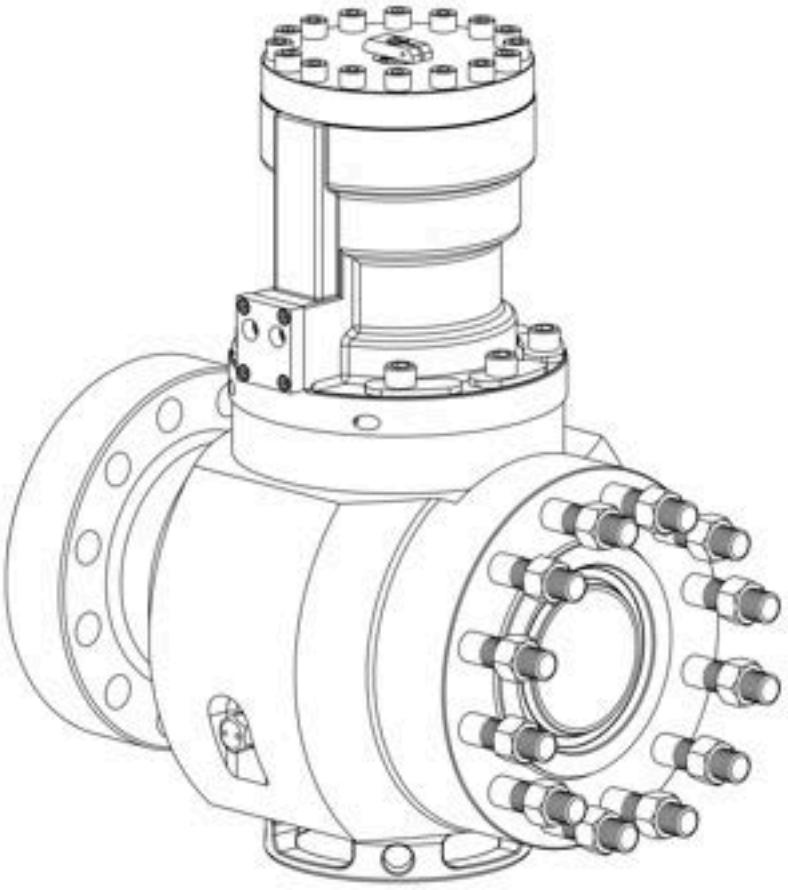
Operation and Maintenance Manual
5 1/8” LT Full Bore Plug Valve



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SECTION 1 SAFETY

This equipment is intended for use in high-pressure and high flow well service applications. High pressure equipment, if not used and maintained properly, can cause serious injury or death and damage to equipment and property.

Only operate the valve in the full open or full close position, never flow through the valve in a partially open state as severe erosion may occur and create a hazardous situation.

Not taking proper precautions and failing to perform routine maintenance and inspections can also contribute to loss of well control, and such loss could cause serious injury or death and damage to equipment and property.

ALL OPERATORS AND MAINTENANCE PERSONNEL SHOULD BE THOROUGHLY TRAINED IN THE SAFE OPERATION, MAINTENANCE, AND INSPECTION OF THIS EQUIPMENT.

SECTION 2 PRODUCT OVERVIEW

2.1 General Description

Since 2002, the MSI 5 1/8” LT plug valve has been operated daily in some of the most severe environments the industry has to offer such as: wellhead protection/isolation, frac stacks, and frac manifold trailers. The valve is engineered to provide exceptional value to the operator by reducing cost of ownership and maximizing throughput of wellhead operations. Compared to a gate valve the MSI plug valve:

- Is more compact and lightweight.
- Is more durable in abrasive environments due to minimal particle intrusion to the body.
- Requires less grease to maintain in operating environments.
- Permits repair without removing the valve from the tree.
- Permits rapid open or close cycles.

This valve is only offered with assisted actuation in the form of handwheel or hydraulic actuators. Handwheel actuators utilize worm gear reduction and are available as single speed or two speed units. Hydraulic actuators permit remote operation to keep personnel away from pressurized equipment, which is required in some cases.

Connections typically provided include API® Flange and Stud Flange, Grant Prideco™ box and pin premium drill connections, or MSI’s ACME box and pin straight thread. Other connections may be applied by request.

MSI also offers the 5” plug valve with dual pockets when a compact installation with redundant sealing mechanisms is desired. Such configurations eliminate a connection point where two valves are normally used, and permit inlets to be added for directly introducing additional flow streams between the closure mechanisms.

SECTION 3 ENGINEERING DATA

3.1 Standard Materials of Construction

MSI utilizes the highest quality ASTM/AISI materials heat treated to produce the safest and most durable valves for severe service applications. All iron based materials are treated to a process that creates a wear and corrosion resistant surface.

- Valve Body, Plug, Adjusting Nut: chromium-molybdenum or nickel-chromium-molybdenum steel
- Inserts: ductile iron
- Seals: NBR elastomer
- SafeTap Grease Fittings – low alloy steel body, alloy balls and springs

NOTE: Alternate materials or surface treatments may be available for special applications. Contact MSI engineering for technical information and assistance in material selection.

