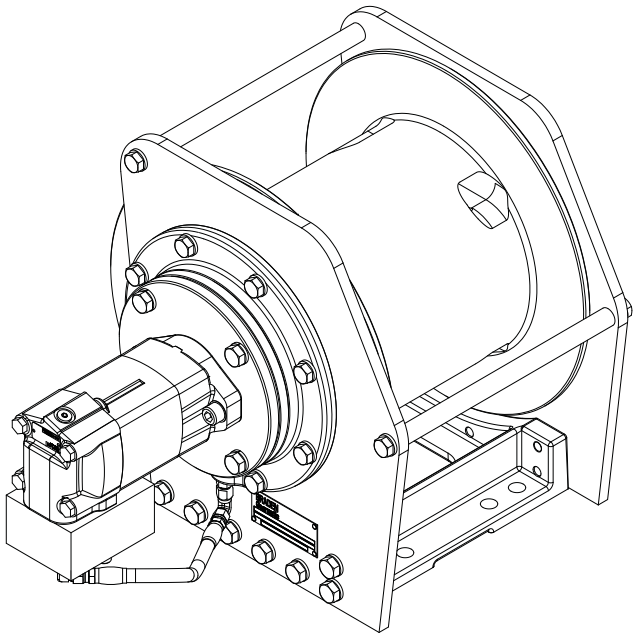
BRADEN®

SERIES
PD7C HYDRAULIC HOIST



INSTALLATION, MAINTENANCE, AND SERVICE MANUAL

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FOREWORD

Read this entire publication and retain it for future reference.

If you have any questions regarding your Braden Planetary Hoist or this publication, contact the Braden Technical Support Department at 1-918-251-8511, 08:00-1630 hours, CT, Monday through Friday, FAX 1-918-259-1575, or email www.paccarwinch.com.

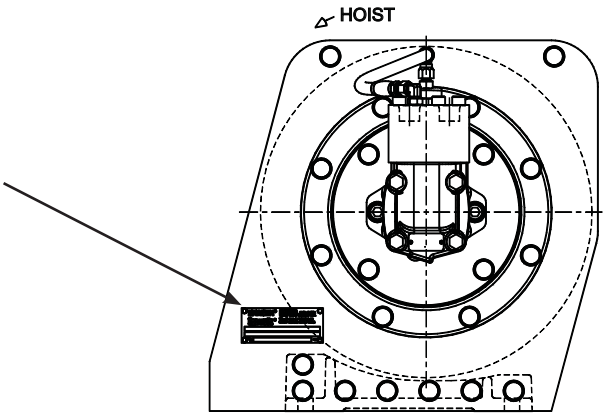
The minimum service intervals specified are for operating hours of the prime mover.

The following service instructions have been prepared to provide assembly, disassembly and maintenance information for the BRADEN Model PD7C series hoist. Before doing any work on these units, all assembly and disassembly instructions shall be read and understood.

Some illustrations in this manual may show details or attachments that are different from your hoist. Also, some components have been removed for illustrative purposes. Illustrations in this manual are of a “typical” unit sold through our distribution network. Some hoists, particularly those sold directly to original equipment manufacturers (OEM), may differ in appearance and options.

Whenever a question arises regarding your BRADEN HOIST, please contact BRADEN Technical Support Department for the latest available information.

Serial Numbers and Model Numbers are located to the left hand side of the hydraulic motor, stamped into the base. Always refer to the Serial Number and Model Number when requesting information or service parts.



EXPLANATION OF MODEL NUMBER

PD	7	C	07	124	-	01	-	U	-	L	-	R
POWER DRUM	MAX RATING	DESIGN SERIES	GEAR RATIO	MOTOR SIZE		DRUM OPTION		ROTATION		BASE		OPTIONAL

PD	DESIGNATES POWER DRUM
7	DESIGNATES 7,000 LB. APPROXIMATE FIRST LAYER LINE PULL
C	DESIGNATES THE MODEL SERIES RELATING TO DESIGN CHANGES
07	DESIGNATES TOTAL GEAR REDUCTION
124	DESIGNATES HYDRAULIC MOTOR DISPLACEMENT IN CU IN/REV (DECIMAL POINT ELIMINATED. EXAMPLE 124 = 12.4 CU IN/REV) IF SHIPPED LESS MOTOR, THE MOTOR INTERFACE IS LISTED AS C2A - SAE C SHAFT 2 BOLT SAE “A” MOTOR MOUNT
01	DESIGNATES THE DRUM OPTION (OTHER DRUMS MAY INCLUDE 02, ETC.)
U	DESIGNATES UNDERWOUND CABLE DRUM – OPTIONAL
L	DESIGNATES LEFT HAND BASE – OPTIONAL, BLANK IS STANDARD RIGHT HAND BASE
R	DESIGNATES TENSION ROLLER - OPTIONAL

GENERAL SAFETY RECOMMENDATIONS

Safety and informational callouts used in this manual include:

⚠ WARNING ⚠

WARNING – This emblem is used to warn against hazards and unsafe practices which could result in severe personal injury or death if proper procedures are not followed.

⚠ CAUTION ⚠

CAUTION – This emblem is used to warn against potential or unsafe practices which could result in personal injury or product or property damage if proper procedures are not followed.

Safety for operators and ground personnel is of prime concern. Always take the necessary precautions to ensure safety to others as well as yourself. To ensure safety, the prime mover and hoist must be operated with care and concern by the operator for the equipment and a thorough knowledge of the machine's performance capabilities. The following recommendations are offered as a general safety guide. Local rules and regulations will also apply.

1. Be certain equipment (boom, sheave blocks, pendants, etc.) is either lowered to the ground or blocked securely before servicing, adjusting, or repairing hoist.
2. Be sure personnel are clear of work area BEFORE operating hoist.
3. Read all warning and caution tag information provided for safe operation and service of hoist.
4. Inspect rigging and hoist at the beginning of each work shift. Defects shall be corrected immediately.
5. Keep equipment in good operating condition. Perform scheduled servicing and adjustments listed in the "Preventive Maintenance" section of this manual.
6. An equipment warm-up procedure is required for all start-ups and essential at ambient temperatures below +40°F (4°C). Refer to "Warm-up Procedure" listed in the "Preventive Maintenance" section of this manual.
7. Operate hoist line speeds to match job conditions.
8. Leather gloves shall be used when handling wire rope.
9. Never attempt to handle wire rope when the hook end is not free. Keep all parts of body and clothing clear of cable rollers, cable entry area of fairleads and hoist drum.
10. When winding wire rope on the hoist drum, never attempt to maintain tension by allowing wire rope to slip through hands. Always use "Hand-Over-Hand" technique.
11. Never use wire rope with broken strands. Replace wire rope.
12. Do not weld on any part of the hoist.
13. Use recommended hydraulic oil and gear lubricant.
14. Keep hydraulic system clean and free from contamination at all times.
15. Use correct anchor for wire rope and anchor pocket in drum.
16. Do not use knots to secure or attach wire rope.
17. The BRADEN designed wire rope anchors are capable of supporting the rated load when installed properly. For additional safety, ALWAYS maintain a minimum of five (5) wraps of wire rope on the drum.
18. Never attempt to clean, oil or perform any maintenance on a machine with the engine or prime mover running, unless instructed to do so in this manual.
19. Never operate hoist controls unless you are properly positioned at the operators station and you are sure personnel are clear of the work area.
20. Assure that personnel who are responsible for hand signals are clearly visible and that the signals to be used are thoroughly understood by everyone.
21. Ground personnel shall stay in view of the operator and clear of hoist drum. Do not allow ground personnel near hoist line under tension. A safe distance of at least 1-1/2 times the working length of the cable shall be maintained.
22. Do not exceed the maximum pressure, PSI (kPa), or flow, GPM (LPM), stated in the hoist specifications.
23. Install guarding to prevent personnel from getting any part of body or clothing caught at a point where the cable is wrapped onto the drum or drawn through guide rollers.
24. "Deadman" controls, which automatically shut off power to the hoist whenever the operator leaves his station, should be installed whenever practicable.
25. Never allow anyone to stand under a suspended load.
26. Avoid sudden "shock" loads or attempting to "jerk" load free. This type of operation may cause heavy loads, in excess of rated capacity, which may result in failure of wire rope and hoist.

THEORY OF OPERATION

DESCRIPTION OF WINCH

The hoist has four basic component groups:

1. Hoist base
2. Hydraulic motor and brake valve
3. Brake cylinder with overrunning clutch
4. Cable drum with gear train

The hoist base includes the two end plates, center base section and drum bearing support. The hydraulic motor group includes the motor, manifold block and counterbalance valve cartridge. The brake cylinder contains the multi-disc, spring applied, hydraulically released static brake and the overrunning, sprag-type brake clutch. The cable drum contains the planetary gear set and the ring gear.

The hydraulic motor is bolted to the motor support which in turn is bolted to the brake cylinder and base. The motor end of the drum, running on a ball bearing, is supported by the brake cylinder. The anchor end of the drum runs on a ball bearing supported by the drum bearing support bolted to the base.

The hydraulic motor drives the input sun gear of the planetary gear set through the splined inner race of the overrunning brake clutch. The planetary carrier is splined to the drum bearing support and cannot rotate. As the planet gears are driven by the sun gear, they will drive the ring gear machined into the inside surface of the cable drum.

Dual Brake System – Description

The dual brake system consists of a dynamic brake system and a static brake system.

The dynamic brake system has two operating components:

1. Brake valve assembly
2. Hydraulic motor

The brake valve is basically a counterbalance valve with good metering characteristics. It contains a check valve to allow free flow of oil to the motor in the hoisting direction and a pilot operated, spring-loaded spool valve that blocks the flow of oil out of the motor when the control valve is placed in neutral. When the control valve is placed in the lowering position, the spool valve remains closed until sufficient pilot pressure is applied to shift it against spring pressure and open a passage. After the spool valve cracks open, the pilot pressure becomes flow-dependent and modulates the spool valve opening which controls the lowering speed. Refer to Figures 1& 2.

The static brake system has three operating components:

1. Spring Applied, Multiple Friction Disc Static Brake
2. Overrunning Brake Clutch Assembly
3. Hydraulic Piston and Cylinder

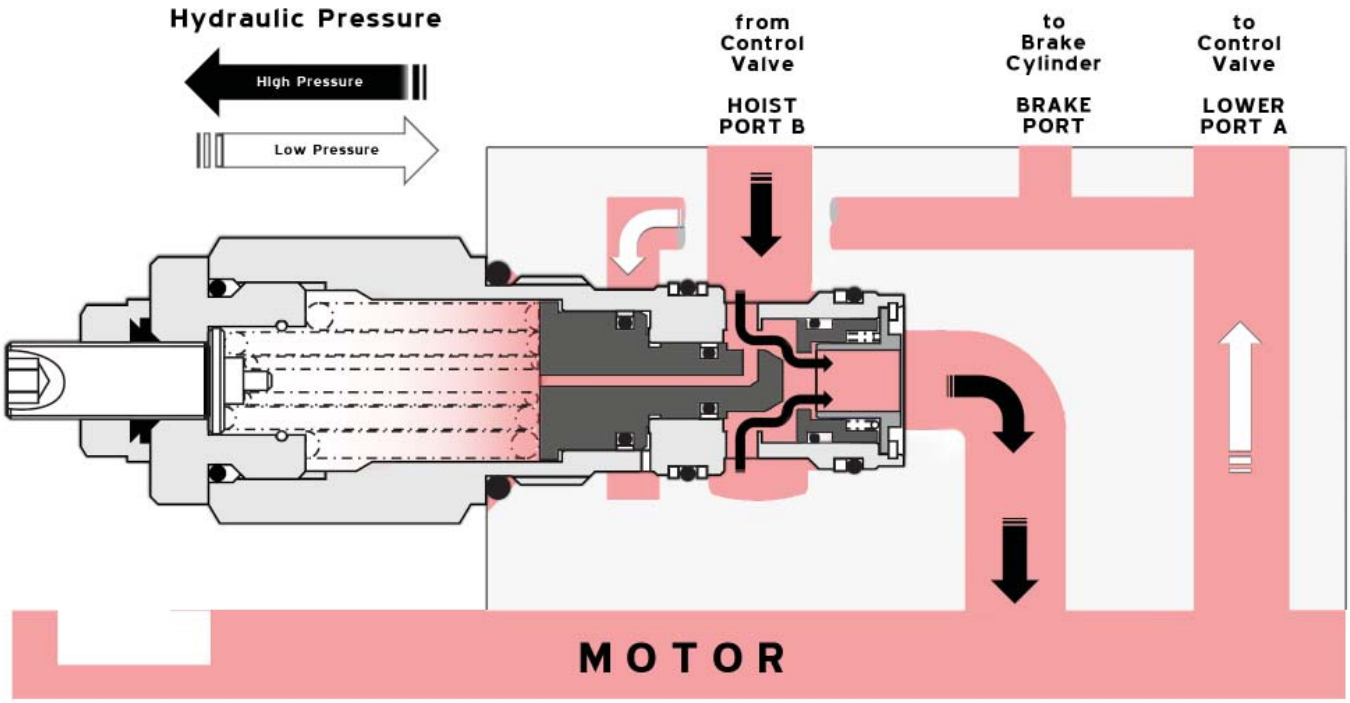


Figure 1 HOISTING

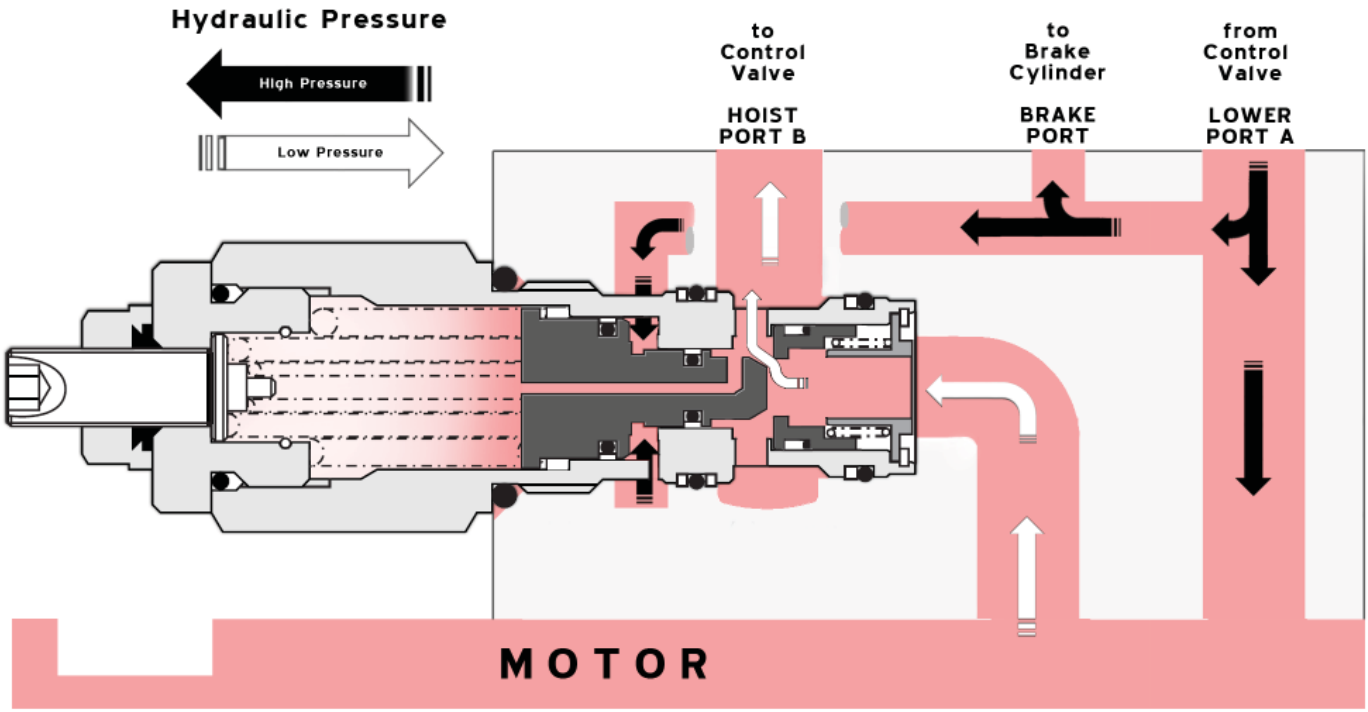


Figure 2 LOWERING

The static brake is released by the brake valve pilot pressure at a pressure lower than that required to open the pilot operated spool valve. This sequence assures that dynamic braking takes place in the brake valve and that little, if any, heat is absorbed by the static brake.

