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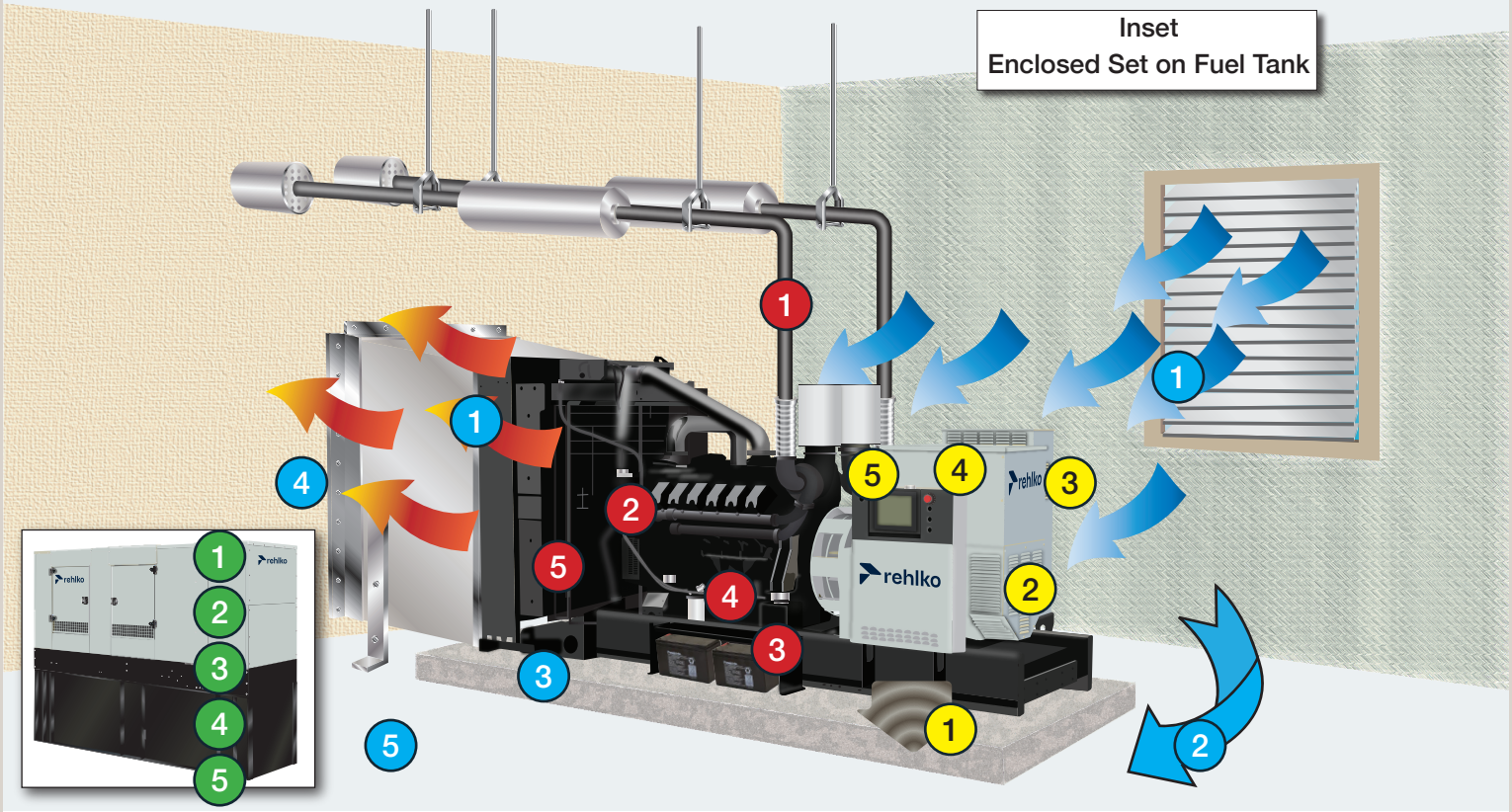
An engine-driven generator system is a complex assembly of many electrical and mechanical components. It follows the principles of electromechanical energy and electromagnetism to convert fuel energy into mechanical energy and then drive a generator to produce electrical energy. The combination of many technologies means a generator is a system subject to many disciplines. Designers, instructors, operators, and service technicians have to be aware of all the codes and governing bodies to ensure the safe operation of an assembly of many components. Engines combust fuel to drive heavy rotating components that, in turn, drive a generator to convert mechanical energy into electrical energy and must be safely delivered to the connected load. As such, a generator safety covers many disciplines. This information sheet discusses the various codes that cover generator safety, both electrical and mechanical, and introduces the reader to the key elements and best practices for safe operation of a generator system.

1.0 THE COMPONENTS WITHIN A GENERATOR SYSTEM:

Generator safety is not just about safely managing the electrical energy generated, but also managing the individual components that make up a complete generator system. These components include: (Continued Over).

Figure 1

Generator System Safety Points



Key Safety Points and Applicable Codes to Maintain Generator Safety

Installation		Electrical		Burn Hazards		Fuel System		Applicable Codes	
1	Ventilation	1	Grounding to code	1	Exhaust gases	1	Check for leaks	NEC	Wiring Grades
2	Free access	2	Insulation	2	Engine surfaces	2	Flexible connections	NEMA	Circuitry
3	Firm level mounting	3	Wiring condition	3	Battery acid/cables	3	Copper/steel piping	NFPA	Safety
4	Flexible connections	4	Check as NEC specs.	4	Lube oil	4	Double walled	OSHA	Safe operation
5	No clutter	5	NEMA	5	Coolant	5	Easily accessible	UL	Design/Build

1.1 ENGINE/PRIME MOVER – The principal safety code covering the engine is the Occupational Safety and Health Administration OSHA. Most codes covering equipment are not legally mandated, but adopted by manufacturers and users to ensure compliance with local codes that refer to particular codes recommended by independent bodies, such as the National Fire Protection Association (NFPA). However, OSHA is legally mandated to protect users' and operators' safety. Engines are moving pieces of equipment where all the moving parts have to be guarded, all hot sources protected from inadvertent touching, and any related electrical and fueling components designed with operator safety in mind. OSHA can levy large fines for any violations. EPA regulates exhaust emissions for various applications, such as standby, prime, and mobile.

