Revisions to this document shall be communicated in accordance with program document AM-EU-P034 to ensure alignment between Maintenance Templates and field work procedures.

Generators - Substation Auxiliary Power				
Component Classification Categories				
	I	X		All locations
Duty Cycle	Standby Service	X		
Service Condition	In-Service	X		
	Spare	N/A		

Condition Monitoring Tasks		**Failure Codes**	**Comments**
Generator Battery Inspection	**6M**	**1b, 2b, 5c**	
Lube Oil Check	**6M**	**1c, 1e-f, 1l, 2c, 2e-f, 2j, 5d**	
Coolant Check	**6M**	**1a, 2a, 5a**	
Fuel Oil Check	**6M**	**1k, 2k, 5b**	Gasoline or diesel fuel
Time Directed Tasks		**Failure Codes**	**Comments**
Exercise Run Generator	**2W**	**1c,2c,2g**	Where timer controlled.
Lubrication, Filter Change and Belt Check	**2Y**	**1a, 1d, 1f, 1h-k, 1m,1p, 2a, 2d-e, 2g-l, 2k-n, 2q, 3a-b, 3e-f, 4a-b, 5a, 5e**	As applicable
Battery Replacement - Valve Regulated (Sealed)	**3Y**	**1b, 2b, 5c**	
Battery Replacement - Vented Lead Acid	**N/A**		
Detailed Inspection	**AR**	**1c-d, 1h-i, 1k, 1m, 1p, 2c-d, 2h-l, 2k, 2m-n, 2q, 3a-b, 3e, 4a-b**	
Major Overhaul	**AR**	**1b, 1d, 1h-i, 1k, 1q, 2b, 2d, 2h-l, 2k-l, 2n, 2r, 4b, 5c**	
Engine Rebuild	**AR**	**1c, 1,j, 1p-q, 2c, 2q-r, 3a-b, 4a**	
Failure Finding		**Failure Codes**	**Comments**
Visual Inspection	**6M**	**1k, 1o, 2k, 2p, 3d, 4d, 5f**	
Engine Start - Run Load Test	**1Y**	**1n, 2o, 3c, 4c, 5e**	
Condition Directed Tasks		**Failure Codes**	**Comments**
None	**N/A**		

FAILURE MODE	FAILURE CAUSES	MAINTENANCE TASKS
1. Fails to Start	1a. Clogged / Corroded Coolers/ Radiator/ Piping	Coolant Check
1. Fails to Start	1a. Clogged / Corroded Coolers/ Radiator/ Piping	Lubrication, Filter Change and Belt Check
1. Fails to Start	1b. Starting System Failure	Battery Replacement
1. Fails to Start	1b. Starting System Failure	Generator Battery Inspection
1. Fails to Start	1b. Starting System Failure	Major Overhaul
1. Fails to Start	1c. Failed Bearing	Detailed Inspection
1. Fails to Start	1c. Failed Bearing	Exercise Run Generator
1. Fails to Start	1c. Failed Bearing	Engine Rebuild
1. Fails to Start	1c. Failed Bearing	Lube Oil Check
1. Fails to Start	1d. Engine Structure / Drive train Failure	Detailed Inspection
1. Fails to Start	1d. Engine Structure / Drive train Failure	Lubrication, Filter Change and Belt Check
1. Fails to Start	1d. Engine Structure / Drive train Failure	Major Overhaul
1. Fails to Start	1e. Degraded oil	Lube Oil Check
1. Fails to Start	1f. Engine Failure	Lube Oil Check
1. Fails to Start	1f. Engine Failure	Lubrication, Filter Change and Belt Check
1. Fails to Start	1h. Failed Miscellaneous Systems	Detailed Inspection
1. Fails to Start	1h. Failed Miscellaneous Systems	Lubrication, Filter Change and Belt Check
1. Fails to Start	1h. Failed Miscellaneous Systems	Major Overhaul
1. Fails to Start	1i. Failed Control and Safe Shutdown Systems	Detailed Inspection
1. Fails to Start	1i. Failed Control and Safe Shutdown Systems	Lubrication, Filter Change and Belt Check
1. Fails to Start	1i. Failed Control and Safe Shutdown Systems	Major Overhaul
1. Fails to Start	1j. Electrical System Failure	Engine Rebuild
1. Fails to Start	1j. Electrical System Failure	Lubrication, Filter Change and Belt Check
1. Fails to Start	1k. Fuel System Failure	Detailed Inspection
1. Fails to Start	1k. Fuel System Failure	Fuel Oil Check
1. Fails to Start	1k. Fuel System Failure	Lubrication, Filter Change and Belt Check
1. Fails to Start	1k. Fuel System Failure	Major Overhaul
1. Fails to Start	1k. Fuel System Failure	Visual Inspection
1. Fails to Start	1l. Head Gasket Failure	Lube Oil Check
1. Fails to Start	1m. Restricted Air Intake / Exhaust	Detailed Inspection
1. Fails to Start	1m. Restricted Air Intake / Exhaust	Lubrication, Filter Change and Belt Check
1. Fails to Start	1n. Systems Not Operating at Design Output	Engine Start - Run Load Test
1. Fails to Start	1o. Systems Not Ready	Visual Inspection
1. Fails to Start	1p. Governor System Failure	Detailed Inspection
1. Fails to Start	1p. Governor System Failure	Engine Rebuild
1. Fails to Start	1p. Governor System Failure	Lubrication, Filter Change and Belt Check
1. Fails to Start	1q. Power Assembly Failure	Engine Rebuild
1. Fails to Start	1q. Power Assembly Failure	Major Overhaul

