Federal Utility Partnership Working Group (FUPWG)

Generator Systems Maintenance

Combined Heat & Power (CHP) Technology

Tier 4 Compliance – EPA Regulations

Generator Systems Maintenance

What happens when your facility loses power?

What happens to your customer / tenant?

What happens to you?

The consequences to loss of electric power are greater today than they ever have been -

- Life Safety
- National Defense
- Emergency Services
- Lost or missed transactions
- Customer and other upstream impacts
- Reputation

If you operate a facility with back-up generators, then let's look at how to keep them up and ready by examining the most common and avoidable reasons they fail……..

Generator Systems Maintenance

Top 10 Reasons Your Generator Fails to Operate Properly…..

1. Dead or dying engine starting batteries
2. Jacket Water Heater failure
3. Contaminated Fuel
4. Coolant hose failure
5. Engine belt failure
6. Automatic Transfer Switch (ATS) failure
7. Lubrication failure
8. Wet Stacking / Exhaust Slobber
9. Plugged radiator core
10. Emergency stop left engaged

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1. Dead or Dying Engine Starting Batteries

Possible Cause:

- Age – with proper care and charging, starting battery performance and reliability becomes very uncertain beyond three years of age.
- Battery Charger Failure – These devices go bad over time as well. As a result of capacitor deterioration, they can under charge, over charge or stop charging your batteries.
- Engine Starting Issues – repetitive attempts to start the engine without success can drain the batteries beyond the charger's ability to keep up.
- Engine Alternator Failure – Once running, the batteries are charged by the engine alternator. An alternator failure can impact starting batteries in the same way as a charger failure.

Prevention:

- Inspection Program – Weekly and monthly by site personnel. Quarterly by an experienced generator service provider where battery and charger testing is prescribed (load testing, specific gravity, etc.).
- Annual building load transfer test on the generator.
- Replace starting batteries every three years and charger every 10-15 years (7-year maintenance interval).

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2. Jacket Water Heater Failure

Possible Cause:

- Failed heating element – as with any heating element, these deteriorate over time at varying rates.
- Failed relay/contactor – these devices are solid state so there is little one can do to predict failure – repetitive activation due to a failing thermostat will wear them out quicker or cause them to overheat.
- Failed Thermostat.

Prevention:

- Inspection Program – Weekly and monthly by site personnel. Quarterly by an experienced generator service provider where the JWH is checked for proper operation.
- Regular exercising schedule, especially in winter, to test starting capability.
- Keep a spare element, contactor, t-stat or entire JWH assembly on the shelf.
- Install/upgrade to redundant switching JWHs
- Recommend you install isolation valves on the input and the output hoses to the JWH as well as the engine block to eliminate the need to drain the coolant when replacing or servicing the JWH or hoses.
- Upgrade JWH to a model with a circulating pump to keep the warm coolant moving over the engine and extend the life of the heating element.

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3. Contaminated Fuel Supply

Possible Cause:

- Diesel fuel deteriorates/breaks down naturally over time (1-3 years in a fresh clean tank).
- Organic growth over time in the tank.
- Condensation build up over time.
- Fuel supplier delivered bad fuel.

Prevention:

- Keep fuel tank topped off – this ensures that a minimal amount of air is present for condensation to form and algae to flourish.
- Conduct annual lab analysis on the fuel – this will establish a trend and baseline on healthy fuel and might detect issues before they would impact engine performance – can be predictive.
- Inspection Program – Weekly and monthly by site personnel. Quarterly by an experienced generator service provider where the tanks & filters are checked regularly and changed annually.
- Have the fuel polished on an annual basis or install a mounted continuous polishing machine for ultimate certainty.
- Keep a stock of spare fuel filters on site.

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4. Coolant Hose Failure

Possible Cause:

- Coolant hoses are made of various materials – Rubber is most common – age and exposure to heat are factors in hose deterioration.
- Excessive engine vibration resulting in mechanical failure at fittings, clamp points or chaffing damage.
- Improper Hose Routing – proximity to high heat engine components and high tension bends resulting in collapse or crimping.

