Oilheating

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Bulkplants
and SPCC regulations

Also:
- Dealing with Soot
- Radiant Heating
- Realtor® Program
- Indirect water heaters and boilers

This East Coast oil company is in the pink!

Causes of soot damage to residential structures

Damage to interior surfaces due to soot and "soot like" substances does still occur in homes today. With the current emphasis on oil as a clean burning fuel, this potential problem must be carefully scrutinized and eliminated.

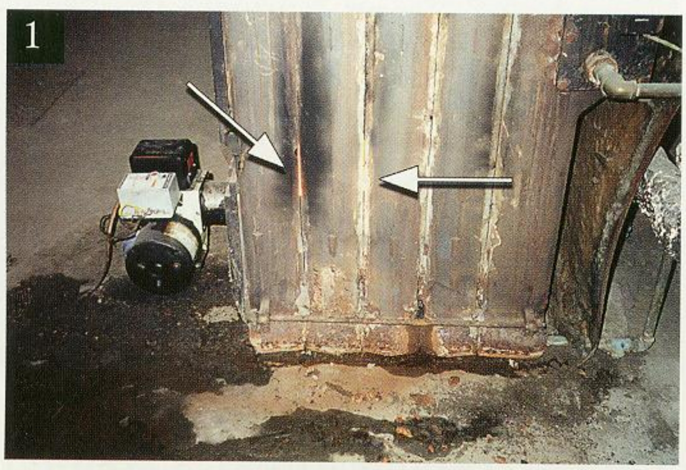
By John Certuse P.E.

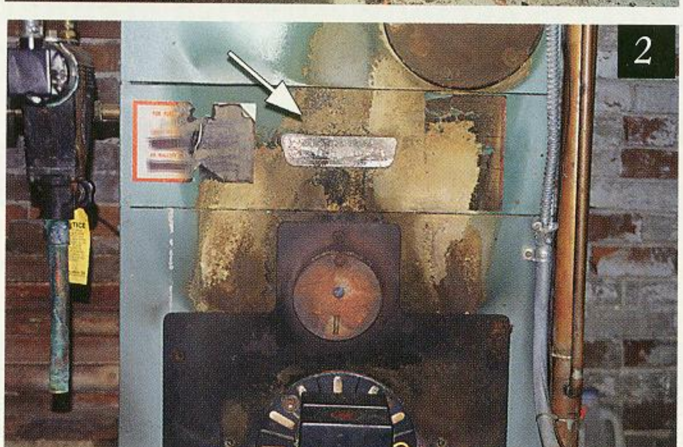
Photo 1: These boiler sections are leaking products of combustion into the structure. The rope packing between the sections has deteriorated, allowing slow entry of soot products into the structure directly from the appliance.

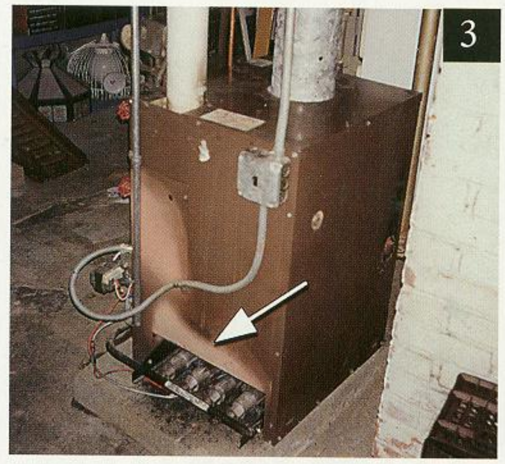
Photo 2: Poor cleaning and poor draft caused the plugged firesides of this boiler. Products of combustion cannot pass through the appliance and are forced back out into the structure. This is known as **backpressure**.

Photo 3: A poor draft can also cause products of combustion to reverse flow and enter the structure. Again, products of combustion cannot pass through the appliance and are pushed back out into the structure. This is called **rollout** *in gas fired appliances.*

Photo 4: Stovepipe pitch should be upward towards the chimney at a slope of ¼ inch per horizontal foot—not as shown here. Upon the burner's shutting down, emissions in the piping may re-enter the structure.







Soot discharges to the interior of homes are caused by the different ways in which a combustion appliance's emissions and the interior air in a house interact. Indoor Air Quality (IAQ) is characterized by the concentration of particles in indoor air, including combustion products, dust and many other substances.