FAILURE MODE	FAILURE CAUSES	MAINTENANCE TASKS
2. Fails to Run	2a. Clogged / Corroded Coolers/ Radiator/ Piping	Coolant Check
2. Fails to Run	2a. Clogged / Corroded Coolers/ Radiator/ Piping	Lubrication, Filter Change and Belt Check
2. Fails to Run	2b. Starting System Failure	Battery Replacement
2. Fails to Run	2b. Starting System Failure	Generator Battery Inspection
2. Fails to Run	2b. Starting System Failure	Major Overhaul
2. Fails to Run	2c. Bearing Failure	Exercise Run Generator
2. Fails to Run	2c. Bearing Failure	Detailed Inspection
2. Fails to Run	2c. Bearing Failure	Engine Rebuild
2. Fails to Run	2c. Bearing Failure	Lube Oil Check
2. Fails to Run	2d. Engine Structure / Drive Train Failure	Detailed Inspection
2. Fails to Run	2d. Engine Structure / Drive Train Failure	Lubrication, Filter Change and Belt Check
2. Fails to Run	2d. Engine Structure / Drive Train Failure	Major Overhaul
2. Fails to Run	2e. Degraded Lube Oil	Lube Oil Check
2. Fails to Run	2e. Degraded Lube Oil	Lubrication, Filter Change and Belt Check
2. Fails to Run	2f. Engine Failure	Lube Oil Check
2. Fails to Run	2f. Engine Failure	Lubrication, Filter Change and Belt Check
2. Fails to Run	2g. Electrical System Failure	Exercise Run Generator
2. Fails to Run	2g. Electrical System Failure	Lubrication, Filter Change and Belt Check
2. Fails to Run	2h. Failed Miscellaneous Systems	Detailed Inspection
2. Fails to Run	2h. Failed Miscellaneous Systems	Lubrication, Filter Change and Belt Check
2. Fails to Run	2h. Failed Miscellaneous Systems	Major Overhaul
2. Fails to Run	2i. Failed Control and Safe Shutdown Systems	Detailed Inspection
2. Fails to Run	2i. Failed Control and Safe Shutdown Systems	Lubrication, Filter Change and Belt Check
2. Fails to Run	2i. Failed Control and Safe Shutdown Systems	Major Overhaul
2. Fails to Run	2j. Head Gasket Failure	Lube Oil Check
2. Fails to Run	2k. Fuel System Failure	Detailed Inspection
2. Fails to Run	2k. Fuel System Failure	Fuel Oil Check
2. Fails to Run	2k. Fuel System Failure	Lubrication, Filter Change and Belt Check
2. Fails to Run	2k. Fuel System Failure	Major Overhaul
2. Fails to Run	2k. Fuel System Failure	Visual Inspection
2. Fails to Run	2l. Loss of Oil Pressure	Lubrication, Filter Change and Belt Check
2. Fails to Run	2l. Loss of Oil Pressure	Major Overhaul
2. Fails to Run	2m. Restricted Air Intake / Exhaust	Detailed Inspection
2. Fails to Run	2m. Restricted Air Intake / Exhaust	Lubrication, Filter Change and Belt Check
2. Fails to Run	2n. Failed Cooling System	Detailed Inspection
2. Fails to Run	2n. Failed Cooling System	Lubrication, Filter Change and Belt Check
2. Fails to Run	2n. Failed Cooling System	Major Overhaul

FAILURE MODE	FAILURE CAUSES	MAINTENANCE TASKS
2. Fails to Run	2o. Systems Not Operating at Design Output	Engine Start - Run Load Test
2. Fails to Run	2p. Systems Not Ready	Visual Inspection
2. Fails to Run	2q. Governor System Failure	Detailed Inspection
2. Fails to Run	2q. Governor System Failure	Engine Rebuild
2. Fails to Run	2q. Governor System Failure	Lubrication, Filter Change and Belt Check
2. Fails to Run	2r. Power Assembly Failure	Engine Rebuild
2. Fails to Run	2r. Power Assembly Failure	Major Overhaul
3. Fails to Provide Quality Power	3a. Governor System Failure	Detailed Inspection
3. Fails to Provide Quality Power	3a. Governor System Failure	Engine Rebuild
3. Fails to Provide Quality Power	3a. Governor System Failure	Lubrication, Filter Change and Belt Check
3. Fails to Provide Quality Power	3b. Electrical System Failure	Detailed Inspection
3. Fails to Provide Quality Power	3b. Electrical System Failure	Engine Rebuild
3. Fails to Provide Quality Power	3b. Electrical System Failure	Lubrication, Filter Change and Belt Check
3. Fails to Provide Quality Power	3c. Systems not operating at design output	Engine Start - Run Load Test
3. Fails to Provide Quality Power	3d. Systems not ready	Visual Inspection
3. Fails to Provide Quality Power	3e. Engine Structure and Drive train Failure	Detailed Inspection
3. Fails to Provide Quality Power	3e. Engine Structure and Drive train Failure	Lubrication, Filter Change and Belt Check
3. Fails to Provide Quality Power	3f. Cooling System Failure	Lubrication, Filter Change and Belt Check
4. Fails to safely shutdown	4a. Governor System Failure	Detailed Inspection
4. Fails to safely shutdown	4a. Governor System Failure	Engine Rebuild
4. Fails to safely shutdown	4a. Governor System Failure	Lubrication, Filter Change and Belt Check
4. Fails to safely shutdown	4b. Failed Control and Safe Shutdown Systems	Detailed Inspection
4. Fails to safely shutdown	4b. Failed Control and Safe Shutdown Systems	Lubrication, Filter Change and Belt Check
4. Fails to safely shutdown	4b. Failed Control and Safe Shutdown Systems	Major Overhaul
4. Fails to safely shutdown	4c. Systems not operating at design output	Engine Start - Run Load Test
4. Fails to safely shutdown	4d. Systems not ready	Visual Inspection
5. Fails to provide Boundary integrity	5a. Coolant System Failure	Coolant Check
5. Fails to provide Boundary integrity	5a. Coolant System Failure	Lubrication, Filter Change and Belt Check
5. Fails to provide Boundary integrity	5b. Fuel System Failure	Fuel Oil Check
5. Fails to provide Boundary integrity	5b. Fuel System Failure	Major Overhaul
5. Fails to provide Boundary integrity	5c. Starting System Failure	Battery Replacement
5. Fails to provide Boundary integrity	5c. Starting System Failure	Generator Battery Inspection
5. Fails to provide Boundary integrity	5d. Lube oil System Failure	Lube Oil Check
5. Fails to provide Boundary integrity	5d. Lube oil System Failure	Lubrication, Filter Change and Belt Check
5. Fails to provide Boundary integrity	5e. Systems not operating at design output	Engine Start - Run Load Test

