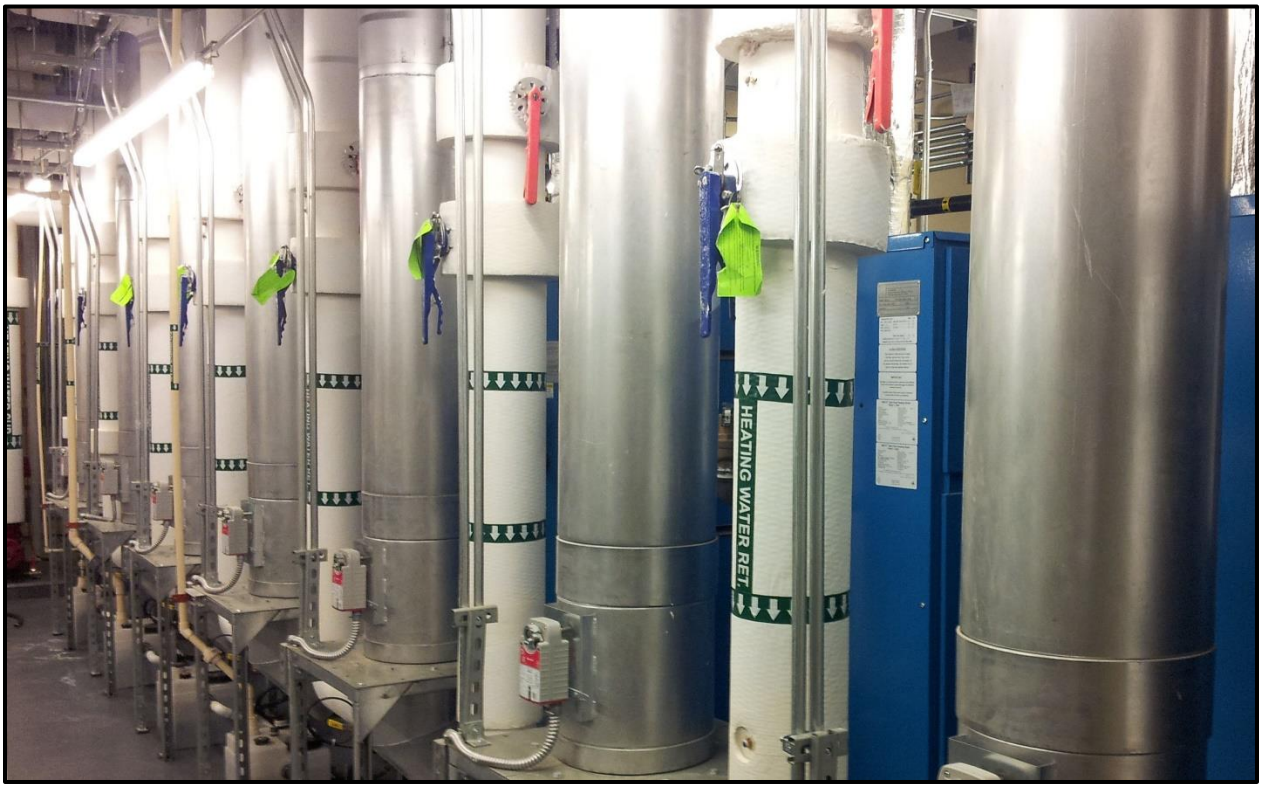
Special Gas Venting Systems

Plastic or Stainless Steel?



Proper product selection for Special Gas Vent exhaust systems for high efficiency boilers and hot water heaters can be a difficult process. There is a definite lack of detail provided by code, including International Mechanical Code, Uniform Mechanical Code, NFPA 211, and National Fuel Gas Code/NFPA 54.

NFPA 211 defines a vent and Special Gas Vent as:

> **3.3.142* Vent.** A flue gas–conveying system intended for use only with certain gas-, liquid-, or pellet fuel–fired appliances that do not produce flue gas outlet temperatures higher than a value specified in the listing vent standards.
>
> > **3.3.142.1** ***Gas Vent.*** A passageway composed of listed factory-built components assembled in accordance with the manufacturer's installation instructions for conveying vent gases from appliances or their vent connectors to the outdoors.
> >
> > **3.3.142.1.1** ***Special Gas Vent.*** A gas vent for venting listed Category II, III, and IV gas appliances.

Boiler/hot water heater vents are categorized by exhaust gas temperature and pressure. Section 3.3.80 of NFPA 211 defines the categories as reflected below.

> Category I — An appliance that operates with a nonpositive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent.