Prevention:

- Inspection Program – Weekly and monthly by site personnel. Quarterly by an experienced generator service provider where the coolant hoses, clamps and fittings are inspected.
- Replacement of rubber coolant hoses with silicone or neoprene hoses – can double the life of the hose.
- Replace JWH hot side/upper hose every 1-2 years & all other hoses every 3 years.
- Install JWH, engine and radiator isolation valves to minimize coolant drain (material & Labor) when replacing hoses on interval.

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5. Engine Belt Failure

Possible Cause:

- Engine belts naturally break down over time, whether used or not.
- Improper alignment or tensioning can accelerate deterioration and failure.

Prevention:

- Inspection Program – Weekly and monthly by site personnel. Quarterly by an experienced generator service provider where the engine belts are inspected and adjusted as necessary.
- Replace engine belts every three years.
- Keep a spare set on hand.
- Have pulleys and fans lubricated and adjusted for proper alignment and tension settings.

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6. Automatic Transfer Switch (ATS) Failure

Possible Cause:

- Lack of maintenance.
- Dusty, moist and/or dirty environment.
- Utility reliability, lightning/surge protection and grounding issues.
- Excessive transfers over time.

Prevention:

- Inspection Program – Weekly and monthly visual by site personnel. Between 1-4 visits per year by an experienced electrical / ATS service provider.
- Annual cleaning and adjusting at minimum depending on device condition and environment (ATS must be de-energized).
- Annual building transfer test (building power may be interrupted twice).
- Employ Thermo-graphic Analysis as a predictive measure. Best to get a baseline thermo-graphic image when the switch is new or at any time where the switch is functioning normally.
- Upgrade your open transition ATS with a closed transition and/or isolation bypass ATS.

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7. Lubrication Failure

Possible Cause:

- Age of the oil – Engine lube oil deteriorates/breaks down naturally over time (3-5 years)
- Overuse – engine has run for more than 250 hours without an oil change.
- Contamination – introduction of internal (carbon, fuel, coolant) or external (dirt, water) contaminants.
- Improper oil type (ANSI Standards set by manufacturer) or weight of oil.

Prevention:

- Inspection Program – Weekly and monthly by site personnel. Quarterly by an experienced generator service provider where the engine oil & oil filters are checked regularly.
- Change the engine oil and oil filter annually.
- Sample and conduct lab analysis of the engine oil between 1-4 times per year, depending on operating profile and past trending results.
- Keep spare filters on hand for rapid change if necessary.
- Keep spare oil on hand.
- Install rapid extraction and fill system for faster change times reducing labor costs (bigger engines).

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8. Wet Stacking / Exhaust Slobber

Possible Cause:

- Running the engine under load and/or for short periods of time – exercising or building load tests where the load factor is under 30% of rated capacity for 30 min or less.
- Engine cannot get up to operating temp and pressure to burn out naturally occurring carbon deposits from the combustion process – black liquid like soot running from joints and couplings in the exhaust system.
- Accelerated wear of certain engine components.
- Limited output of the gen-set.
- Can cause fire.

Prevention:

- Inspection Program – Weekly and monthly by site personnel. Quarterly by an experienced generator service provider where the exhaust system is visually inspected for indicators of wet stacking.
- Annual load bank test where the engine is loaded at least 50% (80-90% recommended) for at least 30-60 minutes (depending on load factor) measuring all critical pressures, temps and output.
- Install a permanent load bank on site to allow for more frequent loading of the engine to ensure health of the generator and save money on your annual maintenance budget.

Generator Systems Maintenance

9. Plugged Radiator Core

Possible Cause:

- Contamination in the coolant – oil, fuel, dirt – from a leaking cooler or engine system (engine slobber).
- Radiator Age – deteriorated / damaged core – excessive vibration, welding slag, separated components.
- Coolant Age – coolant naturally deteriorates over time.
- Wrong additive or wrong coolant introduced to the system.

