

October 2004

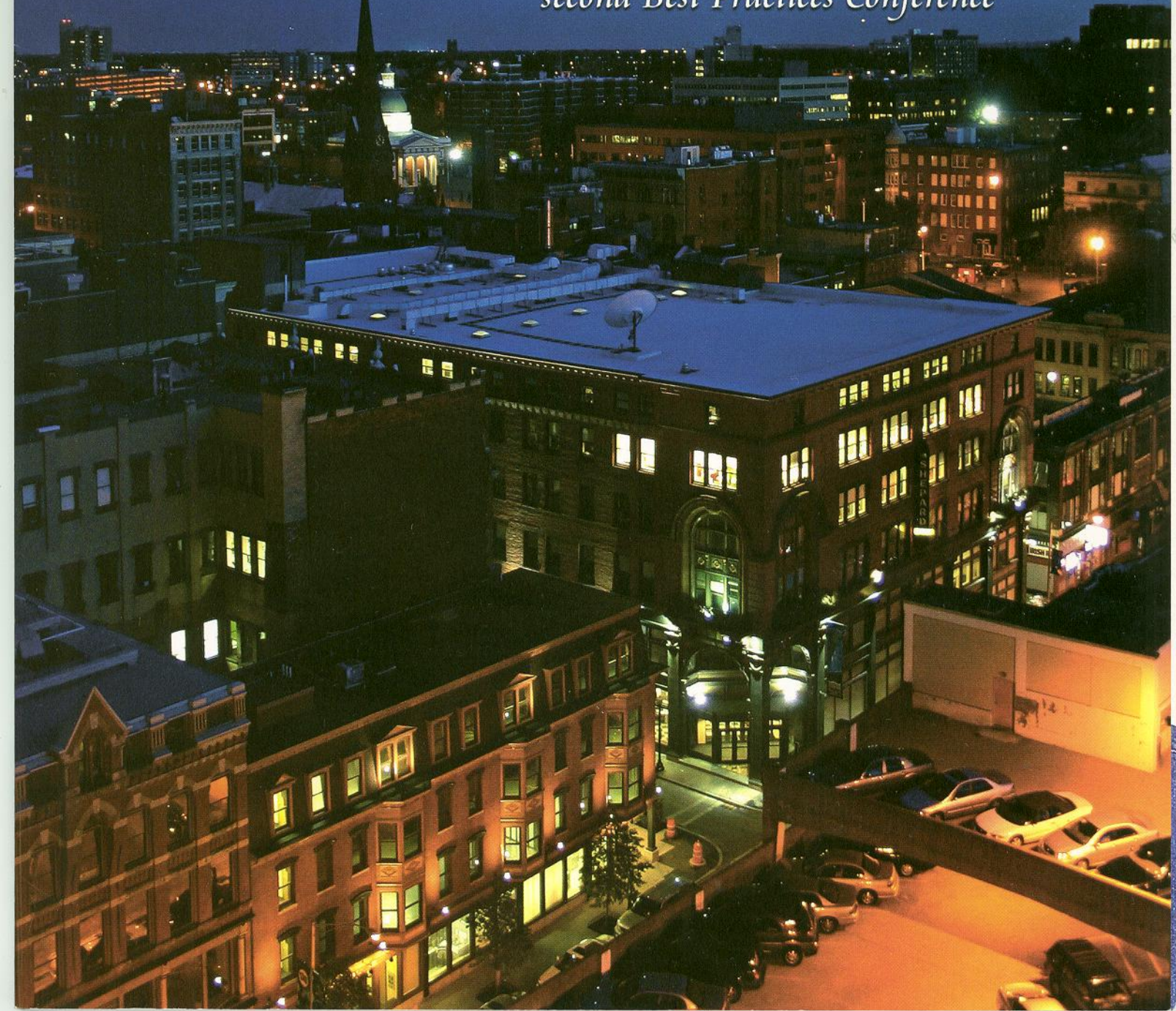
Oilheating



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Residential boiler pressure vessel explosions

John Certuse P.E.



