ball 5/16 grade 200 type 440 stainless steel	1
6	3738	Retaining Ring-Int. Spirolox RRT 100	1
7	5013	Spring Seat	2
8	5014	Spring	1
9	5018	Spring	1
10	5019	Spacer	1
11	5021	Spool End-Detent Pin ① 🛠 .125" x .50" slot	1
12	5027	Sleeve-Detent	1
13	5034	Cap-Spool	1
14	53799	Spacer-Cap,Spool	1
15	53800	Spacer	2

① Clean threads and apply Loctite® 242 (Blue) thread locking adhesive prior to installation.
» Refer to **Installation of a Detent End Mechanism** for recommended installation procedure.
* 7±1.0 ft-lbs. = 9.5±1.4 N-m

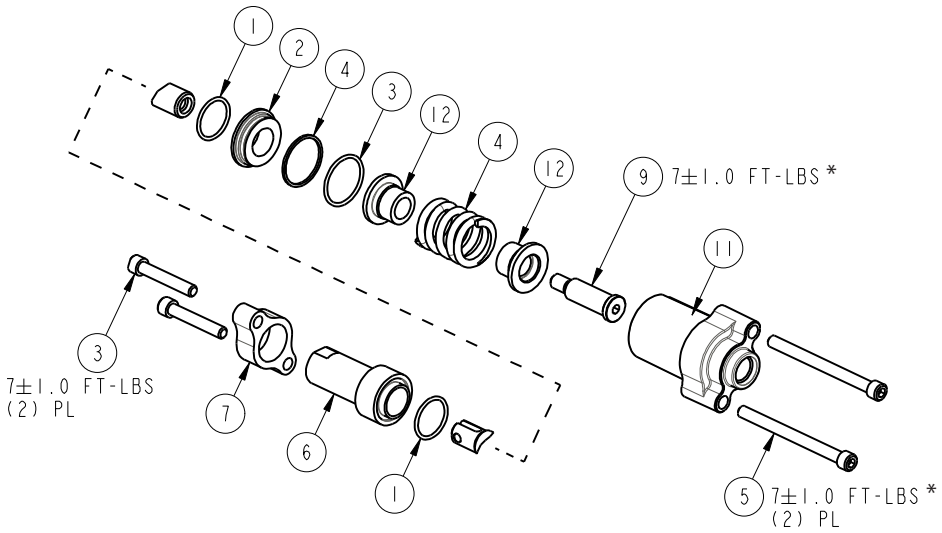
3-Position Spring-Centered hydraulic Pilot End Mechanism for Solid Spools

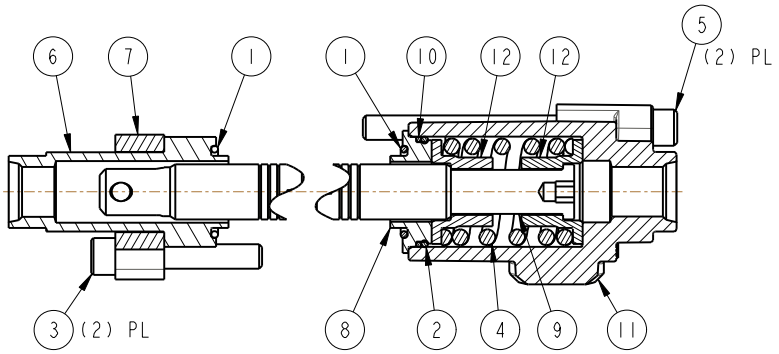


Ref No.	Part No.	Description	Quantity
	B12-108	End Mechanism Kit for 3-Position Spring-Centered Hydraulic Remote – Solid Spools	
1	41-019	O-Ring AS568A-019 70 duro Nitrile ②	2
2	5141	O-Ring AS568A-022 70 duro Nitrile ②	1
3	52193	Spring	1
4	5243	Cap Screw-Soc. Hd. 1/4-20 x 1.50" 3/16 Allen	2
5	52824	Cap Screw-Soc. Hd. 1/4-20 x 3.00" 3/16 Allen	2
6	55032	Cap-Spool, P.O.	1
7	55033	Cap-Spool, P.O.	1
8	55034	Plate-Seal	2
9	55035	Retainer-Cap, Spool	1
10	55036-1	Spool End ① 3/16 Allen	1
11	55037	Spring Seat	2
12	55047	Back-Up Ring	1

① Clean threads and apply Loctite® 242 (Blue) thread locking adhesive prior to installation.
② Lubricate with a high quality lithium based grease prior to installation.
* 7±1.0 ft-lbs. = 9.5±1.4 N-m

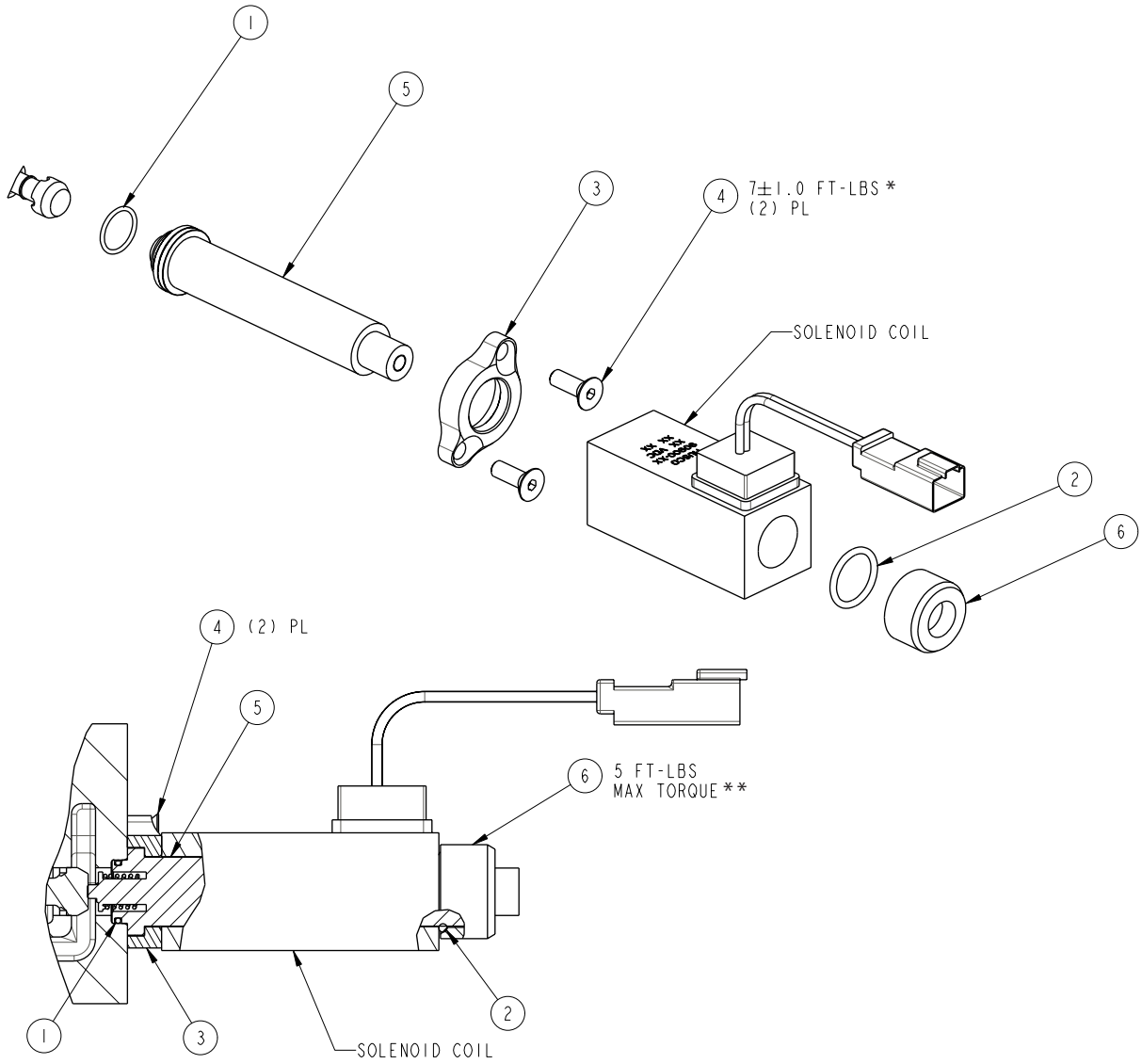
3 Position Spring Centered Hydraulic Pilot End Mechanism for Solid Spools (Die Cast End Cap)





Ref No.	Part No.	Description	Quantity
	B12-112	End Mechanism Kit for 3 Position Spring Centered Hydraulic Remote – Solid Spools	
1	41-019	O-Ring AS568A-019 70 duro Nitrile ②	2
2	5141	O-Ring AS568A-022 70 duro Nitrile ②	1
3	5243	Cap Screw-Soc. Hd. 1/4-20 x 1.50" 🛠 3/16 Allen	2
4	52193	Spring	1
5	52824	Cap Screw-Soc. Hd. 1/4-20 x 3.00" 🛠 3/16 Allen	2
6	55033	Cap-Spool, P.O.	1
7	55034	Plate-Seal	1
8	55035	Retainer-Cap, Spool	1
9	55036-1	Spool End ①	1
10	55047	Back-Up Ring	1
11	59637-5	Cap-Spool, P.O.	1
12	59695	Spring Seat	2

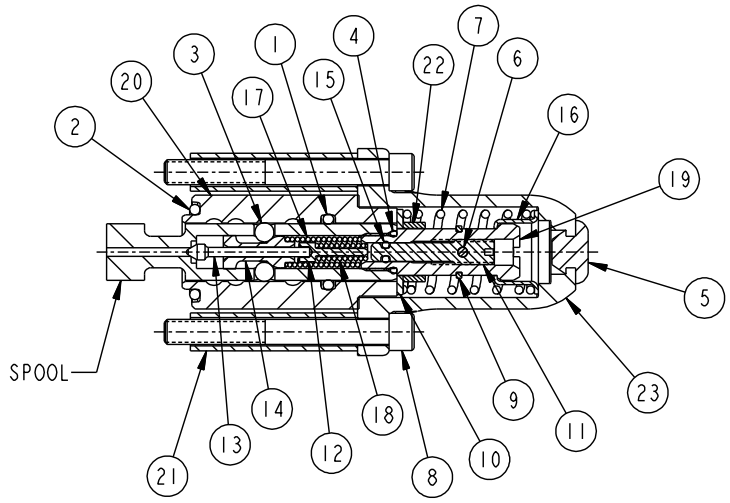
① Clean threads and apply Loctite® 242 (Blue) thread locking adhesive prior to installation.
② Lubricate with a high quality lithium based grease prior to installation.
* 7±1.0 ft-lbs. = 9.5±1.4 N-m



