



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 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.



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

POWER UNIT MASTER SERVICE RECORD S/E

| Engine Hours | Changed Oil and Filters | Changed Fuel Filters | Pump Drive | Hydraulic Filters | Changed Water | Changed Battery | Air Filter | Name and Date: |
|--------------|-------------------------|----------------------|------------|-------------------|---------------|-----------------|------------|----------------|
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Engine oil, filters and fuel filters should be changed every 250 engine hours. Pump drive should be changed every 1000 hours. Vibro oil should be changed every 70 hours and Hydraulic filter should be changed every 300 hours. Place a check mark when checking pump drive, water and battery levels. When changing pump drive oil please write in the word "changed" to indicate that you changed the pump drive oil. Print your name and date in. This form is to stay with the unit at all times.

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

This End Forward when Transporting 

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.

APE Daily Vibro Check List
For use on all Models. Model 200 shown for example.

800 248-2488
813 924-1110
Fax: 213-472-8710
www.apetruck.com

- Check large Elastomers for cracks
- Remove damaged wire rope
- Checked shackles pin center key & nut (some models do not a shackle)
- Inspected small elastomers for cracks
- Inspected pop off safety valve for leaks
- Inspected hoses for wear
- Line pull safety sticker attached
- Check all bolts on elastomers
- check line pull pin for damage
- Inspect motor couplers for leaks
- Check suppressor mounting bolts
- Check bearing covers for damage
- Check all welds for cracks
- Check oil level in gearbox
- Checked breather check valve on center of motor bearing cover. Remove any pin that could block breather.

 **Oil Level**
Mobil Gear SHC 629 or standard AW32 hyd oil
Sight Gauge
(Do not use vegetable hyd oil)
Warning: Never use 90 weight gear oil. It will over heat.
If you cannot read the level then do not operate the machine.
If you cannot read the level then you cannot use it. Remove the gauge and spray some WD40 to clean the glass. Then replace using lubri-laps on the threads. Avoid overfilling or the unit will overheat. If level automatically increases it may indicate a bad motor shaft seal which results in hydraulic in the gearbox.
Remove or replace motor which shows bearing on ground and motor are facing the sky. Consult factory for instructions.
- Check both the movable and fix jaw teeth
- Monitor jaw teeth wear by testing jaw opening width
- Checked clamp mount bolts for tightness
- Removed air from clamp lines by cranking them open at the clamp cylinder while power unit engine is at idle speed
- Check clamp lines and fittings leading to clamp cylinder
- Check hose clamp securing clamp lines
- Check condition of hose bundle

Note: When mounting new clamp, check machined surfaces on bottom of hammer and top of clamp with straight edge. Run a bottom up down each mounting hole. Make sure surface is clean and flat. Torque down using a 9-foot cheater bar. Do not drive piles if any clamp mounting bolts are missing. If clamp attachment falls off, it is due to bolts not being properly tightened. No excuses accepted.

Comments: _____

Daily inspection performed by: _____ Date: _____

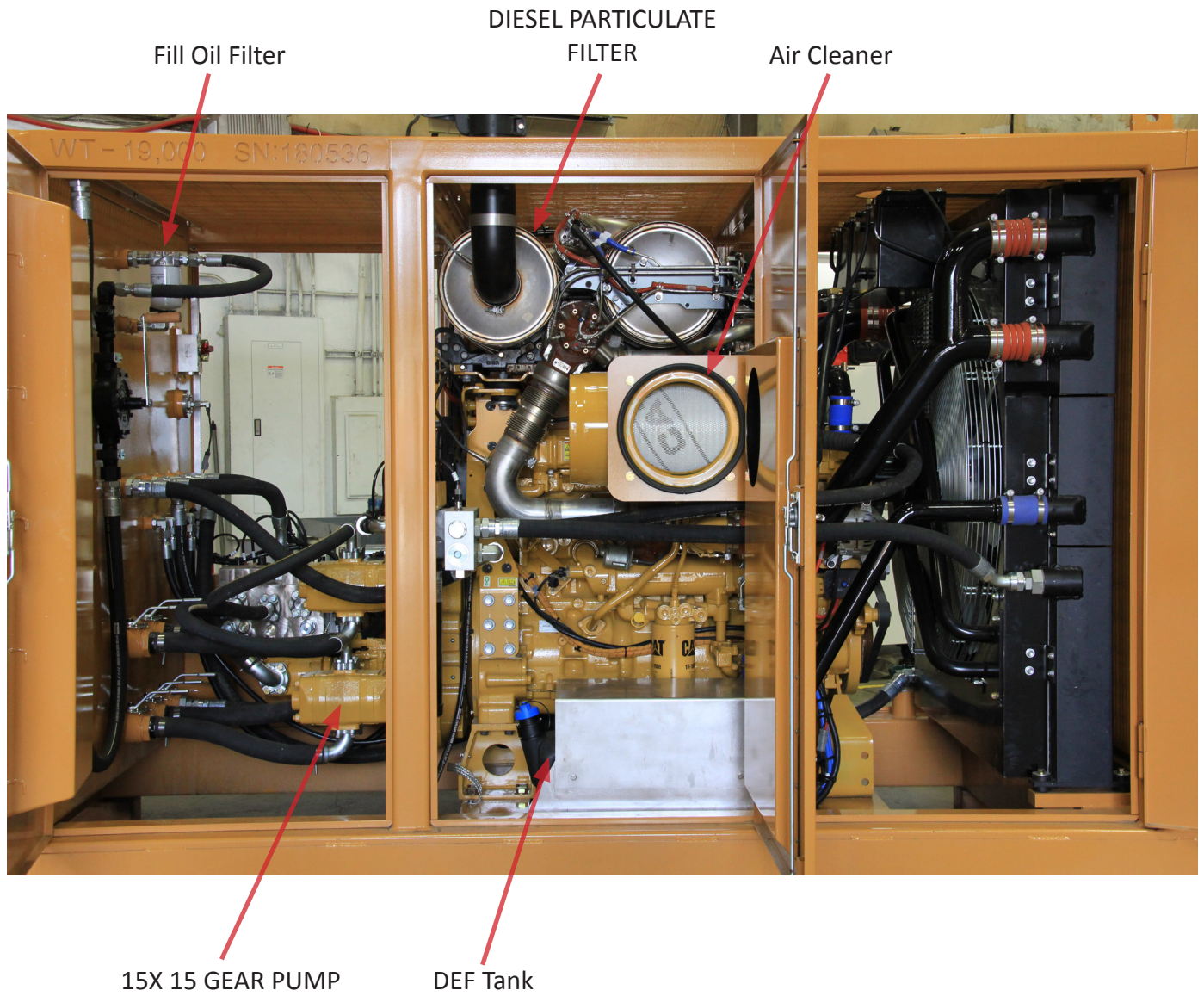
Check list developed by APE. Pie Driving School students of the June 2002 class. Send ideas to jshaw@apetruck.com

PART #090131

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.