FAILURE MODE	FAILURE CAUSES	MAINTENANCE TASKS
5. Fails to provide Boundary integrity	5f. Systems not ready	Visual Inspection

TASK	DEFINITION
Lube Oil Check	Check oil level; change oil annually or based on run hours.
Coolant Check	Check coolant level and general condition. Replace every 3 - 5 years.
Fuel Oil Check	Check fuel level.
Visual Inspection	Perform the following checks: - Verify proper operation of standby keep-warm systems (continuously circulating lube oil system, jacket water system, engine block heater, etc.) - Check air-start system lubricator oil level. - Check air receiver pressure and drain condensation. - Check battery charger for proper operation. - Check fuel oil, lube oil, and coolant levels. - Check governor oil level. - Check for signs of external water, fuel oil, lube oil, and air leaks. - Drain condensate trap. Fuel tank, drain water and sediment. - Inspect radiator externally for blockage and leaks. - Check air inlet and exhaust systems restrictions, leaks and proper operation. - Check all electrical wiring for obvious problems. - Inspect from sub base and vibration dampers. - Replace any burnt out indicating lights.
Generator Battery Inspection	Check battery electrolyte level (if applicable), Battery Voltage, Starting system- battery terminals, clean/tighten electrical connections.
Exercise Run Generator	Task to run engine. It is preferrable to run with available load however no load run is acceptable.Task is usually accomplished by means of a timer and can be performed automatically with no user interface.

TASK	DEFINITION
Engine start run load test	Task to run the generator at greater than 50% rated load. During each engine start test, parameters which have direct impact on the success or failure of the test should be monitored. Examples of pertinent parameters are as follows: - Starting air motor engagement evolution - Fuel rack movement - Governor actuation - Air receiver pressure The diesel should be operated for at least one to two hours during each diesel load run at greater than 50% of its rated loading. Engine checks, pre-test and post test: - Perform engine standby checks. - Check air cleaner service indicator. - Check system gauges to ensure proper operating parameters. - Inspect engine for leaks and loose connections, i.e., check radiator, hoses, fuel lines, belts, battery terminal cables, and governor linkages. - Inspect air intake and exhaust systems, i.e., inlet and exhaust piping, boots, clamps, etc. Engine operating parameters log: - Record and trend operating data during every engine run to assess material condition. With the engine running at rated load and stabilized at normal operating temperatures, record engine operating data, e.g., lube oil temperatures and pressure, jacket water temperatures and pressure, engine speed and load, etc. - During each diesel run, the operator should conduct rounds and record operating parameters at least once every hour. The recorded operating data should be trended and evaluated to monitor equipment health and to identify declining performance or material condition. Battery draw down voltage test: Perform this test during engine start annually to assess battery condition. - Engines located indoors with double wall exhaust systems utilizing thimble devices to penetrate walls shall be checked to ensure the exhaust system is intact with no leaks.

TASK	DEFINITION
Lubrication filter change and belt check	This group of tasks coorelate to manufacturer recomended PMs that should be performed every 200 to 300 operating hours. Examples of tasks to be performed include: - Cooling System: water pump or fan drive belts, check tension. - Aftercooler core: Clean as required based on operating parameters trending. - Engine Structure and Drive Trains: - Gearbox, clutch and control lever, check oil level and lubricate fittings. - Couplings, belts, and pulleys, inspect. Lubricate fan drive and pulley, grease bearings, check belt tension and inspect belts for splits, cracks and glazing. Replace degraded components. - Vibration damper, inspect as required. Check engine vibration damper freeness as required. - Air Intake and Exhaust System: - Air filter element, clean/replace. Clean engine dust collector cap; inspect air filters and replaced if they are degraded or dirty. - Air box damper and linkage lubrication. Inspect for wear points, damage to piping, loose clamps, and leaks; inspect air inlet system (filters, ducting, etc.) for evidence of dirt or debris and clean as necessary. Clean and lubricate mechanical linkages. Fuel pump/governor housing, drain condensation. Fuel tank breather, clean/inspect. Fuel /water separator element, replace. Fuel oil strainer and filter, clean/replace. - Cooling System: - Jacket water heater, inspect/replace. - Coolant strainer and filter, clean/replace. - Raw water strainer, clean. - Heat exchanger, clean tube and shell sides/inspect. Inspect zinc anode and replace if necessary. - Water pump drain hole, clean. - Louvers/dampers and linkages- lubricate,clean/inspect. - Water pump or fan drive belt replace. - Engine coolant, replace as required. - Lube Oil System: - Lube oil heater, clean/inspect. - Lube oil filter, replace. - Strainer clean/inspect. - Engine lube oil, replace as required. - Governor: - Governor and throttle control linkages, inspect/lubricate. All mechanical fasteners of the governor and control linkage assembly should be visual inspected. Check adjustments and tighten loose linkages as required. - Tachometer drive, lubricate.

