Quick Reference Guide

This Quick Reference Guide will assist you in finding the information you’re looking for.

A Table of Contents is included after the Foreword.

Description:
APE C18 TIER 4 POWER UNIT
READ THIS MANUAL THOROUGHLY BEFORE OPERATING AND/OR WORKING ON THE EQUIPMENT

1. Read and follow any safety instructions in the CATERPILLAR ENGINE OPERATOR’S MANUAL.
2. Only well-trained and experienced personnel should attempt to operate or maintain this equipment.
3. NEVER adjust, lubricate or repair the unit when it is in operation or lifted above ground level.
4. NEVER remove, paint over and/or cover warning or safety labels. If labels become damaged or unreadable, replace immediately.
5. All personnel should wear approved safety clothing, including HARD HATS, SAFETY SHOES, SAFETY GLASSES and HEARING PROTECTION when near this equipment.
6. Do NOT stand any closer to this equipment than necessary when it is in operation. Parts may loosen and fall. Dirt and rocks may fall from flighting. NEVER stand under operating or elevated equipment.
7. When maintaining and/or repairing the equipment, NEVER substitute parts not supplied or approved in writing by APE.
8. NEVER use or store flammable liquids on or near the engine.
9. Insure that all lifting equipment, including cranes, wire rope, slings, hooks, shackles, etc., are properly sized for the worst case loads anticipated during operations.
10. If there are any questions about the weights, specifications or performance of the unit, contact APE before handling and/or operating the equipment.
11. If the equipment is to be used for anything other than drilling plumb holes, contact APE before using the unit.
12. Check wire rope clips for tightness and wire ropes for wear daily.
13. Insure that ground vibrations will not damage or collapse adjacent structures or excavations.
14. Remove all tools, parts and electrical cords before starting the unit.

These precautions must be followed at all times to ensure personal and equipment safety.

**DANGER**
DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.

**WARNING**
WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.

**NOTICE**
NOTICE is used to address practices not related to personal injury.

**NOTE**
• NOTE indicates information that may help or guide you in the operation or service of the equipment.

**DISCLAIMER:**
This unit was tested and flushed before leaving our facility. In order to help provide years of trouble free usage, please review the following documentation and make sure to clean and flush the field piping before connecting it to the power unit.

Refer to schematic diagrams and the BOM (Bill of Materials) for component part specifications and recommended spare parts.
When operating in an enclosed area, exhaust fumes should be piped outside. Continued breathing of exhaust fumes may prove FATAL.

When servicing batteries, do NOT smoke or use an open flame in the vicinity. Batteries generate explosive gas during charging. There must be proper ventilation when charging batteries.

When filling the fuel tank, do NOT smoke or use an open flame in the vicinity.

If abnormal equipment operation is observed, discontinue use immediately and correct the problem.

Do NOT leave the equipment control pendant (radio control) unattended.

Store oily rags in approved containers and away from the engine exhaust system.

Make sure that the Auger rotation switch is in NEUTRAL before starting the Power Unit engine.

Do NOT adjust and/or set the hydraulic pressures higher or lower than those specified in this Manual.

NEVER operate this equipment with hydraulic hoses that are damaged or ‘kinked’. Replace damaged hoses immediately.

Do NOT lift and/or support hydraulic hoses with wire rope slings.

NEVER attempt to connect Quick Disconnects (QDs) when the Power Unit is running.

Do NOT pull on and/or attempt to move equipment with the hydraulic hoses.

Do NOT attempt to locate hydraulic leaks with your hands. High-pressure leaks can penetrate skin and cause severe damage, blood poisoning and/or infection.

Do NOT attempt to repair leaks while the equipment is in operation.

Do NOT attempt to tighten and/or loosen fittings and/or hoses when the machine is in operation.

Power Unit must always be placed on level, stable ground.

Do NOT remove Power Unit heat shields. Do NOT attempt to use the Power Unit without heat shields. Severe fires may result.

A properly maintained fire extinguisher, suitable for oil fires, MUST be kept in the immediate vicinity of equipment operations.

When moving and/or transporting this equipment, make sure that the vehicle or vessel is of sufficient capacity to handle the load. Make sure that the equipment is properly tied down.

When moving and/or transporting this equipment, be sure that the QD Dust Caps are tight and that the cap safety cables are in place. Be sure that all equipment parts are tight and/or properly secured before shipment. Unsecured parts may vibrate loose and fall during transport causing injury and/or property damage.

Rounded and/or damaged bolt heads and/or nuts should be replaced so that proper torque values may be obtained. Proper torque values are necessary to prevent parts on this equipment, leads and/or crane booms from loosening and/or falling. (Refer to the torque chart in this manual for the proper values.)

Keep hands away from rotating flighting, auger shaft and/or rotary joint.

Keep hands, feet and tools well clear of the flighting guides.

Do NOT allow clothing, hoses, ropes, etc., to become entangled in, or wrap around, rotating flighting, Auger shaft and/or rotary joint.

When operating in a closed area, pipe exhaust fumes outside. (Warning: Breathing exhaust fumes can cause serious injury or even death.)

Make sure the control pendant is in the “LOCAL” position before starting the unit.

NEVER stand under hammer at any time and keep you eyes on the hammer when it is in operation.

When loading or unloading the power unit using a forklift, the forks must be placed under the entire depth of the unit.

(These precautions must be followed at all times to ensure personal and equipment safety.)
American Piledriving Equipment, Inc. (APE) warranties new products sold by it to be free from defects in material or workmanship for a period of two (2) years after the date of delivery to the first user and subject to the following conditions:

- APE’s obligation and liability under this WARRANTY is expressly limited to repairing or replacing, at APE’s option, any parts which appear to APE upon inspection to have been defective in material or workmanship. Such parts shall be provided at no cost to the user, at the business establishment of APE or the authorized APE distributor of the product during regular working hours.
- This WARRANTY shall not apply to component parts or accessories of products not manufactured by APE, and which carry the warranty of the manufacturer thereof, or to normal maintenance (such as engine tune-up) or normal maintenance parts (such as filters).
- Replacement or repair parts installed in the product covered by this WARRANTY are warranted only for the remainder of the warranty as if such parts were original components of said product.
- APE makes no other warranty, expressed or implied, and makes no warranty of merchantability of fitness for any particular purpose.
- APE’s obligations under this WARRANTY shall not include any transportation charges, costs of installation, duty, taxes or any other charges whosoever, or any liability for direct, indirect, incidental or consequential damage or delay.
- If requested by APE, products or parts for which a warranty claim is made are to be returned, transportation prepaid, to APE.

