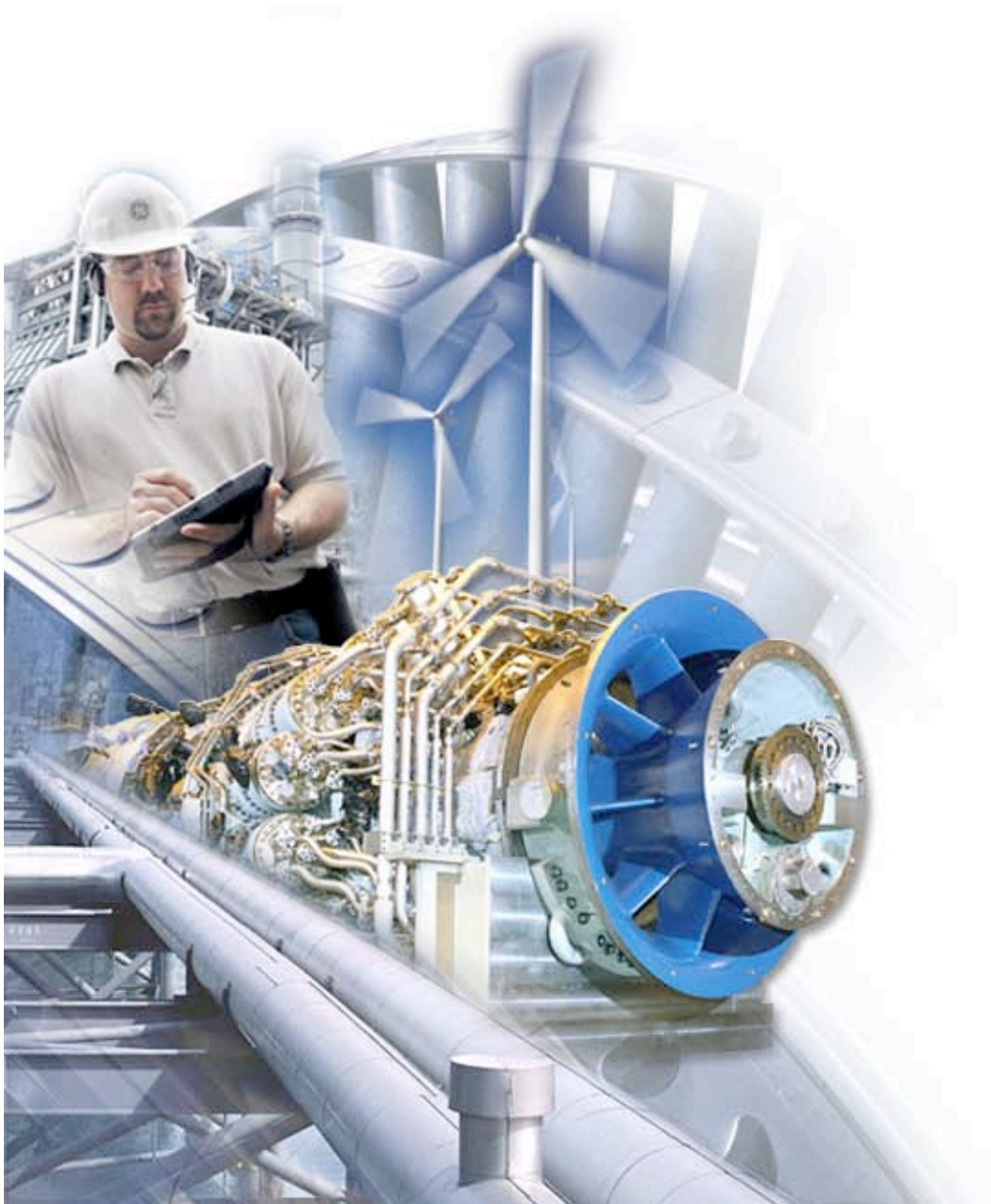


Heat Transfer Surface Cleaning



Bob Taylor

November 2005

Heat Transfer Surface Cleaning

- When coal is burned, a portion of the ash contained in the fuel will deposit on the boiler heat transfer surfaces.
- Two basic types of deposits are formed:
 - Slagging
 - Fouling
- Slagging occurs in the area of the boiler where radiant heating occurs; water walls, etc.
- Fouling occurs in the convection heat transfer section; superheater & reheater

