



HYDRAULIC POWER UNIT OWNER'S MANUAL

APE C13 TIER 4



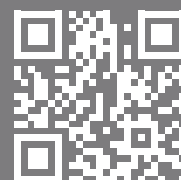
SERIAL NUMBER

180536



800-248-8498

WWW.APEVIBRO.COM



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Quick Reference Guide

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

GENERAL INFORMATION

MAINTENANCE

TROUBLE SHOOTING

REPLACEMENT PARTS

REFERENCE / NOTES

A Table of Contents is included after the Foreword.

Description:

APE C13 TIER 4 POWER 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.

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 fighting. **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.



Do NOT weld or flame cut on this equipment.

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.)



When operating in an enclosed area, exhaust fumes should be piped outside.

Continued breathing of exhaust fumes may prove FATAL.



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

15. 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.
16. When filling the fuel tank, do **NOT** smoke or use an open flame in the vicinity.
17. If abnormal equipment operation is observed, discontinue use immediately and correct the problem.
18. Do **NOT** leave the equipment control pendant (radio control) unattended.
19. Store oily rags in approved containers and away from the engine exhaust system.
20. Make sure that the Auger rotation switch is in NEUTRAL before starting the Power Unit engine.
21. Do **NOT** adjust and/or set the hydraulic pressures higher or lower than those specified in this Manual.
22. **NEVER** operate this equipment with hydraulic hoses that are damaged or 'kinked'. Replace damaged hoses immediately.
23. Do **NOT** lift and/or support hydraulic hoses with wire rope slings.
24. **NEVER** attempt to connect Quick Disconnects (QDs) when the Power Unit is running.
25. Do **NOT** pull on and/or attempt to move equipment with the hydraulic hoses.
26. 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.
27. Do **NOT** attempt to repair leaks while the equipment is in operation.
28. Do **NOT** attempt to tighten and/or loosen fittings and/or hoses when the machine is in operation.
29. Power Unit must always be placed on level, stable ground.
30. Do **NOT** remove Power Unit heat shields. Do **NOT** attempt to use the Power Unit without heat shields. Severe fires may result.
31. When moving and/or transporting this equipment, insure that the vehicle or vessel is of sufficient capacity to handle the load. Make sure that the equipment is properly tied down.
32. 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.
33. 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.)
34. KEEP HANDS AWAY FROM ROTATING FLIGHTING, AUGER SHAFT AND/OR ROTARY JOINT.
35. KEEP HANDS, FEET AND TOOLS WELL CLEAR OF THE FLIGHTING GUIDES.
36. Do **NOT** allow clothing, hoses, ropes, etc., to become entangled in, or wrap around, rotating flighting, Auger shaft and/or rotary joint.
37. When operating in a closed area, pipe exhaust fumes outside. (**Warning:** Breathing exhaust fumes can cause serious injury or even death.)
38. Make sure the control pendant is in the "LOCAL" position before starting the unit.
39. **NEVER** stand under hammer at any time and keep you eyes on the hammer when it is in operation.
40. When loading or unloading the power unit using a forklift, the forks must be placed under the entire depth of the unit.

WARRANTY INFORMATION

American Piledriving Equipment, Inc. (APE) warrants 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 or 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 whatsoever, 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.

FOREWORD

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	146 in	(371 cm)
Overall Width	78 in	(198 cm)
Overall Height	85 in	(216 cm)
Weight	19,000 lbs	(8,618 kg)
Fuel Capacity	120 gal	(443 L)

ENGINE

Type	Caterpillar C13 Tier 4	
Horse Power	475 hp	
Displacement	763 in ³	(12,500 cc)
Compression Ratio	16.1:1	
Engine Speed	1,800 rpm	
Engine Oil	Caterpillar Diesel Engine Oil 10W30 or 15W40	
	42 qt	(40 L)

Hydraulics

Drive Pressure	0-4,500 psi	(310 bar)
Drive Flow	130 gpm	(492 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	
	318 gal	(1,204 L) Lower
	104 gal	(394 L) Upper

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.

GENERAL INFORMATION

[illegible]

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.

NOTICE: QUICK DIS-CONNECTS MUST BE FULLY SEATED TO ALLOW FREE HYDRAULIC FLOW. BLOCKED HYDRAULIC FLOW WILL STOP OR SLOW OPERATIONS AND CAUSE EXCESSIVE HEAT. TO SOLVE PROBLEM, REMOVE CLEAN AND RE INSTALL FITTINGS

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.

APE Daily Vibro Check List

832 264-6428
253 264-7371
Fax: 253 264-7376
www.apeschools.com

For use on all Models. Model 200 shown for example.

☐ Check large flange nut for cracks

☐ Remove damaged wear rope

☐ Check double pin center key fit (key loose means do not use vibrator)

☐ Inspected small clammers for cracks

☐ Inspected pull off safety valve for leaks

☐ Inspected hoses for wear

☐ Lower pull safety switch attached

☐ Check all bolts on clammers

☐ Check line pull pin for damage

☐ Inspect motor coupling for leaks

☐ Check suppressor mounting bolts

☐ Check bearing covers for damage

☐ Check all welds for cracks

☐ Check oil level in gearbox

☐ Check transfer check valve on center of motor bearing cover. Remove oil from point that could leak motor.

Oil Level
Model 200 SHC 625 or standard APE200 Hyd oil
(Do not use vegetable type oil)

Sight Glass
Warning: Never oil weight gun until unit will start over. If you cannot start the level tank do not operate the machine. If you cannot start the level tank then do not go to 2. Remove the glass and examine the oil. Oil should be in the glass. This oil will not reduce up on the thrust. Avoid oil settling in the tank and will work. If level continuously increases it is a bad sign. A bad tank that will leak tends to be bad in the piston.

Remove or replace motor which shows hydraulic ground and motor is leaking the oil. Consult factory for repair.

☐ Check both the inside and the jaw bolts

☐ Machine jaw bolts will wear by using jaw opening tools

☐ Check clamps must be tight on the rollers

☐ Remove air from clamp lines by cracking them open at the clamp cylinder while power is on and it is a slow speed

☐ Check clamp lines and fittings leading to clamp cylinder

☐ Check both clamp bearing clamp lines

☐ Check condition of hose handle

Note: When installing new clamp, check inside surface on bottom of hammer and top of clamp with straight edge like a before up down each mounting hole. Make sure surface is clean and flat. Torque down each clamp 1/2 turn then do it 2nd time if you are done mounting both on bearing. If clamp adjustment lifts off, it is due to bolts not being properly tightened. Do not torque excess.