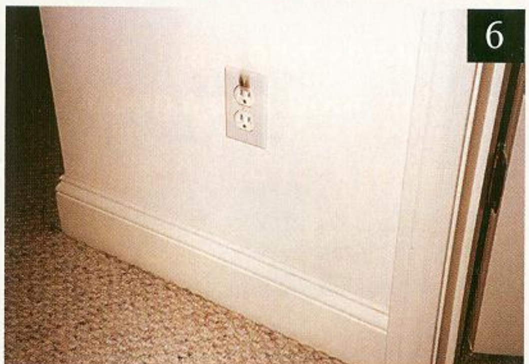
Conventional "Soot" damage ("Puffbacks")

Boilers and furnace heating systems that burn fuel must contain the products of combustion and deliver them to the exterior of the building without allowing any leakage to the interior of the structure.

Even small leaks in the appliance will allow introductions of these products into the interior environment until they accumulate in common locations to the point where they are noticed.

Don't assume too quickly that it's "Soot"

Although many of these concentrations resemble soot, it is important to note that they may not be a result of a product of combustion from the boiler or furnace fuel source (be it gas or oil), and one shouldn't immediately assume that they are. For example, dislodged dust from baseboard heating elements can cause "soot like" deposits to form on the walls above



them. This can result from a combination of the water being too hot in the baseboard (due to an aquastat failure) and/or the heating elements being excessively dusty. This can cause these particles to be discharged and give the appearance of soot from combustion.

Additionally, dust in the ductwork of a forced hot air heating system, which gets heated when it passes through a furnace's heat exchanger, also can have the appearance of being from a product of combustion. Even mold can cause dark spots that may be mistaken for "soot".

Candles may be possible causes of such deposits as well. In the event that candles are being used, homeowners should stop using them and observe if the condition ceases. If the source cannot be identified, laboratory analysis of the soot can help to verify its origin.

Boilers and Furnace Soot Leakage (failed appliance integrity)

Some boilers and furnaces do leak and allow emission entry into the interior of the structure directly. Typically, this is caused by maintenance and age/wear and tear issues of the boiler or furnace*. Some examples of these conditions are shown in photos 1-4.

Soot damage to homes is also commonly encountered by service technicians as a result of a plugged boiler or furnace heat exchanger. This can result in a reversal in flow direction, causing the appliance to "leak" large amounts of combustion products from openings such as combustion chamber observation doors and gasket areas on the firesides of the appliance.

Additionally, a break in the appliance's combustion chamber area due to flame impingement burn-through damage will cause this same soot discharge to result. A failure in the combustion chamber refractory (be it ceramic fiber or brickwork) is the most common cause of this. (See *Oilheating Journal,* July 2002).

*Editor's note: All the more reason to suggest to homeowners that older, inefficient heating systems be upgraded and if necessary, replaced. There are significant advantages to doing so.

Ghosting Soot (The origin of the soot is not obvious)

Soot accumulations also occur in homes where the soot damaging the home was from the same source as the fuel being consumed in the home's boiler or furnace. The appliance, however, was not the direct source of the soot. In such cases, emissions from the heating system were somehow getting into the home, but not leaking from the appliance directly. The appliances and the rooms where they were installed were devoid of any soot contact; however, the attic and upper floors of the homes were damaged with a lighter amount of this same soot.

This damage can be present in heavier concentrations or even light and subtle concentrations known as "Ghosting Soot". Many times these Ghosting Soot deposits are seen above baseboard heating elements, [See photos 5 and 6] or are found coating plastic objects (food storage containers, children's toys). In some cases, they outline where the studs behind wall sheet rock are located.

As soot particles are subjected to a closed room, they will circulate on the connective airflow current that is generated by the heating system and are also attracted to objects with a different static charge. This is why many poor indoor air quality (IAQ) conditions result in common telltale signs of this type of damage at baseboards and on plastic objects.

Is there another way for these emissions to enter a structure?

There are instances where a product of com-

Photo 5: Ghosting soot is plainly visible above these baseboard heating elements. ©*ISE*

Photo 6: Soot-like streaking is seen emitting from the wall plug. ©*ISE*

Photo 7: Soot-soiled insulation is seen at vent location in attic.

Photo 8: Attic stairwell doorjamb coated with soot

bustion does not enter the structure from the appliance directly. However, accumulations in the structure occur at a steady and ongoing rate, as shown in photos 7 and 8.

Deposits of soot or soot-like markings in areas far away from where the combustion appliance is located indicate a path of air flow into the structure, bringing these particles into the home. This condition is caused by *Depressurization Induced Combustion Re-Entry.*

What is Depressurization Induced Combustion Re-Entry?

Component 1) A "Tight House"

Houses today are built with better materials than in years gone by. As such, outside air infiltration (drafts) are kept to a minimum and the building envelope integrity is greater. A tightly insulated house will allow pressure differences to develop in larger magnitudes than in a drafty house. When this pressure difference is negative, the phenomenon is known as depressurization. Depressurization occurs when the air in the building is removed and cannot be instantaneously replaced by exterior air. This results in the building envelope developing a differential pressure in a negative magnitude.