3.2 Working Environment

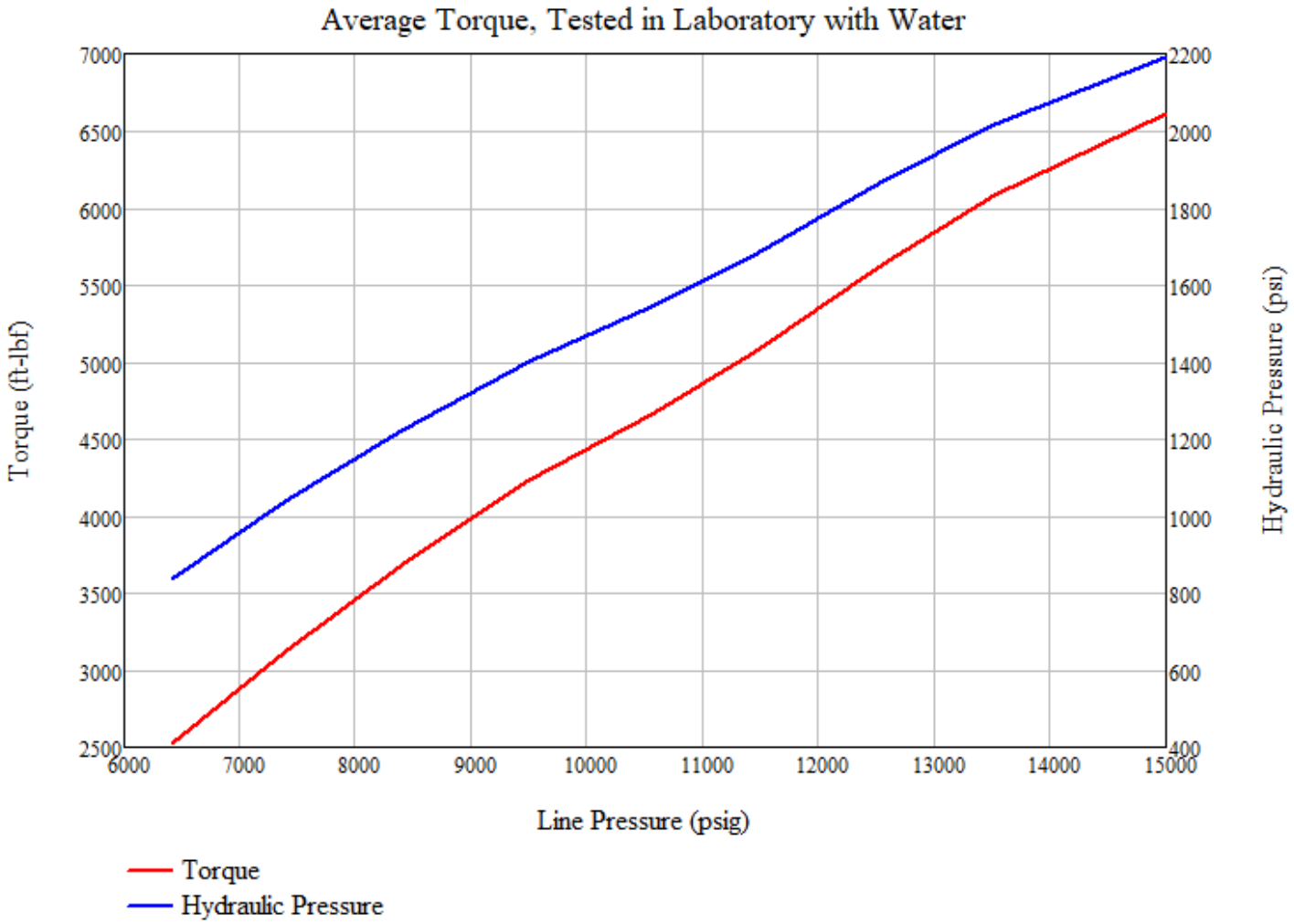
- API material class AA general service (non-sour)
- Temperature Ratings
  - Valve: API Class PU (-20°F to 250°F)
  - Hydraulic Actuator: -13°F to 175°F
  - Handwheel Actuator: -13°F to 230°F
- Rated working pressure up to 15,000 psig
- API Product Specification Level 1, 2, or 3
- API Performance Requirement level 1

3.3 Design & Testing

- Every valve is built to customer specifications using API/ASME design methodology.
- In addition to using traditional numerical solutions during the design phase, computer aided engineering (CAE) tools such as Finite Element Analysis (FEA) are utilized to further optimize the valve and verify suitability for the anticipated service environment.
- Valves designed for offshore applications are rated for static pull loads by numerical analysis. In some cases functional testing is performed by a 3rd party engineering laboratory to validate integrity and function. Please contact MSI Engineering for additional information.
- Following assembly of every valve, hydrostatic testing is performed in accordance with API Specification 6A, which requires a one time pressure application equal to 150% of the rated working pressure, and testing across the closure mechanism at full working pressure in accordance with the applicable PSL.

3.4 Operating Torque

Under differential pressure a large force bias is applied across the plug. This force creates a seal on the downstream side of the valve. To open the valve, the force-induced friction must be overcome by applying torque to the plug. Torque is directly proportional to pressure differential as shown in the following graph.



3.5 Actuator Output

Actuators are sized based on manufacturer data to provide at least 125% of the measured operating torque. This design factor compensates for increases in torque that can occur due to adjustment of the nut, lubrication, temperature, alignment of shaft with plug, and condition of parts; to name a few contributing factors.

Actuator	Max Output Torque (ft-lbf)	Design Factor	Turns Open-Close
Hydraulic	9150 (at 3000 psig hyd)	1.40	1/4 hydraulically
Dual Speed Handwheel	8450 (at 80 lbf rim-pull)	1.30	25 on handwheel[1]
Single Speed Handwheel[2]	8900 (at 80 lbf rim-pull)	1.36	162 on handwheel

[1] Approximate number of turns to break seal at high torque setting + turns to complete opening at high speed setting.

[2] Single speed units have been discontinued and data is provided for legacy units only.

3.6 Maximum Flow Rate

Typical applications for the MSI 5 1/8” plug valve involve high flowing rates of abrasive media such as sand or proppant. Erosion will occur at varying rates according primarily to the geometric characteristics of the media and flow velocity. The user should consider the economic and safety impact of choosing an operational flow rate.

3.7 Recommended Lubricants

MSI recommends the following lubricants for the assembly of the valve. Refer to Section 5.4 for specific applications details.