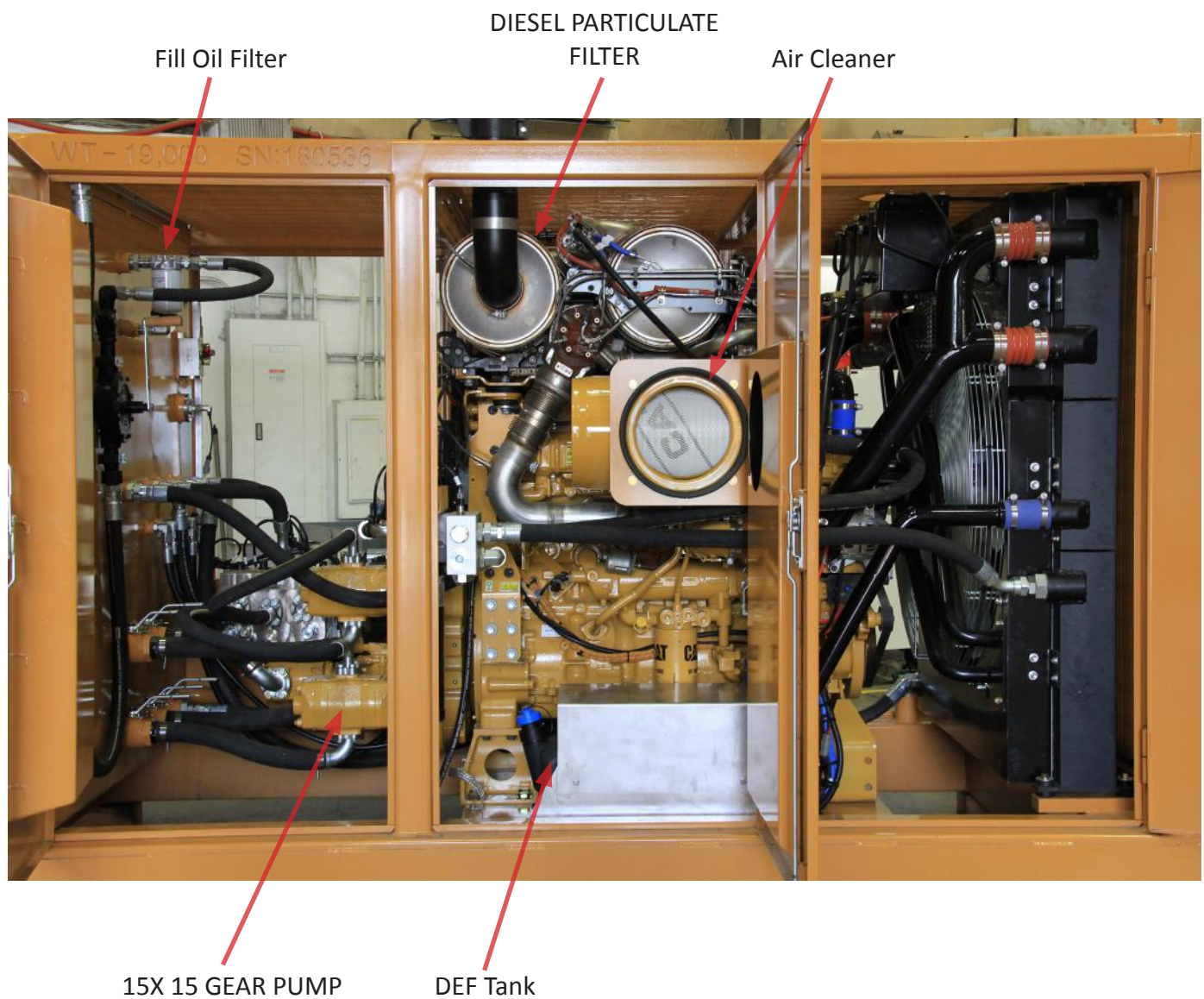
Continued

Daily inspection performed by _____ Date: _____

Check for developed by APE Pilot Driving School students of the June 2002 class. Send ideas to jahone@apeschools.com

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



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.

GENERAL INFORMATION

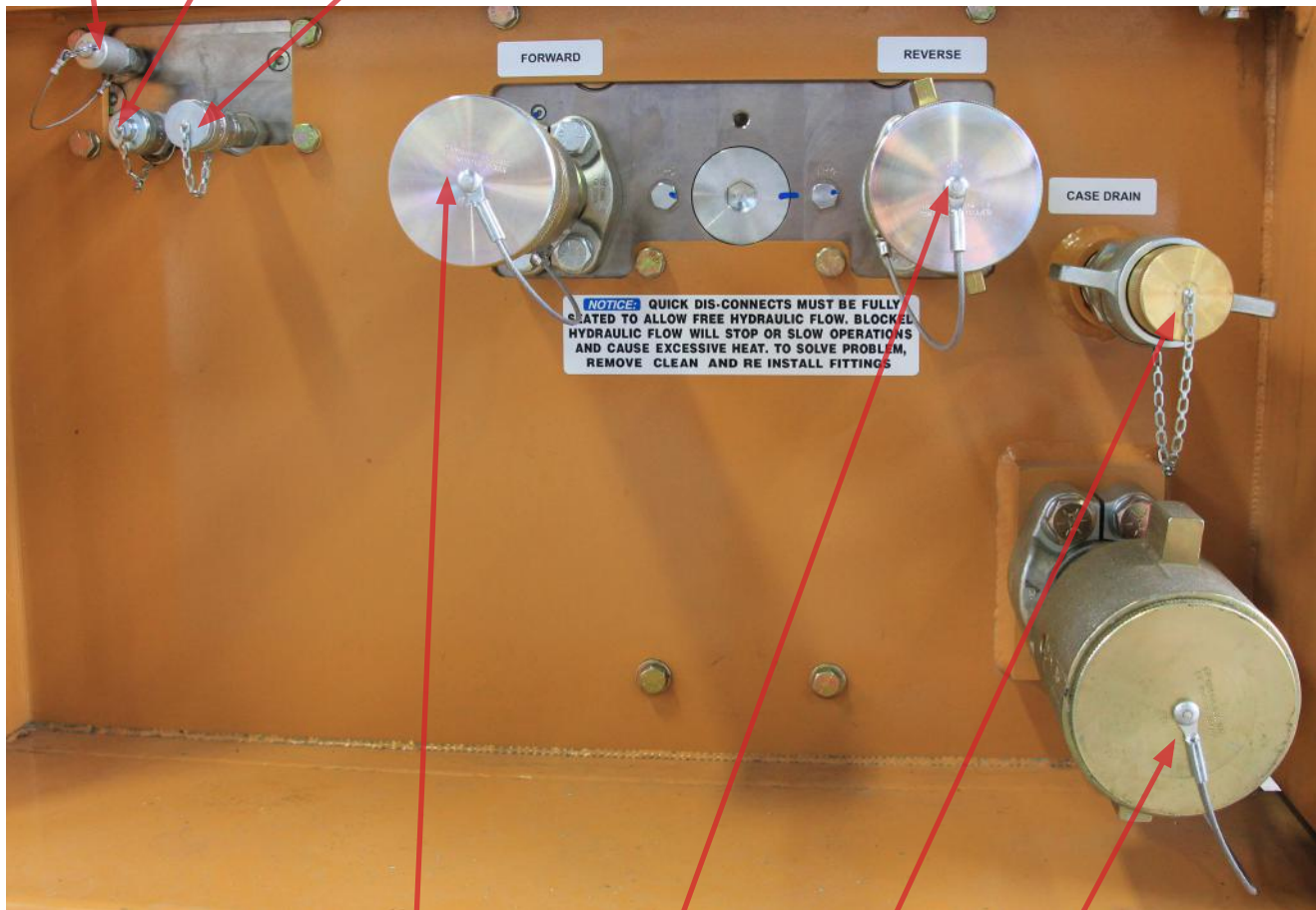
Lifting the Power Unit

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

HI Speed Clamp Open Clamp Close



Drive FWD

Drive REV

Case Drain

HIH Return

GENERAL INFORMATION

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

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!

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 is 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



APE PART NUMBER	PART NUMBER	DESCRIPTION
1000941	11730-02188	Drill Shift NoShok 0-3000 PSI
513007	25.310.7500	Clamp Close/Open NoShok 0-7500 PSI
513007	25.310.7500	Drive FWD / Rev NoShok 0-7500 PSI
1001046	11730-02192	Return Filter Pressure NoShok 0-300 PSI

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 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.