OIL MUST MEET ISO CLEANLINESS CODE 17/15/11. OIL THAT DOES NOT MEET CLEANLINESS CODE WILL VOID THE WARRANTY

ANY IMPROPER USE, INCLUDING OPERATION AFTER DISCOVERY OF DEFECTIVE OR WORN PARTS, OPERATION BEYOND RATED CAPACITY, SUBSTITUTION OF ANY PARTS WHATSOEVER, USE OF PARTS NOT APPROVED BY APE OR ANY ALTERATION OR REPAIR BY OTHERS IN SUCH A MANNER AS, IN APE’S JUDGMENT, AFFECTS THE PRODUCT MATERIALLY AND ADVERSELY, SHALL VOID THIS WARRANTY.

ANY TYPE OF WELDING ON APE’S EQUIPMENT WILL VOID THE WARRANTY UNLESS AUTHORIZED IN WRITING BY APE

NO EMPLOYEE IS AUTHORIZED TO CHANGE THIS WARRANTY IN ANY WAY OR GRANT ANY OTHER WARRANTY UNLESS SUCH CHANGE IS MADE IN WRITING AND SIGNED BY AN OFFICER OF APE, INC.
This manual covers the APE Hydraulic Power Unit installation, maintenance and use.

The data provided in this manual gives the necessary information to operate and maintain APE equipment. The listed procedures are to be performed by qualified personnel who have an understanding of the equipment and who follow all safety precautions.

All information given in this manual is current and valid according to the information available at the time of publication. American Piledriving Equipment, Inc. reserves the rights to implement changes without prior notice.

Using this manual:

- Refer to the Table of Contents for the page location of applicable sections.
- All weights and measurements are in English and Metric units.
- Any revisions to this manual will appear on the Revision Record page at the back of this manual. The revisions themselves will be attached to the back of the manual and entitled ADDENDA with references back to the page in question in the original manual.
- Please visit www.apevibro.com for product data sheets and manual.

DISCLAIMER:
This unit was tested and flushed before leaving our facility. In order to help provide years of trouble-free usage, please review the following documentation and make sure to clean and flush the field piping before connecting it to the power unit.

Refer to schematic diagrams and the BOM (Bill of Materials) for component part specifications and recommended spare parts.

When calling APE, always have the equipment serial number on hand in order to obtain quicker service.
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## SPECIFICATIONS

### DIMENSIONS

- Overall Length: 165 in (419 cm)
- Overall Width: 88 in (224 cm)
- Overall Height: 97 in (247 cm)
- Weight: 14,500 lbs (6,577 kg)
- Fuel Capacity: 145 gal (553 L)

### ENGINE

- Type: Caterpillar C18 Tier 4
- Horse Power: 800 hp
- Displacement: 1,104 in³ (18,091 cc)
- Compression Ratio: 16:1
- Engine Speed: 1,800 rpm
- Engine Oil: Caterpillar Diesel Engine Oil 10W30 or 15W40, 43 qt (40 L)

### Hydraulics

- Drive Pressure: 0-4,500 psi (310 bar)
- Drive Flow: 206 gpm (780 lpm)
- Clamp Pressure: 4,800 psi (331 bar)
- Clamp Flow: 7.6 gpm (29 lpm)
- Pump Drive Oil: Neptune 220, 1.5 gal (5.7 L)
- Hydraulic Oil: Envirologic 146, 568 gal (2,150 L)
General Information

Safety / Warning Labels

This information is important when contacting APE for replacement parts or other information.

* Model
* Serial No.

Hydraulic oil needs to be kept at correct FULL level at all times. Do **NOT** overfill the tank. This may cause leakage when hot, due to insufficient space to expand. Depending on the power unit it will have either one or two electronic hydraulic sensors to monitor low oil level and oil level shutdown, to prevent damage to the power unit.

Do **NOT** weld on or around the power unit unless authorized in writing by APE. Doing so will void all warranties and may cause damage to the power unit or vibro.

Do **NOT** fill fuel tank past 3/4 tank. It is necessary to have a sufficient air gap in the tank to allow for expansion of the fuel. Failing to do so may cause fuel leakage when hot.
The power unit service record sticker is located on the control panel door and is used to record all service done on the power unit.

Make sure all QD’s are installed and connected completely. Failing to do so may cause damage or prevent proper operation.

Ship with the hydraulic tank forward to prevent damage to the radiator cooling package at the front of the power unit skid.

The daily checklist sticker is located on the control panel door and has a list of everything that needs to be checked on the vibro. Failing to do the daily vibro check may cause damage to the vibro.
Power Unit Parts Overview

15X 15 GEAR PUMP

Fill Oil Filter

DIESEL PARTICULATE FILTER

Air Cleaner
Daily Checklist

*Check the entire unit prior to and during set-up each day or at the beginning of each shift*

Prior to starting the unit or at the beginning of each shift, check the following:

- Visually inspect all bolts, nuts and screws
- Check water level in radiator
- Check fuel level
- Check oil level in pump drive
- Check hydraulic oil level
- Check engine oil
- Check fan belts on engine
- Visually inspect all hydraulic fittings for leaks. If a leak is found or suspected, shutdown the power unit. If a fitting appears to be damaged, replace with a new fitting.

*It is absolutely imperative that no dirt or other impurities be permitted to contaminate the hydraulic fluid. Any contamination will drastically shorten the life of the high-pressure hydraulic system.*

*Vibration loosens bolts. Check them thoroughly.*
Lifting the Power Unit

Always load the power unit with the hydraulic tank facing the front of the truck, to prevent damage to the cooler and radiator from flying debris. When lifting the power unit, position the forklift forks forward as far as possible to prevent load shifts. See Photo.
Connecting the Hydraulics

- Clamp Open
- Clamp Close
- Case Drain
- Drive REV
- Drive FWD
Connecting the hoses is one of the most critical aspects of commissioning APE equipment. Take extreme care to keep these connections absolutely clean. Dirty connections are the most common cause of introducing damaging foreign particles into a hydraulic system.

**New hydraulic fluid is NOT clean oil!**

*Oil must meet ISO cleanliness code 17/15/11*

- Connect the hose bundle. Make sure all connections are properly tightened.
- Fill the motor case with clean hydraulic fluid.

---

![CAUTION](image)

**While filling the hydraulic lines, the drill motor shaft will rotate.**

Please do the following:

- Set the engine at idle
- Run at idle for about 10 minutes to fill the lines
- Energize ‘Drive Fwd’ - With the auger, vibro or hydraulic hammer free-hanging will push any remaining air in the lines back to the reservoir.