ASSEMBLY	
Application	**Lubricant**
Plug, Inserts, Adjusting Nut, Seals	MSI WETFIT Grease
Threads*	Copper Anti-Seize Lubricant

*For threaded end connections use an API rotary connection thread compound.

MSI WETFIT grease is a high-tack, high-adhesion grease specifically formulated for plug valves. It may be used with commonly available industrial lubrication pumps.

Other greases may be used but MSI strongly recommends a rigorous evaluation prior to implementing the grease in field operations.

MAINTENANCE	
Application	**Lubricant**
General Service (-10°F to 400°F)	MSI WETFIT Grease
Low-Temp Service (-50°F to 400°F)	MSI WETFIT "Arctic" Grease

CAUTION: Many plug valve grease manufacturers offer both "stick" and "bulk" packaged greases. Bulk typically is a softer grease than stick formulations. High adhesion and cohesion properties are necessary to establish a seal between the plug and inserts. Use only grease with an NLGI classification of 6.

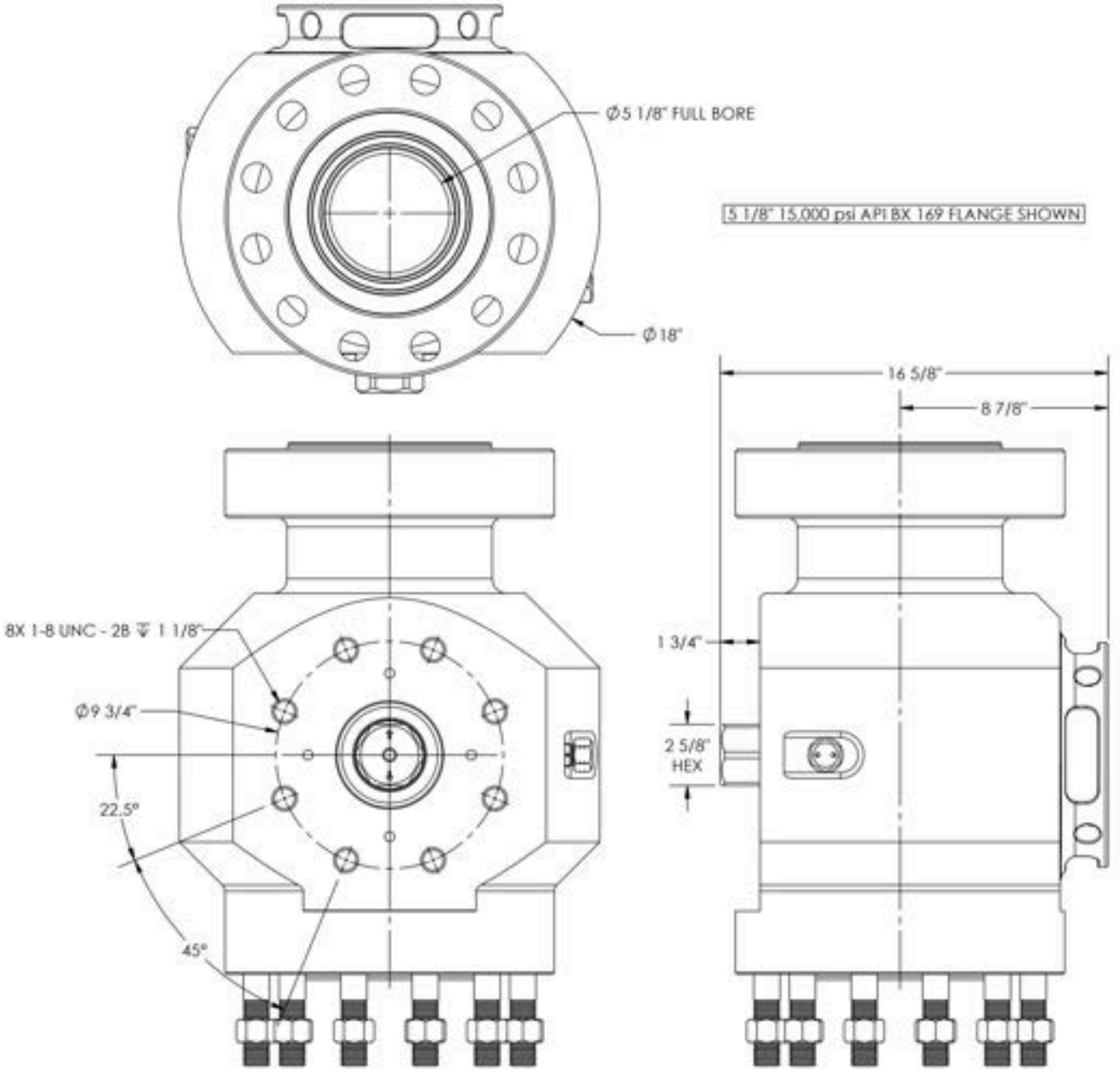
3.8 Lubrication Capacity

Approximately 55 in^3 of void space exists in a fully assembled valve. For proper operation the voids must be charged with plug valve stick grease. A 'K' size grease stick is approximately 18.5 in^3 (1.5" diameter x 10.5" length).

GREASE REQUIREMENT	
Application	**Lubricant**
Rebuild	3-4 'K' sticks
Field Maintenance	Up to 4 'K' sticks[1]

[1] Depends on charge level at time of lubrication.

3.9 **Dimensions & Masses**



Approximate weights for typical valve configurations (does not include actuator weight):

- API flange = 1150 lbs
- ACME thread = 850 lbs

Approximate weights for complete actuator assembly:

- Handwheel actuator single speed = 250 lbs
- Handwheel actuator dual speed = 275 lbs
- Hydraulic actuator = 250 lbs

SECTION 4 DISASSEMBLY & ASSEMBLY

If possible repair work should be performed in a clean environment free of dirt, rust, paint, and protected from inclement weather. Foreign materials readily adhere to grease and may cause damage to the parts. The operator should at a minimum be wearing safety glasses, steel toe boots, and gloves during these activities.