TASK	DEFINITION
	- Control and Safe Shutdown System: - Engine protection devices, check. Check safety shutoff controls, emergency shut down, and overspeed switch. - Start switch, relays, and breaker, inspect. - Starting circuit field wiring, inspection. Inspect and tighten starting circuit field wiring electrical connections. - Instruments, calibrate. - Generator and Voltage Regulator: - Generator/alternator electrical wiring, inspect electrical wiring. - Generator air inlet and outlet, inspect for restriction. - Generator and Voltage regulator, clean/inspect. Inspect the generator as required in accordance with the generator manufacturer's recommendations. - Miscellaneous: Air compressor strainer, clean.
Battery replacement	For Valve Regulated Batteries (sealed): Starting System- battery, replace every 3 years. Starting System- battery charger, inspect Battery charger For Vented Lead Acid Batteries: Starting System- battery, replace battery As Required based on Battery Inspection results and manufatuers recomemndation. Starting System- battery charger, inspect Battery charger.

TASK	DEFINITION
Detailed Inspection	Detailed inspection tasks that correlate to the 500 to 1000 hour manufacturer recommended tasks. - Air compressor mounting bolts: Check torque . generator bearing, lubricate. Inspect the generator bearing for signs of oil leaks, degradation, and wear. Replace the bearing lubricant/grease, analyze the old bearing lubricant/grease for degradation, contamination and wear metals. - Control and Safe Shutdown System: Normally energized control solenoids, replace. - Governor: - Governor set point and low idle speed, check/adjust. - Governor shutdown solenoid valve, replacement. - Overspeed and governor motor, lubricate. - Cooling System: - Jacket water pressure relief cap, replace to prevent potential failure due to elastomer aging. - Radiator, clean/inspect. - Thermostat and seals, replace. - Fuel system: Check valve, Inspect/clean or replace. - Air Intake and Exhaust System: - Crankcase breather, clean/inspect. - Air box, inspect. Clean and inspect airbox drain tube and check valve; inspect airbox for oil and carbon deposits, and ensure that the airbox drain hole is free of obstructions. - Air intake system, inspect for wear points, damage to piping, loose clamps, and leaks; inspect air inlet system (filters, ducting, etc.) for evidence of dirt or debris and clean as necessary. - Turbocharger and blower, inspect. Check rotor shaft freeness, bearing endplay, and radial clearance; visually inspect impeller and turbine blades for damage or excessive deposits; clean and inspect blower screen. A dragging rotor shaft could be indicative of a rubbing rotating assembly or a degraded journal bearing. - Exhaust manifold and silencer, inspect. - Engine Structure and Drive Trains: Gearbox and clutch, replace lube oil and filter.

TASK	DEFINITION
Major Overhaul	Tasks that correspond to manufacturers recomended PM at 1000 to 5000 hrs. - Miscellaneous: Flexible hoses, inspect/replace hoses and hose connections for leaks and /or deterioration. Typical applications of flexible hoses are in connections of starting air motors, jacket water heaters, fuel pumps, etc. In some applications, flexible hoses are grouped as part of subassemblies and would not be apparent in vendor maintenance manuals. A thorough walkdown should be performed to identify flexible hoses. - - Starting System: Starting motors, inspect/rebuild. ----Fuel System - Fuel Pump inspect /replace - Fuel tank Mounting Inspect - Fuel Lines and hoses Inspect/Replace - Control and Safe Shutdown System: - Normally de-energized control solenoids, replace. - Start switch,relays ,replace. - Start Relay & Control Circuit Diode, replace. - Lube Oil System - Oil cooler, clean/test. - Oil pump, inspect/rebuild. - Cooling System: Water pump inspect/rebuild. Replace drive belts every 12 years. Fuel lines and hoses, inspect/replace. Inspect all hoses for cover damage and/or indications of twisted, worn, crimped, brittle, cracked, or leaking lines. Fuel tank mounting, inspect and tighten fuel tank mounting. Power Assemblies System- Adjust valve lash, fuel rack, and timing, Inspect valve train (camshaft, rocker arms, valve bridges, lash adjusters, etc.) Replace fuel injectors and fuel injection pumps
Engine Rebuild	- Generator and Voltage Regulator: Alternator, inspect/rebuild. - Governor: Throttle delay fuel modulator, inspect/replace. - Engine Structure and Drive Trains: Crankshaft and bearings, inspect. Check crankshaft end clearance and bearing wear, and replace crankshaft seals. - Power Assemblies: Rebuild/replace power assembly. A power assembly rebuild would include replacing elastomers and performing an internal visual inspection of the liner, piston, and cylinder head for abnormal wear or overheating.

Generators Template Summary

The Preventive Maintenance program is documented via maintenance templates. Templates have been developed that address transmission, substation, and distribution equipment that is owned and maintained by Exelon Utilities. Each template documents the program tasks, frequencies, failure modes, and maintenance basis for the associated equipment. Tasks and associated frequencies are designed to address known failure modes of the equipment covered by the template. In general, the tasks included in the maintenance templates are the result of good industry practices, industry experience, and manufacturer recommendations.

References:
Internal failure reports
OEM Maintenance Manuals and Interviews
EPRI TR-107135 Diesel Engine Analysis Guide NMAC
Nuclear Maintenance PCM Templates Small Diesel, Inverter, Valve Regulated Battery, Battery Charger, Power Supply, Auto Transfer Switches.

Boundary Definition
The boundary of a Generator system includes all components that make up the system including:

- Engines
- Generators
- Fuel Systems
- Battery Systems
- Chargers / Power Supplies
- Cooling Systems
- Transfer Switches
- Inlet and Exhaust Air Systems

Excluded from this treatment are: Components connected to these systems as load or source systems.

Failure Experience
Many failure experiences have been identified, categorized and documented within Exelon Nuclear and in the Nuclear industry as a whole.
This template intends to take full advantage of experience gained in these venues.

