Analyzing Fireplaces & Chimneys Environments

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The Investigation

Fireplace and chimneys have some unique characteristics that make the investigation of these systems challenging. In the next several paragraphs you will discover that there is much more to these systems than previously considered. You will learn the importance of understanding these systems and the Five Environments in which they interact.

Fire patterns and operation malfunctions on hearth products can be difficult to determine and many times may result in misinterpretation. This is due to the intricate and sometimes combined effects of natural draft characteristics, mechanical systems, confined spaces as well as other outside influences. To complicate our already challenging investigations, we need to understand the micro engineering within the product and its specific or intended function. Recognizing these challenges is necessary to provide an accurate conclusion on our investigations. This article does not address all of these concerns but it does start to break it down into a methodological approach as required by NFPA 921. It is my intent that this process of elimination will assist you in your fire investigations and inspections.

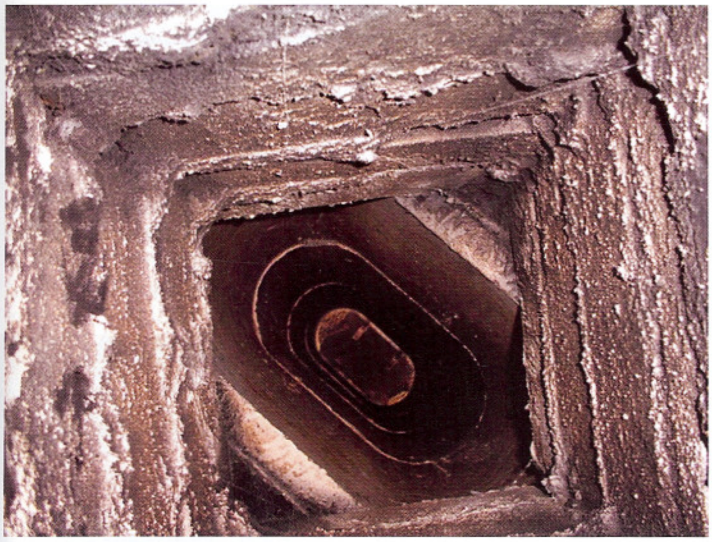
There are always concerns when a heat-producing product has been installed within a residential or commercial dwelling. As investigators we recognize these products due to the common misinstallation and our search for a heat source that is adequate to result in ignition. The public however believes that fireplaces, chimneys and vents systems are basic products with very little concern. As we know, these systems can be complicated and become problematic when they interact with the dwelling, mechanical systems, other appliances and even exterior conditions. We recognize the fact that these systems may result in devastating events. Therefore we should search for a greater understanding of the operation and interaction of these systems. To improve your skills, I recommend that our focus should be on product performance, intended operation, and fire behavior in confined spaces. Regardless of the type of appliance or heat conveying product, this information can be applied when performing a fire or personal injury investigation, performance assessment, or even a general inspection.

General Operation & Concerns

Before we move forward, we should first understand the anticipated operation characteristics of these systems. Although this is fairly basic information, it is necessary to understand these facts prior to considering the application of outside influences.

When a solid fuel or gas-burning fireplace is operated, heat is generated and the heat rises like a hot air balloon. As this heat rises out of the firebox a draft is created. This movement of air out of the firebox creates a call for air to replenish this lost volume. As the new air enters the firebox, this entrainment forces the heated flue gases against the rear wall of the firebox. This results in a greater heat transfer by conduction at this location. The International Building Code and the NFPA 211 Standards both compensate for this condition by requiring a minimum four-inch air space to combustible materials at the rear wall of the firebox only. This air space must be maintained to reduce temperatures.

The heated flue gases will continue to rise through the system. The rate that this gas travels through the chimney or vent system is known as residence time. An extended residence time may increase the heat transfer through the chimney walls and result in increased exposure to the surrounding wood structure or other combustible materials. This is common around offsets, changes in directions and flue obstructions. Under the right conditions, this exposure may result in a structure fire.



