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THE POWER PEOPLE SINCE 1912

GENERAC®
INDUSTRIAL POWER

Generator Operation and Maintenance

POWER RESILENCE for Water and Wastewater Utilities

Overview

- Resources and planning to help prepare for Power Outages
- Areas of Focus:
  - Component review
  - Power Assessment / Sizing
  - Emergency/Standby Generator Application
  - Fuel Types / Maintenance
  - Maintenance and Performance

Introduction

- **Standby Generators** are self-contained systems that provide electricity when primary source is unavailable.
- **Automatic Transfer Switch** (ATS) signals the standby generator to start at power lose, transfers to connect Emergency power to loads and automatically re-transfers to normal when grid is available and signals generator to stop.
- Fuel Sources, diesel fuel, propane, natural gas, or other liquid fuels and operate for a limited amount of time, not meant for extended use.
- This presentation is an overview of system components, maintenance requirements, and best practices for efficient operation of standby generators.

Generator Components

1-Engine—provides mechanical energy, engine's type and size determine generator's fuel use and power output.

2-Generator—converts mechanical energy into electricity.

3-Fuel supply—Sub-base fuel tank, delivery piping, diesel fuel pump, fuel filter, injectors.

4-Lubrication—assures smooth operation and protects against wear; typically housed in a sump or reservoir.

1. Engine
2. Generator
3. Fuel tank
4. Lubrication system
5. Cooling system
6. Starting system
7. Exhaust system
8. Control panel
9. Air intake system
10. Batteries

Generator Components

5-Cooling System— cooling pump, coolant fluid, radiator fan.

6-Starting System—cranks engine rotation for starting.

7-Exhaust System—directs exhaust gases to an appropriate location.

Generator Components

8-Control Panel— system controller manages and monitors generator operation. generator, oil pressure, coolant temps, current, voltage, and frequency.

9-Air Intake System—directs and filters combustion air entering the engine.

10-Batteries—provides power for starting

How water sector utilities can increase power resilience:

1. **Communication** – Establish communications with electric providers, local agencies, and the public to help your utility respond quickly and efficiently to a power loss.

2. **Power Assessments** – Conduct power assessment to understand essential equipment energy needs.

3. **Emergency/Standby Generators** – Select, Size & Maintain, fixed or portable emergency generators.

4. **Fuel** – Develop plans to ensure enough usable / reliable fuel is available during power outage.

5. **Energy Efficiency** – Increase energy efficiency to operate on back-up power longer during emergencies and to reduce your electricity bills during normal operations.

EPA epa.gov/waterresilience

Power Assessments

- Power assessments determine emergency power requirements for critical equipment to maintain water and wastewater services.

- Critical infrastructure components; include treatment processes, key pumping stations. This information is required to properly size emergency generator(s).

- You can learn more about power assessments and generators in online courses, IS-815: ABCs of Temporary Emergency Power, offered by the Federal Emergency Management Agency (FEMA) Emergency Management Institute. https://training.fema.gov/is/courseoverview

Conduct Emergency Power Assessment

• Conduct a Self-Assessment – Perform your own emergency power assessment, consider the assistance of a qualified power assessment team.

• When you upgrade or build new components, re-assess your power requirements.

• Periodically review and update your emergency power requirements.

• If possible, conduct a hydraulic model-based assessment of how performance measures would be impacted when your facility is powered by generators instead of the electric grid, and how failures of one or more generators would affect performance.

• Consider installing stationary generators with automatic transfer switches at all “critical” facilities.

Keep Records of Your Assessment

• Maintain copy of all information from the power assessment for easy access during emergencies. Have summary of power requirements, site locations, and capacity of any existing on-site generators at all critical infrastructure components.

• Generator-specific information requirements; kilowatt, voltage, and phase of the generator required.

• Assessment should include the GPS latitude and longitude or address location of critical equipment.

• Assessment should include a basic order of materials, number and length of cables needed to connect generator to electrical system.

Emergency Standby Generators

- Power assessment can help in sizing your generator(s). Key components:

    1. Voltage - Generator must have the appropriate voltage.
    2. Load - You must know Full startup (inrush power) in kWs needed to start motor load. There are formulas for calculating this value.
    3. Phase (Rotation) –Confirm direction of the motor rotation (i.e., clockwise or counterclockwise).

    - Determine whether portable or stationary generators work best for your critical infrastructures.

    - If your electric demands are significant, and critical, consider stationary generators for immediate starts.

Mobile or Stationary?

Buy, Rent or Borrow ?