(Above) boiler section damaged due to BLEVE

Editor's note: *Oilheating* has, we feel, an obligation to present material of a technical nature that may help reduce risk in the workplace and in the home and to alert our readers to potential problems. The situation discussed here, while not common, is preventable when the appropriate safety maintenance procedures are followed in servicing hot water systems. Service technicians need to be cognizant of these issues.



Hot water heating system

BACKGROUND

Of all of the malfunctions that can occur in a residential heating system, anyone who has seen a boiler explosion will attest to the damage even a small residential boiler can cause.

The type of boiler explosion discussed here is not the type that results from an accumulation of fuel in the combustion chamber that ignites in a rapidly building pressure wave (known as a delayed ignition), but rather of a build-up of pressure within the boiler pressure vessel itself.

The explosion is known by a technical term called a BLEVE or a Boiling Liquid Expanding Vapor Explosion. The National Fire Protection Agency (NFPA) Chapter 921 Describes a BLEVE as:

"...explosions involving vessels that contain liquids under pressure at temperatures above their atmospheric boiling points. The liquid need not be flammable. BLEVEs are a sub-type of mechanical explosions but are so common that they are treated here as a separate explosion type. A BLEVE can occur in vessels as

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small as disposable lighters or aerosol cans and as large as tank cars or industrial storage tanks.

"A BLEVE frequently occurs when the temperature of the liquid and vapor within a confining tank or vessel is raised by an exposure fire to the point where the increasing internal pressure can no longer be contained and the vessel explodes. This rupture of the confining vessel releases the pressurized liquid and allows it to vaporize almost instantaneously."

BLEVE explosions have occurred in steam boilers; however, in residential applications, they are more common in forced hot water heating system boilers.

FORCED HOT WATER

A Forced Hot Water Boiler System is a heating system which transfers the heat of the burning fuel in the boiler combustion chamber to the water in the boiler.

This heated water within the boiler is then pumped throughout the dwelling through piping to baseboards or radiators where the heat is given off to these areas.

The entire system is pressurized.

A constant source of make up water is maintained to the system from the water main which is reduced in pressure in its delivery to the heating system through a backflow preventing valve and **pressure reducing water feeder valve**. Since a



Close up of expansion tank and pressure safety relief valve

forced hot water system is a closed system, it has no room for heated water to expand to other than the **expansion tank**. In the event that this expansion tank is full or damaged, then the boiler's **pressure safety relief valve** opens to relieve this excess pressure.

If this component has also failed, excessive pressures may develop within the system that are capable of bursting the boiler or other system components.

EXPANSION TANK OPERATION AND FAILURE

An expansion tank is a small tank which connects directly to



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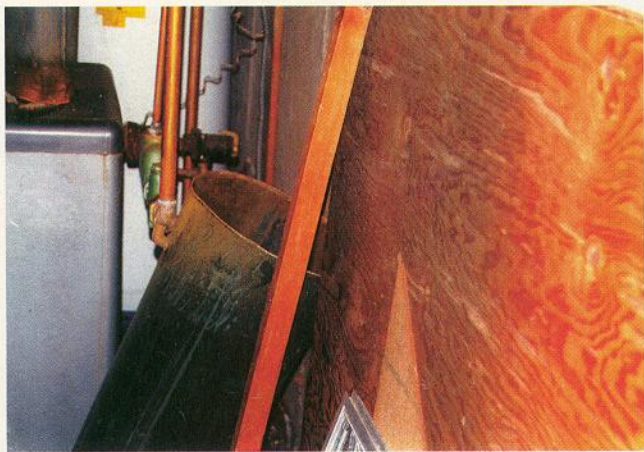
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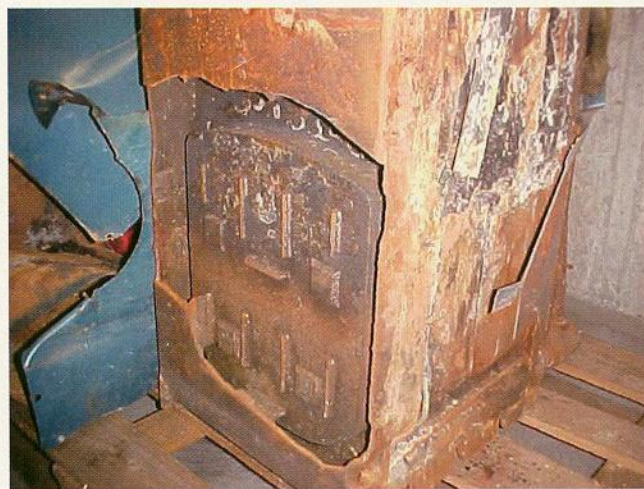
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Residential Boiler Pressure Vessel Explosions *continues from 40*