Category II — An appliance that operates with a non-positive vent static pressure and with a vent gas temperature that may cause excessive condensate production in the vent.

Category III — An appliance that operates with a positive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent.

Category IV — An appliance that operates with a positive vent static pressure and with a vent gas temperature that may cause excessive condensate production in the vent.

High efficiency boilers and heaters are designed to operate as category IV to obtain maximum efficiency and flame stability. The design of the venting system can and will impact the appliance's ability to operate as a category IV appliance. This directly affects the impact of the performance and efficiency. See the detailed presentation on Schebler Chimney's YouTube channel at *www.youtube.com/watch?v=CUtMsPs0eb4*

Safety is the most important aspect of a Special Gas Venting System, and it is often overlooked. Gas fired boilers and hot water heaters are used in high occupancy buildings including large residential complexes, schools, and hospitals. Despite the low emissions and relatively low exhaust gas temperatures, the venting system is carrying poisonous by-products of combustion, which are virtually undetectable without a carbon monoxide detector. The cost of venting products being utilized, and proper application & installation must not override the risk of a leaking or malfunctioning system. Special Gas Venting systems must be clearly engineered, specified, installed, and inspected to ensure the safety of building occupants.

Special Gas Venting Systems constructed of stainless-steel materials have been utilized on condensing appliances under the UL 1738 listing for many years. This UL listing complies with National Fuel Gas Code/NFPA 54 and the manufacturers of condensing boilers and hot water heaters. The UL 1738 standard requires products to be constructed of high-grade stainless-steel materials to handle the corrosive condensate, withstand high operational temperatures, and be pressure tested/rated. Temperature testing is done at higher than normal operational conditions to ensure maximum safety in the event exhaust gas temperatures become elevated, due to equipment malfunction or inadvertent high return water settings. (UL listing requires 480-degree F or higher to obtain the listing).

Due to the cost of UL 1738 listed stainless steel venting systems, PVC, CPVC, and PP have been utilized to exhaust condensing appliances. This started with residential furnaces and has slowly moved to commercial boilers and hot water heaters. At first glance, plastic for venting appears to be a safe, cost effective, and a potentially leak free option to stainless steel. While this may be a good idea, it's important to take a closer look at the various plastic materials, boiler operation, hot water heater operation, and venting system routing to determine if plastic or steel are the right choice.

The first thing that must be addressed with any product and installation is code compliance. NFPA 54/National Fuel Gas Code states plastic piping for use of vent exhaust gas as noted below:

> **12.5.2 Plastic Piping.** Plastic piping used for venting appliances listed for use with such venting materials shall be approved.
>
> **12.5.3 Plastic Vent Joints.** Plastic pipe and fittings used to vent appliances shall be installed in accordance with the appliance manufacturer's installation instructions. Where primer is required, it shall be of a contrasting color.
>
> **12.5.4 Special Gas Vents.** Special gas vents shall be listed and installed in accordance with the special gas vent manufacturer's installation instructions.

This verbiage states that plastic piping used for venting appliances listed for use with such venting materials shall be approved, but it also states, in 12.5.4, that the vent must be listed and installed per the special gas vent manufacturer's specific installation instructions.

What would be the purpose of allowing plastic vents but placing restriction on products and installation? Allowing plastic venting only on the criteria that the appliance manufacturer is approved for use, does little to ensure the safety of the product selected and nothing to ensure proper system design & adequate installation. Unless the appliance manufacturer provides detailed documentation on what plastic vents are allowed, along with design details that could possibly cover all installations, the risk of an improperly selected and installed system is very high. In most cases when plastic venting is utilized, the plumbers end up installing it who generally have little knowledge of proper system configuration or installation of materials for venting of exhaust gases.

So, what about gas vents required to have a listing per NFPA 54/NFGC? Metal chimneys as noted in NFPA 54 are to be listed and comply with NFPA 211 which thoroughly covers positive pressure venting product requirements. Section 12.6.1 of NFPA 54 covering the listing or construction of masonry, metal and factory-built chimneys incorporate the following provisions.

> **12.6.1.1** Factory-built chimneys shall be installed in accordance with the manufacturer's installation instructions. Factory-built chimneys used to vent appliances that operate at positive vent pressure shall be listed for such application.
>
> **12.6.1.2** Metal chimneys shall be built and installed in accordance with NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel–Burning Appliances*.