An open appliance such as a fireplace is known as a negative pressure system. This means that it relies on the negative pressure created by the fuel source. As the fire heats the surrounding air, a negative pressure is created and the column of air will rise much like a hot air balloon on a cool morning. This column of warm air will migrate to the point of least resistance. In the application of a fireplace, this point of least resistance is the unobstructed chimney flue. Under a negative pressure, it is assumed that the chimney and/or vent system does not need to be sealed at the joints. An example might be a factory-built fireplace with locking joints but no airtight seal. The lack of seal is truly not a concern when the system is operating as intended and designed as the air moves past the joints towards the point of least resistance. However, there is a concern of migration of heat through these openings when a positive pressure is applied. An example of this pressure might be an unlisted shroud located at the top of the chimney. If this application restricts the airflow, then a positive pressure or less than desirable pressure may result. The increased migration of heat through any opening within a chimney flue, metal or masonry, may result in a structure fire or be a contributing factor to this loss. We should consider these pressures and intended function during our investigations and inspections.

Combustion under acceptable limits, adequate combustion air, and proper drafting are required of these hearth products. Although carbon monoxide may be produced during the ignition process, these products should vent to the exterior of the dwelling if we have adequate airflow and the proper cross-sectional area for the chimney flue. These minimum requirements prevent ignition in unintended locations and reduce the risk of carbon monoxide poisoning. Personal injury is common as a result of acute or chronic exposure due to malfunctions of the fireplace or chimney systems.

Elevated temperature within the fireplace is a growing concern due to over-firing. Over-firing can result when improper materials are burnt or when too large a volume of fuel is supplied. This use of inappropriate material or increased fuel load can result in a greater transfer of heat through the fireplace and chimney walls as well as damage to the appliance structure itself. This direction has also been driven by consumer request. The consumers have been requesting more heat from decorative gas appliances.

A typical wood burning fireplace has been designed and intended to support an average of 100,000 BTU per hour. Over-firing of these systems has resulted in the documentation of fire loss and the development of our building codes. These minimum requirements set forth by the building codes are based on this 100,000 BTU per hour historical performance. The hearth industry has continued to increase the BTU rating of their gas-burning appliances to accommodate the consumer's desires. Most of these appliances are not a high risk due to the extensive engineering that determines the safe installation requirements. However, there are some after-market gas logs sets that are intended to be installed in existing systems. Some of these log sets are rated as high as 500,000 BTU/hr. This exceeds the intended use of the majority of all masonry and metal fireplace systems and may result in structure fires. This new direction driven by the consumer has provided higher temperatures and placed our simple gas log systems into a whole new dimension. All systems should be evaluated by a qualified investigator in order to confirm or deny its involvement in the fire loss as per the NFPA 921 requirements. Once the hearth product is suspect of a structure fire, back out and call for a specialist to focus in on the exact cause and the responsible parties. I do not recommend assuming that this common heat source is the cause without the proper evaluation. This can hurt your case as well as your reputation.

Regardless of the type of system or the choice of fuel, there are certain conditions that control or affect the environment in which it serves. The use of these products can create a series of conflicts. These conflicts can be found in the firebox area, the wall cavity, the fireplace room, the dwelling in which the appliance serves, and the outside geographic and atmospheric conditions. For the sake of clarity, I am going to isolate each environment and explain some of the conflicts and the expected results.

Focusing on the Five Environments

Environment 1...

This environment should be considered with all fire losses and personal injuries or fatalities.

