The Use of Aftermarket Components and Their Effects on the Safety and Performance of Factory-Built Fireplaces

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DISCLAIMER

This paper is intended to be informational and educational in order to help interested parties better understand the effects and concerns of using aftermarket parts with listed fireplace systems. This document does not provide any authority or permission to use aftermarket parts, with or without listed systems. This document does not endorse any products or services, listed or otherwise. This document is not to be used to deviate from or substitute for manufacturers' instructions, appropriate standards, or local code requirements. This document is not intended to provide specific advice, legal or otherwise, and readers should consult with their legal counsel and other professionals for specific advice on how this information may apply to them. This document is provided in good faith, but without any warranties (expressed or implied), including (without limitation) warranties of merchantability and fitness for a particular purpose, or warranties that the information is accurate, complete, reliable, or error-free. Always follow manufacturers' installation instructions and the requirements of local codes and those of the appropriate authority having jurisdiction. CSIA, Adair Concepts & Solutions, LLC, and their officers, directors, owners, members, and agents shall not be responsible for- and expressly disclaim any liability for- any installer's reliance on the information herein or their compliance with- or failure to comply with- applicable laws, standards, code requirements, and installation instructions.

INTRODUCTION

Issue:

Listed fireplaces, inserts, and chimneys are often refitted with aftermarket parts, not necessarily in accordance with the original listing. Installers encounter situations where a component of a fireplace system needs to be replaced, or where using an aftermarket component may help address a performance issue. The installer may be called upon to make these changes by their customer, often without realizing the effects these actions may have on the safety and performance of the system. If the original component is no longer available from the manufacturer (no longer in production or out of business, etc.), installers can find themselves in a gray area of manufacturer's requirements, safety listings, and legal liability.

While third-party components may in fact solve performance or safety issues, it must be noted that installing an aftermarket part may also potentially create an unintended hazardous situation. The installation of a non-listed component may adversely affect the performance and safety of a fireplace system, and may essentially put an untested installation in the home of the customer. Installers are faced with trying to resolve a situation where a listed system is used together with an unlisted component, yet are still trying to make the overall installation perform properly and operate safely for the homeowner.

Some installers have maintained that aftermarket parts do not have a negative impact on fireplace systems, and that they need definitive proof otherwise. However, the standards for listed products normally have a 2-4x factor of safety associated with their tests, which could essentially hide any negative impact, if any, which the components may cause. The result is currently that we do not know the definitive effect of these components, good or bad. The original listed products are known performers, and have test data supporting them. While an aftermarket component may function properly, and may in-fact even improve performance, unless it is tested as part of the overall system, its total effect is uncertain.

This document examines some of the typical aftermarket parts and their uses, and is intended to provide installers with a better understanding of how various components may affect listed factory-built fireplace and chimney systems. All parties involved with these systems, including the manufacturers, retailers, installers, and homeowners, have the goal of wanting the parts to work properly, perform well, and operate safely.

Motivation:

In May 2008, the Chimney Safety Institute of America (CSIA) modified its position on the use of aftermarket parts for listed products:

> "The CSIA recommends the use of original equipment manufacturer (OEM) parts on any product listed by a nationally-recognized listing agency. Using only OEM parts and replacement parts maintains the original integrity and performance characteristics of the product. If, however, after-market parts are installed, the CSIA recommends the following:
> • The use of the after-market part does not conflict with policies established by the authority having jurisdiction.
> • The after-market part is designed and manufactured to perform in the same manner as the original and does not alter the basic design and operation of the system.
> • The installer explains the installation of the after-market part and the reason for its use to the homeowner.
> • The installer documents that the homeowner acknowledges and authorizes the installation of the after-market part." (CSIA, 2008).

To further examine the issue, the CSIA initiated this paper to investigate some of the concerns arising from using aftermarket parts.

One of the core concerns of the CSIA is the safety of hearth and chimney systems. The education of installers and chimney sweeps is a proactive means of improving the safety of hearth and chimney installations. CSIA intends to educate installers by defining the critical issues and explaining the effects of using aftermarket parts with listed systems. The goal of this document is to educate installers so they can improve the quality of installations and which in-turn will lead to fewer safety or performance problems in the field.

Another motivating concern is the exposure of liability an installer assumes when using aftermarket or unauthorized parts and components. In the event of a fire or other incident, liability often rests with the party who made the modification or installed the questionable part. Even if the aftermarket component did not directly cause the incident, the fact that such an unlisted component was involved will be scrutinized. By being aware of the critical issues involved with aftermarket parts, installers may help their customers with safer installations while also helping themselves minimize their risk of liability.

Scope:

This paper examines some typical aftermarket components and their installation into listed factory-built fireplace and chimney systems. Some of the typical aftermarket products include:

- Wood and Gas Inserts
- Refractory Panels
- Chimney Termination Caps and Shrouds
- Fireplace Grates
- Glass Doors
- Chimney Liners

While not a comprehensive list of aftermarket parts, these are some of most common products encountered in the field, and are the main focus of this paper.

Approach:

This paper explains and evaluates some of the critical concerns that arise from using aftermarket parts with listed factory-built fireplace and chimney systems. As a first step, the different safety standards which cover listed hearth products are reviewed and some of their important tests are summarized. The test summary is provided to help installers better understand the scope to which listed products are tested and evaluated.

Next, there are descriptions of different aftermarket components in the industry. As part of this review there is a summary of critical issues for installers when using these components in a system. The critical issues described are based on the collected opinions of various individuals in the Hearth industry, including representatives of appliance manufacturers, chimney manufacturers, component manufacturers, product engineers, test technicians, listing agencies, fire investigators, and other knowledgeable professionals.

Additionally, the CSIA along with a group of manufacturers have worked together to test a sampling of aftermarket parts with a listed factory-built fireplace system. Intertek Testing Services (ITS) performed the tests. The purpose of the tests is to provide some tangible data of aftermarket part performance in a listed system. The focus is on the temperature changes, if any, that occur from using common aftermarket components when compared to the original factory components. The results of these tests are anecdotal, representing only the specific components and system that were actually tested. These results cannot be applied to other components or other systems, and cannot be used to predict other combinations of components and systems. Refer to the Product Testing section for information on the tests that were performed.

Overall, it is CSIA's purpose to educate installers about the potential concerns and risks of aftermarket parts with the goal to improve installation safety and reduce the occurrence of fires or other hazardous situations.

CODES AND STANDARDS IN THE INDUSTRY

Before we can discuss the use of after-market parts, we must first begin with an understanding of the relevant building codes and product safety standards encountered within the Hearth industry. Additionally, for installers, it may be useful to know what is included in the various standards to better understand the tested capabilities of the products involved.

Installation of fireplaces, chimneys, and other appliances and systems are governed by the requirements of the building codes. Local jurisdictions choose which building codes they will follow and have final authority over what and how appliances can be installed in their jurisdiction. Nearly all building departments use recognized national building codes, making installation requirements reasonably consistent. The most common building code used today is the *International Building Code*. In other parts of the country, the *Uniform Building Code* is used. Both sets of building codes are similar in their requirements.

The portion of the International Building Code that addresses fireplaces and chimneys is in the International Mechanical Code (IMC). The 2012 edition of the IMC requires that factory-built fireplaces are listed, and are installed in accordance with their listing:

> "903.1 General. Factory-built fireplaces shall be listed and labeled and shall be installed in accordance with the conditions of the listing. Factory-built fireplaces shall be tested in accordance with UL 127." (International Mechanical Code, 2012).

The code also allows for masonry fireplaces, but they must be constructed according to requirements set forth in the building code. The IMC does not allow for unlisted metal fireplaces to be installed.

Similarly, the IMC requires factory-built chimneys to be listed:

> "805.1 Listing. Factory-built chimneys shall be listed and labeled and shall be installed and terminated in accordance with the manufacturer's installation instructions." (International Mechanical Code, 2012)

The International Mechanical Code allows for site-built masonry chimneys, the requirements of which are specified in the building code. The IMC also allows for unlisted, field-constructed metal chimneys, however they are not allowed to be installed in one- and two-family homes. The requirements for unlisted metal chimneys (smoke stacks) are specified in NFPA 211 *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*.

So what does it mean for a fireplace, chimney, or other product to be listed? Listed products are those that have been approved (listed) by an authorized listing agency after having been tested to the requirements of recognized national safety standards.

A safety standard is "a technical expression of how to make a product safe, efficient, and compatible with others." (ANSI, 2014). Safety standards used in the United States are overseen by the American National Standards Institute (ANSI), which in-turn gives authority to other organizations to publish product standards. Standards typically encountered in the Hearth industry include publications by Underwriters Laboratories (UL), Underwriters Laboratories of Canada (ULC), the Canadian Standards Association (CSA), and the American Society for Testing and Materials (ASTM). Many CSA standards are accredited by both ANSI and the Standards Council of Canada to be harmonized for use in both the United States and Canada. While not a hard rule, the different agencies tend to publish standards covering certain areas of focus, in an effort to avoid competing requirements and potential conflicts. Generally, UL publishes standards for solid-fuel burning appliances, and CSA publishes standards for gas-burning appliances.

The standards themselves are considered "open" standards, and are managed by committees that use methods of proposals, evaluations, and discussions to arrive at a collaborative consensus-based approval (ANSI, 2014). Depending on the publishing organization, the group responsible may be a single committee or have multiple tiers of groups and committees that evaluate proposed changes. Usually at the root of these committees is a Technical Advisory Group (TAG) made up of experts knowledgeable about the subject matter. These committee groups are made from a balanced mix of Producers, Regulators, and General Interest people to ensure adherence to safety and performance. Often the published standards include a list of the committee members involved.

Each standard begins with a Scope of coverage which defines what is covered by that specific standard. Most standards generally have two main sections: Construction and Performance.

The Construction section of a standard covers basic material requirements such as acceptable alloy types and minimum material thicknesses. Additionally, specific construction requirements for various components detailing their function, requisite size, or overall shape can be found in this section of the standard. In order for products to be listed to the standard, its materials, design, and components must meet the requirements specified. If a product or component differs from the requirements set forth in the Construction section, the listing agency can choose to make an engineering evaluation to either accept or reject the change. Engineering evaluations by the listing agency allows manufacturers and designers to generate new innovations and create new components, which in-turn allow for novel product designs. Even if the change is accepted, the product must still pass the tests described in the Performance section of the standard.

The bulk of each standard is made up of the Performance section. The Performance section includes all the necessary tests required for product compliance under the standard. These requirements include thermal tests, mechanical tests, environmental tests, various component tests, and motor and electrical tests where applicable. The purpose of these tests is to verify both safety and performance of the products. Tests are designed to meet or exceed what the product will normally experience during its life-cycle.

The following are descriptions of different standards related to the Hearth industry. The Appendices include additional test details for some of the standards described. For the sake of simplicity, the standards listed are those required in the United States, although some of these standards are also used in Canada.

Fireplace Standards:

Building codes require factory-built fireplaces to comply with required standards and to be installed in accordance with the manufacturer's listing. This is found in the IMC section described above, as well as in NFPA 211:

> "11.1.1 Factory-build fireplaces shall be listed and installed in accordance with the terms of the listing." (NFPA 211, 2013).

The appropriate standard for factory-built fireplaces depends on the type of fuel it uses:

- For solid-fuel fireplaces, UL 127 *Standard for Factory-Built Fireplaces* is used.

- For natural gas and propane fireplaces, ANSI Z21.50/CSA 2.22 *Vented Gas Fireplaces* and ANSI Z21.88/CSA 2.33 *Vented Gas Fireplace Heaters* are used.

UL 127 *Standard for Factory-Built Fireplaces* covers fireplaces that are intended to be used with solid wood or coal fuel. Fireplace systems can be either be listed with doors or no doors, and those doors can be either open or closed, depending on what the manufacturer chooses. Fireplaces listed to UL 127 can be constructed of metal or masonry, and are meant to use a factory-built chimney.

UL 127 testing is done with a fireplace installed into a plywood enclosure with thermocouples arrayed around the structure. The enclosure is constructed to simulate a residential installation, and the thermocouples determine if temperatures anywhere on or near the structure exceed specified limits and pose a safety hazard.

The Performance section of the UL 127 includes tests that check for radiant heat temperature, surface temperature equilibrium, and verify the system can withstand a creosote burn event. Additional tests are done on the fireplace to address structural integrity, drafting performance, wind resistance, rain infiltration, and evaluate any electrical components if they are part of the system.

In Canada, the equivalent solid-fuel standard is ULC S610 *Standard for Factory-Built Fireplaces*. ULC S610 is similar to UL 127 in its overall evaluation of fireplaces, although many of the individual tests are conducted differently than those required for the American standard.

For a list of tests included in UL 127, refer to Appendix A.

Gas-fired (natural gas or propane) fireplaces are covered under ANSI Z21.50/CSA 2.22 *Vented Gas Fireplaces* and/or ANSI Z21.88/CSA 2.33 - *Vented Gas Fireplace Heaters*. Both standards include gravity-vented appliances (B-vent) and direct-vented appliances (co-axial or co-linear).

These standards focus on safety and performance of the thermal properties of the fireplace as well as the components dealing with burning and controlling its fuel. While gas-burning appliances normally operate at lower temperatures than solid fuel-burning appliance, they have additional safety concerns involving the gas supply and all that it entails. These concerns include the proper performance of gas control valves, flame-outage prevention, and proper exhaust of the products of combustion.

For testing, the appliance is surrounded with combustible materials arrayed with thermocouples and thermally evaluated for unsafe temperatures. In addition, the gas burners, valves, and other related components are also tested to ensure their safe and reliable performance. The added focus on gas components and safety is one reason the ANSI/CSA gas appliance standards are generally longer than the solid fuel-burning UL standards.

For a list of tests included in ANSI Z21.50/CSA 2.22 refer to Appendix B. Due to its general similarity to ANSI Z21.50/CSA 2.22 and for the sake of simplicity, the list of tests for ANSI Z21.88/CSA 2.33 has not been included in this document.

<u>Insert Standards</u>:

Fireplace inserts themselves do not have a true dedicated standard. This is because the standards to which inserts are tested and listed, specify in their scope that they cover "free-standing" appliances and not recessed appliances. However, it is an accepted practice in the industry that these standards are used to test and list inserts. The underlying rationale is that if the standard is used to test a free-standing appliance, then it can also be used to test the same appliance when surrounded by the additional metal layers of the fireplace.

Similar to factory-built fireplaces, the different standards for testing inserts depend on the type of fuel used. These standards evaluate both free-standing and insert variations of appliances.

- For solid-fuel inserts, UL 1482 *Standard for Solid-Fuel Type Room Heaters* is used.

