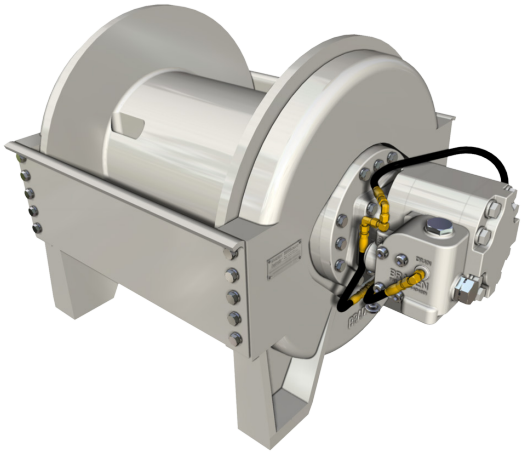
BRADEN®
A PACCAR COMPANY

CH210
CH280

CH210 and CH280
Planetary Hoist

INSTALLATION, MAINTENANCE, AND SERVICE MANUAL



WRITE HOIST SERIAL NUMBER BELOW

First 2 numbers indicate year manufactured

For serial number location, see Page 4

Visit our Web site at www.paccarwinch.com for the most comprehensive collection of winch, hoist, and drive information on the Internet. Most publications and specification sheets are available for downloading.

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BRADEN
CARCO
Gearmatic

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FOREWORD

The following service instructions have been prepared to provide assembly, disassembly and maintenance information for the BRADEN Model CH Series 3 hoist. It is suggested that before doing any work on these units, all assembly and disassembly instructions should be read and understood.

Some pictures in this manual may show details or attachments that are different from your hoist. Also, some components have been removed for illustrative purposes.

Continuing product improvement may cause changes in your hoist, which are not included in this manual. Whenever a question arises regarding your BRADEN Hoist or this manual, please contact BRADEN Service Department for the latest available information.

Managing Waste

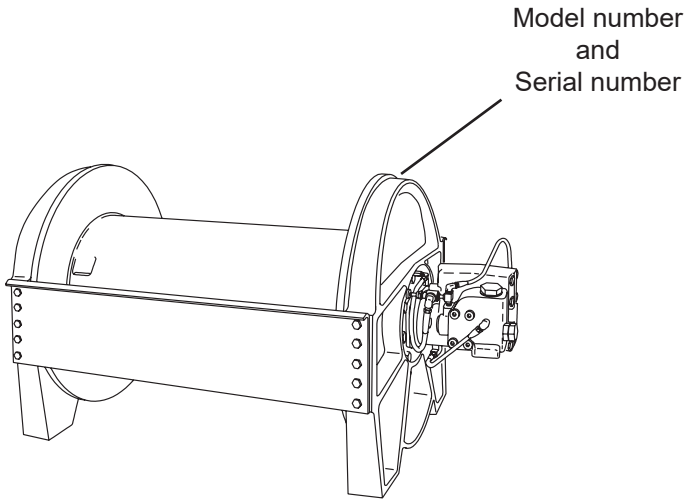
PACCAR Winch believes in a life-cycle approach to our products. We encourage best practices regarding “Going Green” — making environmentally responsible decisions to “reduce, reuse, and recycle.”

- At the end of the winch’s useful life, it is highly recommended to drain and recycle any oil remaining in the equipment.
- Please use a metal recycler for winch disposal to reduce landfill waste.

The U.S. Environmental Protection Agency has developed required practices, called “management standards,” for businesses that handle used oil and metal wastes. Specific guidelines are available at the EPA and API Web sites as well as your state’s environmental agency Web site:

- https://www.epa.gov/
- http://recycleoil.org/

MODEL IDENTIFICATION



MODEL NUMBER AND SERIAL NUMBER

When information on a hoist is needed, always refer to the model number and serial number. Both are located on the top of the motor-side end plate as indicated above.

EXPLANATION OF MODEL NUMBER

CH	210	A	-	36	110	-	01	-	1
Construction Hoist	Max Rating	Design Model		Gear Ratio	Motor Size		Drum Size		Option

CH Construction hoist
210 21,000–lb. first-layer line pull
A Model series relating to design changes
36 Total gear reduction
110 Hydraulic motor displacement in cubic inches/revolution (decimal point eliminated, example: 110–11.0 cubic inches/revolution)
01 Drum option
1 Permits testing and inspection per API 2C for offshore cranes

GENERAL SAFETY RECOMMENDATIONS

Safety 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 and 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.

⚠ WARNING ⚠

Failure to obey the following safety recommendations may result in property damage, personal injury, or death.

1. Read all warning tag information and become familiar with all controls before operating hoist.
2. Never attempt to clean, oil or perform any maintenance on a machine with the engine running, unless instructed to do so in the service manual.
3. Never operate hoist controls unless you are properly seated at the operators station on the prime mover and you are sure personnel are clear of the work area.
4. Assure that personnel who are responsible for hand signals are clearly visible and that the signals to be used are thoroughly understood by everyone.
5. Ground personnel should stay in view of the prime mover operator and clear of hoist drum. Do not allow ground personnel near hoist line under tension. A safe distance of at least 1.5 times the length of the cable should be maintained.
6. On machines having hydraulically, mechanically and/or cable controlled equipment, be certain the equipment is either lowered to the ground or blocked securely before servicing, adjusting and/or repairing the hoist. Always apply the prime mover parking brakes and lower equipment before dismounting the prime mover.
7. Inspect rigging, hoist and hydraulic hoses at the beginning of each work shift. Correct defects immediately.
8. Keep equipment in good operating condition. Perform scheduled servicing and adjustments listed in the Preventive Maintenance section of this manual.
9. An equipment warm-up procedure is recommended for all start-ups and is essential at ambient temperatures below +40°F (4°C). Refer to the Warm-up Procedure listed in the Preventive Maintenance section of this manual.
10. Be sure of equipment stability before operating hoist.
11. The hoists described herein are neither designed nor intended for use or application to equipment used in the lifting or moving of persons.
12. Do not exceed the maximum pressure (PSI or bar) or flow (GPM or LPM) stated in the hoist specifications.
13. Operate hoist line speeds to match job conditions.
14. Leather gloves should be used when handling hoist cable.
15. Never attempt to handle hoist cable when the hook end is not free.
16. When winding hoist cable on the hoist drum, never attempt to maintain tension by allowing hoist cable to slip through hands. Always use the hand-over-hand technique.
17. Never use hoist cable with broken strands. Replace hoist cable.
18. Do not weld on any part of the hoist.
19. Do not use knots to secure or attach hoist cable.
20. Use recommended hydraulic oil and gear lubricant.
21. Keep hydraulic system clean and free from contamination at all times.
22. Use correct size cable anchor for cable and pocket in hoist drum.
23. The BRADEN wire rope anchors supplied with CH210 hoists are not designed to support the rated load of the hoist. ALWAYS maintain a minimum of five wraps of wire rope on the drum.

BASIC OPERATION

DESCRIPTION OF HOIST

The hoist is made up of the following subassemblies:
1. Hydraulic motor and brake valve
2. Drum, drum closure, ball bearings and oil seals
3. Support end plate and bearing support
4. Motor end plate and motor adapter
5. Tie plates
6. Brake clutch assembly
7. Brake cylinder assembly and multiple-disc brake parts
8. Primary, second stage and output planetary reducer assemblies
9. Ring gear

THEORY OF OPERATION

The primary sun gear is directly coupled to the hydraulic motor by the inner race of the brake clutch assembly. As the motor turns in the hoisting direction, the two planetary assemblies reduce the input speed of the motor and rotate the planetary gearing and the cable drum. The ring gear is held stationary by the brake cylinder and the output planet carrier is coupled directly to the cable drum causing the drum to rotate in the same direction as the motor shaft. In the hoisting direction, the static brake remains applied and the input shaft rotates freely through the brake clutch. When the motor is stopped, the load tries to rotate the hoist gear train in the opposite direction. The brake clutch immediately locks up, allowing the fully applied static brake to hold the load firm. See “Dual Brake System – Operation” for a detailed description of the sequence of operation in the lowering direction.

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. 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 the end of the spool 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. See Figures 2, 3, and 4.

The static brake system has three operating components:

1. Spring-applied, multiple friction-disc static brake
2. Brake clutch assembly
3. Hydraulic piston and cylinder

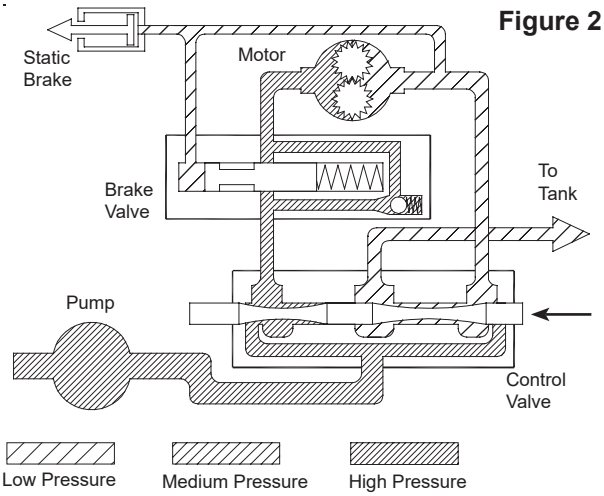


Figure 2

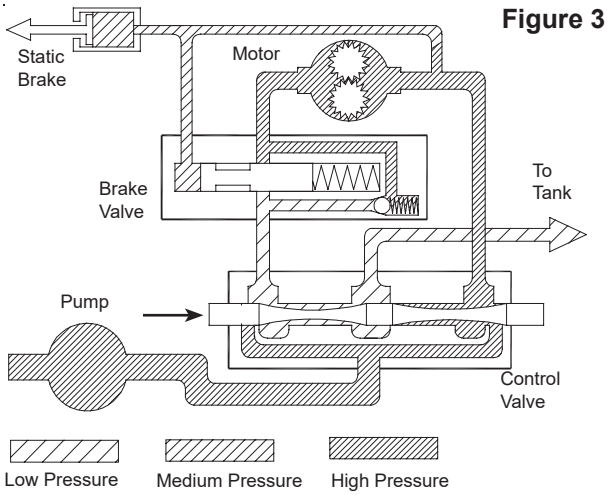


Figure 3

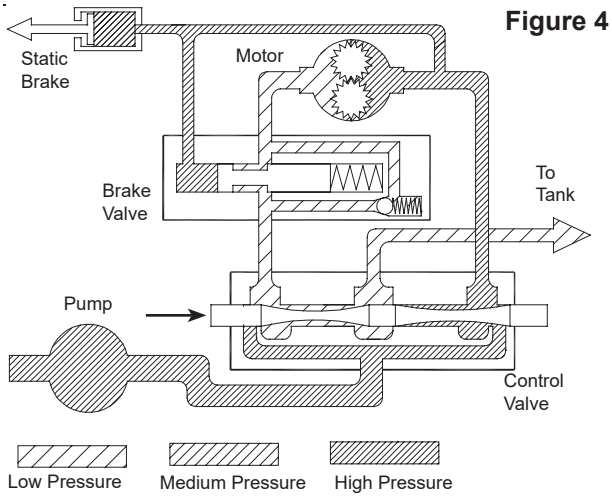


Figure 4

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 friction brake.

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

The brake clutch is splined to the primary sun gear shaft between the motor and the primary sun gear. 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 (Figures 5 and 6).

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 brake clutch which connects the motor shaft to the primary sun gear, allows free rotation. The sprag cams lay over and permit the inner race to turn free of the outer race (Figure 5). The friction brake remains fully engaged. The hoist, in raising a load, is not affected by any braking action (Figure 2).

When the lifting operation is stopped, the load attempts to turn the primary 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 engaged friction brake (Figure 6).

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 (Figures 3 and 4). The 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 hoist 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 friction brake will engage and hold the load after the brake valve has closed.

When lowering a load 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 slow speed and extremely accurate positioning.

The friction brake receives little wear in the lowering operation. All of the heat generated by the lowering and stopping of a load is absorbed by the hydraulic oil where it can be readily dissipated.

Figure 5 Static Friction Brake Applied

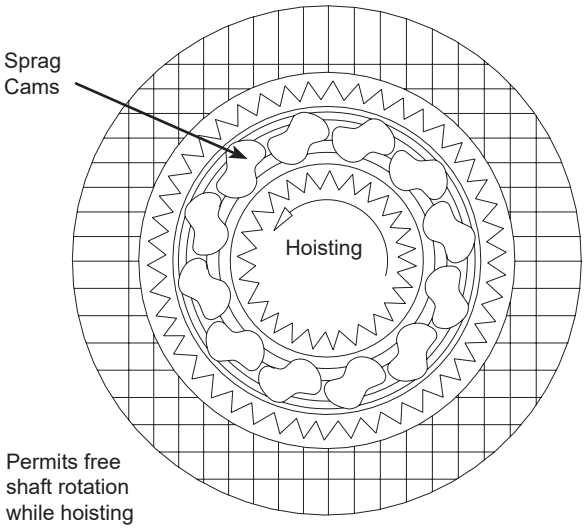
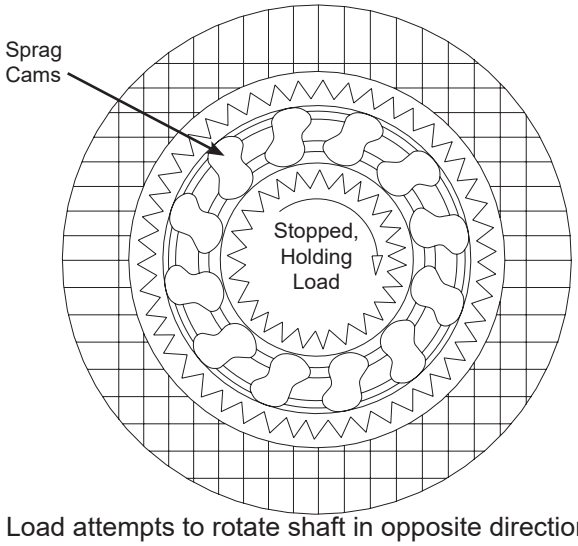


Figure 6 Static Friction Brake Applied



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

HOIST INSTALLATION
GENERAL REQUIREMENTS

1. The hoist should be mounted with the centerline of the drum in a horizontal position. The mounting plane can be rotated to any position around this centerline.

⚠ WARNING ⚠

DO NOT weld hoist to mounting surface. Welding may not provide adequate structural support for hoist loads. This may cause loss of load control, which could result in property damage, injury, or death. Welding may also damage bearings and seals, resulting in premature failure.

