Your Boiler Room:
A Time Bomb?

Is you boiler room a potential Time Bomb?

A few basics you need to know to work safely in the boiler room:

Two potentials for “explosions” in a boiler room:

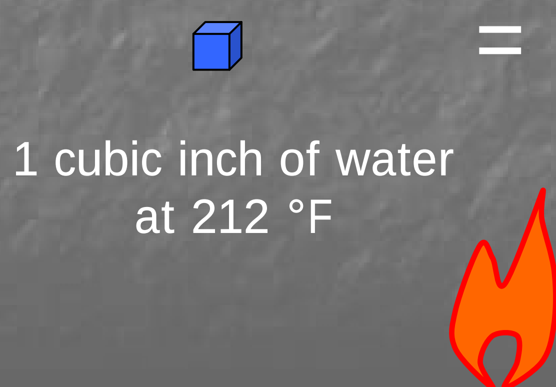
- Water/steam side explosions
- Furnace explosions

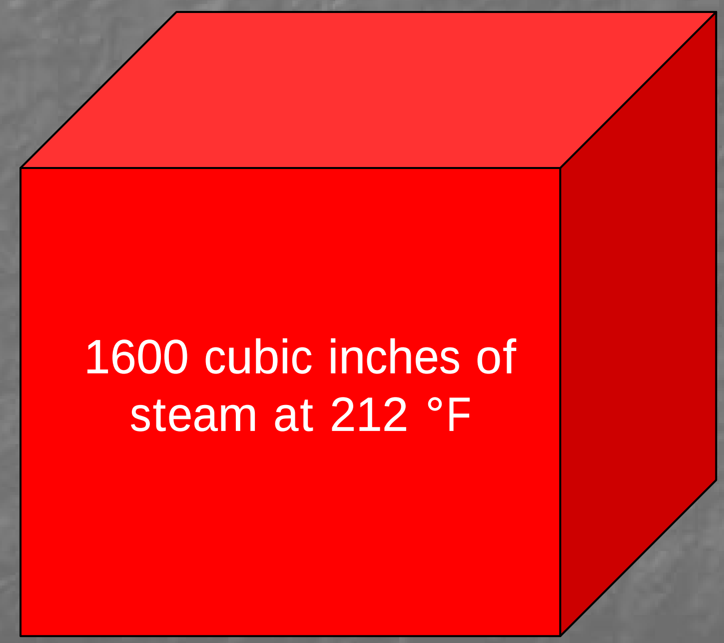
Water/steam side explosions:

- We all know water, as it is heated and changes into steam, expands.
- With this in mind there are two basic principles we need to understand.

Principle #1:

If we take a cubic inch of water and apply heat until it boils it will expand and create 1600 cubic inches of steam at atmospheric conditions.



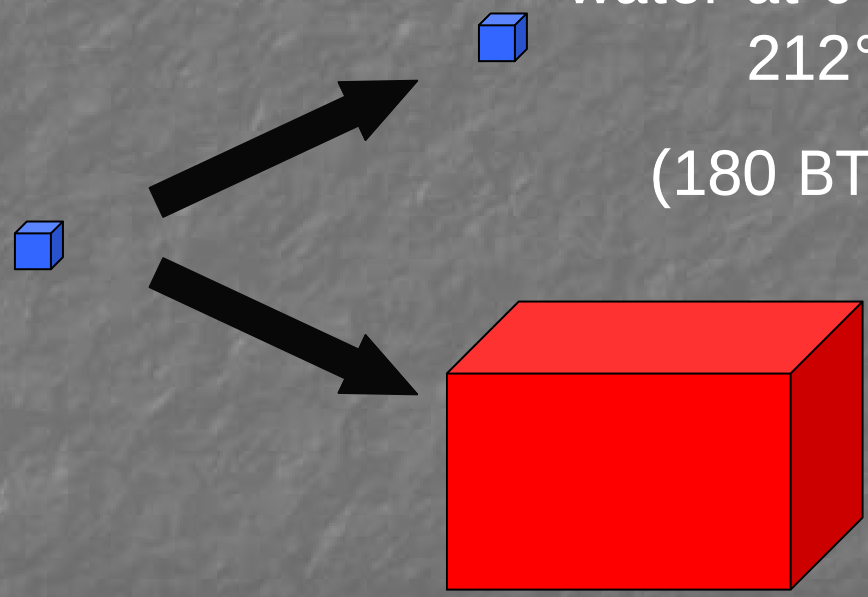


Principle #2:

- Energy in = Energy out

1 pound of water at 100 PSI and 338 °F

(309 BTU/lb)



~ 0.85 pounds of water at 0 PSI and 212°F

(180 BTU/lb)

~ 0.15 pounds of steam at 0 PSI and 212°F

(1151 BTU/lb)

For Example:

If we have a Fire Tube Boiler containing 1,000 gallons of water, operating at a pressure of 100 PSI and a temperature of 338°F and the shell suddenly ruptures, approximately **15%** of the water will instantaneously flash to steam. The remaining water will cool to below 212°F and stop flashing.

- 15% of 1,000 gallons of water = 150 gallons.
- One gallon = 231 cubic inches.
- So; 150 x 231 = 34,650 cubic inches of water is released.
- Since this water immediately flashes to steam, the volume of the steam created = 34,650 x 1600 = 55,440,000 cubic inches.
- One cubic foot = 1,728 cubic inches.
- Converting cubic inches to cubic feet: 55,440,00/1,728 = 32,083 cubic feet of steam will be produced.

If our boiler room is 10 feet high by 20 feet long and 20 feet deep, calculating the volume of the room:

Volume = h x l x w

= 10 x 20 x 20

= 4,000 cubic feet.

Now, taking into account the steam produced as the suddenly released hot water turns into steam:

32,083.33 ÷ 4,000 = 8.02

The boiler room now is forced to try to contain a volume which has increased by a factor of more than 8 times its original volume. This will result in an over pressure of the structure.

The weakest part of the walls, ceiling, windows, and doors will fail causing massive destruction to the building.

This in addition to the shrapnel from the ruptured boiler......

A real life event:

About 1:50 pm on June 18, 2007, boiler #2 (TN#: T24059) located at the Dana Corporation plant in Paris, Tennessee, exploded causing extensive damage to the facility and surrounding area, and seriously injuring one employee. The 2000 model Cleaver-Brooks high-pressure (150 psi) firetube boiler was operating concurrently with a second high-pressure boiler (boiler #1). Both boilers were online to handle the steam demand of plant operations at the time of the incident.

Hole Created by Boiler through Roll Up Door Wall (West Wall)

requirements of ISO 9001:2000
and TS 16949:2002
7:59
PREFORM
CUTTER
#2
CAP1000

Final Location of Boiler After Explosion

Knocked Down Exterior Wall Viewed from Inside Boiler Room (East Wall)

View of East Wall from Outside Plant

View of East Wall from Outside Plant (Note Rear Boiler Door in Ditch)

The investigation:

The investigation team considered many factors during the investigation including:

- The operation of the boilers at the time of the explosion.
- Past and current maintenance.
- Boiler attendance and operation logs.
- Audible and visual alarms.
- Past inspections and findings.
- Installation and condition of controls.
- Safety devices.
- Eye witness accounts.

It is determined that the probable cause of this accident was the sudden introduction of feed water to the boiler. At the time of the explosion, the boiler was operating in a dry-fired state. Before the explosion, inoperative controls and safety devices allowed the boiler to continue to fire even though water levels in the boiler were at a dangerously low.

The excessive, rapid expansion of pressure created due to the introduction of feedwater as it was instantly converted to steam by the overheated surfaces of the boiler imposed dynamic forces on the boiler furnace tube. This caused the furnace tube to collapse and subsequently explode the boiler.

Factors contributing to the accident:

- Lack of standard operator training.
- Inadequate boiler operating procedures.
- Inadequate boiler attendance.
- Improper boiler maintenance.
- Inoperative boiler controls and safety devices.

As fuel is fired, energy is stored in the water in the boiler as well as in the steam generated. Failure of the pressure parts can release this thermal energy of the fluid at a catastrophic rate. Back as far as 1871 some experimental waterside boiler explosions were conducted at Sandy Hook, New Jersey.

During these experiments it was calculated that the theoretical amount of energy released was in excess of 2,000,000,000 ft·lbs, or more than enough to lift a 35 ton boiler to a height of five miles. Fireside (furnace) explosions may likewise release large quantities of energy and cause extensive physical damage.