GENERAL INFORMATION

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

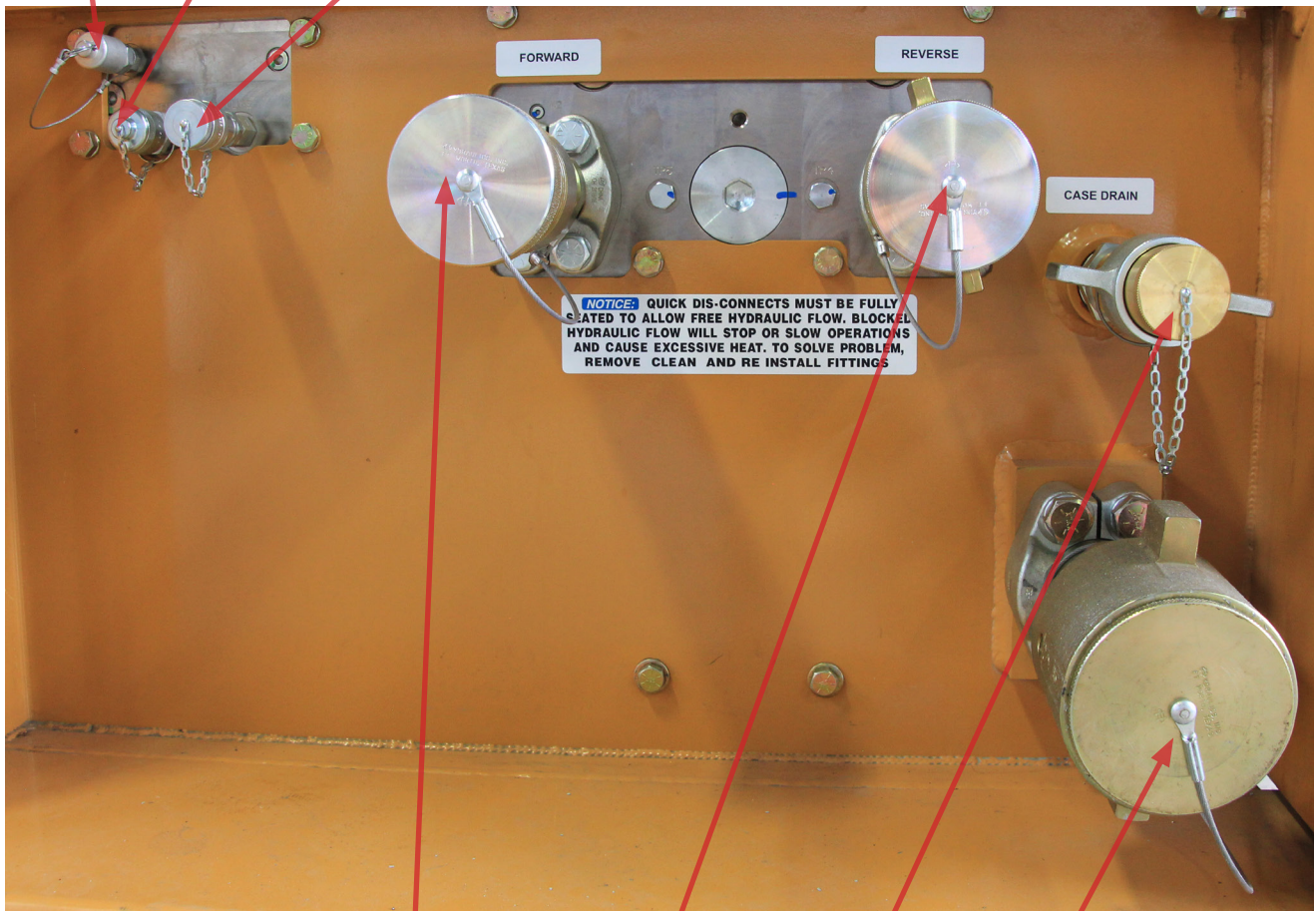
Lifting the Power Unit

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

Emergency Stop

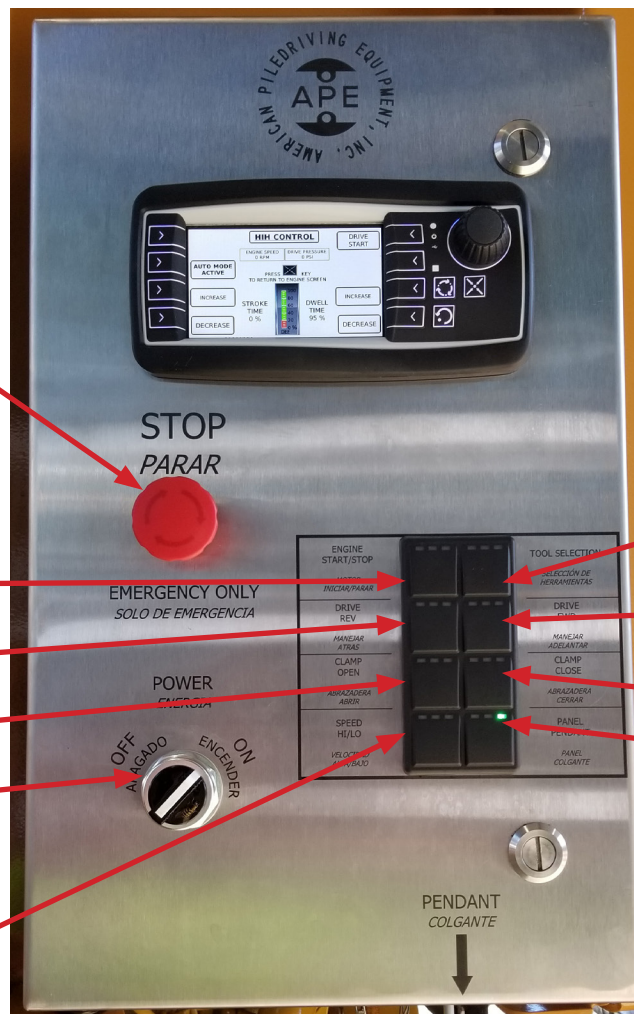
Engine Start / Stop

Drive Rev

Clamp Open

Panel Power

Speed Hi / Lo



Vibro / HIH Mode

Drive Fwd

Clamp Close

Panel Cab Pendant

GENERAL INFORMATION

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

POWER ON / OFF

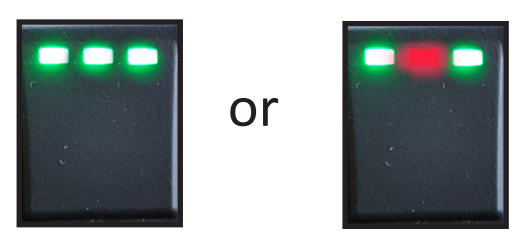
This will turn the power on to the control panel. The power must be on to run the unit.