2. When mounting the CH210A hoist, BRADEN recommends using 4 one-inch Grade 8 bolts and nuts, using both mounting holes in each end plate. The CH280A requires 1-1/4-inch bolts because the side plate hole is 1-3/8 inches.
3. It is important that the hoist be mounted on a surface that will not flex when the hoist is in use, because this could bind the working parts of the hoist. Also, be sure the hoist is mounted on a flat surface. If necessary, use shim stock to ensure proper mounting. The mounting surface should be flat within ±0.020 inch (0.5 mm).
4. Hydraulic lines and components that operate the hoist should be of sufficient size to assure minimum back pressure at the hoist. The gear motor manufacturer recommends that the back pressure not exceed 100 PSI for maximum motor seal life. 150 PSI is the maximum allowable back pressure. The standard CH210A/CH280 hoist is supplied with the motor internally drained. If high back pressures are encountered, the motor can be drained directly to tank to improve motor seal life. To ensure adequate static brake load holding ability, back pressure on the hoist should not exceed 150 PSI. For pressures exceeding 150 PSI, consult BRADEN Engineering. For piston motors, the back pressure must be 30 PSI.
5. Make certain that the hoist drum is centered behind the first sheave and the fleet angle does not exceed 1.5 degrees. The hoist should also be mounted perpendicular to an imaginary line from the center of the drum to the first sheave to ensure even spooling.
6. The hoist directional control valve must be a three-position, four-way valve with a motor spool such that when the valve is in the center position both work ports are opened directly to tank.
7. The hydraulic oil filter should have a 10-micron nominal rating and be a full-flow type.
8. High-quality hydraulic oil is essential for satisfactory performance and long hydraulic system component life.

   Oil having 150 to 330 SUS viscosity at 100°F (38°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 5,000 SUS with a pour point at least 20°F (7°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°F (82°C). A temperature between 120–140°F (49–60°C) is generally considered optimum.

   In general terms: For continuous operation at ambient temperatures between 50–110°F (10–43°C), use SAE 20W. For continuous operation between 10–90°F (50–32°C), use SAE 10W. For applications colder than 10°F (12°C), contact the BRADEN Service Department. The use of multiviscosity oils is generally not recommended.

WIRE ROPE INSTALLATION

⚠ WARNING ⚠

THE CABLE ANCHORS ALONE ON HOISTS ARE NOT DESIGNED TO HOLD RATED LOADS. Hoist loads applied directly to the wire rope anchor may cause the wire rope to pull free and result in the sudden loss of load control and cause property damage, injury, or death. A minimum of 5 wraps of wire rope must be left on the drum barrel to achieve rated load.

The wedge and anchor pocket must be clean and dry. The end of the wire rope being anchored to the drum must be clean and dry and not frayed. Anything on the end of the wire rope to keep it from fraying (tape or wire) must not be in contact with the wedge when the installation is complete. Consult the wire rope manufacturer on the proper treatment of the dead end of the wire rope. Some rope manufacturers recommend when using rotation-resistant wire rope, that the rope end be seized, welded, or brazed before inserting the wire rope into the wedge socket. This prevents core slippage or loss of rope lay.

Take the free end of the wire rope and insert it through the small opening on the cable drum. Loop the wire rope and push the free end about 3/4 of the way back through the pocket. Install the wedge as shown in Figure 7, then pull the slack out of the wire rope. The dead end of the rope needs to extend slightly beyond the end of the wedge as shown in Figure 8.

Using a hammer and brass drift, drive the wedge as deep into the pocket as possible to ensure it is fully seated and no further movement is detected. Applying a load on the wire rope will also help seat the wedge in the pocket.

Check to ensure the wedge does not protrude from either end of the pocket, causing it to interfere with proper spooling of wire rope onto the drum (Figures 9 and 10). If there is interference or the wedge does not seat firmly, contact the BRADEN Product Support Department at 918-251-8511 to determine the proper wedge size.

It is important that the wire rope have the proper tensioning when it is installed on the drum. When the wire rope is first installed, you should operate the hoist, with light to moderate loads, with reeving that let's you place these loads on the block and the drum with all the rope off the drum except for the last three wraps.

Correct Installation

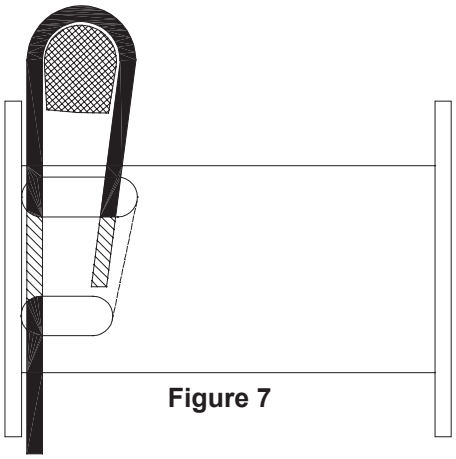


Figure 7

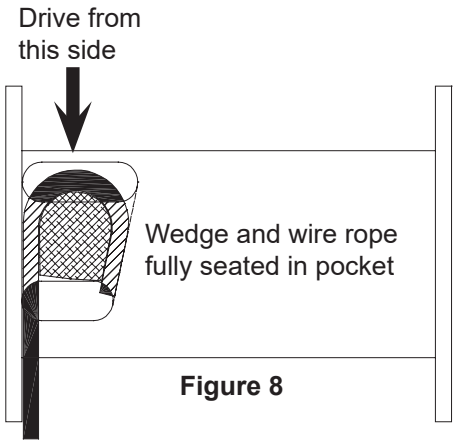


Figure 8

Incorrect Installation

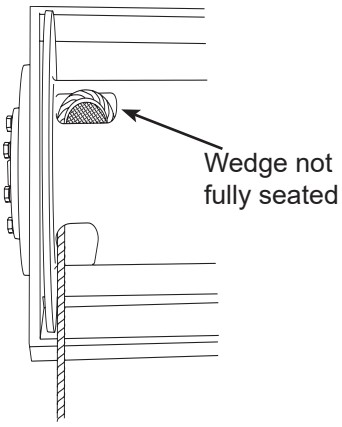


Figure 9

- Wire rope not tight against wedge
- Wedge may be too large

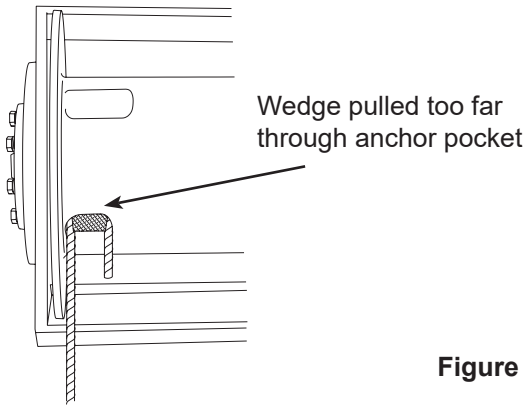


Figure 10

- Dead end of wire rope and/or wedge may interfere with proper spooling
- Wedge may be too small

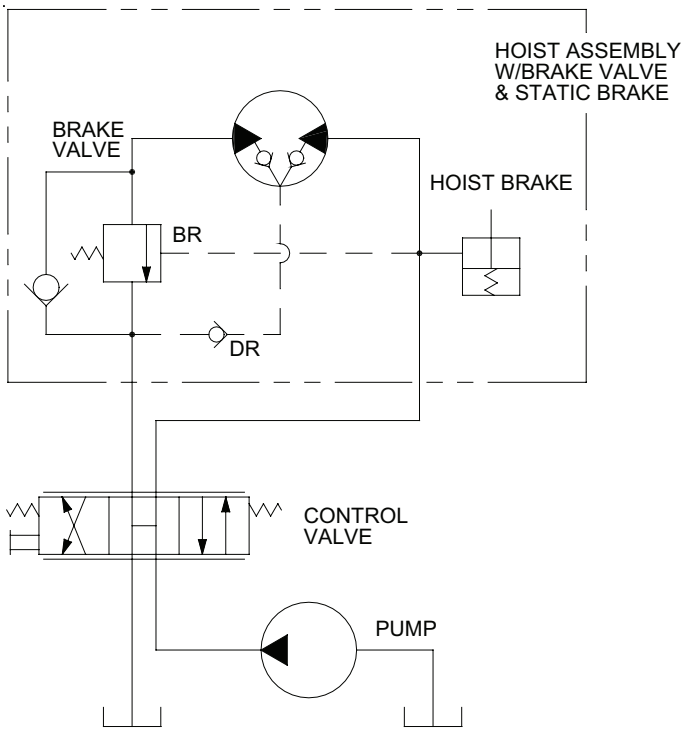
WIRE ROPE WEDGE PART NUMBERS

HOIST MODEL	WEDGE PART NO.
CH210A	24493* for 1/2 through 3/4 inch (13–19 mm)
CH280A	24494* for 7/8 through 1 inch (22–25 mm)
	24493 for 3/4 inch (19 mm)

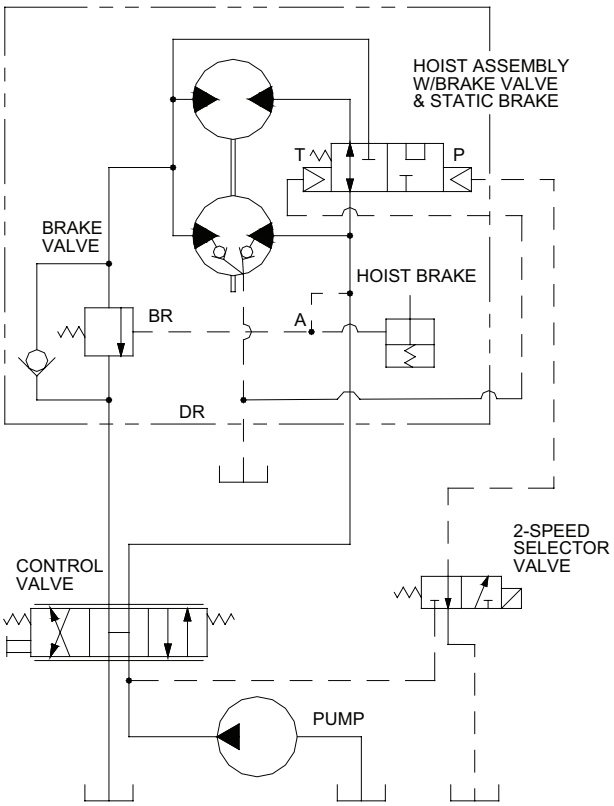
***Standard Anchor**

HYDRAULIC CIRCUIT

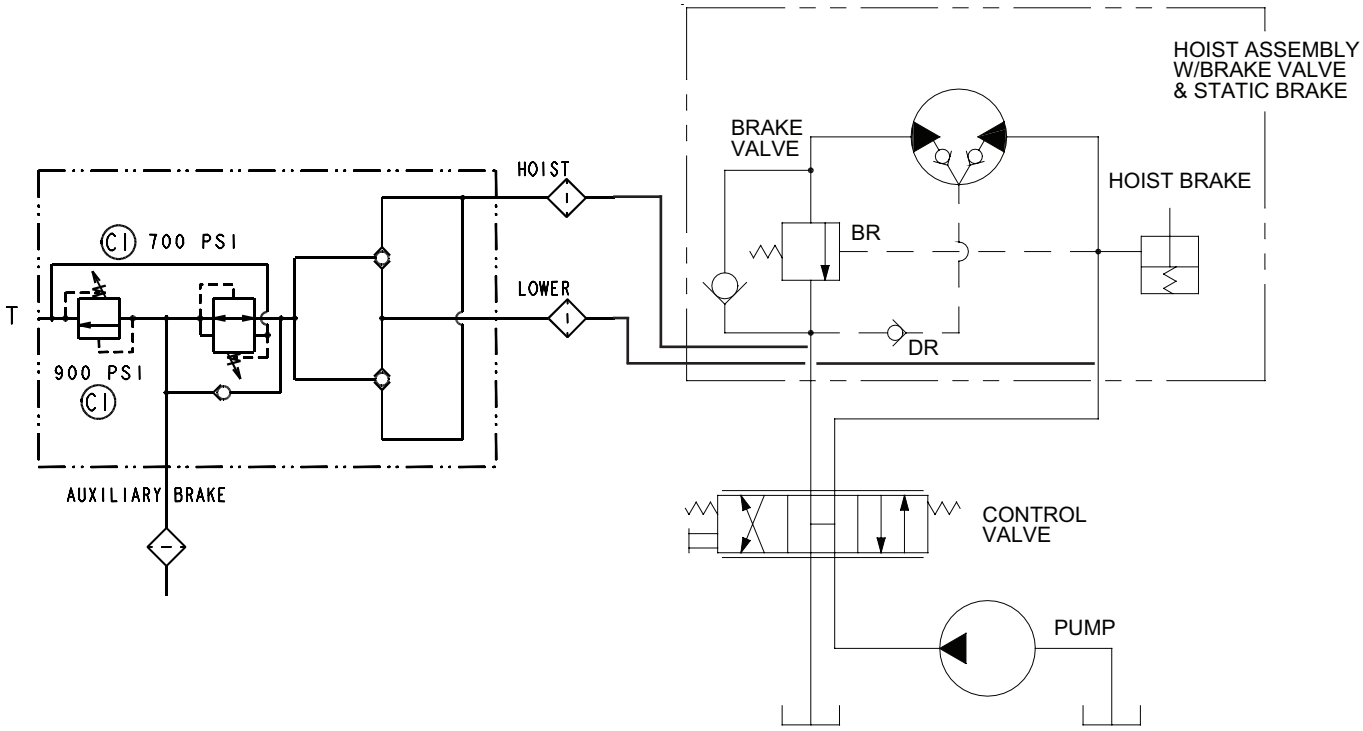
SINGLE-SPEED MOTOR CIRCUIT



TWO-SPEED MOTOR CIRCUIT



WITH AUXILIARY BRAKE

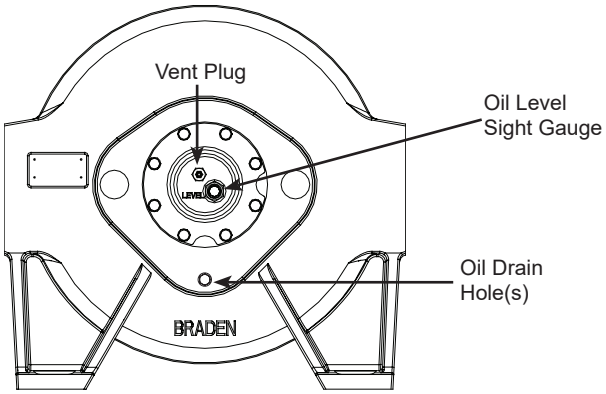


PREVENTIVE MAINTENANCE

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

Initially, the gear oil should be changed after the first 100 hours of operation.

1. Vent Plug and Oil Level
The vent plug and oil level sight gauge are located in the bearing support on the end of the hoist opposite the motor. It is important to keep the vent clean and unobstructed. Whenever gear oil is changed, remove the vent plug and sight gauge, clean in solvent and reinstall.
Do not paint over the vent or replace with a solid plug.



2. Oil Change
Rotate the drum to align the drain plug with the lowest hole in the support bracket. Install a short piece of 1-inch pipe into the threads around the drain plug. Remove the drain plug (5/16-inch hex) and drain the oil into a suitable container. Always dispose of used oil in an environmentally responsible manner. Remove the 1-inch pipe and rotate the drum to align the hole in the drum with the highest hole in the support bracket. Reinstall the pipe and fill the hoist drum with the recommended oil to the center of the sight gauge. Install the drain plug and remove the pipe.

3. Hydraulic System
The original filter element should be replaced after the first 50 hours of operation, then every 500 operating hours or three months, or in accordance with the equipment manufacturer's recommendations.

4. Wire Rope
Inspect entire length of wire rope according to wire rope manufacturer's recommendations.

5. Mounting Bolts
Tighten all hoist base mounting bolts to recommended torque after the first 100 hours of operation, then every 1,000 operating hours or six months, whichever occurs first.