Ref No.	Part No.	Description	Quantity
		Direct Acting Solenoid End Mechanism	
1	41-016	O-Ring AS568A-016 70 duro Nitrile	2
2	3384	O-Ring AS568A-910 70 duro Nitrile	2
3	56934	Adaptor-Solenoid	2
4	56936	Cap Screw-Countersunk Hd. 1/4-20 x .75" 3/16 Allen	4
5	90896	Tube Solenoid	2
6	90897	Nut	2

* 7±1.0 ft-lbs. = 9.5±1.4 N-m
** 5±1.0 ft-lbs. = 6.8 N-m

3-Position Spring-Centered Auto Kickout
Detent "IN & OUT" End Mechanism for Solid Spools



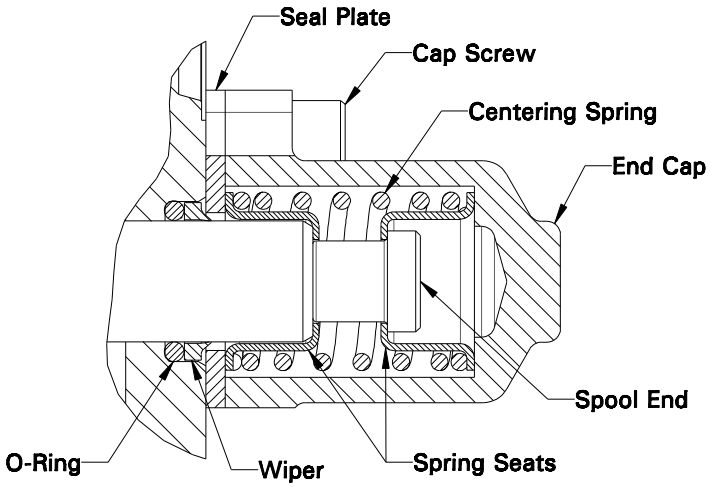
Ref No.	Part No.	Description	Quantity
	B13-104	End Mechanism Kit for 3-Position Spring-Centered Auto Kickout – Detent IN & OUT – Solid Spools	
1	130	O-Ring AS568A-113 70 duro Nitrile	1
2	1490	O-Ring AS568A-116 70 duro Nitrile	1
3	4037	Ball grade 200 hard chrome steel	4
4	4623	O-Ring AS568A-903 90 duro Nitrile	1
5	4938	Plug	1
6	4941	Insert-Locking	1
7	5014	Spring	1
8	5217	Cap Screw-Soc. Hd. 1/4-20 x 2.00" 🛠 3/16 Allen	2
9	5256	Retaining Ring-Ext.	1
10	5257	Washer-Flat	1
11	5258	Screw-Adjust 🛠 1/16 x .25" slot	1
12	5260	Guide-Spring	1
13	5261	Poppet	1
14	5262	Cam-Detent	1
15	5263	O-Ring AS568A-004 70 duro Nitrile	1
16	5264	Spring Seat	1
17	5265	Spring	1
18	5266	Spring	1
19	5270	Spool End ① 🛠 3/32 x .56" slot	1
20	5272	Sleeve-Detent	1
21	5274	Spacer	2
22	52973	Spacer	1
23	5301	Cap-Spool	1

① Clean threads and apply Loctite® 242 (Blue) thread locking adhesive prior to installation.

» Refer to **Auto-Kickout Setting and Adjustment** for recommended installation procedure.

Installation of a Detent End Mechanism

Disassembly of Existing End Mechanism

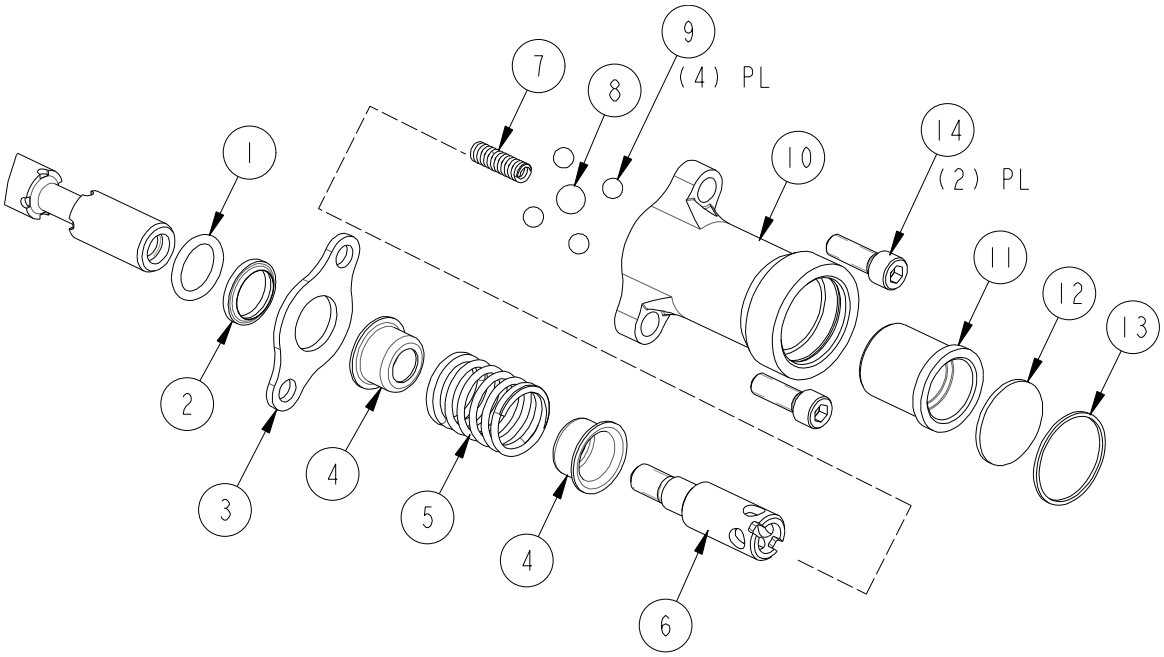


1) Loosen and remove the cap screws along with the end cap and set aside.
2) Slide the spool and end mechanism out of the valve housing as one unit.
3) Clamp the spool into a vise equipped with soft copper or aluminum jaws. Be careful to ensure that the surface of the spool is not damaged by the clamp.
4) Loosen and remove the spool end along with the spring seats and centering spring. Removal may be difficult due to presence of thread locking adhesive on spool end.
   **Caution – The centering spring has about 30 lbs. of pre-load.
5) The seal plate, o-ring and wiper may be re-used or replaced with parts from the detent kit.

Section 3.4 Assembling End Mechanisms

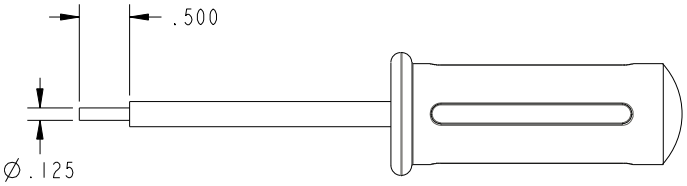
Installation of a Detent End Mechanism

Parts List



1 – O-ring
2 – Wiper
3 – Seal Plate
4 – Spring Seat
5 – Centering Spring
6 – Spool End
7 – Detent Spring
8 – Large Detent Ball
9 – Small Detent Ball
10 – End Cap
11 – Detent Sleeve
12 – Cover Disc
13 – Retaining Ring
14 – Cap Screw

Assembly Tool

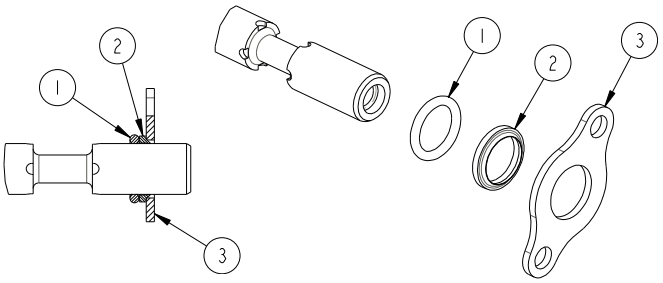


*Assembly tool can be made from a screwdriver (preferred).
Any 0.125" (3mm) diameter rod or allen wrench is sufficient.

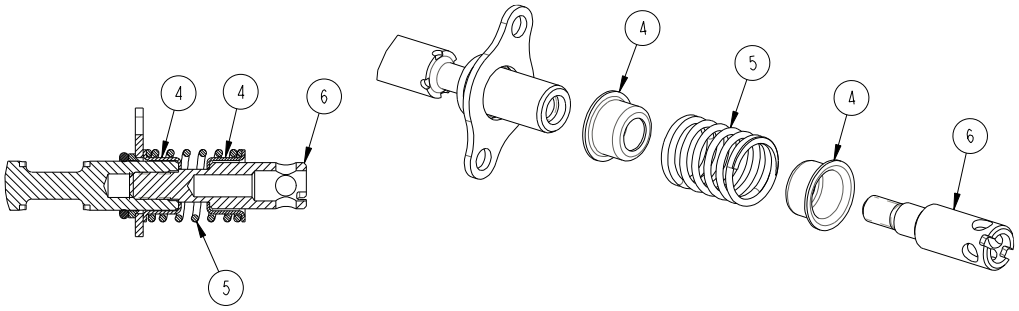
Installation of a Detent End Mechanism

Assembly procedure

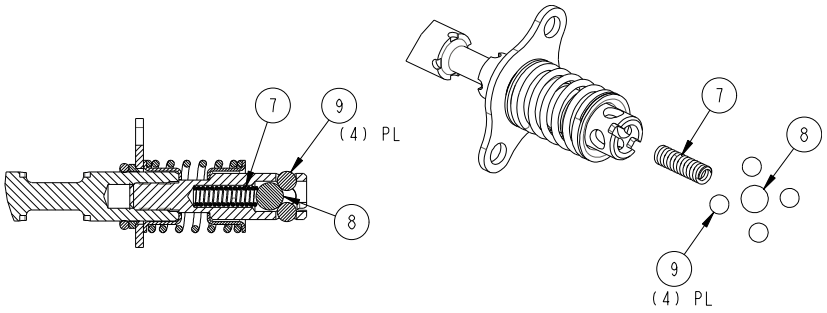
1. Install the o-ring (1), wiper (2), and seal plate (3) onto the spool.