The first environment is the interior of the firebox. Please keep in mind that these are standard fireplaces and not sealed direct-vent systems. This environment is not active until it becomes isolated from the room in which the appliance serves. This isolation is usually by means of glass or steel doors. The closure of these doors will reduce the amount of combustion air delivered to the fuel within the firebox area. Adequate combustion air is required for the proper combustion of the chosen fuel. The reduction of airflow through these doors will vary depending upon the product. A reduction in this airflow can also affect the operation of the fireplace by reducing the pressure applied to the rear wall of the firebox. This pressure holds the heat and all products of combustion to the rear wall. If the fireplace is properly constructed, then the airflow is directed into the fireplace and upward towards the chimney flue. This pressure is best applied when the doors are placed in the full open position. The closure of the doors reduces airflow, which reduces pressure that in turn allows the fire and flame to change direction within the firebox with little to no resistance. One indication of this problem is soot deposits on the fire screens and doors.

Whether you are using wood or gas, when the doors restrict combustion air, the area becomes a fuel rich environment. When adequate air is supplied, the ignition of the fuel occurs towards the rear center of the firebox. This is due to the location of the fuel load and the air pressure applied. This area of ignition is considered the intended area of ignition. When the doors are closed, the rich mixture of fuel and heat can migrate within the firebox without ignition until the proper air to fuel mixture is achieved. Ignition is likely to result where this mixture is adequate to support this process. This usually occurs towards the front of the firebox area as the limited air infiltration enters from this direction. I have named this anomaly "offset ignition" as the ignition occurs offset of the intended or anticipated location. These flames often come in contact with the tempered glass, which can result in damage and personal injury due to flying debris.

This condition is also likely to increase production of carbon monoxide based on the inadequate air to fuel mixture found at the area of ignition. One of several indicators of this condition are the agitated flames. If you have an opportunity to operate the fireplace or appliance you will notice that the flames will leap around the firebox violently and lean towards or make contact with the glass doors. Another indication of this problem is the lack of an inverted "V Pattern" at the rear wall of the fireplace. Offset ignition is likely to leave lower patterns on all walls or sometimes to the left or right side of the firebox.

Offset ignition has also been contributed to uneven heating of specific areas of the firebox due to the migration of the ignition. This condition may increase the possibility of a fire loss when applied to factory-built fireplace as they are designed and tested with a specific location for ignition. The minimum required clearance on the exterior surface of the fireplace may have been correct at the time of construction, but the offset ignition may result in increased temperature on the outer surface. This increase voids the listing results and increases the probability of a structure fire.

Also note that some factory-built fireplace manufacturers are now requiring that their doors be left in the full open position during operation so as to provide adequate combustion air for ignition and proper operation. All clearance requirements are based on the original test results under normal operation. Therefore, we should install and operate the systems as per the fireplace manufacturer's instructions. Any change in operation or intended design can affect the clearance requirements of both the fireplace and chimney system.

Environment 2...

This environment should be considered with all fire losses and could be a contributing factor to carbon monoxide poisoning.

The second environment is the wall cavity or wood framed chase areas directly associated with our hearth products. This area may consist of a single wall cavity facing only one side of the fireplace or chimney system or a large enclosure, which surrounds several if not all sides of the fireplace and chimney. This area should be considered a pressure sensitive environment and a potential hazard based on the construction process and the many contractors involved in this area.

The sensitivity of this environment may increase in smaller or restricted areas. An example of this might be the required horizontal fire block barrier at the ceiling line. When this fire block barrier is properly constructed, it will limit the volume of air within this space. Once the volume is limited then we should look at the affects of this limitation within this cavity and how it interacts with the fireplace and chimney systems. Many air-cooled chimney systems require a volume of air to enter into holes at the base of the chimney, which are open to the chase area. This air then travels to the top of the chimney, which removes heat from this area and reduces the temperature on the exterior surface of the chimney wall. Without adequate air, the surface temperature of the chimney pipe may increase and the minimum clearance requirement may change. Therefore, a certain amount of air infiltration is necessary for safe operation.

