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Understanding the Risks of Appliance Venting with Polyvinyl Chloride (PVC) & Why Polypropylene Is a Superior Alternative

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This paper is written with regard to applicable codes and standards and intended for use and application in the United States of America.

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Is PVC (polyvinyl chloride) pipe safe for combustion venting on high efficiency, condensing water heaters and boilers and furnaces?
This is a question that frequently evolves into another: "does it meet code?" We rely on codes to tell us what is safe; and we rely on codes to help us make decisions that keep us safe from liability. But what if the code is ambiguous? This paper will explain why, when it comes to using PVC for combustion venting, installers must err on the side of safety. While the code is arguably unclear, the safety of PVC in this application is not. Traditional PVC is not designed for and never should be used for venting these types of appliances. There is another option, one that offers far greater safety and stability with a negligible increase in material cost: polypropylene.

Inherent Dangers of PVC

Since the 1950s, the construction industry has turned to PVC piping for a wide range of applications, most notably for plumbing drainage and waste piping. Favored for being lightweight, corrosion-resistant and inexpensive, the product found its way into other applications, including combustion venting for modern high-efficiency appliances. Despite the construction industry's ready acceptance of the product, debate about the safety and environmental impact of the material continues. Those opposed to the use of PVC for virtually any application cite numerous health and environmental risks. Most notable among these are the toxic chlorinated organic compounds (especially dioxins, polychlorinated biphenyls (PCBs), and hexachlorobenzene) that are released in the manufacturing of PVC and the burning of wastes that contain PVC. These are known to be extremely hazardous and long-lived pollutants. [1]

The byproducts produced and released during the lifecycle of PVC have been shown to cause a host of health hazards, including:
- Cancer
- Disruption of the endocrine system
- Reproductive impairment
- Impaired child development and birth defects
- Neurotoxicity (damage to the brain or its function), and
- Immune system suppression

In addition, PVC typically contains a variety of toxic chemical stabilizers including lead and cadmium, among others. In building fires, PVC can release deadly hydrogen chloride, creating safety threats for building occupants as well as firefighters.
These, and other risks, have led many health and environmental agencies to condemn the use of PVC in construction. Such agencies include the U.S. Green Building Council (USGBC) and the Healthy Building Network, which deemed PVC "the worst plastic from an environmental health perspective, posing major hazards in its manufacture, product life and disposal." [2]

Risks Associated with Venting with PVC

Neither the facts listed above, nor the vocal opposition to PVC, have had much impact on keeping it out of construction. In fact, PVC has become the most common venting pipe used for residential natural gas and LPG condensing (high-efficiency) furnaces and water heaters in the United States. The reason is economics.

With the introduction of high-efficiency condensing equipment, traditional (and inexpensive) galvanized steel is no longer an option for venting because the condensation produced by these appliances is highly aggressive and quickly corrodes metal vents, creating rust holes through which deadly carbon monoxide can leak. Manufacturers of this equipment needed another material to recommend to installers. Given the theoretically low flue temperatures of high-efficiency equipment, PVC, which is also inexpensive and non-corrosive, seemed to be the perfect solution. PVC is far from the perfect solution for many reasons especially because of the unpredictability of flue gas temperatures.

Some industry professionals have been highly critical of the use of PVC in combustion venting applications, arguing that the physical properties of PVC change over time due to temperature exposure, chemical exposure from the highly acidic condensing flue gases, and UV exposure. So, while PVC may be rated for temperatures up to 149°F, it cannot be relied upon to consistently perform in an application where temperatures regularly come close to and may even exceed these temperatures. Also, the longer a system operates, the more likely it is that flue temperatures will increase. Scale build-up on the heat exchanger inhibits heat transfer to the supply water, and more heat goes up the flue. Higher return water temperatures can also increase temperature inside the flue.

In any of these cases, PVC may be exposed to temperatures that come dangerously close to exceeding its limits. When this happens, the material itself can become unstable and the following may occur:

- Discoloration of piping to yellow, purple or brown
- Warping, soft spots or cracks in the pipe
- Loosened or separated joints

These are the conditions that typically precede a major pipe failure, failure that can, and has led, to deadly fires and carbon monoxide poisoning. However, since exhaust pipe is frequently hidden behind drywall and above ceilings, these signs of pending disaster aren't likely to be discovered. While most gas-fired boilers include safety shut--offs that turn the appliance off in case flue gas temperatures rise above acceptable limits, there is no mandate requiring this. In most cases, the limit switches are set higher than the safe operating temperature of PVC. Carbon monoxide detectors, the occupants' last line of defense, are expected to at least warn them of dangerous conditions inside the home but small leaks from a compromised flue may not be enough to trip a carbon monoxide alarm.