Vendor Recommendations
OEM manuals were referenced and interviews conducted during the development of this template.

Disposition of Vendor Recommendations
Vendor recommendations have been reviewed and in some cases modified based on the service hours routinely seen by EED system Generators.

Basis For Template Tasks

Generator Coolant Check: Check coolant level and general condition. Replace every 3 - 5 years.

Generator Fuel Oil Check: Check adequate fuel level.

Generator Battery Inspection: Check battery electrolyte level. The engine manufacturer recommends performing this check every 3 months or 200 hours of operations. In non-critical applications, the PM frequency could be changed to perform every 6 months. The loss of battery fluid resulting in battery performance degradation could be identified during periodic engine start surveillance. Additionally,battery fluid leaks would be readily apparent during normal system rounds.

Starting System- battery terminals, clean/tighten electrical connections.

Generator Battery Replacement: Starting System battery, replace every 3 years. This replacement frequency is inline with the manufacturer's recommendation.

Starting System battery charger, inspect.

Battery charger: Inspect every 3 years.

Exercise Run Generator : Task is required to prevent bearing dryout. Engines that utilize oil luibricated bearing systems need to be operated ocasionally to ensure that bearing surfaces stay lubricated and do not dry out. Additionally, cooling system equipment requires occasional operation to prevent the formation of corrosion on exposed components.
The generator should be run for approximately 45 minutes.
This task is usually performed using a timer installed on the system.

Generator Start Run Load Test: During each engine start test, parameters which have direct impact on the success or failure of the test should be monitored. Monitoring these pertinent parameters could expedite the troubleshooting process in the event of a failure to start. Trending of operating parameters and working fluid parameters could identify a problem as it develops and allows correction prior to engine damage.

The diesel engine should be operated for at least one to two hours during each diesel load run at greater than 50% of its

During each diesel run, the operator should conduct rounds and record operating parameters at least once every hour. The recorded operating data should be trended and evaluated to monitor equipment health and to identify declining performance or material condition. Trending of operating parameters and working fluid parameters could identify a problem as it develops and allows correction prior to engine damage.

Generator Detailed Inspection: Air compressor mounting bolts torque check is recommended every 6 years for critical locations. This PM task can be performed in conjunction with the inspection of the engine and drive-train mounting. Since runtime is limited, this PM frequency could be extended to every 12 years in non-critical applications.

Generator bearing lubricate and inspect the generator bearing for signs of oil leaks, degradation, and wear. Replace the bearing lubricant/grease, analyze the old bearing lubricant/grease for degradation, contamination and wear metals. The manufacturer recommends performing this task every 1200 hours, which would equate to over 12 years of service. It is recommended that this task be performed every 6 years to prevent condensation problems.

Governor- governor set point and low idle speed, check/adjust. The recommended frequency is inline with the manufacturer's recommendation to perform task every 500 hours of operation. In non-critical applications, the PM frequency could be changed to perform “as required”. Degradation could be identified during periodic surveillance. Governor shutdown solenoid valve, replacement Degraded solenoid valves had resulted in several start failures on Exelon generators.

Govenor- overspeed governor and governor motor, lubricate. The frequency is inline with the manufacturer’s recommendation to perform task every 500 hours of operation. In non-critical applications, the PM frequency could be changed to perform “as required”. Degradation could be identified during periodic surveillance.

Cooling System- jacket water pressure relief cap, replaceto prevent potential failure due to elastomer aging. Cooling System- radiator, clean/inspect. Task frequency is inline with the manufacturer’s recommendation to inspect fins and core every 500 hours of operation. In non-critical applications, the PM frequency could be extended to every 12 years. Degradation would be identified by trending of operating parameters.

Cooling System- thermostat and seals, replace. The manufacturer recommends replacement every 3000 to 5000 hours of operation. In standby application, 3000 hours of operation would equate to over 30 years of service. This task should be performed every 6 years to prevent potential failure due to aging.

Fuel system check valve, Inspect/clean or replace every 6 years. Trending of fuel pressure could identify a degraded check valve. In non-critical applications, this PM could be performed “as required”. A degraded check valve can result in the loss of fuel prime.

Air Intake and Exhaust System- crankcase breather, clean/inspect. The manufacturer recommends performing this task every 1000 hours of operation. To maintain a conservative approach to maintenance, this PM task should be performed every 6 years. In non-critical applications, this PM frequency could be extended to 12 years (approximately 1000 hours of operation).

Air Intake and Exhaust System- air box, inspect. Clean and inspect airbox drain tube and check valve; inspect airbox for oil and carbon deposits, and ensure that the airbox drain hole is free of obstructions. The manufacturer recommends performing this task every 1000 hours of operation. To maintain a conservative approach to maintenance, this PM task should be performed every 6 years. In non-critical applications, this PM frequency could be extended to 12 years (approximately 1000 hours of operation).

Air Intake and Exhaust System- air intake system, inspect for wear points, damage to piping, loose clamps, and leaks; inspect air inlet system
(filters, ducting, etc.) for evidence of dirt or debris and clean as necessary. Typically, these components do not degrade based on calendar time; the wear mechanism is based on service duty cycle. A thorough air intake system inspection should be performed every 6 years in addition to the pre and post test inspections. In non-critical applications, this PM frequency could be changed to perform “as required”. Degradation of the air intake system would be apparent during periodic surveillance.

Air Intake and Exhaust System- turbocharger and blower, inspect. Check rotor shaft freeness, bearing endplay, and radial clearance; visually inspect impeller and turbine blades for damage or excessive deposits; clean and inspect blower screen. A dragging rotor shaft could be indicative of a rubbing rotating assembly or a degraded journal bearing. The manufacturer recommends inspecting the turbocharger or blower every 800 to 1200 hours. this PM task should be performed every 6 years (approximately 600 hours of operation). In non-critical applications, this PM frequency could be extended to every 12 years (approximately 1000 hours of operation).