Experience indicates that the capture of heat or the restriction of air movement, are major factors in the creation of an undesirable condition. So what really happens within this area to increase the risk of fire? Let's start with our heat source. When the fireplace and/or chimney are operated, the heat will travel through the material by means of conduction. This heat then radiates off of the appliance and chimney surface into this cavity. This radiation will heat the surrounding air and cause this air to rise or migrate up within this cavity. When the air moves up and out of this wall cavity, a negative pressure can result if adequate air exchange is not provided. This negative pressure will attempt to draw air from any possible source. In our situation, the source to consider is the fireplace and chimney system. This call for air can result in the migration of heated gases from our heat source into the wall cavity. This migration of heated gases can travel through any opening which air can travel and commonly include but are not limited to the gas line entry at the side wall of the firebox, the contact between the fireplace face and the veneer or any open flue joint, breach, or crack within the system. Without the negative pressure, these defects might go unnoticed and inactive. Heat will usually travel the path of least resistance but with this call for air, it may find its way into the wall cavity. Ignition of any combustible material within these passageways or the cavity itself is very common. Look for damaged material that under normal fire conditions would have been protected by product. An example of this would be a chase fire where combustible material located on the front face of the fireplace is consumed when the fireplace structure should have shielded it from the radiation exposure.

Also note that outside products and trades can play a large role within these cavities. Wall insulation and construction debris can obstruct airflow to the air-cooled chimneys and restrict the dissipation of heat from both metal and masonry surfaces. Insulation can not only capture the heat, but can act as a bridge to deliver it to combustible materials outside our anticipated clearance. There must be an "air space" clearance supplied and maintained around all of these metal and masonry systems. A free air exchange within this wall cavity can prevent the capture of heat, reduce the surface temperatures of our system and counter act the effects of a negative pressure

When reading the fire patterns be sure to understand the confined space and what affects ventilation might have on these patterns. There is usually a combination of smoldering fire, which includes the slow consumption of product and then a movement into open flame as material fails and additional oxygen is supplied to the fire. This is not an open-air environment and is unlikely to develop "text book" patterns as anticipated.

Environment 3...

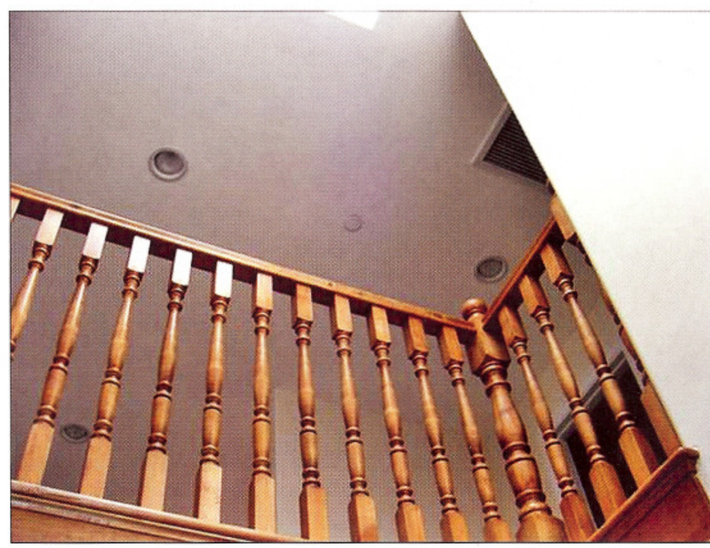
This environment should be considered with all carbon monoxide injuries or fatalities.

The third environment is the room in which the appliance serves. The appliance is relying on the room to deliver adequate air to support combustion. The floor plan of a room can make a great difference in the operation of this system. The Mechanical Code recognizes the concern for a minimum separation between the return air intake grill for the furnace and the opening of any fuel-burning appliances including fireplaces. This requirement indicates a minimum distance of ten-feet between the return air grill and the fireplace or appliance opening. This ensures that under normal conditions, the mechanical system does not overpower the natural draft chimney or vent system. However, the code does not address any adverse affects on either of these two systems once beyond this minimum distance. As an example, if the return air grill is located between the room door, (our air supply) and the fireplace, there will be a competition for that air when the mechanical fan is in operation. This competition usually results in a malfunction of the fireplace or the spillage of dangerous gases into the living space. Remember that a mechanical system will almost always overcome a natural draft appliance. This application becomes a lower risk in old drafty houses. However, the enforcement of the energy codes and remodeling of older homes has resulted in conflicts between our dwellings and our appliances.