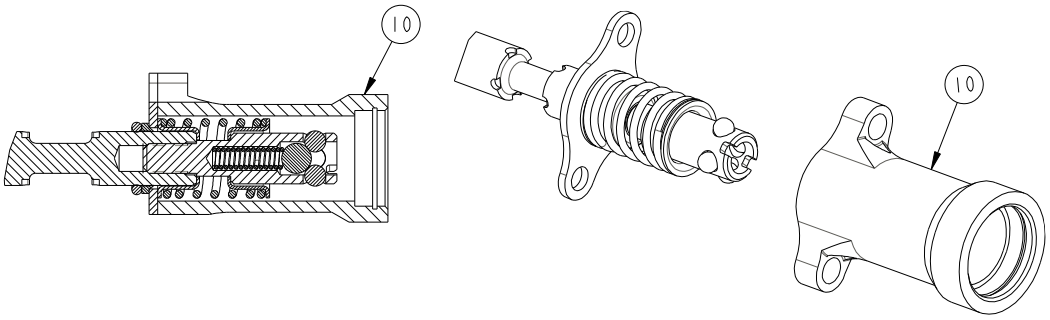
2. Apply Loctite® 242 (blue) thread locking adhesive to the spool end (6). Assemble the two spring seats (4) and centering spring (5) onto the spool end. Torque the spool end to 7 ft-lbs. Note – the spring will require approximately 25 lbs. of force to compress.
   **Caution – Exceeding 7 ft-lbs. (9.5 N-m) torque on the spool end will cause spool deformation and result in spool bind.



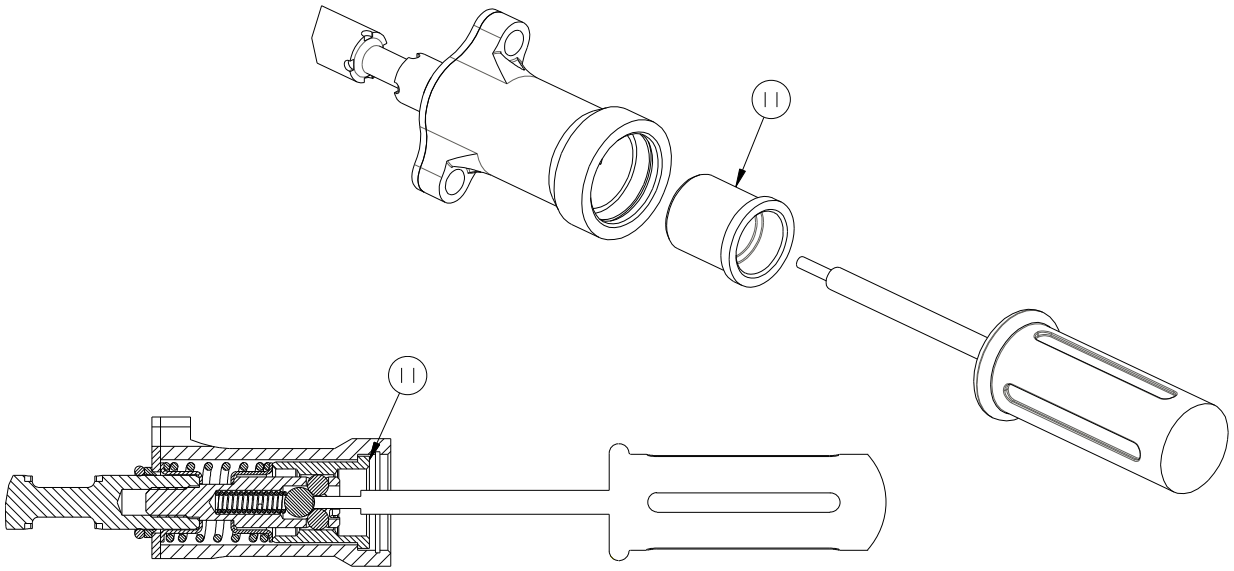
3. Install the detent spring (7), large detent ball (8), and four small detent balls (9) into the spool end. Application of lithium grease will help to retain the parts prior to final assembly.



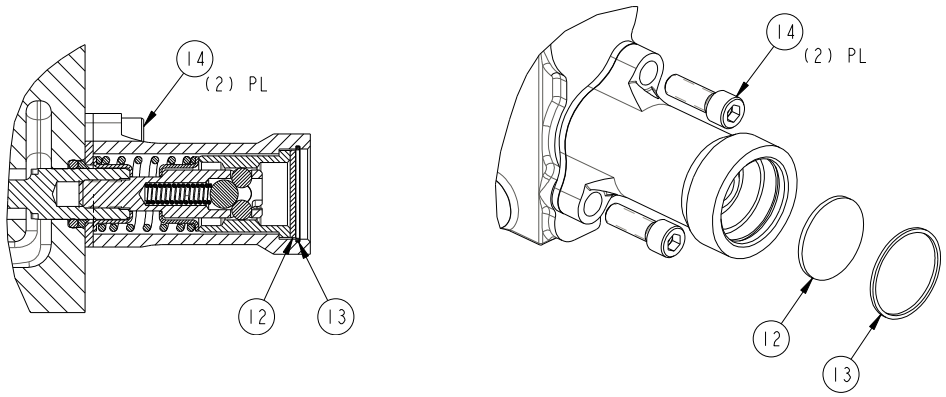
4. Slide the end cap (10) onto the spring mechanism.



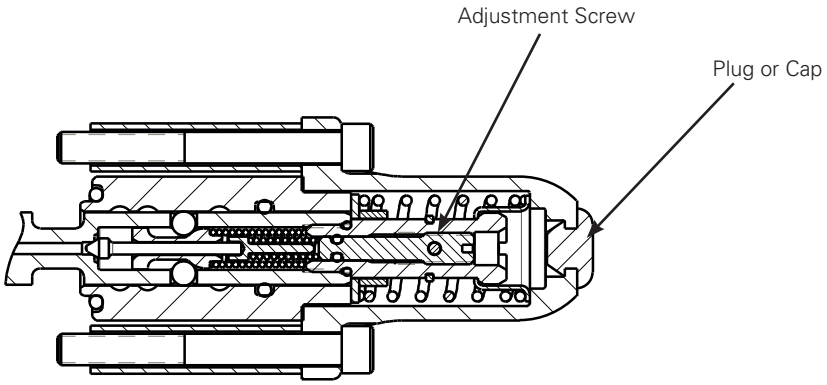
5. Slide the detent sleeve (11) over the assembly tool. Use the assembly tool to push in the large detent ball. This will retract the four small detent balls and allow for installation of the detent sleeve (11) over the spool end and inside the end cap.



6. Insert the cover disc (12) and install the retaining ring (13) into the groove in the end cap. Remove the spool assembly from the vise and insert it into the bore of the valve housing. Thread two cap screws (14) into the valve housing and tighten to 7±1ft-lbs. (9.5±1.4 N-m).



Auto Kick-Out Setting and Adjustment



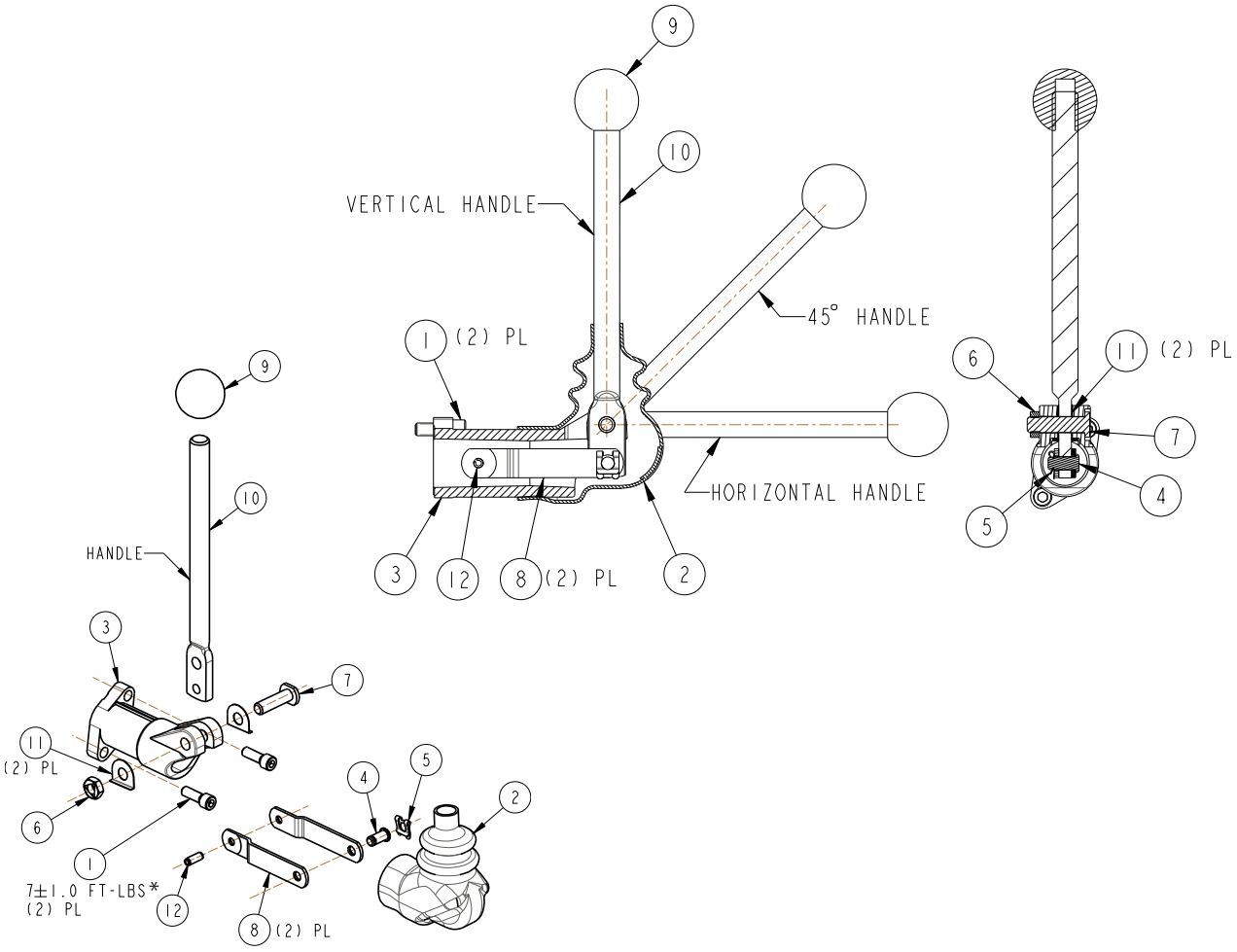
Adjustments to the auto kick-out valve section are made when integrated within a hydraulic circuit.