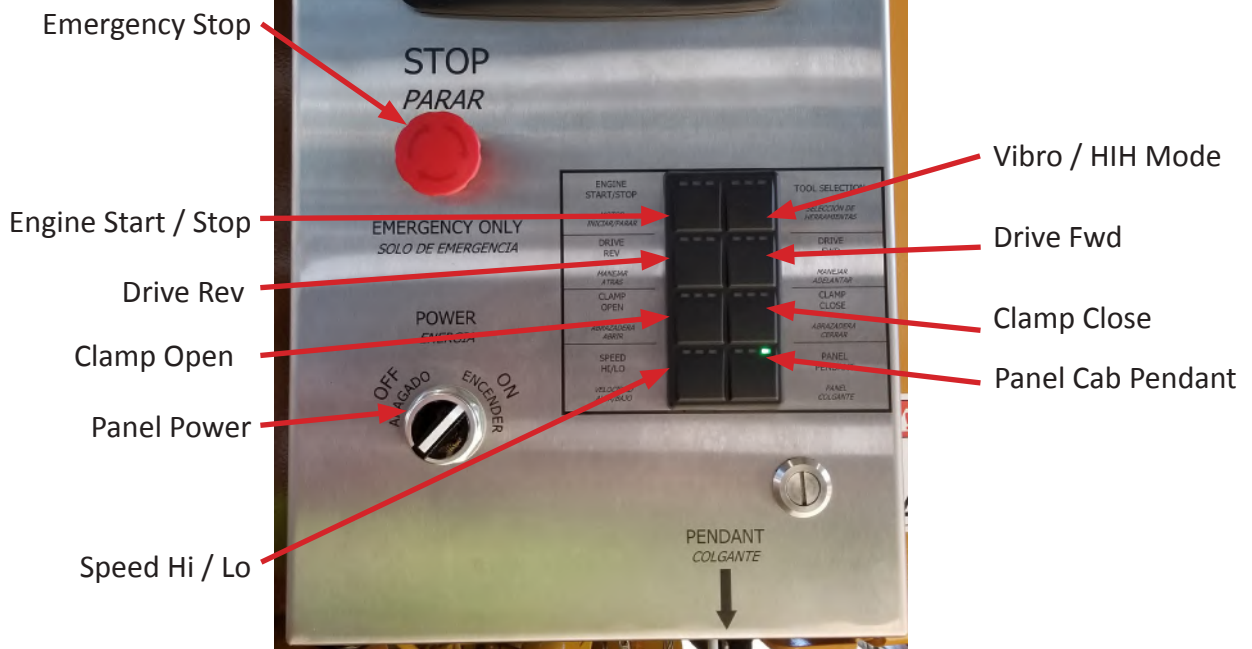
Control Panel Overview

To Select Menu
Option



Governor

Return to Main Menu



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.



or



The color of the light does not matter.

GENERAL INFORMATION

ENGINE RPM

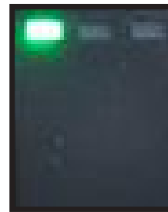
SPIN RIGHT FOR RPM UP
SPIN LEFT FOR RPM DOWN

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.



Radio Remote Control

All functions for the HIH 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. If the pendant goes out of range the power unit will go into an auto idle and disengage drive. For old style pendants 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.



CONTROL MODE

EMERGENCY STOP

DO NOT USE THIS TO SHUT DOWN THE POWER UNIT UNLESS IT IS AN EMERGENCY

ENGINE RPM UP / RPM DOWN

Raises and lower the engine RPM.

DRIVE STOP / START

Starts or stops the Hydraulic Impact Hammer.

STROKE

Adjusts the stroke time from 0-100% in 5% increments. Full stroke is approximately 90% stroke time.

DWELL

Adjusts the time between the weight impact and the next lift cycle. The ram must come to a complete rest before the lifting cycle begins. **NEVER CATCH A FALLING RAM**

Engine Start/Stop

Stops the Engine.

AUTO/MANUAL

-Auto mode continually cycles user set stroke and dwell.
-Manual only raises the ram while the user depresses the stroke up button.

ENABLE

Enables the functions of "Engine Start/Stop, Drive Start/Stop and Auto/Manual" buttons.



CLAMP CLOSE

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 re-pressurized.

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.

TOOL SELECTION



This button switches between HIH and standard vibro functions.

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 reverse line 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.

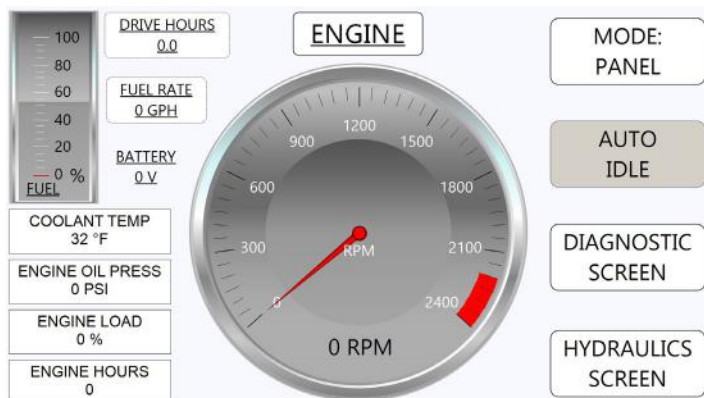


DRIVE FORWARD ON

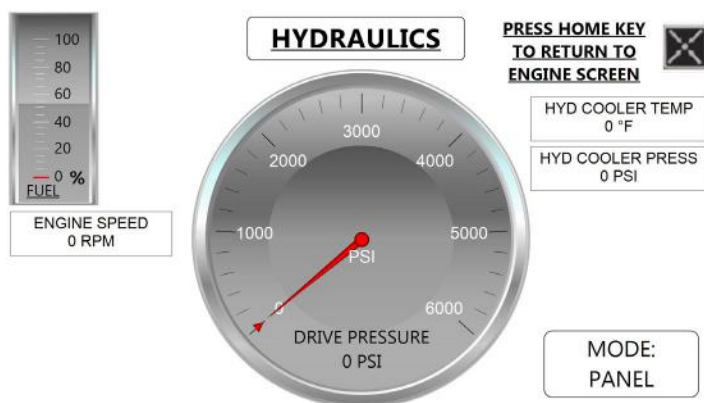
This will start pumping oil out of the forward line circuit.

GENERAL INFORMATION

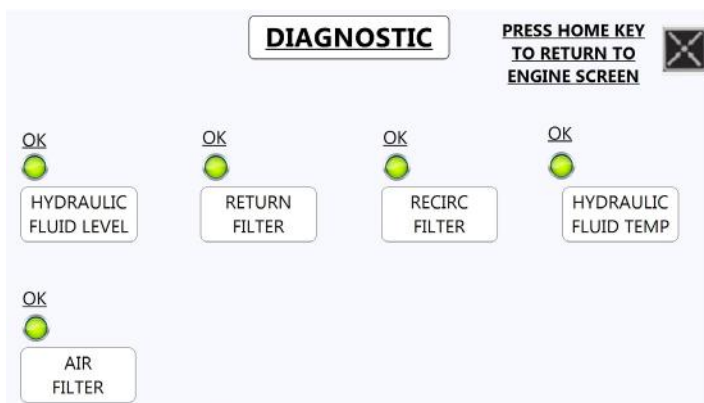
Control Panel Display



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.



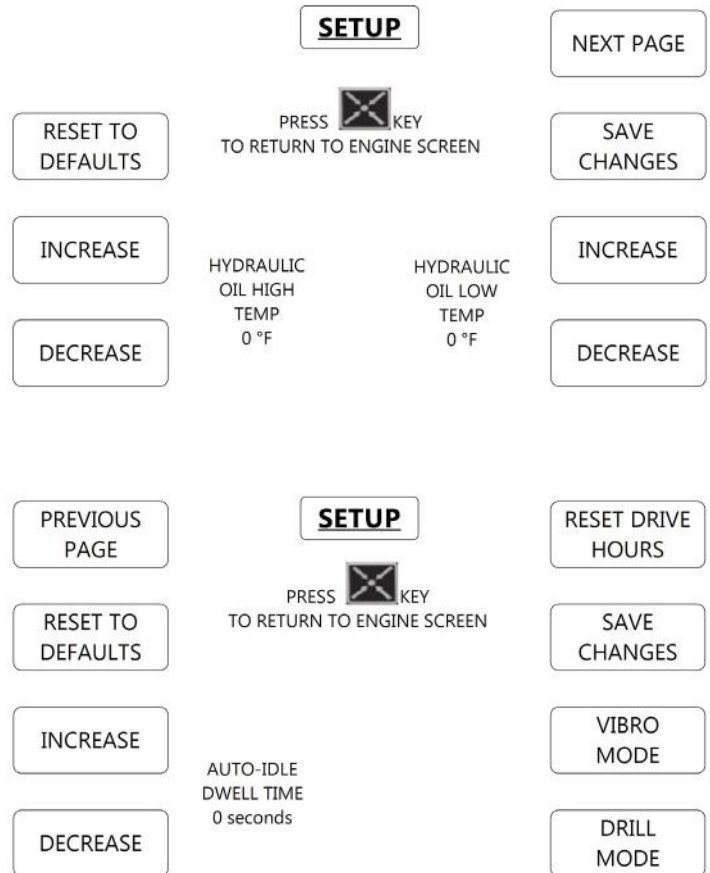
From the main screen you can select a sub-screen reading only critical hydraulic data such as drive pressure, cooler temperature, cooler pressure, engine speed, and fuel level. To return to the main screen from the hydraulic screen push the button with an "X" located right under the governor knob.