Environment 4...

This environment should be considered with all carbon monoxide injuries or fatalities.

The fourth environment is the dwelling in which the fireplace or appliance serves. Adverse conditions can be created by floor plans as well as elevations. Natural air movement as well as mechanical air movement within the dwelling can create conflicts. If negative pressures are created within the dwelling due to this movement then adverse affects can result in all fuel burning appliances within the dwelling. One example might be the location of the stairway in relation to the fireplace. Warm air within the dwelling will naturally move upward through the stairwell like a chimney system. This movement of air can result in a conflict that commonly overpowers the other appliances and vent systems. This again can result in the entry of dangerous gases into the living space. This movement can occur within any dwelling



with two or more floors. However, this condition is exaggerated in multi-story condos or town homes due to the limited volume within a smaller environment. The larger the air volume, the less likelihood of negative affects.

Negative pressure can be associated with all dwellings when the air exiting the exterior envelope of the dwelling is greater than that being returned. Almost all dwelling are negative pressure, but what we are concerned about is when the negative pressure within the dwelling is equal to or exceeds the negative pressure created with the chimney flue. This competition for air can result is an occasional malfunction or a constant exposure. This condition can be magnified by many applications and sources. A short list might be stacking affects due to the floor plan, mechanical hoods, bathroom fans, leaky air ducts, recessed light fixtures, whole house fans, new windows and much more.

Environment 5...

This environment should be considered with all carbon monoxide injuries or fatalities and could be a contributing fact in a fire loss.

The last environment is the exterior elements outside of the dwelling. This environment includes exterior geographic structures and atmospheric conditions. The geographic conflicts include hillsides, cliffs and trees. The atmospheric conflicts include winds, humidity and temperature.

It is common for geographical structures such as hillsides or cliffs to result in system malfunctions. To assist in this understanding, think of the airflow as water. If the water can pour down like a waterfall or crash over the chimney like a wave, then a malfunction is likely. The waterfall affect is common with a step incline of a hill in close proximity to the system termination. The air drops down the incline onto the chimney termination. The wave affect is common with a drop-off or cliff behind the dwelling. The air hits the cliff and is pushed up and over and onto the dwelling like a wave. The presence of trees can have a similar affect as both the waterfall and wave affects based on height and application. Any conflict created with the free flow of draft has an opportunity to result in a malfunction in operation or the migration of burning embers to roofs or open brush.

The atmospheric conflicts such as wind, humidity and temperature can also play an important part in our investigation. If the hearth system as been designed and constructed close to the minimum requirements for a safe draft, atmospheric factors can easily overcome the negative pressure necessary for the system to properly operate. The system may manage to operate just within the tolerance levels under calm and somewhat normal conditions. However, when the winds increase or dense fog applies a heavy pressure, the draft is defeated by this conflict and the system can spills dangerous gases into the living space.

The winds can also play a role in combination with the elevation of the dwelling structure. An example might be when the wind travels from the north and rolls over a peak or ridge of a roof and drops down on top of the south chimney termination. This conflict is directional based on the path of the wind in relationship to the dwelling elevation and the location of the chimney. We must know the wind direction for this site based on the date and time of the loss or event.

The collecting of weather information can assist you in your investigations and application of this fifth environment.

In Conclusion

In conclusion it is important to have a better understanding of these systems, the adopted building codes and the environments in which they serve. These systems are complicated and at times very difficult to correctly evaluate. It is crucial that you continue your education on these products and the ever changing directions of the hearth industry. It is equally important to study fire within small environments and the difference between these confined spaces and common fire behavior.

Please feel free to contact my office with any questions regarding fireplace, chimney or vent systems and your investigations.

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