---

![Attention!](image)

**Pressurizing the system while there is air entrained in the fluid may cause damage to the components.**

Let the system run at idle for an additional 10 minutes to allow the air to rise into the airspace of the hydraulic reservoir.
Start / Warm Up Procedure

Before operation it is necessary to bring the power unit’s hydraulic oil to a working temperature of 80°F. To start and warm up the power unit follow the steps below:

1. On the main control panel, turn main power switch to the ON position.
2. Press and hold engine START/STOP button until engine in running. This should only take a few seconds.
3. Idle power unit in DRIVE until oil temp is above 80°F before doing hard work. Failing to do so may cause seal failures, leaks and excessive pressures through the hydraulic system.

Operating Temperatures

The Operating Temperature references the internal temperature of the engine.

Take into consideration the following requirements:

- 70°C (158°F) – Avoid going over this Operating Temperature for improved service life
- 85°C (185°F) – Highest permissible intermittent Operating Temperature
- -35°C (-31°F) – Lowest permissible Operating Temperature
- 60°C (140°F) – Temperature difference between the motor and the hydraulic fluid

The Operating Temperature may be measured from the hydraulic fluid returning from the engine. Take into account the temperature of the hydraulic fluid returning from the case drain line.
Control Panel Gauges

<table>
<thead>
<tr>
<th>APE PART NUMBER</th>
<th>PART NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000941</td>
<td>11730-02188</td>
<td>Drill Shift NoShok 0-3000 PSI</td>
</tr>
<tr>
<td>513007</td>
<td>25.310.7500</td>
<td>Clamp Close/Open NoShok 0-7500 PSI</td>
</tr>
<tr>
<td>513007</td>
<td>25.310.7500</td>
<td>Drive FWD / Rev NoShok 0-7500 PSI</td>
</tr>
<tr>
<td>1001046</td>
<td>11730-02192</td>
<td>Return Filter Pressure NoShok 0-300 PSI</td>
</tr>
</tbody>
</table>

**Return Filter Pressure**

The Return pressure gauge shows the pressure when hydraulic oil is recirculating through the cooler. This can be used as a indication tool for when filters need to be replaced if the pressure starts to increase.

**Clamp Close / Open**

Clamp Close shows the pressure being applied to the clamp circuit. This pressure should be set at 4500 psi for safe operation.

**Drive FWD / REV**

The Drive pressure gauge shows the pressure while the power unit is driving the equipment in forward or reverse. This should be at 4500 psi while drive is energized.

**HYDRAULIC OIL LOW**

This warning light comes on when the hydraulic oil is low and there is no reserve oil left. The operator must add oil to the hydraulic reservoir.
Control Panel Overview

- Emergency Stop
- Engine Start / Stop
- Drive Fwd
- Clamp Close
- Panel Power
- Speed Hi / Lo
- Governor
- Return to Main Menu
- To Select Menu Option
- Vibro / Drill Mode
- Drive Rev
- Clamp Open
- Panel Cab Pendant

GENERAL INFORMATION
LOCAL DISPLAY SCREEN
- ENGINE RPM
- HYDRAULIC OIL TEMP
- HYDRAULIC PRESSURE
- DIAGNOSTICS

POWER ON / OFF
This will turn the power on to the control panel. The power must be on to run the unit.

ENGINE START / STOP
If the control panel is powered on this button will fully start the engine. You must hold the button down until the engine fully starts.

To stop the engine, press this button again for a short second.

NOTE: Before shutting off the engine, run at 800 RPM idle for at least 1 minute.

The color of the light does not matter.
ENGINE RPM
SPIN RIGHT FOR RPM UP
SPIN LEFT FOR RPM DOWN

EMERGENCY STOP
This can be pressed at any time regardless of what mode the panel is on.
Note: Do not use unless emergency.

CONTROL MODE

LED 1
Indicates the control panel can be controlled locally only.

LED 2
Indicates the control panel can be controlled from the remote pendant.

LED 3
Panel can only be controlled from the master control.
This button can only but toggled at the local panel.
GENERAL INFORMATION

All functions for the drill can be controlled by the hand held pendant. It is the choice of the crew as to where best to locate the pendant. Some prefer that the crane operator control all functions. A 50 foot (15.2 M) cord is provided as standard equipment. If this is not long enough additional 50 foot (15.2 M) sections can be added. Should the pendant become damaged, all functions can be manually operated. See operation instructions.
This button will close the clamps. Push one time to turn the circuit ON, Push again to turn the circuit OFF.

**Clamp Circuit is OFF**
No oil is flowing to the clamps when this is off.

**Clamp Circuit is ON**
The two outside lights indicates the clamp circuit is on but the clamp pressure is not yet to the set limit.

**Clamp Circuit is ON**
When all three clamp lights are on, the clamp pressure has been reached.

**Clamp Circuit is OFF**
However, there is still pressure in the line, but since the clamp circuit is off they will not be repressurized.

**NOTE:**
The color of the light does not matter.
Some keypads are all green or red.
Only the light position matters.
### GENERAL INFORMATION

**CLAMP OPEN**

- Clamp Open OFF
- Clamp Open ON

This button must be pushed and held down to operate the circuit.

**NOTE:**

The color of the light does not matter. Some keypads are all green or red. Only the light position matters.

**AUX 1**

This button switches between panel control, cab control, or pendant control.

**SPEED HI/LO**

This button switches between high and low speeds on the drill.
DRIVE REVERSE

This will pump oil backwards out of the reverse line and into the drive forward line. This is used to fill hoses with oil or to test a line to make sure the QD is properly connected. If a QD is not connected the pressure on this line will hit max.

DRIVE REVERSE ON

This will start pumping oil out of the reverseline circuit.

DRIVE FORWARD

In a standard setup where only one hammer and one power unit is used, this button will start the hammer to vibrate.

In a multi-power unit configuration all power units must have the drive forward button activated at the same time to make the hammer vibrate. If only one power unit activates drive forward it will only send oil out of the power unit and pump it into the other 11 power units.

DRIVE FORWARD ON

This will start pumping oil out of the forward line circuit.

GENERAL INFORMATION
When powered on, the image to the left is the display home screen. The home screen is the basic display for the system and shows all of the vital readings for the hydraulic power unit. There is an auto idle function standard on all power units. The auto idle function will automatically return the power unit to an idle anytime it is not working, then power back up to full throttle as soon as a work function is selected.

From the main screen you can select a sub-screen reading only critical hydraulic data such as drive pressure, cooler temperature, cooler pressure, engine speed, and fuel level. To return to the main screen from the hydraulic screen push the button with an “X” located right under the governor knob.