Prevention:

- Inspection Program – Weekly and monthly by site personnel. Quarterly by an experienced generator service provider where the cooling system is checked regularly.
- Annual lab analysis of the coolant
- Replace the coolant at interval dependent on what type of coolant you are using (every 1, 3 or 6 years).
- Run a chemical flush of the cooling system to clean out obstructive material at the time of coolant change.

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10. Emergency Stop Button Engaged

Possible Cause:

- Vendor or employee used the E-Stop as a lock out method for working on or around the gen-set and forgot to disengage it before putting the gen-set back in service.

Prevention:

- Never use the E-Stop as a Lock Out method (battery or starter disconnect, gen breaker open – tag out all).
- Daily or weekly inspections by site personnel should verify the E-Stop is in the proper position.
- Install remote annunciation and/or monitoring as to the status of the E-Stop switch.

Generator Systems Maintenance

While there are no guarantees, here is what you can do to mitigate the risks:

- Design the best inspection, testing and maintenance program that fits your requirements – follow OEM recommendations.
- Pick the best Vendor to support your scheduled and unscheduled maintenance and repair requirements.
- Evaluate and implement upgrades and improvements to your equipment to enhance reliability and save money by making repairs and maintenance faster and more effective.
- Stock critical spare parts on site to mitigate down time in the event of a failure.
- Install remote monitoring – for a faster preliminary look at an issue and also for predictive indicators of a possible failure.
- Develop a close working relationship with your gen-set service provider.
- **Don’t forget about your UPS and Switchgear systems as well.**

Federal Air Quality Regulations

- Regulations applicable to spark ignition and compression ignition engines
- Tier 4 emission standards
- Emission standards for regulated pollutants
- Definition of emergency (standby)
- Hours an emergency/standby unit can operate
- Testing requirements

Objectives

- Increase awareness of air pollution control regulations applicable to engine-generators
- Discuss key federal regulations
- Provide framework for stack testing requirements

Abbreviations

- CO_2 – Carbon dioxide
- CO – Carbon monoxide
- DOC – Diesel oxidation catalyst
- HC – Hydrocarbons
- NMHC – Non-methane hydrocarbons
- NO_x – Nitrogen oxides
- PM – Particulate matter
- SCR – Selective catalytic reduction

Federal Requirements for Internal Combustion Engines

- **40 CFR Part 60, Subpart IIII – New Source Performance Standards (NSPS) for Stationary Compression Ignition Internal Combustion Engines (ICE) – 11 July 2006:**
  - Impose stricter emission standards for emergency generators and other ICE, based on model year, displacement, and function
  - Emission standards for NMHC, CO, NO_x, PM, and SO_2 – no standards for CO_2
  - Sulfur content of diesel fuel limited to 0.0015%
  - Certification from the manufacturer that the engine meets emission standards (USEPA Certificate of Conformity)
  - Units must have a non-resettable hour meter
  - Emergency engines - maintenance/testing limited to 100 hours/year
  - Must perform maintenance in accordance with manufacturer's recommendations
  - Records must be kept, including time/duration of operation and reason for use

Federal Requirements for Internal Combustion Engines

- **40 CFR Part 60, Subpart JJJJ - NSPS for Stationary Spark Ignition ICE – 12 June 2006:**
  - Require stricter emission standards for emergency generators and other ICE, based on model year, displacement, and function
  - Emission standards for HC/NMHC, CO, NO_x – no standards for CO_2
  - Units must have a non-resettable hour meter
  - Emergency engines - Maintenance/testing limited to 100 hours/year
  - Manufacturers are not required to certify engines; therefore, owner/operator must test engine to demonstrate compliance
    - Initial compliance testing if > 500 horsepower within 180 days of startup
    - Re-testing every three years or 8,760 hours, which ever occurs first
  - Must perform maintenance in accordance with manufacturer's recommendations
  - Records must be kept, including time/duration of operation and reason for use

What is an Emergency/Standby Generator?

