

# Generator Exhaust Systems

## Utilizing Factory-Built UL Listed Products

The use of gas fired, and diesel fueled generators for back-up power and co-generation is increasing due to a higher demand on the current electrical infrastructure, the growing need for backup power and the necessity to improve overall efficiency to ensure uninterrupted power.

Implementation of engine driven systems in high occupancy buildings and central power plants creates challenges to safely exhaust the units due to the need for complex routing of venting systems. In comparison, simple backup generator systems located outside a building are often exhausted directly out the top of the units.



Units located 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.



Generator exhaust systems for years have been fabricated from sections of schedule 40 carbon steel pipe that are field welded, then insulated to reduce surface temperatures.

Modular pre-engineered chimney systems that are factory-fabricated and UL listed have eliminated the need for field-welded breeching and stacks for boilers and hot water heaters for decades. These factory-built UL systems are engineered to safely handle the high temperatures and exhaust gas pressures. The products ensure a consistent quality, cost effective system compared to field-fabricated systems that solely rely on the skills of the specific fabricator.

The same UL listed pressure rated systems are now being utilized for generator exhaust. This generates the following questions that will be addressed in this white paper:

- Would 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 utilize?
- What specific design and engineering is required to ensure a safe reliable system?
- Who is responsible for system design ensuring proper 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?

***UL listed products utilized for high temperature pressurized generator exhaust meet code requirements.***

To investigate code requirements for generator exhaust it is important to start by reviewing the International Mechanical Code® (IMC). Section 915 of IMC 2018 regarding Engine and Gas Turbine-Powered Equipment and Appliances is applicable stating:

**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 refers directly to 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 addresses the requirements for engine generator exhaust and provides a few simple guidelines for the exhaust system. These guidelines will be addressed when covering proper system design. The Chapter specifically stipulates:

**8.1.1\*** Engine exhaust systems shall be designed and constructed such that the system can withstand the anticipated exhaust gas temperatures.

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

**Δ 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 us to NFPA 211 for the chimney or stack section of the system. Since we are looking at code compliance of factory-built systems, chapter 6 of NFPA 211, addresses the requirements.

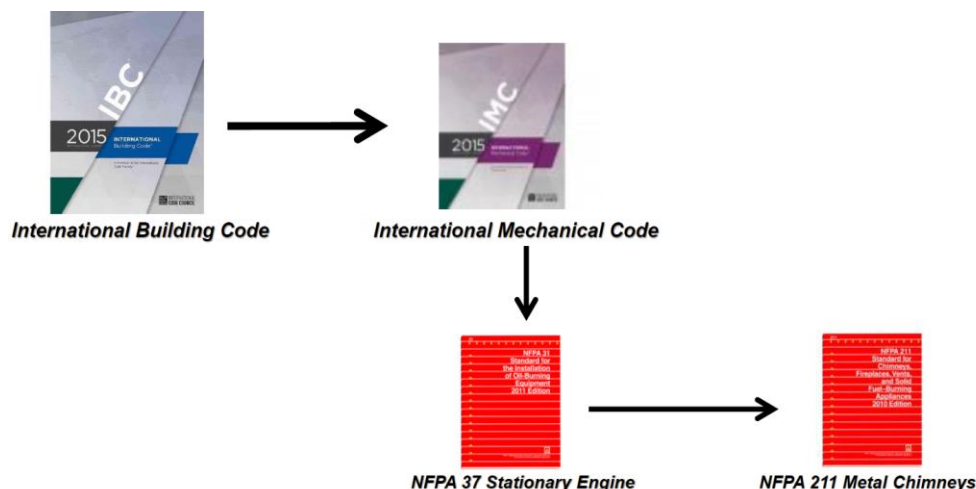
### Chapter 6 Factory-Built Chimneys and Chimney Units

**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 takes us from building/mechanical code to NFPA 37 and NFPA 211 standards. Both state that a product must be able to withstand the temperatures and pressures generated from the exhaust system. NFPA is going to then reference two UL listings for high temperature systems and generator exhaust, which are UL 103 and the new listing UL 2561.



Per codes and standards, UL 103 and UL 2561 listed and labeled products are acceptable for use as generator exhaust in accordance with the listing coverage 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.

**L 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-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, specific materials, and construction materials to utilize.***

UL 103/2561 listed products are manufactured utilizing various grades of stainless steel with single wall to double wall construction using 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. 316 stainless steel is often utilized on generator engines that use diesel fuel due to the potential risk of sulfuric acid being produced.

Factory-built UL listed products are offered as double wall, stainless inner / insulation / stainless steel outer 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.