The diagnostic screen can be accessed from the main screen and will show any trouble codes that cause a warning light. The image to the left shows a diagnostic screen with no trouble codes. You can also access the diagnostic screen from the trouble screen by pressing the check button. To return to the main screen from the diagnostic screen push the button with an “X” located right under the governor knob.
The setup screens are in a hidden menu that can be accessed by holding down the top left two buttons on the display while turning on the control panel power. Once in the setup screen you can increase or decrease your hydraulic oil temp warnings and your auto idle dwell time. To adjust, simply increase or decrease the selected value, then select SAVE CHANGES. You can also change the equipment from vibro to drill mode depending on the equipment that the power unit will be running. If the settings ever become lost or need to be set back to factory, there is a button on the top left of both setup screens that will reset all panel options back to factory default. To return to the main screen from the setup screen push the button with an “X” located right under the governor knob.

The ERROR screen only appears when there is a trouble code or when one of the sensors fails to send a signal. On the bottom right of the screen the “CHECK” button will take you to the diagnostic screen where the trouble code can be checked and resolved. To return to the main display screen push the “CHECK” button then the “X” button on the diagnostic screen.
## MAINTENANCE

### Maintenance Chart

<table>
<thead>
<tr>
<th>DAILY</th>
<th>WEEKLY</th>
<th>250 HOURS OR 6 MONTHS</th>
<th>1500 HOURS OR 1 YEAR</th>
<th>6000 HOURS OR 2 YEARS</th>
<th>6000 HOURS OR 3 YEARS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Check operator’s report&lt;br&gt;• Check oil and bring to correct level&lt;br&gt;• Check coolant and bring to correct level&lt;br&gt;• Visually inspect fan&lt;br&gt;• Visually inspect engine for damage, leaks, loose or frayed belts and correct or record or future action&lt;br&gt;• Drain fuel-water separator</td>
<td>• Check air intake system for wear points or damage to piping, loose clamps, and leaks.&lt;br&gt;• Check air cleaner restriction&lt;br&gt;• Check and clean air cleaner element&lt;br&gt;• Drain moisture from tanks</td>
<td>• Change lubricating oil&lt;br&gt;• Change lubricating oil filters&lt;br&gt;• Change fuel filter&lt;br&gt;• Clean crankcase breather&lt;br&gt;• Check engine coolant concentration level&lt;br&gt;• Replace final fuel filter/clean primary fuel filter. Drain water from fuel tank&lt;br&gt;• Inspect/replace alternator fan and accessory drive belts&lt;br&gt;• Inspect/replace hoses and clamps&lt;br&gt;• Lubricate fan drive bearings&lt;br&gt;• Clean/check battery electrolyte level</td>
<td>• Adjust valves and injectors&lt;br&gt;• Steam clean engine&lt;br&gt;• Check torque on turbocharger mounting nuts&lt;br&gt;• Check torque on engine mounting bolts&lt;br&gt;• Replace hoses as required&lt;br&gt;• Check/adjust engine valve lash&lt;br&gt;• Check/adjust low idle speed&lt;br&gt;• Test/exchange fuel injection nozzles&lt;br&gt;• Inspect/rebuild alternator</td>
<td>• Clean cooling system and change coolant and antifreeze&lt;br&gt;• Inspect Temperature regulator&lt;br&gt;• Inspect/rebuild turbocharger&lt;br&gt;• Inspect/rebuild starter</td>
<td>• Clean and calibrate the following:&lt;br&gt;• -Injectors&lt;br&gt;• -Fuel pump&lt;br&gt;• -Fan Clutch&lt;br&gt;• -Water pump&lt;br&gt;• -Fan Hub&lt;br&gt;• -Fan idler pulley assembly&lt;br&gt;• -Vibration dampener</td>
</tr>
</tbody>
</table>

Follow the manufacturer’s recommended maintenance procedures for the starter, alternator, batteries, electrical components, and fan clutch.<br>At each scheduled maintenance interval perform all previous checks which are due for scheduled maintenance.
MAINTENANCE

Engine Oil

Change engine oil every 250 hours or 6 months, whichever occurs first. Oil should be replaced with Caterpillar 15W-40 or equivalent oil.

Hydraulic Oil

When adding or changing hydraulic fluid, APE uses only Biodegradable Envirologic 146 hydraulic fluid, which is not-toxic and will not harm soil or water, and is biodegradable. Consult your local oil supplier for recommendations on mixing hydraulic oils. Change hydraulic oil if it looks milky; this is an indication that water or other contamination may have occurred.

Pump Drive Oil

Check oil level before starting the power unit. The pump drive requires approximately 2 gallons of oil. APE recommends filling the pump drive with Neptune 220 or equivalent when doing oil changes or adding oil. It is recommended to change the pump drive oil every 500 working hours, or 2 years, which ever occurs first.

Air Cleaner Replacement

Check and clean the air cleaner weekly. If the air cleaner needs to be replaced, use Caterpillar part number 6I-2510.

Return Filter Elements

Change all filters every 500 working hours, 2 years or when indicated dirty, which ever occurs first. To change the return filter element follow the steps below:

1. Shut down power unit.
2. Place warning tag on control panel so that the power unit is not started while filters are being replaced.
3. Clean area around filters so that when they are removed there is no chance of introducing dirt into the hydraulic system.
4. Using a 1-1/4 wrench or socket, turn the filter counter-clockwise and spin the filter element off the filter housing.
5. Install new clean filter making sure the spring and o-ring are in the proper place.
Preventative maintenance includes normal servicing that will keep the power unit in peak operative condition and prevent unnecessary trouble from developing. This servicing consists of periodic lubrication and inspection of moving parts and accessories of the unit.

Lubrication is an essential part of preventative maintenance controlling, to a great extent, the useful life of the unit. Different lubricants are needed and some components in the unit require more frequent lubrication than others. Therefore, it is important that the instructions regarding types of lubricants and frequency of their application be closely followed.

To prevent minor irregularities from developing into serious conditions that might involve shutdown and major repair, several other services or inspections are recommended for the same intervals as the periodic lubrications. The purpose of these services or inspections is to assure the uninterrupted operation of the unit.

- Thoroughly clean all lubrication fittings, caps, filler and level plugs along with their surrounding surfaces before servicing
- Prevent dirt from entering in with lubricants and coolants

The intervals given in the schedule are based upon normal operation.

Perform these services, inspections, etc., more often as needed for operation under abnormal or severe conditions.

Storage

During short-term storage of a power unit, the following should be taken into consideration:

- Cover any pressure openings and open threaded holes with suitable caps
- Protect the unpainted surfaces from dirt and moisture
- The power unit should not be stored in an area with substances that have an aggressive corrosive nature; i.e., solvents, acids, alkalis and/or salts

For long-term storage (over 9 months), the following additional actions are recommended:

- Damages to surface paint must be repaired before item is stored
- Protect the unpainted surfaces with suitable anti-corrosion treatment such as CRC SP-350, CorrosionX corrosion inhibitor, or WD-40 Long Term Corrosion Inhibitor
- Fill the power unit completely with hydraulic fluid

If these instructions are followed to the letter, the power unit may be stored for approximately 2-years. However, as storage conditions do have a significant effect, all suggested time frames should be considered as guide values only.
Understanding the Hydraulic System

It is imperative that the hydraulic fluid is kept clean to a minimum ISO Code 17/15/11. New hydraulic fluid is NOT clean oil.