- Emergency generator means a stationary combustion device, such as a reciprocating internal combustion engine or turbine that serves solely as a secondary source of mechanical or electrical power whenever the primary energy supply is disrupted or discontinued during power outages or natural disasters that are beyond the control of the owner or operator of a facility
- An emergency generator operates only during emergency situations, for training of personnel under simulated emergency conditions, or for standard performance testing procedures as required by law or by the generator manufacturer
- No limit on hours for emergency operations
- Limit of 100 hours per year for maintenance and testing
- Emergency generators are not required to be Tier 4 certified

What is an Emergency/Standby Generator? (Cont'd)

- A generator that serves as a back-up power source under conditions of load shedding, peak shaving, power interruptions pursuant to an interruptible power service agreement, or scheduled facility maintenance shall not be considered an emergency generator
- New non-emergency generators must be USEPA Tier 4 certified

Stack Testing

- Requirements
  - Almost all states allow for 180 days from startup to test and submit report
  - Submit test protocol/test date 30 days prior to testing
  - Test report due 60 days after complete testing
  - Almost all states require testing at >90% load of the engine so load bank is required

Stack Testing (Cont'd)

- EPA Methodology Requirements
  - Requires three 1-hour tests – 3 hours plus time in between for monitor calibration, equipment change out, etc.
  - Stack extension with ports
    - Must be at least three diameters long from the disturbance (SCR or bend in the piping)
  - Port location
    - Two 2" ports on a 90-degree axis at least two diameters from the disturbance and one diameter from the exit (may need larger port for PM or ammonia slip)
    - SCR/DOC: additional 1" port prior to the inlet to the SCR/DOC unit.

Stack Testing (Cont'd)

- Data Recording
  - Various engine and SCR/DOC (if included) operational data required to be recorded during testing:
    - Engine load recorded every 15 minutes: Engine percent output, kW output, Horsepower output, or fuel consumption
    - SCR/DOC data recorded every 15 minutes: Urea injection flow rate, Urea injection pressure, SCR catalyst bed temperature, or SCR/DOC pressure drop

Stack Testing (Cont'd)

- Take Away Message
  - Build in cost for stack extension and a load bank if required to test
  - Install ports at correct locations for testing
  - Test must be completed within 180 days of startup
  - State agencies require submittal of test protocol for review and approval no later than 30 days prior to testing
  - Always check with State air pollution control agencies for state-specific requirements

Combined Heat & Power (CHP) Technology

- The latest in **GREEN** Energy technology – lower energy consumption, low to no emissions, cleaner fuel, abundant supply of fuel.
- The generator becomes the primary supplier of power to the facility.
- Waste heat from coolant and exhaust is recovered for use as steam or hot water in boilers and chillers.
- The utility becomes the back-up power source rather than the primary.
- The combined thermal efficiency of the CHP generator system is over 80%, making it less costly than buying energy from the utility.
- The cost of the fuel and maintenance inputs can be significantly lower than the costs of purchasing them from the utility, resulting in 3- to 6-year paybacks on the capital investment.
- There are multiple government green energy grants available to consume a significant portion of the initial investment.
- Ideal candidate facilities have heavy and consistent thermal energy requirements year-round – hospitals, schools, hotels, manufacturing, government, etc.
- A multitude of product offerings are available in the market to cover electrical loads from 75kW up to over 10MW.

CHP Alternative Fuels

- Natural Gas
- Landfill Gas (Methane)
- Animal Waste (Chicken, Bovine)
- Tires

CHP Products

- Hot Water
- Heat
- Fertilizers
- **ELECTRICITY**

CHP Maintenance

- Units are intended to run 24/7, 365 days per year
- Exception comes from service repairs and general scheduled maintenance.
- Power by the Hour vs Traditional quarterly or annual maintenance agreements.
- Fast moving parts to keep on hand include; spark plugs and transformers, air filters, oil filters.
- To keep maintenance cost at minimum, the layout of the facility is key.

CHP Maintenance (Continued)

- 250, 1000, 1500, 2000, 4000-hour services.
- Top End, overhauls, gear box maintenance, frequent coolant flushes. Spark Plugs and cylinder heads.
- BTUs and gas analyzers.
- Alternator end rebuilds or replacement.

QUESTIONS?

THANK YOU!

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