The static brake is a load holding brake only and has nothing to do with dynamic braking or rate of descent of a load.

The overrunning brake clutch is splined to both the sun gear shaft and the motor shaft. It will allow this shaft to turn freely in the direction to raise a load and lock up to force the brake discs to turn with the shaft in the direction to lower a load. Refer to figures 3 and 4.

The hydraulic cylinder, when pressurized, will release the spring pressure on the brake discs, allowing the brake discs to turn freely.

Dual Brake System – Operation

When hoisting a load, the overrunning brake clutch which connects the motor shaft to the planetary sun gear, allows free rotation. The sprag cams lay over and permit the inner race to turn free of the outer race. Figure 3. The static brake remains fully applied. The hoist, in raising a load, is not affected by any braking action. Figure 1.

When the lifting operation is stopped, the load attempts to turn the planetary sun gear in the opposite direction. This reversed input causes the sprag cams to instantly roll upward and firmly lock the shaft to the fully applied static brake. Figure 4.

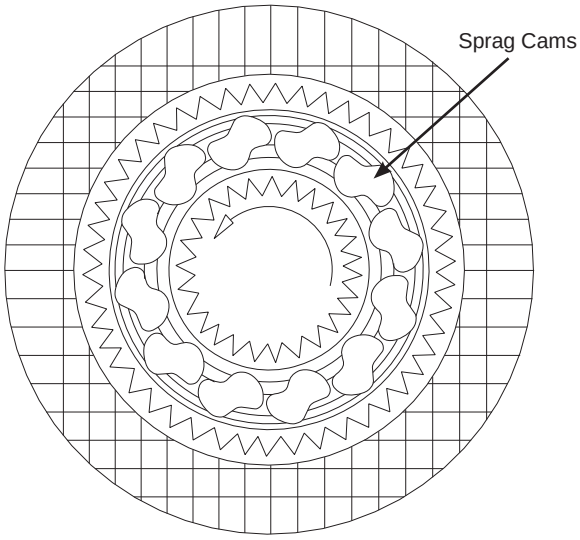
When the hoist is powered in reverse, to lower the load, the motor cannot rotate until sufficient pilot pressure is present to open the brake valve. Figure 2. The static friction brake within the hoist will completely release at a pressure lower than that required to open the brake valve. The extent to which the brake valve opens will determine the amount of oil that can flow through it and the speed at which the load will be lowered. Increasing the flow of oil to the motor will cause the pressure to rise and the opening in the brake valve to enlarge, speeding up the descent of the load. Decreasing this flow causes the pressure to lower and the opening in the brake valve to decrease thus slowing the descent of the load.

When the control valve is shifted to neutral, the pressure will drop and the brake valve will close, stopping the load. The static brake will engage and hold the load after the brake valve has closed.

When lowering a load very slowly for precise positioning, no oil flow actually occurs through the hoist motor. The pressure will build up to a point where the brake will release sufficiently to allow the load to rotate the motor through its own internal leakage. This feature results in a **VERY** slow speed and extremely accurate positioning.
The static brake receives very little wear in the lowering operation. The heat generated by the lowering and stopping of a load is absorbed by the hydraulic oil where it can be readily dissipated.

Figure 3

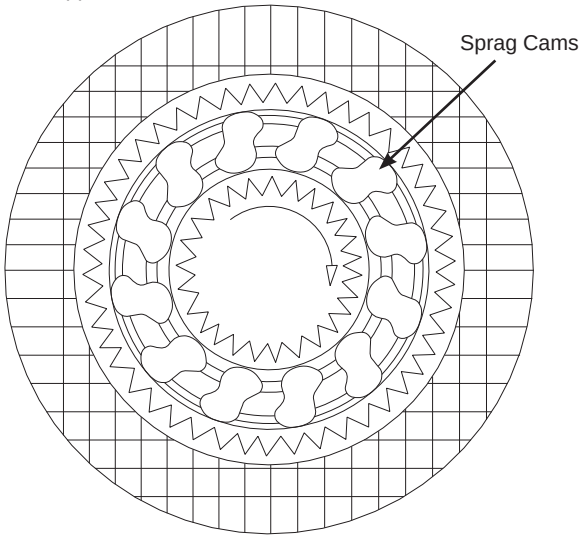
Static Brake Applied



Permits free shaft rotation
while hoisting

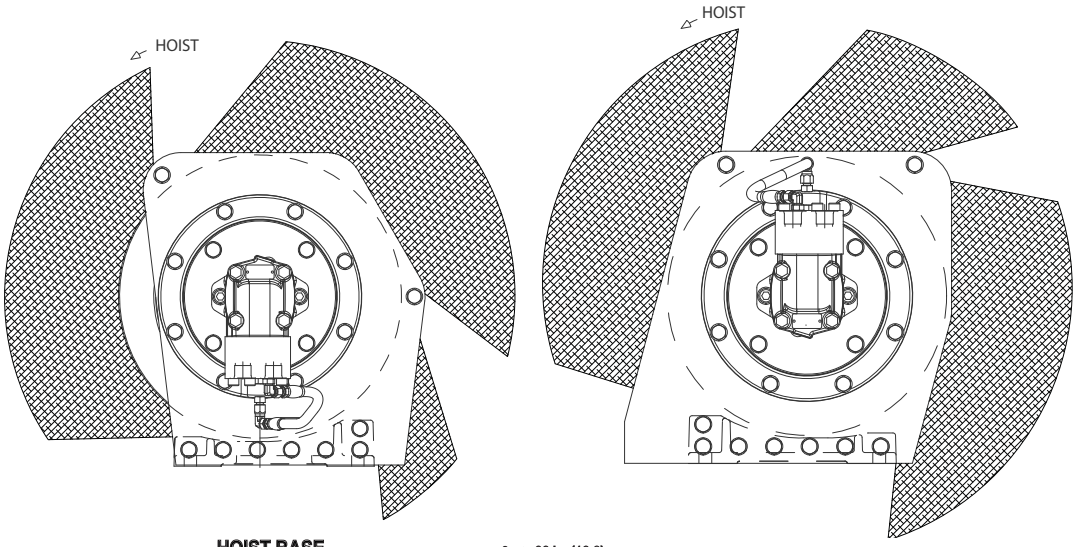
Figure 4

Static Brake Applied

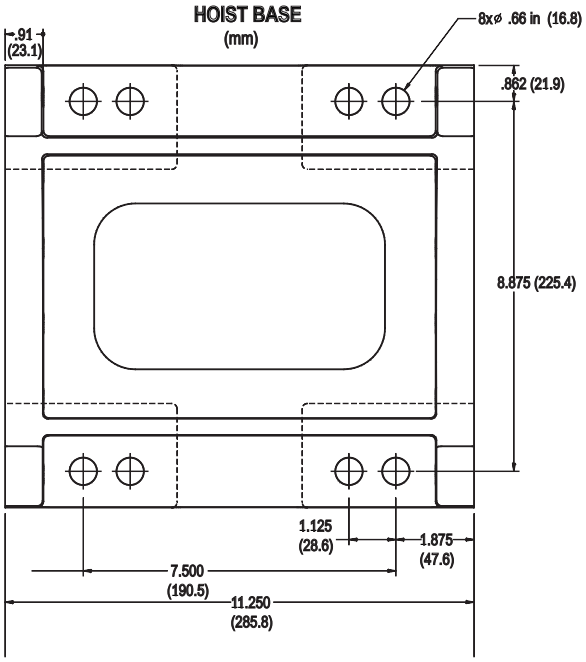


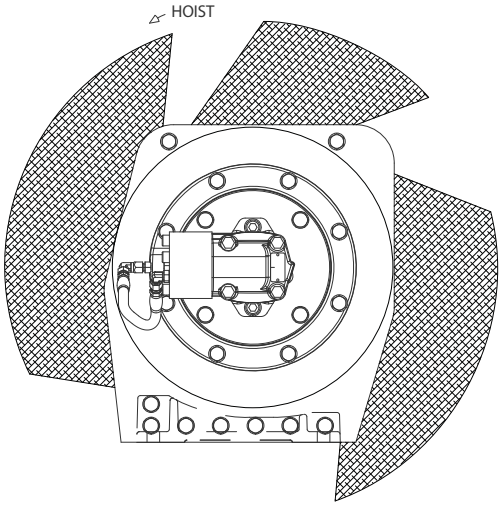
Load attempts to rotate shaft in opposite direction.
Brake clutch locks sun gear shaft to ststic brake discs.

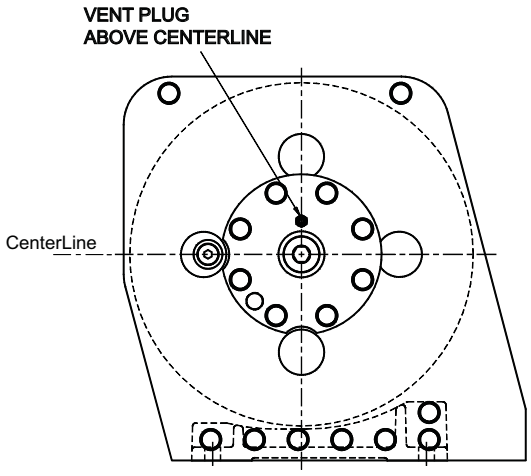
HOIST INSTALLATION



TYPICAL BASE AND SIDE PLATE CONFIGURATION





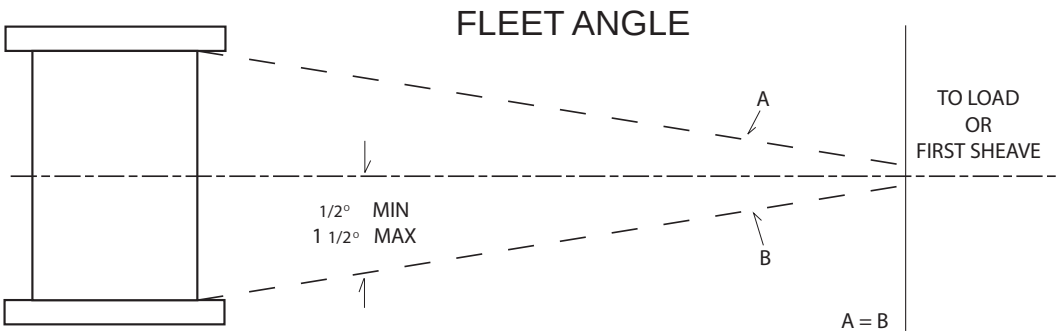


1. The hoist must be mounted with the centerline of the drum in a horizontal position. The mounting plane of the base may be rotated in any position around this centerline as long as the vent plug is located above the horizontal centerline. See Note 4.
2. Because of the design of the mounting base, the direction of line pull should only be as shown in the above illustration. Line pulls in any other direction must be approved by BRADEN Engineering.
3. When mounting the hoist, use all eight (8) mounting holes and 5/8 inch grade 8 capscrews and nuts. Tighten to recommended torque.

The hoist must be mounted on a surface that will not flex when in use and cause binding of the gear train. Binding in the gear train will result in accelerated wear and heat. Also, be sure the hoist is mounted on a flat surface. If necessary, use shim stock to insure the mounting surface is flat within 0.020 in. (0.5 mm). Use stainless steel shim stock as required.

4. The vent plug must always be located above the horizontal centerline. If the hoist is mounted on a pivoting surface, be sure vent plug remains above the centerline in all positions. If necessary, reposition bearing support and vent plug as follows:

   A. Remove bearing support capscrews.
   B. Rotate bearing support until vent plug is positioned correctly and bolt holes are aligned.
   C. Evenly tighten capscrews to recommended torque.

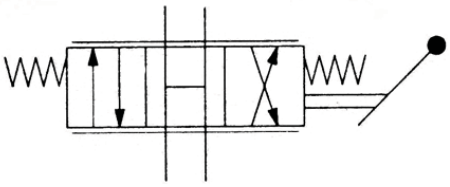


5. Hydraulic lines and components that operate the hoist should be of sufficient size to assure minimum back pressure at the hoist motor. Back pressure shall not exceed 100 psi (690 kPa) for optimum motor performance and brake holding capacity. For back pressures exceeding 150 psi (1,030 kPa) consult BRADEN.

6. The hoist shall be mounted perpendicular to an imaginary line from the center of the drum to the first sheave to insure even wire rope spooling. Make certain the fleet angle does not exceed 1-1/2 degrees. See illustration above.

⚠ WARNING ⚠

DO NOT use a control valve with any detents or latching mechanism that would hold the control valve in an actuated or running position when the operator releases the control handle. Use of the wrong type of control valve could lead to unintentional operation of the hoist, which could result in property damage, personal injury, or death.



