ENGINE-GENERATOR SYSTEM

Scope

When required by code or to satisfy a special program requirement, provide a natural gas fueled engine-generator system. The University considers the probability of a simultaneous failure of both the natural gas utility delivery system and power from the outside electrical utility to be low. Provide a diesel engine-generator system only when a hospital code or the performance requirements cannot be met using a natural gas fueled system.

Related Sections

U-M Design Guideline Sections:
SBA 5.11 – Fire Command Center
210000 – Fire Protection
230060 - Mechanical Sound and Vibration Control
230900 – Mechanical Systems Controls
260526 – Grounding and Bonding for Electrical

U-M Master Specification Sections:
231123 – Natural Gas Systems
263000 – Engine-Generator System

U-M Standard Details:
260000 Series - Electrical Standard Details

Reference Documents
Environmental Protection Agency (EPA) emissions standards for stationary internal combustion engines
NFPA 37, "Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines"
NFPA-110, “Standard for Emergency and Standby Power Systems”
UL 1008, "Standard for Automatic Transfer Switches"
UL 2200, "Standard for Stationary Engine Generator Assemblies"

Design Requirements

Use U-M Master Specification 16231 to specify the engine-generator and associated automatic transfer switches and accessories. Edit Specification 16231 to make it project specific. Turn on hidden text and follow the Spec Editor notes when editing the specification.

Arrange for studies to determine how the unit's sound, vibration and effluent will impact the building and surrounding buildings. Perform these studies early in project design to avoid last minute design changes. See Design Guideline 15240 for applicable sound and vibration limits.

Divide the generator's emergency and standby loads into multiple blocks of load. Sequence the load blocks to start at least 10 seconds apart. Avoid starting more than 50 percent of the generator's full load at one time.

System Requirements

Provide a stationary, standby-rated engine-generator unit with automatic transfer switches, load testing means, and accessories in compliance with NFPA 110 Level 1 and UL 2200. The system shall be designed for full load operation in a Seismic Category A area over a temperature range of minus 22 degrees F to 104 degrees F at an elevation not exceeding 1,000 feet above sea level.

Provide a factory EPA Certified engine to meet the current EPA exhaust emissions standards for engine-generators operated no more than 500 hours per year and no more than 100 hours per year in a maintenance/test mode. When a factory EPA Certified engine is not available, the engine shall be EPA Compliant Capable and the supplier shall provide the first field certification of EPA emissions compliance as part of the field start-up and performance testing.

Evaluate locating the engine-generator in a room versus locating it in an outdoor enclosure.

- Consider initial cost, ease of maintenance, ease of major component replacement, fuel and exhaust piping routes, heat rejection, feeder cable lengths, sound, vibration, etc.
- For non-Regental projects, obtain Exterior Elements Design Review Committee approval before locating a unit or exhaust stack outdoors where visible to the public.

Specify the unit's maximum physical size. Specify its maximum allowable sound (including the load bank) and maximum allowable vibration based upon the sound and vibration studies.

Evaluate the need for an 800 amp generator backfeed tap box to connect a portable engine-generator to an 800 amp unit substation feeder breaker during unit substation maintenance. If required, design the tap box in accordance with Standard Detail 16313004. Locate the tap box at the loading dock or where a portable generator can be parked adjacent to it.

When multiple units are being provided and they will be operated in parallel, the engines shall utilize the same fuel type and the generators shall be wound with a 2/3 pitch.

When multiple units will be operated in parallel, divide their loads into multiple blocks, prioritize them and control them so the highest priority blocks receive power even if one unit fails.

Engine-Generator Sizing

Size the unit based upon its 100 percent standby rating.

Size the unit using generator sizing software from one of the specified manufacturers. Provide sufficient capacity to start the unit's largest block of load while all other loads are running, without exceeding the specified maximum voltage or frequency drop.

Provide 25 percent spare capacity above the peak projected load to feed future growth.

Engine-Generator Load Testing

For units under 1,000 kW, load testing shall be performed using a resistive load bank.

- For an outdoor unit in an accessible location on grade, the Plant Electrical Technical Shop will connect a portable load bank to load test the generator. No permanent load bank is required.
- For an indoor unit or an outdoor unit not in an accessible location on grade, provide a permanent, 100 percent rated, resistive load bank with integral control panel.
  - Specify the direction of heat discharge and show the direction on the drawings.
  - Provide a load dump circuit to immediately trip the load bank if a loss of normal power occurs during a load test. Show the control wiring on the drawings.
  - Provide a digital monitoring system with memory to display and log generator volts, amps, kW and frequency.