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.



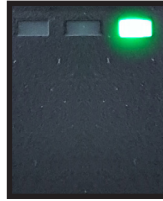


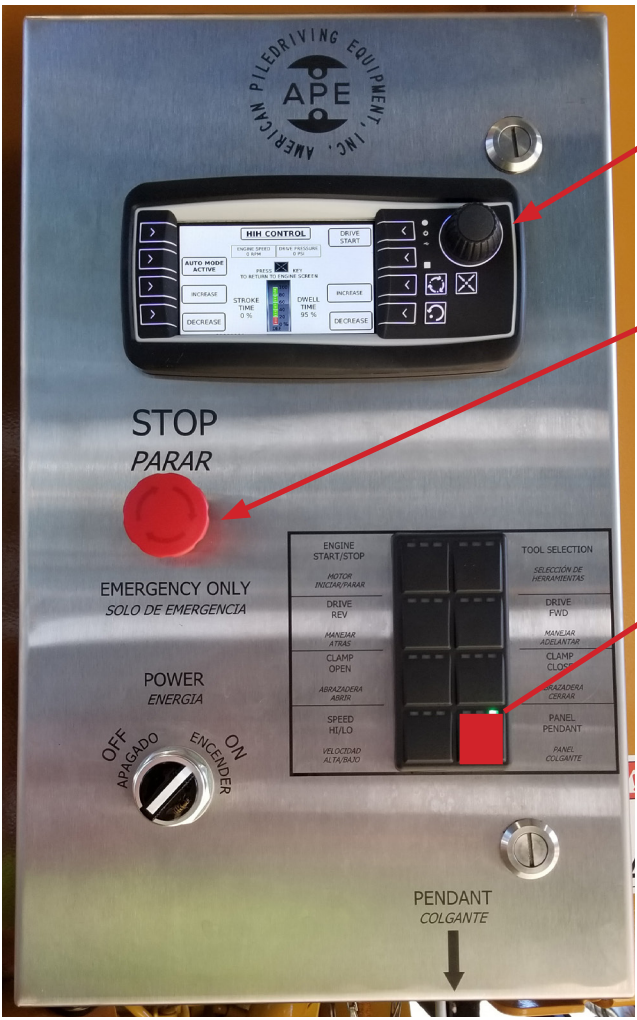
GENERAL INFORMATION

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.

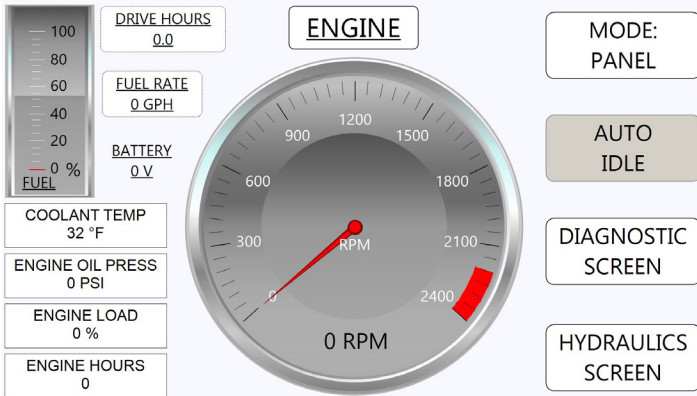


DRIVE FORWARD ON

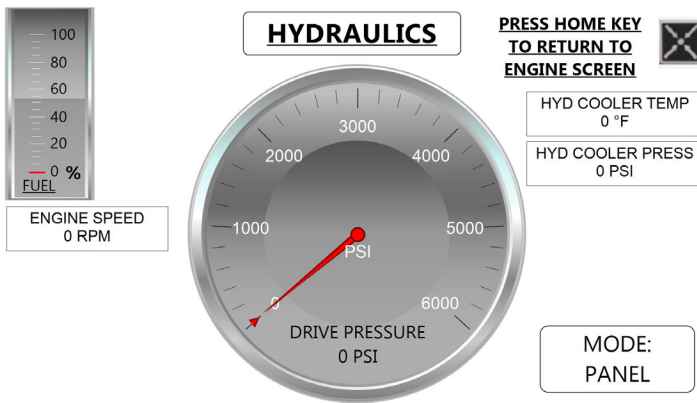
This will start pumping oil out of the forward line circuit.

GENERAL INFORMATION

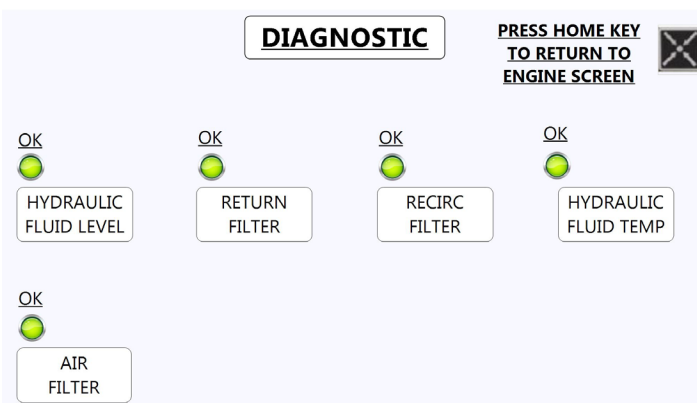
Control Panel Display



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.



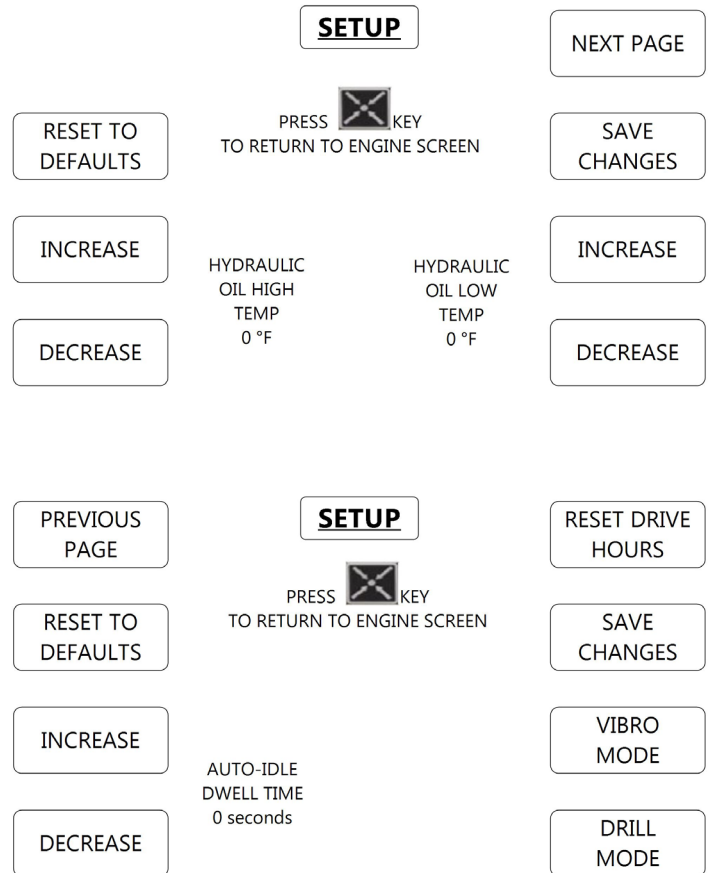
From the main screen you can select a sub-screen reading only critical hydraulic data such as drive pressure, cooler temperature, cooler pressure, engine speed, and fuel level. To return to the main screen from the hydraulic screen push the button with an "X" located right under the governor knob.