The directional control valve must be a three position, four- way valve without detents and with a spring centered motor spool such that the valve returns to the centered position whenever the handle is released, and both work ports are open to tank (open center, open port).

7. High quality hydraulic oil is essential for satisfactory performance and long hydraulic component life.

Oil having 150 to 330 SUS (30-60 cSt) viscosity at 104°F (40°C) and viscosity index of 100 or greater will give good results under normal temperature conditions. The use of an oil having a high viscosity index will minimize cold-start trouble and reduce the length of warm-up periods. A high viscosity index will minimize changes in viscosity with corresponding changes in temperature.

Maximum cold weather start-up viscosity should not exceed 5000 SUS (1000cSt) with a pour point at least 20°F (11°C) lower than the minimum temperature.

Under continuous operating conditions the temperature of the oil at any point in the system must not exceed 180° (82°C). Optimum oil temperature is generally considered to be 120-140°F (49-60°C).

In general terms; for continuous operation at ambient temperatures between 50 and 110°F (10 to 43°C) use ISO 46; for continuous operation between 10 and 90°F (-12 to 32°C) use ISO 32; for applications colder than 10°F (-12°C), contact BRADEN. The use of multi-viscosity oils is generally not recommended.

8. The hydraulic oil filter should have a 10 micron nominal rating and be full flow type and meet the requirements of the hydraulic pump manufacturer.

RECOMMENDED FASTENER TORQUE

Higher or lower torques for special applications will be specified.

Lubricated torque values based on use of SAE 30 engine oil applied to threads and face of fastener.

Avoid using thread lubricants (such as anti-seize compound) as the applied torque may vary by 10 - 40%, depending upon the product used.

Bolt Diam. Inches	Thread per inch	Torque LB-FT (N.m)			
		Grade 5		Grade 8	
		Dry	Lubed	Dry	Lubed
1/4	20 28	8 (11)	6 (8)	12 (16)	9 (12)
5/16	18 24	17 (23)	13 (17)	24 (33)	18 (24)
3/8	16 24	31 (42)	23 (31)	45 (61)	35 (47)
7/16	14 20	50 (68)	35 (47)	70 (95)	50 (68)
1/2	13 20	75 (102)	55 (75)	110 (149)	80 (108)
9/16	12 18	110 (149)	80 (108)	150 (203)	110 (149)
5/8	11 18	150 (203)	115 (156)	210 (285)	160 (217)

Bolt Diam. Inches	Thread per inch	Torque LB-FT (N.m)			
		Grade 5		Grade 8	
		Dry	Lubed	Dry	Lubed
3/4	10 16	265 (359)	200 (271)	380 (515)	280 (380)
7/8	9 14	420 (569)	325 (441)	600 (813)	450 (610)
1	8 14	640 (868)	485 (658)	910 (1234)	680 (922)
1 1/8	7 12	790 (1071)	590 (800)	1290 (1749)	970 (1315)
1 1/4	7 12	1120 (1518)	835 (1132)	1820 (2468)	1360 (1817)
1 3/8	6 12	1460 (1979)	1095 (1485)	2385 (3234)	1790 (2427)
1 1/2	6 12	1940 (2360)	1460 (1979)	3160 (4284)	.2370 (3214)

To convert LB-FT to Kg-m, multiply LB-FT value by 0.1383

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WIRE AND BRAIDED ROPE INSTALLATION

ANCHORING WIRE ROPE

Take the free end of the wire rope and insert it through the small opening of the anchor pocket. Loop the wire rope and push the free end about half of the way back through the pocket. Install the wedge, then pull the slack out of the wire rope. The wedge will slip into the pocket and secure the wire rope into the drum.

CORRECT INSTALLATION

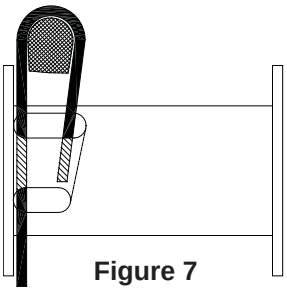


Figure 7

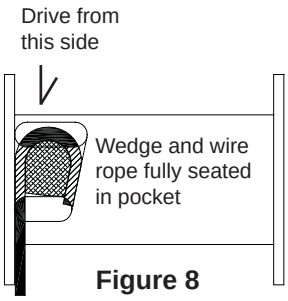


Figure 8

INCORRECT INSTALLATION

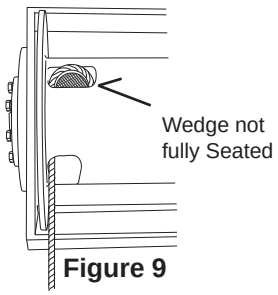


Figure 9

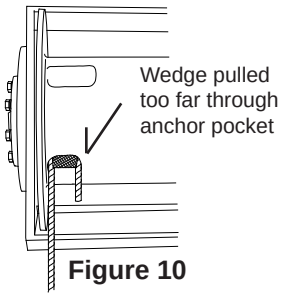


Figure 10

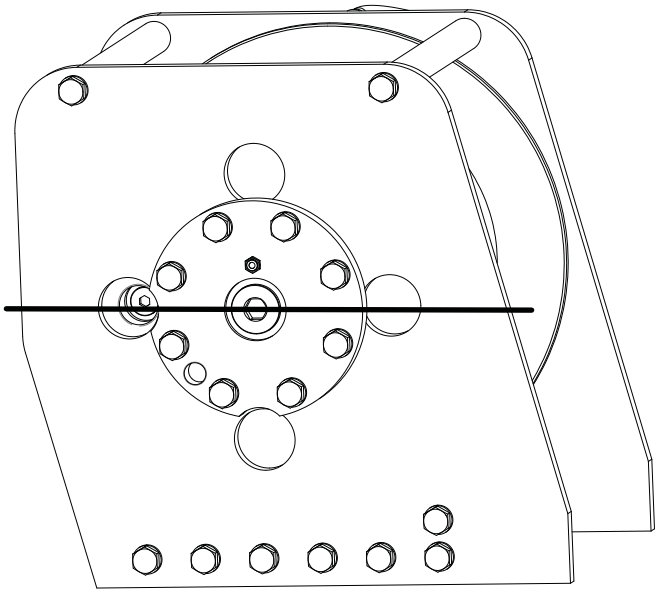
PREVENTIVE MAINTENANCE

A regular program of preventive maintenance for your planetary hoist is required to minimize the need for emergency servicing and promote safe, reliable hoist operation.

Field experience, supported by engineering tests, indicate the three (3) service procedures listed below are the MOST critical to safe, reliable hoist operation and **MUST** be observed.

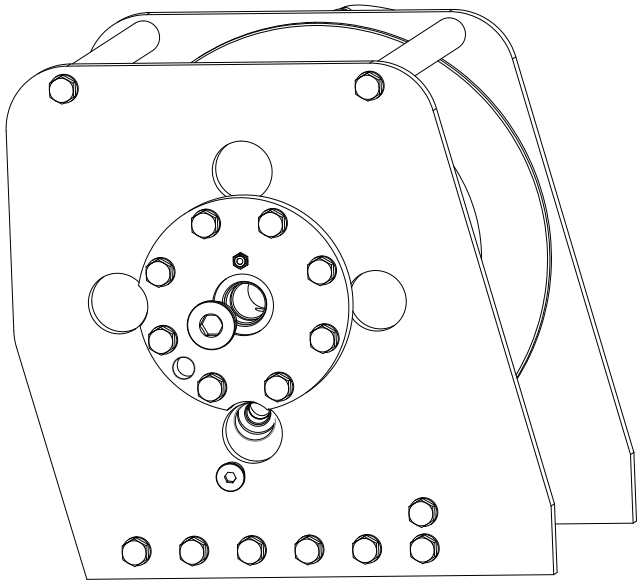
- Regular Gear Oil Changes – every 1000 hours or six (6) months
- Use of Proper Gear Oil – recommended type for prevailing ambient temperature
- Periodic disassembly and inspection of all wear items.

The following minimum service intervals are specified for operating hours of the prime mover.

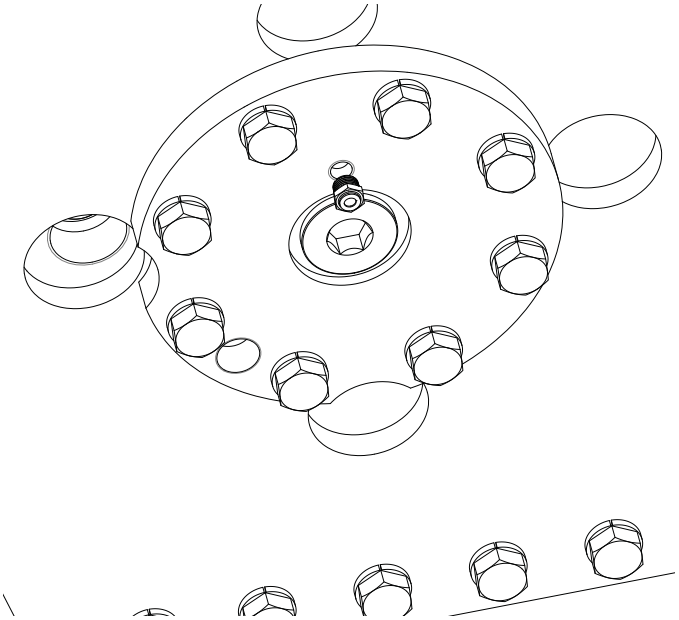


1. **OIL LEVEL**
   The gear oil level should be checked every 500 operating hours or three (3) months, whichever occurs first or whenever an oil leak is detected. To check the oil level, remove the large plug located in the center of the drum support. The oil should be level with the bottom of this opening or approximately half-way up in a sight glass. **This is extremely important due to the accelerated wear that can be caused by insufficient lubricating oil in the hoist.** If additional oil in needed, refer to “Recommended Planetary Gear Oil”.

2. **OIL CHANGE**
   The gear oil must be changed after the first one hundred (100) hours of operation, then every 1,000 operating hours or six (6) months, whichever occurs first. The gear oil must be changed to remove wear particles that impede the reliable and safe operation of the brake clutch and erode bearings, gears and seals. Failure to change gear oil at these suggested minimum intervals may contribute to intermittent brake slippage which could result in property damage, severe personal injury or death.



The gear oil should also be changed whenever the ambient temperature changes significantly and an oil from a different temperature range would be more appropriate. Oil viscosity with regard to ambient temperature is critical to reliable brake clutch operation. Our tests indicate that excessively heavy or thick gear oil may contribute to intermittent brake clutch slippage. Make certain that the gear oil viscosity used in your hoist is correct for your prevailing ambient temperature. Failure to use the proper type and viscosity of planetary gear oil may contribute to brake clutch slippage which could result in property damage, severe personal injury or death. Refer to “Recommended Planetary Gear Oil” for additional information.



3. **VENT PLUG**
   The vent plug is located in the drum support as shown. It is very important to keep this vent clean and unobstructed. Whenever gear oil is changed, remove vent plug, clean in solvent and reinstall.

Do not paint over the vent or replace with a solid plug.

4. **HYDRAULIC SYSTEM**
   The original filter element should be replaced after the first fifty (50) hours of operation, then every 500 operating hours or three (3) months, or in accordance with the equipment manufacturer's recommendations.

5. **WIRE ROPE AND RIGGING**
   Inspect entire length of wire rope according to wire rope manufacturers recommendations.

6. **MOUNTING BOLTS**
   Tighten all hoist base mounting bolts to recommended torque after the first one hundred (100) hours of operation, then every 1000 operating hours or six (6) months, whichever occurs first.

⚠ WARNING ⚠

Failure to properly warm up the hoist, particularly under low ambient temperature conditions, may result in temporary brake slippage due to high back pressures attempting to release the brake, which could result in property damage, severe personal injury or death.

7. **WARM-UP PROCEDURES**
   A warm-up procedure is required at each start-up and is essential at ambient temperatures below +40°F (4°C).

   The prime mover should be run at its lowest recommended RPM with the hydraulic hoist control valve in neutral allowing sufficient time to warm up the system. The hoist should then be operated with no load at low speeds, raise and lower, several times to prime all lines with warm hydraulic oil, and to circulate gear lubricant through the planetary gear set.

8. **INSPECTION**

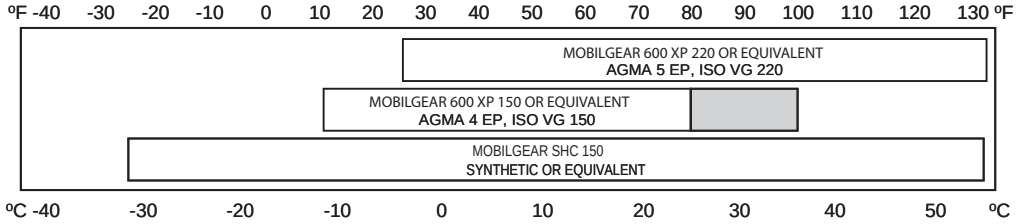
   A. **Bearings and Gears** –
   Refer to DISASSEMBLY OF HOIST, page 20; and PLANET CARRIER SERVICE, page 23.

   B. **Brake Cylinder** –
   Refer to MOTOR SUPPORT – BRAKE CYLINDER SERVICE, pages 25 and 26.

   C. **Brake Clutch** –
   Refer to BRAKE CLUTCH SERVICE, page 28.

RECOMMENDED PLANETARY GEAR OIL

PREVAILING AMBIENT TEMPERATURE



NOTE: *SHADED TEMPERATURE RANGE IN THE CHART ABOVE NOT RECOMMENDED FOR SEVERE APPLICATIONS SUCH AS: OFFSHORE CRANES, SUSTAINED FAST DUTY CYCLES OR FREQUENT LIFTING.*

Planetary hoists are factory filled with Mobilgear 600 XP 150, or equivalent. Consult your oil supplier for other equivalent oils if required.

Mobil	Shell	Chevron	Texaco
Mobilgear 600 XP 150	Omala 150	Gear Compounds EP 150	Meropa 150
Mobilgear 600 XP 220	Omala 220	Gear Compounds EP 220	Meropa 220

OIL CAPACITIES: 4 Pints (1.91)

NOTE: Oil capacity is approximate. Refer to "Oil Level" earlier in this section

⚠ WARNING ⚠

Failure to use the proper type and viscosity of planetary gear oil may contribute to intermittent brake clutch slippage which could result in property damage, severe personal injury or death. Some gear lubricants contain large amounts of EP (extreme pressure) and anti-friction additives which may contribute to brake clutch slippage and damage to brake friction discs or seals. Oil viscosity with regard to ambient temperature is also critical to reliable brake clutch operation. Our tests indicate that excessively heavy or thick gear oil may contribute to intermittent brake clutch slippage. Make certain that the gear oil viscosity used in your hoist is correct for your prevailing ambient temperature.

