Schebler
CHIMNEY SYSTEMS

WHITEPAPER

GENERATOR EXHAUST SYSTEMS

The Certainty of Factory-Built UL Listed Products

EXHAUST CHALLENGES WITH VENTING SYSTEMS

The use of gas-fired and diesel-fueled generators for backup power and co-generation is increasing. That's due to factors such as higher demand on the current electrical infrastructure and the need to improve overall efficiency to ensure uninterrupted power.

Implementing engine-driven systems in high-occupancy buildings and central power plants creates challenges, like the need for complex routing of venting systems to exhaust the units safely. For example, systems inside a building often require the exhaust to be routed up through the roof, up the side of the building or to a free-standing stack. In comparison, simple backup generator systems outside a building are often exhausted directly out of the top of the units.

THE BENEFITS OF FACTORY FABRICATION VS. FIELD FABRICATION

Generator exhaust systems have traditionally been fabricated from sections of schedule 40 carbon steel pipe that are field-welded, then insulated to reduce surface temperatures. But replacing that method with factory fabrication has a number of clear advantages.

For instance, modular pre-engineered chimney systems that are factory-fabricated and UL listed eliminate the need for field-welded breeching and stacks for boilers and hot water heaters. These factory-built UL systems are engineered to safely handle high temperatures and exhaust gas pressures. Factory fabrication also ensures more consistent quality and cost efficiency compared to field-fabricated systems.

UL listed pressure rated systems are now being utilized for generator exhaust. The following questions will be addressed in this whitepaper:

- Does a UL listed product utilized for high-temperature-pressurized generator exhaust meet code requirements?
- How do you determine what product, specific materials and construction materials to use?
- What specific design and engineering is required to ensure a safe and reliable system?
- Who is responsible for system design function and safety?
- How do you develop a proper specification to cover all aspects of system design, installation and inspection required for a trouble-free system?

CRITICAL CODE REQUIREMENTS AND RESTRICTIONS

It should be noted that UL listed products meet code requirements for all high-temperature-pressurized generator exhaust systems.

To investigate code requirements for generator exhaust, it's best to start by reviewing the International Mechanical Code® (IMC). The following sections are applicable.

Section 915 of IMC 2018 regarding Engine and Gas Turbine-Powered Equipment

915.1 General

The installation of liquid-fueled stationary internal combustion engines and gas turbines, including exhaust, fuel storage and piping, shall meet the requirements of NFPA 37. Stationary engine generator assemblies shall meet the requirements of UL 2200.

915.2 Powered Equipment and Appliances

Permanently installed equipment and appliances powered by internal combustion engines and turbines shall be installed in accordance with the manufacturer's instructions and NFPA 37.

Section 915 of IMC 2018 Equipment

This refers directly to the NFPA 37 standard, which is the National Fire Protection Association standard for the installation and use of stationary combustion engines and gas turbines.

Chapter 8.1 of NFPA 37 on the Design and Construction of Engine Exhaust Systems

This addresses the requirements for engine generator exhaust and provides a few simple guidelines for the exhaust system, which will be addressed when covering proper system design. This chapter includes:

8.1.1

Engine exhaust systems shall be designed and constructed so the system can withstand the anticipated exhaust gas temperatures.

8.1.2

Exhaust systems shall be designed and constructed to withstand the intended service.

8.1.3

Chimneys, where required, shall be constructed and installed in accordance with NFPA 211.

8.1.4

Exhaust systems shall be designed and constructed to withstand forces caused by the ignition of unburned fuel or shall have provisions to relieve those forces without damaging the exhaust system.

8.1.5

Low points in exhaust systems shall have drains.

Chapter 8.1 of NFPA 37 also refers to and directs to NFPA 211 for the chimney or stack section of the system. Chapter 6 of NFPA 211 addresses code compliance of factory-built system requirements.

Chapter 6 Factory-Built Chimneys and Chimney Units

6.1.1 General

Factory-built chimneys and chimney units shall be listed and installed in accordance with the temperature and pressure conditions of the listing and the manufacturer's instructions.

6.1.2 Temperature and Pressure Limits

Flue gas temperatures and static pressures within the chimney shall not exceed the limits employed during listing tests.