*See attached document “Understanding ISO Codes” under the Reference / Notes Section*

*See Warranty document regarding fluid cleanliness at the beginning of this manual*

Bulk oil does not typically meet the cleanliness standards required by APE equipment.

- Pressure filters: Clean the hydraulic fluid going to the drill motor and manifold in the forward and reverse directions.
- M1/M2 DRIVE
- LS LOAD SENSE
- 10/11: RDFA-LCN is a direct acting relief valve that is used to protect hydraulic components from pressure variants.
- 8/16/5/19 COILS
- T1 / PD: Both of these ports return to tank.

Electrical System

The electrical system is a normally closed circuit, and runs a self diagnostic test when the panel is powered on. If there is a fault in the electrical system an error screen will appear on the control panel display.
NOTES:

1) CONNECTIONS BETWEEN TERMINALS TO BE HARD JUMPERS UNLESS OTHERWISE INDICATED.

2) REFER TO LAYOUT DRAWING FOR LOCATIONS OF CONNECTORS 'P1', 'P2', 'P3', 'P4', 'AUX POWER', AND 'PENDANT'.

3) DASHED ELECTRICAL WIRE LINES INDICATE WIRING EXTERNAL TO THE ELECTRICAL BOX AND NOT PART OF THIS ASSEMBLY.

4) ALL WIRES TO BE BLUE 18 OR 20 AWG UNLESS OTHERWISE INDICATED.

5) ALL UNUSED POSITIONS IN BULKHEAD CONNECTORS TO BE PLUGGED WITH DEUTSCH SEALING PLUGS.

6) CONNECTOR P5 TO HANG LOOSE (WITH DUST CAP) INSIDE ENCLOSURE. USE CABLE ANCHOR TO SECURE CONNECTOR TO INNER SIDE OF ENCLOSURE. CONNECTOR PART NUMBER IS HD14-9-96P.

7) PINS WITH AN ASTERISK (*) ARE INCLUDED IN WIRE HARNESS TO EITHER A BULKHEAD CONNECTOR OR FLYING LEADS.

8) USE WITH DANFOSS SERVICE TOOL 018394.p1d TO SELECT SENSORS FOR INPUTS 17, 18, 19, 22, 23, 24, 25, 27, 28, AND 30
Hydraulic Schematic

APE 755 / 800 HP C18 CATERPILLAR ENGINE TIER III 200T VIBRO (PISTON PUMP, NO PRESSURE FILTER OR SPARE HYD TANK) PRELIMINARY 1-31-18 JC

205.98 GPM == APPROXIMATE FREE HANG 1701 VPM ENGINE RPM REQUIRED TO LOWER VPM

67.26 GPM 67.26 GPM 205.98 GPM === APPROXIMATE FREE HANG 1701 VPM ENGINE RPM REQUIRED TO LOWER VPM
APE 755/800 HP C18 CATERPILLAR ENGINE TIER III 200T VIBRO
(GEAR PUMP, NO PRESSURE FILTER OR SPARE HYD TANK)

PRELIMINARY 1-31-18 JC

3 12 X 12
1650 VPM

206.51 GPM === APPROXIMATE FREE HANG 1706 VPM ENGINE RPM REQUIRED TO LOWER VPM
Setting up the Program

Prior to any program updates you will need:
1. A blank flash drive
2. A laptop with Plus + One Service guide software installed
   http://www2.powersolutions.danfoss.com/l/38972/2016-05-30/525qvt
3. CAN to USB adapter

To update the program you must first download and format the flash drive as follows:

1. Insert blank USB into your laptop.
   a. Format USB by going to:
   b. My computer
   c. Right click on flash drive
   d. Click on format and format as shown in the figure to the right.
2. Download all files from link provided
3. Extract all downloaded files onto USB drive.
4. All files in the folder labeled “Display Program” must be moved out of the folder or the update will not work.
5. On the bottom right of the screen eject USB to prevent any file corruption.
Updating the Display

To load the program onto the display from the USB drive follow steps below:

1. Make sure main power on the panel is turned off.
2. Open panel and plug-in USB drive into plug on the inside of the panel cover.
3. Hold down the top left two buttons on the display and turn on the main power. Continue to hold the two buttons down until the blue maintenance screen pops up on the display.
4. The display will auto update and count down from 15 and auto restart.
5. Wait 60 seconds then turn off main power and remove the USB drive.
6. Close the panel. Power-on to verify the update was successfully installed.
Updating the Panel

To update the power unit program follow the steps below:

1. Make sure main power on the panel is turned off.
2. Open the panel.
3. Plug in USB to CAN adapter to 2 wire CAN Plug on the inside of the panel.
   • Verify the CAN plug is wired properly. Wire #1131 is CAN high and should be in spot #1 in the plug. Wire #1141 is CAN low and should be in spot #2 in the plug.
4. Turn on main panel power and verify the PWR and CAN lights are both lit on the Danfoss adapter.
   • If no connection is recognized verify that the Plus-One service tool is online by going to communications and selecting online mode.
   • If online mode is on, verify you have the proper adapter model recognized by going to communications, gateway, and CG150-2.
5. Locate the file on the USB drive under the folder labeled Micro-controller Program and open the folder.
7. Follow the prompts and start the download.
8. Once download is complete close the Plus + One service tool.
9. Wait 60 seconds. Turn main panel power off and disconnect the USB to CAN adapter.
10. Power-on the main panel power and verify program is successfully installed.
### Common Replacement Parts

#### FILTERS

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>ENGINE</th>
<th>PART NUMBER</th>
<th>APE PART NUMBER</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine Oil Filter</td>
<td>C18</td>
<td>1R-1808</td>
<td>521033</td>
<td>1</td>
</tr>
<tr>
<td>Engine Fuel/Water Separator</td>
<td>C18</td>
<td>326-1643</td>
<td>555131</td>
<td>1</td>
</tr>
<tr>
<td>Engine Fuel Filter</td>
<td>C18</td>
<td>1R-0751</td>
<td>555129</td>
<td>1</td>
</tr>
<tr>
<td>Air Filter</td>
<td>C18</td>
<td>130-4678 Outer</td>
<td>130-4679 Inner</td>
<td>1</td>
</tr>
<tr>
<td>Return Filter</td>
<td>C18</td>
<td>KKZ25</td>
<td>1000586</td>
<td>2</td>
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</table>