9. **RECOMMENDED PLANETARY GEAR OIL**
   Use of the proper planetary gear oil is essential to reliable and safe operation of the brake clutch and obtaining long gear train life.

For simplicity, BRADEN has listed one (1) readily available product in each temperature range which has been tested and found to meet our specifications.

TROUBLESHOOTING

⚠ WARNING ⚠

If a hoist ever exhibits any sign of erratic operation, or load control difficulties (i.e. load creeping or chattering) appropriate troubleshooting tests and repairs should be performed immediately. Continued operation in this manner may result in property damage, serious personal injury or death.

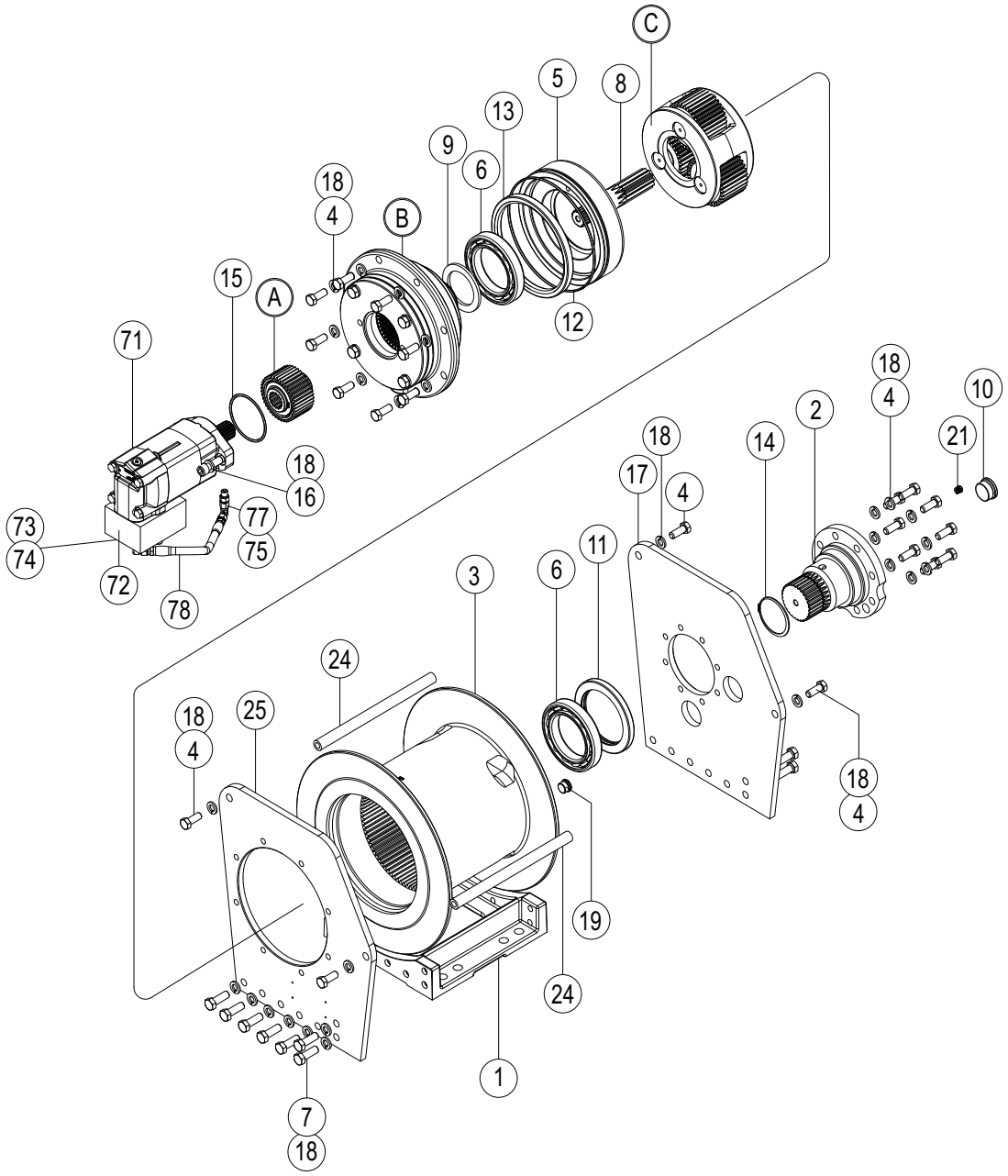
TROUBLE	PROBABLE CAUSE	REMEDY
A The hoist will not lower the load or not lower the load smoothly.	1. The friction brake may not be releasing as a result of a defective brake cylinder seal. **NOTE:** If the brake cylinder seal is defective you will usually find oil leaking from the hoist vent relief plug. 2. Friction brake will not release as a result of damaged brake discs. 3. The counterbalance valve may be sticking due to contamination.	Check brake cylinder seal as follows: A. Disconnect the hose from the brake release port. Connect a hand pump with accurate 0-2000 psi gauge and shut-off valve to the –4 J.I.C. fitting in the brake release port. Disassemble brake to inspect brake discs. Check stack-up height as described in “Motor Support-Brake Cylinder Service”. B. Apply 1000 PSI (6,900 kPa) to the brake. Close shut-off valve and let stand for five (5) minutes. C. If there is any loss of pressure in five (5) minutes, the brake cylinder should be disassembled for inspection of the sealing surfaces and replacement of the seals. Refer to “Motor Support-Brake Cylinder Service”. A. Remove the counterbalance valve cartridge from the brake valve manifold block. Clean in safety solvent and install. Retest. Internal components of cartridge are not servicable; replace cartridge.

TROUBLE	PROBABLE CAUSE	REMEDY
B Oil leaks from vent plug.	1. Same as A1. 2. Motor seal may be defective as a result of high system back pressure or contaminated oil.	Same as A1. System back pressure must not exceed 150 PSI (1,035 kPa). Inspect hydraulic system for a restriction in the return line from the control valve to the reservoir. Be sure control valve and plumbing is properly sized to hoist motor. Oil analysis may indicate contamination has worn motor shaft and seal. Thoroughly flush entire hydraulic system and install new filters and oil. Install new motor seal.
C The brake will not hold a load with the control lever in neutral.	1. Excessive system back pressure acting on the brake release port. 2. Friction brake will not hold due to worn or damaged brake discs. 3. Brake clutch is slipping.	The same as Remedy 2 of Trouble B2. Same as Remedy 2 of Trouble A2. Improper planetary gear oil may cause the brake clutch to slip. Drain old gear oil and flush hoist with solvent. Thoroughly drain solvent and refill hoist with recommended planetary gear oil listed in “Preventive Maintenance”. Brake clutch may be damaged or worn. Disassemble and inspect brake clutch as described in “Brake Clutch Service”.

TROUBLE	PROBABLE CAUSE	REMEDY
D		
The hoist will not hoist the rated load.	1. The hoist may be mounted on an uneven or flexible surface which causes distortion of the hoist base and binding of the gear train. Binding in the gear train will absorb horsepower needed to hoist the rated load and cause heat.	Reinforce mounting surface. If necessary, use shim stock to level hoist. Refer to “Hoist Installation”. First loosen, then evenly retighten all hoist mounting bolts to recommended torque.
	2. System relief valve may be set too low. Relief valve needs adjustment or repair.	Check relief pressure as follows: A. Install an accurate 0-4000 psi (27,580 kPa) gauge into the inlet port of the brake valve. B. Apply a stall pull load on the hoist while monitoring pressure. C. Compare gauge reading to hoist specifications. Adjust relief valve as required. NOTE: If pressure does not increase in proportion to adjustment, relief valve may be contaminated or worn out. In either case, the relief valve may require disassembly or replacement.
	3. Be certain hydraulic system temperature is not more than 180 degrees F (82 deg. C). Excessive hydraulic oil temperatures increase motor internal leakage and reduce motor performance.	Same as remedies for Trouble D1 & D2. Same as remedies for Trouble E2.
	4. Hoist line pull rating is based on 1st layer of wire rope.	Refer to hoist performance charts for additional information.
	5. Rigging and sheaves not operating efficiently.	Perform rigging service as recommended by crane manufacturer.
E		
The hoist runs hot.	1. Same as D1.	Same as remedies for Trouble D1.
	2. Be certain that the hydraulic system temperature is not more than 180 degrees F (82 deg. C). Excessive hydraulic oil temperatures may be caused by:	
	A. Plugged heat exchanger.	Thoroughly clean exterior and flush interior.
	B. Too low or too high oil level in hydraulic reservoir.	Fill/drain to proper level.
	C. Same as D2.	Same remedies as D2

TROUBLE	PROBABLE CAUSE	REMEDY
E The hoist runs hot.	D. Hydraulic pump not operating efficiently.	Same as remedies for Trouble D2. Prime mover low on horsepower or R.P.M. Tune/adjust prime mover. Check suction line for damage. If pump is belt driven, belts are slipping. Replace/tighten belts. Pump worn. Replace pump.
	3. Excessively worn or damaged internal hoist parts.	Disassemble hoist to inspect/replace worn parts.
F Hoist “chatters” while raising rated load.	1. Same as D2.	Same as remedies for Trouble D2.
	2. Hydraulic oil flow to motor may be too low.	Same as remedies for Trouble E2.
	3. Controls being operated too quickly.	Conduct operator training as required.
G The wire rope does not spool smoothly on the drum.	1. The hoist may be mounted too close to the main sheave, causing the fleet angle to be more than 1-1/2 degrees.	Check mounting distance and fleet angle. Reposition hoist as required.
	2. The hoist may not be mounted perpendicular to an imaginary line between the center of the cable drum and the first sheave.	Refer to “Hoist Installation”.
	3. Could possibly be using the wrong lay rope. There is a distinct advantage in applying rope of the proper direction of lay. When the load is slacked off, the several coils on the drum will stay closer together and maintain an even layer. If rope of improper lay is used, the coils will spread apart each time the load is removed. Then, when winding is resumed, the rope has a tendency to criss-cross and overlap on the drum. The result is apt to be a flattened and crushed rope.	Consult wire rope manufacturer for recommendation of wire rope that best suits your application.
	4. The hoist may have been overloaded, causing permanent set in the wire rope.	Replace wire rope and conduct operator/rigger training as required.

BRADEN PD7C COMPONENTS



ITEM	DESCRIPTION	QTY
1	Base	1
2	Bearing Support	1
3	Cable Drum	1
4	Capscrew (1/2 - 13 X 1 1/4 GD8)	20
5	Cable Drum Closure	1
6	Ball Bearing	2
7	Capscrew (1/2 - 13 X 1 1/2 GD8)	14
8	Sun Gear	1
9	Thrust Washer	1
10	Plug	1
11	Oil Seal	1
12	O-Ring	1
13	Oil Seal	1
14	Retaining Ring, External	1
15	O-Ring	1

ITEM	DESCRIPTION	QTY
16	Capscrew (1/2 - 13 X 1 1/2 GD8) (NS)	2
17	Side Plate, Support	1
18	Lockwasher (1/2)	36
19	Plug, O-Ring Flush	1
20	Cable Wedge (NS)	1
21	Vent Relief Valve	1
24	Spacer	2
25	Side Plate, Motor	1
71	Motor	1
72	Brake Valve	1
73	Capscrew	3
74	Hex Head Plug	1
75	Elbow Fitting	1
77	Swivel Nut	1
78	Hose Assy	1

HOIST DISASSEMBLY

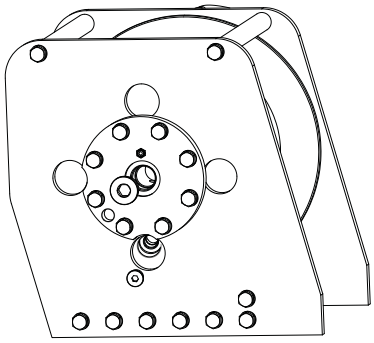
SERVICE PRECAUTIONS

- Before any part is removed from the hoist, all service instructions should be read and understood.
- Work in a clean, dust free area as cleanliness is of utmost importance when servicing hydraulic equipment.
- Inspect all replacement parts, prior to installation, to detect any damage which might have occurred in shipment.
- Use only genuine BRADEN replacement parts for optimum results. Never reuse expendable parts such as oil seals and O-rings.
- Inspect all machined surfaces for excessive wear or damage . . . before reassembly operations are begun.
- Lubricate all O-rings and oil seals with gear oil prior to installation.
- Use a sealing compound on the outside surface of oil seals and a light coat of thread sealing compound on pipe threads. Avoid getting thread compound inside parts or passages which conduct oil.
- Thoroughly clean all parts in a good grade of non-flammable safety solvent. Wear protective clothing as required.

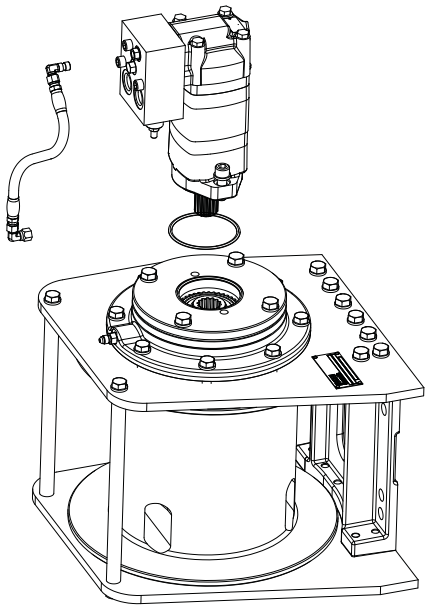
After troubleshooting the hoist and its hydraulic system as covered in the “Troubleshooting” section, and the problem is determined to be in the hoist, use the following procedure to disassemble the hoist.

1. Remove the wire rope from the cable drum and align the drain hole in the drum with a hole in the support side plate before removing the hoses and mounting bolts. After the hoist is removed from its mounting, thoroughly clean the outside surfaces. To drain the oil, install a short piece of 1 inch pipe in the larger threads of the drain hole. If necessary, insert a bar into the anchor pocket and manually rotate the drum in the direction to hoist a load until the drain holes are aligned.