6. Warm-up Procedures
A warm-up procedure is recommended 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 at low speeds, forward and reverse, several times to prime all lines with warm hydraulic oil, and to circulate gear lubricant through the planetary gear sets.

⚠ 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. Recommended Planetary Gear Oil
Field experience, supported by engineering endurance tests, indicates use of the proper gear oil and a program of regular preventive maintenance will help provide extended gear train life and reliable hoist brake performance. Refer to Recommended Gear Oil, later 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 extreme-pressure (EP) and antifriction additives which may contribute to brake slippage and damage to brake friction discs or seals. Oil viscosity with regard to ambient temperature is also critical to reliable brake operation. Our tests indicate that excessively heavy or thick gear oil may contribute to intermittent brake slippage. Make certain that the gear oil viscosity used in your hoist is correct for your prevailing ambient temperature.

For simplicity, BRADEN has listed available products in each temperature range that have been tested and found to meet our specifications. This is not to say that other lubricant brands would not perform equally as well.

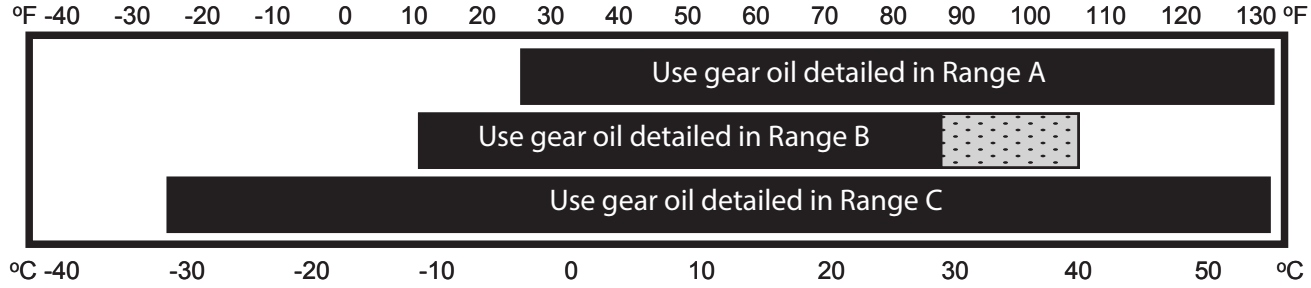
If the following lubricant brands are not available in your area, make certain your lubricant vendor supplies you with oil equivalent to those products listed on following page..

Unless otherwise specified, it is recommended gear oil be changed after the first 100 hours or two months of machine operation, then every 1,000 hours or six months, whichever occurs first. 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.

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 extreme-pressure (EP) and antifriction additives which may contribute to brake clutch slippage or damage to brake friction discs or seals. Oil viscosity, affected by ambient temperature, is also critical to reliable brake clutch operation. Our tests indicate excessively heavy or thick gear oil may contribute to intermittent brake clutch slippage. Make certain gear oil viscosity used in your hoist is correct for your prevailing ambient temperature.

RECOMMENDED GEAR OIL

PREVAILING AMBIENT TEMPERATURE



SHADED TEMPERATURE RANGE IN THE CHART ABOVE NOT RECOMMENDED FOR SEVERE APPLICATIONS SUCH AS SUSTAINED FAST DUTY CYCLES OR FREQUENT WINCHING.

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

	Mobil	Shell	Chevron	Texaco
Range A	Mobilgear 600 XP 220	Omala S2 G 220	Gear Compounds EP 220	Meropa 220
Range B	Mobilgear 600 XP 150	Omala S2 G 150	Gear Compounds EP 150	Meropa 150
Range C	Mobilgear SHC 150	Omala S4 GX 150		

CH210/CH280 Planetary Hoist Oil Capacity

	Pints	Quarts	Litre
CH210-01 (before 7/2003)	34	17	16.1
CH210-01 (after 7/2003)	23	11.5	10.9
CH210-02	60	30	28.4
CH210-03G	36	18	17
CH210-05G	44	22	20.8
CH280A - 01	50	25	22.7
CH280A - 02	108	54	51

BRADEN recommends the following inspection, testing, and preventive maintenance procedures. For additional details, refer to BRADEN publication PB-308.

Inspection, testing, and preventive maintenance requirements are divided into several categories: Pre-use, Quarterly, Semiannual and Annual as outlined below. The Installation, Maintenance, and Service Manual for each model provides specific instructions for maintenance and service.

Some inspection intervals make reference to hoists used in severe-duty applications. Severe-duty applications are where the hoist is operated more than 12 hours per day and/or for extended periods of time at or near the rated capacity of the hoist.

Anytime that the hoist exhibits erratic operation and/or unusual noise(s), the hoist should be taken out of service until it is inspected and serviced by a qualified technician.

REGULAR INSPECTION, TESTING, AND PREVENTIVE MAINTENANCE — Must include, but not be limited to the following:

PRE-USE INSPECTION (each shift the hoist is used): Will be performed prior to placing the crane into service and then as necessary during the day for extended operation.

1. Check for external oil leaks and repair as necessary. **This is extremely important because of the accelerated wear that can be caused by insufficient lubricating oil in the hoist.** Lubricant level must be maintained between the maximum and minimum levels. Use only the recommended type of lubricant; see service manual for details. On models without a sight glass, check oil level monthly.
2. Check the ratchet and pawl mechanism (if so equipped) for proper operation and for full engagement of the pawl with the ratchet wheel. Repair and/or adjust as necessary.
3. Check hydraulic plumbing for damage, such as chafed or deteriorated hoses, and repair as necessary.
4. Visually inspect for loose or missing bolts, pins, keepers or cotter pins and replace or tighten as necessary.

QUARTERLY INSPECTION (every 3 months) or monthly in severe-duty applications or prior to putting the machine into service if it has not been used for 3 months or more. Documentation of the inspections must be kept with the hoist/crane for a minimum of two years from the date of the inspection (see Page 3).

Perform the PRE-USE INSPECTION plus the following:

1. Check the lubricant level in the hoist(s) and maintain it between maximum and minimum levels. Use only recommended type of lubricant; see service manual for details.
2. On hoists used for personnel handling, the internal spring-applied brake shall be tested in accordance with the procedure on Page 6 of publication PB-308.
3. Inspect for corrosion of fasteners, mounting base, drum, etc. and repair/replace as necessary.

SEMIANNUAL INSPECTION (every six months), or quarterly in severe-duty applications. Documentation of the inspections must be kept with the hoist/crane for a minimum of two years from the date of the inspection (see next page).

Perform the **PRE-USE INSPECTION** and **QUARTERLY INSPECTION** plus the following:
Take a sample of the lubricating oil from the hoist drum, following the oil sampling procedure on Page 5 of publication PB-308, and analyze it for wear metals content, the correct viscosity, signs of overheating, water and other contaminates. If the oil sample contains an unusual amount of metallic particles, the hoist should be taken out of service and undergo a teardown inspection. The oil sample must be taken prior to changing the lubricating oil. The semiannual oil analysis can be omitted if the crane has been used less than 250 hours since the previous oil sample.

ANNUAL INSPECTION, Testing, and Preventive Maintenance or semiannually in severe-duty applications. Documentation of the inspections must be kept with the hoist/crane for a minimum of two years from the date of the inspection (see next page). The annual inspection must include, but not be limited to the following:

1.Perform the **PRE-USE INSPECTION, QUARTERLY,** and **SEMIANNUAL INSPECTIONS**, plus the following:

2.Change lubricating oil in hoist drum or gearbox after oil sample is taken. Refer to Recommended Gear Oil, earlier in this section. Failure to follow these recommendations may result in brake failure.

NOTE: If the oil sampling/analysis has not been performed as required, refer to the teardown inspection section below.

The user of BRADEN products is responsible for hoist inspection, testing and maintenance noted above with frequency dependent upon the severity of the hoist duty cycle and the thoroughness of the preventive maintenance program in effect.

Alternate inspection periods may be used if approved in writing by BRADEN. Those that are interested in an alternate inspection period should submit a written proposal to BRADEN that includes typical duty cycle for the hoist along with a detailed description of the preventive maintenance program for these hoists.

Inspection Records and Retention

Crane inspection reports as well as records of preventive maintenance, repairs and modifications to hoists should be available and accessible for a minimum of two years. These records should include, but not be limited to, hoist model and serial number, name and employer of repair/inspection technician, date and description of preventive maintenance, functional test reports and repairs.

To provide customers with qualified outlets for hoist service and repairs, BRADEN has established authorized Service Centers. These Service Centers have factory trained service technicians, up-to-date service information, extensive parts inventories, complete testing facilities, and are audited by BRADEN on a regular basis for compliance. **BRADEN strongly recommends the use of BRADEN authorized Service Centers** for maintenance, repair and inspection of BRADEN/Gearmatic products. Contact the BRADEN Product Support Department at 918-251-8511 for the names of current authorized Service Centers.

TEARDOWN INSPECTION – Any Hoist that has NOT been subject to regular oil sample analysis should undergo a teardown inspection on an annual (12-month) basis. Also, if a hoist has an unknown history of repair and/or maintenance, it is recommended that the hoist undergo a teardown inspection prior to it being placed into service.

A teardown inspection should include the hoist being completely disassembled, cleaned and inspected and replacement of all worn, cracked, corroded or distorted parts such as pins, bearings, shafts, gears, brake rotors, brake plates, drum and base. Refer to the applicable BRADEN or Gearmatic Service Manual for more details. All seals and O-rings should be replaced during a teardown inspection.

Any deficiencies, such as those listed above shall be corrected immediately.

All of the following operations must be performed before the hoist is placed back in service:

The rebuilt hoist must be line pull tested to the rated load of the hoist (hoist rating will vary with motor, gear ratio and drum options) with a dynamometer or equivalent measuring device. This test load should be the maximum rating for the hoist for the specific application (at the normal hydraulic relief valve setting for the hoist), not the reduced rating for personnel lifting.

The hoist must be dynamically tested by rotating the drum several times, in both the hoisting and lowering directions, while under a load of at least 30% of the hoist lifting capacity. Check for smooth operation during this procedure.

The brake should be tested per the brake test procedures on Page 6 of Publication PB-308.

After inspection or rebuild and testing, a new certificate for personnel handling will be issued by the inspector/ service technician effective on the date the hoist is placed back in service.

See sample inspection certificate on next page.

Name of Service Company
Approved by BRADEN for handling personnel
if used and maintained in accordance with BRADEN
Recommendations for Personnel Handling Hoists

Hoist Model No.: _____
Hoist Serial No.: _____
Date of Inspection: _____
Work Order/Job No.: _____
Inspector's Name: _____
For a copy of recommendations write or call: BRADEN
800 E. Dallas St., Broken Arrow, OK, 74012; (918) 251-8511

Sample inspection certificate

PERSONNEL HANDLING

BRADEN recognizes that most hoists and cranes are designed and intended for handling materials and not personnel. **The crane or hoist is to be used to handle personnel only if it can be shown there is no less hazardous way of carrying out the job.** In these situations, all safety precautions must be strictly adhered to. BRADEN recommends adherence to the latest revision of API 2D (RP 2D) and/or ANSI/ASME standard B30.5 and/or OSHA and/or other applicable standards for your application. It is important that you obtain a copy of all applicable safety standards, and that you read and understand them prior to using the hoist. **In addition to**, or in conjunction with, the applicable standards, BRADEN requires the following:

- The hoist must be maintained in accordance with the recommendations in this document and the service procedures in the Installation, Maintenance, and Service Manual for your specific hoist.

- When handling personnel, the allowable line pull will be limited to 30% of the hoist rated line pull. This reduction increases the hoist design factor from 3:1 to 10:1, approximately. Example: a hoist rated at 15,000 lbs. on the first layer will be rated at 15,000 x 0.3 = 4,500 lbs. on the first layer when handling personnel.

- Personnel are permitted to ride in an approved personnel platform only as described in API, OSHA or ANSI/ASME standards.

- The crane must be in good working order and equipped with all required safety equipment, including an anti two-blocking device or warning signal and a boom angle and length indicator. Two-blocking occurs when the load block or hook assembly comes in contact with the upper block or point sheave assembly and often results in damage to the wire rope, rigging and/or hoist.

- Personnel being lifted or supported shall wear safety belts with lanyards attached to designated points unless lifting over water. If lifting over water, provide approved personal flotation devices (PFD).

- The lifting and supporting shall be made under controlled conditions and under the direction of an appointed signal person.

- The operator and signal person shall conduct a test lift, without personnel in the personnel platform, to verify adequacy of the crane footing or support. The crane outriggers, if so equipped, must be fully extended and properly set.

- Cranes shall not travel (move locations) while personnel are on the personnel platform.

- The platform must be landed or tied off, and all brakes set before personnel enters or exits.

TROUBLESHOOTING

⚠ WARNING ⚠

If a hoist ever exhibits any sign of erratic operation, or load control difficulties (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 problem could be a plugged or loose pilot orifice. The pilot orifice is a small pipe plug with a hole drilled through it, located behind the pilot port fitting on the brake valve. If it becomes plugged, it will prevent the pilot pressure, from the manifold, from opening the brake valve. If it becomes loose, it will allow an unregulated amount of oil in to operate the brake valve which cause erratic brake valve operation.	Remove the pilot hose and fitting from the brake valve, then use a 5/32-inch Allen wrench to remove the pilot orifice. The diameter of the orifice is approximately .020 inch. Clean and install the pilot orifice tightly in the brake valve.
	2. 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 plug.	Check brake cylinder seal as follows: A. Disconnect the swivel tee from the brake release port. Connect a hand pump with accurate 0–2,000 PSI gauge and shut-off valve to the –4 JIC fitting in the brake release port. B. Apply 1,000 PSI to the brake. Close shut-off valve and let stand for five minutes. C. If there is any loss of pressure in five 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 section of manual.
	3. Friction brake will not release as a result of damaged brake discs.	Disassemble brake to inspect brake discs. Check stack-up height as described in Motor Support-Brake Cylinder Service section.