A Special Gas Vent that is constructed of plastic and has obtained a UL listing for use as such is rare and very confusing. A product / manufacturer search on the UL listing website will result in no manufacturers other than products produced utilizing stainless steel. How is that possible when there are a few manufacturers of PVC, CPVC, and PP that claim

they are UL 1738 listed and compliant? The simple answer is Underwriters Laboratory 1738 listing requires a product to pass at temperatures which are unobtainable for plastic materials. ETL has decided to test and list products excluding the temperature requirements contained in the UL standard.

Does it really matter if a product is capable of meeting the UL standard temperature requirements? What are the effects of high temperatures on plastic products?

Exhaust gas temperatures of gas burning boilers and hot heaters will vary greatly. For maximum efficiency, the goal is to have exhaust gas temperatures as low as possible. To obtain Cat II and/or Cat IV operation, these temperatures would need to be below the dew point. The return water temperature, which can be set directly on the appliance, directly impacts the exhaust gas temperature, roughly 20° above the return water temp setting.

The information below taken from Engineering Toolbox, shows the operational temperatures for PVC, CPVC, and Polypropylene. It states the maximum operational temperature of each material with or without pressure. Note the pressure in a gas venting system is very low, measured in inches of water column so the pressure may have little impact in the performance.

Plastic Pipe Material	Operating Temperature			
	With Pressure		Without Pressure	
	(°F)	(°C)	(°F)	°C)
PVC - Polyvinylchloride	100	38	140	60
CPVC - Chlorinated Polyvinyl Chloride	180	82	180	82
PP - Polypropylene	100	38	180	82

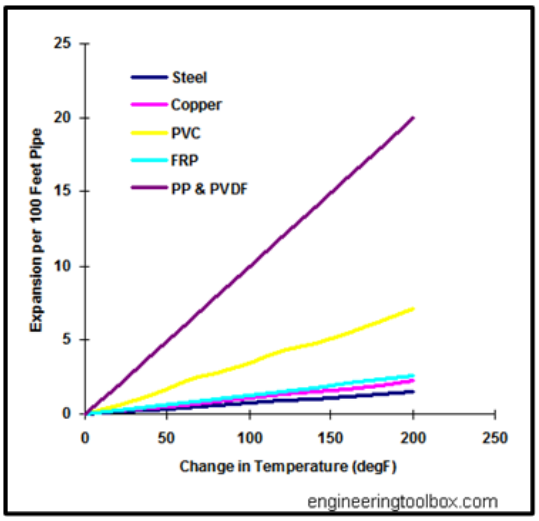
The operating temperature above is the maximum allowable. If we are utilizing plastic for venting, the maximum return water temperatures for a boiler would need to be roughly 20° F below. This means that if CPVC or PP was utilized on a boiler the maximum return water temperature would be roughly 160°F. Some manufacturers of PP venting products published max temperatures that exceed this, stating 230° F max. This maximum exhaust gas temperature can be monitored and provide automatic shut down if the temperature limit is exceeded to avert a systems meltdown. This is a simple setting on the boiler which

also means the return water temperature and disabling of the temper switch could be done by most maintenance staff or a boiler tech. Unfortunately, the limitation of the exhaust gas temperature could possibly force appliances to shut down when needed most, extreme high demand for building heat.

Besides the maximum exhaust gas temperature, the reaction of the plastic material to the cycling of appliances must be taken into consideration. Appliances will cycle on and off based on the demand for heat or hot water. The cycling of these appliances places a strain on the exhaust system as it will expand and contract.

The higher expansion coefficients for plastic materials makes plastic pipes and tubes extremely sensitive to temperature changes. Always pay attention to plastic pipes and tubes when temperature varies, as evidenced by the data in the table below.

Material	Expansion Coefficients
	10^{-6} in/in °F
Aluminum	12.8
Carbon Steel	6.5
Stainless Steel (316L)	8.89
PP Polypropylene	45
PE Polyethylene	83.0
CPVC Chlorinated polyvinyl chloride	44.0
PVC Polyvinyl chloride	28.0