Your state's WARN (Water and Wastewater Agency Response Network) can be a resource to borrow a generator.

• Know your local EMA managers, critical to receiving a state or federal generator if available.

• Private vendors sell or rent mobile generators (pros and cons). If you plan to rent a generator, set up a contract with a vendor.

- Buy your own to store in central location for emergency use.
  - Consider available options for Funding i.e. Grants / Sourcewell type programs.

Generator Sizing – Significant Loads

Design Considerations and Best Practices

- Size generators for full load of plant
  - Generally two smaller generator units are preferable to one larger
  - Establish critical loads for plant
    - Can vary depending on the length of the outage
  - Connection to existing electrical distribution system
    - Minimize potential breakpoints
    - Plan most direct route for flow of electric
- Startup time
  - Assume worst case of highest expected flow
  - Can vary depending on plant configuration
  - Must account for resetting equipment and SCADA
- Fuel Considerations
  - Average length of outages
  - The effects of fuel storage as well as engine type
  - General rule of thumb would be 72 hours at full load

Quality of Effluent

Fuel Type

Fuel type is an important consideration for selecting a generator. What are the Options ?

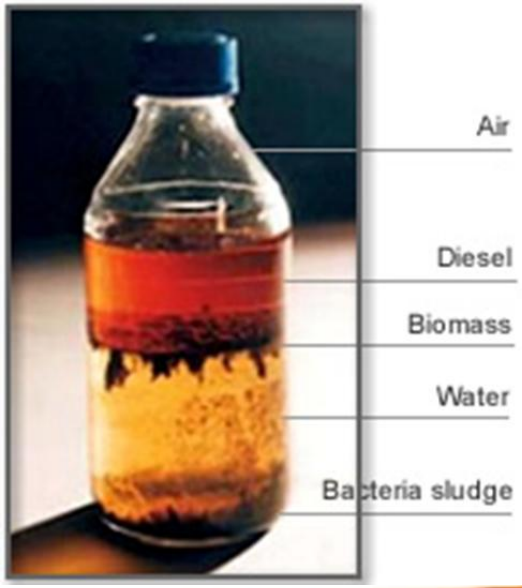
- Diesel generators most common, offer the largest selection, availability and power range.
- Natural gas generators do not require truck refueling, offer extended run times.
- Smaller applications might consider portable, gasoline powered generators.

Diesel Fuel Maintenance

- **Diesel Fuel Must be Maintained to be Reliable**
  - A.7.9.1.2

    *"Fuel **<u>maintenance</u>** and testing should **<u>begin the day of installation</u>** and first fill to establish a benchmark guideline for further comparison."*

  - Diesel failure modes
    - Moisture
    - Gelling
    - Biomass
    - Fuel instability / varnishing
    - Storage / leakage
    - Fuel transfer system
    - Running out



Diesel Fuel Reliability

- **How much fuel is enough?**
- **How much fuel is too much?**

NFPA 110 A.5.5.3

"Consideration should be given to sizing tanks in order to meet minimum fuel supplier delivery requirements, particularly for small tanks.

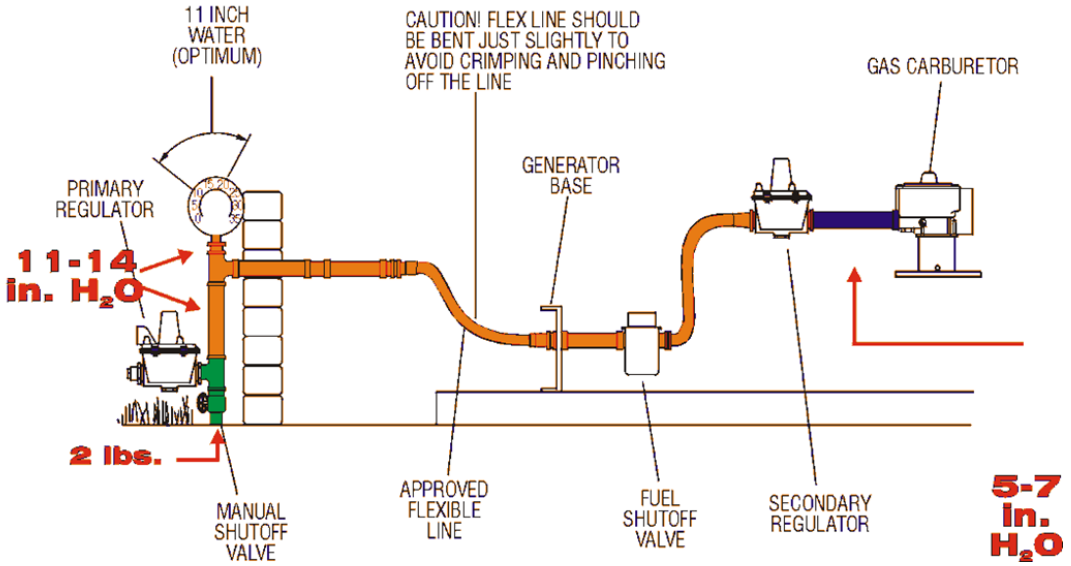
"Consideration also should be given to over-sizing tanks… Where fuel is stored for extended periods of time (e.g., more than 12 months), it is recommended that fuels be periodically pumped out and used in other services and replaced with fresh fuel."