1) Install a pressure gauge in the valve assembly inlet or a cylinder port line which is in communication with the auto kick-out section to be adjusted.
2) With the hydraulic system off, shift the auto kick-out valve section to a detented position.
3) Activate the hydraulic system at a reduced pressure below that of the desired setting. Let the cylinder bottom out or plug the cylinder port to allow pressure to build up for kick-out activation. Slowly increase the hydraulic system pressure (the main system relief may be used for the purpose) until the auto kick-out activates and the spool returns to the center neutral position. Do not exceed system capability. Note the pressure reading at the time of kick-out – this will determine its current setting. Standard factory setting, if not specified, is 2000 PSI (138 bar).
4) To make adjustments, remove the rubber plug (P/N 4938) from the end cap to access the adjustment screw (P/N 5258). With the hydraulic system off, turn the adjustment screw clockwise (in) to increase the pressure setting; counterclockwise (out) to decrease the pressure setting. Repeat Procedure #3 above until the desired setting is achieved. The adjustment range is 1000 – 2600 PSI (70-180 bar). Run a few cycles to assure setting consistency then replace the rubber plug.
   Note: The final main relief setting must be at least 250 PSI (17 bar) higher than the highest auto kick-out setting in the system.

Caution – To avoid damaged or lost part, do not remove the adjustment screw.

Section 3.5 Installing Lever Kits

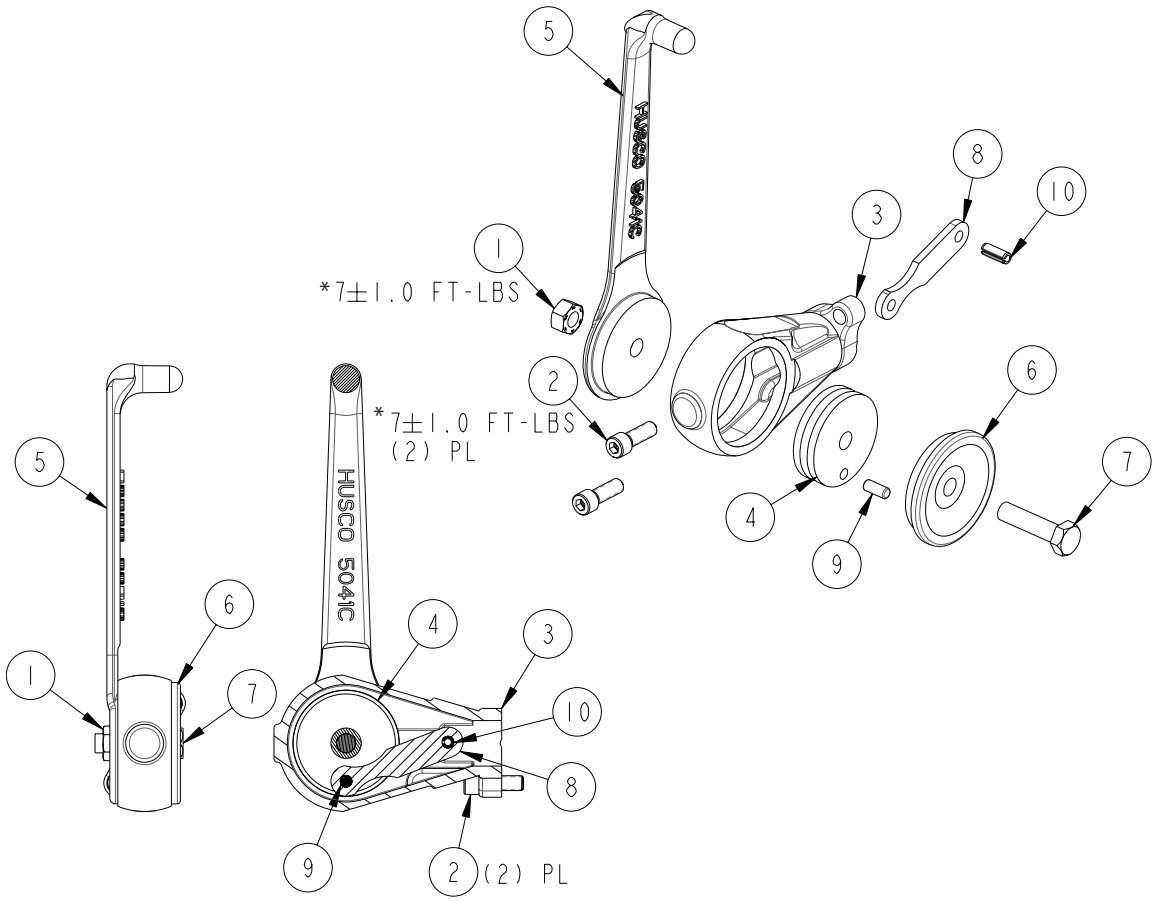
Fixed Position Lever Assembly



Ref No.	Part No.	Description	Quantity
	52250-1, 52250-14 & 52250-12	Fixed Position Lever Assembly	
1	5035	Cap Screw-Soc.Hd. 1/4-20 x .75" 3/16 Allen	2
	51662 52348	Boot – Vertical + 45° Boot – Horizontal	
3	52128-1	Bracket-Handle	1
4	52214	Pin	1
5	52216	Retainer	1
6	52217	Nut 5/16 – 24 x .188 1/2" hex	1
7	52218-1	Bolt-Pivot	1
8	52219-A	Link	2
9	52508	Knob	1
10	52552 52663 52987-3	Handle – Vertical Handle – 45° Handle – Horizontal	1
11	52986	Shim	2
12	5349	Roll Pin .196 OD x .50" LG	1

* 7±1.0 ft-lbs. = 9.5±1.4 N-m

Infinite Position Lever Assembly

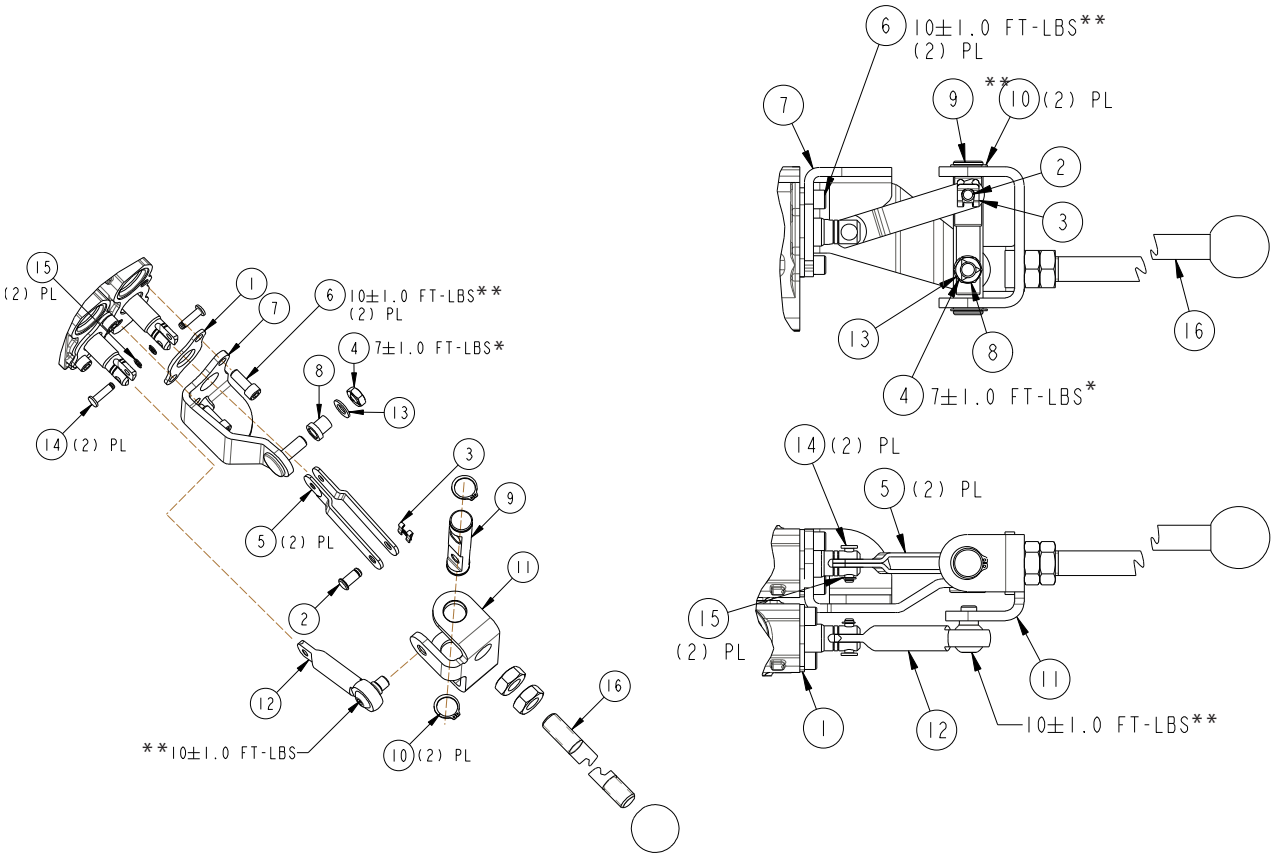


Ref No.	Part No.	Description	Quantity
	5045	Infinite Position Lever Assembly	
1	1861	Nut-Special 🛠 1/2" hex	1
2	5035	Cap Screw-Soc. Hd. 1/4-20 x .75" 🛠 3/16 Allen	2
3	5038	Bracket-Handle	1
4	5039	Hub Link	1
5	5041	Handle	1
6	5042	Hub	1
7	5043	Cap Screw-Hex. Hd.	1
8	5046	Link	1
9	5348	Pin	1
10	5349	Roll Pin 3/16 OD x 7/16" LG dowel pin	1

* 7±1.0 ft-lbs. = 9.5±1.4 N-m

Section 3.5 Installing Lever Kits

Mechanical Joystick Assembly



Ref No.	Part No.	Description	Quantity
	60164-1 RH & 60164-2 LH	Mechanical Joystick Assembly	
1	5012	Plate-Seal	1
2	52214	Pin	1
3	52216	Retainer	1
4	52217	Nut 5/16 – 24 x .188 🛠 1/2" hex	1
5	52219-A	Link	2
6	59664	Cap Screw-Soc. Hd. 1/4-20 x .625" 🛠 3/16 Allen	2
7	60165 60205	Bracket-Mounting RH Bracket-Mounting LH	1
8	60166	Bushing	1
9	60167	Pin-Pivot	1
10	60168	Retaining Ring-Ext .035 for 19/32 shaft 🛠 snap ring pliers	2
11	60169 60206	Bracket-Handle RH Bracket-Handle LH	1
12	60170	Link-Tang End	1
13	60171	Washer	1
14	60259-1	Pin	1
15	60198	Retaining Ring-Ext .025 W E-Ring for 5/32 shaft	2
16	60329 60331	Kit – Handle Assy. (Straight Lever) Kit – Handle Assy. (Angled Lever)	1

* 7±1.0 ft-lbs. = 9.5±1.4 N-m
** 10±1.0 ft-lbs. = 13.6±1.4 N-m

A

ACCUMULATOR: A container which stores fluid under pressure. Used as an energy source or to absorb hydraulic shock. Common types are piston, bladder and diaphragm.