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.

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

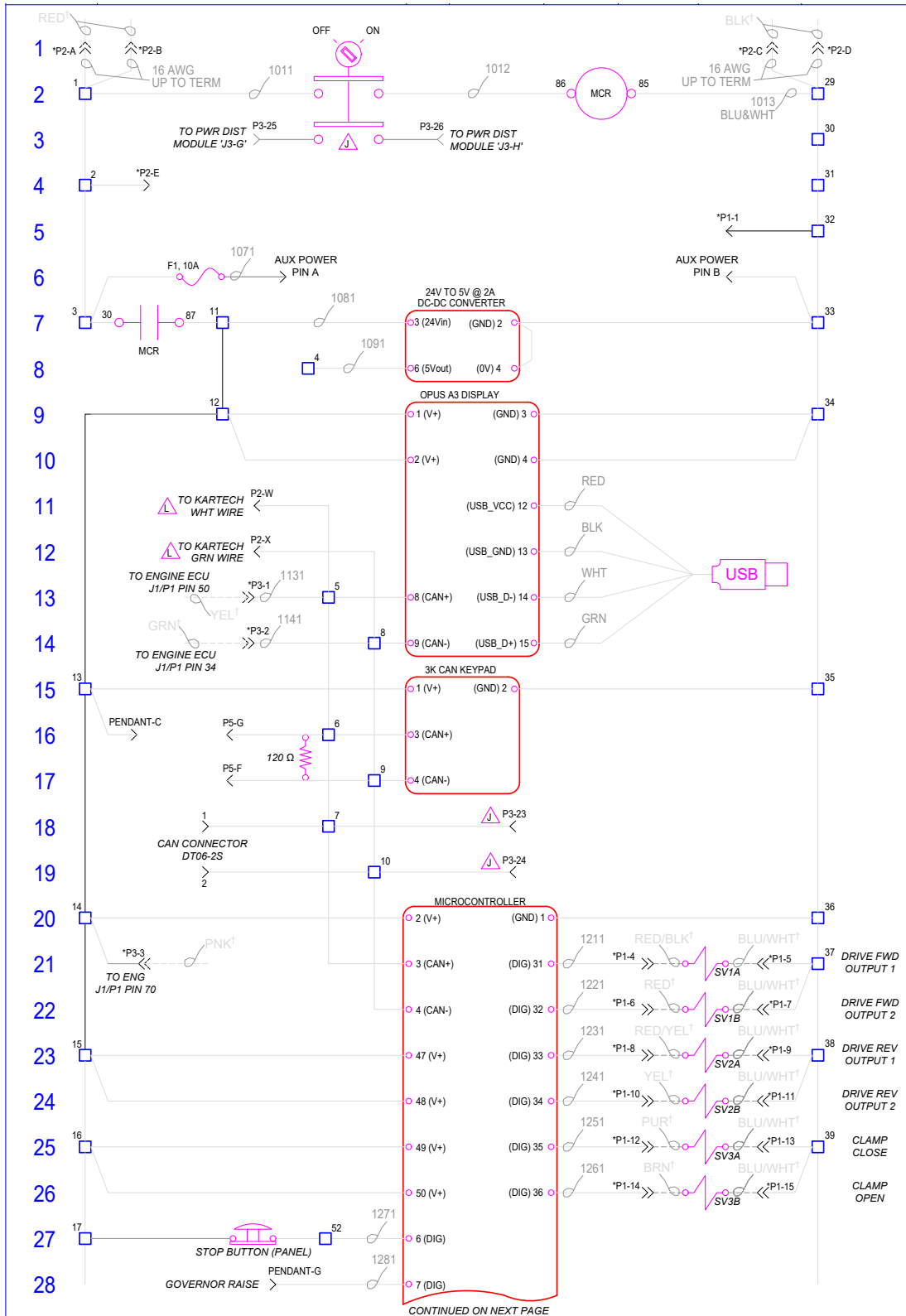
Bulk oil does not typically meet the cleanliness standards required by APE equipment.