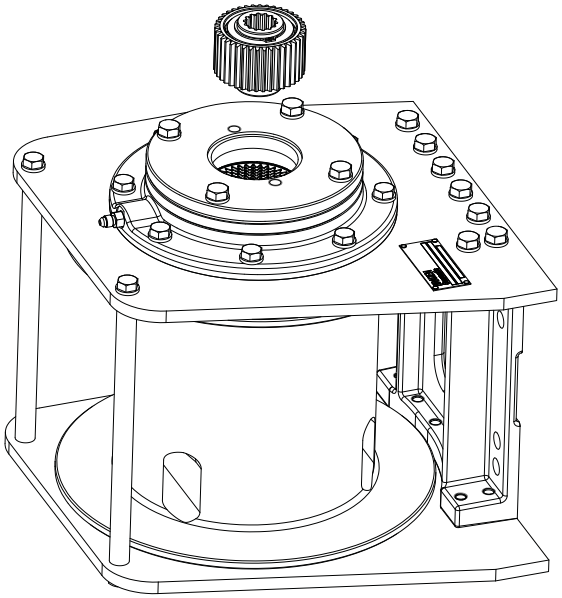
2. Use a 5/16 inch Allen wrench to remove the drain plug through the pipe. Drain oil into a suitable container and recycle oil in an environmentally acceptable manner.



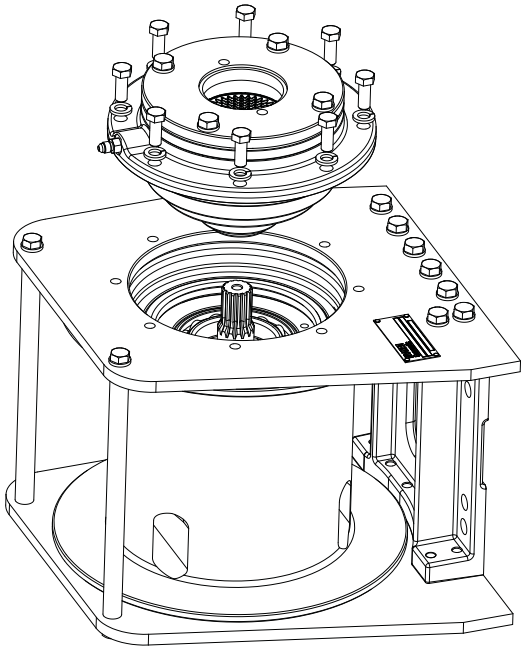
3. Begin disassembly by removing the oil level plug or sight glass and standing the hoist on the bearing support end. Tag and remove the hydraulic hose that connects the brake valve and manifold to the brake cylinder.



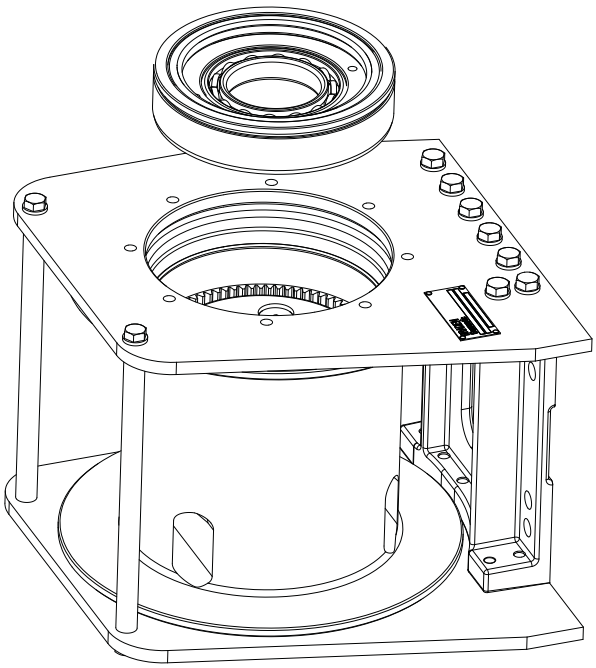
4. Remove the capscrews securing the motor, and lift the motor off the hoist. Remove and discard the O-ring installed on the pilot of the motor.



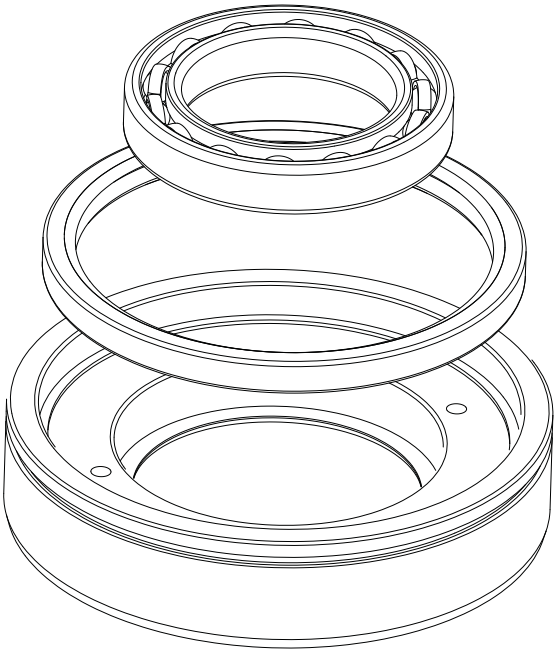
5. Remove the brake clutch assembly from the motor support. Refer to “Brake Clutch Service” for additional information.



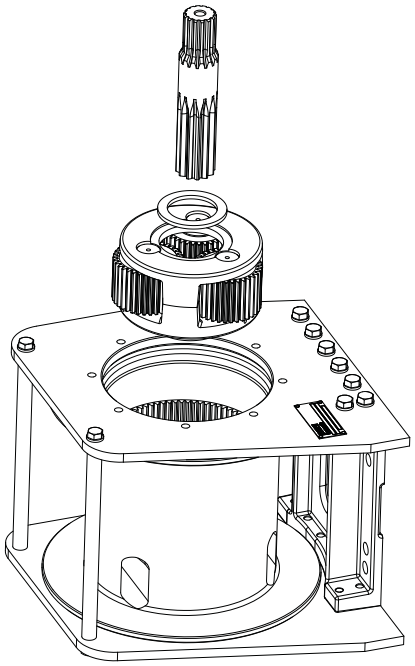
6. Remove the brake cylinder capscrews and install two (2) capscrews and a short piece of chain into the motor support mounting bolt holes. Using the chain as a handle, lift the brake cylinder out of the drum and base, being careful to avoid damaging the sealing or bearing surfaces. Refer to “Motor Support-Brake Cylinder Service” for additional information.



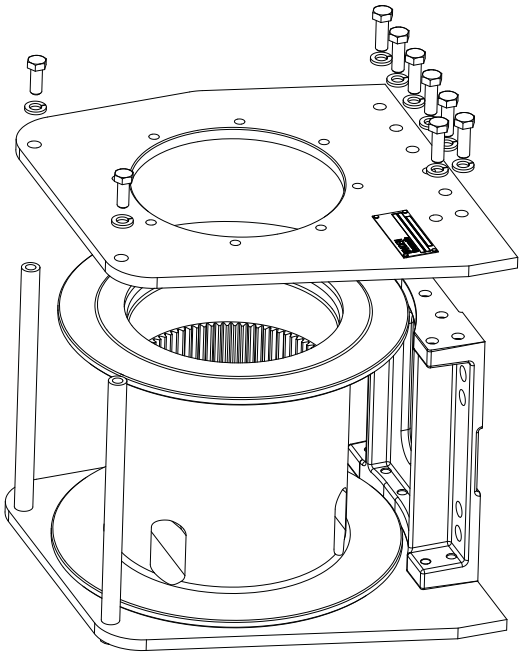
7. Using two heel-type pry bars placed between the planet carrier and the drum closure, pry upward to remove the drum closure. Remove and discard the O-ring from the outside of the drum closure. The drum closure has two, 3/8-16 tapped lifting eye holes that may be used in place of the heel bars.

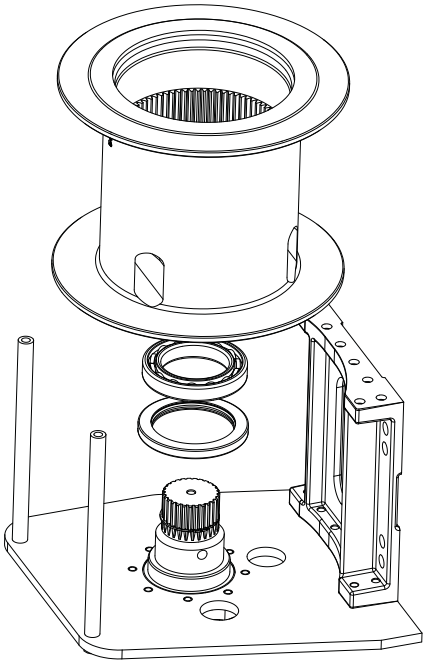


Remove the seal and bearing from inside of closure.



8. Remove the sun gear and thrust washer from the planet carrier. Remove the planet carrier from the drum. Refer to “Planet Carrier Service” for additional information.



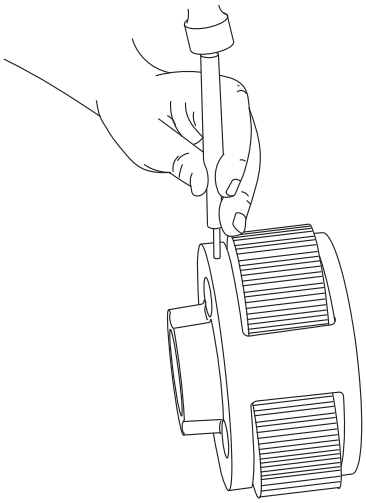


9. Remove drum from bearing support. Turn drum over on work bench and remove seal and bearing from support end of drum.

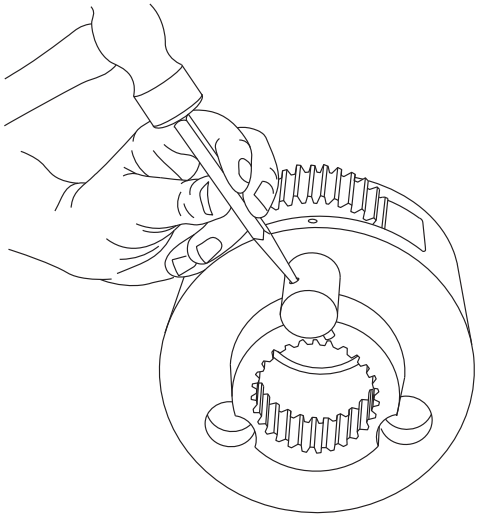
10. Thoroughly clean and inspect drum and base. Check ring gear (machined into inside surface of drum) teeth for nicks, spalling or excessive wear. Replace drum if wear is greater than 0.015 in. (0.4 mm) when compared to unworn area of ring gear teeth.

PLANET CARRIER SERVICE

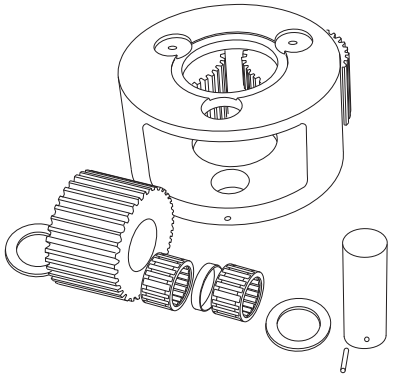
DISASSEMBLY



1. Remove the planet gears by driving the roll pins into the center of the planet shafts. Slide the planet shafts out of the carrier.

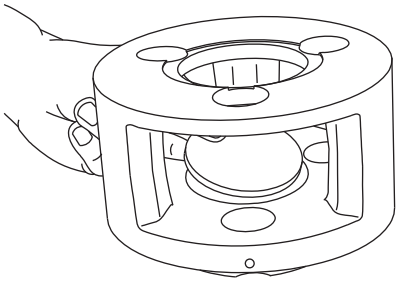


2. Use a punch to drive the roll pins from the planet shafts. Do not reuse the roll pins.

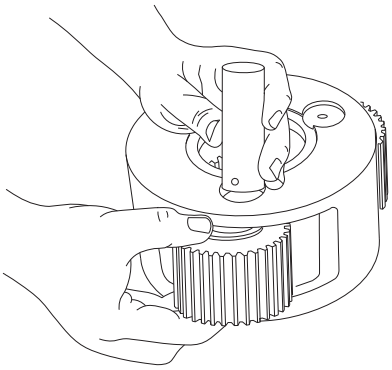


3. Now you can remove the planet shafts, bearings, spacer, thrust washers and gears. Thoroughly clean all parts and inspect for damage and wear. The bearing rollers should not exhibit any irregularities. If the rollers show any sign of spalling, corrosion, discoloration, material displacement or abnormal wear, the bearing must be replaced. Likewise, the cage should be inspected for unusual wear or deformation, particularly the cage bars. If there is any damage that will impair the cage's ability to separate, retain and guide the rollers properly, the bearing must be replaced. The thrust washer contact areas should be free from any surface irregularities that may cause abrasions or friction. The gears and shafts should be inspected for abnormal wear or pitting. Replace if damaged or worn accessively.

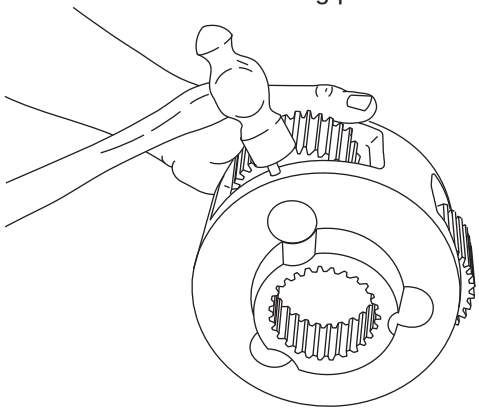
ASSEMBLY



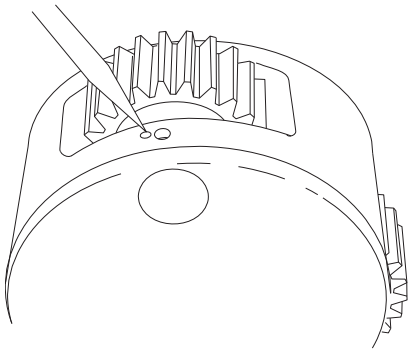
1. Place the planet carrier on workbench with splined coupling side down. Install thrust plate in center of carrier.



2. Insert two (2) bearings and a bearing spacer into a gear with the spacer between the bearings. Place a thrust washer on each side of the gear and position in a carrier opening. Slide the shaft through the carrier, thrust washer, bearing-gear sub-assembly and remaining thrust washer. Be careful to avoid damaging thrust washers when installing planet shafts.



3. Carefully align the pin hole in the carrier with the hole in the planet gear shaft and drive the roll pin into place. Always use NEW roll pins. When properly positioned, 50% of the roll pin will engage the planet gear shaft and 50% will remain in the planet carrier.