4.1 **Disassembly**

Verify that all lifting and supporting equipment is capable of safely handling the weight of the valve prior to attempting service. Contact MSI for assistance in determining valve weight if you are unsure.

1. Secure the valve to a sturdy frame or table capable of withstanding the load and orient the valve so that the adjusting nut can be removed.

CAUTION: In some cases pressure may become trapped in the valve cavity even after it has been removed from service. Trapped pressure is a safety hazard that could cause bodily injury if a sudden release occurs. MSI recommends venting grease fittings prior to disassembly.

2. Remove the screw (or grease fitting) and washer from the plug.
3. Using a valve operating bar or 1” diameter rod, engage the holes in the adjusting nut and remove by rotating in a CCW direction.
4. Steps specific to valve generation.
    a. GEN I Adjusting Nut:
        i. Remove the seal ring.
        ii. Extract the inserts.
    b. GEN II Adjusting Nut:
        i. The integral adjusting nut will extract the inserts as it is rotated out of engagement with the valve.
5. Remove the plug. An eyebolt may be installed into the tapped hole to aid this step.

NOTE: Make certain to verify the thread pitch before inserting the eyebolt. Regular plugs utilize a 3/4"-10 UNC thread; GreaSeal plugs utilize a 3/4"-16 UNF thread. Be extremely careful not to damage the GreaSeal plug port.

6. Remove all seals being careful not to scratch or ding any surfaces immediately around the seal.
    a. Discard all seals if the valve has been in service or in storage for longer than 6 months.
7. Body grease fittings do not normally need to be removed. If a fitting is removed plug the port to prevent foreign material from entering.

4.2 **Cleaning**

Thoroughly clean all parts with a suitable solvent to remove grease and dirt. Do not use heavy abrasives or scraping tools as that could result in irreparable damage to the parts.

4.3 **Inspection**

All inspections should take place in a clean and well-lit work area. Non-marring surfaces should be provided for setting parts on.

Examine all metal parts for damage such as dings, wear, erosion, and pitting; especially on the sealing surfaces. Replace as needed.

Examine the button head of all grease fittings, replace those that are damaged. See assembly section for grease fitting installation requirements.

4.4 **Assembly**

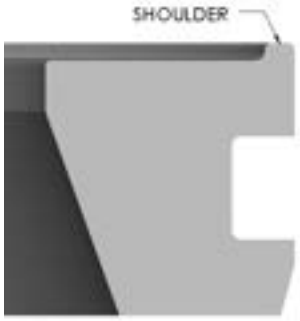
Prior to re-building the valve it is recommended that all parts be thoroughly inspected and cleaned, especially reused parts. Scratches, dings, wear, and pitting may result in failure of the valve to hold pressure. If any parts need to be dressed prior to assembly perform this work in a different area to prevent contaminating the assembly area.

1. Orient the valve body with the pocket cavity facing up.
2. Apply a film of stick grease in the plug seal cavity of the valve body, install the plug seal with the groove facing out, then pack seal groove and immediate area with stick grease.
3. Apply a thin film of stick grease on the outer surfaces of the plug (green areas highlighted below) and gently insert the hex end into the valve body. An eyebolt may be used to assist lifting the plug. NOTE: Make certain to verify the thread pitch before inserting the eyebolt. Regular plugs utilize a 1/2"-20 UNF thread; GreaSeal plugs utilize a 3/4"-16 UNF thread. Be extremely careful not to damage the GreaSeal plug port.

4. Apply a film of stick grease in the plug seal cavity of the adjusting nut, install the plug seal with the groove facing out, then pack seal groove and immediate area with stick grease.
5. Place insert seals into the face groove and pack with stick grease to keep them in place.
6. Apply a coat of thread anti-seize compound to the adjusting nut threads and/or the mating threads in the valve body pocket.
    a. GEN I Adjusting Nut:
        i. Lower inserts into the valve body making certain the pins engage the slots on the sides of the inserts.

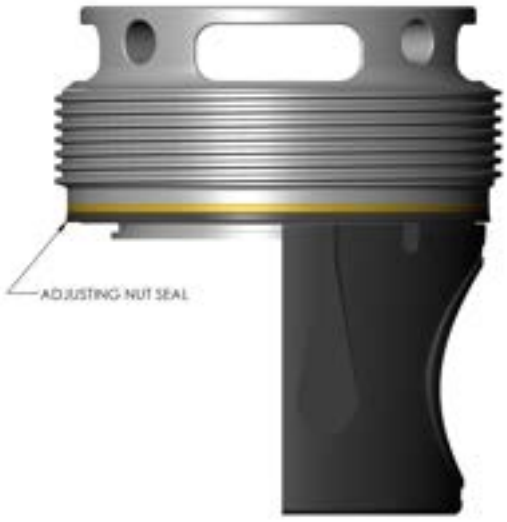
ii. Press inserts down by hand until they stop. Inserts will not fully align with the valve bore yet, this is normal.
iii. Install larger o-ring on seal ring and apply stick grease around outer surfaces.
iv. Place the seal ring in the valve body and press into the seal bore until it is fully engaged. If necessary a non-metallic rod may be used to tap the ring into position.