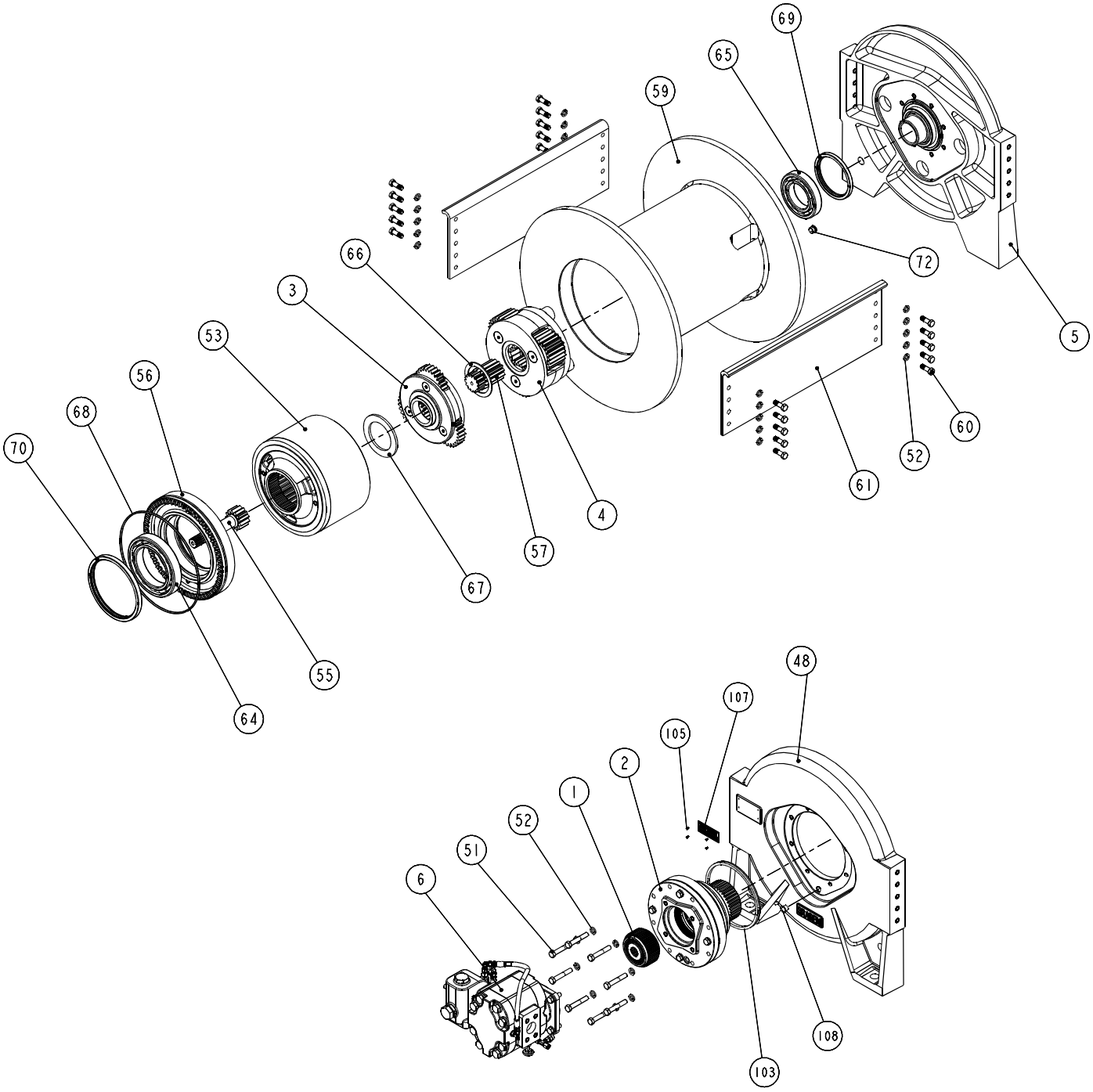
TROUBLE	PROBABLE CAUSE	REMEDY
B Oil leaks from vent plug	1. Same as A2. 2. Motor seal may be defective as a result of high system back pressure or contaminated oil.	Same as A2. System back pressure must not exceed 150 PSI. Inspect hydraulic system for a restriction in the return line from the control 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 3 of Trouble A3. 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 section of manual. Brake clutch may be damaged or worn. Disassemble and inspect brake clutch as described in Brake Clutch Service section.
D The hoist will not raise 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. 2. System relief valve may be set too low. Relief valve needs adjustment or repair.	Reinforce mounting surface. If necessary, use shim stock to level hoist. Refer to Hoist Installation section. First loosen, then evenly retighten all hoist mounting bolts to recommended torque. Check relief pressure as follows: A. Install an accurate 0–4,000 PSI gauge into the inlet port of the brake valve.

TROUBLE	PROBABLE CAUSE	REMEDY
TROUBLE “D” CONTINUED FROM PREVIOUS PAGE The hoist will not raise the rated load.		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°F (82°C). Excessive hydraulic oil temperatures increase motor internal leakage and reduce motor performance.	Same as remedies for Trouble D1 and D2. Same as remedies for Trouble E2.
	4. Hoist line pull rating is based on first 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	1. Same as D1.	Same as remedies for Trouble D1.
	2. Be certain that the hydraulic system temperature is not more than 180°F. 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 as remedies for Trouble D2.
	D. Hydraulic pump not operating efficiently.	Prime mover low on horsepower or RPM 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.

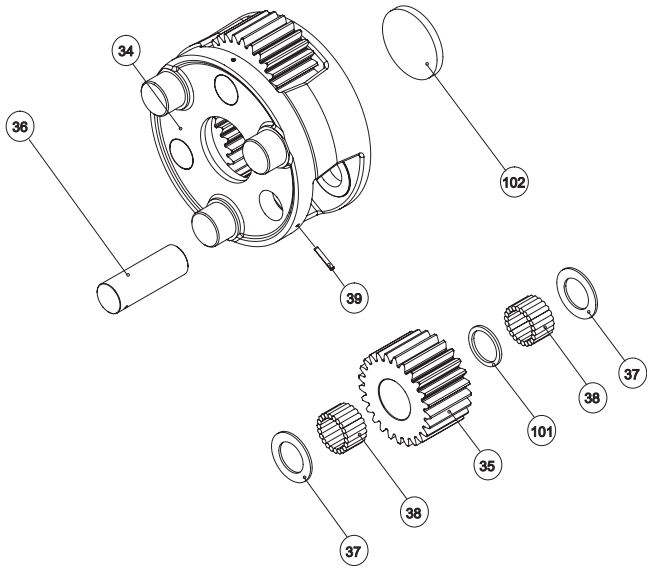
TROUBLE	PROBABLE CAUSE	REMEDY
F Hoist chatters while raising rated load.	1. Same as D2. 2. Hydraulic oil flow to motor may be too low. 3. Controls being operated too quickly.	Same as remedies for Trouble D2. Same as remedies for Trouble E2. Conduct operator training as required.
G The wire rope does 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 1.5 degrees. 2. The hoist may not be mounted perpendicular to an imaginary line between the center of the cable drum and the first sheave. 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 crisscross and overlap on the drum. The result is apt to be a flattened and crushed rope. 4. The hoist may have been overloaded, causing permanent set in the wire rope.	Check mounting distance and fleet angle. Reposition hoist as required. Refer to Hoist Installation section of manual. Consult wire rope manufacturer for recommendation of wire rope that best suits your application. Replace wire rope and conduct operator/rigger training as required.

BRADEN CH210 COMPONENTS

Hoist Assembly

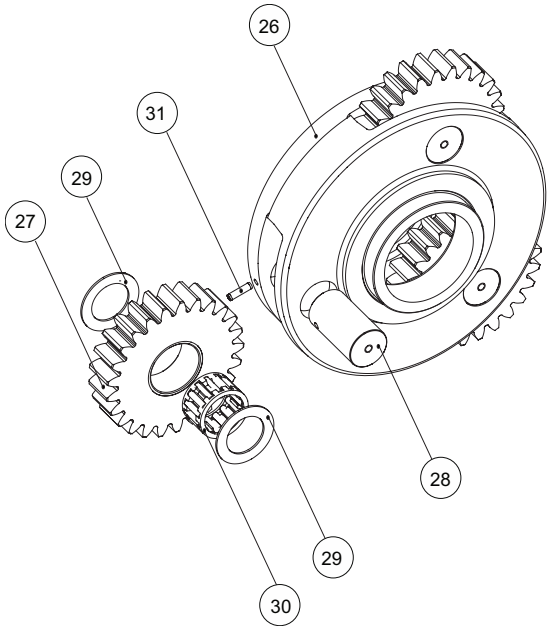


ITEM	DESCRIPTION	QTY.
1	Over-running Clutch Assembly	1
2	Brake Cylinder Assembly	1
3	Primary Planet Carrier Assembly	1
4	Output Planet Carrier Assembly	1
5	Drum Support Asssembly	1
6	Motor Asssembly	1
48	Motor Endplate	1
50	Retaining Ring	2
51	Capscrew	8
52	Lockwasher	28
53	Ring Gear	1
55	Primary Sun Gear	1
56	Drum Closure	1
57	Output Sun Gear	1
59	Cable Drum	1
60	Capscrew (Special)	20
61	Tie Plate	2
64	Ball Bearing	1
65	Ball Bearing	1
66	Thrust Washer	1
67	Thrust Washer	1
68	O-Ring	1
69	Seal	1
70	Seal	1
71	Cable Wedge - Not Shown	1
72	Plug, O-Ring Flush	2
103	V-Ring Seal	1
105	Drive Screw	4
107	Nameplate	1
108	Closure	1
109	Tie Plate Spacer-Not Shown (02 Drum ONLY)	4



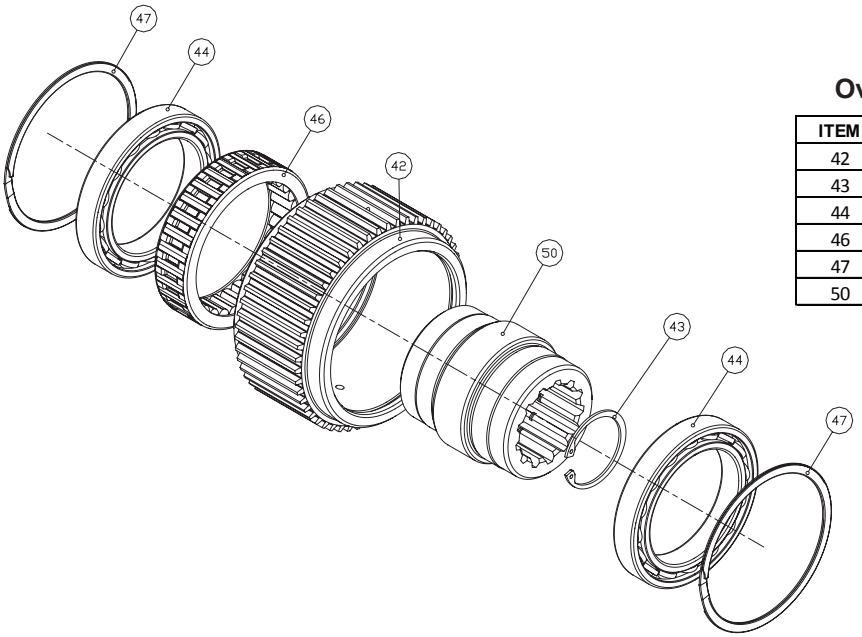
CH210 Output Planet Carrier Assembly
(See Page 29 for CH280)

ITEM	DESCRIPTION	QTY.
34	Output Planet Carrier	1
35	Output Planet Gear	3
36	Output Planet Gear Shaft	3
37	Thrust Washer	6
38	Loose Rollers	132
39	Spirol Pin	3
101	Bearing Spacer	3
102	Thrust Plate	1



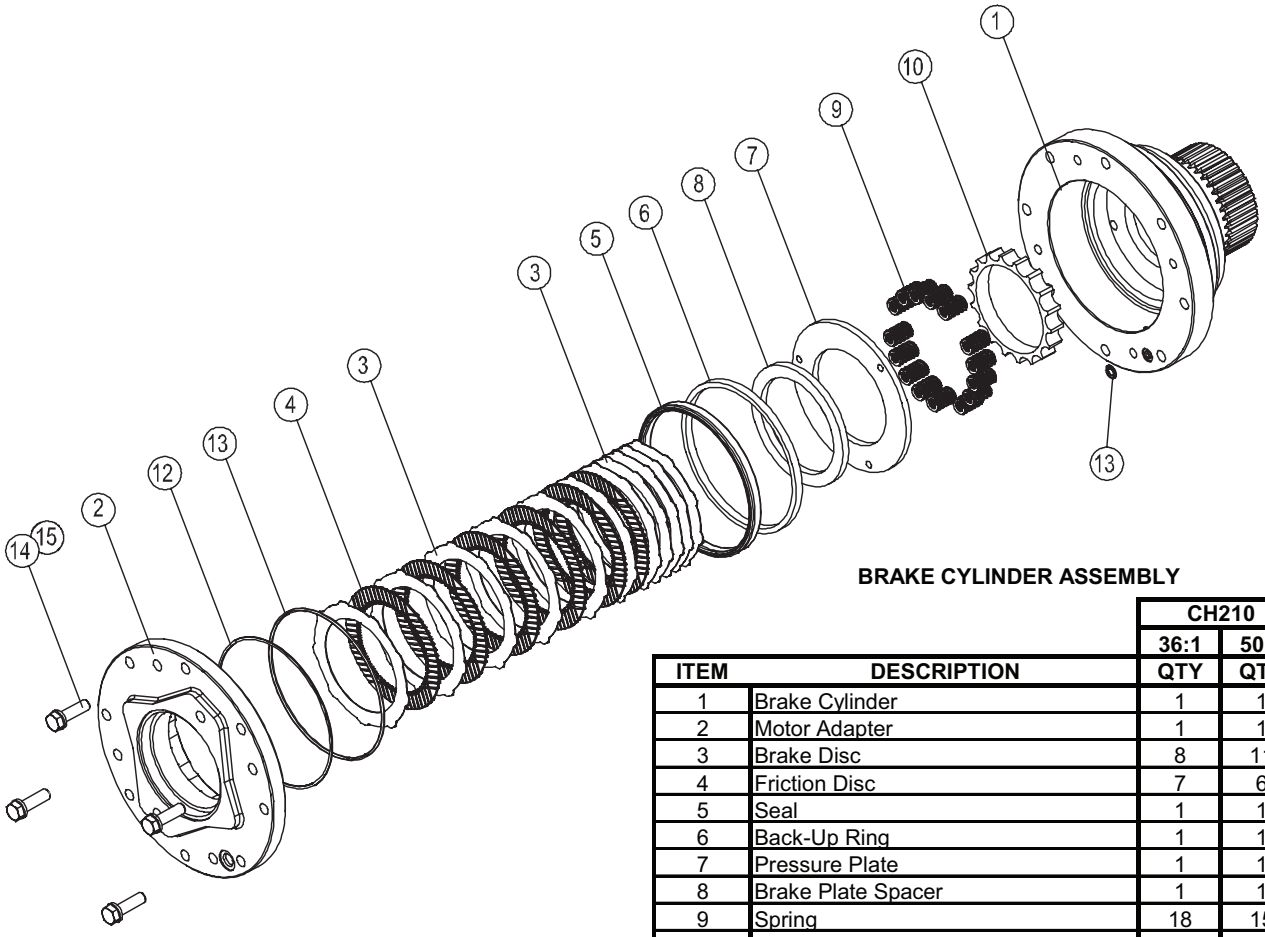
CH210 Primary Planet Carrier Assembly
(See Page 28 for CH280)

ITEM	DESCRIPTION	QTY.
26	Primary Planet Carrier	1
27	Primary Planet Gear	3
28	Primary Planet Gear Shaft	3
29	Thrust Washer	6
30	Roller Bearing	3
31	Spirol Pin	3



Overrunning Clutch Assembly

ITEM	DESCRIPTION	QTY.
42	Outer Race	1
43	Retaining Ring	2
44	Ball Bearing	1
46	Over-running Clutch	1
47	Retaining Ring	2
50	Inner Race	1