#### FLUID CAPACITY

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>ENGINE</th>
<th>OIL TYPE</th>
<th>APE PART NUMBER</th>
<th>CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine Oil</td>
<td>C18</td>
<td>Caterpillar DELO 15W-40</td>
<td>513001-15W40-D400-1</td>
<td>17 qt (16L)</td>
</tr>
<tr>
<td>Engine Coolant</td>
<td>C18</td>
<td>Caterpillar DEAC Antifreeze</td>
<td>513001-ANTI-A DEAC-1</td>
<td>6 qt (5.7L)</td>
</tr>
<tr>
<td>Pump Drive</td>
<td>C18</td>
<td>Neptune 220 Arctic Gear Oil</td>
<td>513001S-A NEP220</td>
<td>6 qt (5.7L)</td>
</tr>
<tr>
<td>Fuel</td>
<td>C18</td>
<td>Diesel Fuel</td>
<td>513001</td>
<td>145 gal (553L)</td>
</tr>
<tr>
<td>Hydraulic Oil</td>
<td>C18</td>
<td>Envirological 146</td>
<td>513001</td>
<td>568 gal (2,150L)</td>
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</tbody>
</table>

#### SENSORS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>PART NUMBER</th>
<th>APE PART NUMBER</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Level Sensor</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Hydraulic Level Sensor</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Drive Pressure Transducer</td>
<td>3202H60CPS1P8R00</td>
<td>1005409</td>
<td>1</td>
</tr>
<tr>
<td>Cooler Bypass Transducer</td>
<td>3202H500PG1P8R00</td>
<td>1005295</td>
<td>1</td>
</tr>
<tr>
<td>Schroeder Indicator Sending Unit</td>
<td>MS19TNC-50</td>
<td>1003577</td>
<td>2</td>
</tr>
</tbody>
</table>

#### MISC ITEMS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>ENGINE</th>
<th>PART NUMBER</th>
<th>APE PART NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery</td>
<td>C18</td>
<td>Group Size 4D</td>
<td>541009</td>
</tr>
<tr>
<td>Fan Belt</td>
<td>C18</td>
<td>2M-8183 DF</td>
<td></td>
</tr>
<tr>
<td>Alternator Belt</td>
<td>C18</td>
<td>9L4896</td>
<td></td>
</tr>
<tr>
<td>Water Pump Belt</td>
<td>C18</td>
<td>9L-4896 DF</td>
<td></td>
</tr>
<tr>
<td>Hydraulic Sight Gauge 6”</td>
<td>G607-06-A-1-4-513003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic Sight Gauge 30”</td>
<td>G607-30-A-1 1/2-513003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic Level Sensor</td>
<td>b40040A/2C758/6amp</td>
<td>1006759</td>
<td></td>
</tr>
<tr>
<td>Hydraulic Tank Breather</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel Level Gauge</td>
<td></td>
<td>8680-010255</td>
<td>513050</td>
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</table>
## REPLACEMENT PARTS

### Drive Manifold

<table>
<thead>
<tr>
<th>CALLOUT</th>
<th>PART #</th>
<th>DESCRIPTION</th>
<th>QTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1007251</td>
<td>VIBRO DRIVE MANIFOLD</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>CBCG-LJN</td>
<td>COUNTERBALANCE VALVE</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>RPEC-LAN</td>
<td>PISTON RELIEF VALVE</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>LOKA-XDN</td>
<td>VENT TO OPEN POPPET</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>RVIS-LAN</td>
<td>POPPET RELIEF VALVE</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>DTDA-SCN</td>
<td>SOFT SHIFT SOLENOID</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>DMDM-LAN</td>
<td>DIRECTIONAL SPOOL VALVE</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>770-924</td>
<td>24V DC COIL</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>6400-04-06</td>
<td>ORB-JIC REDUCER</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>6408-06</td>
<td>HEX PLUG</td>
<td>13</td>
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<tr>
<td>11</td>
<td>6408-08</td>
<td>HEX PLUG</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>EPCO 06</td>
<td>EPCO HEX PLUG</td>
<td>3</td>
</tr>
<tr>
<td>13</td>
<td>EPCO 16</td>
<td>EPCO HEX PLUG</td>
<td>3</td>
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<tr>
<td>14</td>
<td>XIOA-XXN</td>
<td>CAVITY PLUG</td>
<td>3</td>
</tr>
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</table>

![Diagram of Drive Manifold](image-url)
## REPLACEMENT PARTS

<table>
<thead>
<tr>
<th>CALLOUT</th>
<th>PART #</th>
<th>DESCRIPTION</th>
<th>QTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>6410-06-04</td>
<td>ORB REDUCER</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>KC503KXXSD5</td>
<td>PRESSURE FILTER</td>
<td>2</td>
</tr>
<tr>
<td>17</td>
<td>6408-24</td>
<td>HEX PLUG</td>
<td>4</td>
</tr>
<tr>
<td>18</td>
<td>7619264</td>
<td>CAVITY PLUG</td>
<td>1</td>
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<tr>
<td>19</td>
<td>MS19</td>
<td>ELECTRICAL THERMAL LOCKOUT</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>RPE4-103Z11</td>
<td>DIRECTIONAL CONTROL VALVE</td>
<td>1</td>
</tr>
<tr>
<td>21</td>
<td>C31A-E12</td>
<td>COIL</td>
<td>2</td>
</tr>
<tr>
<td>22</td>
<td>PS75-70-4MSZ-C-FLS18-DE-FS4500PSIR-W126435</td>
<td>GEMS PRESSURE SWITCH</td>
<td>1</td>
</tr>
<tr>
<td>23</td>
<td>3202H500PG1P8R00</td>
<td>PRESSURE TRANSDUCER</td>
<td>2</td>
</tr>
<tr>
<td>24</td>
<td>1951-32</td>
<td>CPDE 61 SPLIT FLANGE</td>
<td>2</td>
</tr>
<tr>
<td>25</td>
<td>6401-08-06</td>
<td>ORB-NPT ADAPTER</td>
<td>1</td>
</tr>
<tr>
<td>26</td>
<td>S31-3P</td>
<td>MALE CLAMP QD</td>
<td>1</td>
</tr>
<tr>
<td>27</td>
<td>6405-08-06</td>
<td>ORB-NPT ADAPTER</td>
<td>1</td>
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<td>28</td>
<td>S35-3P</td>
<td>MALE CLAMP QD</td>
<td>1</td>
</tr>
<tr>
<td>29</td>
<td>S515W-10</td>
<td>FEMALE CASE DRAIN QD</td>
<td>1</td>
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<tr>
<td>30</td>
<td>6401-20-20</td>
<td>ORB-NPT ADAPTER</td>
<td>1</td>
</tr>
<tr>
<td>31</td>
<td>6TV MALE 32</td>
<td>MALE DRIVE QD</td>
<td>1</td>
</tr>
<tr>
<td>32</td>
<td>6TV FEMALE 32</td>
<td>FEMALE DRIVE QD</td>
<td>1</td>
</tr>
<tr>
<td>33</td>
<td>1952-32</td>
<td>CODE 62 SPLIT FLANGE</td>
<td>2</td>
</tr>
<tr>
<td>34</td>
<td>1952-24</td>
<td>CODE 62 SPLIT FLANGE</td>
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<td>35</td>
<td>6408-20</td>
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<td>1</td>
</tr>
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<td>36</td>
<td>6400-08-12</td>
<td>ORB-JIC REDUCER</td>
<td>1</td>
</tr>
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<td>37</td>
<td>6400-12-12</td>
<td>ORB-JIC REDUCER</td>
<td>1</td>
</tr>
<tr>
<td>38</td>
<td>6400-20-24</td>
<td>ORB-JIC REDUCER</td>
<td>1</td>
</tr>
</tbody>
</table>
The ISO cleanliness code is used to quantify particulate contamination levels per milliliter of fluid at 3 sizes 4μ[c], 6μ[c], and 14μ[c]. The ISO code is expressed in 3 numbers (ie 19/17/14). Each number represents a contaminant level code for the correlating particle size. The code includes all particles of the specified size and larger. It is important to note that each time a code increases the quantity range of particles is doubling.