NOTE: Seal rings with a shoulder require installation in one direction only. These rings are identifiable by a small shoulder that protrudes from one face as shown below. If using a shouldered seal ring make certain this shoulder is facing the adjusting nut. Be careful to avoid deforming the shoulder during installation.



v. Install the smaller seal in the groove on the bottom of the adjusting nut and pack with stick grease to keep the seal in place.
vi. Set adjusting nut onto valve.
vii. Go to Step 7.

b. GEN II Adjusting Nut:
i. Apply a thin film of stick grease to the adjusting nut seal and place on adjusting nut with groove facing out.
ii. Engage inserts with adjusting nut hook feature as shown below.



iii. Slowly lower the adjusting nut/insert sub-assembly into the valve body making certain the pins engage the slots on the side of the inserts. The sub-assembly is lowered until the threads on the nut contact the threads on the valve body.

c. GEN III Adjusting Nut:
i. Place the adjusting nut on a work surface handle side down.

ii. Install the smaller seal in the groove on the bottom of the adjusting nut and pack with stick grease to keep the seal in place.
iii. Install larger o-ring on seal ring and apply stick grease around outer surfaces.
iv. Place the seal ring on the adjusting nut.
v. Engage inserts with adjusting nut hook feature.
vi. Carefully turn assembly so that the adjusting nut is up and is setting on the inserts. Be sure to support the inserts during rotation so that they do not fall off of the nut.
vii. Using a lifting aid, pick up the assembly and carefully lower it into the valve body being careful to keep the insert slots aligned with the roll pins.

7. Rotate the adjusting nut CCW by hand just until the thread starts align. This is usually indicated by a gradual lifting then sudden drop.
8. After the thread starts are aligned rotate the nut CW by hand until at least half the threads are engaged. It might be necessary to alternate CW and CCW rotations until the body roll pins fully engage the slots on the inserts. If resistance occurs before the nut is halfway threaded on it is possible the pins are not engaged into the slots. Back-out the adjusting nut and repeat the installation.
9. Keep rotating the nut CW using a valve bar until the flow bore of the inserts align concentrically to the flow bore of the valve. It may be necessary to perform this step in incremental stages of tightening the nut, rotating the plug, and tightening the nut again. As the parts come closer to alignment running clearances become very small. Rotating the plug during this step will help displace excess grease and permit these clearances to close.

NOTE: Correct adjustment of the nut is essential to a properly functioning valve. Adjust the nut to achieve approximately 125 ft-lbf torque to rotate the plug.

10. Once the alignment is satisfactory move the plug to open position and drift the valve. Adjust the nut until the valve drifts.

NOTE: Drifting bars should be in accordance with dimensions and tolerances specified in API 6A. For a 5 1/8" nominal bore size the large "D1" diameter of the drift shall not exceed 5.117".

11. Apply thread anti-seize to retaining screw or grease fitting.

d. Regular Plug:
    i. Install washer and screw and tighten snug.
e. GreaSeal Plug:
    i. Install washer and grease fitting then tighten to 125 ft-lbs torque.

12. Install body grease fittings if needed then tighten to 125 ft-lbs torque.

CAUTION: The metal-to-metal sealing design of the SafeTap grease requires high contact pressure at a conical interface to maintain a leak-free seal. If any foreign material is present at this interface permanent damage to the sealing face in the valve body may occur during tightening. Take extreme care in keeping the port and fitting completely clean. Do not use sealing aids such as PTFE tape or paste on the SafeTap grease fitting.

4.5 **Post-Assembly Grease Charging**

Prior to use or storage, voids in the valve cavity must be filled with stick grease. This step ensures readiness for operation by displacing moisture, providing a reserve of lubricant, and evacuating pockets of air. Sufficient charging is measured by volume of grease injected and pressure. 3 to 4 sticks are typically required to fully charge the valve cavity after rebuilding. During injection the grease pressure gauge will indicate a rise in pressure, keep pumping until this pressure reaches a peak and drops, or pressure builds to at least 3000 psi. Stop pumping when either of those events occur, this indicates the cavities are fully charged with grease and excess is flowing into the bore.

1. With plug in open position inject plug valve grease through the body fitting closest to the adjusting nut.
2. Actuate plug one full cycle.
3. Repeat step 1 & 2 for the second body fitting.

NOTE: Grease may exit the weep hole in the plug during injection. This is normal, once this occurs stop injecting grease.

4. If a GreaSeal plug is utilized inject plug valve grease through the plug fitting.

4.6 **Actuator Mounting**

After the valve has been fully assembled and drifted the actuator is ready for mounting and final alignment. Use appropriate lifting equipment to avoid damage and personal injury. Specific information regarding actuator parts and fastener torques may be found in the appendix.

1. Orient valve with exposed hex of plug facing up and in open position.
2. Lift actuator and carefully align the parts to the plug.
3. Completely lower the actuator making certain it is not in a bind.
4. Install mounting bolts and tighten to the recommended torque values.
5. Actuate valve to verify 90° rotation and that plug indexes consistently from full open to full close.
6. Adjust position stops as necessary.
7. Drift valve to verify final alignment.

SECTION 5 MAINTENANCE & PRESERVATION

The following are general maintenance guidelines, actual maintenance practices should be tailored to the specifics of the usage frequency and severity of operations.

5.1 Maintenance Lubrication

Trouble-free function of the valve depends to a large degree on lubrication. As mentioned in Section 4.7, specialized greases have been developed for plug valves used in high pressure and high temperature service. These greases contain friction-reducing additives to keep operating torque at reasonable levels. Do not use grease that is not intended for use in plug valves.

Reference Section 5.5 for field greasing procedures. If line pressure is present the greasing pressure must be greater than line pressure but shall not exceed the rated working pressure of the valve. Always verify that the equipment is rated for the anticipated pressure.

5.2 Inspection

It is advised to frequently inspect the valve and establish maintenance routines that suit the service conditions. During operation the valve is subject to erosion and corrosion damage which are highly influenced by many factors. Erosion can cause material loss to the point that the equipment fails to function or actually becomes unsafe. MSI Specification 9-2014 should be referenced for minimum wall thickness requirements.

5.3 Preservation and Storage

Between Jobs:

- Lubricate valve to purge contaminants from the critical areas.
- Flush valve with clean water to remove debris and chemical residue, thoroughly dry.
- Apply an aerosol corrosion inhibitor to the exposed, unpainted metal surfaces.