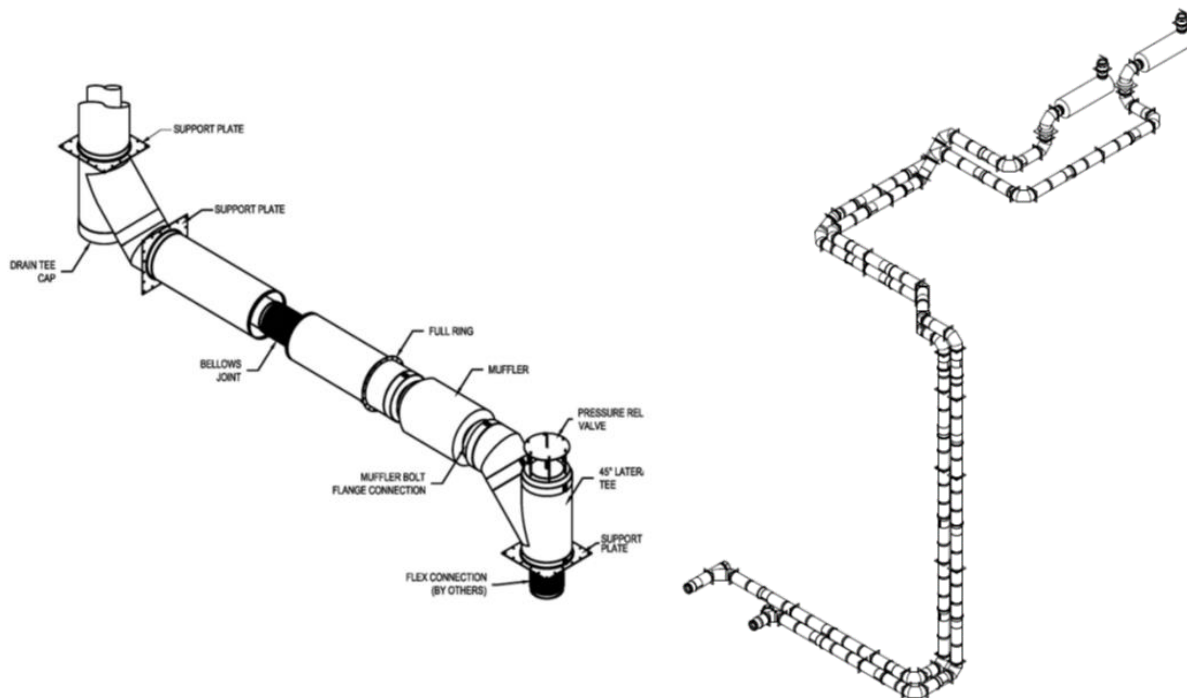
The maximum exhaust gas temperature determines the amount of insulation required. Most manufacturers of UL listed products publish the clearance to combustibles, which are tested temperatures of 1,000°F or 1,400°F exhaust temperature. This does not tell us what the surface



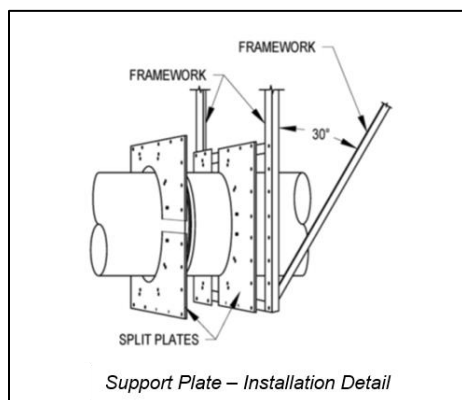
temperature of the system would be during operation. To protect potential personal contact with the system, the outer shell temperature must be below 140°F. These temperature calculations can and should be performed by the UL listed manufacturer based on specific product design criteria.

Field-fabricated generator exhaust also requires insulation. The amount and type of insulation should be stipulated by the mechanical engineer who is responsible for this system to ensure protection for the facility and personnel.

***Specific design and engineering required to ensure a safe reliable system.***



Generator exhaust systems need to be properly designed to ensure correct engine performance and safe operation. System design has become more complex with the desire to keep emissions low, along with the desire to utilize the heat energy in the exhaust gas. As a result, the use of 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.

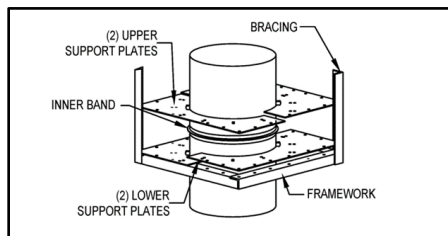


Generator exhaust systems must also be engineered and properly installed to accommodate thermal expansion. Generator exhaust systems emit exhaust at temperatures anywhere from 500°F up to 1300°F depending on the unit size, manufacturer, and type of fuel burned. As the system temperature increases, the 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 systems 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. It is imperative this bellow is installed properly to allow it to perform correctly. Explosion protection devices must also be incorporated in the system, as noted in NFPA 37. Pressure relief valve devices must be incorporated in the system design at proper locations to function effectively.

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.



Pressure Relief Valve & Support Plate

***The engineering firm of record must ensure the proper function and safety of the exhaust system.***

The proper design and functionality of a generator exhaust system falls on the responsibility of the engineering firm of record. If a field fabricated system is being utilized, the design and installation of the system must be a collaboration between the engineering firm and the installing contractor. 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 is highly dependent on which manufacturer is selected because engineering services and the competence of the manufacturer's engineering staff vary greatly.

***A proper specification covering all aspects of system design, installation, and inspection is vital for a trouble-free system.***

Developing a detailed and complete specification is paramount to ensuring a properly functioning and safe exhaust system. The specification needs to provide details on the critical steps to engineering, design, installation, and inspection. Each step must be clearly defined along with indicating who is the responsible party. Proper detailed documentation is required not only for submittals but for verification of installation testing and/or inspection.

**Conclusion:** Factory manufactured pre-engineered UL listed generator exhaust systems provide a great alternative to field-welded and fabricated systems. Factory-built products are pre-insulated, double wall construction, creating lightweight, strong, long-life exhaust solutions compared to field-fabricated carbon steel systems. The ability of a manufacturer to offer complete engineering services with their products is imperative to provide a complete solution, thus reducing the workload of mechanical engineering firms.