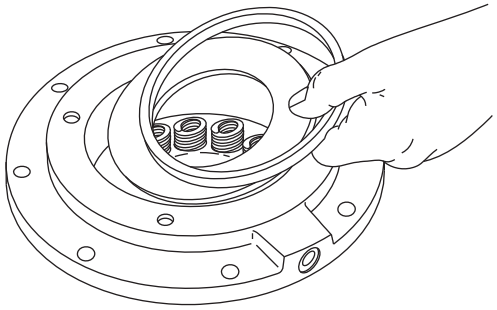


4. Note that the roll pin is slightly recessed in the carrier when properly installed. With a center punch, stake the carrier next to the pin hole as shown. This will distort the hole so the pin will not back out. Repeat these steps for each of the three planet gears.

MOTOR SUPPORT-BRAKE CYLINDER SERVICE

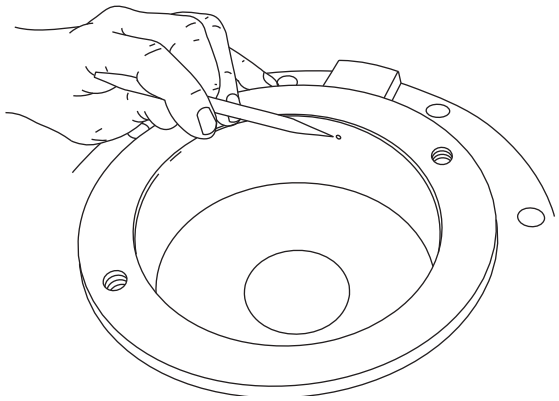
DISASSEMBLY

1. Remove the motor support and brake clutch assembly. Continue brake cylinder disassembly by removing the spacer, friction brake discs and steel brake discs.

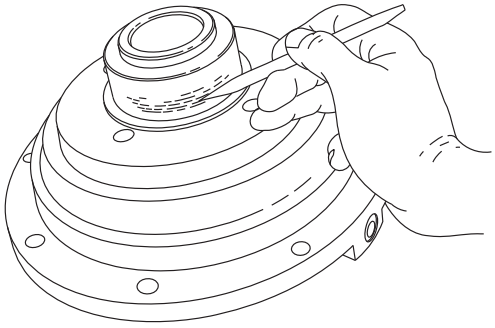


2. Remove the piston back-up ring and pressure plate. Remove the brake springs.

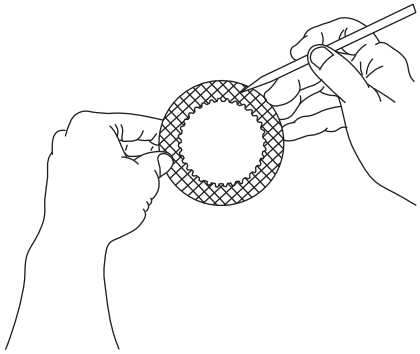
CLEAN AND INSPECT



1. Thoroughly clean and inspect all parts at this time. Check brake piston sealing surfaces on brake cylinder and motor support. Be sure brake release port is free of contamination.

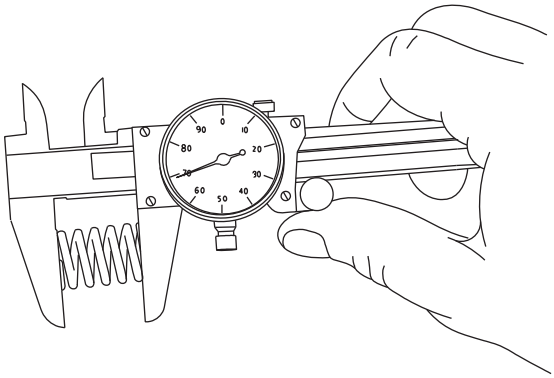


2. Check oil seal and bearing surfaces on brake cylinder for damage or wear.



3. Place friction brake disc on flat surface and check for distortion with a straight edge. Friction material should appear even across entire surface with groove pattern visible. Replace friction disc if splines are worn to a point, disc is distorted, friction material is worn unevenly, or groove pattern is worn away.

4. Place steel brake disc on flat surface and check for distortion with a straight edge. Check surface for signs of material transfer or heat. Replace steel disc if lobes are worn, disc is distorted or heat discolored.

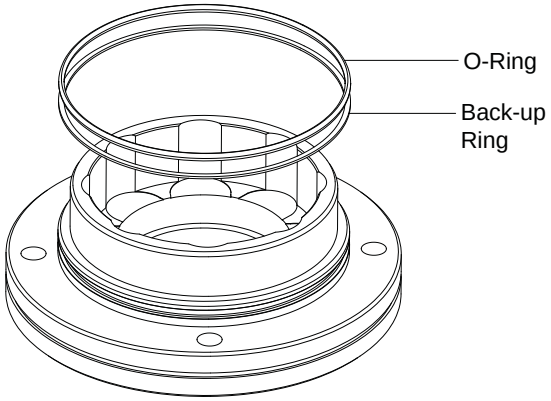


5. Check brake spring free length; minimum free length is 1.188 inch (30.2 mm). Check springs for any sign of cracking or failure. If a brake spring must be replaced for any reason, then ALL brake springs must be replaced.

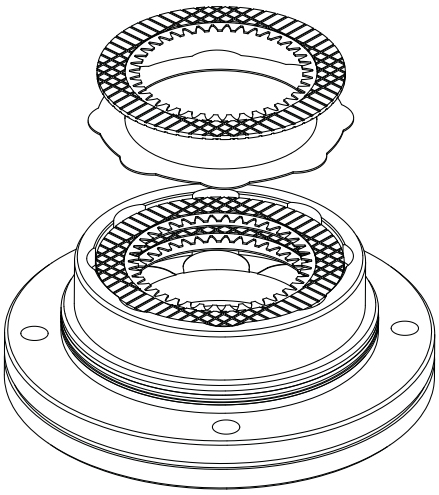
⚠CAUTION⚠

Failure to replace brake springs as a set may result in uneven brake application pressure and repeated brake spring failure.

ASSEMBLY

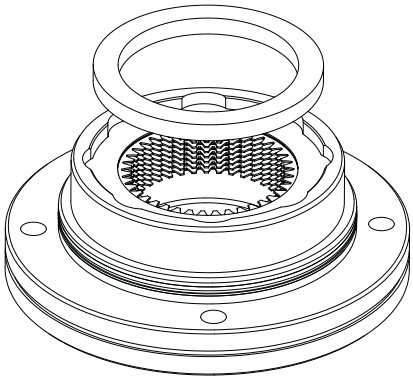


1. Begin assembly by placing motor support on workbench with motor mounting surface down. Install new O-ring and back-up ring as shown.

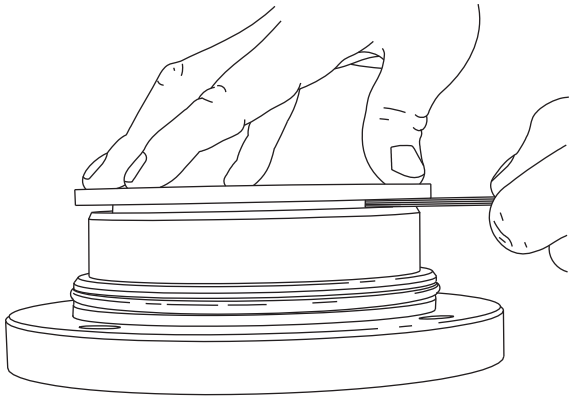


2. Insert first, a steel brake disc against the motor support followed by a friction brake disc then alternate steel and friction discs until nine (9) friction and ten (10) steel discs have been installed. Finish with a steel brake disc on top.

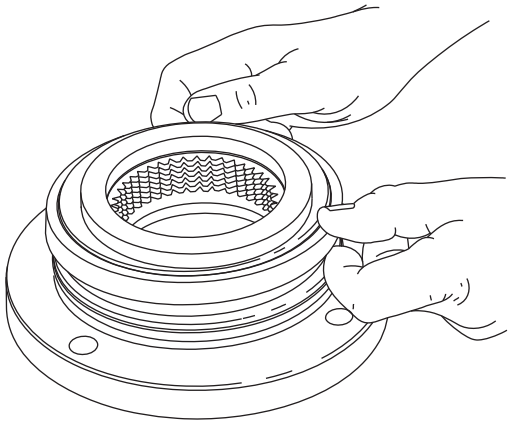
NOTE: It is a good practice to pre-lubricate the discs in hydraulic oil prior to assembly.



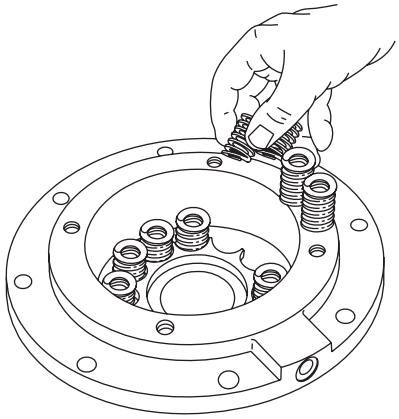
3. Install the brake spacer on top of the last steel brake disc.



4. To check brake stack height, place pressure plate on top of brake spacer. Hold pressure plate down firmly by hand and measure clearance in three places between motor support and pressure plate. Average gap must measure between .153 in. (4 mm) maximum and .080 in. (2 mm) minimum. If the gap exceeds the maximum limit, there are too many brake discs in stack-up or the discs are distorted. If the gap is less than the minimum, there are too few discs in stack-up or the discs are worn out. When stack height is correct, remove pressure plate and continue assembly.

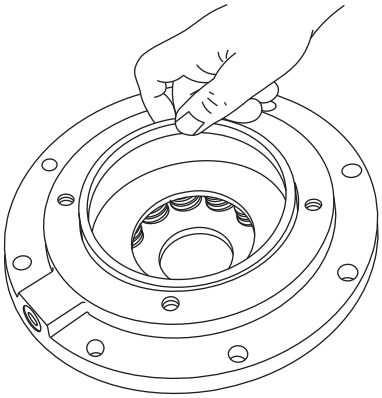


5. Lubricate the brake piston seal and motor support sealing surface with petroleum jelly or hydraulic oil. Install new piston seal to motor support, seal lip down.



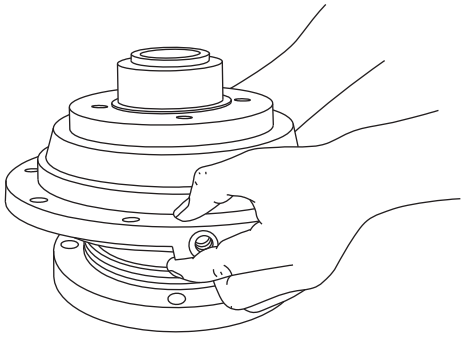
⚠ WARNING ⚠

Always use the molded spring spacer. The brake springs must be properly positioned by the spring spacer. Failure to install the spring spacer may allow the springs to contact each other and become damaged. This could result in loss of load control, property damage, injury or death.



6. Install the spring spacer, then the brake springs.

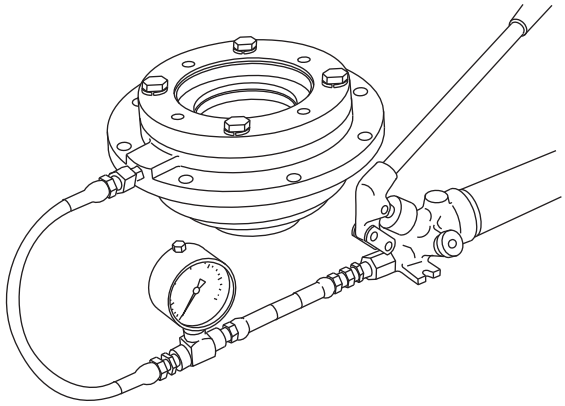
7. Install pressure plate into brake cylinder followed by the piston back-up ring. The close-fitting piston back-up ring may be depressed slightly to one side to lodge the back-up ring in the brake cylinder bore and temporarily hold the pressure plate and springs in place while you lower the brake cylinder over the motor support.



8. Apply light assembly grease to the entire sealing surface of the brake cylinder and to the piston seal. Install the brake cylinder over the motor support being careful to avoid damaging the piston seal or motor support O-ring. (A press may be necessary to avoid cocking the brake cylinder during installation.)

9. Install motor support capscrews and evenly tighten to recommended torque.

BRAKE CYLINDER PRESSURE TEST



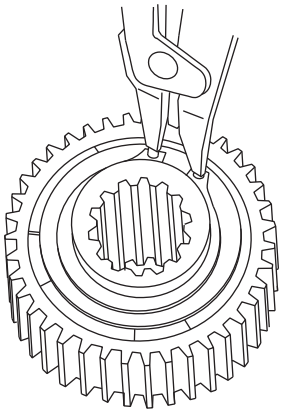
1. Install the –4 J.I.C. fitting into the brake release port. Connect a hand pump with accurate 0-2000 psi (0-13,800 kPa) gauge and shut-off valve to this fitting. Apply 1000 psi (6,900 kPa) to the brake. Close shut-off valve and let stand for five (5) minutes. If there is any loss of pressure in five (5) minutes, the brake cylinder should be disassembled for inspection of the sealing surfaces and brake piston.

2. WHILE PRESSURE IS APPLIED AND THE BRAKE RELEASED, install the brake clutch assembly in the brake pack, short end of the inner race toward motor. Turn the clutch back and forth as you align the outer race splines with the brake disc splines.

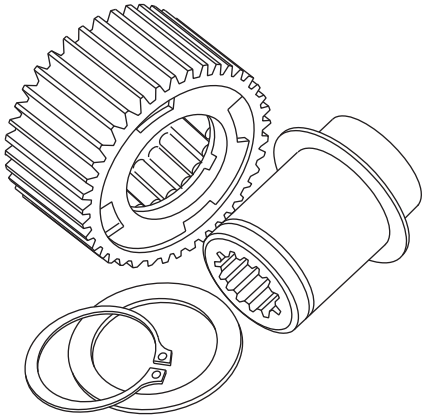
3. Release the pressure on the brake cylinder then remove the brake clutch assembly. The brake cylinder assembly is now complete and ready to be installed in the hoist.