Every 3 – 6 months:

- Re-grease and operate by cycling the plug several times from open to close, returning to open.
- Test valve to verify seals are in good condition.
- Drain test fluid, thoroughly dry, then apply an aerosol corrosion inhibitor to the exposed, unpainted metal surfaces.

Greater than 6 months:

- Disassemble valve and discard all elastomer seals and grease.
- Rebuild valve according to Section 5.4 using new elastomers then test.
- Drain test fluid, thoroughly dry, then apply an aerosol corrosion inhibitor to the exposed, unpainted metal surfaces.

Always transport and store plug valves in the full open position to protect the critical sealing surfaces from damage.

Appendix A **Parts Lists**

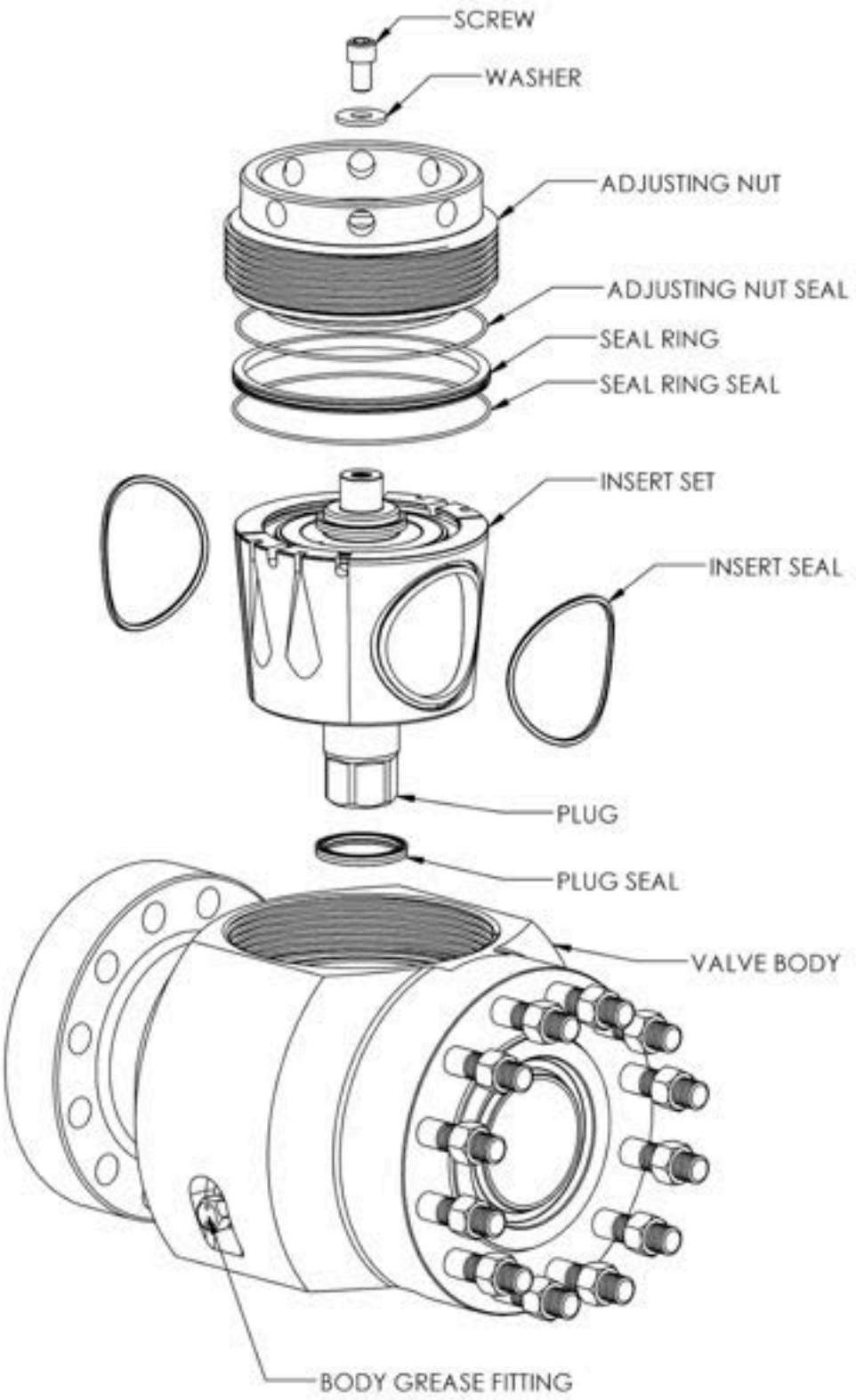
GEN*eration* III is the recommended configuration for most applications but options are available for special requirements. Contact MSI Engineering for assistance in part selection.

See accompanying diagrams on the following pages.