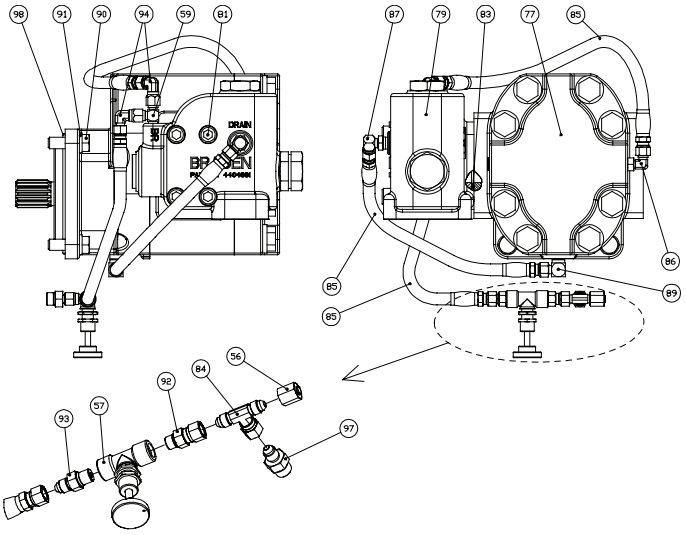


BRAKE CYLINDER ASSEMBLY

		CH210		CH280
		36:1	50:1	54:1
ITEM	DESCRIPTION	QTY	QTY	QTY
1	Brake Cylinder	1	1	1
2	Motor Adapter	1	1	1
3	Brake Disc	8	11	9
4	Friction Disc	7	6	8
5	Seal	1	1	1
6	Back-Up Ring	1	1	1
7	Pressure Plate	1	1	1
8	Brake Plate Spacer	1	1	1
9	Spring	18	15	18
10	Spring Spacer	1	1	1
11	O-Ring	1	1	1
12	Back-Up Washer	1	1	1
13	O'Ring	1	1	1
14	Capscrew (1/2-13 x 1 3/4 G8 Z)	4	4	4
15	Lockwasher (1/2)	4	4	4

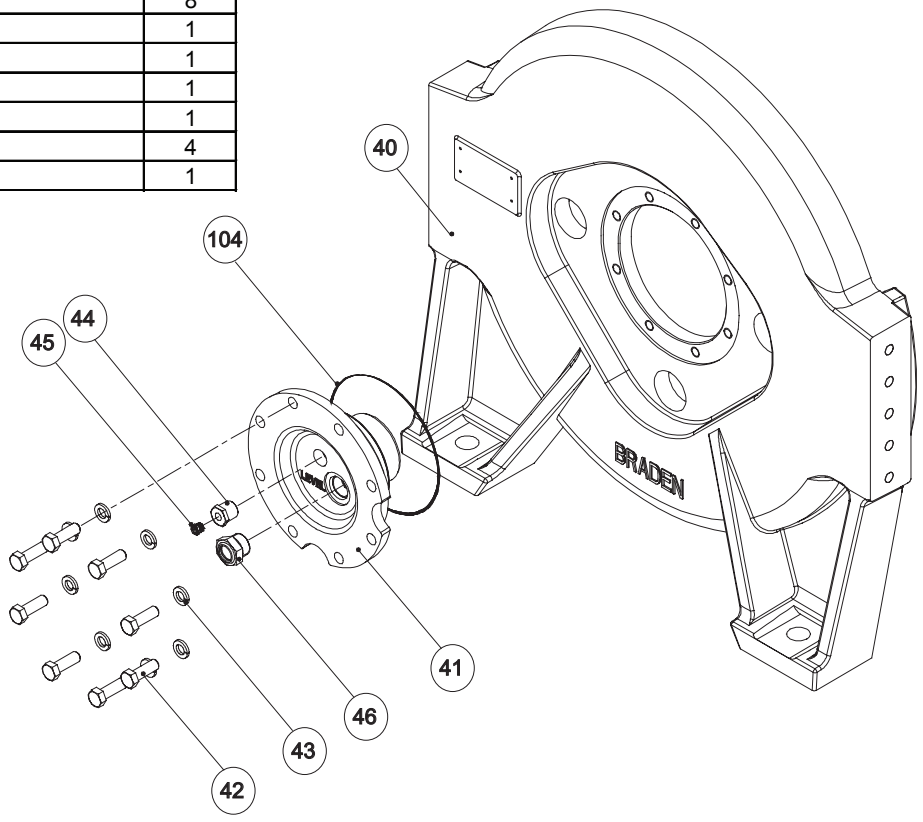
Motor Group

ITEM	DESCRIPTION	QTY.
56	Cap Nut	1
57	Needle Valve	1
59	Male Run Tee	1
77	Hydraulic Motor	1
79	Brake Valve	1
81	Capscrew (1/2 - 13 X 4-1/2 G8 Sock Hd)	4
83	O-Ring	1
84	Swivel Tee Fitting	1
85	Hose Assembly	3
86	Elbow Fitting	1
87	Elbow Fitting	1
89	Elbow Fitting	1
90	Capscrew (1/2 - NC x 1-1/2 G5)	4
91	Lockwasher (1/2)	4
92	Adapter	1
93	Adapter	1
94	Swivel Nut Elbow, 90 degree	2
97	Adapter	1
98	O-Ring	1
--	Warning Tag (not shown)	1



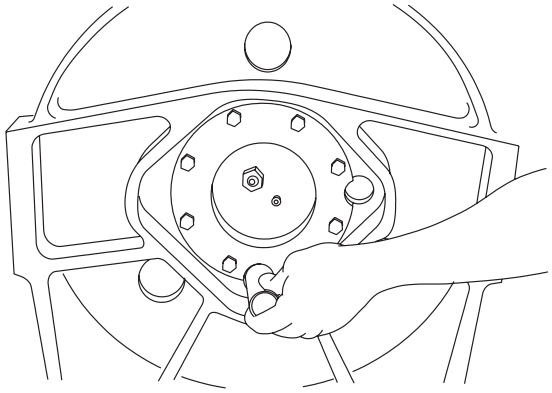
Drum Support Assembly

ITEM	DESCRIPTION	QTY.
40	Support Endplate	1
41	Bearing Support	1
42	Capscrew (1/2 NC X 1-1/2 G8 Z)	8
43	Lockwasher (1/2)	8
44	Reducer Bushing	1
45	Vent Plug	1
46	Sight Gauge	1
104	V-Ring Seal	1
105	Drive Screw (not shown)	4
106	Approval Plate (not shown)	1

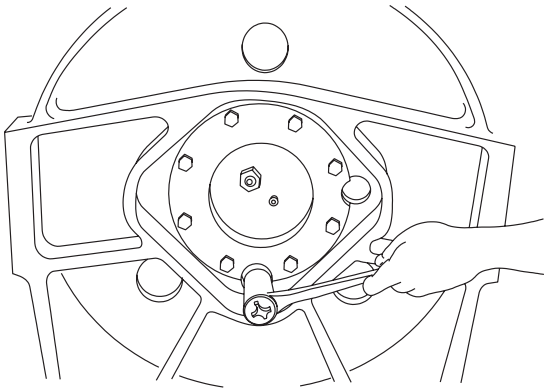


HOIST DISASSEMBLY

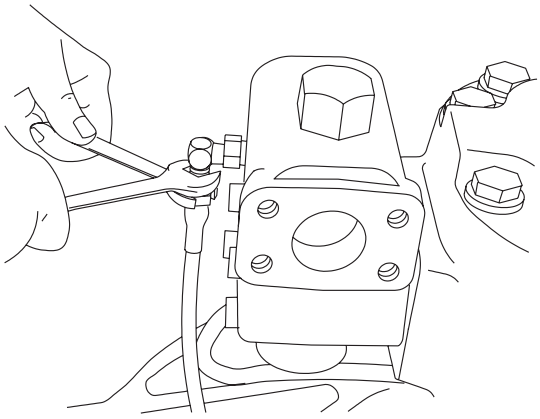
1. Remove the wire rope from the hoist drum and align the drain plug in the drum with the lowest hole in the support end plate before removing the hoses and mounting bolts. After the hoist is removed from its mounting, clean the outside surfaces.



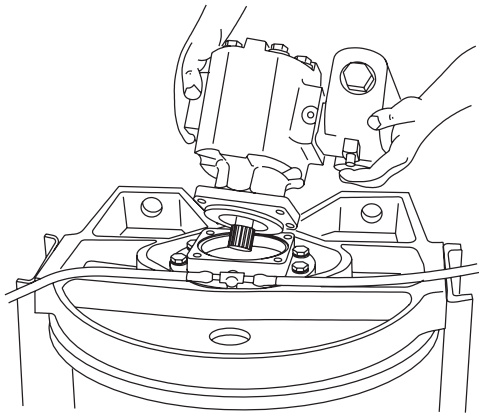
2. To drain the oil, screw a short piece of 1-inch pipe into the larger threads of the drain hole.



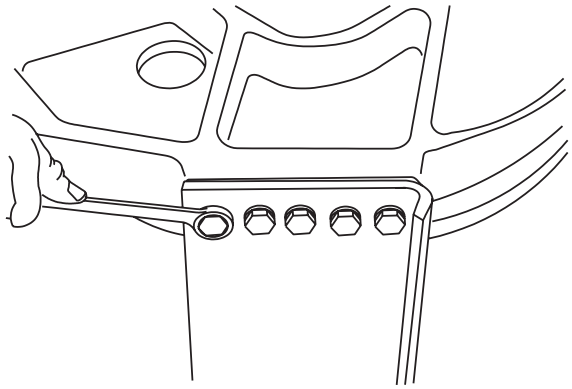
3. Use a 5/16-inch Allen hex to remove the drain plug through the pipe. If the drain holes were not aligned before the hoist was removed from its mounting, the oil can be drained by removing the vent plug and sight gauge in the bearing support and turning the hoist upward on the bearing support end.



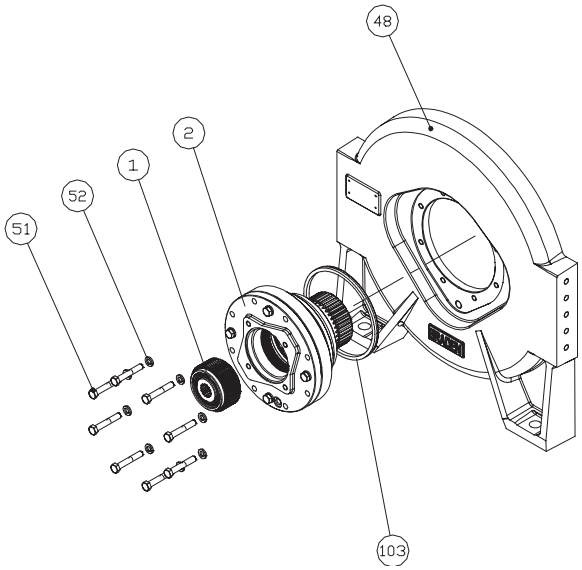
4. Begin the disassembly by standing the hoist on the end opposite the motor. Tag and remove the hydraulic hoses that connect the brake valve and the motor (manifold in the case of a two-speed motor) to the brake release port.



5. Remove the four capscrews and lockwashers securing the motor and lift the motor off the hoist. Remove and discard the O-ring installed on the outside of the motor pilot.

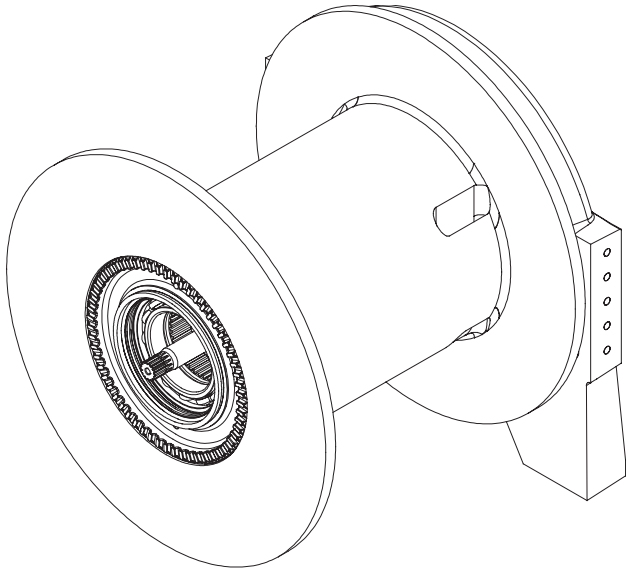


6. Remove the 20 capscrews and lockwashers from the two tie plates, and remove the plates.



7. Remove the overrunning clutch assembly (Item 1) from the center of the brake cylinder assembly. Refer to Overrunning Clutch Assembly Service section in this manual for additional information. Remove the eight capscrews (Item 51) and lockwashers (Item 52) from the motor adapter, and remove the brake cylinder assembly. Remove and discard the V-ring seal (Item 103) that was under the brake cylinder. Do not remove the four capscrews holding the motor adapter to the brake cylinder at this time. Refer to Brake Cylinder Service section of manual.

8. Remove the motor end plate (Item 48) from the drum.



9. There are two 1/2-inch NC tapped holes in the drum closure (Item 56). Install two capscrews or threaded eyebolts to aid in removing the closure from the cable drum. Remove and discard the O-ring (Item 68) from the OD of the drum closure.

10. Install two eyebolts into top end of ring gear. Lift ring gear out of drum. Remove planet gear sets from drum.

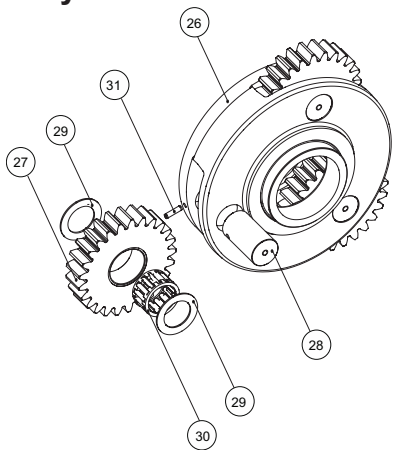
11. Lift the cable drum (Item 59) off of the drum support assembly (Item 5).

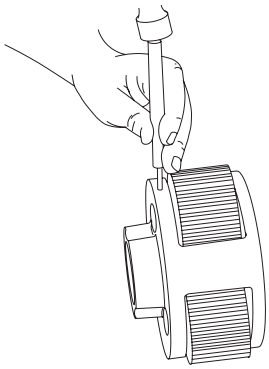
12. Thoroughly clean and inspect all disassembled components at this time. Inspect bearings in the drum closure and cable drum (Items 64 and 65), and replace as required. Inspect sealing surfaces on the drum support and brake cylinder and repair any damaged areas if possible, or replace components as required. During a complete hoist teardown, drum seals (Items 69 and 70) and V-ring seals (Items 103 and 104) should always be replaced. Inspect thrust washers (Items 66 and 67) for signs of excessive wear, heat damage or metal transfer and replace as necessary. Inspect the ring gear teeth for nicks, spalling, or excessive wear. Replace if wear in contact areas is greater than 0.015 inch (0.4 mm) when compared to unworn area of teeth.