Burst boiler due to pressure relief valve seizure



the piping of the forced hot water heating system. The main function is to allow a reservoir of compressed air where system water can expand to reduce system pressure fluctuations. One type is air filled and has system water flowing into it,



Burst expansion tank

allowing it to compress this air. These older tanks were installed in number throughout the 1950s and 1960s and are usually cylindrical in shape. These are often positioned in the home's floor joists in the basement.

A second and more common expansion tank is the diaphragm expansion tank. This type of tank is divided in half by a rubber diaphragm which has the system water on one side and is charged with air on the other.

As the water within the system expands, the gas on the opposite side of this diaphragm is compressed.

These components can flood completely with water due to air leaks. This prevents any expansion of water and dampening of the system pressure, allowing pressures to rise above intended system levels.

SAFETY RELIEF VALVE FAILURE

The safety relief valve lets water escape if pressure in the boiler gets too high. In forced hot water residential systems, this is maintained at 30 psig. The valve is a spring loaded device that will open if system pressure exceeds its rated lift pressure.

The effects of corrosion and system impurities can immobilize the moving components of these devices. These same impurities can also block water flow through the water intake piping, eliminating this flow path as well.

BLEVES ARE COMMON AFTER A RECENT SERVICE EVENT

These types of explosions most often occur immediately after a shutdown burner is repaired and the boiler is returned back into service. In addition to failures of the expansion tank and pressure relief valve, the inherent cooling and contraction of a boiler's water during this downtime can set the stage for an unsafe condition to develop.

During downtimes in burner operation, the water in the heating system cools and reduces the system pressure. This boiler pressure will assume the pressure of water entering the system through the boiler's pressure reducing water feeding valve due to increased water density and cooler temperatures.

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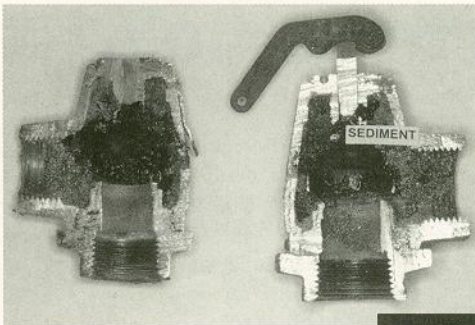
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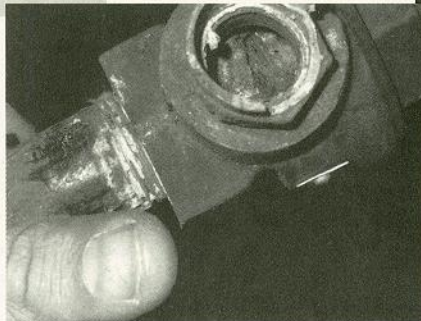
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Relief valve seized with sediment



(Above) Lifting the handle of a pressure relief valve to check for proper operation



Relief valve seized closed

Upon a burner being returned to operation, this water will then rise in temperature and expand. Without a functioning expansion tank to compensate for this expansion, the system pressure will quickly rise.