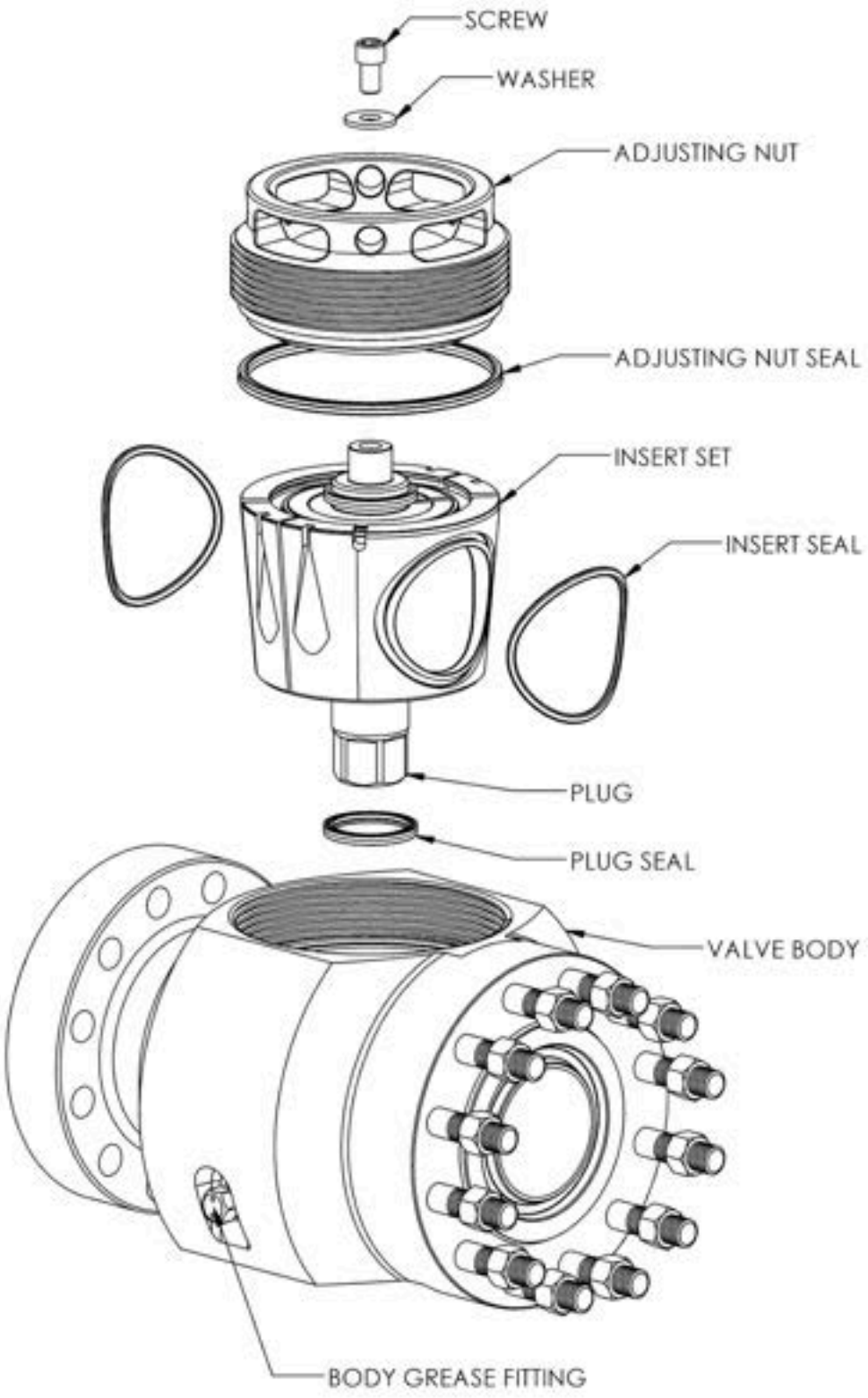
ITEM	GEN III
Plug, GreaSeal	VC0468
Plug, Regular	VC0656
Insert Set, Split	VC0865S
Insert Set, Split (offshore)	VC0904S
Insert Seal, NBR	OC0030
Adjusting Nut	VC0863
Adjusting Nut Seal, NBR	OC0121
Seal Ring	VC0592
Seal Ring Seal, NBR	OC0084
Plug Seal, NBR	VC0313

NOTE: Contact MSI Sales for information regarding optional non-metallic seal materials.