- For gas- and propane-burning inserts, ANSI Z21.50/CSA 2.22 - *Vented Gas Fireplaces*, ANSI Z21.86/CSA 2.32 *Vented Gas-Fired Space Heating Appliances* and ANSI Z21.88/CSA 2.33 *Vented Gas Fireplace Heaters* are used.

- For pellet-burning inserts, ASTM E1509 *Standard Specifications for Room Heaters, Pellet Burning Type* is used.

Under UL 1482, a solid-fuel room heater is placed within a room having combustible plywood floor, walls, and ceiling. The test apparatus simulates a typical residential installation. Thermocouples are placed around the apparatus to measure surface temperatures, and tested to ensure temperatures do not exceed specified safety limits. The appliance is connected to stovepipe which is then connected to a chimney system leading out of the test apparatus. However, when testing solid fuel-burning inserts for factory-built fireplace, a factory-built fireplace is used as part of the test apparatus. The fireplace is first installed in a framed, plywood enclosure as specified in the fireplace standard, UL 127, and the insert is then installed into the fireplace. The appropriate tests are then performed on the system.

The Performance section of the standard includes tests addressing thermal, electrical, and mechanical tests. Thermal tests comprise a radiant heat test, a flash fire test, and an equilibrium test. These tests verify the fireplace can safely burn wood long-term, and verifying the system can withstand a creosote burn event. Additional tests are performed to check the glass (if any) for impact and water shock resistance. Any electrical control components for the appliance are also evaluated for safety and reliability. Mechanical tests are performed to ensure the heater can resist being tipped over, and has overall structural stability.

Refer to Appendix B for a list of tests included in UL 1482.

For gas-burning appliances, the ANSI Z21.50 standard is also used when evaluating free-standing appliances and inserts, as well as fireplaces, described above. Depending on whether the insert is intended on being a heating appliance or a decorative appliance (not intended to produce significant heat), the appliance may be listed ANSI Z21.86, or Z21.88.

The standards, ANSI Z21.86/CSA 2.32 *Vented Gas-Fired Space Heating Appliances* and ANSI Z21.88/CSA 2.33 *Vented Gas Fireplace Heaters* are both similar to ANSI Z21.50. The ANSI Z21.88 standard limits itself to fireplaces that are specifically intended on heating, as opposed to decorative fireplaces which are covered by the ANSI Z21.50 standard. The ANSI Z21.86 standard focuses on space heating appliances which typically include stoves and inserts. The test setup for both standards is similar to that of ANSI Z21.50, as are many of the required performance tests.

Refer to Appendix C for a list of performance tests for ANSI Z21.50. Due to their general similarity to ANSI Z21.50, the performance tests for ANSI Z21.86 and ANSI Z21.88 have not been included in the appendices.

Pellet-burning appliances are tested to ASTM E1509 *Standard Specification for Room Heaters Pellet Fuel-Burning Type*. The test apparatus is a framed plywood room arrayed with thermocouples on the surfaces. The appliance is positioned at specified distances to the walls. For units to be inserted into a factory-built fireplace, the setup involves a fireplace installed into a framed enclosure as prescribed in UL 127, with the pellet appliance then installed into the fireplace. The necessary tests of ASTM E1509 are then performed on the appliance.

As with the other appliance standards, ASTM E1509 limits the maximum temperature on nearby combustibles, but the standard also limits the maximum temperature of the flue gas. This temperature limitation is to ensure the exhaust gases do not exceed the capability of the venting systems used for pellet appliance. Although pellet appliances can be connected to masonry or factory-built chimneys, they are typically vented with specialized L-vent, which is listed to the requirements of UL 641 *Type L Low Temperature Venting Systems* (or for Canada, ULC S609 *Standard for Low Temperature Vents Type L* and ULC/ORD C441 *Pellet Vents*). The appliance is limited to a maximum exhaust temperature of 500^{O}F when using these low-temperature venting systems.

ASTM E1509 also includes tests to address the amount of exhaust spillage, the negative pressure of the burn chamber, and to verify the fuel in the hopper does not ignite. There are additional tests for the appliance's structural, mechanical, and electrical integrity including glass strength, rain protection, appliance stability, and blower controls.

Refer to Appendix D for a list of performance tests required in ASTM E1509 for pellet-burning appliances.

<u>Chimney Standards</u>:
As noted previously, the International Mechanical Code requires factory-built chimneys to be listed, but NFPA 211 also requires factory built chimneys to be listed and installed in accordance with their listing:

> "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." (NFPA 211, 2013).
>
> "6.1.3.1 Factory-built chimneys shall comply with the requirements of ANSI/UL 103 *Standard for Factory-Built Chimneys for Residential Type and Building Heating Appliances*..." (NFPA 211, 2013).

For residential solid-fuel chimneys in the US, the appropriate standard is UL 103. This standard addresses the material requirements for factory-built chimneys (usually certain stainless steel alloys, but other materials are also allowed), and the critical thermal performance expected of residential chimneys.

For the Performance section of UL 103, the chimney is installed into a multi-story wooden structure simulating a residential home. A specific flue-gas generator is employed to control the amount of gas and temperature used for the tests. The chimney is enclosed within a plywood chase at the minimum clearance between the chimney pipe and combustible materials (2" is normal in the industry). The interior of the chase is painted flat black to absorb as much heat as possible, creating a worst-case scenario. Thermocouples are arrayed on the inside surface of the chase and structure to check temperatures and verify they do not exceed the allowed maximum.

The chimney system is exposed to thermal shocks in order to pre-condition the chimney before the remainder of thermal tests are performed. Thermal tests include:

- An equilibrium tests at a flue temperature of 1000 ^{O}F for 4-1/2 hours or more
- A forced-fire test at a flue temperature of 1400 ^{O}F for 1-hour, after reaching equilibrium
- Three creosote burnout tests at flue temperature of 2100 ^{O}F or 1700 ^{O}F (meeting HT or non-HT requirements), each for 10-minutes, after reaching equilibrium

For each test, there is a maximum temperature the thermocouples are allowed to reach. If any of the thermocouples exceed the allowed limit, the entire system fails. After all thermal testing is completed, the system must not show any evidence of excessive damage, and must be able to be used again. The allowed maximum temperatures are well below the combustibles' ignition temperature, and so provides a certain factor of safety. As an example, for the equilibrium test, the maximum allowed temperature is 90 ^{O}F above ambient for the first 4-1/2 hours, and 117 ^{O}F above ambient thereafter. For the creosote burnout tests, the maximum allowed temperature is 175 ^{O}F above ambient; well below the ignition temperature of most common building materials.

In addition to the thermal tests, chimneys listed to UL 103 must meet strength and resiliency tests. Chimney supports are evaluated to determine the amount of weight they can carry. Support tests are performed using a 4x factor of safety. That is, if a Support Box or Tee Support has been listed to hold 40-ft of chimney, then that support was actually tested using the weight equivalent of 160-ft (4x40-ft) of that model chimney. Similarly, joint loads tests, the allowed distance between elbows, spacing of wall brackets, are all done with 4x factor of safety. The chimney must also undergo an impact test from the side, a longitudinal test for the joints, and a torsion resistance test to ensure the sections do not disconnect when they are cleaned with a chimney brush.

Note that the components of the chimney system are typically not tested independent of the system itself, as many of the components will have an effect on the system's performance. As an example, while the chimney cap may be independently tested for rain infiltration, the cap is also part of the complete system during the thermal tests, since the cap affects the chimney's draft performance.

Refer to Appendix E for a list of UL 103 tests that are required for factory-built chimneys.

In Canada, the equivalent chimney standard is ULC S629 *Standard for 650 ^{O}C Factory-Built Chimneys*. While there are many similarities between ULC S629 and UL 103, there are some notable exceptions. The most well-known difference is that the Canadian standard requires 30-minute duration creosote burnout tests at 2100 ^{O}F, although the tests begin at a lower 600 ^{O}F equilibrium state. Another difference is that the Canadian standard allows for 45^{O} elbows, whereas UL 103 limits chimney elbows to a maximum of 30^{O} from vertical.

Additionally, factory-built chimneys can also be listed to UL 127, the fireplace standard described above, but are done so as part of the factory-built fireplace. Factory-built fireplaces must be listed with their usable chimney systems, and the appliance manufacturers may develop proprietary chimney systems for their fireplaces to use. These chimney systems are not independently listed for use with other appliances, as they would be if they were carried a UL 103 listing. Often these proprietary chimney systems are made by the appliance manufacturer, but may also have been developed in partnership with another manufacturer. This may mean multiple chimney systems are listed with the fireplace model.

Liner Standards:

The standard that covers chimney liners in the US is UL 1777 *Standard for Chimney Liners*. This standard covers both metallic and non-metallic liners as they would be installed inside masonry chimneys. Note: although there has been a proposal to include coverage for liners to be installed into factory-built chimneys, as of 2014 the standard only addresses liners to be installed into masonry chimneys.

The masonry chimneys in which liners are installed are intended to be compliant with Building Code and NFPA requirements. The typical masonry brick chimney requires at least a 1-inch clearance to combustibles (NFPA 211, 2013). However, it is often found that masonry chimneys in the field are not constructed with the appropriate standoff, and instead are in direct contact with combustible framing.

UL 1777 includes the accepted materials from which a liner can be manufactured. Depending on the fuel type, the standard specifies various acceptable materials, and the types of thermal and mechanical tests required for listing.

For testing, liners are installed in a vertical masonry chimney without clay tiles. The masonry is then surrounded by wooden framing to simulate a residential installation. Thermocouples are arrayed on the inside surface of the wood to check temperatures. The liner manufacturer determines the specifications as to whether or not insulation is used with the liner, the clearance between the liner and the masonry (inside the chimney), and the clearance between the masonry and combustible framing (outside the chimney). Even though the building codes require a 1" clearance on the outside of the masonry, some liners are listed so they can accommodate a 0" clearance, and thereby can handle non-compliant masonry chimneys.

Liners used with solid fuel or oil-burning appliances are typically made from stainless steel alloys (type 300 or 400 series), but may also include cast iron, porcelain-enameled steel, or other materials. Thermal tests are similar to those for factory built chimneys, and include a 1000^{O}F equilibrium test, a 1-hour 1400 ^{O}F forced-fire test, and either a 10-minute 1700 ^{O}F test (liners used for oil) or a 2100 ^{O}F test (liners used for solid fuel). Liners are subjected to longitudinal force tests (pull tests) and vertical support tests using a load of 200-lbs, as well as other tests including sweep tests, torsion (rotating) tests, and bending tests to ensure they can take the abuse of sweeping.

Liners for natural gas and propane appliances are typically made from aluminum alloy (Type 1100 or 3003). UL 1777 liners for gas-burning appliances are limited to natural drafting or fan-assisted appliances. This excludes category II, III, or IV appliances, which require more corrosive resistant materials for their venting systems. Venting for these appliances are covered under a different standard, UL 1738 *Venting Systems for Gas-Burning Appliances, Categories II, III, and IV*.

Thermal testing for gas liners is limited to an equilibrium test of 540 ^{O}F. Most mechanical tests are similar to that of the solid-fuel liners, except the loading tests are limited to 100-lbs.

For Canada, there are two different liner standards, each with a different focus: ULC S635 *Standard for Lining Systems for Existing Masonry or Factory-Built Chimneys and Vents*, and ULC S640 *Standard for Lining Systems for New Masonry Chimneys*. ULC S635 is focused more on the mechanical properties of the liner, as the thermal protection is performed by the existing masonry chimney. In contrast, ULC S640 is more focused on the thermal performance of the liner with the chimney, as its liners are typically insulated and intended to be installed in a masonry chimney without a clay liner.

Gas Log Standards:

Gas logs sets are included in this discussion because they are often installed in factory-built fireplaces. However, gas log sets are tested such that their approval is independent of the fireplace into which they are installed. An exception is with vent-free gas log sets, which requires that the fireplace is specifically listed to accept a vent-free gas log set. The reason is that it is possible that a vent-free log set could potentially overheat the fire chamber. As gas log sets are independently listed from the fireplace, this document will only review their standards.

Gas log sets which are to be installed into solid-fuel factory-built fireplaces are tested to different standards depending on their intended function and operation. The standards are divided into vented or unvented, decorative or heater, and even automatic or manually ignited:

- ANSI Z21.60 *Standard for Decorative Gas Appliances for Installation into Solid-Fuel Burning Fireplaces* is used for decorative gas log sets (vented) with automatic ignition systems.
- ANSI Z21.84 *Manually Lighted Natural Gas Decorative Gas Appliances for Installation In Solid-Fuel Burning Fireplaces* is used for decorative gas log sets (vented) with manual ignition. Note: this is for natural gas units only, not for appliances using liquid propane.
- ANSI Z21.11.2 *Gas Fired Room Heaters - Volume II, Unvented Room Heaters* is for vent-free gas log sets.
- ANSI Z21.86 *Vented Gas-Fired Space Heating Appliances* is for gas log sets that are intended as heaters.

It should be noted that for vent-free heating gas log sets, a combination of the appropriate tests from both ANSI Z21.11.2 and ANSI Z21.86 are used.

The tests required of units listed to ANSI Z21.60 are similar to those prescribed in the other ANSI standards previously discussed. Tests cover burner operating characteristics, ignition systems, valve operation and integrity, combustion, burner durability, etc.

Other Components:

Most other components encountered in the hearth industry do not have their own standard. However, some accessory components which are to be used in conjunction with a masonry fireplace do have a separate standard. UL 907 *Fireplace Accessories*, applies only to field installed accessories into a *masonry* fireplace for solid-fuel burning components, including heat exchangers, blowers, glass doors, and similar products to be placed in or near the firebox chamber (UL 907, 2005). The test apparatus used for this standard is a masonry fireplace with nearby combustible framing. The performance tests are similar to some of the thermal tests in UL 127 for fireplaces, with various thermocouples placed in appropriate locations to evaluate the components.

While this standard specifically states that it applies only to components used with masonry fireplaces, it has been used to list components that may also be used in conjunction with factory-built fireplaces. Currently, there is no separate standard to address components for factory-built fireplaces.

Often when a manufacturer introduces a new product or component which differs from others in the market, it may not have a proper standard to which it can be listed. In order to gain market acceptance, and building department approval, the manufacturers will turn to the listing agencies to help evaluate the new product. If acceptable to the listing agency, the product will be evaluated using pertinent sections of existing standards, a combination of standards, and/or other tests to fully evaluate the product before it can be listed.