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.

GENERAL INFORMATION

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.

ERROR: ENGINE OR HYDRAULIC SYSTEM
PRESS 'CHECK' BUTTON FOR DETAILS



CHECK

MAINTENANCE

Maintenance Chart

DAILY	WEEKLY	250 HOURS OR 6 MONTHS	1500 HOURS OR 1 YEAR	6000 HOURS OR 2 YEARS	6000 HOURS OR 3 YEARS
<ul style="list-style-type: none"> • Check operator's report • Check oil and bring to correct level • Check coolant and bring to correct level • Visually inspect fan • Visually inspect engine for damage, leaks, loose or frayed belts and correct or record or future action • Drain fuel-water separator 	<ul style="list-style-type: none"> • Check air intake system for wear points or damage to piping, loose clamps, and leaks. • Check air cleaner restriction • Check and clean air cleaner element • Drain moisture from tanks 	<ul style="list-style-type: none"> • Change lubricating oil • Change lubricating oil filters • Change fuel filter • Clean crankcase breather • Check engine coolant concentration level • Replace final fuel filter/clean primary fuel filter. Drain water from fuel tank • Inspect/replace alternator fan and accessory drive belts • Inspect/replace hoses and clamps • Lubricate fan drive bearings • Clean/check battery electrolyte level 	<ul style="list-style-type: none"> • Adjust valves and injectors • Steam clean engine • Check torque on turbocharger mounting nuts • Check torque on engine mounting bolts • Replace hoses as required • Check/adjust engine valve lash • Check/adjust low idle speed • Test/exchange fuel injection nozzles • Inspect/rebuild alternator 	<ul style="list-style-type: none"> • Clean cooling system and change coolant and antifreeze • Inspect Temperature regulator • Inspect/rebuild turbocharger • Inspect/rebuild starter 	<ul style="list-style-type: none"> • Clean and calibrate the following: <ul style="list-style-type: none"> • -Injectors • -Fuel pump • -Fan Clutch • -Water pump • -Fan Hub • -Fan idler pulley assembly • -Vibration dampener
<p>Follow the manufacturer's recommended maintenance procedures for the starter, alternator, batteries, electrical components, and fan clutch.</p> <p>At each scheduled maintenance interval preform all previous checks which are due for scheduled maintenance.</p>					

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, whichever 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, whichever 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, alkalies 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.

TROUBLESHOOTING

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.

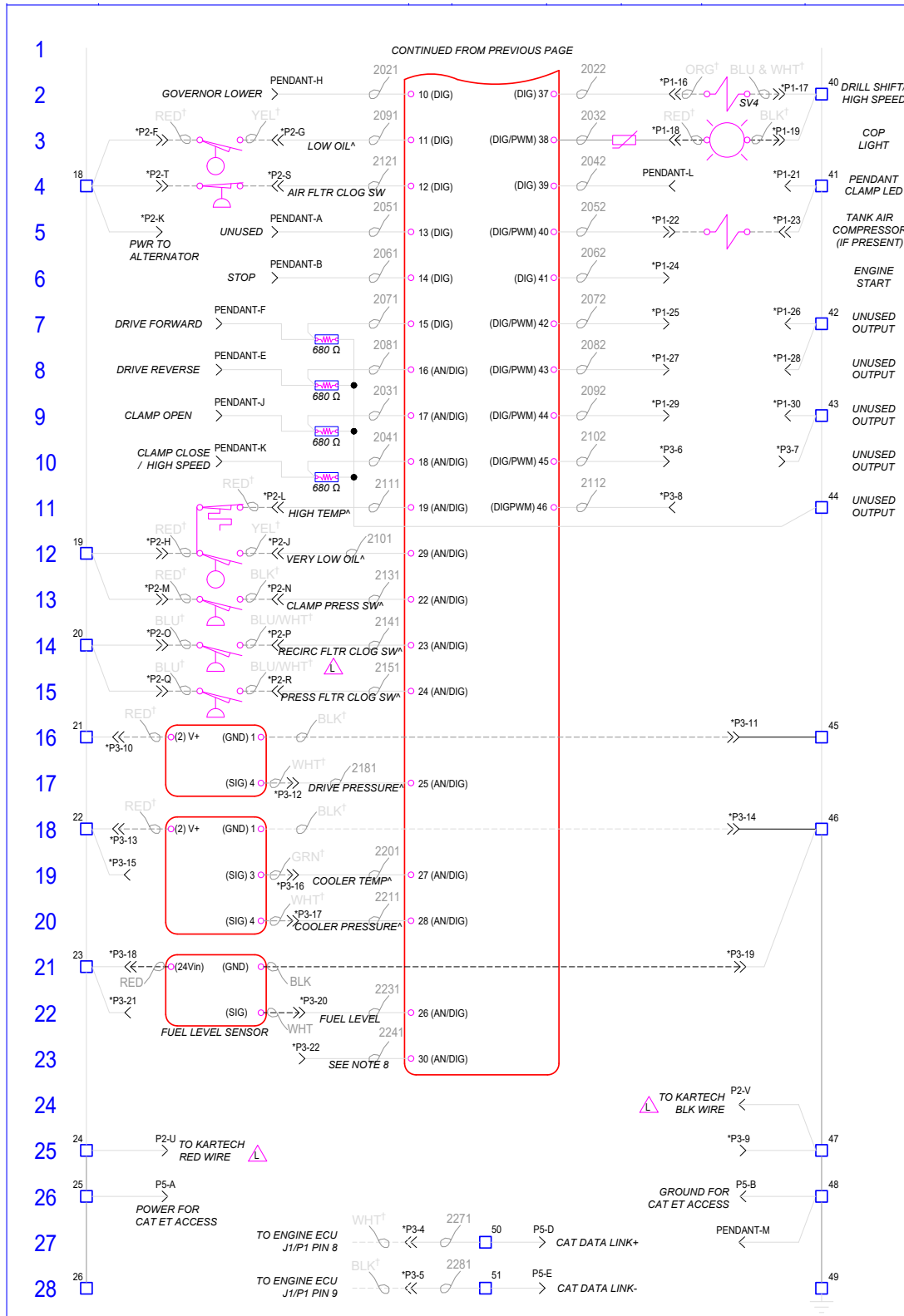
- Pressure filters: Clean the hydraulic fluid going to the drill motor and manifold in the forward and reverse directions.
- M1/M2 DRIVE
- LS LOAD SENSE
- 10/11: RDFA-LCN is a direct acting relief valve that is used to protect hydraulic components from pressure variants.
- 8/16/5/19 COILS
- T1 / PD: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