Air Intake and Exhaust System- exhaust manifold and silencer, inspect. Typically, these components do not degrade based on

calender time; the wear mechanism is based on service duty cycle. Check connections for tightness and exhaust system for leaks every 6 years in addition to the pre and post test inspections. In non-critical applications, this PM frequency could be changed to perform “as required”. Degradation of the exhaust system would be apparent during periodic surveillance.

Engine Structure and Drive Trains- gearbox and clutch, replace lube oil and filter. The engine manufacturer recommends performing this PM task every 1000 to 1200 hours of operations. In standby service, where run time is limited, this PM task should be performed every 6 years to ensure proper filter performance. A filter element immersed in oil over long period of

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Lubrication Filter Change and Belt Check: This group of tasks coorelate to manufacturer recomended PMs that should be performed every 200 to 300 operating hours.

Cooling System - water pump or fan drive belts, check tension aftercooler pressure drop measurement for trending.

Aftercooler core: Clean as required based on operating parameters trending. A partially plugged aftercooler can be detected by a decrease in airbox pressure or degraded engine performance. Measure pressure drop across aftercooler to assess cooler condition.

Engine Structure and Drive Trains- gearbox, clutch and control lever, check oil level and lubricate fittings in accordance with the manufacturer’s recommendation.

Engine Structure and Drive Trains- couplings, belts, and pulleys, inspect. Lubricate fan drive and pulley, grease bearings, check belt tension and inspect belts for splits, cracks and glazing. Replace degraded components. The engine manufacturer recommends performing this PM task every 200 to 250 hours of operations. The 2-year visual inspection frequency

Engine Structure and Drive Trains- vibration damper, inspect as required. Check engine vibration damper freeness as required. A degrading damper would result in elevated vibration amplitudes. The manufacturer recommends inspecting the damper every 1200 hours of operation. In standby service, no significant amount of wear would accumulate in the limited number of operating hours.

Air Intake and Exhaust System- air filter element, clean/replace. Filter fouling is due to operation over time and operating environment. Clean engine dust collector cap; inspect air filters and replaced if they are degraded or dirty. A clogged air cleaner element would cause excessive intake restriction and reduce air supply to the engine. This condition would result in high operating temperatures, increased fuel consumption, inefficient engine operation, engine malfunction or damage. The manufacturer recommends performing this PM task every 200 to 250 hours of operation (approximately 2 years of standby service).

Air Intake and Exhaust System- air box damper and linkage lubrication. Inspect for wear points, damage to piping, loose clamps, and leaks;

inspect air inlet system (filters, ducting, etc.) for evidence of dirt or debris and clean as necessary. Clean and lubricate mechanical linkages. Typically, these components do not degrade based on calendar time; the wear mechanism is based on service duty cycle. A thorough air intake system inspection should be performed. In non-critical applications, this PM frequency could be changed to perform “as required”. Degradation of the air intake system would be apparent during periodic surveillance.

Air Intake and Exhaust System - aftercooler pressure drop measurement. Aftercooler core: Clean as required based on operating parameters trending. A partially plugged aftercooler can be detected by a decrease in airbox pressure or degraded engine performance. Measure pressure drop across aftercooler every 2 years to assess cooler condition for critical application. Measure pressure drop across cooler as required based on operating parameters trending.

Air Intake and Exhaust System- aftercooler core, clean as required based on operating parameters trending. A partially plugged aftercooler can be detected by a decrease in airbox pressure or degraded engine performance.

Fuel pump/governor housing, drain condensation. Drain condensation in accordance with the manufacturer’s recommendation. Fuel tank breather,
clean/inspect. The manufacturer recommends performing this PM task every 3 months or 200 hours of operation. Since degradation is duty cycle
dependent rather than time dependent, it is recommended that this PM task be performed every 2 years (approximately 200 hours of runtime).
Fuel /water separator element, replace. The manufacturer recommends performing this PM task annually or 250 hours of operation. Since
degradation is duty cycle dependent rather than time dependent, it is recommended that this PM task be performed every 2 years (approximately
200 hours of runtime). Fuel oil strainer and filter, clean/replace. Fuel filter strainers should be cleaned when filters are replaced. The manufacturer
recommends performing this PM task annually or 250 hours of operation. Since degradation is duty cycle dependent rather

Cooling System- water pump drain hole, clean.

Cooling System- louvers/dampers and linkages- lubricate,clean/inspect. The manufacturer recommends performing this PM task annually. Since degradation is duty cycle dependent rather than time dependent, it is recommended that this PM task be performed every 2 years (approximately 200 hours of runtime) to maintain a conservative approach to maintenance. In non-critical applications, the PM frequency could be changed to perform “as required”. Degradation would be identified during periodic surveillance.

Cooling System - water pump or fan drive belt replace.

Cooling System- engine coolant, replace. Replace as required. The manufacturer recommends coolant replacement every 2 years or 3000 to 4000 hours of operation. Since fluid analysis is performed regularly, this task can be performed as required based on coolant analysis results. Sampling and testing will eliminate unnecessary coolant change out. Cooling system should be thoroughly clean prior to filling with new coolant.

Lube Oil System- lube oil heater, clean/inspect. In noncritical applications, the PM frequency could be changed to perform “as required” based on
periodic operator rounds.

Lube Oil System- lube oil filter, replace. Filter elements should be replaced every 2 years regardless of material condition. A proper filter replacement interval is important toward prolonging engine life. Thus, to maintain a conservative approach to diesel maintenance, a time-directed filter replacement interval should be used. A filter element immersed in lube oil over long period of time may experience degradation in filtration capability, or it may be more susceptible to collapse during cold oil engine starts. The 2-year interval is inline with the vendor’s recommendation of 250 operating hours between replacements.