Heat Transfer Surface Cleaning

- Chemical composition of the ash and the furnace temperature determine the slagging and fouling potential.
- The ash fusion temperature is an indication of the potential for slagging and fouling.
- Ash which melts at a relatively low temperature and remains sticky until impinging on the heat transfer surface create slag.
- Volatiles released from the ash which condense in the convection sections create fouling.

Heat Transfer Surface Cleaning

- Ash Fusion temperature is defined through a laboratory test.
- An ash sample is prepared from the coal supply
- The sample is pressed into a mold which creates a cone approximately $\frac{3}{4}$ inch tall.
- The sample is heated at an increasing rate, and the shape of the cone is observed.

Heat Transfer Surface Cleaning

- The four conditions observed are:
 - Initial deformation temperature – This is the furnace temperature at which the tip of the cone deforms.
 - Fusion temperature – This is the temperature at which the cone has deformed into a shape where the base and height are of equal dimensions.
 - Hemi spherical temperature – This is the temperature at which the height of the cone is equal to half the width of the base.
 - Fluid temperature – At this temperature, the cone has melted into a puddle no more than $1/16$ inch tall.

Heat Transfer Surface Cleaning

The ash fusion temperature is an indication of the ease with which deposits can be removed:

- If the initial ash deformation temperature is above the furnace temperature, deposits will be dry and relatively easy to remove.
- If the initial ash deformation temperature is below the deposits have a plastic consistency which adheres to heat transfer surfaces.
- If the heat transfer surface temperature is above the fluid temperature of the ash, the deposits will drip from the surface controlling the depth of the deposit.
- If the heat transfer surface temperature is between the hemispherical and initial deformation temperature of the ash, deposits will be difficult to remove and build in thickness.