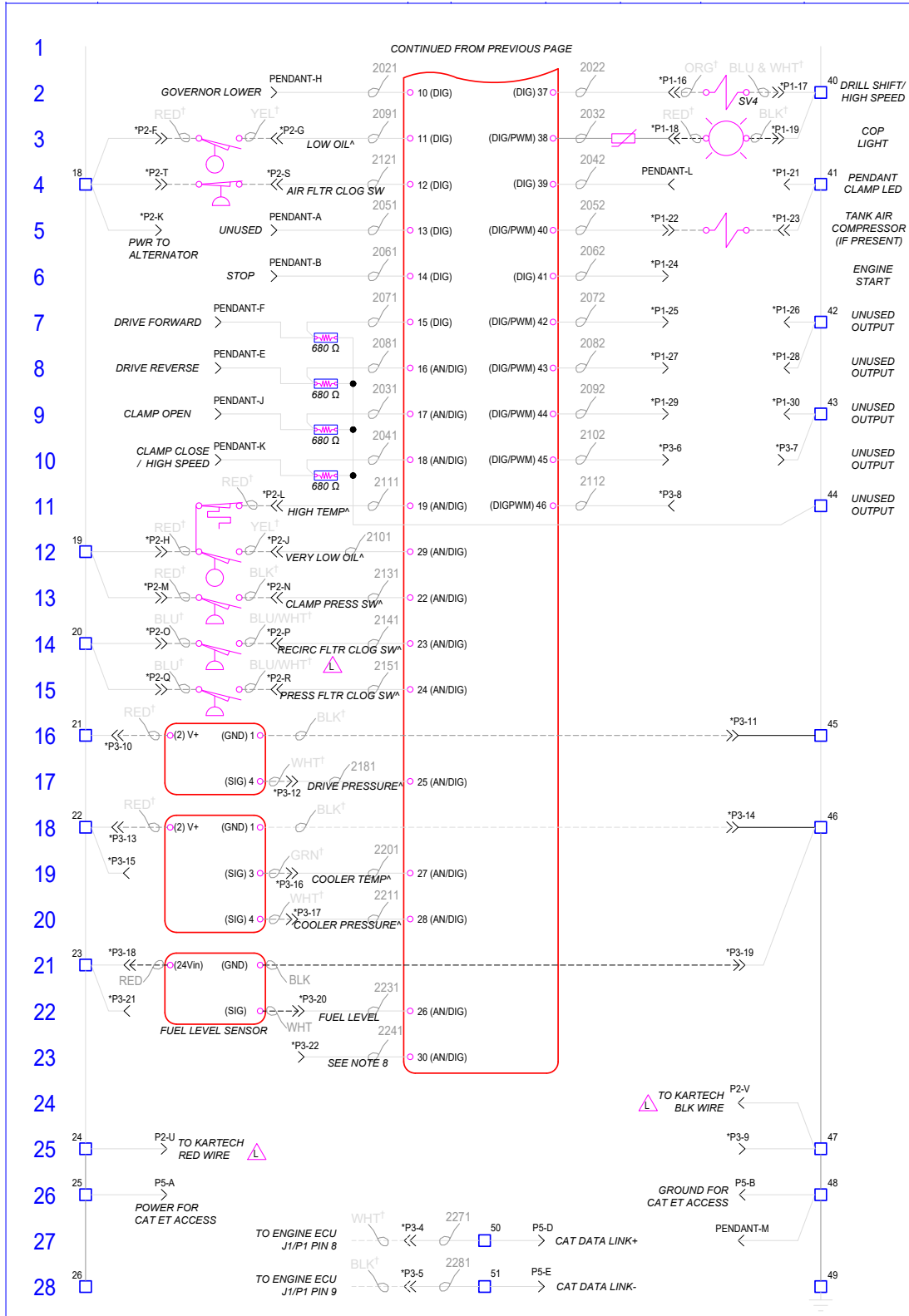
- Pressure filters: Clean the hydraulic fluid going to the drill motor and manifold in the forward and reverse directions.
- M1/M2 DRIVE
- LS LOAD SENSE
- 10/11: RDFA-LCN is a direct acting relief valve that is used to protect hydraulic components from pressure variants.
- 8/16/5/19 COILS
- T1 / PD: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

Electrical System

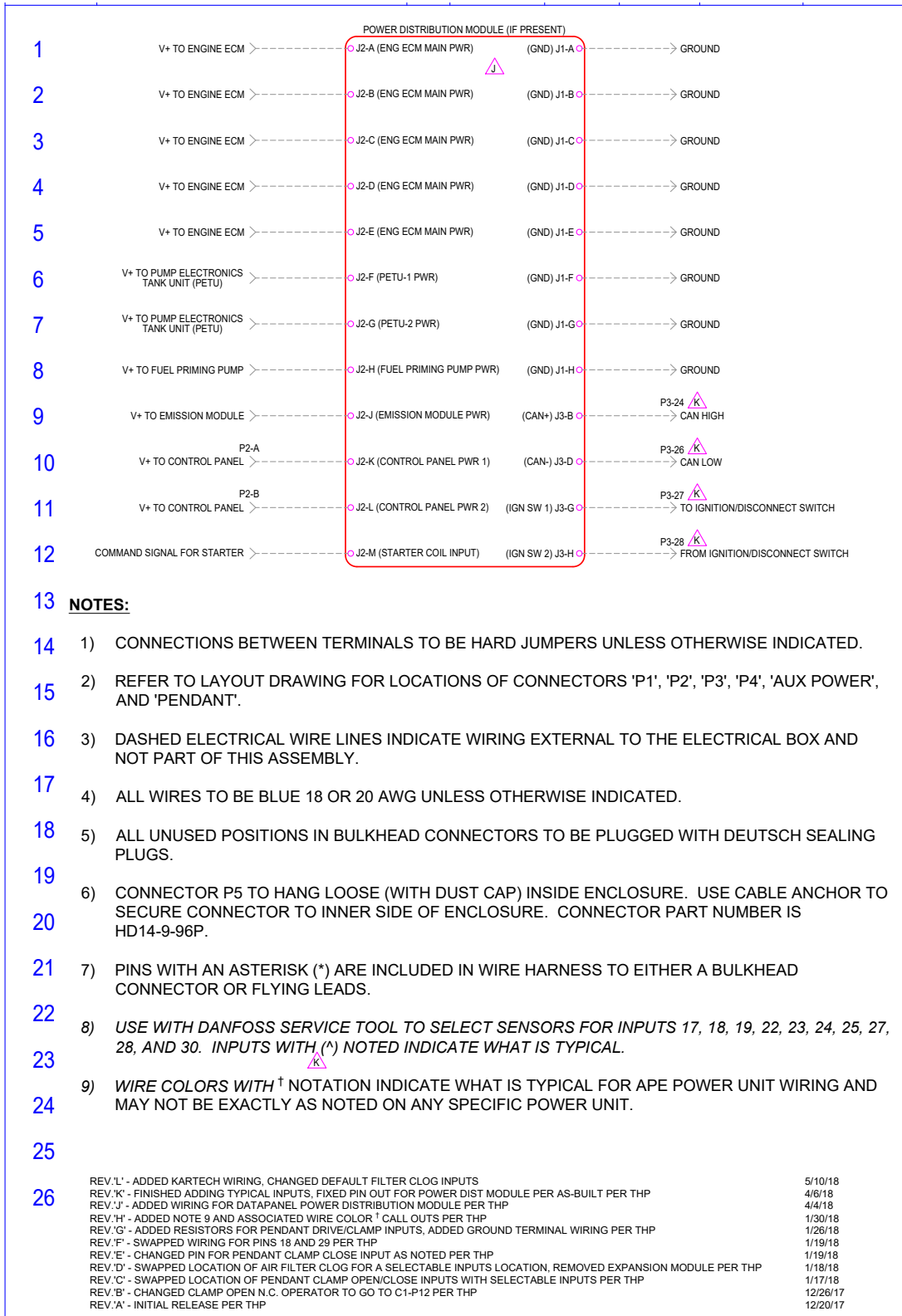
The electrical system is a normally closed circuit, and runs a self diagnostic test when the panel is powered on. If there is a fault in the electrical system an error screen will appear on the control panel display.

