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1.0 OBJECTIVE OF PROCEDURE

This method statement provides guideline for the starting up and preventive maintenance of a typical electrical Generator Set (Genset).

2.0 SCOPE OF WORKS

The method of starting up and conduct preventive maintenance of electrical Genset.

3.0 TOOLS AND EQUIPMENT TO BE USED

ITEM	DESCRIPTION
1	Oil Drip Tray
2	Screwdriver, Wrench, Torque Wrench, Pier
3	Earth Tester, Insulation Tester, IR Tester, Multi-Meter, Hydrometer

4.0 SAFETY & ENVIRONMENTAL PROGRAMME

- All start up and maintenance works are to be carried out in accordance with the Project Safety Plan, Owner Safety Procedures and Statutory Regulations.
- All necessary personal protective equipment will be provided and worn by workers at all time.

- All the tools and equipment used at site must be compliance to safety requirement.
- The site of all work activities will be kept in clean and tidy manner.

5.0 WORK METHOD STATEMENT

a. Before Genset Engine Starting

Before the engine is started, perform the required daily maintenance and any other periodic maintenance that is due.

Maintenance Interval Schedule

When Required
Battery - Replace
Battery or Battery Cable - Disconnect
Engine - Clean
Engine Oil Sample - Obtain
Fuel System - Prime
Severe Service Application - Check

Daily
Cooling System Coolant Level - Check
Driven Equipment - Check
Engine Air Cleaner Service Indicator - Inspect
Engine Oil Level - Check
Fuel System Primary Filter/Water Separator - Drain
Walk-Around Inspection

Every Week
Jacket Water Heater – Check

Every 250 Service Hours or 1 Year
Battery Electrolyte Level - Check
Fuel Tank Water and Sediment - Drain

Initial 500 Service Hours
Engine Valve Lash - Inspect/Adjust

Every 500 Service Hours
Belts - Inspect/Adjust/Replace
Engine Valve Lash - Inspect/Adjust

Every 500 Service Hours or 1 Year
Aftercooler Core - Clean/Test
Engine Air Cleaner Element (Single Element) - Inspect/Replace
Engine Crankcase Breather - Replace
Engine Mounts - Inspect
Engine Oil and Filter - Change
Fan Drive Bearing - Lubricate
Fuel System Primary Filter (Water Separator) Element - Replace
Fuel System Secondary Filter - Replace
Hoses and Clamps - Inspect/Replace
Radiator – Clean

Every 1000 Service Hours or 1 Year
Electronic Unit Injector - Inspect/Adjust

Every 2000 Service Hours
Alternator - Inspect
Water Pump – Inspect

Every 3000 Service Hours or 2 Years
Cooling System Water Temperature Regulator - Replace
Crankshaft Vibration Damper - Inspect
Engine Protective Devices - Check
Engine Speed/Timing Sensors - Check/Clean/Calibrate
Turbocharger – Inspect

Every 5000 Service Hours
Starting Motor – Inspect

Every 6000 Service Hours
Overhaul Considerations

Every 6000 Service Hours or 3 Years
Cooling System Coolant (ELC) – Change

Every 12 000 Service Hours or 6 Years
Overhaul Considerations

Before starting the engine

(1) Ensure fuel supply valves are open.
(2) Prime the fuel system to ensure no air pockets.
(3) Ensure Genset room/area/site is well ventilated to allow dispersal of engine exhaust.
(4) Ensure that the coolant level is correct
(5) Ensure that the engine oil level is correct

Open the fuel supply valve (if equipped)

NOTICE: All valves in the fuel return line must be open before and during engine operation to help prevent high fuel pressure. High fuel pressure may cause filter housing failure or other damage. If the engine has not been started for several weeks, fuel may have drained from the fuel system.

There should be no air pockets

Air may have entered the filter housing. Also, when fuel filters have been changed, some air pockets will be trapped in the engine. In these instances, prime the fuel system.