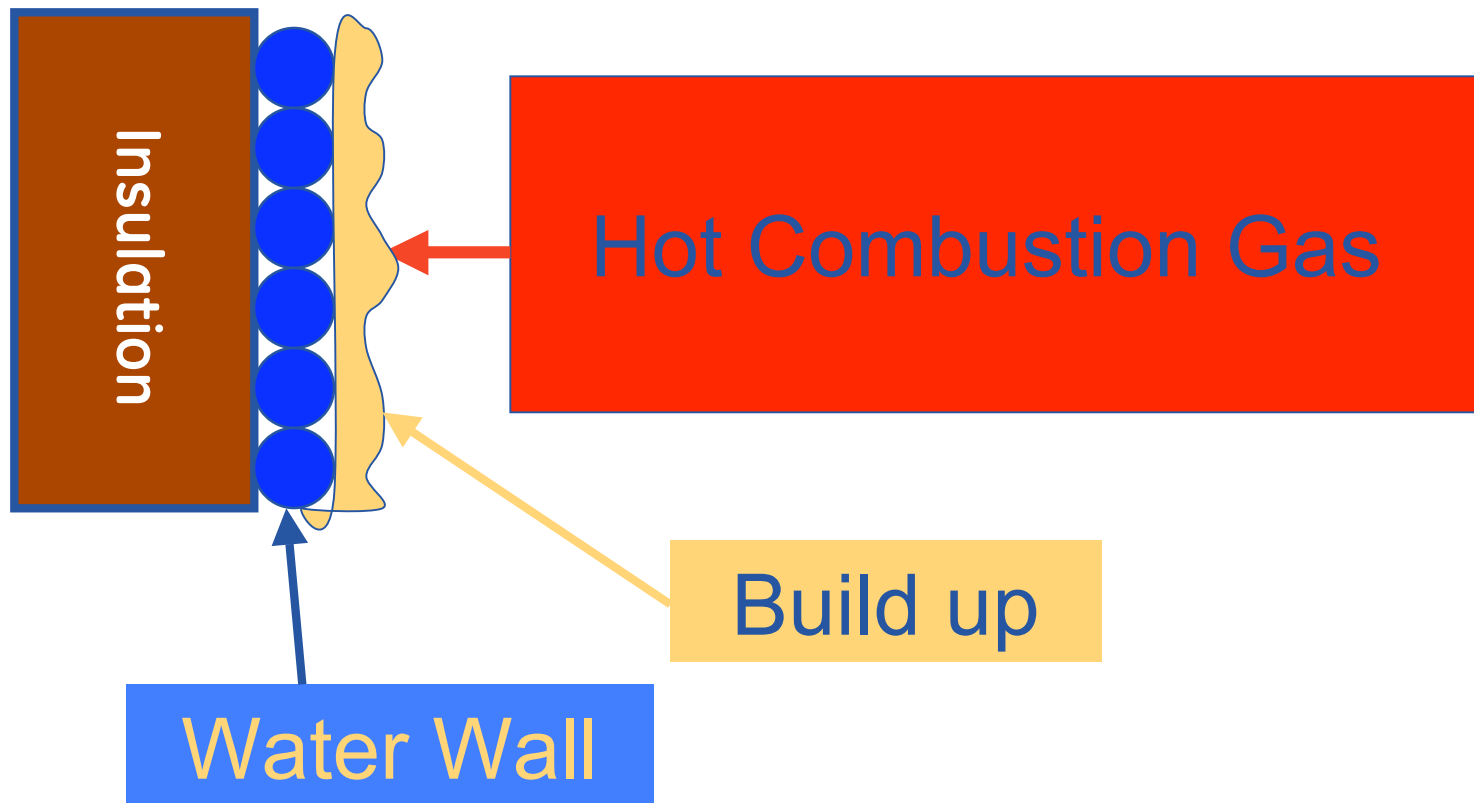
Heat Transfer Surface Cleaning

- As slagging increases, the furnace exit gas temperature will increase.
- Increased furnace temperatures will have the effect of decreasing the potential for fouling in the convection passes.
- Decreased furnace temperatures will have the effect of increasing the potential for fouling in the convection passes.

Heat Transfer Surface Cleaning

- The thermal efficiency of a boiler is directly related to the ability to transfer heat from the combustion products.
- As material builds up on the surface of the water walls and boiler tubes, heat transfer degrades.
- The material insulates the heat transfer surface.
- As a result of build up, furnace exit gas increases and more coal must be burned to achieve comparable output.