<table>
<thead>
<tr>
<th>Range Code</th>
<th>Particles per milliliter</th>
<th>Up to/including</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>80000</td>
<td>160000</td>
</tr>
<tr>
<td>23</td>
<td>40000</td>
<td>80000</td>
</tr>
<tr>
<td>22</td>
<td>20000</td>
<td>40000</td>
</tr>
<tr>
<td>21</td>
<td>10000</td>
<td>20000</td>
</tr>
<tr>
<td>20</td>
<td>5000</td>
<td>10000</td>
</tr>
<tr>
<td>19</td>
<td>2500</td>
<td>5000</td>
</tr>
<tr>
<td>18</td>
<td>1300</td>
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<td>17</td>
<td>640</td>
<td>1300</td>
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<td>1.3</td>
<td>2.5</td>
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<tr>
<td>7</td>
<td>0.64</td>
<td>1.3</td>
</tr>
<tr>
<td>6</td>
<td>0.32</td>
<td>0.64</td>
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</table>

Sample 1 (see photo 1)

<table>
<thead>
<tr>
<th>Particle Size</th>
<th>Particles per ml*</th>
<th>ISO 4406 Code range</th>
<th>ISO Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>4μ[c]</td>
<td>151773</td>
<td>80000~160000</td>
<td>24</td>
</tr>
<tr>
<td>6μ[c]</td>
<td>38363</td>
<td>20000~40000</td>
<td>22</td>
</tr>
<tr>
<td>10μ[c]</td>
<td>8229</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14μ[c]</td>
<td>3339</td>
<td>2500~5000</td>
<td>19</td>
</tr>
<tr>
<td>21μ[c]</td>
<td>1048</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38μ[c]</td>
<td>112</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sample 2 (see photo 2)

<table>
<thead>
<tr>
<th>Particle Size</th>
<th>Particles per ml*</th>
<th>ISO 4406 Code range</th>
<th>ISO Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>4μ[c]</td>
<td>492</td>
<td>320 ~ 640</td>
<td>16</td>
</tr>
<tr>
<td>6μ[c]</td>
<td>149</td>
<td>80 ~ 160</td>
<td>14</td>
</tr>
<tr>
<td>10μ[c]</td>
<td>41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14μ[c]</td>
<td>15</td>
<td>10 ~ 20</td>
<td>11</td>
</tr>
<tr>
<td>21μ[c]</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38μ[c]</td>
<td>1</td>
<td></td>
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</tr>
</tbody>
</table>
TARGET ISO CLEANLINESS CODES

When setting target ISO fluid cleanliness codes for hydraulic and lubrication systems it is important keep in mind the objectives to be achieved. Maximizing equipment reliability and safety, minimizing repair and replacement costs, extending useful fluid life, satisfying warranty requirements, and minimizing production down-time are attainable goals. Once a target ISO cleanliness code is set following a progression of steps to achieve that target, monitor it, and maintain it justifiable rewards will be yours.

Set the Target. The first step in identifying a target ISO code for a system is to identify the most sensitive on an individual system, or the most sensitive component supplied by a central reservoir. If a central reservoir supplies several systems the overall cleanliness must be maintained, or the most sensitive component must be protected by filtration that cleans the fluid to the target before reaching that component.

Other Considerations

Table 1 recommends conservative target ISO cleanliness codes based on a several component manufacturers guidelines and extensive field studies for standard industrial operating conditions in systems using petroleum based fluids. If a non-petroleum based fluid is used (i.e. water glycol) the target ISO code should be set one value lower for each size (4 \( \mu \text{c} / 6 \mu \text{c} / 14 \mu \text{c} \)). If a combination of the following conditions exists in the system the target ISO code should also be set one value lower:

- Component is critical to safety or overall system reliability.
- Frequent cold start.
- Excessive shock or vibration.
- Other severe operation conditions.