It should be noted that elevated flue gas temperatures can occur even under normal operating conditions. Several industry professionals have identified and outlined the conditions that could cause flue temperatures that exceed the operating limits of PVC and even CPVC. Among them are several boiler manufacturers that do not recommend either of these products on their condensing gas appliances.

In a statement released in August 2007, a leading worldwide supplier of hot water heating appliances stated that they do not recommend the use of PVC or CPVC on its gas-fired wall-mounted condensing boilers. Although these boilers are certified to ANSI Z21.13 CSA 4.9 Low Pressure Steam and Hot Water Heating Boiler Standard by CSA, a test standard at which the boilers show flue gas temperatures of 107^{0}F, the manufacturer contends that the test conditions are unrealistic. They state that the manufacturer of the equipment being tested can simply select a very low return water temperature (e.g. 80 ^{0}F) to the boiler which drives the flue gas temperature extremely low. In lieu of the ANSI test criteria, the following full input- design condition was offered to illustrate their point that temperatures inside the flue can reach much higher levels:

If the boiler water supply temperature would be 82^{0} C (180^{0} F), provided the boiler is certified to that temperature, then one would typically assume a temperature differential of 11^{0} C (20^{0} F) to the heat exchanger and therefore the return water temperature would return at 71^{0}C (160^{0} F) to the heat exchanger. The dew point of natural gas is 57^{0} C (135^{0} F) at sea level.

The boiler would not condense and the stack temperature would be higher than the return water temperature of 71^0 C (160^0 F). It may reach the 85^0 C (185^0 F) to 88^0 C (190^0 F) mark.

This operating condition now clearly shows flue gas temperatures higher than what the limit is on standard PVC, CPVC, and ABS. Even if the heating boiler has a limit at 71^0 C (160^0 F) set for the boiler water supply temperature and an 11^0 C (20^0 F) spread to the return water temperature, the return temperature would still be 60^0 C (140^0 F) and the flue gas temperature could exceed the listed temperature limits. [3]

Increasing Restrictions on PVC

The dangers of using PVC to vent appliances has not gone unnoticed by the National Fire Protection Association (NFPA) or various building code jurisdictions around the country, and efforts have been made to curb its use in this application, albeit with limited success.

In 2013, the New York City Building Code officially prohibited the use of PVC for appliance venting of any kind. And in 2016, the New Hampshire Department of Safety and the State Fire Marshall issued an amendment requiring installers of Category IV venting systems to select venting materials based on the high limit set point of the appliance. In a bulletin announcing the amendment, it was noted that "Upon investigation and the study of Category IV venting, it was concluded that certain types of venting systems recommended by the appliance manufacturer can fail when exposed to periods of operation outside the parameters of the safe operating temperature of the venting material. Several causes were identified as contributing factors for these types of failures." [4]

The bulletin went on to identify the following causal conditions:

- Failure of the installer to vent the appliance in accordance with the manufacturers installation instructions
- Improper fuel system conversion of the appliance
- Improper final adjustments and testing of the appliance as prescribed by the manufacturer's installation instructions
- Improper selection of venting material materials to the joints; including the selection of the proper primer and adhesives as specified by the installation instructions and the National Fuel Gas Code (FNPA 54, 2009)
- Lack of consumer education with respect to the appliance operation and required maintenance when a new appliance is placed into service
- Adjustments made to the limit settings of appliances that exceeded the safe operating temperature of the venting material installed
- Lack of routine or proper regularly scheduled maintenance as prescribed by the appliance manufacturer.

Safety, Code and Liability

Safety is (or should be) the most compelling factor when it comes to selecting vent material. Most installers will look to the International Mechanical Code (IMC) to tell them what is safe. Unfortunately, the current language in the IMC has left many debating whether PVC is or is not allowed. The points of ambiguity are explained in brief here.

The 2009 IMC states that all vent system shall be listed and labeled. However, since there is no listing for plastic piping for flue gas venting applications, one would assume this would not apply for PVC or any other type of plastic piping.