"Prudent disaster management could require much larger on-site temporary or permanent fuel storage, and several moderate-sized tanks can be preferable to a single very large tank."

- Fuel Strategies
  - Manageable amounts of diesel (tank size – 24 hrs)
  - Strong fuel maintenance or fuel exchange programs
  - Replace diesel with natural gas generators

Gas Piping Requirements

- Meet generators needs: pressure regulators, pipe sizing, flexible fuel lines, etc. (7.9.9)
- Tapping ahead of the building's main shutoff (7.9.7)
- Securing shutoff valves (A.7.9.7)



Propane Requirements

- **Propane**
  - On-site fuel
  - Considered reliable by AHJ's
  - Often configured as dual fuel
  - Fuel doesn't degrade
  - Fuel level sensing required (5.5.2)
  - Dedicated fuel supply for vapor withdrawal (5.5.1.1)
  - Cold weather boil-off rate considerations (7.9.9 (9))
    - Bury the tank
    - Use LP liquid withdrawal & vaporizer (outdoor generators)

Generator Connection to Loads - Manually

Generators require special connections, or a transfer switch, to connect to facility's

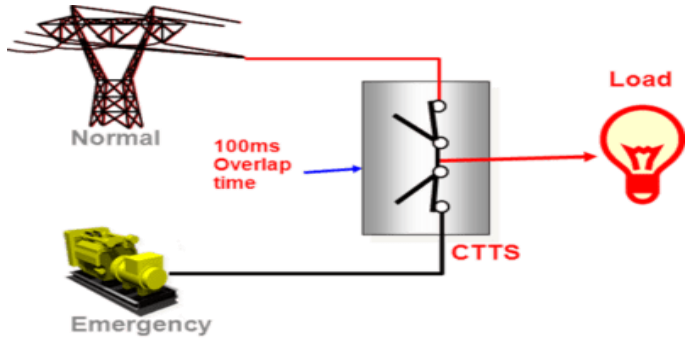
• Consider installing a manual transfer switch if facility or equipment do not need automatic transfer. *Dispatch time to access site should be considered in the determination of a manual versus automatic transfer switch.*

• The connection type for portable generators must be considered when sharing resources or ordering from an outside vendor. Examples of some known plug types are Appleton, Crouse Hinds, single cable cam-locks, hardwired, and outside building tap-box

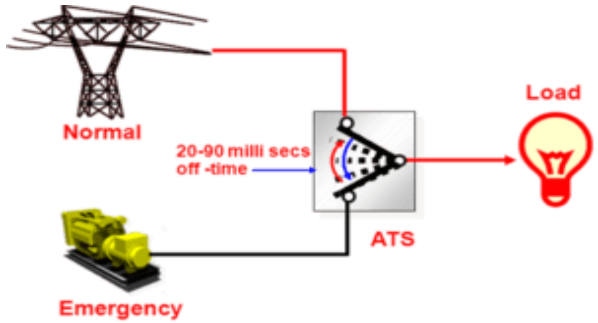
• *Ensure that personnel responsible for manual transfers receive appropriate training on switch operations.*

Generator Connection to Loads – Automatically

- Automatic transfer switches move from grid to generator at unmanned facilities or at critical equipment.



- Consider connecting sites into (SCADA) system to know when the automatic transfer switch has been activated.
- Consider Closed Transition Transfer switches to minimize transients during testing
- Motor load transfer provisions – In-phase and time delay neutral are common



Transfer Switches

- **Paralleled generation** (6.3)
  - Priority loading and load shedding (6.3.1)
- **Bypass-Isolation allowed** (6.4)
  - But not required within NFPA 110
- **ATS must have adequate capacity**
  - Normal intended loading (6.1.4)
  - Fault current (6.1.5)
- **Service Entrance Rated**

PREVENTATIVE
MAINTENANCE PROGRAM

- If Generators are not maintained, they will not function properly during emergencies.
- Adopting preventive and predictive maintenance programs are critical for assuring generator systems functions properly.
- Maintenance requirements for generators vary, be sure to have qualified, trained personnel performing scheduled maintenance as recommended by the manufacturer.