Photo 9: This chimney is below the peak of the structure. Discharge of gases should be at least two feet above the structure (see text) to prevent their re-entering the building.

Photo 10: Malfunctioning burner's smoke lies closer to the house structure due to decreased stack effect. ©ISE

Causes of this air displacement include:

- Wind over a building
- Air moving devices in the building, such as exhaust fans, clothes dryers, oil burners etc.
- Air temperature variations and their associated density differences.

When a negative pressure is present, the house will try to equalize this pressure by drawing air in from the exterior of the home. Typically, this is in the vents of the structure in the roof area and sometimes down chimney flues.

If this infiltrating air is clean, the only result is colder air entering the house. If the infiltrating air contains particles from the heating system appliance's combustion emissions, this allows these particles to re-enter the home and accumulate to the point where they eventually become noticed.

Component 2) A location of emission discharge that allows emissions to mix with air re-entering the structure.

If a structure is depressurizing, it will draw a slight vacuum, causing the house to bring in air to equalize this difference. If the emissions of the combustion appliance are located such that they do not distance themselves from the boundary layer of the structure, they can re-enter the structure by being entrained in this infiltrating air.

Although each home has its own unique characteristics for the "fluid flow" of air (and discharge gases over and from the building), general observations have been documented, and guidelines have been presented by The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

These guidelines recommend that discharge gases be discharged above the eddy zone, and if possible, above the wake zone, which is generally two feet above the peak of a structure. Photo 9 shows an arrangement that would be inappropriate under these guidelines.

Stack Effect

Homes where this problem did not exist previously can also suffer this type of damage. In these instances, either the potential for intermittent burner failure or a known burner failure has resulted. Causes for burner failure can be an identified breakdown of the burner, the result of many events, including:

- Burner component failure (transformer, poor service, lack of service)
- Confined space causing intermittent burner failure
- Leak in combustion path

This failure causes heavier products of combustion, which cannot exit the chimney with the same velocity and hence distance themselves from the house as quickly as those from a properly firing burner. The force a chimney develops is known as the ***Stack Effect.***

The Stack Effect is the pressure difference caused by the difference in air and flue gas densities. The value of the Stack Effect directly correlates to the burner gases' ability to exit the chimney with an acceptable velocity and the discharge distance from the structure.

What Can Be Done To Correct This? Each house has its own particular characteristics for infiltration and wind flow geometry that affect depressurization reentry conditions. As such, without extensive research to each home, detailed steps to guarantee the correction of this problem cannot be presented; however guidelines which have proven effective in similar homes can be used.

Remember, the problem is usually caused by a combination of variables—the pressures to which a structure is subjected, and the location of emissions and quality of combustion of the appliance. Annual tuning and service is a *must* for all heating appliances, regardless of the fuel being used.

Eliminating one of the following conditions should improve, if not entirely correct, this problem:

- Make sure the appliance itself is not leaking emissions into the structure and make sure there is no other combustion condition which may be the possible source of the soot. Aggressive examination of the appliance, including the entire surfaces of the heat exchanger, may be necessary. Think of leaking products of combustion much in the same way as you would consider leaking water from a boiler. Look for "trails" of soot on the boiler or furnace surfaces. This is an indicator of combustion leakage.
- To address the first variable—depressurization (negative pressure)—companies such as Field Controls and Tjernlund make devices that add air to a structure when the combustion appliance is energized. In addition to addressing confined space code issues, these devices ensure the appliance is receiving adequate combustion air and may eliminate a decreased stack effect due to a combustion air deficiency.
- The second variable is the point of discharge. If the point of discharge is located at a position in the building where it is mixing with infiltration air in small amounts, moving the point of discharge to a new location where the emissions will not strike the building has proven to be the most effective remedy in case studies.

Although each house has its own unique wind flow conditions that may require trial and error approaches to correction, ASHRAE studies have identified the most desirable discharge locations from structures.

Direct venting of appliances may not be possible in all locations due to the distinct characteristics each home has for wind flow patterns. Poor chimney height or placement will also cause the emissions to mix with infiltrating air. NFPA 211 directs the vertical termination heights above structures to keep emission plumes flowing free of structures.

Poor combustion will also affect the plume characteristics emitting from a chimney if the burner is running poorly. This results in a decreased stack effect that will alter the discharge point of emissions from a chimney, increasing the likelihood of re-entry with infiltration air.

Annual tuning and combustion performance tests of the burner will verify correct firing conditions.