Lube Oil System - strainer clean/inspect. A clogged or partially plugged strainer will limit oil flow to the engine.

Lube Oil System - filter bypass valve, clean/inspect. A degraded valve could allow foreign material to by-pass the lube oil filter and enter the engine.

Lube Oil System- engine lube oil, replace. Replace as required Perform lube oil analysis and change oil as needed based on analysis results.

Governor- governor and throttle control linkages, inspect/lubricate. All mechanical fasteners of the governor and control linkage assembly should

be visual inspected. Check adjustments and tighten loose linkages as required. This is inline with the manufacturer's recommendation to perform task every 250 hours of operation. In non-critical applications, the PM frequency could be changed to perform "as required". Degradation could be identified during periodic surveillance.

Governor- tachometer drive, lubricate. This is inline with the manufacturer's recommendation to perform task every 250 hours of operation. In non-critical applications, the PM frequency could be changed to perform "as required". Degradation could be identified during periodic surveillance.

Control and Safe Shutdown System- engine protection devices, check. Check safety shutoff controls, emergency shut down, and overspeed switch.

Control and Safe Shutdown System- start switch, relays, and breaker, inspect.

Control and Safe Shutdown System -starting circuit field wiring, inspection. Inspect and tighten starting circuit field wiring electrical connections.

Control and Safe Shutdown System- instruments, calibrate: 6.10.3 Instruments: Calibrate every 2 years. Generator and Voltage Regulator- generator/alternator electrical wiring, inspect. Generator/alternator electrical wiring: Inspect. Clean/tighten electrical connections. This is inline with
the manufacturer's recommendation to perform task every 250 hours of operation.
Generator and Voltage Regulator- generator air inlet and outlet, inspect. Generator air inlet and outlet: Inspect for restriction.

Generator and Voltage Regulator- voltage regulator, clean/inspect.

Generator and Voltage Regulator- measure generator winding resistence. Inspect the generator as required in accordance with the generator manufacturer's recommendations. Since runtime is limited, this PM frequency could be extended to every 6 years for non-critical applications. Miscellaneous- air compressor strainer, clean. This is inline with the manufacturer's recommendation of 250 hours of operation between PM. Engine checks, standby.

Major Overhaul: Tasks that correspond to manufacturers recomended PM at 1000 to 5000 hrs. Flexible hoses, inspect/replace hoses and hose connections for leaks and /or deterioration. Typical applications of flexible hoses are in connections of starting air motors, jacket water heaters, fuel pumps, etc. In some applications, flexible hoses are grouped as part of subassemblies and would not be apparent in vendor maintenance manuals. A thorough walkdown should be performed to identify flexible hoses. Particles of deteriorated hose can be carried through cooling system or lubricating system and restrict or clog small passages, especially in radiator core and lubricating oil cooler, and slow or partially stop circulation. Degradation would be apparent during periodic surveillance.

Industry operating experience reveals that a service life of at least 15 to 20 years is regularly achieved. Additionally, a technical evaluation performed by MPR Associates on the Cooper-Bessemer engine flexible hoses concluded that a 6-year replacement interval is overly conservative and is not warranted. The recommended 12-year replacement frequency is inline with the manufacturer's recommendation of 700 to 1000 hours of
operation between PM. In non-critical applications, this PM frequency could be changed to perform "as required.

Starting System- starting motors, inspect/rebuild The manufacturer recommends rebuilding the starting motor every 3600 hours of operation. In standby service, due to the high number of engine starts to satisfy surveillance requirements, starting motors should be inspected every 12 years (approximately 1000 hours of operation). In non-critical applications, this PM task could be performed "as required" based on periodic surveillance

Control and Safe Shutdown System- normally de-energized control solenoids, replace.

Control and Safe Shutdown -Start switch,relays, replace.

Control and Safe Shutdown System - Start Relay & Control Circuit Diode, replace.

Lube Oil System- oil cooler, clean/test. In non-critical applications, this PM task could be performed "as required" based on operating parameters trending.

Lube Oil System- oil pump, inspect/rebuild. In non-critical applications, this PM task could be performed "as required" based on operating parameters trending. When engine operating data trending indicates degradation in performance, disassemble, clean, inspect and repair the engine driven lube oil pump. Proper operation of the lube oil system could be checked during engine surveillance. Lube oil pressure trending would
identify obstructions within the system

Replace drive belts every 12 years. Degradation or loosening of the drive belt will reduce cooling capability and cause engine temperature to increase. In non-critical application, this PM task can be performed on an as required basis. The engine coolant temperature can be used as an indicator to monitor belt condition. An increasing engine coolant temperature trend would be a precursor to belt degradation or loosening.

Cooling System- water pump inspect/rebuild: The manufacturer recommends replacement every 4000-5000 hrs of operation. In standby application, 4000 operating hrs equates to over 40 years of service. This task should be performed every 12 years to prevent potential failure due to elastomers (seals) aging. In non-critical applications, this PM could be performed “as required” based on operating parameter.

Fuel tank mounting, inspect and tighten fuel tank mounting. In non-critical applications, perform this task as required. Fuel pump, inspect/replace in addition to verifying the pump operation during each engine run. This takes the place of the manufacturer recommended annual inspection. Past inspections have revealed minimal degradation. In non-critical applications, this PM could be performed “as required”. A degraded fuel pump would be apparent during periodic surveillance.