6.1.3.1

Factory-built chimneys shall comply with the requirements of UL 103, Standard for Factory-Built Chimneys for Residential Type and Building Heating Appliances, UL 2561, Standard for 1400 Degree Fahrenheit Factory-Built Chimneys, or UL 959, Standard for Medium Heat Factory-Built Appliance Chimneys.

The path for determining code compliance for engine exhaust goes from building/mechanical code to NFPA 37 and NFPA 211 standards. Both state that a product must be able to withstand temperatures and pressures generated from the exhaust system. NFPA then references two UL listings for high-temperature systems and generator exhaust: UL 103 and the new listing UL 2561.

International Building Code

International Mechanical Code

NFPA 37 Stationary Engine

NFPA 211 Metal Chimneys

Per codes and standards, UL 103 and UL 2561 listed and labeled products are acceptable for use as generator exhaust, as outlined below.

UL 103

This category covers residential-type and building-heating-appliance chimneys intended for venting flue gases at a temperature not exceeding 1000°F (540°C), under continuous operating conditions, from gas-, liquid- and solid-fuel-fired residential-type appliances and building-heating appliances specified in the Chimney Selection Chart of ANSI/NFPA 211, "Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances." These chimneys are intended to be installed in accordance with the "International Mechanical Code," the "International Residential Code," or the "Uniform Mechanical Code." These chimneys are identified as either "Residential" models or "Building-heating Appliance" models.

UL 2561

This category covers factory-built 1400°F chimneys intended for venting flue gases at a temperature not exceeding 1400°F under continuous operating conditions, from building and heating appliances and other low-heat appliances as specified in the Chimney Selection Chart of ANSI/NFPA 211, "Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances."

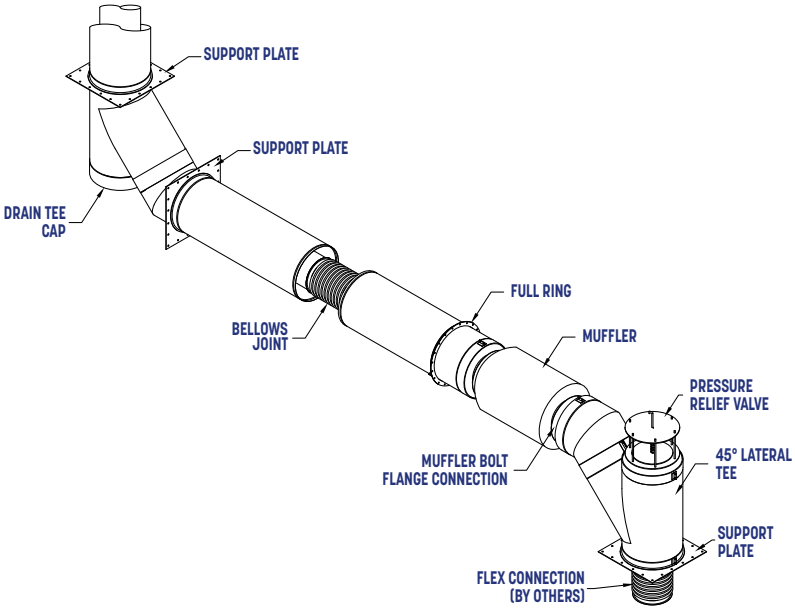
PRODUCTS, CONSTRUCTION MATERIALS AND MORE

UL 103/2561 listed products are manufactured utilizing various grades of stainless steel with single wall to double wall construction and with various levels of insulation. For most applications, 304 grade stainless steel offers adequate corrosion protection and tensile strength under the high temperatures of generator operation. Due to the potential risk of sulfuric acid being produced, 316 stainless steel is often utilized on generator engines that use diesel fuel.

Factory-built UL listed products are offered with a double wall, consisting of a stainless inner wall, insulation and a stainless steel outer wall, creating a well-insulated, well-protected system. Generator exhaust systems are insulated to reduce the amount of heat radiated to the mechanical space, chase and chimney. Based on the system routing, a risk of direct contact to the system by maintenance or repair personnel must also be considered.

The maximum exhaust gas temperature determines the amount of insulation required. Most manufacturers of UL listed products publish the clearance to combustibles with tested exhaust temperatures of 1000°F or 1400°F. However, this does not provide information about the surface temperature of the system during the operation. So, to protect individuals who make personal contact with the system, the outer shell temperature must be below 140°F. The UL listed manufacturer should perform the temperature calculations, based on the specific product design criteria.