Electrical System

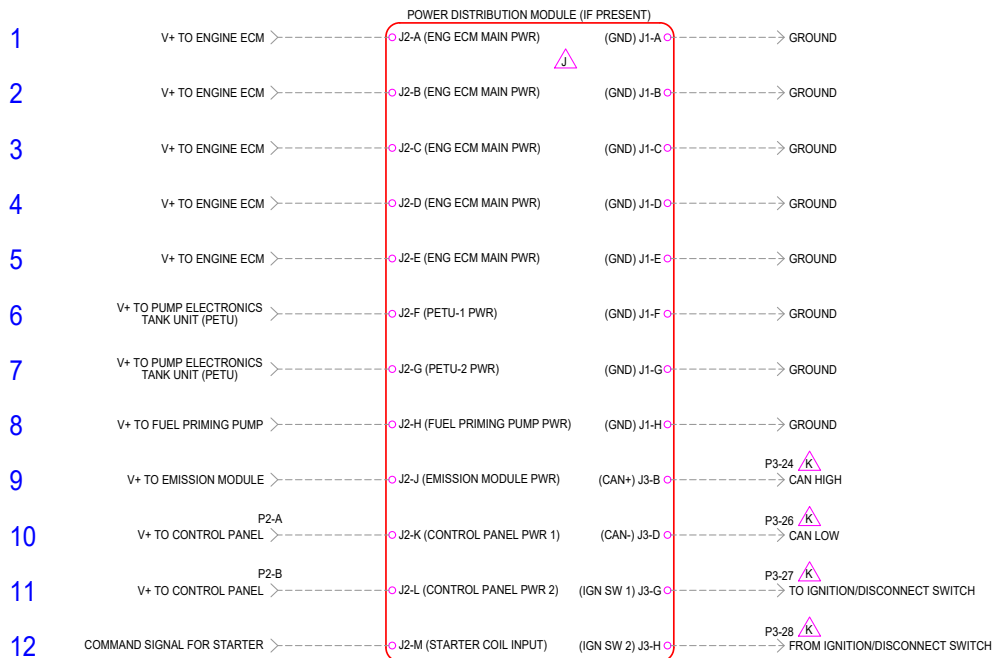
The electrical system is a normally closed circuit, and runs a self diagnostic test when the panel is powered on. If there is a fault in the electrical system an error screen will appear on the control panel display.

Electrical Schematic





TROUBLESHOOTING

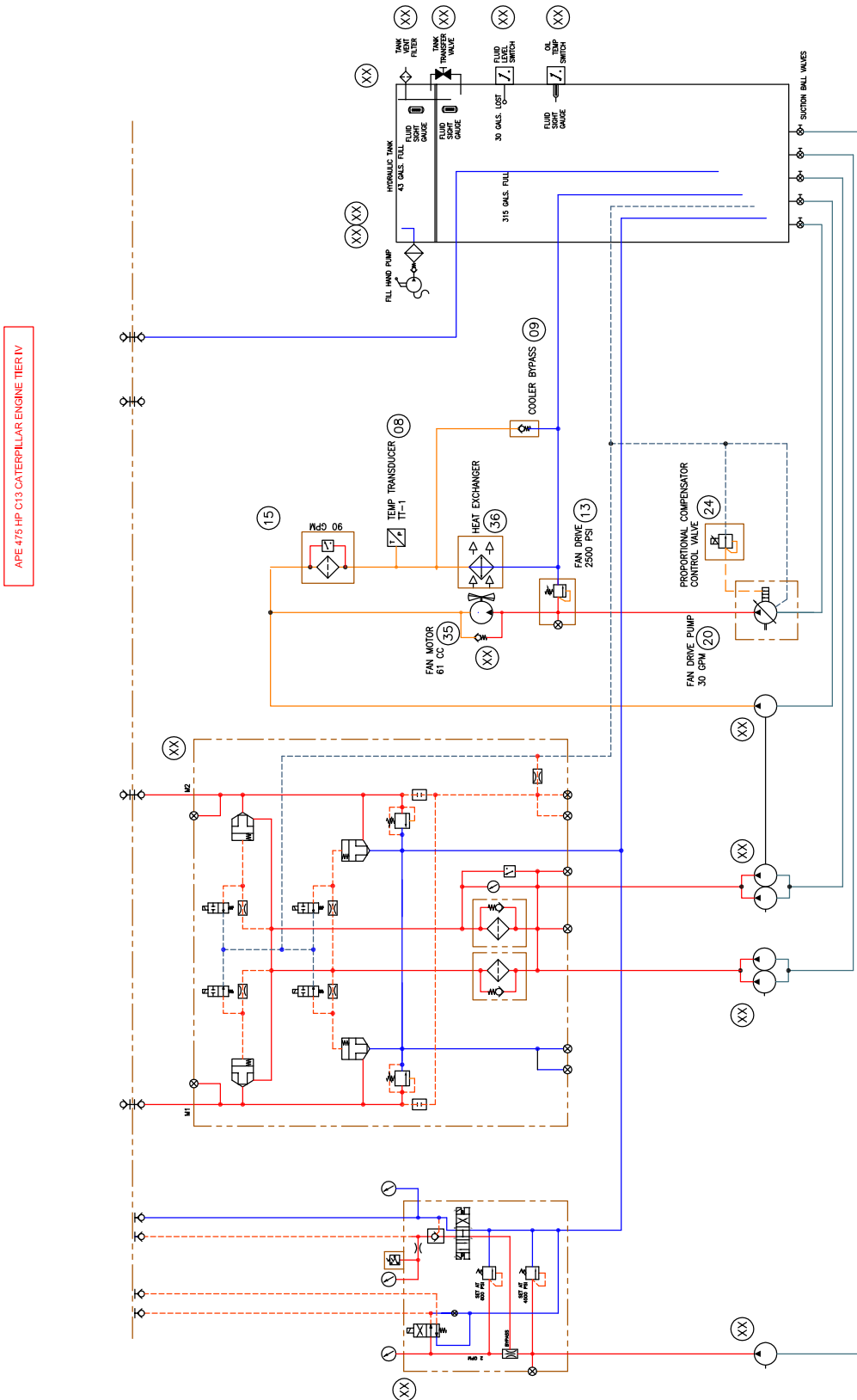


13 NOTES:

- 14 1) CONNECTIONS BETWEEN TERMINALS TO BE HARD JUMPERS UNLESS OTHERWISE INDICATED.
- 15 2) REFER TO LAYOUT DRAWING FOR LOCATIONS OF CONNECTORS 'P1', 'P2', 'P3', 'P4', 'AUX POWER', AND 'PENDANT'.
- 16 3) DASHED ELECTRICAL WIRE LINES INDICATE WIRING EXTERNAL TO THE ELECTRICAL BOX AND NOT PART OF THIS ASSEMBLY.
- 17 4) ALL WIRES TO BE BLUE 18 OR 20 AWG UNLESS OTHERWISE INDICATED.
- 18 5) ALL UNUSED POSITIONS IN BULKHEAD CONNECTORS TO BE PLUGGED WITH DEUTSCH SEALING PLUGS.
- 19 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.
- 20 7) PINS WITH AN ASTERISK (*) ARE INCLUDED IN WIRE HARNESS TO EITHER A BULKHEAD CONNECTOR OR FLYING LEADS.
- 21 8) *USE WITH DANFOSS SERVICE TOOL TO SELECT SENSORS FOR INPUTS 17, 18, 19, 22, 23, 24, 25, 27, 28, AND 30. INPUTS WITH (*) NOTED INDICATE WHAT IS TYPICAL.*
- 22 9) *WIRE COLORS WITH [†] NOTATION INDICATE WHAT IS TYPICAL FOR APE POWER UNIT WIRING AND MAY NOT BE EXACTLY AS NOTED ON ANY SPECIFIC POWER UNIT.*
- 23
- 24
- 25
- 26