BRAKE CLUTCH SERVICE

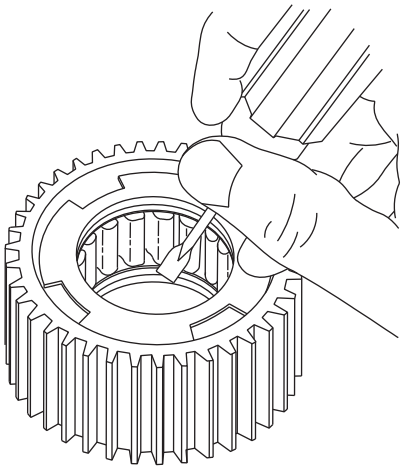
DISASSEMBLY



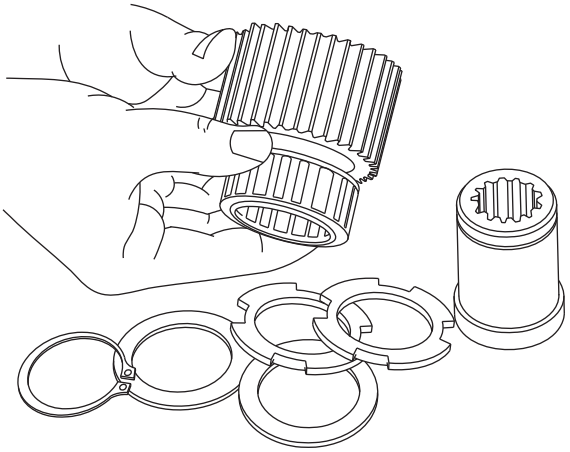
1. Remove the snap ring and sprag bushing retainer from one end only.



2. Pull the inner race out. Examine the race for scoring, wear or indentations caused by the sprag cams.



3. Use a screwdriver and mallet to remove the sprag bushing from one end of the outer race. There are four special cut-outs in the bushing for this purpose. Be careful not to damage the bushing inside surface. If a bushing's inside surface is damaged or shows wear, replace it.

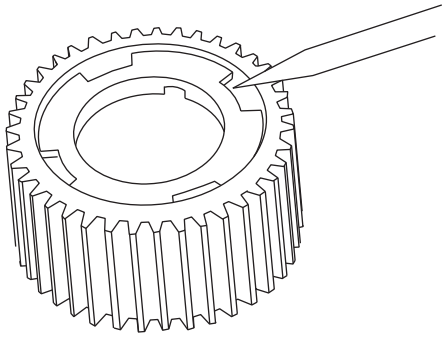


4. Next, slide the sprag clutch out, inspect the sprag clutch closely for abnormal wear, cracks, pitting or corrosion. Check small clips for breakage or bright spots; the signs of excessive wear. Unless the outer race or remaining sprag bushing is damaged or shows excessive wear, there is no need for further disassembly. If disassembly is necessary, remove the bushing according to the procedure covered in Step No. three (3). All brake clutch assembly parts should be thoroughly cleaned and inspected before assembly.

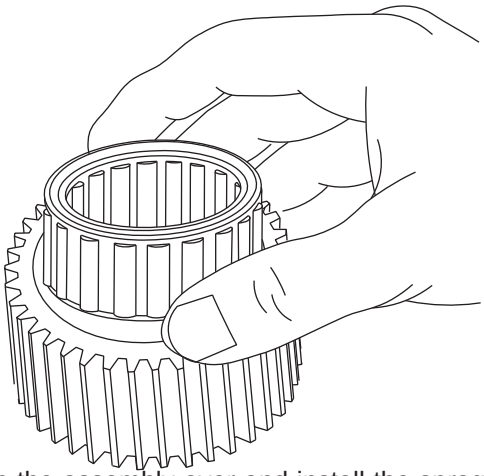
⚠ WARNING ⚠

The polished surfaces of the races and sprag cams must be perfectly smooth to insure positive engagement of the clutch. The slightest defect may reduce brake clutch effectiveness, which may lead to loss of load control and result in property damage, personal injury or death. Replace the entire brake clutch assembly if any component is defective.

ASSEMBLY

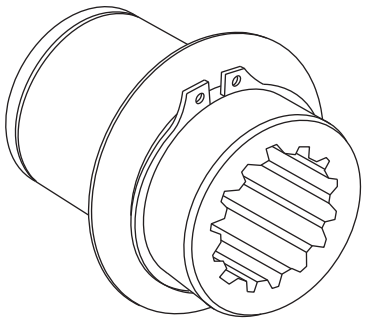


1. Press a sprag bushing into the outer race, using a mechanical or hydraulic press. A flat plate of approximately the same diameter as the bushing flange outside diameter should be placed between the press and bushing during assembly to protect the bushing. Be certain the bushing flange is against the shoulder in the outer race.

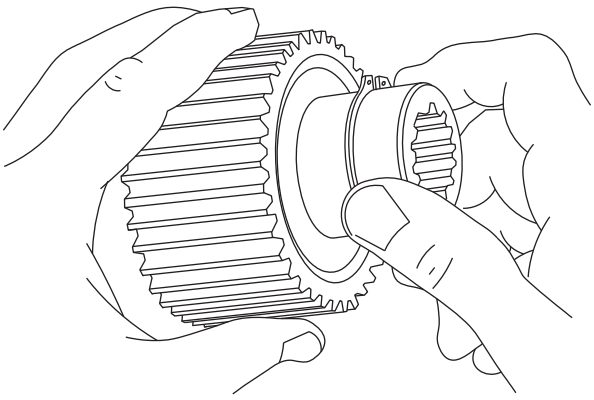


2. Turn the assembly over and install the sprag clutch in the bore of the outer race.

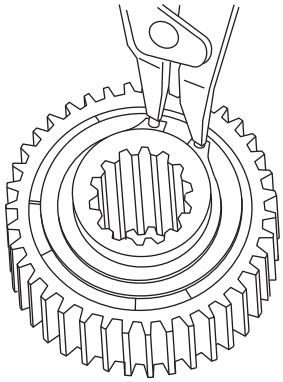
3. Press the remaining bushing into the race. Again, make sure the bushing is against the shoulder.



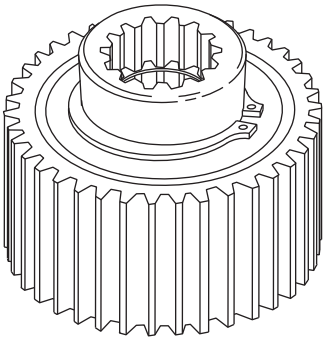
4. Next, install a sprag bushing retainer, then a snap ring on the inner race. Be sure the snap ring is seated in the snap ring groove.



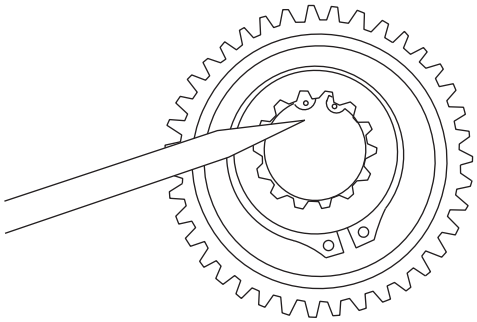
5. Slide the inner race through the bushings and sprag clutch (the race will have to be rotated in the free-wheeling direction to start it through the sprag clutch). If the inner race will not go through the bushings, the bushings may be damaged and should be replaced.



6. Turn the assembly over with the snap ring down. Install the second retainer and snap ring. Make certain the snap ring is seated in the groove properly.



7. This is a completed brake clutch assembly.



⚠ WARNING ⚠

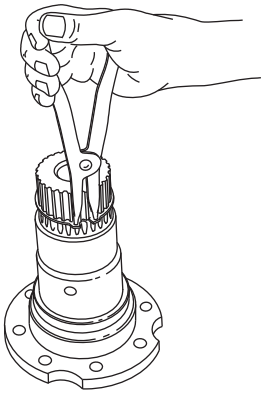
Be certain the snap ring is seated in the groove in the splined bore of the inner race. This snap ring will keep the brake clutch assembly correctly positioned in the center of the friction brake pack. Binding of the brake or brake failure may occur if this snap ring is omitted.

HOIST ASSEMBLY

⚠CAUTION⚠

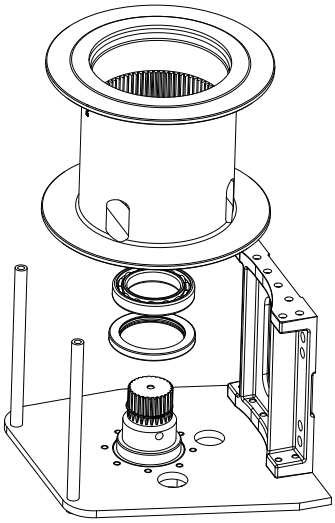
Hoists with a three piece fabricated base use special shoulder capscrews to fasten side plates to the base plate. DO NOT use standard capscrews in their place.

1. Install a new bearing in the drum if replacement is necessary. Apply a non-hardening sealant on the outside diameter of the new seal. Install the spring side of the seal next to the bearing, then press into the drum, using a flat plate to avoid distortion. Be sure drain plug is installed securely.



⚠CAUTION⚠

Make certain the snap ring is installed on the bearing support. This snap ring will keep the planet carrier correctly positioned in the hoist. Gear train damage may occur if this snap ring is omitted.



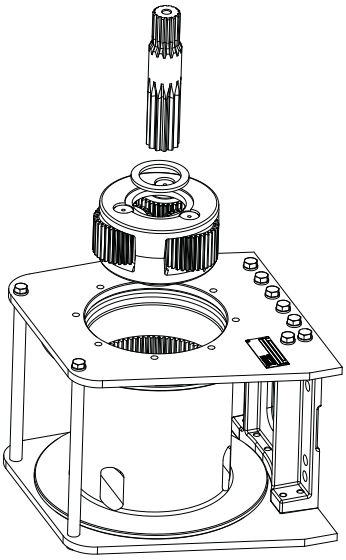
2. Install bearing support into support end plate.

⚠CAUTION⚠

Be sure the vent relief valve is located above the horizontal centerline for the intended application. Oil leakage may occur if vent is positioned incorrectly.

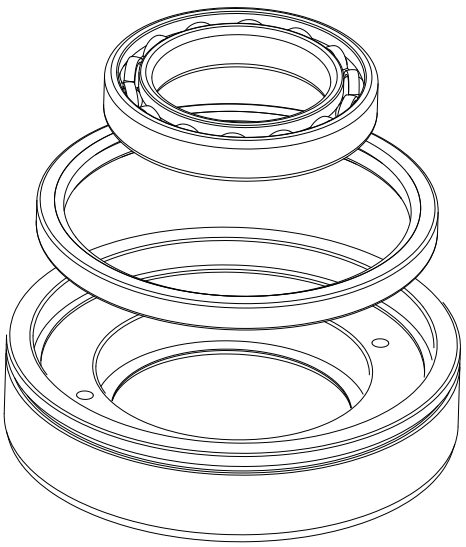
Tighten bearing support capscrews to a firm hand-tight. All capscrews must be tightened to recommended torque when hoist assembly is completed.

3. Center the drum in the opening of the base. Lubricate the bearing support with petroleum jelly or gear oil and install onto bearing support and drum with bearing and seal.

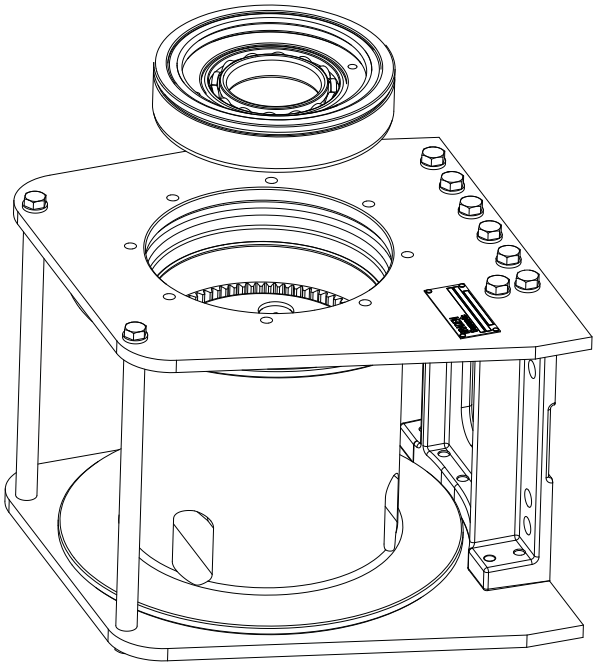


4. Stand hoist on bearing support end. Install the output sun gear and thrust washer into output planet carrier.

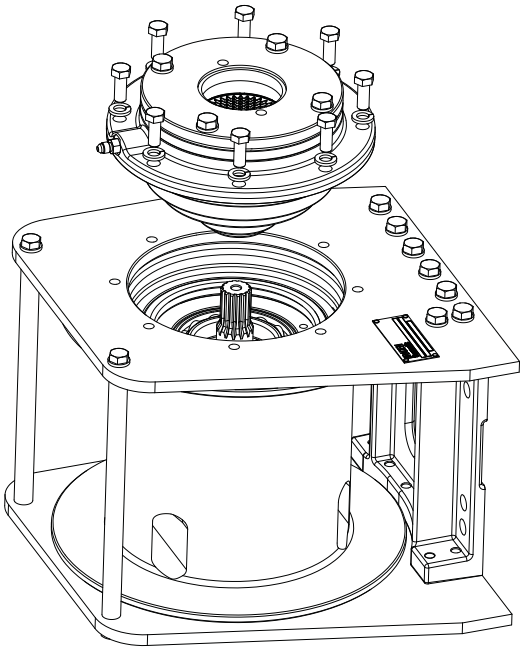
5. Install the planet carrier into the drum while meshing the planet gears with the ring gear and the planet housing with the bearing support.



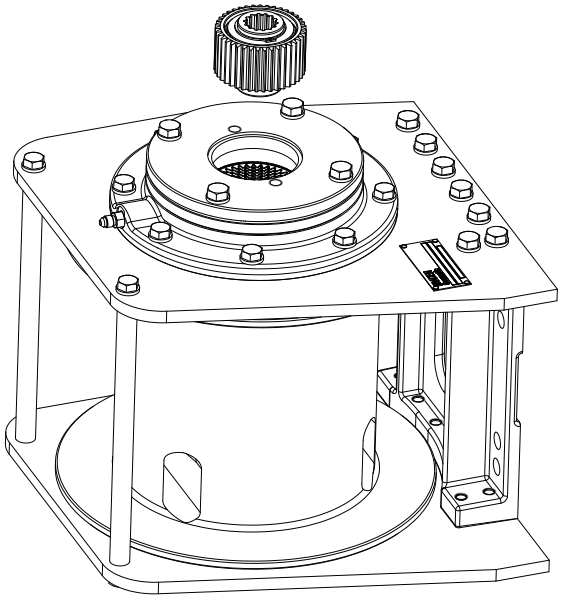
6. Install a new bearing in the drum closure as required. Use sealant on the outside surface of the oil seal. Install with spring side of the seal toward bearing, using a flat plate to avoid distortion. Install a new O-ring in the groove on the O.D. of the drum closure.