However, the code includes the following language:

"801.20 Plastic Vent Joints. Plastic pipe and fittings used to vent appliances shall be installed in accordance with the appliance manufacturer's installation instructions."

Some argue this language gives installers a pass to use PVC. After all, many if not most manufacturers of condensing gas equipment do show PVC as a venting option and provide instruction for its proper installation. But there is yet another section in the code on installation that could easily make one think that PVC is not allowed:

"304.2 Conflicts. Where conflicts between this code and the conditions of listing or the manufacturer's installation instructions occur, the provisions of this code shall apply."

Admittedly, it's a tangled web of seemingly contradictory language, but one point that opponents of PVC continue to bring up is the fact that there is no independent testing for PVC that confirms its safety in an appliance venting applications. It is a point that even the United States' top manufacturer of plastic pipe and fittings openly acknowledges with this statement:

"At present, there is little data available on the safety or durability of plastic pipe products used to vent combustion gases." [5]
Thus, the question becomes not one of safety or code, but rather one of liability.

A Safer, Less Problematic Alternative to PVC

All the debate and speculation about PVC safety, codes, and liability has become irrelevant to at least one group of installers. Those who are informed about the properties of polypropylene know that it is a safer material than PVC for venting appliances and that it costs a fraction of what stainless steel costs.

Polypropylene has a higher maximum operating temperature limit of 230°F compared to PVC (149°F) and CPVC (194°F), giving it a greater safety margin in venting applications. The material, though considered a relatively new venting option in the United States, has been used for this purpose for more than 20 years throughout Europe where PVC is not allowed. Made from hydrogen and carbon, polypropylene is environmentally safe and 100 percent recyclable.

DuraVent, a full-service designer and manufacturer of venting solutions for the commercial and residential markets, developed its line of PolyPro® pipe for venting applications. DuraVent has tested and listed to the only standard that exists for plastic vent pipe, ULC S636, a standard developed in Canada. This contrasts with PVC pipe which was never designed for heating applications, but rather drain and waste.

PolyPro® is engineered for use with Category II and IV condensing gas/oil appliances and heating equipment, including tankless water heaters, high- efficiency water heaters, condensing boiler, and warm air furnaces. The piping systems come complete with all fittings and gaskets so there is no mismatching of parts which can compromise the integrity of the system. PolyPro also complies with LEED® credit IEQc4.1, addressing volatile organic compound limits.

PolyPro® has also received approvals from all major boiler, water heating, and furnace manufacturers. Although it costs more than PVC, it is still less expensive than the higher rated CPVC, and far less expensive than stainless steel. The venting system usually costs less than $200.00, much less than the appliance itself, which may cost thousands.

Given the availability of products like PolyPro, there is little reason for installers to put people or their own reputations at risk by using PVC to vent heating appliances.

Conclusion

For reasons primarily based on price, PVC has become a go-to material for venting heating appliances – an application for which it was never intended. To date there is still no standard test to evaluate its safety in a real-world venting application even though it is installed on countless boilers, water heaters and furnaces in homes throughout the country. This is cause for great concern, especially given that under normal operating conditions, the temperature of flue gases in these applications can come close to and even surpass the temperature limits of the material. Contradictory language in building codes has led many to wrongly assume the safety of PVC in these applications despite compelling arguments and various manufacturers' statements to the contrary.

Given the high chance, and the associated consequences of a PVC failure in this application, installers would be well advised to look for an alternative. Polypropylene is a safe and economical choice for appliance venting. Not only is it rated for higher temperatures, it carries none of the health risks or environmental baggage of PVC. Although slightly more expensive than PVC, the cost is a relatively small price to pay for the added safety of homeowners and the peace-of-mind it provides to installers.

1. Thornton, J., 2002, Environmental Impacts of Polyvinyl Chloride Building Materials, Healthy Building Network Washington, DC.
2. https://healthybuilding.net/uploads/files/pvc-in-buildings-hazards-and-alternatives.pdf
3. http://www.rural-energy.net/docs/viessmann_Venting.pdf
4. https://www.nh.gov/safety/divisions/firesafety/bulletins/documents/2016-01-PVCTechnicalBulletin-NFPA54Amendment.pdf
5. https://www.nh.gov/safety/divisions/firesafety/building/mechanical/gasfitters/documents/pvc-venting-notice-from-charlotte.pdf

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