If the market shows a demand for this new type of product, then a standard will be published for it. Occasionally this means a standard for a similar product will be adopted and edited accordingly. In some cases, a completely new standard is developed. However, it may take many years for a new standard to be created, and then it must be acknowledged by the building codes. This explains why building codes do not always stay current with available technology. When updates do occur, the proposed change will have to wait for the next revision cycle of the code, which is typically done every three years or more.

Components

This section examines different types of aftermarket components associated with factory-built fireplaces and chimneys, along with the critical issues pertaining to their use. For safe installations, it is important that all components are installed in accordance with the manufacturer's installation instructions. Deviating from the manufacturer's instructions can create unintended or hazardous situations.

While not a component, inserts are included in this section since their installation into a factory-built fireplace makes them similar to components for the purpose of this analysis. Inserts have their own safety and performance listing and should always be installed in accordance with their listing and the manufacturer's installation instructions. Similarly, chimney liners are included as a component although they are listed to their own safety standard.

It should be noted that other components (refractory panels, fireplace grates, glass doors, and chimney caps) do not have their own independent standards to which they can be listed, with the exception of those that can be listed to UL 907 *Fireplace Accessories* for use with a masonry fireplace. The standards described above include clear test procedures for components and how those components affect the overall system. However, the standards do not provide for components to be listed separately from their system.

Many in the industry have suggested that there should be generic component requirements or standards to address both safety and compatibility of components. An often cited analogy is that of the SAE (Society of Automotive Engineers) and their listed parts for automobiles. The analogy suggests that if a mechanic can use a part that meets SAE specifications, than a hearth installer should be able to use an appropriate component as long as it meets a specific hearth standard.

This is a valid premise and the industry may eventually reach that point. However, there are problems with this analogy. First, the desired component standards do not currently exist. As mentioned, the standards currently apply to the system as a whole, not just components. In order to have component standards, the standards would need to be completely overhauled and re-written. As described previously, that would be for UL, CSA, ANSI, and ASTM to address in their respective standards. Most of these standards are maintained and edited by committees working off of proposals. So the method of implementing changes to these standards exists, but no one has yet submitted the detailed proposals to address all of the necessary changes for each of the affected standards. As can be imagined, that would require a significant amount of effort.

Second, the analogy implies all "approved" components are the same. For the hearth industry, this is not the case. Different components are designed differently and perform differently, even though they may fit into the system at the same location (cap, grate, panel, etc.). The uncertainty of a component's performance is what normally leads manufacturers to not allow these types of components in their system. It is simply an unknown quantity that may, or may not, affect their listed system's safety and performance.

Third, once listed, there is a chance that aftermarket components could be changed in design or function without the knowledge of the appliance manufacturer. With a generic component standard, the part may still meet the requirements, but even a subtle design could adversely affect the performance of the appliance. This is another reason that appliance manufacturers generally do not approve aftermarket components with their listed systems.

This leads to the another issue: safety factor of the listing. When a system is tested and passes the requirements of a standard, there is a factor of safety included. As an example, if the temperature of nearby framing reaches a few degrees higher than the maximum allowed by the standard, the wood does not suddenly burst into flames. Instead it would have to reach a significantly higher temperature; this is the factor of safety. An untested component may work with the system, but until it is tested to the same standard in combination with the system, the level of performance of the component is unknown, and may infringe on the factor of safety which is part of the original listing.

However, this is not to say any or all aftermarket components negatively impact the performance. Indeed, anecdotal indications from the field suggest that many available aftermarket components may exceed the performance of their original listed counterparts. But, until laboratory tested with the system, the results of the components with the system are still unknown. If an incident does occur, there may not be tangible proof of what was at fault, and the cause may remain vague. This is especially true if an aftermarket component reduces the factor of safety of the original listing.

The local Authority Having Jurisdiction (AHJ) has the authority to approve modifications to listed equipment. However, since the AHJ cannot be held responsible in the event of a fire or similar incident, it is the responsibility of the installer to ensure the system is safe and works as intended. To that end, various aftermarket components are described below along with some of the critical issues that that may occur when installing them into a listed fireplace and chimney systems.

INSERTS:

As already mentioned, inserts cannot truly be considered aftermarket parts as they have their own standard. However, when they are installed into a listed fireplace system, the insert essentially becomes a component.

Inserts themselves are tested to the same standards that are used to test and list free-standing appliances (i.e. standing directly on the ground, such as a typical wood-burning stove). Like free-standing stoves, inserts operate with closed-doors to the fire chamber and a tightly controlled air supply for combustion. Controlling the air enables the appliance to maximize the heat output and minimize the amount of fuel burned.

Inserts by their functional nature and design are more efficient than open-face fireplaces, which is one of the main reasons people choose to have inserts installed. Being more efficient not only means using less energy (wood or gas) than a fireplace, but usually providing a higher heat output as well. The reason why an insert might typically be chosen over the free-standing stove version is that the customer already has the fireplace space available, which is often in a prime location in the home. Additionally, wood-burning inserts burn cleaner than standard wood-burning fireplaces. The US Environmental Protection Agency (EPA) publishes a list of wood-stove and insert models that have passed the current emission requirements (EPA, 2014). Choosing one of these models can still enable customers to use wood when local air quality control districts may otherwise restrict wood-burning fireplaces. Similarly, changing to a gas- or propane-burning insert is another clean-burning alternative, and may be the only choice in areas where wood-burning appliances have been prohibited altogether.

Inserts, as their name suggests, are essentially a stove which is inserted into a fireplace. Although inserts were originally intended to be installed into masonry fireplaces, this analysis is limited to inserts being installed into factory-built fireplaces. Check with the fireplace manufacturer as to whether or not an insert can be installed. Some fireplace manufacturers specifically disallow inserts in their fireplaces. Also, solid-fuel inserts (stoves) normally require an HT chimney system (2100^{O}F), but the original fireplace's chimney may only be listed for non-HT use (1700 ^{O}F). A liner system may be installed to address the higher temperature requirements of the insert. The use of liners and their issues are discussed in the Liner section.

Critical Issues:

- Wood Insert into Wood Fireplace Only: If allowed, wood-burning inserts are limited to installation into wood-burning fireplaces only, as a gas-burning fireplace would be inadequate for housing the insert. A wood-burning fireplace has a chimney system in place, and has been tested to handle certain structural loads (see Appendix A). A gas-burning fireplace does not have the same load capacity as its wood-burning counterpart, and its dedicated venting system cannot handle the heat of a solid-fuel insert, nor will it likely be large enough to physically enclose the insert.

- Gas Insert into Wood or Gas Fireplace: A gas-burning insert can be installed into a either a gas-burning fireplace or a wood-burning fireplace, if permitted by the fireplace manufacturer. Before installing a gas-burning insert into a gas-burning fireplace, check the limitations of both the fireplace and the insert, as the installation may not be allowed because of either temperature and/or structural reasons.

- Ability to Re-Install Fireplace to Original Condition: The insert manufacturer will have details on how its appliance must be installed. The installation process as shown in the insert's instructions reflects the method of how the insert was tested and listed by the listing agency. As a general rule, the existing fireplace may only be modified such that it can be re-installed to its original condition if the insert is removed. Removing the damper, smoke shelf, and sometimes the refractory panels is common, as each of these can be re-installed back into the fireplace. However, some listings for gas-burning inserts allow additional parts of the fireplace to be removed, such as the floor. If so, this is part of their listing, and has been tested and approved by the listing agency as such. Always follow the appliance manufacturers' installation instructions. Additionally, for gas inserts, a warning tag must be placed on the fireplace indicating it has been modified:

“WARNING. This fireplace has been converted for use with a gas fireplace insert only and cannot be used for burning wood or solid fuels unless all original parts have been replaced, and the fireplace re-approved by the authority having jurisdiction.” (ANSI Z21.50, 2007).

- Check the Listing: Normally, inserts are required to be tested and listed with each factory-built fireplace into which they may be installed. This has been an ongoing problem in the industry, as testing and listing every combination of insert and fireplace would be excessively time consuming and highly cost prohibitive. Given that many fireplace models encountered in the field are no longer in production, achieving a combination listing may not even be possible. Currently, the industry does not have a standard to address testing and listing an insert into a generic fireplace model. The UL 127 Standards Technical Panel (STP) has tried to address this problem, but the issue is currently unresolved.

  In the meantime, listing agencies have gone forward with testing and listing inserts to be installed in factory-built fireplaces. While not strictly adhering to the letter of the standard, the rationale is based on historic empirical test data and engineering evaluations. Over the years of testing different inserts with a variety of fireplaces, it has been noticed by the listing agencies that most fireplace models do not have a significant impact on the performance of the insert. It is important to note that this is not a blanket approval or endorsement of all inserts and fireplaces combinations, but rather a general understanding that the fireplace housing may not adversely affect the performance of the insert when installed in accordance with the manufacturer's installation instructions.

- Maintain Structural Integrity of Fireplace: If an insert is installed into a factory-built fireplace, the structural integrity of the fireplace must be maintained. This may sound obvious, but there have been installations in the field where a fireplace had its back and side walls removed in order to fit a large insert. The problem that occurs is that the insert may end up much closer to combustible framing than is required by its listing, creating a hazardous situation. Again, the underlying rationale for allowing an insert into a factory-built fireplace is that the fireplace itself provides additional protection; however, if that protection is removed, a fire hazard can be created.

- Maintain the Fireplace's Chimney System: Another critical issue is the venting system must remain intact. Inserts require a dedicated liner to be run through the fireplace's existing chimney system. For air-cooled chimneys, it is critical that the airflow for the chimney is maintained. Even for solid-filled chimneys, the functionality of the chimney must remain intact in order to help maintain a safe installation. This issue is discussed further in the Liner and Termination Cap sections, below.

Prior to installing an insert, an appropriate inspection should be performed on a fireplace system to verify the required clearances. Such an inspection may require the use of a borescope. To safely install an insert into a factory-built fireplace, it is important to follow the manufacturer's installation instructions and local code requirements. Ensure that the existing fireplace maintains its structural integrity, and the liner and chimney system are also properly installed and functioning. If there are any concerns about the installation, contact the insert manufacturer and the local Authority Having Jurisdiction.

REFRACTORY PANELS:

Refractory panels cover the interior of the firebox chamber and add thermal and structural protection to the fireplace, or are used as decorative enhancements. Refractory panels are generally available in two types: a concrete and/or brick version for wood-burning fireplaces, and a ceramic fiber version for gas-burning fireplaces. The panels for solid-fuel fireplaces are typically molded or cast from a concrete and aggregate mixture, or are otherwise made from cut bricks molded into the necessary forms. Panels for gas-burning fireplaces are typically molded from a mixture of ceramic fibers and light-weight concrete.

Depending on the type of fuel, the fireplace itself is listed to either UL 127 or one of the ANSI standards (Z21.50, Z21.86, or Z21.88) as previously described. These standards include thermal tests for the fireplace, and the refractory panels must also be able to handle these tests. Additionally, refractory panels for solid-fuel fireplaces must withstand the required internal structural and impact tests. As noted in Appendix A, the Fire Chamber Strength Test of UL 127 requires a weighted log to repeatedly impact the back of the fire chamber. It is the refractory panels that absorb these impacts and protect the fireplace.

Over time, refractory panels break down either through the repeated heating-cooling process, trauma of some sort (log impacts, etc.), or general wear and tear from normal operations. Replacing or repairing the panels helps to maintain the safety of the fireplace, as well as its aesthetic appeal.

Critical Issues:

- Maintain Thermal Performance of Fireplace: When replacing panels, the important factor is to maintain the same thermal performance as the original fireplace. Whenever possible, always refer to the fireplace manufacturer for replacing refractory panels. Some fireplace manufacturers still have refractory panel molds for both current and discontinued fireplace models. To maintain the listing, the fireplace manufacturer may require a replacement part to be ordered from the manufacturer; this addresses three concerns:
    - 1) the thermal performance of the panel is consistent with what was listed,
    - 2) the panels are the correct size without needing to be field-cut, and
    - 3) the panels will match the existing panels already in the appliance.

  Some fireplace manufacturers also allow, or even endorse, third-party refractory panels. Check with the appliance manufacturer for any limitations or recommendations.

- Keep Same Panel Thickness as Original: By using replacement panels with the same thickness as the original panels helps to keep the thermal performance the same, and helps to ensure a good fit and finish of the panels.

- Completely Cover Interior of Firebox: When replacing panels, the interior of the firebox must be completely covered, as intended by the fireplace manufacturer. This helps to maintain the same thermal performance as the original fireplace, and helps to ensure heat is not escaping somewhere and potentially creating a hazardous situation.

Different fireplaces will have different refractory panels, but they essentially perform the same function: to protect the firebox. Over time the refractory panels can break down and will need to be replaced or repaired. Check with the fireplace manufacturer for their requirements on replacing their panels. If using an aftermarket panel, be sure to follow the manufacturer's directions, and be aware of the critical issues described above.

<u>GRATES:</u>

A fireplace grate is a frame support to hold wood in a fireplace. Not all factory-built fireplaces use fireplace grates. Some fireplace models are available without grates, which means they have been tested and listed without their use. The construction of a fireplace grate is simple; grates are typically made from low-carbon steel, or for outdoor uses, stainless steel. In the case of some decorative aftermarket grates or andirons, they may be cast iron or similar. The purpose of the fireplace grate is simple enough; it elevates the fuel off the bottom of the fireplace and allows air to flow under it to promote better combustion. While it is a simple component, it can have a critical effect on the operation of the fireplace.

The grate limits the fuel size for the fireplace. The fireplace is designed to work with a specific maximum load, which is controlled by the size and position of the grate. Without a grate, the fuel load could be as big as the firebox itself. For those fireplaces that were listed without grates, that is how they were tested; by filling the firebox for the appropriate tests. Changing the grate can change the fuel size, and thereby alter the performance of the fireplace.

Since a normal fireplace grate is typically made from cold-rolled steel or similar material, it can over time fall apart, crack, burn-out, and collapse due to repeated heating. This is the main reason for replacing a grate. Often this can occur long before the fireplace itself needs to be replaced. When replacing the grate, there are some critical issues that must be addressed.

Critical Issues:

- <u>Keep Same Grate Footprint</u>: The biggest concern is that the replacement grate has the same footprint, or smaller, than the original grate. The reason is that the grate helps to control the fuel burned. If the grate is larger, it can lead to a larger fuel load. A larger fuel load can cause problems for the fireplace, which was tested to ensure temperatures remain below a certain level (refer to Appendix A). A larger fuel load can increase the temperatures in the firebox, as well as increase temperatures in the surrounding framing and nearby combustibles.