Priming the fuel system

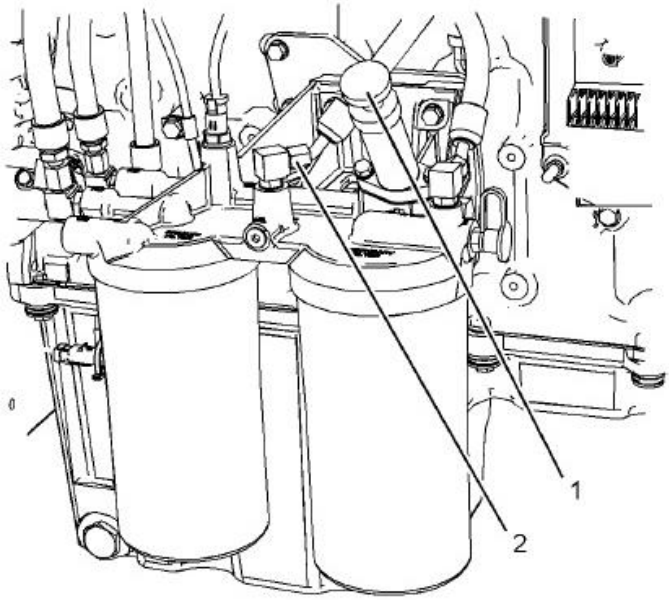
NOTICE: Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

NOTICE: Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

(1) Turn the ignition switch to the “OFF” position.

(2) Ensure that the fuel tank is full with clean diesel fuel. Place a suitable container under the fuel filters in order to catch any split fuel.

(3) Fuel System Primary Filter/Water Separator – Drain.



(4) Loosen the union (2).
Note**:** Do not remove the union completely. Open the union enough to allow the air that is trapped to be purged from the fuel system.

(5) Unlock the hand priming pump (1). Operate the hand priming pump until fuel free from air flows from the union.

(6) Tighten the union securely.

(7) Operate the hand priming pump until a strong pressure is felt on the pump. Push the priming pump plunger inward and tighten the plunger by hand. Remove the container and clean any split fuel.

Engine exhaust – adequate ventilation

Engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.

- Do not start the engine or move any of the controls if there is a “DO NOT OPERATE” warning tag or similar warning tag attached to the start switch or to the controls.

- Reset all of the shutoffs or alarm components (if equipped).

- Ensure that the coolant level is correct.

- Ensure that the engine oil level is correct.

b. <u>Genset – Start The Engine</u>

NOTICE: Do not crank the engine continuously for more than 30 seconds. Allow the starting motor to cool for 30 seconds before cranking the engine again.

If the engine will not start, allow the starting motor to cool for 30 seconds. Repeat steps 3 to 6 in order to eliminate air from the fuel system.

Continue to eliminate air from the fuel system if these events occur:
- The engine starts, but the engine does not run evenly.
- The engine starts, but the engine continues to misfire or smoke.

Run the engine with no load until the engine runs smoothly.

Note: Do not adjust the engine speed control during start-up. The electronic control module (ECM) (if any) will control the engine speed during start-up.

Note: For new engines, you need to prime the turbocharger. This can be achieved by cranking the engine briefly with no fuel. If necessary, stop a new engine if an over-speed condition occurs. If necessary, press the Emergency Stop button.

<u>Starting the Engine</u>

(1) Move the ignition switch to the ON position.

(2) If a system fault is indicated, investigate the cause.

(3) If necessary, use the electronic service tool.

(4) Push the start button or turn the keyswitch to the START position in order to crank the engine.

(5) If the engine fails to start within 30 seconds, release the start button or the ignition switch. Wait for 30 seconds in order to allow the starting motor to cool before attempting to start the engine again.

Note: A system fault may be indicated after the engine is started. If this occurs the ECM has detected a problem with the system. If necessary, use the Perkins Service Tool to investigate the problem. Note: Oil pressure should rise within 15 seconds after the engine starts. The engine electronic controls monitor the engine oil pressure. The electronic controls will stop the engine if the oil pressure is below normal.

(6) When possible, allow the engine to run at no load for approximately three minutes. Run the engine at no load until the water temperature gauge has started to rise. Check all gauges during the warm-up period.

(7) After Starting Engine

Note: In temperatures from 0 to 60°C (32 to 140°F), the warm-up time is approximately three minutes. In temperatures below 0°C (32°F), additional warm-up time may be required.

Note: Ensure that the self-test for the monitoring system (if equipped) is completed before operating the engine under load.

(8) When the engine idles during warm-up, observe the following conditions:

- Check for any fluid or for any air leaks at idle rpm and at one-half full rpm (no load on the engine) before operating the engine under load. This is not possible in some applications.