PLANET CARRIER SERVICE

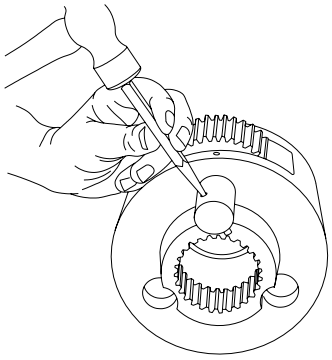
PRIMARY PLANET CARRIER CH210 ONLY

Disassembly





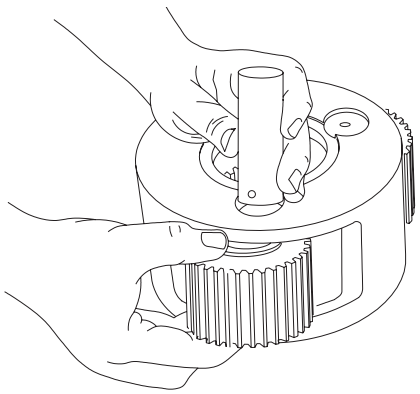
1. Remove the planet gears by first driving the roll pins (Item 31) into the center of the planet gear shafts (Item 28).



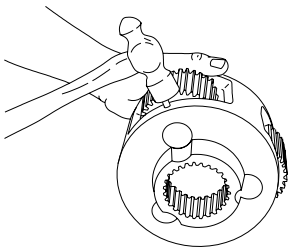
2. Use a punch to drive the roll pins from the planet gear shafts. **DO NOT** reuse the roll pins.

3. Now you can remove the planet shafts, bearings, 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 should 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 should 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 necessary

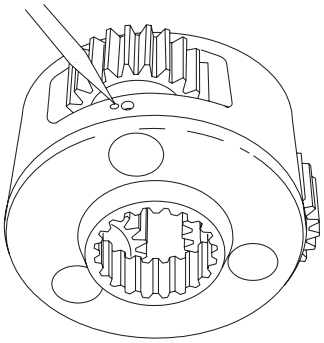
Assembly



1. Install a bearing into a planet gear and place a thrust washer on each side of the gear. Position this assembly into an opening in the carrier. Slide a planet gear shaft through the carrier, thrust washer, bearing and remaining thrust washer.



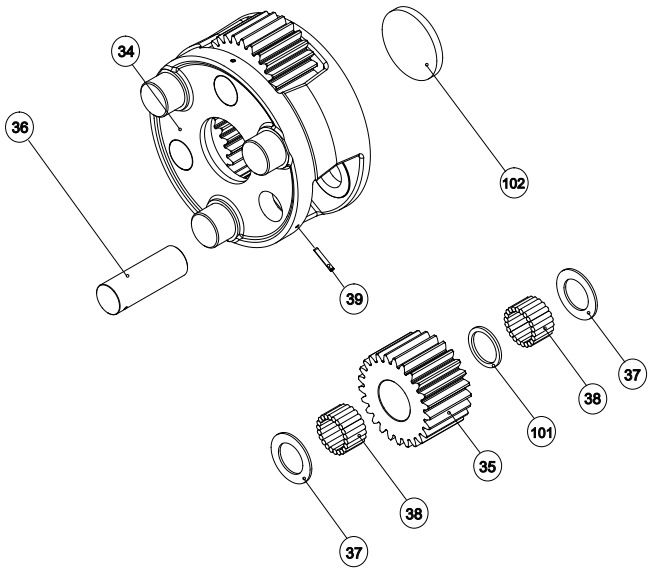
2. Carefully align the pin hole in the carrier with the hole in the shaft and drive a new roll pin into place. **ALWAYS** use **NEW** roll pins. When properly positioned, 50% of the roll pin will engage the planet gear shaft and 50% will remain in the carrier.



3. Note that the roll pin is slightly recessed into the carrier when properly installed. With a center punch, stake the carrier next to the pin hole as shown. This will distort the hole and prevent the pin from backing out in operation. Repeat these steps for each of the three planet gears.

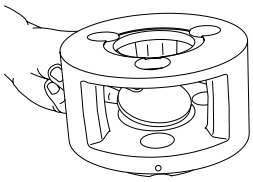
OUTPUT PLANET CARRIER
CH210 ONLY

Disassembly



1. Follow steps 1 and 2 of the Primary Planet Carrier disassembly procedure to remove the roll pins from the planet gear shafts.
2. Now you can remove the planet shafts, bearings, spacers, 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, they should be replaced. The thrust washer contact areas should be free from any surface irregularities that may cause abrasions or friction. Inspect gears and shafts for abnormal wear or pitting and replace if necessary.

Assembly

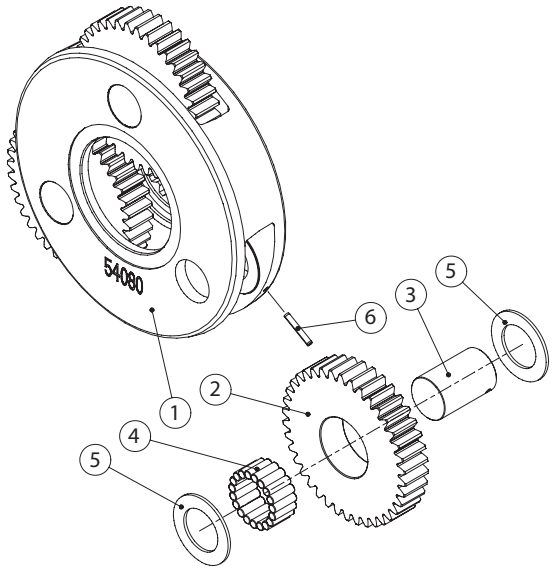


1. Place the output carrier on a clean work surface with the drive pins down. Install the output thrust plate (Item 102) into the center of the carrier.
2. Apply a liberal coat of oil soluble grease to a thrust washer and center it on one side of a planet gear. Place the planet gear on a clean work surface with the thrust washer down. Apply a liberal coat of oil soluble grease to the bore of the gear. Stack a row of loose roller bearings into the planet gear, using the grease to hold them in position. There are 22 rollers in each row. Install a bearing spacer. Stack a second row of loose roller bearings on top of the bearing spacer. Place a second thrust washer on the planet gear. Carefully slide the planet gear, bearings and thrust washers into the carrier. Install a planet gear shaft into the carrier and through the planet gear bearings.
3. Follow steps 2 and 3 of the Primary Planet Carrier assembly procedure to install and stake a **NEW** roll pin in the carrier.

Repeat this procedure for each of the planet gears.

PRIMARY PLANET CARRIER
CH280 ONLY

Disassembly



1. Remove the planet gears using a punch and driving the roll pins (Item 6) into the center of the planet gear shafts (Item 3). Slide the planet shafts out of the planet carrier.

2. Use a punch to drive the roll pins out or the planet gear shafts. **DO NOT** reuse the roll pins.

3. Remove the planet shafts, bearings, spacers, thrust washers and gears. The bearing rollers are loose in the planet gear, so take precautions to ensure they are contained when the planet gear is removed from the planet carrier. Holding the thrust washers against the gear as it is removed from the planet carrier will help keep them in place.

4. 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, they should 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 necessary.

Assembly

1. Place the planet carrier on a clean work surface with the roll pin side down.

2. Place a planet gear (Item 2) on a clean work surface resting on the gear teeth. Apply grease to the loose rollers (Item 4) and set in the lower half of the planet gear. Apply grease to one of the thrust washers (Item 5) and push onto the planet gear letting the grease hold in place. Slide the planet shaft (Item 3) into the planet gear and through the thrust washer. Grease and install the remaining rollers around the planet shaft. There are 19 rollers in each planet gear. Grease and install the remaining thrust washer (Item 3) onto the planet gear shaft and against the planet gear. Rotate the planet gear so it is positioned for installation into the planet carrier resting on the table. Remove the planet shaft while holding the thrust washers against the gear to keep the loose rollers in place.

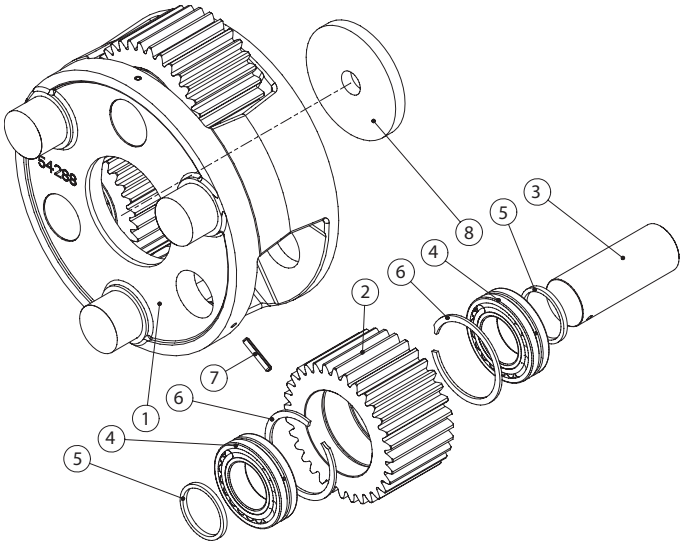
3. Carefully slide the planet gear, bearings, and thrust washers into the planet carrier. The thrust washers must be held against the gear to keep the loose rollers positioned in the planet gear. Slide the planet gear shaft into the carrier and through the planet gear bearings.

4. Carefully align the pin hole in the planet carrier with the hole in the planet shaft and drive a new roll pin into place – **ALWAYS USE NEW ROLL PINS**. Ensure that the new roll pin is slightly recessed into the planet carrier. With a center punch, stake the planet carrier next to the pin hole. This will distort the hole and prevent the pin from backing out during operation.

5. Repeat the above steps for each of the three planet gears.

OUTPUT PLANET CARRIER
CH280 ONLY

Disassembly



1. Remove the planet gears using a punch and driving the roll pins (Item 6) into the center of the planet gear shafts

2. Slide the planet shafts out of the planet carrier and remove bearings, spacers, thrust washers and gears from the planet carrier.

3. Thoroughly clean all parts and inspect for damage and wear. The bearings should not exhibit any irregularities. If the bearings show any sign of spalling, corrosion, discoloration, material displacement or abnormal wear, they should 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 necessary.

Assembly

1. Place the output carrier on a clean work surface with the drive pins down. Install the output thrust plate (Item 8) into the center of the carrier.

⚠ WARNING ⚠

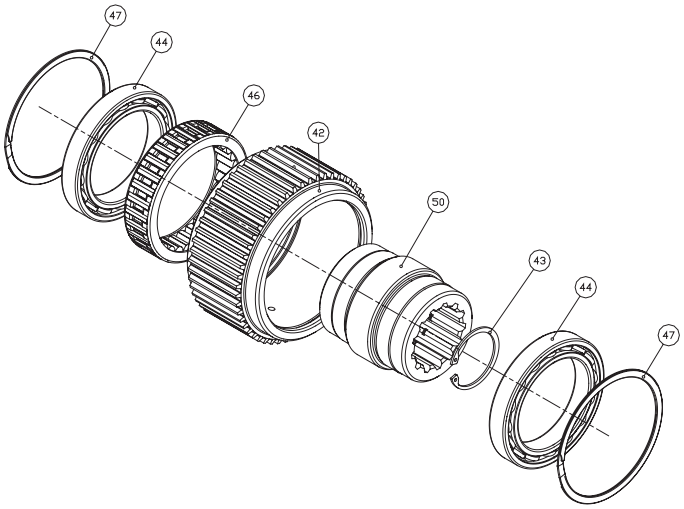
Follow safety procedures and wear safety glasses when operating a hydraulic press. Failure to follow procedures may result in death or personal injury.

2. Install the retaining rings (Item 6) into the planet gear (Item 2) bore and ensure they are seated in the groove. Use a hydraulic press to press the bearings (Item 4) into the gear until the bearing is seated against the retaining ring. Press the second bearing into the opposite side of the gear. Apply a light coat of grease to the bearing races and the spacers (Item 5) and set the spacers on top of the bearing on each side of the gear. Carefully slide the planet gear, bearings and spacers into the carrier. Install a planet gear shaft (Item 3) into the carrier and through the planet gear bearings.

3. Follow step 4 of the Primary Planet Carrier assembly procedure to install and stake a **NEW** roll pin in the carrier.

4. Repeat this procedure for each of the planet gears.

OVERRUNNING CLUTCH SERVICE



NOTE: Outer race (Item 42), Inner race (Item 50) and Overrunning clutch (Item 46) are NOT SOLD individually as replacement parts. If any of these parts require replacement, the entire overrunning clutch assembly must be replaced. Carefully note the relative orientation between the inner and outer races, and the direction of free rotation of the inner race. The clutch MUST be reassembled correctly for proper hoist operation.

⚠ WARNING ⚠

The polished surfaces of the inner and outer race and the overrunning cams must be perfectly smooth to ensure positive engagement of the clutch. The slightest defect may reduce clutch effectiveness, which may lead to loss of load control and result in property damage, injury, or death. It is generally recommended to replace the entire clutch assembly if any component is defective. For these reasons, the overrunning clutch assembly should be disassembled for inspection only if the hoist has exhibited any unusual operation that would point toward a clutch malfunction, or the overrunning clutch assembly shows external signs of mechanical damage.

Disassembly

1. Remove one of the retaining rings (Item 47) from the outer race (Item 42). Push the inner race (Item 50), bearings (Item 44) and overrunning clutch (Item 46) through the outer race.

2. Use a small punch and hammer to tap one of the bearings (Item 44) off of the inner race. The overrunning clutch can now be removed from the inner race. Closely inspect the overrunning clutch and the polished surfaces of the inner and outer race for wear, cracks, pitting, corrosion or mechanical damage. Closely inspect the bearings for any signs of damage, wear, corrosion, pitting or heat discoloration.

Assembly

⚠ WARNING ⚠

Failure to assemble the overrunning clutch assembly with all parts oriented correctly may result in reduced brake effectiveness, which may lead to loss of load control and result in property damage, injury, or death.

1. If both bearings (Item 44) have been removed from the inner race, install one of them now.

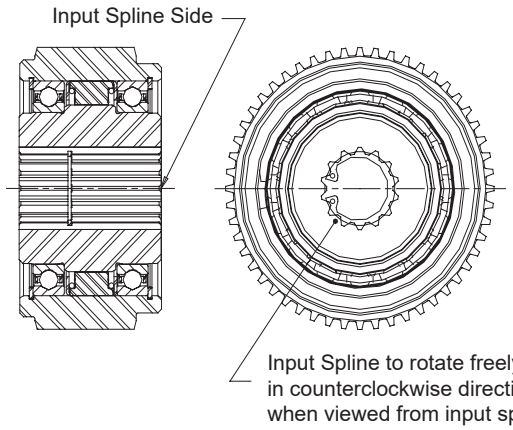
2. Install the overrunning clutch onto the inner race. Rotate the inner race slightly to get the clutch started onto the inner race.

3. Install the other bearing onto the inner race.

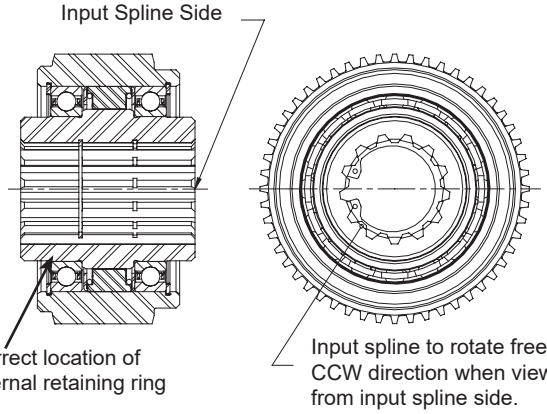
4. The outer race should have one retaining ring (Item 47) installed in one end. Carefully slide the inner race, with bearings and clutch, into the outer race. Install the other retaining ring into the outer race.