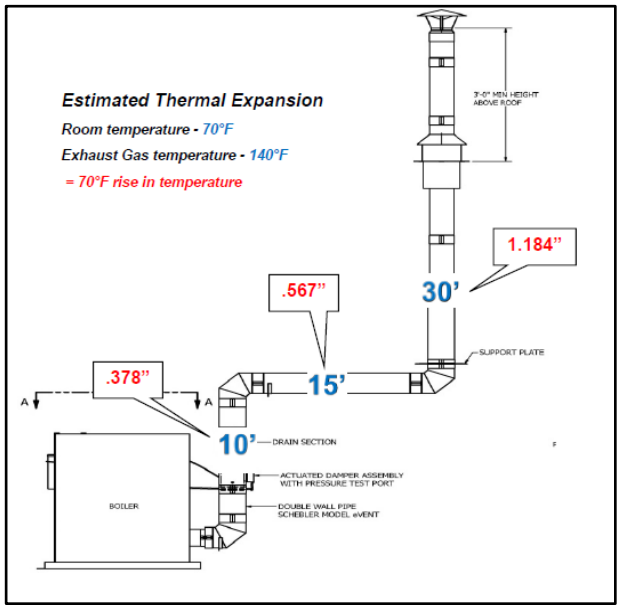


The impact of the thermal expansion coefficients becomes evident when applying it to the exhaust piping of various materials as represented in the graph above.

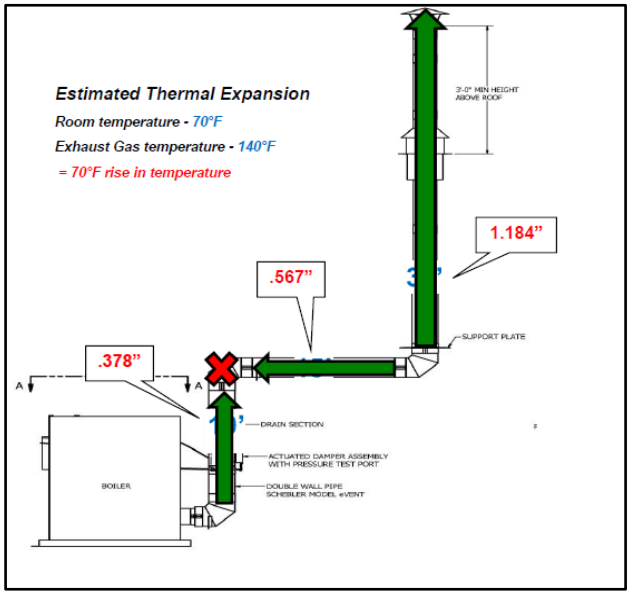
How does this information impact the decision to utilize plastic material and/or how to properly design ensuring a safe and effective system?

The significant thermal expansion and contraction of plastic material requires a system layout and supports that are capable to accommodate variations. The following is an example of the amount of thermal expansion from an exhaust system constructed from vent constructed of Polypropylene.

This example represents a simple exhaust routing for a boiler with a return water temperature of 120°F, making the exhaust gas temperature about 140°F. The amount of expansion experienced in the exhaust would be determined by the rise in temperature the system would experience from boiler off to boiler on, which in this example is 70°F. At a 70°F rise in temperature a system constructed of polypropylene or CVPC (since they have almost the same thermal expansion coefficients) would experience about 3/8" per 10 ft of vent length, see expansion amounts noted in red. Oddly, PVC which has a low temperature threshold, would experience much less expansion but at 140°F would be almost at its maximum allowable temperature.