Maintenance Checklist

Component	Action	Maintenance Frequency			
		Weekly	Monthly	Bi-Annually	Annually
Electric Generator	Run generator with no load for several minutes until operating temperature is achieved; verify control function and look for alarms, warnings, or indicator lights.	X			
	Inspect engine, radiator, and generator for debris, as well as for loose or broken fittings, hoses, wires, and guards.	X			
	Run the system for 1 hour under a full building load initiated by ATS. Record the system operating parameters (e.g., coolant temperature, oil pressure, battery voltage, and generator alternating current voltage).				X
	Perform load bank test.				X

Maintenance Checklist

Component	Action	Maintenance Frequency			
		Weekly	Monthly	Bi-Annually	Annually
Fuel System	Check fuel tank to assure levels are adequate and, if present, drain water from filter bowl.	×			
	Assure there are no fuel or other fluid leaks.	×			
	Inspect accessible areas of fuel tank for damage and corrosion. Verify that emergency vent components move freely and are not obstructed (all tanks).				×
	Replace fuel filter(s).				×
	Inspect fuel hose, replace if necessary.				×
Lubrication System	Check oil level and inspect system components for leakage.		×		
	Sample oil.			×	
	Grease generator bearing (if applicable).				×
	Replace oil and oil filter (based on oil sample results) and inspect system components.				×
	Replace engine oil hoses if necessary.				×

Maintenance Checklist

Component	Action	Maintenance Frequency			
		Weekly	Monthly	Bi-Annually	Annually
Cooling System	Inspect hoses and belts, replacing if needed, and verify that the engine block heater is operating properly.	X			
	Check engine coolant level.		X		
	Check coolant lines and connections.			X	
	Check coolant condition with kit/test strip, replace if needed.				X
	Inspect and adjust belts, verify engine block heater is operating, check radiator cap (replace cap if gasket is cracked or damaged), clean exterior of radiator, inspect fan shroud, and inspect system components.				X

Maintenance Checklist

Component	Action	Maintenance Frequency			
		Weekly	Monthly	Bi-Annually	Annually
Starting System	Assure that the generator is in “Auto” mode for automatic start-up.	X			
	Clean battery connections and apply corrosion inhibitor. Check starter motor and charger connections and inspect system components.			X	
	Check battery electrolyte level and specific gravity.			X	
	Inspect and clean engine speed timing sensor.				X
Exhaust System	Perform visible emissions observation.	X			
	Clean crankcase breather and inspect system components.			X	
	Inspect exhaust system, muffler, and exhaust pipe.			X	

Maintenance Checklist

Component	Action	Maintenance Frequency			
		Weekly	Monthly	Bi-Annually	Annually
Electrical System	Check that the generator's circuit breaker is closed.	X			
	Clean out electrical boxes, panels, and alarm boxes. Inspect wiring.			X	
	Inspect and clean ATS contacts and wiring.				X
Air Intake System	Inspect air intake system. Replace filter if needed.			X	
System Documentation	Record all run hours.	Upon activity completion			
	Document all maintenance activities in log book or electronic computerized maintenance management system.	Upon activity completion			

Generator Operation and Maintenance Tips

- Regularly run generators under full load for extended periods.
- Test generators under load, 50%, 75%, and 100% for expected loads.
- Perform additional maintenance if generator is planned to run for scheduled outages.
- Record all maintenance activities.
- Consider send oil samples to be tested for the presence of metals.
- Test fuel for viability. Consider fuel conditioning or fuel maintenance programs.

PREVENTATIVE
MAINTENANCE PROGRAM

- Single Point of Contact Whether you have one location or a thousand.
- Single point of contact is key.
- Gain piece of mind with record retention and consistency with one source for all your service and parts needs.
- Periodic maintenance ensures maximum performance for years of reliable service and protects your investment.

Emergency Contact

Emergency Assistance –

- Having service available 24/7/365 is crucial to the success of your backup power system.

- While downtime is unexpected, it is also unacceptable. Engaging with a reputable service provider to provide quality Preventative Maintenance Programs and Emergency Response services is highly recommended.

Did you know?

During Hurricane Sandy, many generators failed after 24 to 48 hours because they had not been properly exercised and maintained.

Thank you!

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