For units 1,000 kW and above, specify the most heavily loaded ATS as a soft-loading ATS. Only one ATS can be soft-loading. Usually the best choice is the required standby power ATS.

- Size the soft-loading ATS for at least 70 percent of generator full load. Size the ATS feeder cable from the generator, the ATS feeder cable from the unit substation, and the unit substation feeder breaker to match the ATS size. The generator shall be load tested to at least 70 percent by paralleling with and back-feeding through the unit substation.
- Provide shunt trip units on the unit substation and generator breakers that feed the soft-loading ATS. Provide conduits and control wires from the soft-loading ATS to trip the shunt trips.
- Calculate the voltage relay, current relay, time delay and soft-loading control settings of the ATSs in accordance with manufacturer's instructions. Provide the settings in table format to U-M for approval prior to ATS startup.
- When the elevators are supplied generator emergency or standby power, do not supply the elevators from the soft-loading ATS.

Automatic Transfer Switches

Specify the automatic transfer switches (ATSs) to be provided as part of the engine-generator package. Do not specify them separately.

- Provide 3 pole ATSs rather than 4 pole except where the generator neutral is grounded, the generator feeds multiple buildings, or 4 pole ATSs are required by code.
- Provide open transition ATSs to feed loads that can withstand interruptions and will restart automatically after transfer to and retransfer from the generator.
- Provide closed transition ATSs to feed loads including elevators that will need to reboot or will not restart automatically after retransfer from the generator.
- Provide a soft-loading ATS when required for periodic engine-generator load testing.
- Verify the ATSs are adequately rated for the full amount of fault current available. Add in the generator fault contribution if the ATSs are closed transition or soft-loading.
- ATSs shall include full manual bypass.
- One ATS shall include a programmable generator exerciser time clock.

Natural Gas Fuel System

Contact DTEEnergy and ascertain the range of natural gas pressure available at the outlet of the DTEEnergy regulator. Update Specification 16231 to specify this gas pressure range.

Size the gas piping system for negligible pressure drop at maximum gas flow. A frequent cause of generator problems is undersized gas piping.

Provide gas piping in accordance with NFPA 37, a gas regulator at the engine in compliance with the engine-generator manufacturer's recommendations, and a gas pressure gauge downstream of the gas regulator.

Obtain the approximate dimensions of the DTEEnergy gas meter train (often 12 feet or more in length) and locate the meter train where it won't detract from the building's appearance. Provide concrete-filled steel pipe bollards with yellow PVC jackets where appropriate to protect against vehicle impact.

Engine Exhaust System

Design the exhaust system in accordance with the results of the exhaust effluent study and in accordance with engine-generator manufacturers' instructions.

- Provide a flexible section to isolate the exhaust system from engine vibration.
- Calculate the exhaust system's expansion and contraction with temperature, and provide supports, slides and restraints as required.
- Direct the exhaust upward rather than horizontal, and away from buildings, trees, plants and anything else that is combustible.
- Provide a hinged, flapper style rain cap at the top of the exhaust stack. Do not provide a stack termination that deflects exhaust horizontally, including an inverted cone style cap.
- Provide a manual blowdown valve in a pipe tapped into the lowest point of the exhaust system, and pipe the discharge to a bucket on the floor.

Provide a silencer with 35 dBA minimum attenuation when the engine-generator is located in or near an occupied building. Provide a silencer with 25 dBA minimum attenuation when the engine-generator is located remote from occupied buildings. Provide a higher attenuation silencer when required by the results of the sound study.

A natural gas unit will require a 3-way catalytic converter. A diesel unit may require a catalytic converter or at least a particulate filter. Integrate the catalytic converter or particulate filter with the silencer if possible. Provide access for maintenance of the catalyst or filter.

Controls and Indications

Provide an NFPA 110 compliant control panel mounted on the engine-generator no more than 78 inches above the finished floor to the top of the panel, including the concrete housekeeping pad.

When the unit includes multiple accessories requiring power, provide a 208Y/120 volt, three phase load center panel to feed the battery charger, water jacket heater, and any electric lube oil pumps, motorized dampers, lights, and receptacles. Feed the panel with standby power.

Provide a guarded, remote manual stop station in accordance with NFPA 110. Locate it on the outside of the generator room or enclosure near the latch side of the door. Label it with a laminated plastic nameplate, white letters on a red background.

When the building is classified as a high rise building and it includes a Fire Command Center, provide a remote generator annunciator panel in the Fire Command Center. Otherwise, provide a remote annunciator panel in a location where it will be readily visible to maintenance personnel. The remote annunciator panel shall mirror all status indicators and alarms contained on the engine-generator control panel.