- Operate the engine at low idle until all systems achieve operating temperatures. Check all gauges during the warm-up period.

  Note: Gauge readings should be observed and the data should be recorded frequently while the engine is operating. Comparing the data over time will help to determine normal readings for each gauge. Comparing data over time will also help detect abnormal operating developments. Significant changes in the readings should be investigated.

c. <u>Stopping the Engine</u>

NOTICE: Stopping the engine immediately after it has been working under load, can result in overheating and accelerated wear of the engine components.

Avoid accelerating the engine prior to shutting it down. Avoiding hot engine shutdowns will maximize turbocharger shaft and bearing life.

Note: Individual applications will have different control systems. Ensure that the shutoff procedures are understood.

Use the following general guidelines in order to stop the engine.

(1) Remove the load from the engine. Allow the engine to run under no load conditions for five minutes in order to cool the engine.

(2) Stop the engine after the cool down period according to the shutoff system on the engine and turn the ignition key-switch to the OFF position. If necessary, refer to the instructions that are provided by the OEM.

d. <u>Emergency Stopping</u>

NOTICE: Emergency shutoff controls are for EMERGENCY use ONLY.

DO NOT use emergency shutoff devices or controls for normal stopping procedure.

The Genset OEM may have equipped the application with an emergency stop button. For more information about the emergency stop button, refer to the OEM operating manual.

Ensure that any components for the external system that support the engine operation are secured after the engine is stopped.

e. <u>After Stopping Engine</u>

Note: Before you check the engine oil, do not operate the engine for at least 10 minutes in order to allow the engine oil to return to the oil pan.

- Check the crankcase oil level. Maintain the oil level between the “LOW” mark and the “HIGH” mark on the oil level gauge.

  Note: Only use oil that is recommended in this Genset OEM Operation and Maintenance Manual, “Fluid Recommendations”. Failure to use the recommended oil may result in engine damage.

- If necessary, perform minor adjustments. Repair any leaks and tighten any loose bolts.

  Note: The service hour meter reading. Perform the maintenance that is stated in the Genset OEM Operation and Maintenance Manual or follow the “Maintenance Interval Schedule” as indicated above.

- Fill the fuel tank (diesel tank) in order to help prevent accumulation of moisture in the fuel (diesel). Do not overfill the fuel tank.

- Allow the engine to cool. Check the coolant level. Maintain the cooling system at 13 mm (0.5 inch) from the bottom of the pipe for filling.

  Note: Only use coolant that is recommended in the Genset OEM Operation and Maintenance Manual on "Fluid Recommendations". Failure to use the recommended oil may result in engine damage.

- Perform all required periodic maintenance on all driven equipment as recommended in the Genset OEM Operation and Maintenance Manual.

f. **AMF Control Panel/Board Maintenance**

Note: AMF – Automated Mains Failure.

Note: The AMF control panel is fitted with an AMF controller that manages, in a fully automatic way, the connection assignment of the LOAD to MAINS or GENERATOR avoiding connection MAINS to GENERATOR. The panel includes miscellaneous equipment: battery charger, electronic circuit boards, power relays and terminal blocks.

The servicing of AMF Board for Genset should be conducted at least once every five years.

The scope of servicing for AMF Board are as follows:

(1) To draw out Incomer Circuit Breaker and conduct full service with mechanical and IR tests.
(2) To check and calibrate Overcurrent & Earth Fault (OCEF) Relay (if any).
(3) To check battery charger and AMF controls.
(4) To replace worn out Indicator Lights (if any).
(5) To conduct panel cleaning, busbar support tightening, re-torque all termination and general servicing.

g. **Genset Battery Maintenance**

Maintenance of a generator set's starter battery is critical to ensuring sufficient ampere capacity to start the engine. As a precaution, generator users routinely change out the batteries every 2 years.

Signs of Battery Failure

The following are key signs of existing or pending battery failure.

Battery local action - A slow chemical reaction between a battery's plates and trace impurities will slowly discharge a standing battery. Battery chargers should be connected to standby generator set to maintain a minimum float charge that compensates for local action discharges.

Cell voltage - Cell voltage is critical to correct battery operation. Any deterioration from recommended levels in any cell should be recorded and tracked on battery maintenance charts. Just one cell with low voltage will drop overall battery voltage, which can harm equipment and result in too little power to start an engine.