ACTUATOR: A device in which power is transferred from one pressurized medium to another without intensification. Converts fluid pressure to mechanical motion.

ANTI-CAVITATION VALVE: A valve usually located in the workport area which is used to allow the workport to draw oil from the tank area when the workport pressure is lower than the tank pressure. (Can also be part of a relief valve.)

ANTI-VOID VALVE: See ANTI-CAVITATION VALVE

ARMATURE: The steel portion (with high iron content) of a solenoid that moves when a current is introduced to the metallic coil surrounding the armature. The force output of the armature can be varied by the amount of current supplied to the looped wire that is wrapped on the metallic coil.

AUTOMATIC KICK-OUT: A specifically designed spool and end mechanism that allows the spool to automatically self-center when a specific work port pressure is reached. The spool is manually placed into a detented position by the operator. When a predetermined pressure is reached at the work port being pressurized, the detent balls are released and the centering spring returns the spool to the neutral position.

B

BACK PRESSURE: The pressure encountered on the downstream or return side of a component.

BALANCING GROOVE: The annular groove(s) on a spool or poppet used to help hydraulically center the spool or poppet in its bore when under pressure. Balancing grooves should be square or rectangular in shape vs. "V" shaped in order to have a common area exposed to the bore on all positions around the diameter of the spool or poppet.

BANG-BANG: A term used to indicate On – Off relationship where there is no metering involved.

BERNOULLI FORCES: Bernoulli's Principle says that a rise (fall) in pressure in a flowing fluid must always be accompanied by a decrease (increase) in the speed, and conversely, an increase (decrease) in the speed of the fluid results in a decrease (increase) in the pressure. Bernoulli forces during the metering of fluid in a spool valve have to be controlled to prevent unwanted flow forces on the spool.

BLEEDER (BLEED VALVE): A device for removal of pressurized fluid. Used to bleed air from a hydraulic system.

BORE: Generally referring to the honed hole in which the spool is placed.

C

CASTING: The poured body of the valve prior to machining. Hydraulic valve castings are made out of Grey Iron, Compacted Graphite or Ductile Iron.

CAVITATION: A gaseous condition within a liquid stream caused when pressure is reduced to the vapor pressure. To be avoided due to destructive effects on pumps and motors.

CHECK VALVE: A device in a hydraulic circuit or valve that allows free flow of the oil in one direction and blocks the flow of oil in the opposite direction.

CHECK VALVE LEAKAGE: The measurement of flow rate through the clearance between the check valve device and its seat (measured in cubic inches per minute or cubic centimeters per minute).

CIRCUIT, PILOT: Used to control a main circuit or component.

CIRCUIT, REGENERATIVE: Used to increase cylinder speed by directing rod end discharge to the piston side of the cylinder. Can be incorporated into a directional control valve as the fourth position.

CLEVIS: The end of a spool in a forked shape used to pin the end of a rod to the spool for manual actuation.

CLOSED-CENTER VALVE: A valve type that has the inlet port blocked from the outlet and work ports when in neutral.

CLOSED LOOP: Used to describe hydrostatic drives where return oil goes directly back to the pump from the actuator. Also describes electrohydraulic systems where a feedback provides information as to the position or condition of the device being controlled.

COMPCHEK: A trademarked HUSCO term for the combination compensator and check valve hardware used in some HUSCO closed center load sensing valve designs.

COMPENSATOR: A spool device in a control valve used to maintain a pre-designed pressure across a fixed orifice and thus constant flow, independent of changes in system pressure.

CONTAMINANT: Any material or substance which is unwanted or adversely affects the fluid power system.

CONTROLLER: Electronic component that contains software used to drive electrohydraulic systems.

CONVENTIONAL VALVE: See SERIES-PARALLEL VALVE

COUNTERBALANCE VALVE: Valve mounted on the cylinder that only allows oil to be exhausted from the cylinder to the tank when pressure is generated in the supply chamber. Counterbalance valves are mandated for safety reasons since they prevent the bottom from being lowered in case of a hose bursting between the hydraulic valve and the cylinder. Counterbalance valves also provide an anti-cavitation feature, which means that they will open to allow oil to flow from the return (tank) passage into the cylinder if pressure in the cylinder is lower than the tank passage. Note: Counterbalance valves severely impair fine metering.

CYLINDER PORT: See WORK PORT (preferred term)

CYLINDER RATIO: Ratio of the head area to rod area. Unit-less value greater than or equal to one. A typical cylinder ratio is 2:1.

CYLINDER: A device which converts hydraulic energy into linear mechanical motion and force.

CYLINDER, DEPTH CONTROL: An adjustable mechanical or hydraulic device for limiting cylinder stroke.

CYLINDER, DOUBLE-ACTING: A cylinder which can apply force and motion in either direction.

CYLINDER, REPHASING: A cylinder design which permits the use of two or more cylinders in series, automatically synchronizing cylinder position at the end of each stroke.

CYLINDER, SINGLE-ACTING: A cylinder which can apply force in one direction only.

D

DEADBAND: In a spool valve or joystick, the deadband is the amount of travel of the spool or handle where no output occurs. Some deadband is required to allow for overlap of the spool to the metering land in order to control leakage, but too much is undesirable.

DETENT: A spring and cam device which maintains the spool of a directional control valve in a specified position.

DETENT RELEASE: A mechanical, hydraulic or electrical device for releasing the detent.

DIAMETRICAL CLEARENCE: Clearance between a bore and a rod. Diametrical Clearance = D_{bore} - D_{rod}

DIRECT-ACTING SPOOL: A 3-position spool that has the work ports blocked from the connection to the reservoir when the spool is in the neutral position. In the full shifted position one work port is connected to the pump, and the other work port is connected to the reservoir. In the opposite full shifted position, the work port that was connected to the reservoir is now connected to the pump, and the work port that was connected to the pump is now connected to the reservoir. This type of spool is used to operate a double acting cylinder or a bi-directional hydraulic motor.

DIRECT SOLENOID ACTUATION: Proportional or direct acting (bang-bang) solenoids are attached to the housing and push / pull on the spool.

DIRECTIONAL CONTROL VALVE: A device for directing the oil flow in a system also consisting of a flow source (pump) and an actuator (cylinder or motor).

DIVERTER VALVE: Usually a three way or six way valve used to divert flow. These valves are designed to be shifted before flow or pressure are applied and are generally not good for metering.

DRIFT CHECK: Combines internal leakage with actuator (generally a cylinder) leakage. The movement of the attachment is measured against time to a customer-developed specification.

DURABILITY TESTING: Entire valve assembly is cycled for a pre-determined number of iterations in order to validate the integrity of all components.

E

EH OPERATION: Actuation of the valve spool via hydraulic pressure from an internal or external source through a direct acting or proportional solenoid valve.

EMERGENCY LOWER: A device built into the control valve to internally bleed work port oil to the reservoir in an emergency situation when the prime mover (engine) is unable to function.

EXTERNAL LEAKAGE: Leakage external to the device through the body of the device or past dynamic or static sealing devices.

F

FEATHERING: The practice of modulating a spool in an intermediate position to allow only partial flow to the function.

FEEL POSITION: A mechanical interference position at a specific location during the stroking of a spool to indicate a specific spool location to the operator. Additional force has to be applied to the spool to get beyond this position.

FILTER: A device incorporated into a hydraulic system to remove contaminants from the oil.

FITTING: A device for connecting hose or pipe to hydraulic components.

FIXED DISPLACEMENT PUMP: Any pump that generates a fixed flow of oil for a given speed of the pump. The common pump types are gear, vane or piston.

FLOAT SPOOL: A spool similar to the double acting spool but with the addition of a fourth position. This fourth position allows both work ports to be connected to each other and to the reservoir.

FLOW CONTROL VALVE: A valve whose primary function is to control a specified flow rate.

FLOW DIVIDING VALVE: A valve which divides the flow from a single source into two or more separate flows.

FLOW FORCES: Axial or radial forces caused by the velocity of oil flow across a land edge or through a metering notch in the spool. Flow forces can exceed the centering spring forces and cause "sticking" or "hesitating" spools.

FLOW SENSING: A device whose operation is controlled by measuring a flow. This flow can be either an active part of the circuit or the waste (excess) flow. Also a type of load sensing.

FLOW: The volume of fluid per unit of time (F=V/T), expressed in gallons per minute (gpm), cubic inches per minute (cipm), liters per minute (l/m), cubic centimeters per minute (cc/min), etc.

FLUID POWER: Energy transmitted and controlled through the use of a pressurized fluid.

FOUR-WAY: In, out and two work ports. Used with double acting cylinders or bi-directional motors.

G

GEAR PUMP: Rotary fixed displacement pump in which two meshing gear wheels counter-rotate so that the fluid is entrained on one side and discharged on the other.

H

HIGH PRESSURE CARRY OVER: See POWER BEYOND

HONE: The process used to remove additional material from the spool bore in a machined housing to prepare the bore for the fitting of a spool. The process is usually a two step process consisting of a roughing and finishing operation. All housings are washed after the process to remove the loose fine cast iron grit created by the process.

HOUSING: A machined casting. A single casting can be machined into many different housing configurations.

HUSCO: Acronym for Hydraulic Unit Specialties Company.