- <u>Maintain Same Grate Depth</u>: Besides the overall size of the fireplace grate, another critical dimension is the depth (front-to-back dimension) of the grate. If the depth of the replacement grate is larger than the original grate, it may move the fuel load too far forward, which may cause exhaust, and even flames, to spill into the room. Similarly, if the grate depth is increased, the fireplace may fail to draft properly through the smoke shelf and into the chimney. Exhaust spillage into the home can not only affect air quality by increasing carbon dioxide (CO_2) and carbon monoxide (CO) levels, but can have a dramatic temperature rise on the mantle or nearby combustibles, potentially creating a fire hazard.

- Maintain Same Grate Height: The height of the grate is also a concern, although less so than the overall size and depth of the grate. The height of the grate helps to control the airflow to the wood. By raising or lowering the grate, the burn quality can be affected. However, after multiple uses there will be an ash bed of a certain height, which should help to minimize any impact from the grate height. An exception is if the grate moves the burning fuel significantly closer to the top of the firebox, causing it to heat up more than intended, potentially overheating nearby framing and creating a hazardous situation.

Discussions with representatives from fireplace manufacturers, test agency engineers, and fire investigators have all commented that the grate size has a critical effect on the performance of a fireplace. To minimize any potential problems, use a replacement grate from the fireplace manufacturer. If that is not available, use a replacement grate with the same size (or smaller), footprint, depth, and height in order to help minimize any changes to the performance of the fireplace.

GLASS DOORS:

Common styles of fireplace glass doors include single hinge door, double doors, and typical bi-fold doors. The doors themselves are fitted to the outside face of the fireplace with individual glass panels. There are gaps between the panels to allow the doors to fold or move. If the fireplace is allowed to operate with the doors closed, then the gaps also allow combustion air into the fireplace during operation.

The type of glass used for fireplace doors is either tempered glass (also called safety glass) or ceramic glass. Fireplace manufactures often supply their doors with tempered glass. Tempered glass has been treated to withstand typical fireplace temperatures (up to about 500 ^{O}F), and provides structural strength to withstand impacts. In the event that the glass is broken, it shatters into tiny pieces, as opposed to large sharp shards (hence the term, safety glass). Structural strength is necessary to withstand the required impact tests of the UL and ANSI standards. A drawback to tempered glass is that it tends to restrict the heat from radiating into the room. Additionally, tempered glass cannot be cut, and instead must come from the manufacturer in the appropriate sizes.

While tempered glass is available for replacement parts, often ceramic glass is a choice with aftermarket doors. Ceramic glass is not truly glass, but a transparent ceramic material that has a high temperature limit of about 1300-1400 ^{O}F (Fireplacedoorsguide.com, 2014). Ceramic glass allows heat to radiate into the room better than tempered glass. The downside is that ceramic glass does not have the same structural strength as tempered glass, and if it does break, it will do so in large, sharp pieces. Additionally, ceramic glass often looks tinted, which may not be as aesthetically appealing as tempered glass.

It is important for an installer to know whether or not doors are allowed on the fireplace in question. For some listings, doors are not allowed at all on the fireplace, as it may adversely affect the fireplace's performance. Even if doors are allowed on, or supplied with, the fireplace, the listing may require that the doors remain open during operation. Check the fireplace's operating instructions, or check with the fireplace manufacturer directly to determine the correct position of the doors, if allowed. If the doors can be closed during operation, normally that means the doors must be either fully opened or fully closed. If the doors are partially opened/closed this can create a potential fire hazard, as the airflow for the fireplace may have been changed, and could possibly direct heat out the front of the fireplace and upward into the mantle area. While this is more of an operating concern, it is worthwhile for installers to be aware of the issue.

Critical Issues:

- Are Doors Allowed with Fireplace? If doors are not listed or approved for use with the fireplace, then using doors can increase temperatures in the firebox. Higher internal temperatures can result in higher exterior temperatures for the fireplace. This may mean that nearby framing and combustible materials have insufficient clearance, and can create a fire hazard.

- Check Manufacturer's Requirements for Doors: Some fireplace manufacturers require replacement doors to come from the factory. There are different reasons for this, including the need to ensure a proper size and fit for the door or glass panel. This may be especially true for tempered glass since it cannot be field cut. Alternatively, there may be a concern on how aftermarket doors are attached to the fireplace, if it was not an original option from the fireplace manufacturer. Some aftermarket doors are supplied with their handles at the top of the door. Often doors from the fireplace manufacturer are provided with handles at the bottom. If the handles are at the top of the doors, they can be exposed to additional heat and potentially create a burn hazard. The can vary from different models and different manufacturers.

- Must Provide Airflow Into Fireplace: Another concern about using aftermarket glass doors is the amount of airflow into the fireplace they provide. The gaps between glass panels and doors are not standard in the industry, and in fact can vary between models from the same manufacturer. Finding aftermarket doors that perform similarly to those of the fireplace manufacturer may be difficult. If the gaps in the doors are too large, there may not be much of a problem. However, if the gap is too small, this could lead to a hotter fire in the chamber, resulting in overheating the glass and the firebox. Alternatively, if the air supply is too constricted, it could potentially starve the airflow such that incomplete combustion occurs, resulting in a poor performing fireplace. Either condition is possible, and will depend on the specifics of the situation.

Again, not all fireplace models are allowed to use glass doors, so be sure to check the fireplace owner's manual or with the fireplace manufacturer directly to determine if that model was listed with the option of glass doors. Even if doors are allowed, their position may be restricted during operation. While aftermarket glass doors provide decorative options, they need to meet the listing requirements in order for the fireplace to operate safely and effectively. Always check fireplace manual if available, or the fireplace manufacturer, for any limitations or restrictions on glass doors.

LINERS:

Liners are the interior sleeve of a chimney system. While liners come in various forms, for the analysis here, the discussion is limited to metallic liners installed into factory-built chimney systems. As noted previously, the US standard that covers liners is UL 1777, but currently that standard only addresses liners for use with masonry chimneys. Using a liner in a factory-built chimney is currently not part of the standard. Despite this limitation, installing liners into factory-built chimneys has become a common practice in the industry.

There are two main reasons for replacing a liner system. The first is because the existing liner has degraded due to use, environmental conditions, or other reasons; and the second is when there is a change to the appliance and the required diameter needs to be reduced, such as when an insert is installed into a factory-built fireplace. It is this second condition that is the focus of this section.

Critical Issues:

- Liner Must Be Properly Sized: When installing a chimney liner, it must be properly sized to the appliance. Normally this means the liner must be the same diameter as the outlet on the insert. Occasionally, depending on the requirements of the insert, the liner may actually be downsized. If so, it will be specified in the insert's installation instructions. Only downsize on the specific instructions from the appliance manufacturer.

- Maintain the Performance of Existing Chimney System: For air-cooled chimney systems, it becomes critical to maintain the operational performance of the chimney when installing a new liner. An air-cooled chimney system functions by cycling the air between the two or three walls of the chimney, and using that air flow to remove heat from the system. Too often, when a liner is installed, a simple but problematic approach is to block off the top of the chimney system with a plate and terminate the liner with its own cap. With this method, the chimney system itself has been reduced in its effectiveness because its air flow has been eliminated. So, maintaining the original air flow for the chimney system helps to ensure the chimney still functions properly. There are aftermarket relining systems that provides a means of maintaining the air flow of air-cooled chimneys. Their liner cap design provides a standoff that lifts the covering plate up off the outer wall of the chimney. By doing this, air between the two walls has a means to escape through the gap provided. Solid-packed chimneys are not affected as much as an air cooled system, but capping off their pipe still creates potential problems.

- Avoid Trapping Heat in Chimney: Capping off a chimney system not only creates the problem described above, but can lead to another issue. Heat coming through the liner along its length (insulated or not) and off the top of the insert is being trapped to the inside of the chimney's inner wall without a means to escape. If the top of the chimney has been blocked off, that trapped heat has the potential to cause the chimney system to overheat. There is at least one listed chimney/liner cap system available on the market that specifically addresses this issue. The cap includes a screened and covered standoff to allow heat in the chimney to escape, while still providing a proper termination cap for the liner.

- Be Aware of the Chimney Temperature Rating: Additionally, there is a concern about the type of appliance being used with the liner, and how that may differ from the original chimney system. The chimney system listed with an open-face fireplace is often listed to withstand a 1700 ^{O}F temperature, instead of the 2100 ^{O}F HT requirements needed for wood-stoves and solid-fuel inserts. The extra dilution air available with a fireplace helps to cool the exhaust. The additional air flow also helps reduce the time that the exhaust travels through the chimney system, which in-turn helps to keep the overall system's temperature down. By adding an insert and relining, the chimney system is potentially exposed to higher temperatures than originally intended. The possibility of higher temperatures is balanced somewhat by the liner itself. The liner acts as a third (or fourth) wall for the chimney system. The temperature increase is further mitigated if the liner is insulated. Also, since the liner has a smaller diameter than the original chimney, heat escaping the liner is somewhat diluted by the volume of the chimney itself.

As a standard practice, the liner should be insulated. However, there is a caveat to this practice that should be noted. If a liner with insulation is tightly installed into a chimney system, with minimal room between the liner and the chimney's inner wall, the heat coming from the liner and the top of the insert has nowhere to go. Depending on the details of the installation, the heat may be trapped inside the shell of the fireplace, which could increase temperatures around the fireplace housing. This trapped heat can increase the temperature of the fireplace housing, which in-turn may cause the original framed clearance requirements of the fireplace to be insufficient; i.e. the added heat may mean the fireplace now needs a larger clearance to combustibles than what it current has, which can lead to a fire hazard. Again, this is an issue to be aware of, and not something that affects every installation.

When using a liner, always follow the installation instructions of the liner manufacturer. The liner manufacturer can best advise an installer about issues of a specific installation. Check with the insert manufacturer as well for any specific details that may be required to connect a liner. Be aware of where heat from the system could become trapped and prevent it from doing so. Additionally, to minimize overheating problems, always maintain the performance and functionality of the existing chimney, especially with an air-cooled chimney system.

TERMINATION CAPS AND SHROUDS:

Termination caps serve the basic function of topping the chimney or vent system and minimizing rain, snow, debris, or animals from entering the chimney. Shrouds are the decorative enclosures placed around chimney caps to hide them in an effort to make the termination more aesthetically appealing. Solid-fuel caps may or may not require a spark arrestor screen to prevent ash and embers from exiting the chimney system, depending on local code requirements. Caps also help maintain negative draft in the chimney system and prevent possible down drafts, which could in-turn cause smoking problems in the home. All factory-built chimney and vent systems have been listed with their own chimney caps. They may or may not be listed with additional aftermarket termination caps.

Aftermarket termination caps may be needed for a variety of different reasons. One reason may be if a replacement cap from the chimney manufacturer is unavailable (out of business, discontinued model, etc.), but also an aftermarket cap may be wanted to address a performance issue. Local environmental conditions, specific to individual installations, may need something other than the chimney manufacturer's listed termination cap. Situations such as excessive winds, nearby trees or structures can cause problems for a chimney or venting system. While the chimney manufacturer's listed caps work well in most situations, it is possible that the specific performance issues may be better handled by an aftermarket cap. Note: due to the peculiarities of each installation, it may be that the stock chimney cap is the best performing cap; it just depends on the situation.

A different cap may be able to prevent down-drafting of a system, or to help prevent excessive weather infiltration. Changing the cap may also be an economical means to address the problem, as opposed to either extending the chimney, or replacing the system altogether. There are different reasons to install an aftermarket cap on a listed chimney, but they must be installed in such a way as to ensure the safe operation of the existing system.

Shrouds are associated with chimney caps, but their purpose is different. The purpose of a chimney shroud is to essentially hide the cap from view. Shrouds prevent the utilitarian look of the chimney cap from otherwise interrupting the exterior style of the home. A shroud is not typically connected to the chimney system itself, but instead surrounds the termination cap. In some areas of the country shrouds are not very common, whereas in other areas, shrouds are installed on nearly every home.

Much like chimney caps, shrouds can affect chimney performance. If too restrictive, the shroud can limit the draft performance of the chimney or cause other problems. Depending on the design of the shroud, it may be open or screened on the sides, or may be solid on the sides but open on the top. Both the size and style of the shroud can affect the thermal performance of the system by stifling draft and increasing thermal transfer in the chimney.

Both the NFPA 211 document and the International Mechanical Code require chimney shrouds to be listed and installed accordingly:

> "6.1.5 Decorative Shrouds. Unlisted decorative shrouds shall not be permitted as the termination of a factory-built chimney." (NFPA 211, 2013).

> "805.6 Decorative shrouds. Decorative shrouds shall not be installed at the termination of factory-built *chimneys* except where such shrouds are *listed* and *labeled* for use with the specific factory-built *chimney* system..." (International Mechanical Code, 2012).

There are at least two major chimney manufacturers that have produced listed specifications for shrouds to be used with their own listed chimney systems. The purpose is to allow installers, architects, and others to design shrouds for the specific home that meet general parameters, as opposed to limiting the listed shrouds to a few fixed designs. If a given shroud design complies with the specifications, then the shroud can be used as part of those particular listed chimney systems. Despite having a listed specification for shrouds, some local jurisdictions may still object to the shrouds because of the lack of appropriate labeling, as required by the building code. This is typically addressed by each individual jurisdiction.

While shrouds are not directly connected to the chimney system, they still share some of the critical issues with termination caps.

Critical Issues:

- Do Not Restrict Exhaust Flow: A concern of chimney and vent manufacturers is that aftermarket caps may restrict the flow of exhaust flow. If a cap is more restrictive to the exhaust, the chimney or vent system can absorb additional heat that would have otherwise left the system. This in-turn could increase the chimney's outer wall temperature, which may also increase the temperatures of nearby combustibles.

- Maintain Cooling Air Flow: For air-cooled chimneys, there is a critical concern that the cooling air flow is maintained for the system. Without a proper cooling air flow, a chimney or vent system is not as effective, and could create a hazardous situation. Any obstruction of the cooling air flow can potentially cause a problem. This is similar to the problem that can be created by a liner, where the end of the chimney system is capped off, preventing the system from cooling properly.

- Prevent Weather Infiltration: Another concern involves the weatherization of the chimney system. Some chimney systems, both air-cooled or solid-filled, have open ends or rings that are normally covered by the listed chimney cap. An aftermarket cap would need to cover these same openings to prevent weather infiltration into the system. If these open ends or rings are left exposed, rain, snow, or ice could find their way in between the walls, and eventually cause the chimney system to deteriorate from within over time through oxidation (rusting). This can occur with galvanized steel, aluminized steel, and stainless steel. Note: stainless steel can (and will) rust, but it is more resistant to oxidation than standard carbon or coated steels.