Cell balance - One cell that fails to charge equally with others also indicates a problem. An undercharging will cause gradual sulfation of negative plates and reduce battery life or capacity of lead acid batteries. Overcharging corrodes the grids of the positive plates. NiCad batteries are not affected like lead acid batteries.

Specific gravity (SG) - SG indicates electrolyte weight. Heavier electrolyte means a heavier charge. Low SG indicates plate sulfation, cell deterioration and reduced battery capacity.

Water use - All batteries other than valve regulated types use water. Using the maintenance chart to track the rate at which water is added will identify excessive use. Reasons for any increased usage must be identified.

Battery connections - Terminal connections over time can loosen causing excessive heat.

Dirty battery - Dirt on the top of the battery can lead to conductivity between the poles. Dirt will also mask other problems such as leakage and loose connections.

Reduced capacity - Reduced capacity will degrade a battery's ability to crank the engine during start.

Maintaining the Battery

Tests and checks to maintain correct battery operation:

Typical Battery Maintenance Schedule for Diesel Generator Set							
No.	Starter Battery Maintenance Items	Method of Checking and Action to Take					Frequency of Check
		Visual	Charge	Top Up	Clean	Measure	
1	Specific Gravity					X	Monthly
2	Equalize Charge		X				Annually
3	Battery Capacity Test					X	Monthly
4	Electrolyte Level	X		X			Weekly
5	Connections				X		Monthly
6	Clean Battery Surfaces	X			X		Monthly
7	Leakages and Spillage	X					Weekly
8	Batery Charger	X					Weekly

Genset battery maintenance schedule (see chart above) should carry out the following checks and tests to ensure the battery remains within the required specifications.

Reading specific gravity - SG levels are tested with a hydrometer. Levels normally are an SG of 1265 at 80°F which means 1.265 times that of water, but exact levels should be confirmed with the battery supplier. Before testing the battery has to be rested with no charge or discharge for 24 hours. After removing the cell vents, a hydrometer is inserted to draw liquid into the syringe several times until enough liquid is withdrawn to support the float and take a reading. This ensures the float has a uniform electrolyte temperature for a more accurate reading. The electrolyte is returned to the cell after a reading is taken. This is repeated for each cell. Cell-to-cell differences of no more than 30 points can be adjusted by equalization. However, differences of more than 50 points indicate a bad battery. The battery should be charged if SG is below 1215 at 80°F.

Equalize charge - This position on the charger ensures that every plate in each cell reaches a full state of charge. Equalizing charging is not recommended to be used on a routine basis.

Battery capacity testing - Before testing, fully charge the battery. Use a resistive battery tester to place a load of about 5% of battery capacity. Attach the tester's clamps to the battery terminals. The battery can be tested while connected, but each battery should be tested individually. All loads and charger inputs should be shut off. After closing the tester's toggle switch, the voltmeter should fall slightly for a few seconds. However, if the tester reads close to battery voltage at no load but drops significantly when the load is applied, it is a strong indication the battery needs replacing.

Electrolyte level - Visually check the fluid level in each battery cell. Fluids should never be allowed to fall below the top level of the separator. If the level is low, add distilled water to cover the plates.

Connections - Make sure all cable connections are tight. A thermal image tool will show whether heat is being generated by a poor connection. Loose connections may affect starting.

Visual check for corrosion and dirt - Dirt can block current flow in connectors and cause resistance between terminals. Dirty or corroded terminals and connectors should be cleaned with a wire brush dipped in a solution of one pound of baking soda mixed with one gallon of water. After cleaning, rinse with clean water and coat terminals with a thin coat of petroleum jelly or a corrosion inhibitor.

Leakages - Visually check for leakages that could result from a cracked battery casing or spilled electrolyte. If the battery cannot be repaired, it should be replaced.

6.0 SITE TEST

(1) Only licensed Chargeman are allowed to conduct Genset start ups and tests.

(2) Auto changeover tests involving the Main Switchboard, Essential Main Switchboard and AMF Control Panel/Board should be conducted at least once every five years.

(3) Forms and checklists to be used for Genset & its related components are as follows:

(a) PD-REC-FSRGM - Field Service Report for Genset Service & Maintenance
(b) PD-REC-GSIC - Generator Set Inspection Checklist

End