HYDRAULIC MOTOR: A device which converts hydraulic fluid power into rotary motion.

HYDROSTATIC TRANSMISSION: Combination of one or more hydraulic pumps and motors forming a unit.

HYSTERESIS: The difference in an output parameter (force, pressure, flow, etc.) at a given position in the curve from zero to full value vs. full to zero value.

I

IMPULSE TESTING: Cyclic pressure testing of a valve per NFPA standards to determine the pressure rating of the valve housing.

INSTABILITY: Fluctuation in a pressure setting or flow rate outside of specified limits.

INTERNAL LEAKAGE: Leakage internal to the device from the pressurized side to the reservoir side.

ISO: International Standards Origination. http://www.iso.org/iso/en/ISOOnline.frontpage

ISOCOMP: A trademarked HUSCO term for the combination of isolator and compensator / check valve hardware used in some HUSCO closed center load sensing valve designs.

J

JOYSTICK, HYDRAULIC: A control unit consisting of four separate pressure reducing units to actuate two separate functions of a hydraulic control valve. No more than two of the pressure reducing units can be actuated at one time. The operator supplies a mechanical input to the pressure reducing units through a single handle.

JOYSTICK, MECHANICAL: A mechanical device consisting of linkage rods, bell cranks and bearings used to actuate a hydraulic control valve. Two separate functions are controlled by the input of a single joystick.

L

LAP (OVERLAP): The length in which the spool and the land in the housing are in contact with each other. Greater lap allows for larger spool to bore clearance to hold the same leakage value.

LOAD CHECK (LIFT CHECK): A device which prevents a load from dropping when a valve is shifted, until ample pressure and flow are available to hold or move the load.

LOAD SENSING: 1. The sensing of the work port pressure. This pressure is used as a pilot signal to control variable volume piston pumps or other functions. 2. The sensing of the excess flow from a valve. This signal is used as a pilot signal to control variable volume pumps or other functions.

LOCKOUT POPPET ASSEMBLY: A low leakage assembly consisting of a poppet, bias spring and a body to contain the poppet. The assembly is located in a spool valve between the work port and the spool to minimize the leakage at the Work Port to a value less than the leakage that could be obtained by a spool to bore clearance. The Lockout Poppet Assembly opens (work port to tank) when it is mechanically opened by a spool located between the work ports of the spool section. Pressure on the opposite work port moves the lockout spool to open, allowing work port oil through it, across the main spool and then to tank.

LOOP DROP: Refers to the total pressure drop as measured from inlet to work port plus work port to reservoir.

LOW LEAKAGE CHECK VALVE: A poppet, generally non-metallic, located in a spool valve between the Work Port and the spool to minimize the leakage at the work port to a value less than the leakage that could be obtained by a spool to bore clearance. The low leakage check valve opens (work port to tank) when the spool moves and pressure behind the poppet is removed.

LVDT: Linear Variable Differential Transformer. A position measurement device often used to provide feedback information in electro-hydraulic controls.

M

MANUAL ACTUATION: The valve spool will be actuated via a direct linkage by the operator. The linkage can be directly mounted to the valve as a series of mechanical rods and bearings or flexible cable. Spools will have a clevis, tang, threaded or slotted end on them to accept the linkage connection. Spool seals are required to prevent external leakage around the spools to atmosphere.

METER-IN: Used to describe a circuit where a majority of the metering is done when oil flows from pump to work port.

METERING CURVE: Flow vs. spool position, pressure vs. spool position, pilot signal vs. flow, etc., used to predict system actions when using the device for which the curve was developed.

METERING NOTCH: The machined notches in a spool used to control the flow characteristic of the spool as it transitions from a first position to a second position. Metering notches can be tailored to create specific curves required for the customer's application. Metering notches can also be designed to control flow forces.

METERING RANGE: The portion of the spool stroke where the metering notches control the shape of the output flow vs. the spool position. The first 10 to 15 percent of the spool stroke is deadband where there is no flow. Also, the last 10-15 percent of the spool stroke is dead band to guarantee full shutoff of the lands. This leaves 70-80 percent of the spool stroke to tailor the metering notches to meet the customer or the application specification for metering from a very small flow to maximum flow.

METER-OUT: Used to describe a circuit where a majority of the metering is done when oil flows from work port to tank.

MONOBLOCK VALVE: A single casting valve able to control one or many functions in a hydraulic system. The casting will have a unique internal circuit for its specific part number.

MOTOR SPOOL (full): A 3-position spool that allows the two work ports to connect to the reservoir when the spool is in the neutral position. When the spool is shifted to the full position, it performs like a double acting spool.

MOTOR SPOOL (partial): A 3-position spool that has a restricted passage between the work ports and the reservoir when the spool is in the neutral position. When the spool is shifted to the full position, it performs like a double acting spool. Often used in conjunction with counterbalance valves or PO checks.

MOTOR: A device which converts hydraulic energy into rotary motion, either fixed or variable.

MRV: See RELIEF VALVE – MAIN (SYSTEM)

O

OPEN CENTER (TANDEM) VALVE: A valve type that has the inlet port connected to the outlet (tank) port in neutral.

OPEN LOOP: Used to describe hydrostatic drives where return oil goes directly back to the reservoir from the actuator. Also describes electrohydraulic systems where no feedback is provided as to the position or condition of the device being controlled.

ORIFICE: An aperture (hole) which is used to create a pressure drop.

PARALLEL VALVE: A multiple spool valve in which the inlet oil is connected to all spools simultaneously. If more than one spool is actuated, the function requiring the lowest pressure will operate first.

P

PCLS (PRESSURE COMPENSATED LOAD SENSING): A PCLS hydraulic system uses a pressure compensated control valve with the ability to send a pressure (pilot) signal to a variable volume pump. The variable volume pump only generates enough flow to satisfy the command from the control valve. This saves energy over an open center fixed displacement system.

PILOT OPERATED CHECK: An adaptation to a standard check valve that allows the blocked direction of the oil to be opened when an external signal is applied to the device.

PILOT OPERATION: Valve actuation via hydraulic pressure from a source external to the control valve. Spools are not required to have any mechanical interface ends on them. Spool seals are not required as the caps for the pilot pressure have seals to prevent external leakage. Hydraulic pilot signals are generally controlled by a hydraulic joystick.

PISTON PUMP: A fixed or variable volume pump that uses a cam action against multiple pistons to convert rotary motion into hydraulic power. Many different control devices can be used on the variable volume versions to control the output of the pump based on the commands given to the controls.

PORT: The internal or external terminus of a passage in the valve housing. The port is the point where the fitting is attached.

POWER BEYOND (HIGH PRESSURE CARRYOVER): A connection point (port) which permits the oil flow from one valve (when in neutral) to be used by another valve downstream. Hence, a 3-spool valve could be connected to a 2-spool valve to create a 5-spool valve. The first valve takes priority and has a separate outlet port to return oil from an activator back to the reservoir.

PPC: Proportional Pilot Control. A proportional pilot pressure output device in which output pressure is related to handle or foot pedal position.

PRESSURE COMPENSATED VALVE: A control valve with a spool device separate from the directional spool used to maintain a pre-designated flow across a fixed orifice, independent of changes in system pressure.

PRESSURE DROP: The amount of pressure loss from one position in the flow stream to another due to a restriction in the flow stream.

PRESSURE: The force per unit area (P=F/A), expressed in pounds per square inch (psi), bars, or kilopascals (kpa). (1 bar = 14.5 PSI)

PRESSURE, CRACKING: The pressure at which a pressure relief valve begins to pass fluid.

PRESSURE, MAXIMUM RATED: The maximum pressure at which a component should be operated on a continuous basis, usually the relief valve setting at maximum flow rate.

PRIORITY STEERING: The functionality built into a valve that provides flow to a steering circuit before allowing flow to go to the other outputs of the valve. This is usually done with an unloader spool that directs pump oil to the priority circuit before allowing it to go downstream to other functions.

PROPORTIONAL CONTROL: The actuation of a valve in infinite steps to control the output flow vs. on / off control where the valve would have no output flow to full output flow in one step.

PROPORTIONAL SOLENOID: A solenoid that produces output force on the armature in varying amounts based on the current supplied to the solenoid coil.

PUMP: A device which converts mechanical energy into hydraulic energy, either fixed or variable. Pump types are gear, vane or piston. Gear pumps have a fixed displacement. Vane and piston pumps can be fixed or variable volume.

Q

QUICK DISCONNECT: Mechanical components on the end of a fluid line which can quickly connect or disconnect the fluid line from another component or another fluid line without the use of tools.

R

REGENERATIVE SPOOL (high pressure): Can be a 3- or 4-position spool. In the regenerative mode, the spool transfers exhaust oil from the rod end of the cylinder across the bridge in the housing and onto the base end of the cylinder. This is used to create faster cylinder speed as the rod end oil combines with the pump oil in the extend mode of the cylinder.

REGENERATIVE SPOOL (low pressure): This is a 3-position spool used to help prevent "voids" in the hydraulic system. An internal check valve allows pump oil to supplement the pump only if the return oil is at a higher pressure than the pump oil. If the pump pressure is greater than the return oil (work port to reservoir), the spool acts like a double acting spool.

RELIEF VALVE: An assembly used to limit the pressure in the valve. Relief valve types are direct acting, differential pressure or pilot operated. HUSCO manufactures relief valves of their own design and purchases relief valves from outside vendors. The HUSCO relief valves are used in HUSCO control valves and are also used by customers who make their own control valves (i.e. Caterpillar).

RELIEF VALVE LEAKAGE: Measurement of the flow rate through the clearance between the poppet(s) and its seat.

RELIEF VALVE – CIRCUIT (PORT): A pressure relief valve assembly used to limit the pressure in the work port of the control valve. The circuit relief valve is generally set higher than the main relief valve. The pressure setting of the circuit relief valve may depend on the rating of the actuator, the lift capacity of the vehicle or the structural members of the vehicle.

RELIEF VALVE – DIFFERENTIAL: A differential relief valve is a single stage relief valve. The main components are the relief valve body, poppet and spring. The design of this type of relief valve allows the pressure to work on a smaller area of the poppet than on the direct acting style. Differential relief valves are manually adjustable or shim adjustable. Differential relief valves have a given flow range where the pressure vs. flow curve is flat. Increasing flow will generate increasing pressure but to a lesser extent than the direct acting relief valve type.