- Avoid Collecting Debris: This is a specific concern for some shrouds, but could potentially apply to chimney caps as well. Certain designs or models of shrouds can collect dried leaves and similar debris in or near the shroud itself. Depending on the relative location of the chimney cap, this could present a possible fire hazard, especially for caps that do not have spark arrestors. Some shrouds have their openings screened to help prevent such collection, but it does not remove the concern entirely.

There are aftermarket cap manufacturers that try to address these issues. Some cap designs differ for air-cooled chimneys and solid-filled chimneys, trying to ensure the cooling air flow of the chimney system is maintained. Some designs try to avoid restricting the exhaust draft, while still providing protection against down-drafts and weather infiltration.

If choosing to use an aftermarket cap or installing a shroud with a listed chimney or vent system, be aware of the potential performance impact as described above. Follow the chimney manufacturer's installation instructions and recommendations. If the chimney manufacturer's stock cap does not perform as needed, it may be possible to find an aftermarket cap that can address the situation better. However, always maintain the functional performance of the chimney in order to minimize any potential problems.

PRODUCT TESTING

To further explore the performance of aftermarket components with listed factory-built fireplace systems, the CSIA in conjunction with various manufacturers, contracted with Intertek Testing Services to perform a series of tests. The tests were directly taken from those required in UL 127 *Standard for Fireplaces*. The names of the manufacturers and the models of the components are withheld, as this document is not making any endorsements or criticisms of products, listed or not. The purpose of testing these products was to see if aftermarket components have any impact on the thermal performance of the listed factory-built fireplace system.

With this in mind, a UL 127 listed fireplace system was used, a model common in the industry, along with some popular components, including a set of replacement panels, a log grate, and a chimney cap. As the scope of testing is limited, no definitive conclusion can be drawn for these tests. The results are simply indicative of the performance of these particular components on this one listed fireplace system.

To establish a baseline set of data, the listed fireplace system is enclosed in a plywood construction as prescribed in UL 127, with thermocouples placed on the inside surfaces of the enclosure and other locations. It should be noted that the fireplace unit was enclosed, but the connected chimney system was not due to testing limitations. The closest thermocouples to the chimney portion were around the flue collar.

The Brand Fire Test was then performed three times to determine typical operating temperatures. The Brand Fire Test is from Section 13 in UL 127, and is performed by burning wood brands in the fireplace. The brands themselves are made from prescribed wood with a limited moisture content assembled together in a specified lattice construction pattern. The dimensions of both the individual pieces of wood and the overall brands are also specified in the standard and can depend on the size and shape of the fireplace model. Brands are added to the fireplace at fixed time intervals, and the temperatures of the various thermocouples are monitored until equilibrium is attained on all surface thermocouples (i.e. until all the thermocouples reach their maximum temperature and stop rising). As the fuel source is wood, the flue gas temperatures generated can vary significantly during the testing, but the intention is to be reliable. Some fluctuations in flue temperatures were encountered that are not necessarily attributable to either the fireplace's performance, nor that of the components, but instead result from using wood brands as the fuel source.

Following the baseline tests, one feature of the fireplace was replaced with an aftermarket component, such as replacing the original refractory panels with aftermarket panels. The same three Brand Fire Tests were then performed on the system, and the highest temperatures noted for each area of the test enclosure. Afterwards, the fireplace was restored to its original components, and then a different component was changed to an aftermarket part, and then the Brand Fire Tests were run again. During each set of tests, only one component was different from the original fireplace equipment. This was done in order to isolate any performance differences, and to avoid compound errors that may have occurred from using multiple component changes in the same test.

The Product Test results are shown in **Table 1**. With the exception of the Ambient temperatures, the values shown indicate the temperature increase or decrease (ΔT or delta-T) relative to the average temperatures of the original factory-built fireplace at the same locations. The intention is to show the differences between the original fireplace components, and those of the aftermarket components. Positive values show an increase, negative values show a decrease in relative temperature for each of the different areas of the test structure noted at the top of the table.

Table 1: Aftermarket Component Temperatures Relative to Original Fireplace Equipment

	Highest Temperature Recorded (°F)									
	Ambient	Flue Gas	Floor Under Fireplace	Hearth Extension	Enclosure Right Side	Enclosure Left Side	Enclosure Back	Enclosure Top	Header face	Flue collar
Refractory Panels										
Test 1	84	271.3	37.0	11.7	18.7	16.3	21.7	15.7	1.0	12.3
Test 2	71	222.3	34.0	14.7	16.7	13.3	19.7	11.7	12.0	9.3
Test 3	75	33.3	27.0	12.7	13.7	9.3	15.7	9.7	3.0	7.3
Average:	**76.7**	**175.7**	**32.7**	**13.0**	**16.3**	**13.0**	**19.0**	**12.3**	**5.3**	**9.7**
Log Grate										
Test 1	75	109.3	4.0	-8.3	-3.3	-1.7	-1.3	-0.3	-12.0	0.3
Test 2	75	94.3	12.0	0.7	2.7	1.3	3.7	2.7	4.0	4.3
Test 3	72	33.3	-3.0	-11.3	-0.3	-3.7	-2.3	-6.3	-25.0	1.3
Average:	**74.0**	**79.0**	**4.3**	**-6.3**	**-0.3**	**-1.3**	**0.0**	**-1.3**	**-11.0**	**2.0**
Chimney Cap										
Test 1	71	201.3	16.0	-7.3	4.7	2.3	6.7	-3.3	-31.0	0.3
Test 2	73	12.3	-11.0	-26.3	-10.3	-5.7	-7.3	-13.3	-40.0	-11.7
Test 3	71	-97.7	22.0	-8.3	7.7	3.3	13.7	4.7	-22.0	2.3
Average:	**71.7**	**38.7**	**9.0**	**-14.0**	**0.7**	**0.0**	**4.3**	**-4.0**	**-31.0**	**-3.0**
Repaired Panels										
Test 1	76	-60.7	23.0	-8.3	5.7	-0.7	15.7	35.7	34.0	1.3
Test 2	73	173.3	14.0	-2.3	3.7	-1.7	11.7	23.7	25.0	2.3
Test 3	71	-111.7	18.0	-11.3	5.7	0.3	10.7	22.7	25.0	1.3
Average:	**73.3**	**0.3**	**18.3**	**-7.3**	**5.0**	**-0.7**	**12.7**	**27.3**	**28.0**	**1.7**

A review of the table shows that the flue gas temperature for each test varies significantly. This variance in flue temperature is mostly due to the use of the required wood brands, as specified by UL 127.

Refractory Panels

The first component change was the refractory panels. The original panels supplied with the fireplace system were a refractory material molded into a brick pattern. The original panels were 1-inch thick. The aftermarket panels were also refractory material molded into a brick pattern, and were cut down in size to match the original panels in order to fit inside the fireplace. The aftermarket panels were 1.25-inch thick, although some of the thickness difference was due to the pronounced brick pattern. The difference in thickness did not affect how the panels fit into the fireplace.

While the temperatures shown for the various areas of the test enclosure are higher than that of the original fireplace equipment, it must be noted that the flue temperatures for each test were also significantly higher as well. Higher temperatures on enclosure surfaces is expected when the flue temperature is hotter, but it is unknown if the rise shown here is proportionate or not. However, as the temperatures show only an increase between 5-19^{O}F, it is reasonable to attribute these rises to the increased flue temperature. As such, it appears that the panels did not have a significant performance impact on the fireplace system, although additional testing would be necessary before this can be stated conclusively.

Log Grate

The second component change was the log grate. As previously noted, the original refractory panels were reinstalled into the fireplace, and then the supplied log grate was removed and replaced with an aftermarket grate. The original log grate was constructed using 3/4-inch steel bar stock, molded into a grate shape. The overall dimensions of the grate were 25-in wide x 9.5-in deep, and 7.5-in tall.

The replacement log grate was constructed of cast iron. Its overall dimensions differed from the original grate, and measured 22-in wide x 11-in deep, and 6.5-in tall. While the overall area of the grates is similar (237.5 in^2 for the original grate versus 242 in^2 for the replacement grate), the height as well as the depth of the grates differ.

The results on the aftermarket grate are a little contradictory. The average temperatures show essentially no change from that of the original grate. However, when reviewing the test in detail with representatives from Intertek, it must be noted that the wood brands used are the same size as were the brands used for the original grate, and they were placed in the back of the firebox, not necessarily centered on the grate itself. This is consistent with the UL 127 test protocol, but does not highlight some of the critical issues that may occur in the field, as noted in the component discussion of grates. The limited data shown here does not reflect some of the issues described, nor does it negate those issues.

Chimney Cap

The fireplace's original chimney termination cap was changed to a popular aftermarket cap. Again, the original grate was reinstalled into the fireplace before the caps were changed. The original chimney cap had a diameter of 16.75-in, a 7-in screen height, and allowed for 2.5-in of cooling (airflow space between walls of the air-cooled chimney). The aftermarket cap had a diameter of 16-in, a 5.5-in screen height, and allowed for 1.625-in of cooling.

The aftermarket chimney cap shows a neutral change across certain areas of the test enclosure, but a cooler result at the fireplace header. This is possibly due to a higher draft, and may be a result from the performance of the cap itself. Based on these testing results, this cap appears to have no adverse effects, and seems to work well with this factory-built fireplace system.

Repaired Panels

Another set of tests was performed on the original fireplace panels using a new product that repairs cracks in refractory panels. The original panels on the left and back sides were broken across the full length of the panel and then repaired using this product. The panels were prepared and then the cracks were filled with a thermal refractory mixture. A ceramic paper material is used to cover the crack, and then the repaired area is then covered with an appropriate thermal coating. The panels were allowed to dry/set for the recommended time before being tested. The results for the enclosure temperatures on the left and back sides show that the repaired panels performed essentially the same as the original fireplace panels, with variations in the temperature being attributable to the burn process due to using wood brands. The temperature rises seen in other locations are disregarded, as the repairs would not have an effect on these other areas of the enclosure.

The product testing performed was intended to highlight differences between the original factory-built components and those of aftermarket components. As seen in the results, there is a significant amount of variability in the test process, despite adhering to the proper test protocols of UL 127. Most of the component tests did not show any significant difference from those of the original fireplace system. The testing performed was limited in its scope, so these results cannot be taken as definitive. The results do show an indication that at least some aftermarket components, when properly installed, can approximate the performance of the original equipment. However, as stated previously, these results cannot be used to predict the performance of other components on other systems. Always follow the installation instructions of both the fireplace manufacturer, and those of the component manufacturer.

LIABILITY

This section discusses liability in general. As specific laws and case studies vary from state to state, this section should not be considered complete in its explanation, but instead should be used only for a general understanding of liability. Always refer to the laws in your state, and check with appropriate legal counsel before addressing any legal issue.

What is liability? Merriam-Webster dictionary defines liability as "the state of being legally responsible for something" (Merriam-Webster, 2014). With our modern society being as litigious as it is, installers and contractors need to be aware of their exposure to liability.

Liability for any installation starts with the manufacturer, and extends down through the supply chain, all the way to the retailer, installer, and even the end user. Manufacturers are typically exposed to *product liability*:

> "There are three types of product defects that incur liability in manufacturers and suppliers: design defects, manufacturing defects, and defects in marketing. Design defects are inherent; they exist before the product is manufactured. While the item might serve its purpose well, it can be unreasonably dangerous to use due to a design flaw. On the other hand, manufacturing defects occur during the construction or production of the item. Only a few out of many products of the same type are flawed in this case. Defects in marketing deal with improper instructions and failures to warn consumers of latent dangers in the product." (Cornell Law Library, 2014).

While product defects do occur, they are rarely the cause when it comes to fires and other incidents related to hearth products. The good news for installers is they are generally not liable for product defects, but they do have their own share of liability exposure when it comes to the installation of products.

When installers and contractors are doing any work for a consumer they are exposed to possible *breach of contract* and *negligence* claims. Breach of contract can occur when the installation is not done in accordance with a contract, building codes, manufacturer's instructions, or standard industry practices. It is not necessary for a contract to be signed in order for breach of contract to occur. The "contract" may be as simple as an understanding between people, as long as there has been an offer of payment or compensation, acceptance of an offer, and performance of work. Refer to your state and local laws for details and clarification. Similarly, negligence can be defined as "failure to take the care that a responsible person usually takes" or "lack of normal care or attention" (Merriam-Webster, 2014). Allegations against contractors and installers often include both claims.

To help minimize an installer's exposure to liability, the installer should always follow the appropriate instructions for the products to be installed. This sounds obvious enough, but observations from the field repeatedly show that problems often occur because installers fail to follow the instructions. Failing to install a product in accordance with the manufacturer's installation instructions, or altering the intent of the instructions can significantly increase the installer's exposure to liability, even to the point where most, or all, of the liability becomes theirs. Deviating from the published installation instructions could also possibly increase the chance that an incident may occur. This is one reason the CSIA adopted its policy statement regarding the use of aftermarket parts with listed systems (refer to the Motivation segment in the Introduction for the policy statement).

If for some reason an installer needs to deviate from the installation instructions, be sure to obtain the approval from the manufacturer for doing so. Written approval from the highest resource you can get is best, but even verbal permission may do, although verbal approval is difficult to defend if a controversy arises. Once you have the manufacturer's authorization, be sure to check with your local building department or other Authority Having Jurisdiction (AHJ). Getting both authorizations will help to minimize (not eliminate) possible liability. In the event an incident occurs, the installer may then be able to redirect at least some of the liability to the manufacturer. However, an AHJ would likely not be included in any claims if it were to go to litigation.

As a best practice suggestion: Besides reading and following the installation instructions and getting additional authorization if needed, the next best thing for an installer to minimize their exposure to liability is document, document, document! Document and record all changes that occur, delays, ideas, problems, etc. that might affect the installation. If something were to occur, this type of documentation provides the foundation for an effective defense.

If an incident does happen, the process typically happens as follows: the homeowner files a claim with their insurance company, and then the insurance company evaluates the claim. If they pay the claim, depending on the severity and value of the incident, the insurance company may start an investigation and look for other parties to subrogate (repay the insurance company). When this occurs, the attorney for the insurance company notifies every potential party that may have had any influence on what happened. For anything to do with a hearth installation, the installer would certainly be put on notice.

If an installer is put on notice for a claim, they should immediately report it to their insurance carrier. Often, the insurance company may then take an initial stance dealing with the potential claim, but that may depend on the details of the installer's insurance policy. Typically, there may be a group inspection of the site with representatives from all the notified parties. Following that, there may be an indication of which party or parties could have been responsible. Then litigation begins, which attempts to determine which parties will be held responsible for the liability.