REV:'L' - ADDED KARTECH WIRING, CHANGED DEFAULT FILTER CLOG INPUTS 5/10/18
REV:'K' - FINISHED ADDING TYPICAL INPUTS, FIXED PIN OUT FOR POWER DIST MODULE PER AS-BUILT PER THP 4/6/18
REV:'J' - ADDED WIRING FOR DATAPANEL POWER DISTRIBUTION MODULE PER THP 4/4/18
REV:'H' - ADDED NOTE 9 AND ASSOCIATED WIRE COLOR [†] CALL OUTS PER THP 1/30/18
REV:'G' - ADDED RESISTORS FOR PENDANT DRIVE/CLAMP INPUTS, ADDED GROUND TERMINAL WIRING PER THP 1/26/18
REV:'F' - SWAPPED WIRING FOR PINS 18 AND 29 PER THP 1/19/18
REV:'E' - CHANGED PIN FOR PENDANT CLAMP CLOSE INPUT AS NOTED PER THP 1/19/18
REV:'D' - SWAPPED LOCATION OF AIR FILTER CLOG FOR A SELECTABLE INPUTS LOCATION, REMOVED EXPANSION MODULE PER THP 1/18/18
REV:'C' - SWAPPED LOCATION OF PENDANT CLAMP OPEN/CLOSE INPUTS WITH SELECTABLE INPUTS PER THP 1/17/18
REV:'B' - CHANGED CLAMP OPEN N.C. OPERATOR TO GO TO C1-P12 PER THP 12/26/17
REV:'A' - INITIAL RELEASE PER THP 12/20/17

Hydraulic Schematic



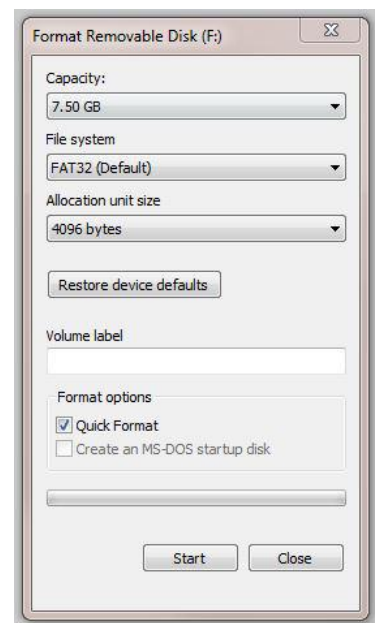
Setting up the Program

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.

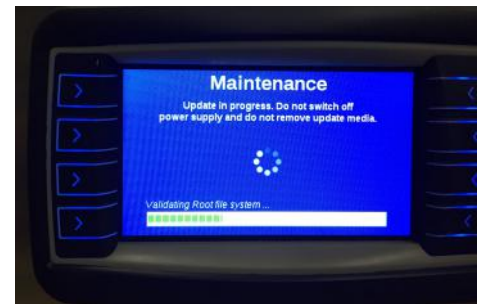


Updating the Display

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.

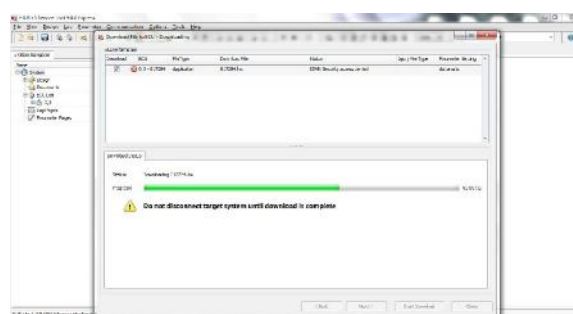
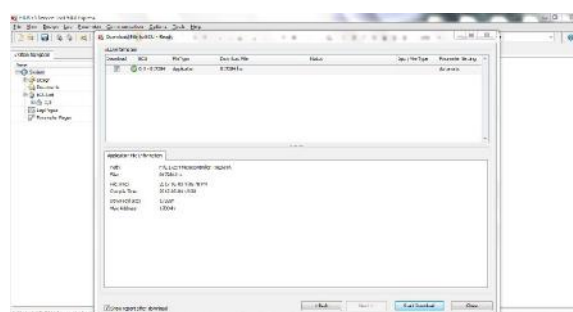
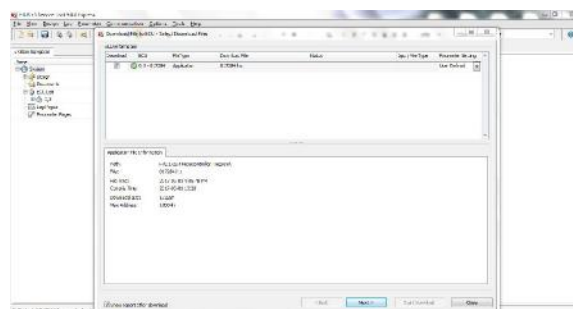
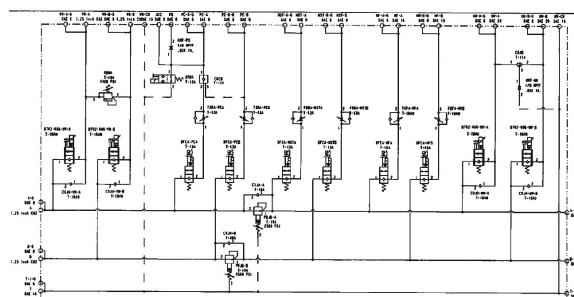
PRESS
HERE



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.
6. Double click on the file .
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.



REPLACEMENT PARTS

Common Replacement Parts

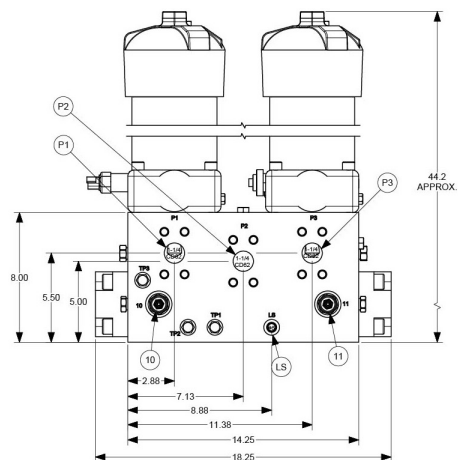
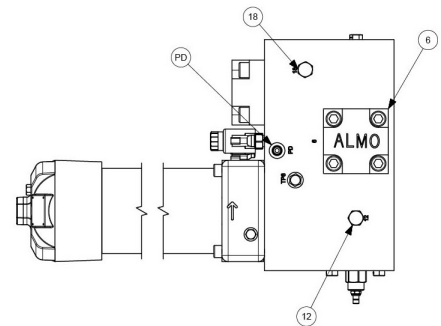
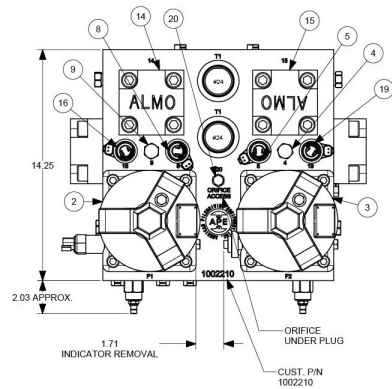
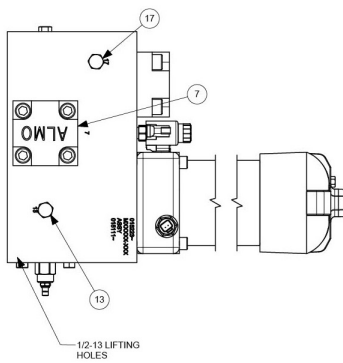
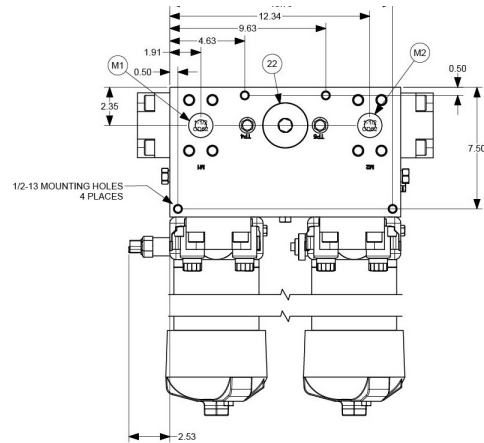
FILTERS				
LOCATION	ENGINE	PART NUMBER	APE PART NUMBER	QUANTITY
Engine Oil Filter	C13	1R-1808	521033	1
Engine Fuel/Water Separator	C13	326-1643	555131	1
Engine Fuel Filter	C13	1R-0751	555129	1
Air Filter	C13	6I-2509/6I-2510	555137/521025B	1
Return Filter	C13	KKZ25	1000586	2