RELIEF VALVE – DIRECT ACTING: A direct acting relief valve is a single stage relief valve. The main components are the relief valve body, poppet and spring. Direct acting relief valves are manually adjustable or shim adjustable. Direct acting relief valves have a limited flow range where the pressure vs. flow curve is flat. Increasing flow will increase pressure.

RELIEF VALVE – DUAL STAGE: This is a feature that can be designed into any of the relief valve types. The feature allows the relief valve to be set at a lower pressure and then activated to a higher pressure via an external (generally hydraulic) signal.

RELIEF VALVE – LOAD SENSE: A low flow (.5 - 1.0 gpm (2 - 4 lpm)) relief valve that relieves the pressure in the load sense line.

RELIEF VALVE – MAIN (SYSTEM): A pressure relief valve assembly used to limit the pressure in the system to protect the pump, valve and actuator. Relief valves with a flat pressure vs. flow curve are best for main relief valve applications.

RELIEF VALVE – PILOT OPERATED: A HUSCO pilot operated relief valve is a two-stage relief valve assembly. Most of the models of this style of relief valve also have an active anti-cavitation sleeve. For main relief valve applications, the anti-cavitation sleeve can be locked out. Pilot operated relief valves have a flat pressure vs. flow curve. This style of relief valve is manually adjustable.

RELIEF VALVE – SECONDARY: A relief valve in a hydraulic control valve set at a lower pressure than the main relief valve. This relief valve limits specified functions to run at a pressure less than the setting of the main relief valve.

RELIEF VALVE SETTING: The adjustment of a pressure relief valve within its specified pressure value specified by the customer or by the application.

RESERVE FORCE: The amount of force generated by the centering spring to overcome frictional forces, seal drag and flow forces when a spool is returning to the neutral position.

RESERVOIR (TANK): A container which stores the liquid in a fluid power system.

RETURN-TO-DIG: A device similar to a mechanical detent where the detent cam and balls are replaced with an electromagnetic coil and a clapper (steel plate). When electrical power is applied to the coil it will have the ability to hold the clapper against the force of the centering spring. The centering spring will return the spool to the neutral position when the electrical power connection is broken or if additional mechanical force is applied to the spool to overcome the holding force of the coil.

S

SAE: Society of Automotive Engineers. http://www.sae.org/servlets/index

SEAL: A device which prevents or controls the escape or passage of hydraulic fluid. HUSCO's common seals are o-rings. Special lip seals are used on some applications.

SECTIONAL VALVE: A valve assembly using multiple housings able to control one or many functions in a hydraulic system. The individual housings will each have a unique internal circuit to make a valve assembly with its own specific circuit.

SELECTOR VALVE: See DIVERTER VALVE

SERIES VALVE: A multiple spool valve in which the return oil from the first spool is directed to the inlet of the second spool (and from the second to the third, etc.). This type of valve permits simultaneous operation of two or more functions with the same oil flow. However, the total pressure requirements of all functions are accumulative.

SERIES-PARALLEL VALVE: A multiple-spool valve which has all spools connected to the open center

passage in neutral. However, when actuated, the upstream valve takes full priority. The return oil is directed to downstream spools as in a series type valve. An upstream spool must be "feathered" in order to operate more than one function.

SINGLE ACTING SPOOL: A 3-position spool that has the work ports blocked from the connection to the reservoir when the spool is in the neutral position. In the fully shifted position, one work port is connected to the pump and the other work port is connected to the reservoir. In the opposite fully shifted position, the work port that was connected to the reservoir remains connected to the reservoir, and the work port that was connected to the pump is now connected to the reservoir. This type of spool is generally used to operate a single-acting cylinder like the lift cylinder on a forklift truck.

SOLENOID: A solenoid consists of wire wrapped around a metallic core, which produces a magnetic field when an electrical current is passed through it. The magnetic field generates a force on the moveable steel core (armature) that is inside the inner diameter of the metallic core. The force output of the armature can be varied by the amount of current supplied to the looped wire.

SOLENOID, ACTUATOR: A solenoid used to move a spool in a control valve.

SOLENOID, VALVE: An electrically actuated valve that uses a magnetic force to open and close the valve components.

SPOOL: A precision machined piece of bar stock in the housing used to direct the oil to different ports in the valve. Spools are made of high-grade steel that has been chrome plated and ground to a close tolerance.

SPOOL EFFORT: The force required to move the spool in a spool valve from the neutral position to the fully stroked position. The maximum force experienced must include centering spring force, flow forces, seal drag and mechanical spool-to-bore fit forces.

SPOOL LEAKAGE: Measurement of the flow rate through the clearance between the spool and the spool bore.

SPOOL END – BLANK: Pilot operated spools do not require a special connection with the end mechanism. Generally, the spool end may be turned down smaller than the spool diameter in order to accept a centering spring.

SPOOL END – CLEVIS: The end of a spool in a forked shaped used to pin the end of a rod to the spool for manual actuation of the spool.

SPOOL END – SLOT: A special spool end to accept the connector from a cable end used to manually actuate the spool.

SPOOL END – TANG: The end of a spool in a flat shape with a perpendicular hole that will accept the connection of a rod or cable for manual actuation of the spool.

SPOOL END – THREADED: Internal thread in inch or metric units to accept special direct linkage or cable end connections for a manually actuated linkage.

SPOOL LOCK (INTERLOCK): A solenoid device used to lock a spool in a control valve in the neutral (non-actuated) position when there is no electrical signal supplied to the solenoid.

SPOOL RESERVE: The minimum amount of spring force left when returning a spool from a fully stroked position. The test is performed with blocked ports and at full flow and pressure. Hydraulic flow forces, seal drag and mechanical drag of the spool against the spool bore subtract from the centering spring force.

STICTION: A term used to describe the failure of a spool to return to the neutral position in the valve. The centering spring is unable to overcome the friction (spool to bore fit), hydraulic flow forces or mechanical drag (due to seals or the end mechanism).

T

THREE-WAY: In, out and 1 work port, normally used with a single acting cylinder or uni-directional motor.

THRESHOLD: The level at which an event or change occurs in the metering element in a valve. Threshold values are designed and verified to produce maximum performance.

TIE ROD: Refers to rods with threaded ends used to clamp sectional valve housings together in a complete valve assembly.

TILT LOCK SPOOL: A 3-position spool with an internal spool / poppet that only allows the work port oil to go to the reservoir from one of the work ports when the spool is in a shifted position and pump pressure is present. Lack of pump pressure will allow the spool / poppet to close and prevent the work port oil from flowing to the reservoir. Commonly used on the "tilt" function of a forklift truck.

TRANSDUCER: A device which converts a parameter in a hydraulic system (pressure, temperature, flow, etc.) to an electrical signal.

V

VACUUM: Pressure less than ambient atmospheric pressure.

VALVE: A device which controls fluid flow rate, direction or pressure.

VANE PUMP: A fixed or variable volume pump that uses a cam action with sliding vanes to generate hydraulic fluid flow. Many different control devices can be used on the variable volume versions to control the output of the pump based on the commands given to the controls. A vane pump is less popular than the piston pump and more expensive than a gear pump.

VOID (CAVITATION): Air incurred in the hydraulic oil due to an overrunning load on the cylinder, i.e., the cylinder is moving at a speed faster than the pump can supply the oil.

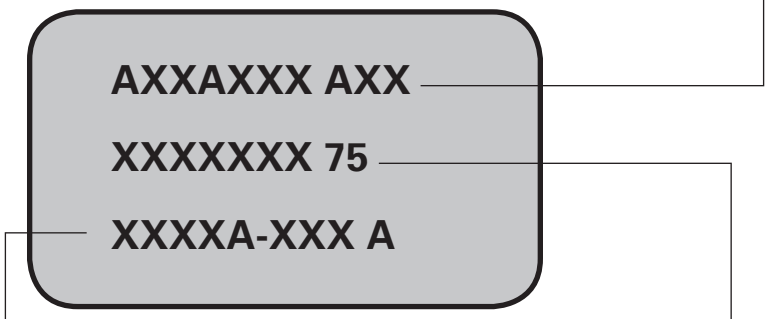
W

WORK PORT LEAKAGE: The measurement of flow rate through the clearance between the spool bore and spool in a control valve (measured in cubic inches per minute or cubic centimeters per minute). Other devices in the work port (relief valve, anti-void assemblies, etc.) are additive to the spool-to-bore leakage.

WORK PORT: The port that provides fluid passage to a linear or rotary actuator.

Date Code & Serial Number Line

Month | Year | Alphanumeric Sequence | Revision
G 07 D812 C02



Customer Part Number Line

("75" indicates valve was built / tested in the engineering lab)

HUSCO Part Number Line

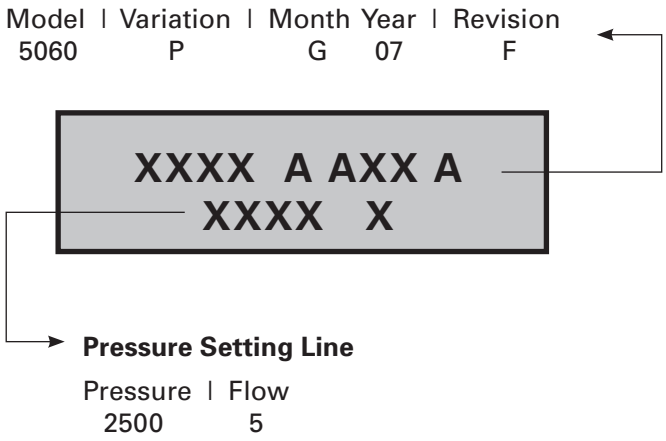
Model | Variation | Issue Letter
5000C 135 C

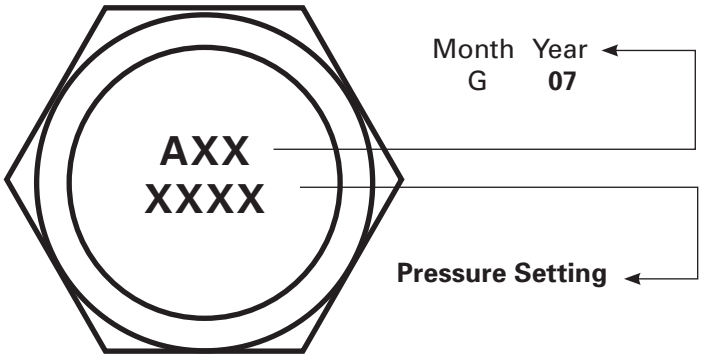
Date Coding:

Month	Date Code	Month	Date Code	Month	Date Code
January	A	May	E	September	J
February	B	June	F	October	K
March	C	July	G	November	L
April	D	August	H	December	M

Section 4.3

Relief Valve Identification

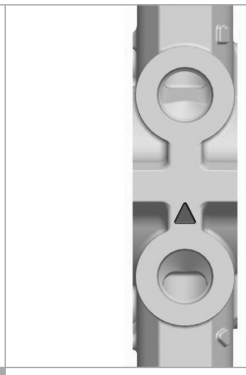
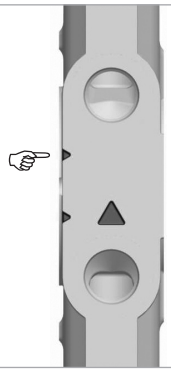
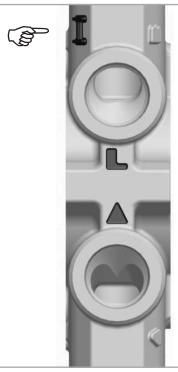
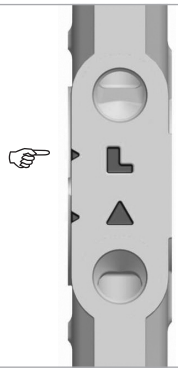




Date Coding:

Month	Date Code	Month	Date Code	Month	Date Code
January	A	May	E	September	J
February	B	June	F	October	K
March	C	July	G	November	L
April	D	August	H	December	M

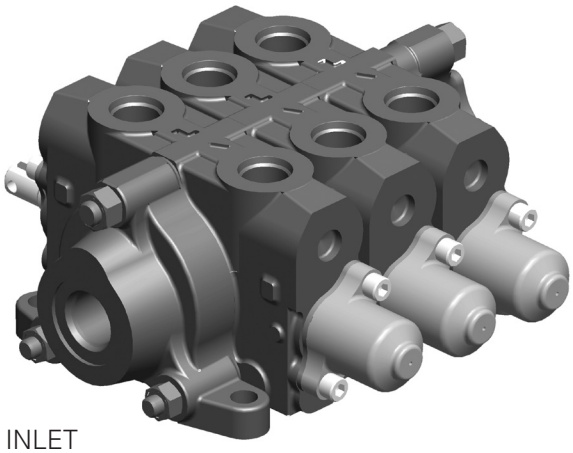
5000 Spool Section Castings Identification

			
Section P/N	5005A	5005AH	5005DA
Iron Type	Grey	Grey	Ductile
Circuit	Parallel R.H.	Parallel R.H. Heavy Duty	Parallel R.H.
			
Section P/N	5005E	5005B	5005V
Iron Type	Grey	Grey	Grey
Circuit	Series R.H.	Conventional R.H.	Parallel L.H.
			
Section P/N	5005VH	5005DV	5005W
Iron Type	Grey	Ductile	Grey
Circuit	Parallel L.H. Heavy Duty	Parallel L.H.	Conventional L.H.

Section 4.5

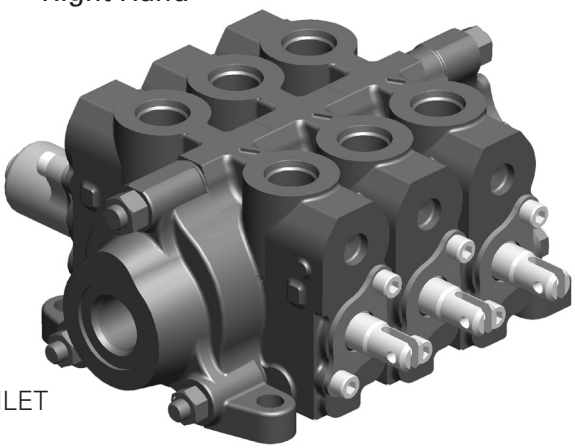
Assembly Convention

Left Hand



INLET

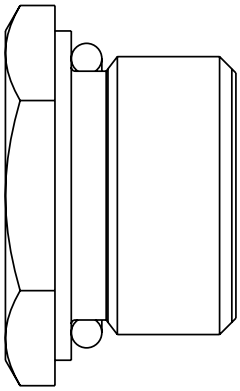
Right Hand



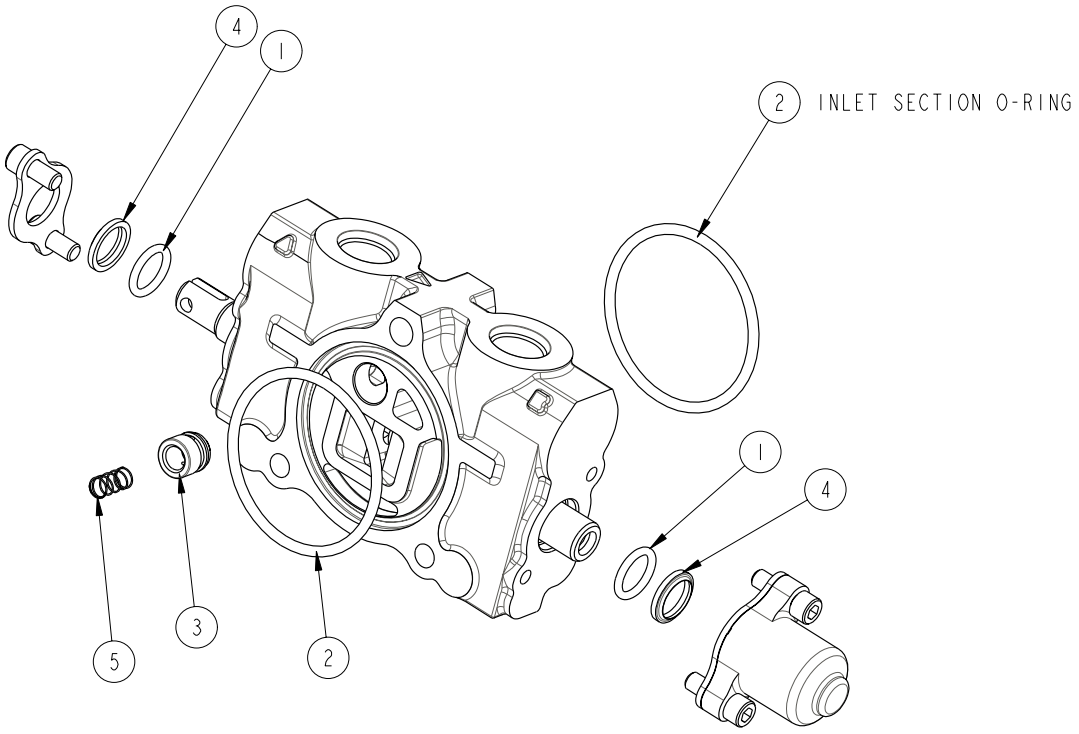
INLET

Section 4.6

Standard SAE Plugs



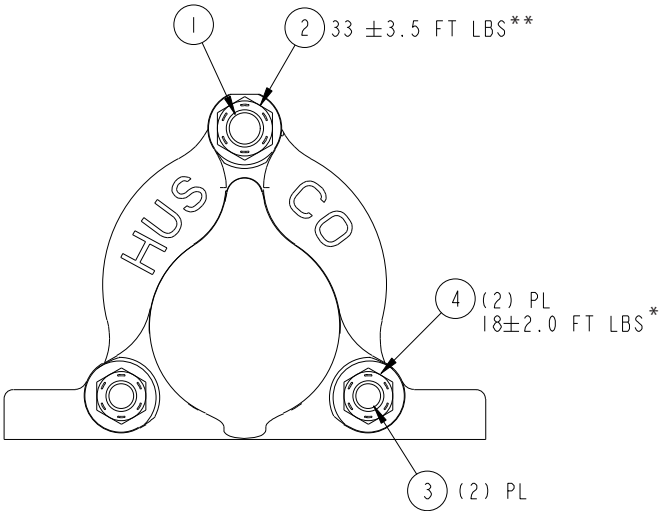
Description	HUSCO Part No.	Includes O-Ring	Torque	
#6 SAE $^{9}/_{16}$-18 Thd	11120	AS568A-906 90 duro Nitrile	16-20 ft-lbs. 22-27 N-m	$^{1}/_{4}$" Allen
#8 SAE $^{3}/_{4}$-16 Thd	11150	AS568A-908 90 duro Nitrile	30-36 ft-lbs. 41-49 N-m	$^{15}/_{16}$" Hex
#10 SAE $^{7}/_{8}$-14 Thd	11180	AS568A-910 90 duro Nitrile	43-53 ft-lbs. 58-72 N-m	1" Hex
#12 SAE $1^{1}/_{16}$-12 Thd	11210	AS568A-912 90 duro Nitrile	66-82 ft-lbs. 89-111 N-m	$1^{1}/_{4}$" Hex



Ref No.	Part No.	Description	Quantity
	51086	Seal Kit for a 1-Section Valve	
1	130	O-Ring - Spool AS568A-113 70 duro Nitrile	2
2	564	O-Ring - Section AS568A-228 75 duro Nitrile	2
4	5029	Wiper	2
Ref No.	Part No.	Description	Quantity
		Service Kit for a 1-Section Valve	
1	130	O-Ring - Spool AS568A-113 70 duro Nitrile	2
2	564	O-Ring - Section AS568A-228 75 duro Nitrile	2
3	5011	Poppet - Check Valve	1
4	5029	Wiper	2
5	5064	Spring	1
Ref No.	Part No.	Description	Quantity
	61530	Service Kit for a 5-Section Valve	
1	130	O-Ring - Spool AS568A-113 70 duro Nitrile	10
2	564	O-Ring - Section AS568A-228 75 duro Nitrile	6
3	5011	Poppet - Check Valve	5
4	5029	Wiper	10
5	5064	Spring	5

Section 4.8

Tie Rod Kits



Part Number	Number of Sections
6131-1	1
6131-2	2
6131-3	3
6131-4	4
6131-5	5
6131-6	6
6131-7	7
6131-8	8
6131-9	9
6131-10	10
6131-11	11

Ref No.	Description	Quantity
1	Top Tie Rod	1
2	Top Tie Rod Nuts 🛠 9/16" hex	2
3	Bottom Tie Rods	2
4	Bottom Tie Rod Nuts 🛠 1/2" hex	4

Note: Hardened washers are required for valve assemblies with more than eight sections

* 18±2.0 ft-lbs. = 24.4±2.7 N-m

** 33±3.5 ft-lbs. = 44.7±4.7 N-m

Notes

Notes

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