With respect to insurance policies for installers and contractors, check with the broker and understand the limitations and deductions that come with the policy. The insurance company will abide by those clauses, and so the installer needs to know what is, and what is not covered in their policy.

Reviewing claims with attorneys, manufacturers, fire experts, and other knowledgeable people, it appears that most claims are the result of one or more installation errors. Installation errors may result from a single party's work, or may also be a combination of errors between multiple trades (roofer, framers, electricians, insulators, etc.).

An example of a combination of errors: a contractor installs a new fireplace and chimney in a new home under construction. At the time of installation, the home is only stick-framed and the contractor puts in the fireplace and chimney, but does not install an attic insulation shield since there is no insulation present. Later, the insulation contractor sprays blown-in insulation and buries the chimney where it passes into the attic. In the event of a fire, both subcontractors would likely be held responsible; the fireplace installer for failing to install the necessary shield, and the insulation contractor for failing to keep the insulation away from chimney pipe. Unfortunately, this example is an all-too-common occurrence in the field.

If there are questions about a project before starting, or after work has begun, it may be worthwhile to contact an attorney and seek legal advice. Having a good representative could help to resolve issues before they become problems.

For installers and contractors, there is exposure to liability for every installation performed. To minimize the possibility of an incident, and also minimize the exposure to liability, always follow the manufacturer installation instructions. If a situation occurs where something needs to deviate from the instructions, get written authorization from the manufacturer and the AHJ. Document everything, especially when something is out of the ordinary. Be aware of your state and local laws which affect liability and how they may affect you. Understand the limits of your insurance coverage, and always practice good workmanship.

CONCLUSION

The installation of aftermarket parts with listed fireplace systems is a regular practice in the industry. Installers are sometimes placed in difficult situations where a customer wants something, but it may not agree with the original listing. Installers are expected to be the professionals and need to be armed with knowledge to best address the customer's wants, while still making sure the installation is safe and performs properly.

Aftermarket parts can act as necessary replacement components when the original factory-built components are unavailable, or to help address a performance problem in the field. If aftermarket parts are the only ones available, it may be better to use these components rather than to go without a component at all and risk an unsafe situation. However, the installer must verify the aftermarket part is installed correctly and that it does not make the situation worse.

With the exception of inserts and liners, most aftermarket parts do not have their own safety and performance standards. Even if a component has been designed to address the requirements of the standards, it does not necessarily mean that the component will work properly for all the different systems with which it may be used. This is the unknown factor and a reason that appliance and chimney manufacturers are hesitant to allow aftermarket parts to be used with their systems. Unless the component in question has been tested and listed with the system, the effect of its use is unknown.

Different types of components have their own critical issues that must be properly addressed. For installers, it is their responsibility to understand these issues and deal with them in the field. If in doubt, contact the manufacturers and get their opinions about the situation. Mitigate any risks and work to ensure a safer installation. The homeowners themselves may be asking for something that is not allowed, or may even be unsafe. The installer needs to educate them appropriately.

Each installation performed by an installer or contractor brings with it a certain amount of liability. The safer the installation, the less risk of incident, and therefore the smaller the exposure to liability. By accurately adhering to the manufacturers' installation instructions, the installer minimizes their risk of liability. By using aftermarket parts with a system, the risk of liability increases. Obtaining authorization from both the manufacturer and the AHJ can not only help to make the installation safer, but can also minimize the installer's exposure to liability. Following the listed installation instructions, and documenting details of the installation can help the installer with a defensible position if a claim should occur.

Until there is a time when universal components are available and approved for all systems, installers must ensure installations are safe and perform properly. The best advice is the same advice that has been given all along: Always follow the manufacturers' installation instructions and install in accordance with their listing, and follow local codes and standards. The instructions reflect how the appliance or system was actually tested and listed, and reflects how it performs. If an aftermarket part is used, the installer must ensure that the integrity of the existing system is maintained. Ultimately it is the installer that has the knowledge and experience to help ensure the fireplace system is both safe and performs well for the homeowners.

<u>APPENDIX A</u>

<u>Performance Tests included in UL 127 *Factory-Built Fireplaces*</u>

The following performance test descriptions are provided as a summary only, and should not be regarded as a complete description of the required tests. For a complete description of the tests, refer to the standard itself.

General - Requires that after testing, the fireplace must still be able to operate. No part of the fireplace may reach temperatures that will cause damage or corrosion to occur. No part may become permanently damaged or distorted. During thermal testing, screens are to remain open.

Test Installation - Describes the fireplace test assembly, including required plywood and other combustible materials, floor construction and framing, and relative height and locations of back and side walls, ceilings, and floors. For fireplaces with doors, they are tested with doors fully opened or doors fully closed.

Test Measurement - Type J and K thermocouples are used throughout the test structure to measure temperature. Typical locations and method of attachment of thermocouples are described so all combustible surfaces and metallic components are sufficiently evaluated, subject to the approval of the testing agency.

Preconditioning Tests

- **General** - Requires the fireplace assembly be subjected to the Thermal Shock Test and either the 1700 ^{O}F Flue Gas or the 2100 ^{O}F Flue Gas test, before any performance testing occurs.

- **Thermal Shock Test** - Subjects the fireplace and chimney system to three exposures of 1700 ^{O}F flue gas for a duration of 10 minutes each, in an effort to condition and pre-stress the fireplace and chimney assembly.

- **Temperature Test - 1700 ^{O}F Flue Gas** - After the test assembly reaches equilibrium with a flue temperature of 1000 ^{O}F, the flue gas is then raised to 1700 ^{O}F for 10 minutes. The combustible materials around the fireplace cannot be greater than 175 ^{O}F above ambient.

- **Temperature Test - 2100 ^{O}F Flue Gas** - After the test assembly reaches equilibrium with a flue temperature of 1000 ^{O}F, the flue gas is then raised to 2100 ^{O}F for 10 minutes. The combustible materials around the fireplace cannot be greater than 175 ^{O}F above ambient. The test is performed three times, cooling to room temperature between each test. Passing this test provides compliance with the HT requirements of the standard.

Radiant Fire Test - Charcoal briquettes are burned within a basket of specific size and shape inside the fireplace at specified intervals. Temperatures on test assembly surfaces cannot exceed 117 ^{O}F above ambient for exposed surfaces, or 90 ^{O}F above ambient for enclosed surfaces. Similarly, the maximum temperature on the air outlet for a duct system cannot exceed 250 ^{O}F, and the temperature of surface grills of the duct system cannot exceed either 140 ^{O}F or 180 ^{O}F, depending on location.

Brand Fire Test - An andiron is used to hold in wood brands of specific size and shape, which are burned at regular intervals in the fireplace. Neither flames nor combustion gases are allowed to spill into the room. Brands are added until maximum temperatures are reached on the test assembly. Temperatures are cannot exceed 117 ^{O}F above ambient for exposed surfaces, or 90 ^{O}F above ambient for enclosed surfaces. Similarly, the maximum temperature on the air outlet for a duct system cannot exceed 250 ^{O}F, and the temperature of surface grills of the duct system cannot exceed either 140 ^{O}F or 180 ^{O}F above ambient, depending on location.

Flash Fire Test - Continues from the Brand Fire Test. Brands are stacked in a specific configuration in the fireplace. The maximum temperatures cannot exceed 140 ^{O}F above ambient for the test enclosure, parts of the fireplace at zero clearance to combustibles, area underneath the hearth pad.

Optional Unvented Decorative Log Temperature Test - An unvented log set complying with ANSI Z21.11.2 *Standard for Unvented Room Heaters* is operated in the fireplace with the damper fully closed. Maximum temperatures are not allowed to exceed 117 ^{O}F above ambient for exposed surfaces, or 90 ^{O}F above ambient for enclosed surfaces.

Support Test - Parts of a fireplace cannot be damaged or distorted when a load of four times the weight of the maximum chimney height is applied to the fireplace for 1 hour.

Fire Chamber Strength Test - The fireplace sides and back must withstand repeated impacts from a rolling log of specified size and weight, without becoming damaged beyond continued use. The hearth area is subjected to a load of 100 lbs/ft^2 without showing signs of distortion or damage. Similarly, the hearth extension is subjected to a 400 lbs load applied to different points without showing permanent distortion or damage. Lastly, the edge of the hearth is subjected to a load of 300 lbs, without showing any damage to the fireplace or surrounding structure.

Glazing Test

General - requires the glazing to not crack, break, dislodge, or lose strength as a result of the Radiant Test, Brand Test, or Flash Fire Test described above, or the two following tests.

Impact Test - A 2" diameter, 1.18 lbs steel ball is swung on a pendulum arc, starting at a height of 16.25", where the at-rest position of the ball is 1" away from the face of the glass. The impacts are done:

- Prior to any testing, at room temperature,
- During the Radiant Test, at maximum temperature,
- After the Radiant Test, at room temperature,
- During the Brand Test, at maximum temperature,
- After the Flash Fire Test, at room temperature,
- And for outdoor fireplace, during the hot and cold exposure tests.

Water Shock Test - During the Radiant Fire Test, the glass panels are wiped by a wet cloth at room temperature; and subjected to three sprays of water from a household cleaner-style mister. The glass panel cannot crack or break.

There are additional construction and performance requirements for fireplaces intended to be used outdoors or in manufactured homes

The following tests apply to the factory-built chimney system that is listed and used with the fireplace. These tests are the same as specified in UL 103 *Standard for Factory-Built Chimneys for Residential Type and Building Heating Appliances*, and are described in Appendix F.

Chimney Strength Test

- General
- Impact Test
- Longitudinal Force Test
- Load Test for Elbows
- Chimney Joint Load Test
- Chimney Joint Torsion Test

Wind Load Test
Rain Test
Crushing Test for Nonmetallic Flue-Gas Conduit or Insulation
Freezing and Thawing Test of Water-Absorptive Nonmetallic Materials
Cemented Joint Test of Flue-Gas Conduit
Sulfuric Acid Extraction Test for Porcelain Coated Steel Used for Flue-Gas Conduit

APPENDIX B

Performance Tests included in UL 1482 *Solid-Fuel Type Room Heaters*

The following performance test descriptions are provided as a summary only, and should not be regarded as a complete description of the required tests. For a complete description of the tests, refer to the standard itself.

General - Requires that when the room heater is tested, the temperature limits are not exceeded, that no spillage into the room of exhaust gasses occurs, and that the appliance can continue to be used as intended. After testing, no part of the room heater can be damaged, melted, or distorted, such that the unit is prevented from operating.

Test Installation - Describes the test structure and the plywood combustible materials used to build the test structure. The test structure resembles one room of a residential home, with floor, back and side walls, and ceiling.

Temperature Measurement - Type J and K thermocouples are used throughout the test structure to measure temperature. Typical locations and method of attachment of thermocouples are described so all combustible surfaces and metallic components are sufficiently evaluated, subject to the approval of the testing agency.

Fire Tests - Room heaters must comply with the fire tests listed below. Specifies that if a grate is used, then it must be used with all tests. If fire is to be built directly on bottom of chamber (no grate), then notice must be provided with the appliance to not elevate the fire. The maximum temperature on handles and exterior surfaces are specified, depending on material. Also requires that products of combustion do not spill into the room.

Radiant Fire Test - Charcoal briquettes are burned within a basket of specific size and shape inside the fireplace at specified intervals. Temperatures on test assembly surfaces cannot exceed 117 ^{O}F above ambient for exposed surfaces, or 90 ^{O}F above ambient for enclosed surfaces. The maximum temperature of flue gases to enter the chimney cannot exceed 1000 ^{O}F or 1400 ^{O}F if less than a cumulative 12.5% of the test duration.

Brand Fire Test - An andiron is used to hold in wood brands of specific size and shape, which are burned at regular intervals in the fireplace. Neither flames nor combustion gases are allowed to spill into the room. Brands are added at regular intervals until maximum temperatures are reached on the test assembly. Temperatures are not allowed to exceed 117 ^{O}F above ambient for exposed surfaces, or 90 ^{O}F above ambient for enclosed surfaces. The maximum temperature of flue gases to enter the chimney cannot exceed 1400 ^{O}F or 1700 ^{O}F for less than a cumulative 10 minutes of the test duration.

Flash Fire Test - Continues from the Brand Fire Test. Brands are stacked in a specific configuration in the fireplace. The maximum temperatures cannot exceed 140 ^{O}F above ambient for the test enclosure, parts of the room heater at zero clearance to combustibles, area underneath the hearth pad. The maximum temperature of flue gases to enter the chimney cannot exceed 1400^{O}F or 1700^{O}F for less than a cumulative 10 minutes of the test duration.

Fire Tests for Coal Heaters - Coal burning heaters are required to comply with additional tests:

- **Coal Fire Test** - The appliance is filled with coal to the halfway point and operated until maximum temperatures are reached. The appliance is then filled fully and operated until maximum temperatures are reached. Temperatures are not allowed to exceed 117 ^{O}F above ambient for exposed surfaces, or 90 ^{O}F above ambient for enclosed surfaces. The maximum temperature of flue gases to enter the chimney cannot exceed 1000 ^{O}F or 1400 ^{O}F if less than a cumulative 12.5% of the test duration.

- **Abnormal Radiant Fire Test** - Tests a room heater without a storage hopper. The heater is filled with coal to the greater of 6-in depth or half the volume of the chamber and then operated as in the Radiant Fire Test. The maximum temperatures on the test structure, zero clearance points of contact to the heater, and beneath the floor protector is 140 ^{O}F above ambient. The maximum temperature of flue gases to enter the chimney cannot exceed 1400^{O}F or 1700^{O}F for less than a cumulative 10 minutes of the test duration.

- **Abnormal Brand Fire Test** - Tests a room heater without a storage hopper. The heater is operated as in the Brand Fire Test. The maximum temperatures on the test structure, zero clearance points of contact to the heater, and beneath the floor protector is 140 ^{O}F above ambient. The maximum temperature of flue gases to enter the chimney cannot exceed 1400^{O}F or 1700^{O}F for less than a cumulative 10 minutes of the test duration.

Glazing Test

General - requires the glazing to not crack, break, dislodge, or lose strength as a result of the Radiant Test, Brand Test, or Flash Fire Test described above, or the two following tests.

Impact Test - A 2" diameter, 1.18 lbs steel ball is swung on a pendulum arc, starting at a height of 16.25", where the at-rest position of the ball is 1" away from the face of the glass. The impacts are done:

- Prior to any testing, at room temperature,
- During the Radiant Test/Abnormal Radiant Fire Test, at maximum temperature,
- After the Radiant Test/Abnormal Radiant Fire Test, at room temperature,
- During the Brand Test/Coal Fire Test, at maximum temperature,
- After the Flash Fire Test/Abnormal Brand Fire Test, at room temperature,
- And for outdoor fireplace, during the hot and cold exposure tests.