Shown below are the two types of clutch assemblies used in CH210 hoists. The drawings show each type properly assembled.

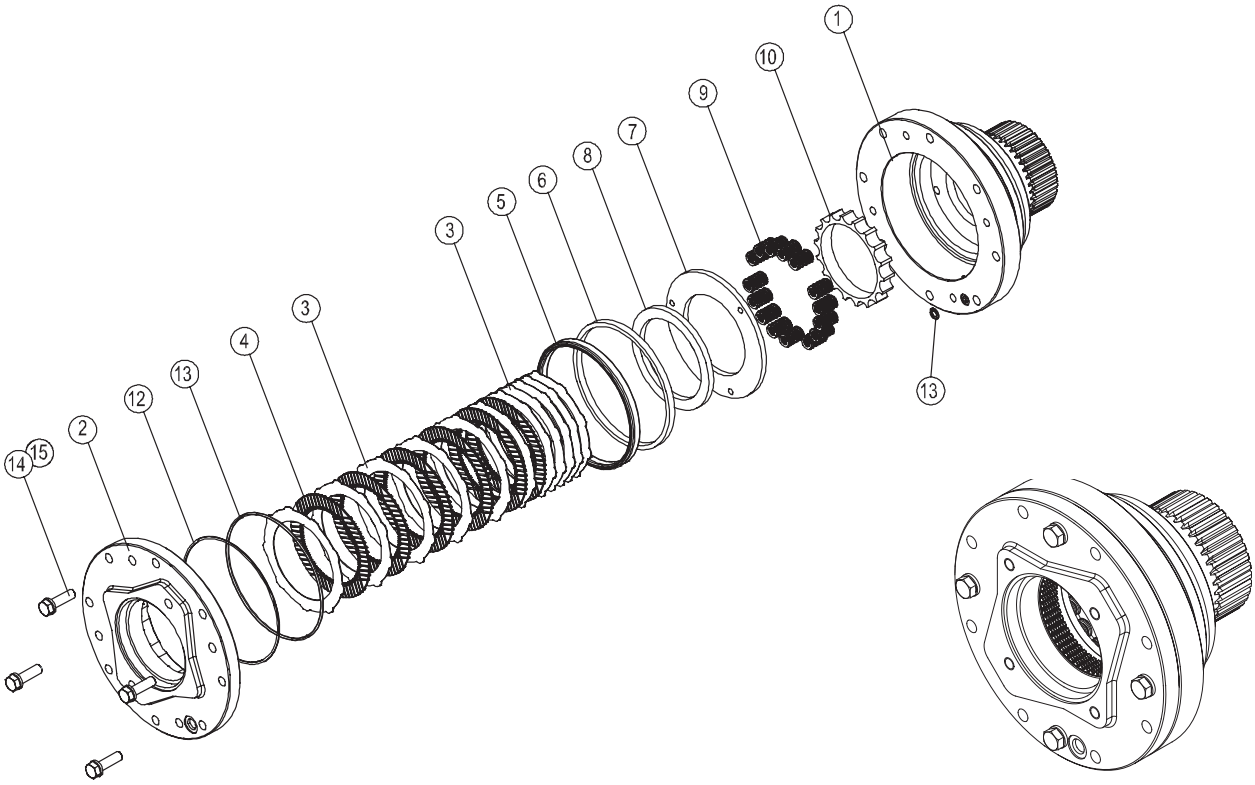
14 TOOTH INTERNAL SPLINE



13 TOOTH INTERNAL SPLINE



BRAKE CYLINDER SERVICE



Disassembly

⚠ CAUTION ⚠

The motor adapter is under spring tension from the brake springs. Loosen each of the capscrews one turn at a time until spring tension is released.

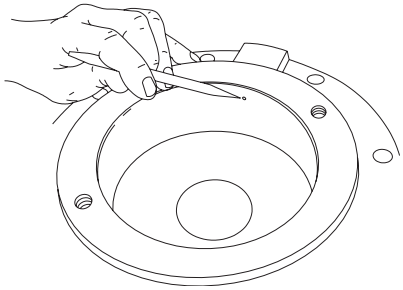
1. Stand the brake assembly on the splined end, with the motor adapter upward. Remove the four capscrews (Item 14) and lockwashers (Item 15). Use a crisscross pattern and loosen each capscrew one turn at a time until spring tension is released.

2. Remove the motor adapter (Item 2). Lift out all the brake discs (Item 3), friction discs (Item 40) and the spacer (Item 8).

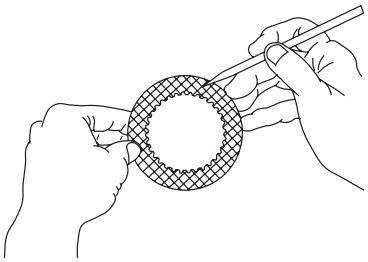
3. Remove and discard the O-ring and backup ring (Items 11 and 12) from the motor adapter. Remove and discard the seal (Item 5) from the brake cylinder. Remove the steel backup ring (Item 6).

4. Remove the pressure plate (Item 7) and the springs and spacer (Items 9 and 10) from the brake cylinder.

Clean and Inspect

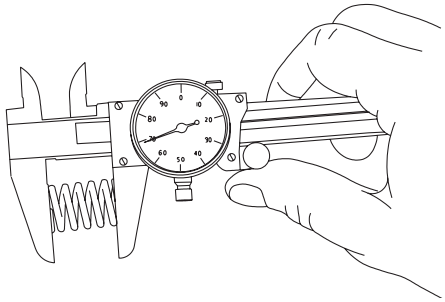


1. Thoroughly clean and inspect all parts at this time. Check sealing surfaces on both the motor adapter and brake cylinder. Be sure the brake release port is open and free of contamination.



2. 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 burned or worn unevenly, or groove depth is less than 0.003 inch (0.08 mm).

3. Place steel disc on flat surface and check for distortion with a straight edge. Check surface for signs of material transfer or excessive heat. Replace steel disc if distorted, heat discolored, or mechanically damaged.



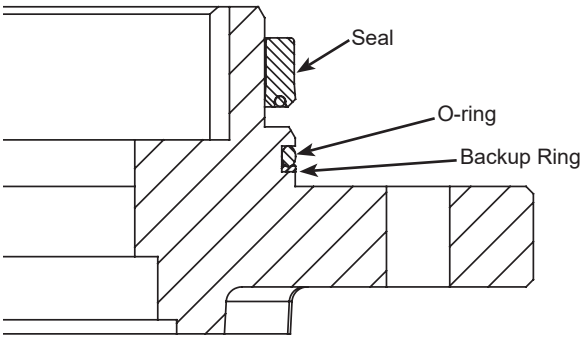
4. Check brake spring free length. Minimum free length is 1-7/16 inch (36.5 mm). Check springs for any signs of cracking or failure. If a brake spring must be replaced for any reason, then **ALL** brake springs must be replaced.

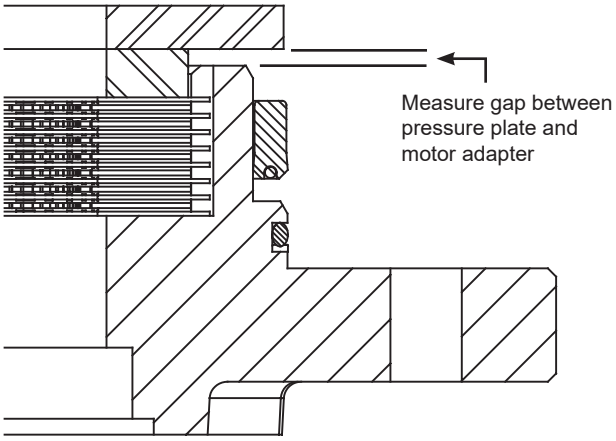
⚠ CAUTION ⚠

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

Assembly

NOTE: See Page 22 for the quantity of brake discs, friction discs, and brake springs for each hoist model.





1. Place the motor adapter on a clean work surface with the motor-mounting surface down. Apply a light coat of oil to a new backup ring (Item 12) and O-ring (Item 11) and install them into the groove on the motor adapter. Backup rings are always placed on the low pressure side of the O-ring. In this case, the backup ring is toward the motor-mounting surface. Lightly oil the brake cylinder seal (Item 5) and install it onto the motor adapter with the seal lip down.

2. Install a steel brake disc (Item 3) into the motor adapter, followed by a friction disc (Item 4). Continue to alternately install steel and friction discs. A steel disc will be on top.

3. Install the brake plate spacer (Item 8) on top of the last steel disc.

4. To check brake stack height, place pressure plate (Item 7) on top of brake spacer. Hold pressure plate down firmly by hand and measure gap (in three places) between motor adapter and pressure plate. Average gap must measure between 0.160 inch (4 mm) maximum and 0.080 inch (2.0 mm) minimum. If the gap exceeds the maximum limit, there may be too many discs in the stack-up or the discs are distorted. If the gap is less than the minimum, there may be too few discs or the discs are worn beyond their serviceable limit and should be replaced. When the gap is within the minimum and maximum values, remove the pressure plate and all brake discs. Lubricate all friction discs with the same oil to be used in the hoist. Install all brake discs and brake plate spacer as described in steps 2 and 3.

5. Place the brake cylinder on a clean work surface with the splined end down. Install the spring spacer (Item 10), then the springs (Item 9).

⚠ WARNING ⚠

Always use the molded spring spacer to properly position the springs in the brake cylinder. 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 pressure plate (Item 7) into the brake cylinder. Be careful that none of the springs fall over. Install the steel backup ring (Item 6). Apply petroleum jelly or an oil soluble grease to a new O-ring (Item 13) and install it in the brake cylinder.

   NOTE: The close fitting backup ring may be depressed slightly to one side to lodge it in the brake cylinder bore and temporarily hold the pressure plate and springs in place while the brake cylinder is inverted and lowered over the motor adapter.

   As an alternate, the motor adapter and brake plates can be turned over and installed into the brake cylinder, holding the brake plates and spacer in place through the center opening. Be careful to not pinch your fingers between the spacer plate and the pressure plate.

7. Apply petroleum jelly or an oil soluble grease to the sealing surface of the brake cylinder and the piston seal. Turn the brake cylinder over and lower it onto the motor adapter, being careful not to damage the piston seal or O-ring on the adapter. Be careful the O-ring (Item 13) does not fall out of place, and the oil passages are aligned. The alternate assembly method above could also be used.

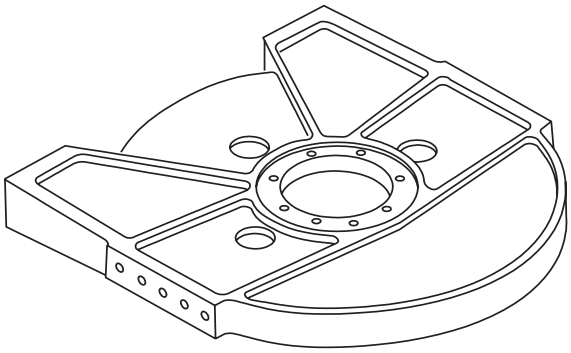
8. Turn the entire assembly over and install the four capscrews and lockwashers. After the capscrews make contact with the motor adapter, evenly tighten them one turn at a time until the motor adapter is drawn tight against the brake cylinder, then torque to the recommended value.

BRAKE CYLINDER PRESSURE TEST

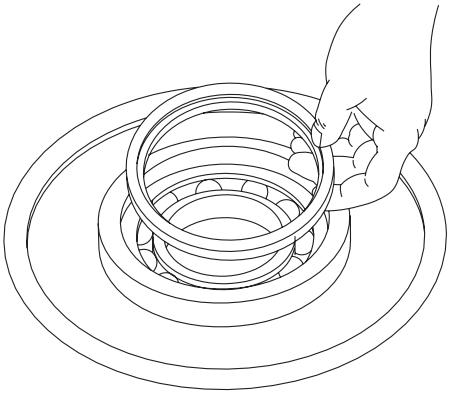
1. Install a -6 ORB fitting into the brake release port on the motor adapter. Connect a hand pump with an accurate 0–2,000 PSI (0–138 bar) gauge and shut-off valve to this fitting. Apply 1,000 PSI (69 bar) to the brake and close the shut-off valve. Let the unit stand for five minutes. If there is any loss of pressure, the brake cylinder should be disassembled for inspection of the sealing surfaces, seal and O-ring. When the source of the pressure leak has been determined and corrected, reassemble the brake cylinder and repeat the test.

2. WHILE PRESSURE IS APPLIED AND THE BRAKE IS RELEASED, install the overrunning clutch assembly into the brake pack. Turn the clutch back and forth to align the splines on all the friction discs. Release the pressure on the brake cylinder and remove the clutch assembly. The brake cylinder is now complete and ready to be installed in the hoist.

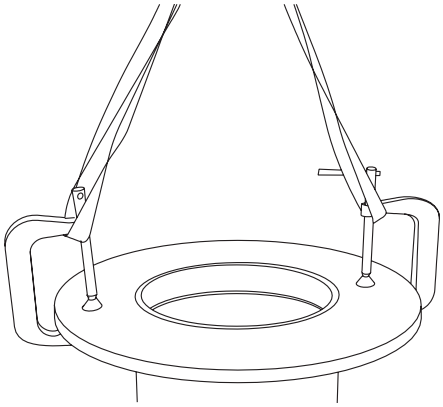
HOIST ASSEMBLY



1. Place the drum support assembly on a clean work surface with the bearing support facing up. Lubricate the bearing and sealing surfaces on the bearing support. Install a new V-ring seal onto the bearing support.



2. Install a new bearing in the drum if replacement is necessary, making certain to press it against the shoulder in the bottom of the bearing bore. Coat the outside diameter of a new seal with a good grade of sealant. Turn the spring side of the seal toward the bearing, and press the seal into the seal bore, leaving it flush with the surface of the drum bore.



3. Turn the drum over, and set it down on the bearing support. Be careful not to damage the seal when lowering the drum onto the bearing support.

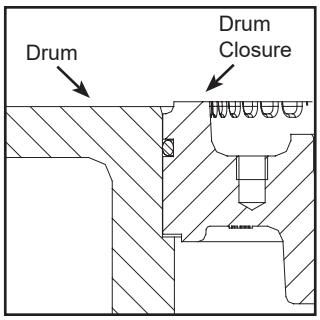
4. Lower the output planet carrier assembly into the cable drum and engage the three lugs on the carrier into the three holes in the drum. Be sure the carrier is firmly seated against the web in the drum.

5. Install the thrust washer (Item 66) into the recess in the output planet carrier, then install the output sun gear (Item 57) into the center of the output planet gears.

6. Install the primary planet carrier assembly on top of the output planet carrier, engaging the splines in the primary carrier with the output sun gear. Install the thrust washer (Item 67) onto the primary carrier.

7. Install the ring gear into the drum. Rotate the ring gear back and forth to engage the internal splines with the primary and output planet gears. When correctly installed, the bottom of the ring gear adapter will be resting on the thrust washer (Item 67), which is on the primary planet carrier.