As the system's temperature and pressure continue to rise even further, the system now becomes reliant upon the operation of the safety relief valve, which as mentioned above, is usually set at 30 psig in residential heating systems.

If the safety relief valve is incapable of lifting, pressures approaching thousands of pounds per square inch may develop and such pressures can cause boiler cast iron sections to fail while immediately vaporizing the compressed and heated water within.

THE EFFECTS OF A BLEVE EXPLOSION

BLEVE explosions damages include a boiler's cast iron sections being broken apart and cast iron fragments dispersed throughout the mechanical room. The forces generated can cause entire cast iron boilers to be dislocated from piping and their foundations moved many feet from their initial locations.

Another manifestation of BLEVE damage is not in a failure of the boiler pressure vessel but rather the expansion tank. BLEVEs of these components also cause significant damage to homes and possible fatal injury where failures occur.

PROPER SERVICING SHOULD INCLUDE CHECKING THESE COMPONENTS

The American Society of Mechanical Engineering, Chapter 5, calls for annual maintenance of the pressure relief valve to insure that it is operating properly. When an oil burner fires into a boiler, not only must the oil burner be maintained, but also the boiler and associated components.

Even though a burner technician usually deals with burner maintenance and service, it is a simple task to make sure a pressure relief valve is not seized and is capable of functioning properly. A seized valve should be replaced.

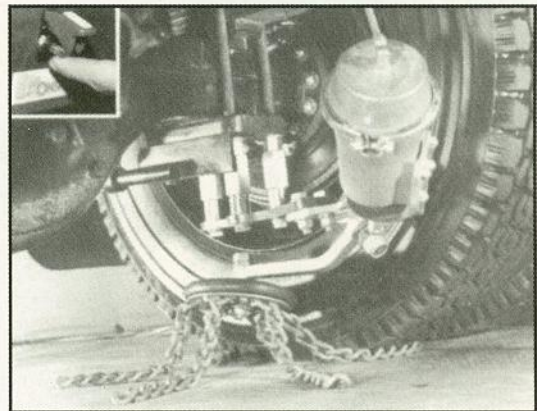
The relief valve should then be checked for dripping water

and the system pressure should be monitored for proper pressure.

If the valve drips, flushing the valve and connecting piping with water should remove any impurities. If dripping contin-



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**Residential Boiler Pressure
Vessel Explosions** *continues from 43*

ues, the valve should be replaced.

A seized valve can be identified by lifting the valve handle to make sure it is clear of obstructions and will move freely.

Care must also be taken to make sure it is properly installed directly onto the boiler and that its discharge piping is not reduced in diameter or sealed with a piping fitting. This action can also remove impurities that collect in the valve and connecting piping.

Watts Regulator, a manufacturer of relief valves recommends proper service and installation in their literature, noting: "Important, the discharge line must be the same size as the valve outlet and must pitch downward from the valve to a safe place for disposal. Valve lever must be tripped at least once a year to insure that waterways are clear."

Diaphragm types of expansion tanks should have the air valve tested for pressure to make sure there is a proper charge present. This can be done with a tire pressure gauge. This air valve portion of the tank should not contain water which will flow out of the valve if the valve is depressed. If water is present in this portion of the tank, the unit should be replaced.

Older Cylindrical expansion tanks should not be completely full of water and should be slightly drained if these are overfilled. System water must have an "air space" area within these tanks so that this space can receive any volume of expanding water.

CONCLUSION

With systems off during summer months or due to burner shutdown, the return into operation of these heating systems will induce changes in pressures and temperatures not experienced since the end of the last heating season.

During this time, the system will attempt to achieve a thermal and pressure equilibrium in operation.

Common failures due to a seized pressure relief valve or flooded expansion tank are easily diagnosed and if caught in time can prevent an explosion capable of extensive damage or even bodily injury to the building occupants.

It is a simple task to make sure these safety components are functioning properly during annual service events and it is a task every professional service technician should include into his annual preventative maintenance checklist. □

Air valve on expansion tank