<table>
<thead>
<tr>
<th>Process</th>
<th>Pressure</th>
<th>Media</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumps</td>
<td>&lt; 140 bar</td>
<td>( \mu \text{c} = 1000 )</td>
</tr>
<tr>
<td></td>
<td>&lt; 2000 psi</td>
<td>( \mu \text{c} = 200 )</td>
</tr>
<tr>
<td>Fixed Gear</td>
<td>20/18/15</td>
<td>12 ( \mu \text{c} / 14 \mu \text{c} )</td>
</tr>
<tr>
<td>Fixed Piston</td>
<td>20/18/15</td>
<td>12 ( \mu \text{c} / 14 \mu \text{c} )</td>
</tr>
<tr>
<td>Fixed Vane</td>
<td>20/18/15</td>
<td>12 ( \mu \text{c} / 14 \mu \text{c} )</td>
</tr>
<tr>
<td>Variable Piston</td>
<td>18/16/13</td>
<td>7 ( \mu \text{c} / 6 \mu \text{c} )</td>
</tr>
<tr>
<td>Variable Vane</td>
<td>18/16/13</td>
<td>7 ( \mu \text{c} / 6 \mu \text{c} )</td>
</tr>
<tr>
<td>Valves</td>
<td>18/16/13</td>
<td>12 ( \mu \text{c} / 12 \mu \text{c} )</td>
</tr>
<tr>
<td>Check Valve</td>
<td>20/18/15</td>
<td>12 ( \mu \text{c} / 12 \mu \text{c} )</td>
</tr>
<tr>
<td>Directional (solenoid)</td>
<td>20/18/15</td>
<td>12 ( \mu \text{c} / 12 \mu \text{c} )</td>
</tr>
<tr>
<td>Flow Control</td>
<td>19/17/14</td>
<td>12 ( \mu \text{c} / 12 \mu \text{c} )</td>
</tr>
<tr>
<td>Pressure Control (modulating)</td>
<td>19/17/14</td>
<td>12 ( \mu \text{c} / 12 \mu \text{c} )</td>
</tr>
<tr>
<td>Proportional Cartridge Valve</td>
<td>17/15/12</td>
<td>7 ( \mu \text{c} / 6 \mu \text{c} )</td>
</tr>
<tr>
<td>Proportional Directional Flow Control</td>
<td>17/15/12</td>
<td>7 ( \mu \text{c} / 6 \mu \text{c} )</td>
</tr>
<tr>
<td>Proportional Pressure Control</td>
<td>17/15/12</td>
<td>7 ( \mu \text{c} / 6 \mu \text{c} )</td>
</tr>
<tr>
<td>Servo Valve</td>
<td>16/14/11</td>
<td>5 ( \mu \text{c} / 5 \mu \text{c} )</td>
</tr>
<tr>
<td>Bearings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ball Bearing</td>
<td>15/13/10</td>
<td>5 ( \mu \text{c} / 3 \mu \text{c} )</td>
</tr>
<tr>
<td>Gearbox (industrial)</td>
<td>17/16/13</td>
<td>12 ( \mu \text{c} / 12 \mu \text{c} )</td>
</tr>
<tr>
<td>Journal Bearing (high speed)</td>
<td>17/15/12</td>
<td>7 ( \mu \text{c} / 6 \mu \text{c} )</td>
</tr>
<tr>
<td>Journal Bearing (low speed)</td>
<td>17/15/12</td>
<td>7 ( \mu \text{c} / 6 \mu \text{c} )</td>
</tr>
<tr>
<td>Roller Bearing</td>
<td>16/14/11</td>
<td>7 ( \mu \text{c} / 6 \mu \text{c} )</td>
</tr>
<tr>
<td>Actuators</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylinders</td>
<td>17/15/12</td>
<td>7 ( \mu \text{c} / 6 \mu \text{c} )</td>
</tr>
<tr>
<td>Vane Motors</td>
<td>20/18/15</td>
<td>12 ( \mu \text{c} / 12 \mu \text{c} )</td>
</tr>
<tr>
<td>Axial Piston Motors</td>
<td>19/17/14</td>
<td>12 ( \mu \text{c} / 12 \mu \text{c} )</td>
</tr>
<tr>
<td>Gear Motors</td>
<td>20/18/14</td>
<td>12 ( \mu \text{c} / 12 \mu \text{c} )</td>
</tr>
<tr>
<td>Radial Piston Motors</td>
<td>20/18/15</td>
<td>12 ( \mu \text{c} / 12 \mu \text{c} )</td>
</tr>
<tr>
<td>Test Stands, Hydrostatic</td>
<td>15/13/10</td>
<td>5 ( \mu \text{c} / 3 \mu \text{c} )</td>
</tr>
<tr>
<td>Test Stands, Hydrostatic Transmissions</td>
<td>17/15/13</td>
<td>7 ( \mu \text{c} / 6 \mu \text{c} )</td>
</tr>
</tbody>
</table>

*Depending upon system volume and severity of operating conditions a combination of filters with varying degrees of filtration efficiency might be required (i.e. pressure, return, and off-line filters) to achieve and maintain the desired fluid cleanliness.

Example

<table>
<thead>
<tr>
<th>ISO Code</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>156 bar, 2200 psi</td>
<td>Operating Pressure</td>
</tr>
<tr>
<td>Directional Solenoid</td>
<td>Most Sensitive Component</td>
</tr>
<tr>
<td>Water Glycol</td>
<td>Fluid Type</td>
</tr>
<tr>
<td>18/16/13</td>
<td>Operating Conditions</td>
</tr>
</tbody>
</table>

- Remote location, repair difficult
- High ingress rate

Adjust down one class, combination of critical nature, severe conditions
# Torque-Tension Relationship for ASTM A574 Socket Head Cap Screws

<table>
<thead>
<tr>
<th>Nominal Dia (in.)</th>
<th>Unified Coarse Thread Series</th>
<th>Fine Thread Series</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tensile Stress Area (sq. in.)</td>
<td>Clamp Load (lbs)</td>
</tr>
<tr>
<td></td>
<td>threads per inch</td>
<td>(ft-lbs)</td>
</tr>
<tr>
<td>1/4</td>
<td>20</td>
<td>0.0318</td>
</tr>
<tr>
<td>5/16</td>
<td>18</td>
<td>0.0524</td>
</tr>
<tr>
<td>3/8</td>
<td>16</td>
<td>0.0775</td>
</tr>
<tr>
<td>7/16</td>
<td>14</td>
<td>0.1063</td>
</tr>
<tr>
<td>1/2</td>
<td>13</td>
<td>0.1419</td>
</tr>
<tr>
<td>5/8</td>
<td>11</td>
<td>0.2260</td>
</tr>
<tr>
<td>3/4</td>
<td>10</td>
<td>0.3335</td>
</tr>
<tr>
<td>7/8</td>
<td>9</td>
<td>0.4617</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>0.6057</td>
</tr>
<tr>
<td>1 1/8</td>
<td>7</td>
<td>0.7633</td>
</tr>
<tr>
<td>1 1/4</td>
<td>7</td>
<td>0.9891</td>
</tr>
<tr>
<td>1 3/8</td>
<td>6</td>
<td>1.1549</td>
</tr>
<tr>
<td>1 1/2</td>
<td>6</td>
<td>1.4053</td>
</tr>
<tr>
<td>1 3/4</td>
<td>5</td>
<td>1.8995</td>
</tr>
</tbody>
</table>

Clamp load calculated as 75% of the proof load for socket head cap screws as specified in ASTM A574.

Torque values calculated from formula \( T = KDF \), where

- \( K = 0.15 \) for "lubricated" conditions, \( K = 0.16 \) "as-received" and \( K = 0.20 \) for "dry" conditions
- \( D \) = Nominal Diameter
- \( F \) = Clamp Load

**Caution:** All material included in this chart is advisory only, and its use by anyone is voluntary. In developing this information, Fastenal has made a determined effort to present its contents accurately. Extreme caution should be used when using a formula for torque/tension relationships. Torque is only an indirect indication of tension. Under/over tightening of fasteners can result in costly equipment failure or personal injury.
All information given in this Manual is current and valid per the information available at the time of publication. (Please check the updated revision date at the bottom of each page.)

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