8. Install a new bearing in the drum closure if replacement is necessary, making certain to press it against the shoulder in the bottom of the bearing bore. Coat the outside diameter of a new seal with a good grade of sealant. Turn the spring side of the seal toward the bearing, and press the seal into the seal bore, leaving it flush with the surface of the drum closure. Lubricate a new O-ring (Item 68) and install it into the groove on the outside diameter of the closure. Lubricate the outside diameter of the closure and install it into the drum. When correctly installed, the drum closure will be approximately 0.034 inch (0.9 mm) above the drum flange. If the drum closure cannot be installed as shown, one or more components may be out of position or not properly seated. The most common causes of this problem are the thrust washers being out of position, or the output planet carrier not fully seated into drum. **DO NOT** proceed with assembly until the source of the problem has been identified and corrected.



9. Place the motor end plate on the cable drum, aligning it approximately with the support end plate, and centering it on the drum. Lubricate and install a new V-ring (Item 103) onto the brake cylinder. Lubricate the sealing surface of the brake cylinder and carefully install the brake cylinder assembly through the end plate into the drum. Position the brake release port in the same location as removed. Rotate the brake cylinder back and forth to align the splines with those on the ring gear adapter. Install the input sun gear (Item 55) through the center of the brake cylinder, engaging the teeth on the three input planet gears.

10. Install the eight capscrews and lockwashers (Items 51 and 52) through the brake cylinder into the motor end plate. Loosely tighten all capscrews until they are snug against the motor adapter. Continue to tighten the capscrews in a crisscross pattern onto turn at a time until the motor end plate is drawn up tightly against the brake cylinder. Torque capscrews to their correct value.

11. Install the two tie plates (Item 61) between the two end plates of the hoist, using all 20 BRADEN SPECIAL capscrews and lockwashers (Items 60 and 52). Be sure the curved sides of the tie plates are toward the top of the hoist. Torque all capscrews to their correct value.

12. Install the overrunning clutch assembly into the center of the brake pack. Refer to Page 26 for correct orientation. Input spline side, shown on Page 26, is the end of the clutch facing outward, toward the motor. It may be necessary to rotate the drum slightly in either direction to align the clutch splines with the input sun gear. The internal retaining ring in the clutch should be seated against the input sun gear when correctly installed.

13. Lubricate and install a new O-ring onto the hydraulic motor pilot. Engage the motor shaft with the inner race of the overrunning clutch and lower the motor into place. Install motor capscrews and lockwashers and torque to correct value.

14. Install all hydraulic lines disconnected during disassembly, then tighten all connections.

15. After the hoist assembly is complete, check all capscrews and fittings to make certain they have been properly installed and tightened correctly. Refill the hoist with the recommended oil listed in Recommended Gear Oil section of manual.

16. Before returning the hoist to full service, a light load should be lifted and held a few feet 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 correctly, refer to Troubleshooting section for additional information.

RECOMMENDED BOLT TORQUE

Higher or lower torques for special applications will be specified such as the use of spanner nuts, nuts on shaft ends, jam nuts and where distortion of parts or gaskets is critical.

Lubricated torque values based on use of SAE 30-wt engine oil applied to threads and face of bolt or nut.

Avoid using thread lubricants as the applied torque may vary by 10 - 40%, depending upon the product used.

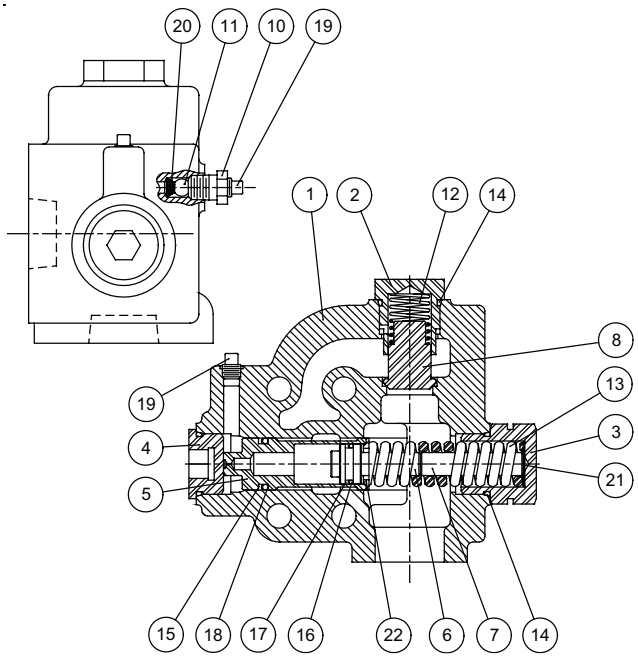
Bolt Diam. Inches	Thread per inch	Torque LB-FT (N.m)			
		Grade 5		Grade 8	
		Dry	Lubed	Dry	Lubed
1/4	20 28	8 (11)	6 (8)	12 (16)	9 (12)
5/16	18 24	17 (23)	13 (17)	24 (33)	18 (24)
3/8	16 24	31 (42)	23 (31)	45 (61)	35 (47)
7/16	14 20	50 (68)	35 (47)	70 (95)	50 (68)
1/2	13 20	75 (102)	55 (75)	110 (149)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

8-2008

BRAKE VALVE SERVICE



Most CH Series hoists are supplied with our BRADEN 1.5-inch brake valve. It is a reliable hydraulic valve with internal components manufactured to close tolerances. Due to these close tolerances, several individual parts are not available as replacement parts and are noted in the following parts lists as not serviced separately (NSS).

Before disassembling the brake valve, be sure you have conducted all applicable troubleshooting operations and are certain the brake valve is causing the malfunction.

Thoroughly clean the outside surfaces of the valve and work in a clean dust-free area, as cleanliness is of utmost importance when servicing hydraulic components.

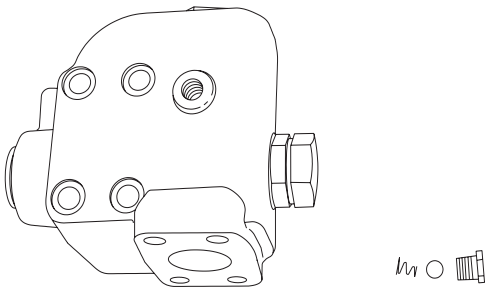
1.5-inch brake valves built after mid-March 1997 contain a spring seat (Item 22) between the spool spring and the spool. This provides a slightly larger, more uniform area for the spring to seat against the spool. The result is increased spring service life and improved repeatability of pressure/flow modulation over the full compression range of the spring.

The spring retainer has been modified to allow for the additional thickness of the spring seat and a groove machined into the hex end cap serves as a visual indication that the valve contains the new spring seat. The spring seat improvement may be added to earlier brake valves by installing kit, Part Number 62805. Items 3, 7, 13, 14 and 22 are included in the kit. We recommend that this kit be installed whenever the brake valve is removed for inspection or service.

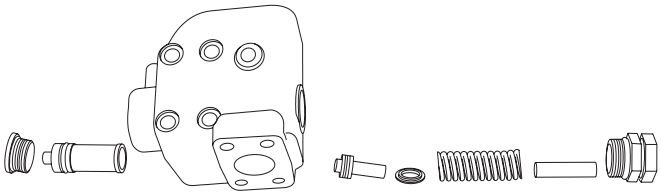
It is always a good practice to check the initial opening or cracking pressure of the brake valve whenever the hoist is serviced or inspected. Refer to BRADEN Service Bulletin 527 for complete brake valve test and adjustment procedures.

ITEM	DESCRIPTION	QTY.
1	Valve Housing	1
2	Check Valve Retainer	1
3	Spring Retainer	1
4	Plug	1
5	Main Piston	1
6	Damper Piston	1
7	Damper Piston Extension	1
8	Check Valve Poppet	1
10	Reducer	1
11	Check Ball	1
12	Check Valve Spring	1
13	Main Piston Spring	1
14	O-ring	1
15	Backup Ring	1
16	O-ring	1
17	Backup Ring	1
18	O-ring	1
19	Pipe Plug	1
20	Check Spring	1
21	Shim	1
22	Spring Seat	1

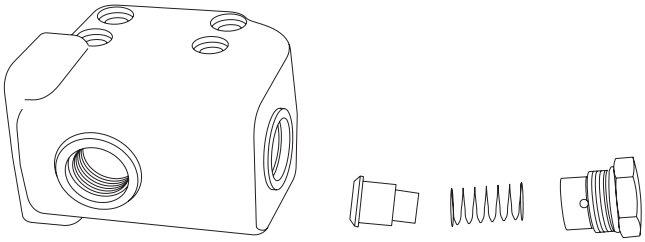
DISASSEMBLY



1. Remove the fitting, motor drain check ball and spring.



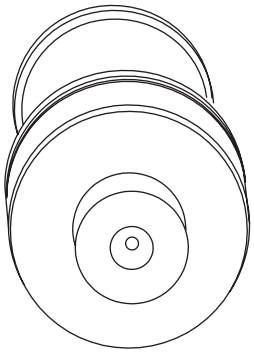
2. Remove the spool spring retainer and spool spring. Remove the spool plug and carefully remove the spool assembly. Remove the damper piston from the spool. The piston will come out of the spool slowly, because of a partial vacuum formed between the two. Use extreme care to avoid damaging the polished surfaces of either piece



3. Remove the check valve spring retainer, spring and check valve poppet.

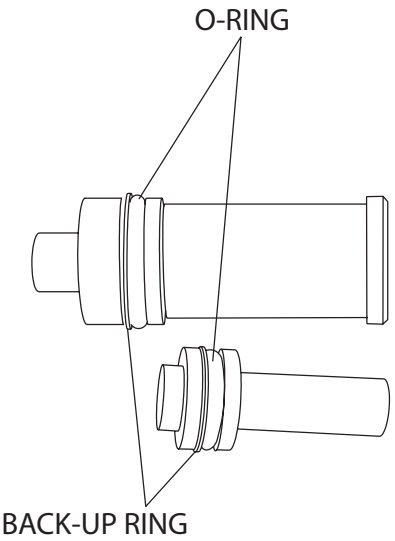
CLEAN AND INSPECT

1. Discard all O-rings and backup rings. Clean all parts in solvent and blow dry. Inspect polished surfaces of spool and damper piston for damage that may cause binding or leakage. Inspect spool bore in valve housing for damage or scoring. Inspect check valve seat in valve housing and check valve poppet. If the spools, bores or valves are damaged, the entire brake valve must be replaced. Check the free length of main piston spring. Replace if less than 3-7/16 inch (87.3 mm) long. Check the free length of the check valve spring. Replace if less than 1-1/2 inch (38.1 mm) long.



2. Inspect the 0.020–inch (0.5 mm) orifice in the end of the spool to be certain it is open.

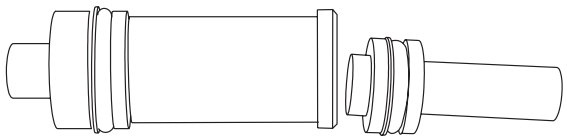
ASSEMBLY



1. Install new O-rings and backup rings on spool and damper pistons as shown. It is important that each backup ring is on the correct side of its O-ring. Take care not to cut the O-rings during assembly. Let the spool and piston set for 10 minutes before installing them into the brake valve housing. This allows O-rings to return to their original size after being stretched.

2. Install new O-rings on the plug and spool retainers.

3. Lubricate the spool and damper piston O-rings with hydraulic oil. Carefully install the damper piston into the spool. Carefully install the spool into the valve housing. Always install the spool into the valve body from the plug end, so the O-ring enters the bore first. Install the spring seat, spool spring, damper piston extension and spring retainer.



4. Install the check valve poppet, spring and check valve retainer.

5. Install the motor drain check ball, spring and fitting.

6. The brake valve is now completely assembled and ready to be installed on the hoist motor.

BRAKE VALVE OPENING PRESSURE TEST

Whenever brake components are replaced or a brake component malfunctions or fails, the entire brake system should be inspected and tested. Your testing must include checking the brake valve opening pressure in addition to a thorough inspection of the failed components.

Preparation

Begin the inspection by verifying that the brake valve and motor piping is correct for this application. If you are not certain, contact your nearest BRADEN distributor, the crane OEM, or the BRADEN factory Product Support Department before proceeding. Do not attempt repairs on equipment you are not familiar with. Fully remove the load from the hoist and block or secure any moveable parts of the crane or hoist before proceeding with brake valve test. It will be necessary to lower the hook block or ball to the ground (deck) because the brake will be completely released. Make certain the test area is clear of all unauthorized personnel as the hoist will be operated in raise and lower functions.

Brake Valve Pressure Test

1. Shut off the engine or motor driving the hydraulic system and vent residual pressure as recommended by the crane OEM.

2. Install an accurate 0–2,000 PSI (0–138 bar) pressure gauge teed into the brake release line, located at the lowering (nonbrake valve) side of the hydraulic motor. This is typically a -4 JIC connection.

3. To eliminate the slight drag effect of the internal multi-disc brake, remove the brake release line from the hoist brake port and install a plug in the line or close to the needle valve if so equipped.

4. To the internal brake port, install a hand pump with an accurate 0–2,000 PSI (0–138 bar) gauge. Operate the hand pump and apply approximately 1,000 PSI (69 bar) to the brake port to fully release the brake. Close the hand pump valve to hold the brake released during the remainder of the test.

5. Operate the crane power source at full throttle and VERY slowly move the hoist control lever toward the lowering direction while monitoring the brake valve opening pressure. Record the pressure when the cable drum begins to turn in the lowering direction.

6. The initial lowering pressure should be no lower than 575 PSI for the 1.5-inch BRADEN brake valve, Part Number 81609 which is used on most single-speed motors on CH165A and CH230B planetary hoists.

If the initial lowering pressure is less than the specification listed the brake valve should be adjusted.

ADJUSTMENT OF BRAKE VALVE

1. Inspect the main spool spring to make certain it is not damaged. If the spring is in good condition, the brake valve opening pressure should be adjusted by installing shims between the spring retainer (Item 3) and the main piston spring. A maximum of .062-inch (1.6 mm) shims are allowed in the 1.5-inch valves. Additional shims may result in accelerated spring failure because of overcompensation.

2. If the spring requires more than the maximum number of shims listed above to achieve the recommended opening pressure, the spring should be replaced.

3. Inspect the brake valve piston and damper piston for scoring and seal ring condition. The seal rings should be replaced following disassembly and inspection. If there is any scoring of the pistons and/or the brake valve housing, the entire brake valve must be replaced.

4. Inspect the check valve poppet and seat for irregular wear or damage. It the poppet set is damaged, the entire brake valve must be replaced. Tighten the spring retainers to 40 lb.-ft. torque.

NOTE: Always recheck the brake operation following inspection or adjustment, prior to placing the hoist back in service.

METRIC CONVERSION TABLE

English to Metric			Metric to English		
LINEAR					
inches (in.)	X 25.4	= millimeters (mm)	millimeters (mm)	X 0.03937	= 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_2O (60°F)	X 0.2488	= kilopascals (kPa)	kilopascals (kPa)	X 4.0193	= inches H_2O (60°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°C) + 32

COMMON METRIC PREFIXES

mega	(M)	= 1,000,000 or 106	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	(m)	= 0.000.001 or 10^{-6}

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