Field-fabricated generator exhaust also requires insulation. The mechanical engineer should stipulate the amount and type of insulation that should be used, as the engineer is responsible for ensuring system protection for the facility and its personnel.



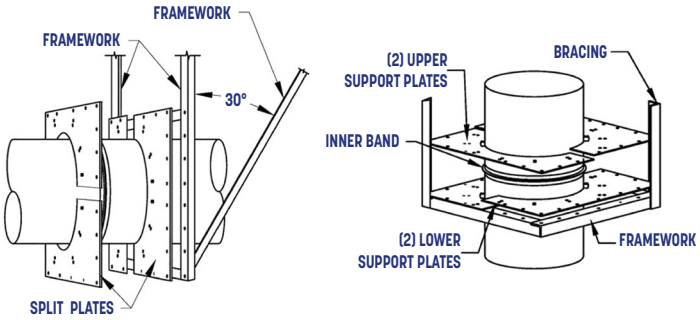
Pressure Relief Valve & Support Plate

DESIGN AND ENGINEERING REQUIREMENTS FOR SAFETY AND RELIABILITY

Generator exhaust systems need to be properly designed to ensure optimal engine performance and safe operation. System design has become more complex due to the need to keep emissions low and to utilize the heat energy in the exhaust gas. Catalysis and heat absorber units/ economizers significantly impact the exhaust flow. Every system should have a detailed pressure loss calculation performed to account for the impact these units will have on the system.

Generator exhaust systems must also be engineered and properly installed to accommodate thermal expansion. Generator exhaust systems emit exhaust at temperatures anywhere from 500°F up to 1300°F depending on the unit size, manufacturer and type of fuel burned. As the system temperature increases, the system will experience a significant amount of thermal expansion force, requiring the incorporation of devices like expansion bellows to adequately absorb the expansion. Along with expansion bellows, the system must be properly restrained and guided to ensure the thermal expansion is properly absorbed by the bellow and not by the system's joints or fittings. This creates a complex structural component that must be fully engineered for every system. An improperly designed and installed system will fail and leak harmful exhaust gas.

Vibration isolation must also be accurately addressed during system design. Often the generator manufacturer will provide an isolation bellow at the exhaust outlet. This bellow must be installed properly to allow it to perform correctly. Explosion protection devices must also be incorporated into the system, as noted in NFPA 37, as must pressure relief valve devices at proper locations for them to function effectively.



Support Plate-Installation Detail

Many UL listed product manufacturers provide supports, expansion bellows and guides as part of a pre-engineered system. Manufacturers will not typically supply the structural design to correctly secure and brace the UL factory-supplied supports and guides. It is important to select a manufacturer with a competent engineering department that can offer consultation and/or structural engineering services, especially on complex systems.

PROPER FUNCTION AND SAFETY RESPONSIBILITY

It is the engineering firm of record's responsibility to ensure a generator exhaust system's proper design and functionality. If a field-fabricated system is being used, the engineering firm and the installing contractor must collaborate on the design and installation of the system. As mentioned earlier, this must include vibration isolation, thermal expansion and explosion relief. Utilizing a UL listed pre-engineered system allows much of the system design to be shouldered by the chimney manufacturer. The amount of engineering and quality of this work substantially depends on which manufacturer is selected because engineering services and the competence of the manufacturer's engineering staff vary greatly.

ENSURING A TROUBLE-FREE SYSTEM

Developing a detailed and complete specification is paramount to ensure a properly functioning and safe exhaust system. It must clearly define the critical steps for engineering, design, installation and inspection, while identifying the responsible party for each. Proper detailed documentation is required not only for submittals but for verification of installation testing and inspection.

THE CERTAINTY OF FACTORY-MADE

Factory-manufactured pre-engineered UL listed generator exhaust systems provide a superior alternative to field-welded and fabricated systems. Factory-made options are pre-insulated, double wall constructed, creating lightweight, strong, long-life exhaust solutions. The ability of a manufacturer to offer complete engineering services with their products is imperative for a complete solution, reducing the workload of mechanical engineering firms.

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