Water Shock Test - During the Radiant Fire Test, the glass panels are wiped by a wet cloth at room temperature; and subjected to three sprays of water from a household cleaner-style mister. The glass panel cannot crack or break.

Mechanical Tests

- **Strength Tests - Chimney Connector** - When the unit is supplied with a chimney connector, the connector will not break, disassemble, or otherwise become damaged when subjected to a pendulum impact test. An 8-ft assembly of connector pipe will have a 20-lbs sandbag, raised to a height of 9-inches, impact against the joint section or at the midpoint of the middle pipe section.

- **Stability Test** - Requires that if the heater is tipped in any direction, the minimum force used multiplied by the angle before it falls is at least 150 lbs-degrees.

There are additional construction and performance requirements for solid-fuel room heaters intended to be used outdoors or in manufactured homes

<u>APPENDIX C</u>

<u>Performance Tests included in ANSI Z21.50 / CSA 2.22 *Vented Gas Fireplaces*</u>

The performance tests of ANSI Z21.86 and ANSI Z21.88 are generally similar to those of ANSI Z21.50, but have specific differences related to the scope of their respective standards. For the sake of simplicity, the performance tests of ANSI Z21.86 and Z21.88 have not been included here. Refer to those standards for their performance tests.

The following performance test descriptions are provided as a summary only, and should not be regarded as a complete description of the required tests. For a complete description of the tests, refer to the standard itself.

General - Section describes the coverage that applies to natural gas or propane appliances, direct vent, or gravity vented appliances. If appliance is equipped with doors, must be tested with doors open and doors closed. If appliance to be operated with only doors open, then appliance must be designed to prevent doors from being closed when in operation. This section further describes the test structure around the appliance, and other details that apply to testing.

Test Gases - Describes the specific test gases to be used in testing and their burn characteristics. Test Pressure and Burner Adjustments - Describes the minimum, normal, and maximum gas input pressures used for testing.

Combustion - Appliance is operated for 24 hours. Carbon deposits formed cannot affect testing. Afterwards, appliance is operated for 45-minutes and sampled for CO production. Appliance cannot have an excess of CO: 25ppm for normal operation or 40ppm for abnormal operations.

Appliance and Burner Durability Test - The appliance's burner is operated 23-hours on, 1 hour off, and repeated 4 times. There cannot be any evidence of corrosion, excessive carbon deposits, or leakage of flue gases.

Burner Operation Characteristics - Tests the burner to verify all ports are ignited under various conditions, and that no flash-back or delayed ignition occurs. Natural drafting appliance burners are tested for flameout when subjected to a 3 mph draft. Additional tests also ensure that gas expelled from the burner shall be ignited. This is done by introducing a draft onto the burner face. Flame ports shall remain ignited and not flash-back or flameout.

Loose Burner Material - Requires that if loose burner material is provided by the manufacturer, it must be used during testing and not interfere with any of the other tests in the standard.

Pilot Operating Characteristics - Requires that appliances equipped with a pilot will ignite the main burner without delay, and that the pilot will not become extinguished when the gas to the main burner is shut off. The pilot for non-direct vent appliances must also be protected against drafts.

Pilot Burners and Safety Shut Off Devices - Requires that appliances equipped with a pilot shall ignite the gas as soon as it reaches the burner and that the pilot will remain on whether the main burner is on or off. Tests are performed under different gas inlet pressures and under various conditions that may affect the gas valve and pilot. Multiple tests are done to ensure proper safety of the burner and gas valve.

Direct Ignition Systems - For appliances that use a direct ignition system, it specifies requirements for the ignition system. The igniter must be able to ignite the main burner without delay.

Proved Igniter Systems - Specifies the operation requirements for appliances using an igniter system which already complies with ANSI Z21.20. Additionally, the igniter must ignite the gas within 4 seconds of reaching the main burner port.

Delayed Ignition and Integrity Tests For Direct Vent Gas Fireplaces - For a direct vent system, the tests are run with the maximum number of elbows and maximum horizontal run and minimum vertical run, as well as other configurations. A specified amount of gas is introduced into the combustion chamber. The gas is ignited after a 5 minute delay, which cannot result in glass breaking or nearby materials igniting. Additional tests are also performed to verify the accumulation of gas into the appliance will not cause any breakage or damage when ignition is delayed.

Glass Fronts - Sets the maximum allowable temperature for viewing glass at 500 ^{O}F and for direct-vent units, sets the maximum allowed stress on the face of the glass at 10,000psi.

Impact Test of Glass Materials - The glass will not break or crack when impacted by a 2" diameter, 1.2-lbs steel ball is swung on a pendulum arc at a height of 13.25". The at-rest position of the ball is 1" away from the face of the glass. The test is done at room temperature.

Water Shock Test - During the maximum temperature of the Wall, Floor, and Ceiling Temperature test, the glass panels are wiped by a wet cloth at room temperature; and subjected to three sprays of water from a household cleaner-style mister. The glass panel cannot crack or break.

Main Burner Temperatures - Tests if parts of the burner made from materials with a melting point below 1450 ^{O}F will not reach an operating temperature of 875 ^{O}F. The burner is exposed to a temperature of 875 ^{O}F for 30 minutes. At the end of the test, the burner cannot have been melted, sagged, or become distorted.

Non-load Bearing Flue Gas Baffle Temperatures - With thermocouples at high-temperature points of the baffle, the burner is cycled 8 times with hard and soft flames until equilibrium temperatures are reached. The temperatures measured cannot exceed the material limits described in Table VIII of the standard.

Appliance Main Gas Valves - During the Wall, Floor, and Ceiling Temperature test , the appliance main gas valves are tested to ensure they do not reach temperatures beyond which the valves were designed.

Gas Appliance Pressure Regulators - During the Wall, Floor, and Ceiling Temperature test, the pressure regulators are tested to ensure they do not exceed the pressures beyond which they were designed.

Automatic Valves - During the Wall, Floor, and Ceiling Temperature test , the valves are tested to ensure they do not reach temperatures beyond which the valves were designed.

Safety Circuit Analysis - Tests that demonstrate that control components will properly meet their Failure Mode and Effects Analysis, and will not result in an unsafe condition.

Manifold and Control Assembly Capacity - The manifold pressure is measured downstream to ensure proper input, while operating at minimum gas pressure. This is done in order to ensure the manifold and controls have sufficient flow capacity to supply the minimum rated BTU input while at the lowest allowed supply pressure.

Condensate Drain System Located in Blower Compartment - Tests that flue gases will not come from the condensate drain system if located on the negative pressure side of the air blower.

Temperatures at Discharge Air Openings - Tests the temperatures limits on the discharge openings of the unit:

- With a temperature limit control, the discharge temperature must not exceed an average of 250 ^{O}F before the control shuts off the gas supply to the main burner.
- For units without temperature limit controls, the discharge temperature cannot exceed 280 ^{O}F after 1 hour.
- Distribution duct discharge temperature must not exceed 130 ^{O}F above the air inlet temperature while the circulating fan is on.
- With the circulating fan off, the duct discharge temperature must not exceed 180 ^{O}F.

Wall, Floor and Ceiling Temperatures - Fireplace inserts are installed in a non-combustible surround simulating a fireplace of the minimum size, according to the manufacturer. Free-standing appliances are installed at the minimum specified clearances. Various thermocouples are placed around a room with 3/4" plywood panels painted flat black, which surround the appliance (walls, floor, and ceilings).

- For non-direct vent appliances, the flue outlet is progressively blocked and tested to equilibrium. The temperatures on exposed combustible surfaces must not exceed 117 ^{O}F above ambient, and not exceed 90 ^{O}F for unexposed combustible surfaces.
- For fan-equipped units, the fan is turned off. For a unit with temperature limit control, a non-direct vent appliance is installed in the same type setup, with the outlet flue completely blocked. When tested to equilibrium, temperatures on combustible surfaces cannot exceed 175 ^{O}F above ambient, for the first cycle of the temperature limit control. After the 6th cycle of the temperature limit control, temperatures on combustible surfaces must not exceed

117 ^{O}F above ambient, and not exceed 90 ^{O}F above ambient for unexposed combustible surfaces.

- For a fan-type, direct-vent appliance with a safety shut off valve and secondary temperature control, temperatures on combustible surfaces cannot exceed 350 ^{O}F when tested to equilibrium.
- For horizontal terminating vent systems, the temperature of the exterior wall must not exceed 90 ^{O}F above ambient, when using the shortest vent run allowed and when tested to equilibrium.

Flue Gas Temperatures - For gravity vented appliances, the flue gas temperature may not exceed 480 ^{O}F above ambient, when the vent is restricted to achieve the maximum temperature. The appliance is tested until equilibrium temperatures are attained. For direct-vent appliances, as long as the flue gas temperature is sufficient that no fire hazard is apparent to the safety listing agency, the requirements are met.

Surface Temperatures - This test limits the allowed temperature of various surfaces:

- On sides, face, and top of the unit, as well as for up to 18" above the bottom of the appliance, the temperature limit is 140 ^{O}F above ambient. For areas above 18", the temperature limit is 180 ^{O}F above ambient.
- All parts of the appliance which are normally expected to be handled by the consumer, must not exceed 40 ^{O}F above ambient for metallic parts, and not exceed 60 ^{O}F above ambient for non-metallic parts.
- Under conditions that the vent terminal surface temperature exceeds 180 ^{O}F above ambient, its markings shall indicate that a certified guard surrounding the terminal must be installed so that the temperature of the guard does not exceed 180 ^{O}F above ambient.

Evaluation of Clothing Ignition Potential - Tests to ensure the appliance will not readily ignite nearby clothing. After running the fireplace for 1 hour, a strip of specific cotton material is hung on a probe and placed in contact with the fireplace for 30 seconds, and must resist igniting.

Venting - Tests the appliance vent system for leaks. After the appliance is in operation for 45 minutes at standard pressure, a smoking/fuming material is introduced into the vent system. The vent system must not show any leaking. If a mechanical draft device is used with the system, if the device stops, the flames must not extinguish, lift, flash back, or produce excessive CO, before the gas supply is shut off.

Draft Hoods - Tests the functionality and safety of draft hoods:

- After operating the appliance for 30 minutes, the vent outlet is blocked and operated for an additional 15 minutes. During that time, the main burner must maintain stable flames, and must not let them become extinguished, nor produce excessive CO.
- After the appliance is operated for 45 minutes, a downdraft of up to 12 Pa is introduced at the appliance outlet. Neither the main burner nor the pilot can let its flames extinguish, lift, or flash back.
- The appliance is operated for 15 minutes with a section of chimney pipe on the outlet. The updraft pressure must be between 15-17 Pa. Neither the main burner nor the pilot can let its flames extinguish, lift, or flash back.

- The appliance is operated for 15 minutes with the minimum vent length setup. A fuming/smoking material is introduced into the relief opening. Exhaust gases must not emanate from the draft hood opening.

Draft Tests for Appliances Not Equipped With Draft Hoods - The appliance's flue is blocked to a certain amount and operated for 45 minutes. The CO cannot exceed 40ppm, and if the flames are extinguished, raw gas must not be forced into the combustion chamber when the blockage is removed. Additionally, the appliance is also operated for 15 minutes with a section of chimney pipe on the outlet. The updraft pressure must be between 15-17 Pa. Neither the main burner nor the pilot can let its flames extinguish, lift, or flash back.

Vent Safety Shutoff Systems - This test only applies to appliances with draft hoods. This test requires that if the vent is blocked, the main burner will be shut off. The appliance is tested under various conditions for compliance.

Wind Tests (Sidewall Termination) - Applies to both power vented and direct vent appliances. The appliance is setup with a worst-case vent configuration. A wind with a speed of 2.5, 5, 10, 20, 40 mph is directed at the sidewall terminal from different directions (top, bottom, sides, head on, and 45-degrees above, below and from sides). Under different conditions, the pilot must be able to ignite main burner without excessive delay and remain stable. The flames cannot be extinguished, lift, or float.

Wind Test (Vertical Termination) - Applies to both gravity vented and direct vent appliances. A minimum length vent configuration is used. A wind with a speed of 2.5, 5, 10, 20, 40 mph is directed at the cap from horizontal and from 45-degrees above and below horizontal. Under different conditions, the pilot must be able to ignite main burner without excessive delay and remain stable. The flames cannot be extinguished, lift, or float.

Vent and Vent-Air Intake Terminal Assemblies - Vents and air-intake terminals must be able to pass the following tests:

- The terminal must withstand a 150-lbs load without excessive damage or distortion.
- The vent terminal must withstand a 45-degree pendulum impact from a 20-lbs sandbag, without excessive damage or distortion.
- The vent terminal must be constructed such that when subjected to a 30-minute rain test of 3 nozzles pointing downward at 45-degrees and pressurized at 5psi, no water accumulates in the terminal or vent.
- Vent sections 24" long taken from the temperature tests, must withstand a 20-inch free-fall puncture test using a 2-lbs 3/8" diameter steel rod with a 9/16" diameter steel head.
- For vent systems using other materials (cements, tapes, fabrics, etc.) in the assembly of the system, these materials are subjected to various exposure and temperature tests.
- An 8-ft assembly of vent pipe is subjected to a 10-inch free-fall impact from a 20-lbs sandbag, at the top of the vent's longitudinal axis. The vent system must remain intact without rupture, torn, distortion, or collapse.
- An 8-ft assembly of vent pipe is subjected to a pendulum impact from a 20-lbs sandbag, raised to a height of 10-inches, impacting the side of the vent at a joint, and at the middle of a

vent section. The vent system must remain intact without rupture, torn, distortion, or collapse. The vent terminal is also subjected to the same pendulum impact.

- Two section of vent are subjected to a 100-lbs longitudinal pull test for 5 minutes. The vent sections must not break, disassemble, or become damaged.
- Vent elbows supports must withstand without breaking or disassembling 4 times the weight of the maximum distance between supports (10-lbs minimum) for 5 minutes.
- A vent joint must withstand without breaking or disassembling 4 times the weight of the maximum distances between supports (19-lbs minimum) for 5 minutes.
- A vent support must support 4 times the weight of the maximum load to which the support is rated for, without breaking or collapsing. The weight is maintained for 1-hour.
- The tallest roof assembly specified must withstand a perpendicular load of 30-lbs/ft^3 without breaking or collapsing. The load is maintained for 1-hour.
- Corrugated flexible vent must not rupture, split, crease or otherwise become damaged when subjected to either a 25-8 ft-lbs torque or turned up to 180 degrees, whichever occurs first.