1.2 GENERATOR – Apart from OSHA regulations, generators must be designed and manufactured to meet best practices. Entities such as NFPA influence best practice, which sets wiring codes through the National Electrical Code (NEC).

NEC protects anyone who works or lives in a building with electrical wiring. At the same time, NFPA 70, as dictated by NEC, is the benchmark for safe electrical design, installation, and inspection to protect people and property from electrical hazards.

1.3 CONTROL GEAR – Controls for the generator and standby generators equipped with Automatic Transfer Switches (ATS) are regulated by the National Electrical Manufacturers Association (NEMA). NEMA focuses on electrical standards as an industry trade association.

1.4 ELECTRICAL WIRING – NEC sets the standards for defining the correct cable sizes to manage certain amperages. It also provides color indication for defining the wires within an electrical circuit. *See information sheets on codes for cable sizes and color codes*.

1. 5 FUEL TANKS – Fuel tank design and management are governed by the Underwriters Laboratories (UL), which tests and certifies products to ensure they meet safety standards. UL codes set the standards for safe storage and management of fueling systems.

1. 6 COMPLETE GENERATOR SYSTEM – In addition to individual component safety codes, a generator system, enclosed or open, if it follows best practice, is designed and manufactured to UL standards, particularly UL2200. UL 2200 is the standard for the safety of stationary engine generator assemblies. *See the information sheet on UL2200.*

2.0 GENERATOR BEST PRACTICES FOR SAFE OPERATION:

While manufacturers design and assemble generator systems following the standards set by bodies such as NFPA, NEC, OSHA, and UL, to ensure safety, installers, users, and operators also have to follow the industry standards regarded as Best Practice:

For safety best practices ***See Figure 1***

2.1 INSTALLATION – In a stationary application location, mounts and wiring are critical:

- **Location -** If located inside, adequate ventilation and louvers should be allowed for air input to cool the engine radiator and generator end, with outlet louvers and air ducting to exhaust hot air from the generator room.
- **Free Access -** The generator should be positioned to allow free access for maintenance and inspection, and placed away from combustible material.
- **Mounting -** Generators should be mounted to a rigid surface, preferably a concrete plinth as recommended by the manufacturer, and if required, fitted with vibration isolators. Flexible connections for exhaust, inlet louvers, outlet louvers, fuel lines, etc, should be used between the generator and adjacent surroundings.

2.2 ADDITIONAL SAFETY CONSIDERATIONS FOR MOBILE GENERATORS – In addition to stationary generators, mobile generators include:

- **Trailer -** Must be to DOT standards for towing on the highway. Check the wheel and tire condition.
- **Positioning -** Verify that hitch and couplings are secure on a level, firm surface using chock blocks for leveling.

2.3 SAFETY SHUT DOWN DEVICES – Protection devices will shut down the generator is various components are outside limits:

- **Engine -** Fit shutdown switches for high engine temperature, low oil pressure, high oil temperature, and overspeed.
- **Generator End -** Shutdown switches for high/low volts, circuit breakers high amps/short circuit, and high/low frequency.

2.4 OPERATOR SAFETY GUIDE LINES – Any personnel checking or working on the generator should note the following:

- **Burn Hazards -** Do not remove/replace radiator cap while engine is hot. Do not remove the coolant drain plug while the coolant is hot. Do not remove the engine oil drain while the oil is hot. Allow sufficient cooling time before commencing maintenance.
- **Battery Safety -** Keep battery charges and avoid the build-up of combustible gases. Replace worn cables. Recharge the battery in a vented environment. Rinse the skin and eyes if they come into contact with battery liquid.
- **Electrical Safety -** Only a qualified generator technician should work on electrical equipment. All wiring should be made and maintained within NEC and local codes. Check cables for fraying and other defects. Don't lay cables in water. Never touch output terminals without protection gear and approved metering. Do not connect to the location load without a correct device, such as an ATS or a bypass isolator switch.
- **Grounding for Safety -** Correct grounding is a critical element of generator safety. Verify whether the generator is a separately derived or non-separately derived system where neutral is solidly bonded through the system. *See the information sheet on this grounding.*

3.0 NFPA PLANNED SERVICE LEVEL 1 AND LEVEL 2, AND PLANNED MAINTENANCE:

A key factor for ensuring generator safety is having a solid maintenance program in place. As a moving piece of equipment is subject to wear and tear, over time, components within the system will no longer function as originally designed and assembled. NFPA 110 was drafted to ensure that standby generator systems are maintained and ready to run as required within all their design criteria. While NFPA was implemented to ensure equipment was prepared to supply critical loads, it demonstrates that the likelihood of unplanned equipment failure is reduced if a planned maintenance program is implemented. See the information sheet on NFPA 110.

To fulfill our commitment to be the leading supplier in the power generation industry, the Buckeye Power Sales team ensures they are always up-to-date with the current power industry standards as well as industry trends. As a service, our Information Sheets are circulated on a regular basis to existing and potential power customers to maintain their awareness of changes and developments in standards, codes and technology within the power industry.

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