GEN I & III Typical Assembly

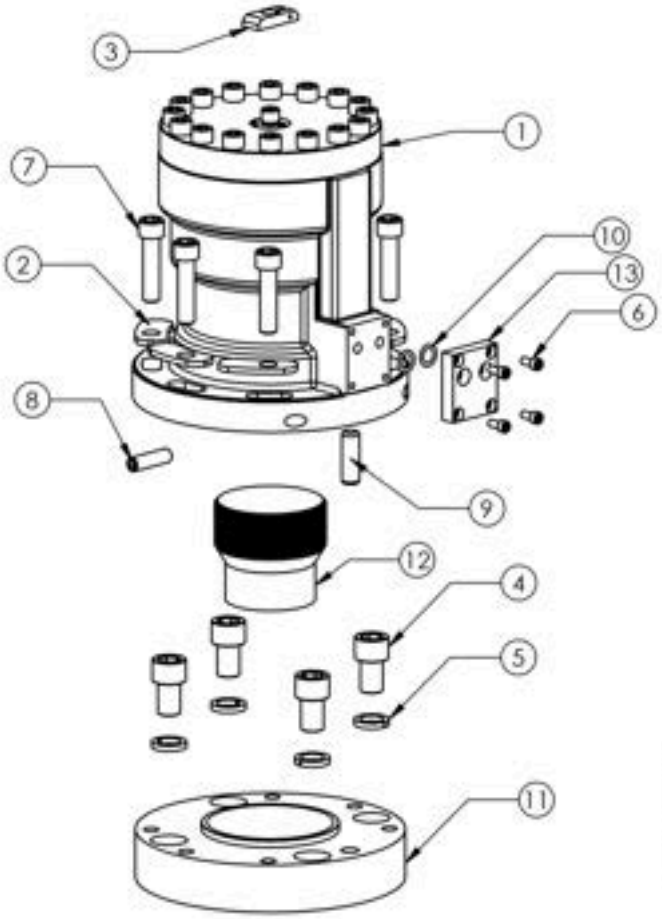


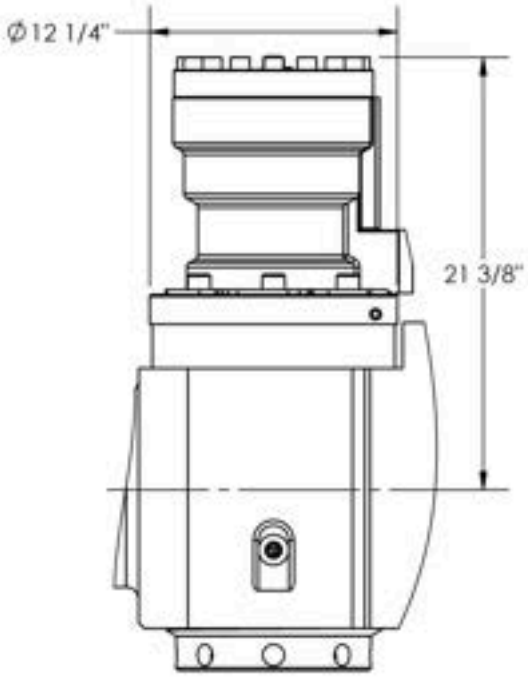
GEN II Typical Assembly



HYDRAULIC

ITEM NO.	QTY.	PART NUMBER	DESCRIPTION
1	1	AA0065	ACTUATOR BARE, DAMCOS BRC8000 (DOUBLE ACTING)
2	6	AC0006	OBLONG WASHER, BRC8000
3	1	AC0021	ACTUATOR INDICATOR, BRC1000, 2000, 4000, 8000
4	4	HC0184	SOC HD, 1"-8 x 1.50"
5	4	HC0185	LOCK WASHER, 1" HIGH COLLAR
6	4	HC0415	SOC HD, M8 x 1.25 - 18mm LONG
7	6	HC0480	SOC HD, 3/4"-10 x 3.00"
8	2	HC0483	SOC SET SCREW, M16 SIZE BRC2000,4000,8000
9	1	HC0488	DOWEL PIN, M20 DIAMETER 60MM BRC8000
10	2	OC0078	O-RING, 2-210 BUNA 90
11	1	VC0636	ACT MOUNTING PLATE, BRC8000-5"LT
12	1	VC0637	ACT ADAPTER, BRC8000 FOR 5"LT
13	1	VC0700	ACT ADAPTER BLOCK, G1/4 TO 1/2NPT

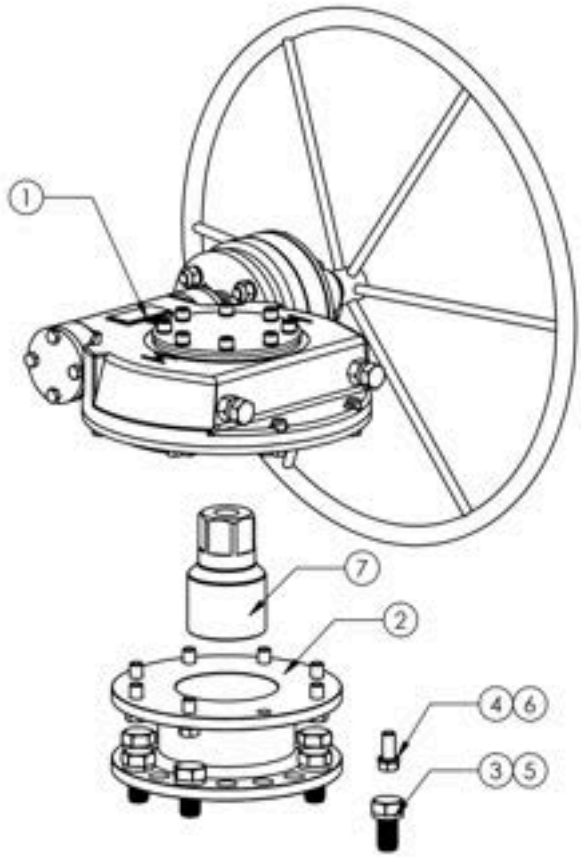


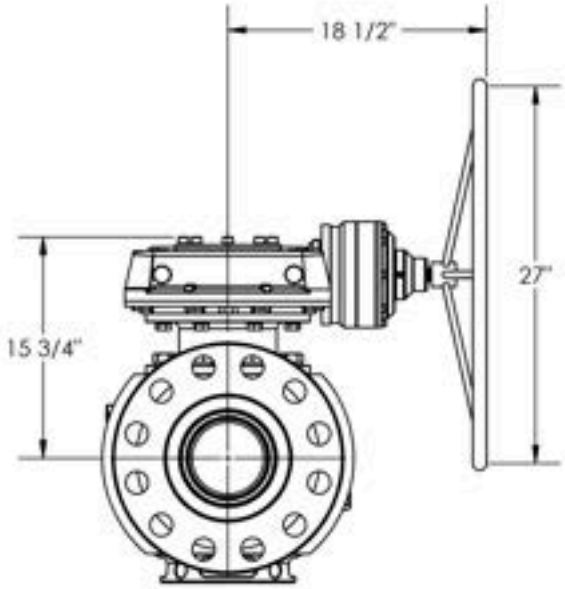


PART NUMBER	TORQUE (LUBRICATED)
HC0184	767 FT-LB
HC0415	14 FT-LB
HC0480	317 FT-LB

HANDWHEEL ACTUATOR ASSEMBLY – DUAL SPEED

ITEM NO.	QTY	PART NUMBER	DESCRIPTION
1	1	AA0074	GEAR OPERATOR, ROTORK IW62 DSIR, 70:1
2	1	ACG-5LT-16000	GEAR OPERATOR MOUNTING SPOOL, 5" VALVE
3	8	HC0185	LOCK WASHER, 1" HIGH COLLAR
4	8	HC0209	LOCK WASHER, 5/8" STANDARD
5	8	HC0419	HEX HD, 1"-8 X 2.00"
6	8	HC0874	HEX HD, 5/8"-11 x 1.50"
7	1	VC0840	ACT ADAPTER, ROTORK IW62, 5" VALVES





PART NUMBER	TORQUE (LUBRICATED)
HC0419	483 FT-LB
HC0874	113 FT-LB

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