FLUID CAPACITY				
LOCATION	ENGINE	OIL TYPE	APE PART NUMBER	CAPACITY
Engine Oil	C13	Caterpillar DELO 15W-40	513001-15W40-D400-1	42 qt (40L)
Engine Coolant	C13	Caterpillar DEAC Antifreeze	513001-ANTI-A DEAC-1	
Pump Drive	C13	Neptune 220 Arctic Gear Oil	513001S-A NEP220	5 qt (#4.75L)
Fuel	C13	Diesel Fuel		117 gal (443L)
Hydraulic Oil	C13	Envirological 146	513001	425 gal (1,609L)

SENSORS			
DESCRIPTION	PART NUMBER	APE PART NUMBER	QUANTITY
Fuel Level Sensor			1
Hydraulic Level Sensor			1
Drive Pressure Transducer	3202H60CPS1P8R00	1005409	1
Cooler Bypass Transducer	3202H500PG1P8R00	1005295	1
Schroeder Indicator Sending Unit	MS19TNC-50	1003577	2

MISC ITEMS			
DESCRIPTION	ENGINE	PART NUMBER	APE PART NUMBER
Battery	C13	Group Size 4D	541009
Fan Belt	C13	2M-8183 DF	
Alternator Belt	C13	9L4896	
Water Pump Belt	C13	9L-4896 DF	
Hydraulic Sight Gauge 6"		G607-06-A-1-4-513003	
Hydraulic Sight Gauge 30"		G607-30-A-1 1/2-513003	
Hydraulic Level Sensor		b40040AFD2C758/6amp	1006759
Hydraulic Tank Breather			
Fuel Level Gauge		8680-010255	513050

Drive Manifold

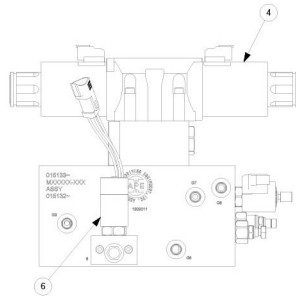
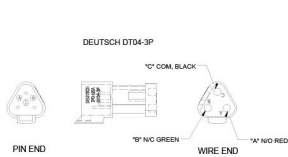
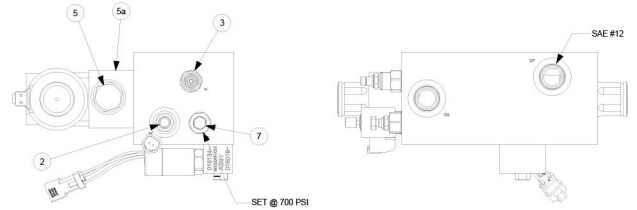
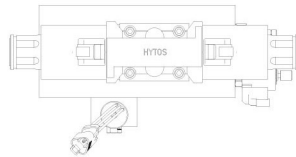
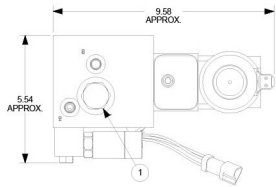


REPLACEMENT PARTS

CALLOUT	PART #	APE PART NUMBER	DESCRIPTION	QTY
1	015223		Ductile Manifold Body	1
1a			Electroless Nickel Plate	1
2	KC50 12ZKZ10 O L MS19LCT		Filter Assembly	1
2a			SHCS 1/2-13 X 3.5	4
3	KC50 127KZ10 O L D9		Filter Assembly	1
3a			SHCS 1/2-13 X 3.5	4
4	FXAA-XBN 20-IN3		Press Comp Flow Control Fixed 20 IN3	1
5	RBAP-XWN		Electro-Proportional Relief Valve	1
5a	924		Coil 24 VDC Deutsch	1
6	AMT-LCV-32-1.6-D-30		Logic Cartridge w/ Throttle	1
6a	AMT-PCC-32-C-BL		Cartridge Cover w/ Mounting Bolts	1
7	AMT-LCV-32-1.6-D-30		Logic Cartridge w/ Throttle	1
7a	AMT-PCC-32-C-BL		Cartridge Cover w/ Mounting Bolts	1
8	RBAP-XWN		Electro-Proportional Relief Valve	1
8a	924		Coil 24 VDC Deutsch	1
9	FXAA-XBN 201-IN3		Press Comp Flow Control Fixed 20 IN3	1
10	RDFA-LCN		Relief Valve, Direct Acting	1
11	RDFA-LCN		Relief Valve, Direct Acting	1
12	XACA-XXN		Cavity Plug, T-8A	1
13	XACA-XXN		Cavity Plug, T-8A	1
14	AMT-LCV-32-1.6-D-30		Logic Cartridge w/ Throttle	1
14a	AMT-PCC-32-C-BL		Cartridge Cover w/ Mounting Bolts	1
15	AMT-LCV-32-1.6-D-30		Logic Cartridge w/ Throttle	1
15a	AMT-PCC-32-C-BL		Cartridge Cover w/ Mounting Bolts	1
16	RBAP-XWN		Electro-Proportional Relief Valve	1
16a	924		Coil 24 VDC Deutsch	1
17	FXAA-XBN 20-IN3		Press Comp Flow Control Fixed 20 IN3	1
18	FXAA-XBN 20-IN3		Press Comp Flow Control Fixed 20 IN3	1
19	RBAP-XWN		Electro-Proportional Relief Valve	1
19a	924		Coil 24 VDC Deutsch	1
20	EIS-TPS-125.020		Orifice Ø 0.020 1/8 NPT	1
21	6408-06		Port Plugs #6 SAE	7
22	6408-HHP-32		Fitting, Hollow Hex Plug, SAE O-Ring -32	1

REPLACEMENT PARTS

Clamp Manifold



CALLOUT	PART #	APE PART NUMBER	DESCRIPTION	QTY
0		015133	Ductile Manifold Body	1
1	FRDA-XAN		Priority Flow Control	1
2	SV08-40M-0-N-00		Solenoid Valve	1
2a	4301524		Coil, 24V DC Deutsch	1
3	RPEC-LWN	1001658	Relief Valve, PO, Balanced Piston	1
4	RPE4-103H11 / 02400E11B		Directional Valve	1
4a			SHCS 1/4-20 x 3.5	1
5	CKEB-XCN	222016	P.O. Check Valve T-2a	1
5a	BBA/S		Sandwich Body (D05)	1
6	015018		Pressure Switch Assembly	1
7	RDDA-LBN		Relief Valve	1
8	HPS 1/16 NPT-FL/ PLG-7/8 TOR-SOFT		Orifice Plug Ø0.031	1
9			Not Used	0
10	HPS 1/16 NPT-FL/ PLG-7/8 TPR-SOFT		1/16 NPT Plug	1

UNDERSTANDING ISO CODES

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.