When the building contains a Fire Command Center, provide a generator remote "Auto-Run" switch and ATS status indicators in accordance with Design Guideline SBA-J.

Connect "generator running" and "generator trouble" output contacts to separate points in a Building Automation System (BAS) DDC panel. Show these DDC points on the drawings.

Connect in series an "on generator power" auxiliary contact in each ATS to a single point in a DDC panel to notify BAS if any ATS transfers to generator power. Show this DDC point on the drawings.

Do not connect any generator or ATS output contacts to MOSCAD or to the fire alarm system.

Do not use ATS auxiliary contacts to control mechanical systems because false mechanical system operation can occur during ATS testing and maintenance.

Generator Room Requirements

Separate the generator room from occupied areas or provide sound-proofing so engine-generator noise will have minimal impact on surrounding areas. Provide sound attenuation at intake and exhaust dampers when required by the results of the sound study.

Extend the walls from the floor to the deck above. CMU block walls are recommended for noise mitigation and safety. Where required by code, provide fire-resistance rated walls and doors.

Provide the NEC-required working spaces on all sides of each piece of electrical equipment. Provide the NEC-required dedicated equipment space above each piece of electrical equipment.

Provide a minimum of 2 exit doors on opposite ends of the room if the generator is rated 1200 amps or more.

- Exit doors shall swing outward from the room.
- Exit doors shall be equipped with panic bars. Double doors require only a single panic bar.
- One door shall be large enough for passage of the largest piece of the unit.

Provide a 4 inch minimum concrete housekeeping pad with chamfered edges under each piece of floor-mounted equipment. The engine-generator housekeeping pad shall be steel reinforced in accordance with the engine-generator manufacturer's instructions.

Provide 2 coats of water-borne epoxy paint over a compatible primer on the concrete floor.

Provide paint or a concrete sealer on concrete walls and ceilings.

Provide a 10 pound Type ABC fire extinguisher at each exit door.

Provide an unobstructed route to the building exterior to permit replacement of the engine or generator. Design the floor of the entire route for the weight of the heaviest piece of the unit.

Provide a route to move drums of oil and other large maintenance items to the generator room.

In below-grade generator rooms, provide a floor drain tight to a side wall.

- Provide a backwater check valve for the floor drain.
- Provide a water leak detector adjacent to the floor drain and tight to the wall so it isn't a trip hazard. Connect its alarm contact to a Building Automation System DDC panel, and show this DDC point on the drawings.

Provide a propylene glycol or dry pipe sprinkler system in accordance with Design Guideline 15300. A wet pipe sprinkler system shall not be used.

- Locate the sprinkler heads and route the piping over aisles, not over electrical equipment.
- Provide wire guards on the sprinkler heads.

Provide motorized dampers fed by generator power for combustion and cooling air in accordance with Design Guideline 15975 and engine-generator manufacturer's instructions.

- Size the dampers for less than 500 feet per minute air flow. Provide calculations to document compliance.
- Provide louvers exterior to the dampers when the dampers are visible to the public.

Provide generator power to the controls associated with combustion air, ventilation air and other systems that must operate when the engine-generator is operating. Provide generator power to any pumps providing fuel or cooling water to the engine-generator.

Provide unit heaters to maintain room temperature above 45 degrees F when the unit isn’t running.

Provide grounding in accordance with Design Guideline 16450.

Provide manually-switched fluorescent lighting and connect it to an emergency power circuit. Provide a battery-backed emergency lighting fixture to light the engine-generator control panel.

Provide exit signs above the exit doors.

Provide a fire alarm system horn/strobe or speaker/strobe.

Provide duplex receptacles and connect them to standby power.

Outdoor Enclosure Requirements

Provide the engine-generator manufacturer’s standard weather-protective, non-walk-in outdoor enclosure for most projects. When recommended by the results of the sound study or when the engine-generator is adjacent to an occupied building, provide an appropriately rated walk-in, sound-attenuating enclosure.

- Provide a floor unless the enclosure will be fastened down to a level concrete pad. Enclosures that are open on the bottom to air or grating are not acceptable.
- Provide clearance above the radiator cap to permit viewing down into the radiator without using a mirror, and to permit adding coolant without using a pump.
- Provide access and clearance around the engine and generator for routine maintenance.
- When providing a walk-in enclosure, provide manually-switched, cold weather starting fluorescent lighting and at least two duplex receptacles.

Installation Requirements

The engine-generator, automatic transfer switches, load bank, accessories and supporting systems shall be shall be installed, adjusted and tested in accordance with Specification 263000 and the other Division 23 and 26 specifications.