Electrical Schematic

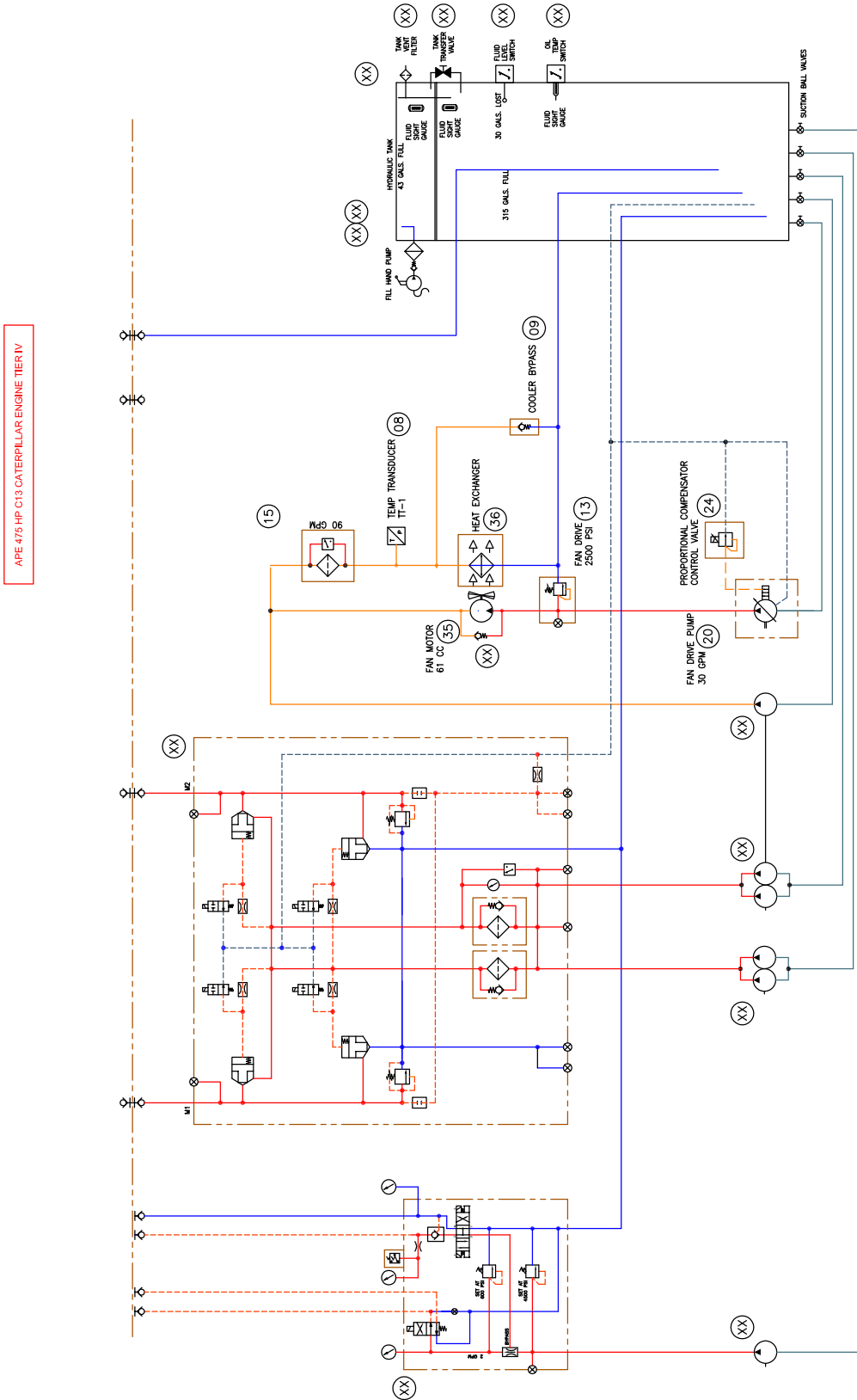




TROUBLESHOOTING



Hydraulic Schematic



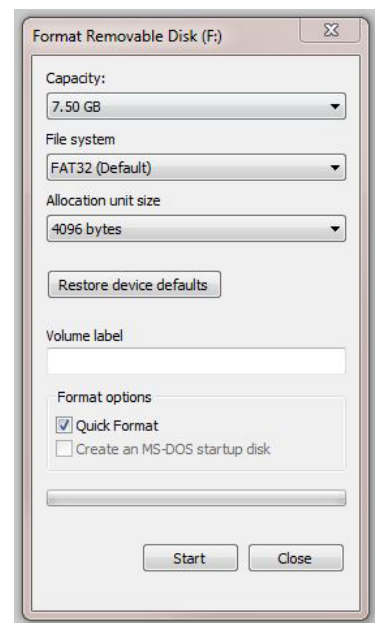
Setting up the Program

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.

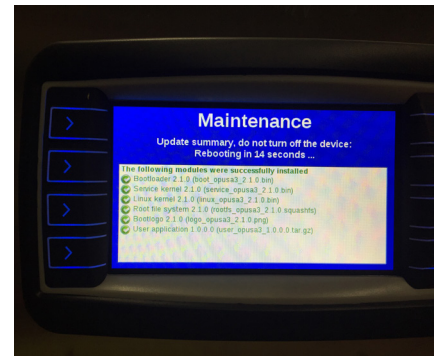
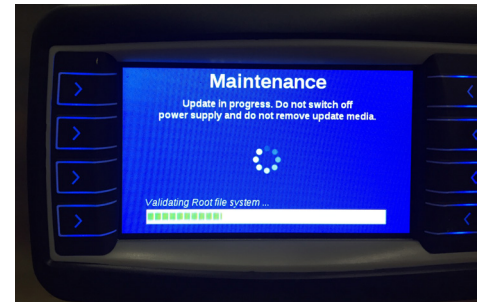


Updating the Display

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.

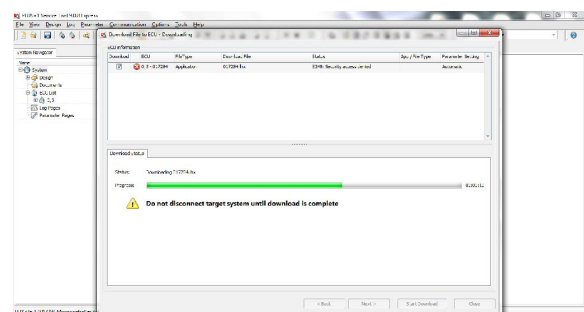
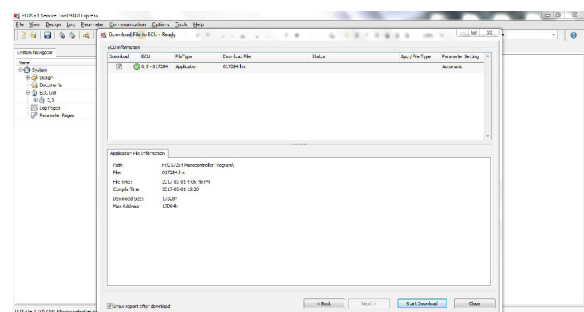
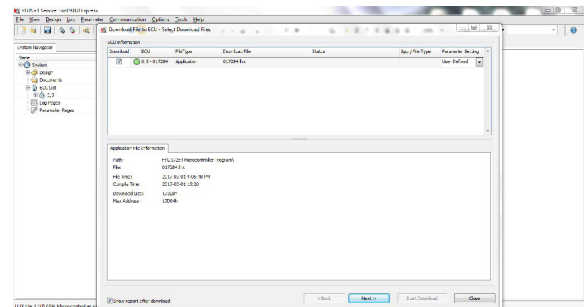
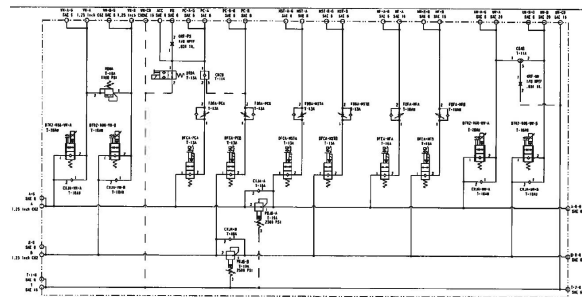
PRESS
HERE