ISO 4406 Chart		
Range Code	Particles per milliliter	
	More than	Up to/including
24	80000	160000
23	40000	80000
22	20000	40000
21	10000	20000
20	5000	10000
19	2500	5000
18	1300	2500
17	640	1300
16	320	640
15	160	320
14	80	160
13	40	80
12	20	40
11	10	20
10	5	10
9	2.5	5
8	1.3	2.5
7	0.64	1.3
6	0.32	0.64

Sample 1 (see photo 1)

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

Sample 2 (see photo 2)

Particle Size	Particles per ml*	ISO 4406 Code range	ISO Code
4µ[c]	492	320 ~ 640	16
6µ[c]	149	80 ~ 160	14
10µ[c]	41		
14µ[c]	15	10 ~ 20	11
21µ[c]	5		
38µ[c]	1		

Photo 1

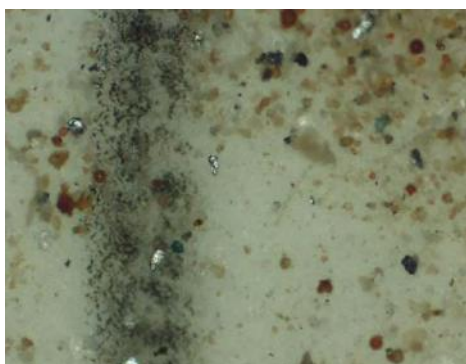


Photo 2



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 μ [c]/6 μ [c]/14 μ [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.

Recommended* Target ISO Cleanliness Codes and media selection for systems using petroleum based fluids per ISO4406:1999 for particle sizes 4 μ [c] / 6 μ [c] / 14 μ [c]

	Pressure < 140 bar < 2000 psi	Media $\beta_{x[c]} = 1000$ ($\beta_x = 200$)	Pressure 212 bar 3000 psi	Media $\beta_{x[c]} = 1000$ ($\beta_x = 200$)	Pressure > 212 bar > 3000 psi	Media $\beta_{x[c]} = 1000$ ($\beta_x = 200$)
Pumps						
Fixed Gear	20/18/15	22 μ [c] (25 μ)	19/17/15	12 μ [c] (12 μ)	-	-
Fixed Piston	19/17/14	12 μ [c] (12 μ)	18/16/13	12 μ [c] (12 μ)	17/15/12	7 μ [c] (6 μ)
Fixed Vane	20/18/15	22 μ [c] (25 μ)	19/17/14	12 μ [c] (12 μ)	18/16/13	12 μ [c] (12 μ)
Variable Piston	18/16/13	7 μ [c] (6 μ)	17/15/13	5 μ [c] (3 μ)	16/14/12	7 μ [c] (6 μ)
Variable Vane	18/16/13	7 μ [c] (6 μ)	17/15/12	5 μ [c] (3 μ)	-	-
Valves						
Cartridge	18/16/13	12 μ [c] (12 μ)	17/15/12	7 μ [c] (6 μ)	17/15/12	7 μ [c] (6 μ)
Check Valve	20/18/15	22 μ [c] (25 μ)	20/18/15	22 μ [c] (25 μ)	19/17/14	12 μ [c] (12 μ)
Directional (solenoid)	20/18/15	22 μ [c] (25 μ)	19/17/14	12 μ [c] (12 μ)	18/16/13	12 μ [c] (12 μ)
Flow Control	19/17/14	12 μ [c] (12 μ)	18/16/13	12 μ [c] (12 μ)	18/16/13	12 μ [c] (12 μ)
Pressure Control (modulating)	19/17/14	12 μ [c] (12 μ)	18/16/13	12 μ [c] (12 μ)	17/15/12	7 μ [c] (6 μ)
Proportional Cartridge Valve	17/15/12	7 μ [c] (6 μ)	17/15/12	7 μ [c] (6 μ)	16/14/11	5 μ [c] (3 μ)
Proportional Directional	17/15/12	7 μ [c] (6 μ)	17/15/12	7 μ [c] (6 μ)	16/14/11	5 μ [c] (3 μ)
Proportional Flow Control	17/15/12	7 μ [c] (6 μ)	17/15/12	7 μ [c] (6 μ)	16/14/11	5 μ [c] (3 μ)
Proportional Pressure Control	17/15/12	7 μ [c] (6 μ)	17/15/12	7 μ [c] (6 μ)	16/14/11	5 μ [c] (3 μ)
Servo Valve	16/14/11	7 μ [c] (6 μ)	16/14/11	5 μ [c] (3 μ)	15/13/10	5 μ [c] (3 μ)
Bearings						
Ball Bearing	15/13/10	5 μ [c] (3 μ)	-	-	-	-
Gearbox (industrial)	17/16/13	12 μ [c] (12 μ)	-	-	-	-
Journal Bearing (high speed)	17/15/12	7 μ [c] (6 μ)	-	-	-	-
Journal Bearing (low speed)	17/15/12	7 μ [c] (6 μ)	-	-	-	-
Roller Bearing	16/14/11	7 μ [c] (6 μ)	-	-	-	-
Actuators						
Cylinders	17/15/12	7 μ [c] (6 μ)	16/14/11	5 μ [c] (3 μ)	15/13/10	5 μ [c] (3 μ)
Vane Motors	20/18/15	22 μ [c] (25 μ)	19/17/14	12 μ [c] (12 μ)	18/16/13	12 μ [c] (12 μ)
Axial Piston Motors	19/17/14	12 μ [c] (12 μ)	18/16/13	12 μ [c] (12 μ)	17/15/12	7 μ [c] (6 μ)
Gear Motors	20/18/14	22 μ [c] (25 μ)	19/17/13	12 μ [c] (12 μ)	18/16/13	12 μ [c] (12 μ)
Radial Piston Motors	20/18/15	22 μ [c] (25 μ)	19/17/14	12 μ [c] (12 μ)	18/16/13	12 μ [c] (12 μ)
Test Stands, Hydrostatic						
Test Stands	15/13/10	5 μ [c] (3 μ)	15/13/10	5 μ [c] (3 μ)	15/13/10	5 μ [c] (3 μ)
Hydrostatic Transmissions	17/15/13	7 μ [c] (6 μ)	16/14/11	5 μ [c] (3 μ)	16/14/11	5 μ [c] (3 μ)

*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	ISO Code	Comments
Operating Pressure	156 bar, 2200 psi	
Most Sensitive Component	Directional Solenoid	19/17/14 recommended baseline ISO Code
Fluid Type	Water Glycol	18/16/13 Adjust down one class
Operating Conditions	Remote location, repair difficult High ingress rate	17/15/12 Adjust down one class, combination of critical nature, severe conditions



Torque-Tension Relationship for ASTM A574 Socket Head Cap Screws

Nominal Dia (in.)	Unified Coarse Thread Series					Fine Thread Series				
	threads per inch	Tensile Stress Area (sq. in.)	Clamp Load (lbs)	Tightening Torque		threads per inch	Tensile Stress Area (sq. in.)	Clamp Load (lbs)	Tightening Torque	
				K = 0.15 (ft-lbs)	K = 0.16 (ft-lbs)				K = 0.15 (ft-lbs)	K = 0.16 (ft-lbs)
1/4	20	0.0318	3341	10	11	28	0.0364	3819	12	13
5/16	18	0.0524	5505	22	23	24	0.0581	6097	24	25
3/8	16	0.0775	8136	38	41	24	0.0878	9222	43	46
7/16	14	0.1063	11162	61	65	20	0.1187	12465	68	73
1/2	13	0.1419	14899	93	99	20	0.1600	16795	105	112
5/8	11	0.2260	22883	179	191	18	0.2560	25916	202	216
3/4	10	0.3345	33864	317	339	16	0.3730	37762	354	378
7/8	9	0.4617	46751	511	545	14	0.5095	51584	564	602
1	8	0.6057	61332	767	818	14	0.6799	68839	860	918
1 1/8	7	0.7633	77282	1087	1159					
1 1/4	7	0.9691	98123	1533	1635	12	1.0729	108636	1697	1811
1 3/8	6	1.1549	116932	2010	2144	12	1.3147	133115	2288	2440
1 1/2	6	1.4053	142282	2668	2846	12	1.5810	160079	3001	3202
1 3/4	5	1.8995	192320	4207	4487					
2	4.5	2.4982	252945	6324	6745					

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.

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Rev 3-4-09

REFERENCE / NOTES

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