Engine Structure and Drive Trains- engine and gearbox mounting, inspect. Check mounting bolts and the condition of the mounting and tightened as required. Typically, mounting bolts would not become loose unless the engine was operating out of its design specifications; e.g., bolts might become loose after extended running if the engine/drivetrain was out-of-balance or out-of-alignment. A loose mounting bolt would be accompanied by increased engine structural vibration level. In commercial application, this maintenance task is recommended every 1200 to 1600 hours. Torque relaxation is a duty cycle affected phenomenon and not time-based; bolt torque relaxation is not anticipated with the limited hours of operation in standby service. This is inline with the 1200 to 1600 operating hours recommendation. In non-critical applications, this PM frequency could be changed to perform “as required” based on trending of the engine structural vibration levels.

Engine Structure and Drive Trains- flywheel cranking gear, inspect. The manufacturer recommends inspecting the engine flywheel cranking gear every 3600 hours of operation. In standby service, the engine cranking gear should be inspected (approximately 1000 hours of operation). In non-critical applications, this PM could be performed “as required”. A failed cranking gear would be notable during the periodic surveillance runs.

Power Assemblies- valve lash, fuel rack, and timing, adjust lash adjusters and fuel rack, and perform injector timing. The hydraulic lash adjusters maintain zero lash to the valve stem to minimize impact and valve stem wear. As the rocker arm rotates, the valve bridge/lash adjusters will depress the exhaust valves to vent the combustion chamber. Valve train adjustments deterioration is a function of runtime; not calendar time. The lash adjuster inspection verifies that excessive wear of the plunger has not occurred. A lash adjuster failure would cause exhaust valve stem wear to accelerate; however, it would not compromise engine operability in an emergency. Lash adjuster failures can be identified by a loud clicking noise during engine operation. Identification of unexpected impacts during the exhaust valve opening and closing events would indicate excessive clearance between the valve stem and lash adjuster.
In commercial service, the engine manufacturer recommends performing these PM tasks every 1200 to 1500 hours of operation. In standby service, the engine operates less than 100 hours each year. Thus, valve lash, fuel rack and injector timing adjustments should be performed every 12 years. In non-critical applications, this PM frequency could be changed to perform “as required” based on operating parameters trending.

Power Assemblies- valve train (camshaft, rocker arms, valve bridges, lash adjusters, etc.), inspect. Perform visual inspection to check camshafts, valve train, and rocker arm assemblies. Inspect injector cam and valve cam lobes and rocker arm rollers for excessive wear and pitting. Degradation of these components is a function of service duty cycle, not calendar time. The manufacturer recommends performing this PM task every 6000 hours of operation. In standby service, where the engine runs less than 100 hours per year, it would take over 60 years to accumulate 6000 operating hours. To maintain a conservative maintenance approach, the valve train inspection should be performed every 12 years in conjunction with the valve lash adjustment and injector timing. In non-critical applications, this PM frequency could be changed to perform “as required”. Component degradations would be apparent from trending of fluid analyses results and operating parameters.

Power Assemblies- fuel injectors and fuel injection pumps, replace. Fuel injector degradation would be evident as a change in the cylinder exhaust temperature; the degradation is a function of duty cycle (not calendar time). The manufacturer recommends cleaning and calibrating each injector every 2400 hrs and replacement every 5000 hrs of operation. The re-qualification process includes leak check and ‘pop’ test to check the spray pattern. In standby service, where the engine accumulates less than 100 hours per year, injectors should be replaced every 12 years in conjunction with the valve train work. In non-critical applications, this PM frequency could be changed to perform “as required”. Injector degradation would be apparent from trending of cylinder exhaust temperatures.

Generator Engine Rebuild: Generator and Voltage Regulator- alternator, inspect/rebuild. The manufacturer recommends performing this task every 3600 hours. In order to maintain a conservative maintenance approach, it is recommended that this task be performed every 24 years. In non-critical application, this PM task could be performed “as required” based on periodic surveillance.

Governor- throttle delay fuel modulator, inspect/replace. The manufacturer recommends replacement every 5000 hours of operation. To maintain a conservative approach to maintenance, this PM should be performed every 24 years. In non-critical application, this PM task can be performed as required instead of periodically. Component degradation would be apparent during periodic surveillance.

Engine Structure and Drive Trains- crankshaft and bearings, inspect Crankshaft and bearings. Check crankshaft end clearance and bearing wear, and replace crankshaft seals. The engine manufacturer recommends performing this PM task every 6000 hours of operation (approximately 60 years in standby service.
years in standby service. To maintain a conservative approach to maintenance, this PM task should be performed every 24 years. In non-critical applications, this PM task is not required periodically. The predictive maintenance techniques (i.e., oil analysis, vibration analysis, and operating parameters trending) are sufficient to monitor the material condition.

Power Assemblies- rebuild/replace power assembly. A power assembly rebuild would include replacing elastomers and performing an internal visual inspection of the liner, piston, and cylinder head for abnormal wear or overheating. The engine manufacturer recommends performing this PM task every 6000 hours of operation. In standby service, where runtime is limited, it is recommended that this PM task be performed every 24 years. In non-critical applications, this PM frequency could be changed to perform “as required”. Excessive power assembly wear could be identified from wear metals in lube oil analyses.

Generator Visual Inspection: Perform checks and inspections to ensure the engine is capable to respond in an emergency. Task listed will provide sufficient information to ensure the system is ready to react.

	Revision 0	Date 09/11/2015
Writer	Hugo Castaneda (Material Condition)	
Reviewer(s)	Ken Wendt	
Approver(s)	Michael Moy (UFAM ComEd)	
Reason Written	Created to document the ComEd maintenance program tasks, frequencies, failure modes, and maintenance basis.	

	Revision 1	Date 09/05/2018
Writer	Hugo Castaneda (Material Condition)	
Reviewer(s)	Dale Player (Mgr Material Condition)	
Approver(s)	Michael Moy (UFAM ComEd)	
Reason Written	3yr cycle review. No significant changes.	