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 |

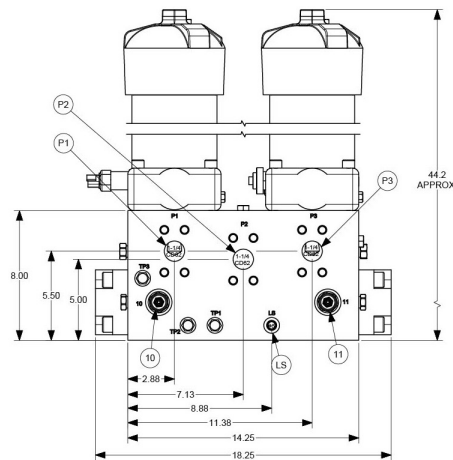
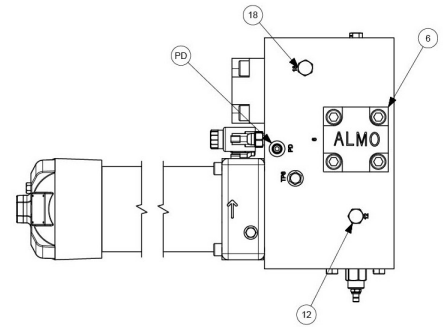
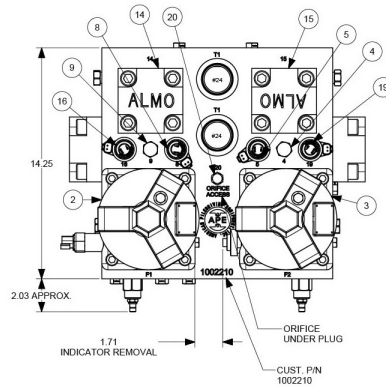
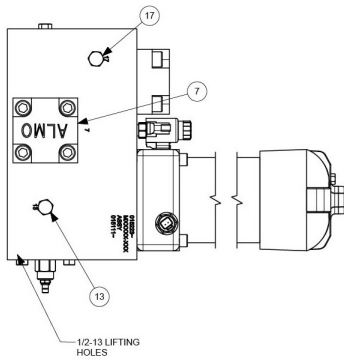
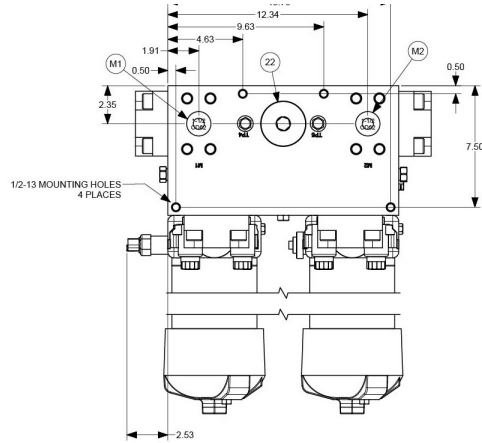
| FLUID CAPACITY | | | | |
|----------------|--------|-----------------------------|----------------------|------------------|
| LOCATION | ENGINE | OIL TYPE | APE PART NUMBER | CAPACITY |
| Engine Oil | C13 | Caterpillar DELO 15W-40 | 513001-15W40-D400-1 | 42 qt (40L) |
| Engine Coolant | C13 | Caterpillar 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 | |

REPLACEMENT PARTS

Drive Manifold

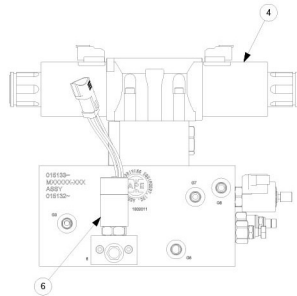
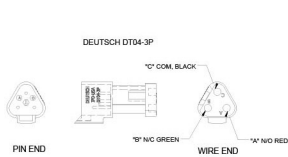
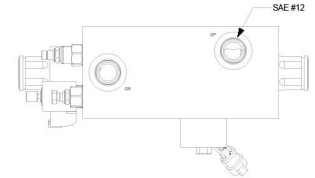
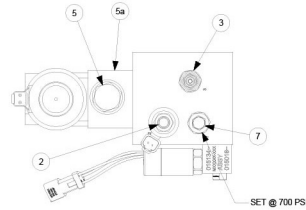
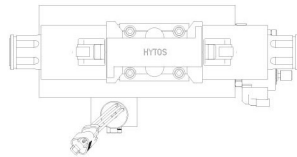
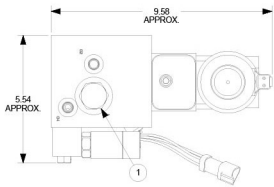


REPLACEMENT PARTS

| 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 | R DFA-LCN | | Relief Valve, Direct Acting | 1 |
| 11 | R DFA-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 \varnothing 0.031 | 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

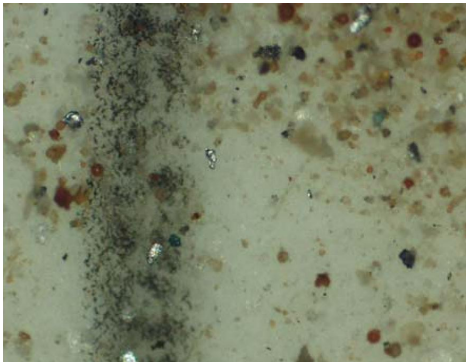


Photo 2



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]/6μ[c]/14μ[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 4μ[c] / 6μ[c] / 14μ[c]