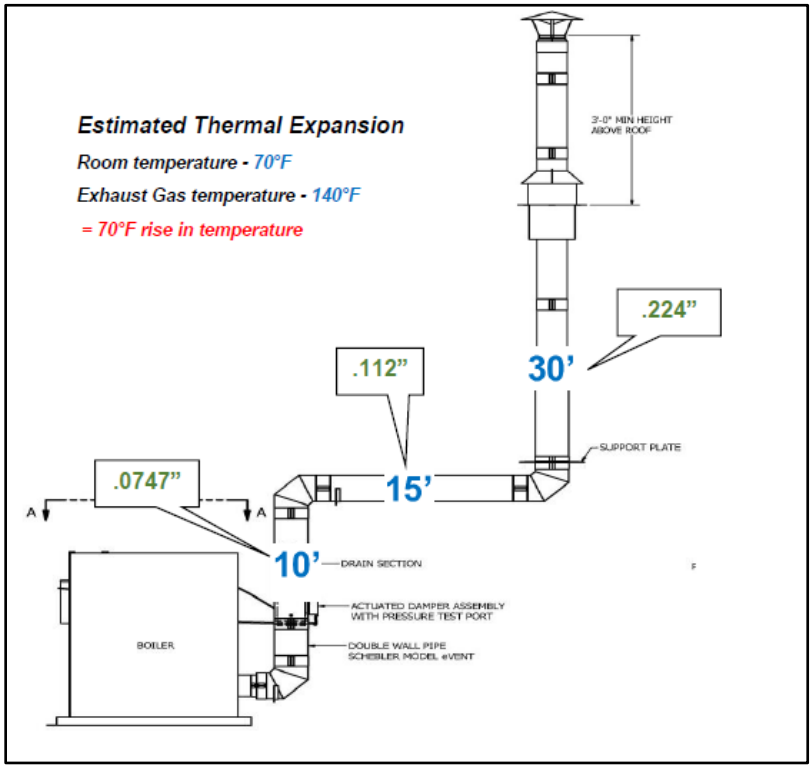


The thermal expansion will force the system to grow in the directions noted on the drawing due to the secure attachment points at the boiler exhaust outlet, and at a support located near the bottom of the stack to support the weight. The problem arises at the intersection of the riser off the boiler to the breeching. This would place a real strain on the 90° elbow and reduce the pitch of the breeching IF the contractor installed the system within the code requirement of ¼" per foot pitch.



Plastic vents of CPVC or PVC will not be provided with any design or supports to ensure the system can handle the forces created during expansion and contraction. These systems are completely at the mercy of the installer ensuring it is supported correctly, along with the ability to handle the forces of expansion/contraction on the joints, dips or sags that could be created, and retain proper pitch for condensate drain back to the boiler. Inspection of these systems to ensure proper design criteria and installation would be extremely difficult for the AHJ and the mechanical engineer of record.

Stainless venting would experience a much lower amount of expansion as reflected in the illustration below.



The thermal expansion experienced places force on the joints and supports designed in the system. UL listed stainless steel products are designed to handle this small amount of expansion and contraction within the UL listed supports, included with the complete system design. Most often manufacturers of these systems also provide complete system engineering along with detailed system submittal drawings which ensures a system will function correctly. These system drawings allow the contractor to properly install the system and provide the AHJ documentation to properly inspect during, and after installation.

The question becomes, when would plastic material be safe and reliable for use as a Special Gas Vent?

1) What is the exhaust temperature for this specific system?
    - What materials will be able to handle max temperature under high demand of heat or hot water?
        - ✓ The focus needs to be on the potential max temperature when the demand for hot water is extremely high. The exhaust system should not be the reason an appliance must shut down to protect the system.

- ✓ If the anticipated exhaust temperatures during any time of operation are close to the max noted in the charts above, that material should not be utilized.

- Can the exhaust gas temperature be monitored, and the appliance shut down if the max temperature is exceeded?
  - ✓ The boiler or hot water heater must have an exhaust gas temperature sensor that allows for a max temp setting based on the venting material. During appliance start up, this must be a locked setting to ensure the setting is not inadvertently adjusted or disabled.
  - ✓ This is very important since initial settings are often changed over time.

2) System design - layout
   - Length of runs
     - ✓ Long length runs, horizontal and/or stacks, will experience significant expansion. This will cause the system to sag, bow, or move.
   - Number of changes in direction
     - ✓ Each change in direction will place significant stress on the joints and elbows, greatly increasing the risk of system damage from expansion and contraction.
   - Ability to properly install the required supports
     - ✓ The recommendation for most plastic materials is a support every 5 ft of horizontal run and every other floor on stacks. If this is not possible or the contractor chooses to support against the guidelines, the system could experience damage during operation. A submittal drawing of the system must be available to ensure installation is done properly.

3) Warranty
   - PVC – CPVC manufacturers that advertise product for venting provide a 10-year warranty.
   - Polypropylene manufacturers provide a 10-year warranty
   - Stainless Steel UL 1738 listed products vary by manufacturer, but some offer “Limited Lifetime Warranty”.
   - A venting product should have a warranty at least as long as the appliance life it supports.

Summary

Cost always plays a factor in product selection for building materials, but in this case a “low bidder wins” approach is dangerous. Plastic material for venting can appear attractive from a cost and functionality standpoint; however, when taking a closer look at the safety, design responsibility, product lifespan, and installation concerns, the material leaves a lot to desire. Simple straight up system configurations with all the safety mechanisms in place to limit exhaust gas temperatures may be the only real safe place to apply plastic venting material.

It is important to remember that no matter how efficient and low emission these appliances are, the Special Gas Venting system is still venting deadly exhaust gases. The selection of products and system design must be thoroughly engineered regardless of how simple the routing and/or layout.

Stainless steel UL 1738 listed products, when purchased from a reputable manufacturer and rep firm, providing detailed system design, performance engineering, product supports, superior safety, and a product with a lifetime warranty. These systems can easily handle the exhaust gas temperatures without risk of shut down, thermal expansion/contraction, and ensure a safe reliable system.