Furnace Explosions:

Boiler operation involves both fuel firing and steam generation. Either of these can be hazardous if inadequate attention is paid to safety conditions. Air, fuel and ignition energy are the principal ingredients required for firing a furnace. But, with improper combination and timing, they can also cause an explosion.

Perhaps the most important point:

Before attempting to light any gas, fuel oil, or pulverized coal boiler the furnace must be purged of any ignitable vapor or dust by operating the combustion air fan(s) for a specified period of time.

Looking at History

History should teach us lessons, but often it doesn't. Immediately after an accident occurs we become safety conscious and even write new policies and procedures. However, as time passes we tend to forget. Often we revert back to our old ways simply because we have been doing it that way for years. That's when accidents can happen and its too late.

Times Have Changed

We have less:

1. People
2. Money
3. Time

Now we are expected to do more with less.

We now must justify and quantify every item.

We must plan and execute that plan to time tables.

We have to look at alternative ideas.

Where to look for help:

#1 - Look at the employees.

Trained personnel can make decisions, follow fault trees, conduct potential problem analysis, problem solving and troubleshooting. But to do so they need to know the fundamentals.

#2 - Look at ourselves.

As managers and make sure we understand the fundamentals as well.

Often if an incident does occur one of the first questions posed to the manager is; why wasn't that person properly trained?

How then can we look at the training issue and perhaps justify the cost?

Cost aside, human safety is our #1 concern!

From a purely financial perspective:

Look at the lost time of the equipment or product divided by the cost of training and we find that the training is a small fraction of the cost of a failure.

Now we will discuss why it is important as a owner/operator that maintenance technicians have an understanding while working on or operating facility boilers.

As owners or operators we often **assume** that the personnel have knowledge to operate and repair the equipment. The equipment could be a small package boiler located in a basement room of apartment house or a large system of boilers supplying steam to a process or heating or both.

Boilers come in all shapes and sizes.

They can operate with pressures from just above atmospheric pressure to hundreds of pounds pressure.

Operating temperatures may vary from 212ºF to more than 1000ºF.

Some systems operate at a single pressure and temperature.

More complex systems may operate with multiple pressures and temperatures.

What can we do?

As operators/owners we need to have a good understanding so we can insure that correct repairs are made to the equipment we operate and/or own.

Does this sound familiar?

I was having a small package boiler in an apartment house repaired, the repair technicians told me the flame was a little high but it was **ok**.

When I observed the flame, it was hitting directly on the heating surface of the boiler. When I questioned the technicians they assured me everything was fine. Their comment back to me was the water will just heat up faster. They were not aware the flame would damage the heating surface and eventually lead to a failure.

Improper training of repair technicians can lead to the use the wrong valves, material for repairs, or other components.

This can be very dangerous with respect to boiler’s operation and could create premature failure of boiler parts, steam lines, and equipment.

A Time BOMB?

Cast Iron Sectional Boiler


View from basement boiler room looking up through ceiling to 1st floor
5 9:24AM

The following is a sample check list you should go over before ever letting repair work start on your boiler:

Can the repair person access the area safely?

Is the area properly lit?

Are material improperly stored around the operating equipment?

Is material blocking access walkways?


Boiler Room Door

Is there a dead end that perhaps someone could walk down by mistake and become trapped?

Is there material sitting around the electrical access panels which could prevent quick access?

Are there combustibles stored area around the boiler?


EX

Notice The "Auto" Lighting Stick

Do maintenance and operations personnel have access to all equipment and the means for proper isolation for the equipment being repaired?

Are there hazardous substances surrounding the equipment or other components which require removal before work can be completed?

Does the rooms other safety equipment function as required? Has this equipment been tested lately?


GAS
GAS
GAS
HOT WATER RETURN
HOT WATER SUPPLY
HOT WATER RETURN
HOT WATER SUPPLY
KOHLER
KOHLER

Does everyone associated with the work process know a repair technician or technicians are going to be in the area working?

Before the repair technician starts their repair, do they know how to get in touch with emergency services should they be required?

Does everyone associated with the work process know a repair technician or technicians are going to be in the area working?

Do they properly isolate the equipment for repairs to be conducted?


MDB

These are only a few questions that should be asked but the list is by no means complete.

Perhaps is starts the thinking process about how we can prevent an accident or, worse yet, an explosion.

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For More Information or a copy of his presentation

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