| | Pressure < 140 bar < 2000 psi | Media βx[c] = 1000 (βx = 200) | Pressure 212 bar 3000 psi | Media βx[c] = 1000 (βx = 200) | Pressure > 212 bar > 3000 psi | Media βx[c] = 1000 (βx = 200) |
|---------------------------------|-------------------------------------|-------------------------------------|---------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| Pumps | | | | | | |
| Fixed Gear | 20/18/15 | 22μ[c] (25 μ) | 19/17/15 | 12μ[c] (12 μ) | - | - |
| Fixed Piston | 19/17/14 | 12μ[c] (12 μ) | 18/16/13 | 12μ[c] (12 μ) | 17/15/12 | 7μ[c] (6 μ) |
| Fixed Vane | 20/18/15 | 22μ[c] (25 μ) | 19/17/14 | 12μ[c] (12 μ) | 18/16/13 | 12μ[c] (12 μ) |
| Variable Piston | 18/16/13 | 7μ[c] (6 μ) | 17/15/13 | 5μ[c] (3 μ) | 16/14/12 | 7μ[c] (6 μ) |
| Variable Vane | 18/16/13 | 7μ[c] (6 μ) | 17/15/12 | 5μ[c] (3 μ) | - | - |
| Valves | | | | | | |
| Cartridge | 18/16/13 | 12μ[c] (12 μ) | 17/15/12 | 7μ[c] (6 μ) | 17/15/12 | 7μ[c] (6 μ) |
| Check Valve | 20/18/15 | 22μ[c] (25 μ) | 20/18/15 | 22μ[c] (25 μ) | 19/17/14 | 12μ[c] (12 μ) |
| Directional (solenoid) | 20/18/15 | 22μ[c] (25 μ) | 19/17/14 | 12μ[c] (12 μ) | 18/16/13 | 12μ[c] (12 μ) |
| Flow Control | 19/17/14 | 12μ[c] (12 μ) | 18/16/13 | 12μ[c] (12 μ) | 18/16/13 | 12μ[c] (12 μ) |
| Pressure Control (modulating) | 19/17/14 | 12μ[c] (12 μ) | 18/16/13 | 12μ[c] (12 μ) | 17/15/12 | 7μ[c] (6 μ) |
| Proportional Cartridge Valve | 17/15/12 | 7μ[c] (6 μ) | 17/15/12 | 7μ[c] (6 μ) | 16/14/11 | 5μ[c] (3 μ) |
| Proportional Directional | 17/15/12 | 7μ[c] (6 μ) | 17/15/12 | 7μ[c] (6 μ) | 16/14/11 | 5μ[c] (3 μ) |
| Proportional Flow Control | 17/15/12 | 7μ[c] (6 μ) | 17/15/12 | 7μ[c] (6 μ) | 16/14/11 | 5μ[c] (3 μ) |
| Proportional Pressure Control | 17/15/12 | 7μ[c] (6 μ) | 17/15/12 | 7μ[c] (6 μ) | 16/14/11 | 5μ[c] (3 μ) |
| Servo Valve | 16/14/11 | 7μ[c] (6 μ) | 16/14/11 | 5μ[c] (3 μ) | 15/13/10 | 5μ[c] (3 μ) |
| Bearings | | | | | | |
| Ball Bearing | 15/13/10 | 5μ[c] (3 μ) | - | - | - | - |
| Gearbox (industrial) | 17/16/13 | 12μ[c] (12 μ) | - | - | - | - |
| Journal Bearing (high speed) | 17/15/12 | 7μ[c] (6 μ) | - | - | - | - |
| Journal Bearing (low speed) | 17/15/12 | 7μ[c] (6 μ) | - | - | - | - |
| Roller Bearing | 16/14/11 | 7μ[c] (6 μ) | - | - | - | - |
| Actuators | | | | | | |
| Cylinders | 17/15/12 | 7μ[c] (6 μ) | 16/14/11 | 5μ[c] (3 μ) | 15/13/10 | 5μ[c] (3 μ) |
| Vane Motors | 20/18/15 | 22μ[c] (25 μ) | 19/17/14 | 12μ[c] (12 μ) | 18/16/13 | 12μ[c] (12 μ) |
| Axial Piston Motors | 19/17/14 | 12μ[c] (12 μ) | 18/16/13 | 12μ[c] (12 μ) | 17/15/12 | 7μ[c] (6 μ) |
| Gear Motors | 20/18/14 | 22μ[c] (25 μ) | 19/17/13 | 12μ[c] (12 μ) | 18/16/13 | 12μ[c] (12 μ) |
| Radial Piston Motors | 20/18/15 | 22μ[c] (25 μ) | 19/17/14 | 12μ[c] (12 μ) | 18/16/13 | 12μ[c] (12 μ) |
| Test Stands, Hydrostatic | | | | | | |
| Test Stands | 15/13/10 | 5μ[c] (3 μ) | 15/13/10 | 5μ[c] (3 μ) | 15/13/10 | 5μ[c] (3 μ) |
| Hydrostatic Transmissions | 17/15/13 | 7μ[c] (6 μ) | 16/14/11 | 5μ[c] (3 μ) | 16/14/11 | 5μ[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 ingestion 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 | | Clamp Load (lbs) | 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 | 14 | 28 | 0.0364 | 3819 | 12 | 13 | 16 |
| 5/16 | 18 | 0.0524 | 5505 | 22 | 23 | 29 | 24 | 0.0581 | 6097 | 24 | 25 | 32 |
| 3/8 | 16 | 0.0775 | 8136 | 38 | 41 | 51 | 24 | 0.0878 | 9222 | 43 | 46 | 58 |
| 7/16 | 14 | 0.1063 | 11162 | 61 | 65 | 81 | 20 | 0.1187 | 12465 | 68 | 73 | 91 |
| 1/2 | 13 | 0.1419 | 14899 | 93 | 99 | 124 | 20 | 0.1600 | 16795 | 105 | 112 | 140 |
| 5/8 | 11 | 0.2260 | 22883 | 179 | 191 | 238 | 18 | 0.2560 | 25916 | 202 | 216 | 270 |
| 3/4 | 10 | 0.3345 | 33864 | 317 | 339 | 423 | 16 | 0.3730 | 37762 | 354 | 378 | 472 |
| 7/8 | 9 | 0.4617 | 46751 | 511 | 545 | 682 | 14 | 0.5095 | 51584 | 564 | 602 | 752 |
| 1 | 8 | 0.6057 | 61332 | 767 | 818 | 1022 | 14 | 0.6799 | 68839 | 860 | 918 | 1147 |
| 1 1/8 | 7 | 0.7633 | 77282 | 1087 | 1159 | 1449 | | | | | | |
| 1 1/4 | 7 | 0.9691 | 98123 | 1533 | 1635 | 2044 | 12 | 1.0729 | 108636 | 1697 | 1811 | 2263 |
| 1 3/8 | 6 | 1.1549 | 116932 | 2010 | 2144 | 2680 | 12 | 1.3147 | 133115 | 2288 | 2440 | 3051 |
| 1 1/2 | 6 | 1.4053 | 142282 | 2668 | 2846 | 3557 | 12 | 1.5810 | 160079 | 3001 | 3202 | 4002 |
| 1 3/4 | 5 | 1.8995 | 192320 | 4207 | 4487 | 5609 | | | | | | |
| 2 | 4.5 | 2.4982 | 252945 | 6324 | 6745 | 8432 | | | | | | |

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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