7. Lubricate the O-ring and drum opening with oil soluable assembly grease or gear oil and install the drum closure into the drum.



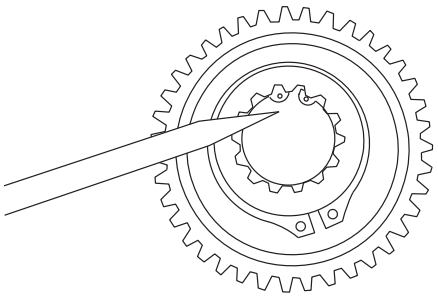
8. Lubricate the pilot, oil seal and bearing surfaces of the brake cylinder and carefully install brake cylinder into base and drum. Locate the brake release port in the same location as it was received to match the customer motor orientation. Tighten brake cylinder capscrews to recommended torque.



9. Install the brake clutch assembly with the short end of the inner race toward motor.

When installed correctly, the inner race should turn freely in the opposite direction the drum turns to pull wire rope in. An easy way to check the rotation is to hold the outer race in your left hand, and rotate the inner race with your right hand. The inner race should freewheel in the clockwise direction as viewed from the motor end for standard drum rotation.

If the clutch free wheels in the wrong direction, disassemble the clutch and reverse the inner race. Refer to “Brake Clutch Service” for additional information.

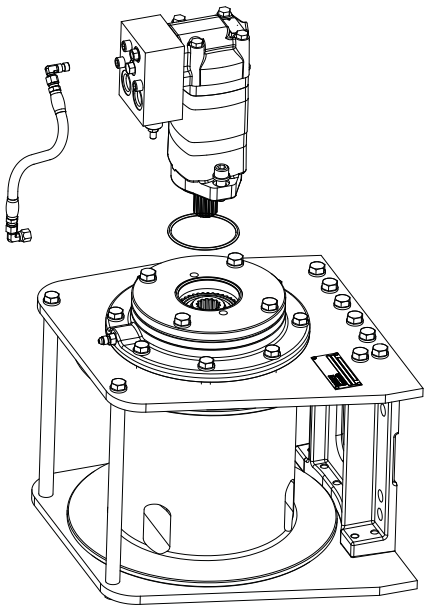


⚠ WARNING ⚠

Be certain the snap ring is seated in the groove in the splined bore of the inner race. This snap ring will keep the brake clutch assembly correctly positioned in the center of the friction brake pack. Binding of the brake or brake failure may occur if this snap ring is omitted.

10. If the brake discs are misaligned, preventing the installation of the clutch, then use a hand pump to apply 750-1000 PSI (5100 - 6900 kPa) to the brake release port. The brake discs will move freely with the brake released, permitting alignment of the discs, brake clutch and input sun gear. The brake clutch inner retaining ring should be against the sun gear when the clutch is correctly installed.

11. Install the hoses and fittings to the brake cylinder release port. Install a new O-ring on the motor pilot then lubricate with petroleum jelly or gear oil. Engage the motor shaft with the brake clutch inner race and lower motor into place. Tighten capscrews to recommended torque.

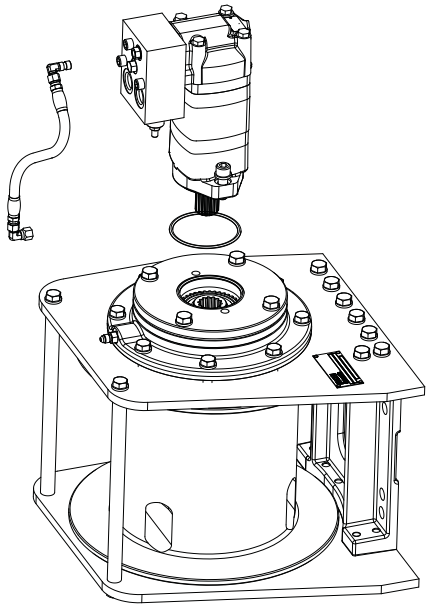


12. Install the hose that connects the brake valve to the brake cylinder.

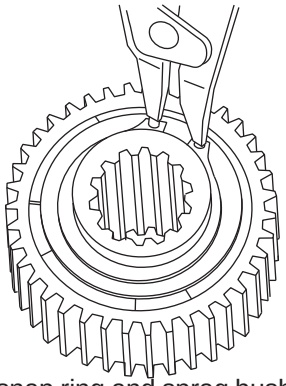
13. After the hoist assembly is complete, check all capscrews and fittings to make certain they have been tightened correctly. Tighten end-plate, brake cylinder and drum bearing support capscrews to 80 lb. ft. (108 N-m) torque. Refill the hoist with the recommended oil listed under “Preventive Maintenance”, and install the oil level plug.

REVERSING DIRECTION OF DRUM ROTATION

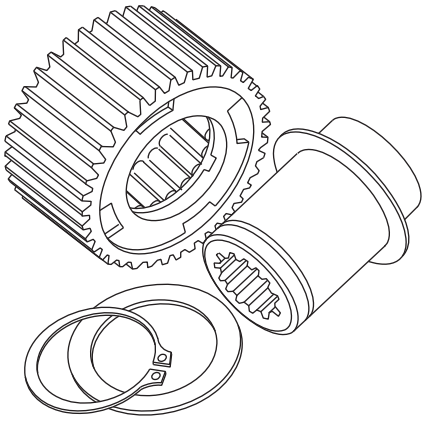
In order to change the direction of rotation and brake operation, 2 components must be changed on the hoist. First, the motor must be made to rotate in the opposite direction for raising and lowering. A new brake valve assembly is required due to internal oil passages and cartridge valve location. At the time of printing this manual, a revised rotation brake valve group has not been released. This is done by exchanging positions of the brake valve cartridge in the manifold block on the motor. Secondly, the brake clutch assembly must be made effective for the opposite direction of rotation. This is done by reversing the inner race of the brake clutch assembly, as described in steps 1-5.



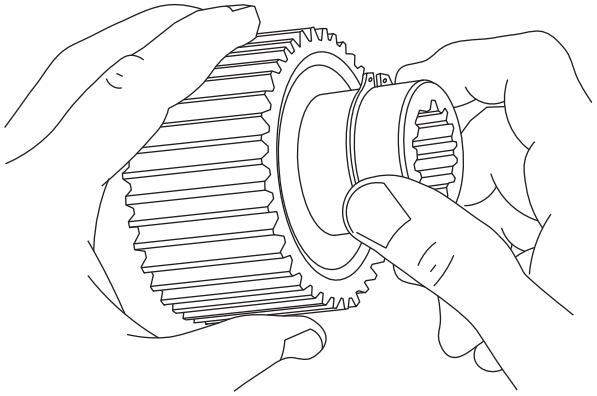
1. Remove the capscrews securing the motor to the hoist and carefully remove the motor. Remove the brake clutch assembly from the motor support.



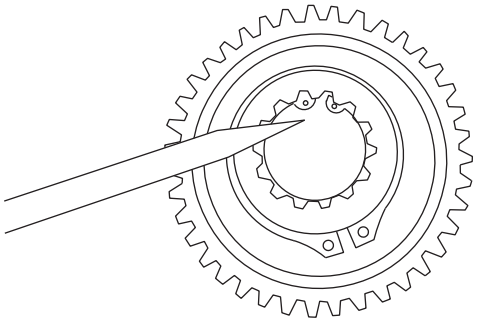
2. Remove the snap ring and sprag bushing retainer from one end only of the brake clutch assembly.



3. Pull the inner race out. Examine the race for scoring, wear or indentations caused by the sprag cams. If the inner race is not completely smooth, the assembly should be replaced.



4. Turn the sprag assembly around and slide the inner race (with 1 snap ring and bushing retainer) through the bushings and sprag clutch (the race will have to be rotated in the free-wheeling direction to start it through the sprag clutch). Install the remaining bushing retainer and snap ring. Make certain the snap ring is properly seated in the groove.



⚠ WARNING ⚠

Be certain the snap ring is seated in the groove in the splined bore of the inner race. This snap ring will keep the brake clutch assembly correctly positioned in the center of the friction brake pack. Binding of the brake or brake failure may occur if this snap ring is omitted.

5. Before installing the brake clutch, be sure the inner race turns free in the opposite direction the drum will turn to pull-in wire rope. An easy way to check the rotation is to hold the outer race in one hand and rotate the inner race. Install the brake clutch with the short end of the inner race toward the motor. Install a new O-ring on the motor pilot and install it onto the hoist. Install and tighten motor capscrews to recommended torque.

6. Install new O-rings on the brake valve manifold block. Attach the brake valve manifold block to the motor using the original capscrews and tighten to recommended torque.

7. Operate the hoist slowly in both directions and check for oil leaks and/or unusual sounds. The hoist should operate smoothly in both directions. Refer to “WIRE ROPE INSTALLATION” and properly install rope onto the hoist drum.

8. Before returning the hoist to full service, a light load should be lifted and held three feet (1 meter) off the ground to be sure the static brake is functioning properly. The hoist should also be able to slowly lower the load in a smooth and controlled manner. If the hoist does not perform either of these functions, refer to “TROUBLESHOOTING” for additional information.

METRIC CONVERSION TABLE

English to Metric			Metric to English		
LINEAR					
inches (in.)	X 25.4	= millimeters (mm)	millimeters (mm)	X 0.3937	= inches (in.)
feet (ft.)	X 0.3048	= meters (m)	meters (m)	X 3.281	= feet (ft.)
miles (mi.)	X 1.6093	= kilometers (km)	kilometers (km)	X 0.6214	= miles (mi.)
AREA					
inches ^{2} (sq.in.)	X 645.15	= millimeters ^{2} (mm ^{2})	millimeters ^{2} (mm ^{2})	X 0.000155	= inches ^{2} (sq.in.)
feet^2 (sq.ft.)	X 0.0929	= meters ^{2} (m ^{2})	meters ^{2} (m ^{2})	X 10.764	= feet ^{2} (sq.ft.)
VOLUME					
inches ^{3} (cu.in.)	X 0.01639	= liters (l)	liters (l)	X 61.024	= inches ^{3} (cu.in.)
quarts (qts.)	X 0.94635	= liters (l)	liters (l)	X 1.0567	= quarts (qts.)
gallons (gal.)	X 3.7854	= liters (l)	liters (l)	X 0.2642	= gallon (gal.)
inches ^{3} (cu.in.)	X 16.39	= centimeters ^{3} (cc)	centimeters3 (cc)	X 0.06102	= inches ^{3} (cu.in.)
feet^3 (cu.ft.)	X 28.317	= liters (l)	liters (l)	X 0.03531	= feet ^{3} (cu.ft.)
feet^3 (cu.ft.)	X 0.02832	= meters ^{3} (m ^{3})	meters3 (m3)	X 35.315	= feet ^{3} (cu.ft.)
fluid ounce (fl.oz.)	X 29.57	= millileters (ml)	milliliters (ml)	X 0.03381	= fluid ounce (fl.oz.)
MASS					
ounces (oz.)	X 28.35	= grams (g)	grams (g)	X 0.03527	= ounces (oz.)
pounds (lbs.)	X 0.4536	= kilograms (kg)	kilograms (kg)	X 2.2046	= pounds (lbs.)
tons (2000 lbs.)	X 907.18	= kilograms (kg)	kilograms (kg)	X 0.001102	= tons (2000 lbs.)
tons (2000 lbs.)	X 0.90718	= metric tons (t)	metric tons (t)	X 1.1023	= tons (2000 lbs.)
tons (long) (2240 lbs.)	X 1013.05	= kilograms (kg)	kilograms (kg)	X 0.000984	= tons (long) (2240 lbs.)
PRESSURE					
inches Hg (60 °F)	X 3600	= kilopascals (kPa)	kilopascals (kPa)	X 0.2961	= inches Hg (60 °F)
pounds/sq.in. (PSI)	X 6.895	= kilopascals (kPa)	kilopascals (kPa)	X 0.145	= pounds/sq.in. (PSI)
pounds/sq.in. (PSI)	X 0.0703	= kilograms/sq.cm. (kg/cm ^{2})	kilograms/sq.cm. (kg/cm2)	X 14.22	= pounds/sq.in. (PSI)
pounds/sq.in. (PSI)	X 0.069	= bars	bars	X 14.5	= pounds/sq.in. (PSI)
inches H $_2$O (60 ^{o}F)	X 0.2488	= kilopascals (kPa)	kilopascals (kPa)	X 4.0193	= inches H $_2$O (60 ^{o}F)
bars	X 100	= kilopascals (kPa)	kilopascals (kPa)	X 0.01	= bars
POWER					
horsepower (hp)	X 0.746	= kilowatts (kW)	kilowatts (kW)	X 1.34	= horsepower (hp)
ft.-lbs./min.	X 0.0226	= watts (W)	watts (W)	X 44.25	= ft.-lbs./min.
TORQUE					
pound-inches (in.-lbs.)	X 0.11298	= newton-meters (N-m)	newton-meters (N-m)	X 8.851	= pound-inches (in.lbs.)
pound-feet (ft.-lbs.)	X 1.3558	= newton-meters (N-m)	newton-meters (N-m)	X 0.7376	= pound-feet (ft.-lbs.)
pound-feet (ft.-lbs.)	X .1383	= kilograms/meter (kg-m)	kilogram/meter (kg-m)	X 7.233	= pound-feet (ft.-lbs.)
VELOCITY					
miles/hour (m/h)	X 0.11298	= kilometers/hour (km/hr)	kilometers/hour (km/hr)	X 0.6214	= miles/hour (m/h)
feet/second (ft./sec.)	X 0.3048	= meter/second (m/s)	meters/second (m/s)	X 3.281	= feet/second (ft./sec.)
feet/minute (ft./min.)	X 0.3048	= meter/minute (m/min)	meters/minute (m/min)	X 3.281	= feet/minute (ft./min.)

TEMPERATURE

°Celsius = 0.556 (°F - 32) °Fahrenheit = (1.8 X °C) + 32

COMMON METRIC PREFIXES

mega	(M)	= 1,000,000 or 10 ^{6}	deci	(d)	= 0.1 or 10 $^{-1}$
kilo	(k)	= 1,000 or 10 ^{3}	centi	(c)	= 0.01 or 10 $^{-2}$
hecto	(h)	= 100 or 10 ^{2}	milli	(m)	= 0.001 or 10 $^{-3}$
deka	(da)	= 10 or 10 ^{1}	micro	(μ)	= 0.000.001 or 10 $^{-6}$