Joints in Direct Vent Systems - The longest vent length configuration, along with maximum number of elbows is used for testing. The vent system is disconnected from the appliance and both the vent and air-intake are sealed at both ends, and both are independently pressurized to 0.1"w.c. above their normal operating pressure. The leakage amount is measured, and compared to a formula that determined the allowable leakage amount based on sealed volume and appliance gas input.

Allowable Vent Pipe, Heating Element and Load Bearing Flue Gas Baffle Temperatures - The appliance is installed in the same Wall, Floor, and Ceiling Temperature test setup, with thermocouples placed at various locations on the vent pipe, heating element, and load bearing flue gas baffles. The appliance is set to operate and then the thermocouples are monitored every 15 minutes until maximum temperatures for each thermocouple are achieved. The maximum temperatures are compared to the allowed maximum temperatures set in the standard's appendix based on different material type and thickness.

Automatic Vent Damper Devices - Automatic vent dampers are subjected to the following:

- A vertical outlet vent damper must be able to operate when subjected to a load of 5 lbs/in of vent diameter and cycled 10 times. A horizontal outlet vent damper must be able to operate when 10-ft of vent pipe is attached to the damper and cycled 10 times.
- An electric vent damper must be able to operate when supplied with voltage between 85%-110% of normal, and cycled 10 times. A mechanically operated vent damper must be able to operate when supplied with power between 75%-125% of normal, and cycled 10 times.
- A thermally actuated vent damper must be able to supply a force of 2-oz in both opening and closing directions.
- A vent damper must be able to cycle 10 times after being exposed to 600 ^{O}F for 24 hours, and after being exposed to 32 ^{O}F for 24 hours. A thermally actuated vent damper is additionally exposed to 750 ^{O}F for 2 hours, and then must cycle 10 times.
- A vent damper must be able to cycle between open and closed for at least 5 seconds each. Temperature changes between 600 ^{O}F and 200 ^{O}F when open. The heat is shut off when closed. Thermally actuated dampers are subjected to 600 ^{O}F only.

Marking Material Adhesion and Legibility - Specifies that appliance markings meet the requirements of CSA 2.22 *Adhesive Labels* or UL 969 *Marking and Labeling Systems*. Labeling materials are exposed to 2-weeks in oven temperatures of 250 ^{O}F or 350 ^{O}F, depending on material.

APPENDIX D

Performance Tests included in ASTM E1509 *Standard Specifications for Room Heaters, Pellet Fuel-Burning Type*

The following performance test descriptions are provided as a summary only, and should not be regarded as a complete description of the required tests. For a complete description of the tests, refer to the standard itself.

Fire Tests:

Maximum Burning Conditions Test: This test is used to verify the appliance does not exceed the temperature limits when tested at its maximum burn rate. The appliance is installed in a room arrayed with thermocouples. The appliance is burned at its maximum burn rate until equilibrium temperatures have been reached. Surface thermocouples are monitored as well as the flue gas temperature to ensure they stay below the maximum limit.

Component Failure Test: This test checks the feed rate controls, combustion air controls, thermostat controls, etc. to determine if their failures create a hazardous situation. The appliance is burned at maximum burn rate, and then the individual controls are bypassed in an effort to determine if temperatures exceed the allowed limit.

Negative Pressure Tests: This test checks to see if carbon monoxide can spill into the room during operation. The appliance is operated at its maximum burn rate with the combustion blower disabled and the vent blocked. The surrounding room is conditioned to be at negative pressure (0.07-in w.c.) while the unit is operating. Samples of the room air are taken to see the concentration of carbon monoxide present. A table is provided indicating the allowed concentration of CO for a given period of time.

Door Ajar Test: This test is to ensure no more than 100 ppm of CO is allowed into the room if the door is opened. This test continues from the Negative Pressure Tests. While the appliance operates, the door is opened by 15^{O}, and samples are taken from the surrounding air and checked for CO concentration.

Physical Properties Tests:

Glazing Water Shock Test: This test checks that the glazing used can withstand the thermal stress of operation. While the appliance is operating at maximum temperature, a cloth with room temperature water is wiped across the glass panels. The glass panel is allowed to dry and then is sprayed with a water mist. The glazing cannot show any evidence of cracking, breaking, or becoming dislodged during this test.

Glazing Impact Test: This test checks the glazing can withstand impacts, and only applies to tempered glass. At both room temperature and maximum operating temperature, a 2-inch diameter, 1.18-lbs steel ball is swung on a pendulum against the glass. The glazing cannot show any sign of cracking, breaking, or dislodging.

Rain Test: This test checks the rain infiltration of the pellet appliance's exhaust vent. Three nozzles of specified design are approximately 3-ft away and pressured to 5psig. The nozzles are sprayed at the top and sides of the vent cap to determine the amount of water infiltration that occurs. The allowable amount of water collected cannot be more than 2% compared to that collected from an uncapped vent.

Mechanical Properties Tests:

Stability Test: This test is to ensure the appliance cannot be tipped over easily. The test requires that it takes at least 150-lbs of force to tip the appliance over in any direction, when applied horizontally at the highest point on the appliance.

Drop Test: Performed after the Fire Tests. This test ensures the appliance can withstand repeated impacts. The appliance is raised 1-inch off of a plywood sheet covering concrete and dropped repeatedly 10 times. Ceramic material must not break, fall away, or show any significant cracks, and the unit must be able to be operated properly.

APPENDIX E

Performance Tests included as part of UL 103 *Standard for Factory-Built Chimneys for Residential Type and Building Heating Appliances*

The following performance test descriptions are provided as a summary only, and should not be regarded as a complete description of the required tests. For a complete description of the tests, refer to the standard itself.

General
Thermal Shock Test - Requires that the chimney system be exposed to three 10-minute blasts of 1700 ^{O}F before any other thermal testing can be performed.

Temperature Test - 1000 ^{O}F (538 ^{O}C) Flue Gases - The chimney system is run at a flue temperature of 1000 ^{O}F until equilibrium of reached. Thermocouples are monitored to ensure wooden temperatures do not exceed 90 ^{O}F above ambient (for first 4-1/2 hours) or 117 ^{O}F above ambient (after 4-1/2 hours).

Temperature Test - 1400 ^{O}F (760 ^{O}C) Flue Gases - Continuing from the 1000 ^{O}F equilibrium test, the chimney system is exposed to flue gas temperature of 1400 ^{O}F for 1-hour. Temperatures on the wooden surfaces cannot exceed 140 ^{O}F above ambient.

Temperature Test - 1700 ^{O}F (927 ^{O}C) Flue Gases - Continuing from the 1000 ^{O}F equilibrium test, the chimney system is exposed to flue gas temperature of 1700 ^{O}F for 10-minutes. Temperatures on the wooden surfaces cannot exceed 175 ^{O}F above ambient. This test is used for non-HT chimney systems.

Temperature Test - 2100 ^{O}F (1149 ^{O}C) Flue Gases - Continuing from the 1000 ^{O}F equilibrium test, the chimney system is exposed to flue gas temperature of 2100 ^{O}F for 10-minutes. Temperatures on the wooden surfaces cannot exceed 175 ^{O}F above ambient. This test is performed three times, each starting from room temperature. The second and third tests are performed with the connector pipe wrapped with 3" of insulation to funnel more heat into the system. This test is performed to meet the HT requirements of the standard.

Positive Pressure Applications Test - This test applies only to positive pressure chimney systems. A configuration of chimney sections are capped and sealed and pressurized to 60" w.c., then subjected to the Thermal Shock Test, and re-pressurized to at least 60" w.c. or four times the manufacturer's rated pressure. A formula determines what the allowable leakage rate can be for the system.

Draft Test - The test ensures the chimney system will produce at least a minimum draft rate of 0.006" w.c. while being subjected to a flue temperature of 1000 ^{O}F.

Vertical Support Test - This test evaluates the support components (Ceiling Support, Tee Support, etc.) for the maximum height. The support is installed with one chimney section and loaded with 4-times the weight of the maximum rated height, as specified by the manufacturer. The component must not become damaged threaten to come free from the structure.

Strength Test

General - Components must not come apart or break when subjected to the following tests.

Impact Test - An 8-ft span of chimney is impacted three times with a 20-lbs or 50-lbs sandbag (depending on diameter) raised to a specified height. The chimney sections are not allowed to come apart. This test simulates a sideways impact to the system.

Longitudinal Force Test - Two or more chimney sections are subjected to a 100-lbs longitudinal pull to test the chimney joint integrity.

Load Test for Chimney Elbows - Two elbows are separated by the maximum unsupported length of chimney, as specified by the manufacturer. A load equal to 4-times the weight of the chimney between the elbows is applied to the center of the span. The load is held for 5-minutes.

Chimney Joint Load Test - Chimney sections are attached at the maximum distance between supports, as specified by the manufacturer. A load of 4-times the weight of the pipe between supports is applied perpendicular at the midpoint of the span. The load is applied for 1-hour.

Chimney Joint Torsion Test - Three chimney sections are connected. A sweeping brush of appropriate diameter is inserted into the pipe at the midpoint of the top chimney section and then rotated 10-times (both directions) to simulate cleaning. The chimney sections cannot come apart or disengage.

Wind Load Test

General - Chimney pipe sections cannot become damaged or disengaged when subjected to the wind loading tests.

Roof Assemblies - On the tallest unsupported roof assembly allowed by the manufacturer, a side load of 30-lbs/ft^2 is applied to the exposed pipe. The load is applied for 1-hour.

Lateral Supports - On the longest chimney span between supports allowed by the manufacturer, a side load of 30-lbs/ft^2 is applied to the exposed pipe. The load is applied for 1-hour.

Attic Insulation Shield Ventilation Opening Test - This test is for attic insulation shields which feature openings. A box is constructed around an Insulation Shield and chimney section. Cellulose insulation is then blown into the box until it is filled. Not more than 1 in^3 of insulation is allowed to get to the inside of the insulation shield.

Rain Test - A specific rain-tree featuring three spray nozzles is used. The chimney cap is subjected to a 5 psi pressurized spray from each nozzle, downward at 45-degrees. The allowed volume of water to enter the chimney is based on a calculated amount depending on diameter of the pipe.

Crushing Test of Nonmetallic Flue-Gas Conduit - Used for chimneys made from nonmetallic materials. Eight samples are tested. Four are tested as-is, four are tested after being heated to

550^{O}F for 24 hours and then cooled. Each sample is subjected to incremental loading up to 450-lbs. The samples are not allowed to show any visible damage.

Resistance to Action of Acids Test of Nonmetallic Flue-Gas Conduit - For chimneys made from nonmetallic materials. Uniform sections of the chimney material are immersed in a sulfuric acid solution for 24-48 hours. The sections are dried and weighed. No more than 3% of the chimney material by weight is allowed to be acid soluble.

Freezing and Thawing Test of Water-Absorptive Nonmetallic Materials - This test applies only to chimneys using water-absorptive nonmetallic materials. Samples of materials are immersed in water and the water is brought to a boil for 5 hours. Samples are removed, dried, and weighed to determine any absorption. Samples are then subjected to multiple cycles of 0 ^{O}F for 16 hours, 230 ^{O}F for 7 hours, and submerged for 1 hour, for a total of 240 hours. The samples are dried and weighed, and cannot show cracking, disintegration, or more than a 5% loss of weight.

Cemented Joint test of Flue-Gas Conduit - This test is used for chimney systems that employ cement at their joints. A dried cemented joint section is submerged in a sulfuric acid solution for 72 hours. The acid solution is then removed and replaced with water. The joint cannot show any sign of softening or leeching of the cement.

Sulfuric Acid Extraction Test for Porcelain-Coated Steel Used for Flue-Gas Conduit - This test applies only to chimneys using porcelain-coated steel as the flue-gas conduit. 2"x2" material samples are submerged in a sulfuric acid solution for 44 hours. The samples are removed, dried, and weighed. No more than 0.30% weight loss is allowed.

About CSIA

The Chimney Safety Institute of America (CSIA) is a non-profit, educational organization dedicated to chimney and venting system safety. CSIA, which marked its 30th anniversary in 2013, is committed to the elimination of residential chimney fires, carbon monoxide intrusion and other chimney-related hazards that result in the loss of lives and property. To achieve these goals, CSIA devotes its resources to educating the public, chimney and venting professionals and other fire prevention specialists about the prevention and correction of chimney and venting system hazards.

Certifying Chimney Sweeps and More

As a measurement of technical expertise, the CSIA certifies chimney and venting professionals. The CSIA Certified Chimney Sweep ® and the CSIA Dryer Exhaust Duct Technician ® credentials are the hallmark of excellence among chimney and venting service professionals. The professionals who have earned the CSIA Certified Chimney Sweep and CSIA Dryer Exhaust Duct Technician credentials have demonstrated their commitment to fire and chimney safety.

See more at: http://www.csia.org

About the Author

Eric Adair has a Bachelors degree in Mechanical Engineering from the University of California at Davis, a Masters degree in Business Administration from the University of Phoenix, and is a Licensed Professional Engineer in California. Mr. Adair has worked in the venting and hearth industry for over 20 years, starting with building and tenant HVAC systems. He transitioned to product design and testing with Simpson Dura-Vent (now M&G DuraVent), and later became the Manager of Research & Development. After many years of doing product testing, research and development, coordinating projects with listing agencies, appliance manufacturers, and customers, he then founded Adair Concepts & Solutions LLC. Mr. Adair is also the co-inventor of several venting related patents.

Currently, Adair Concepts & Solutions LLC helps companies and individuals with product development and product testing related to the venting and hearth industry. Additionally, ACS works with attorneys and insurance companies regarding fire investigations related to venting and hearth products, and offers services as an expert witness.

Mr. Adair has also served on these industry committees:

- Chimney Safety Institute of America (CSIA) Board of Directors
  - Chairman, Product Acceptance Committee

- Hearth, Patio, and Barbeque Association (HPBA) Technical Committee

- Underwriters Laboratories Standards Technical Panel for Chimneys and Venting
- Underwriters Laboratories Standards Technical Panel for Solid Fuel Appliances

- Air Conditioning, Heating, and Refrigeration Institute (AHRI)
  - Chairman, Venting Products Division

- Gas Appliance Manufacturer's Association (GAMA)
  - Chairman, Gas Venting Products Division
  - Member of Gas Venting Products Division

- American National Standards Institute (ANSI) / Canadian Standards Association (CSA)
  - Joint Technical Advisory Group Standards for Vented Gas-Fired Warm Air Heaters
  - Joint Technical Advisory Group Standards for Gas-Fired Water Heaters

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