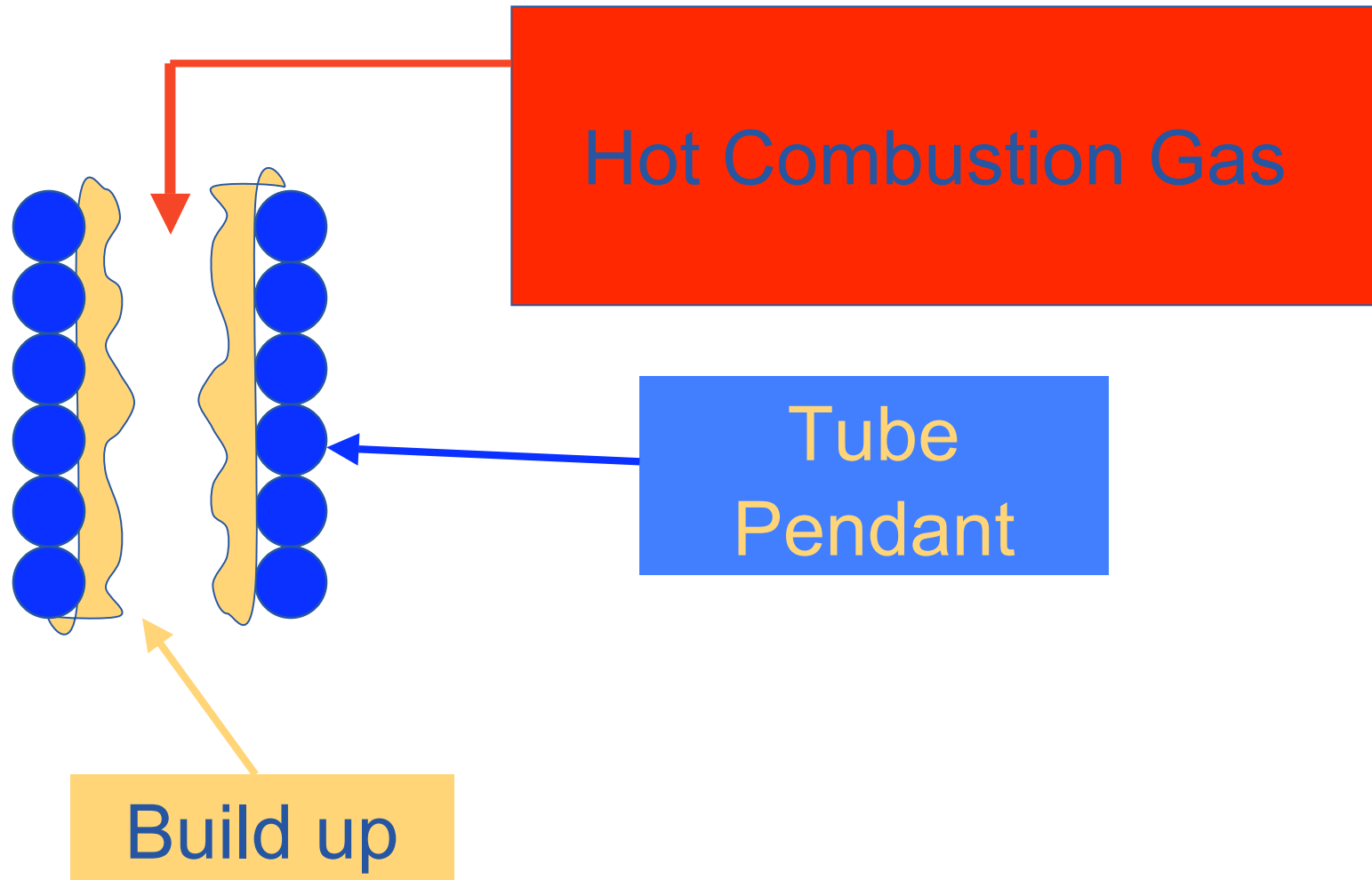
Heat Transfer System



Heat Transfer Passage Cleaning

- In addition to thermal losses, material build up causes increased pressure drop.
- When material builds up on the surface of pendant heat transfer sections, the passage width decreases.
- When passage width decreases, pressure drop through the boiler increases.

Heat Transfer System



Heat Transfer Surface Cleaning

- To maintain satisfactory thermal efficiency and pressure drop, it is necessary to periodically clean the heat transfer surfaces.
- There are multiple methods of cleaning heat transfer surfaces:
 - Soot blowers
 - Acoustic horns
 - Water cannons
 - Pulse Detonation
 - Dynamite blasting

Soot Blowers

- Soot blowers are the most common device used to clean heat transfer surfaces.
- Soot blowers can be fixed or retractable.
- The soot blowing cycle is initiated based on boiler draft loss and or furnace exit gas temperature.
- Changing gas temperature and increased dust burden affects the ESP operation.

Soot Blowers

- Soot blowers utilize steam, water, or compressed to impact the material build up.
- Superheated steam and compressed air are the most desirable cleaning media due to lower erosion potential.
- Steam and air may not be effective on plastic deposits.
- Water media can be effective on plastic deposits. To avoid thermal shock, water is injected only during the inbound pass.

Soot Blowers

- Soot blowers are relatively high capital cost items.
- Soot blowers are relatively high maintenance items.
- Steam and water impinging on the tubes can result in erosion.

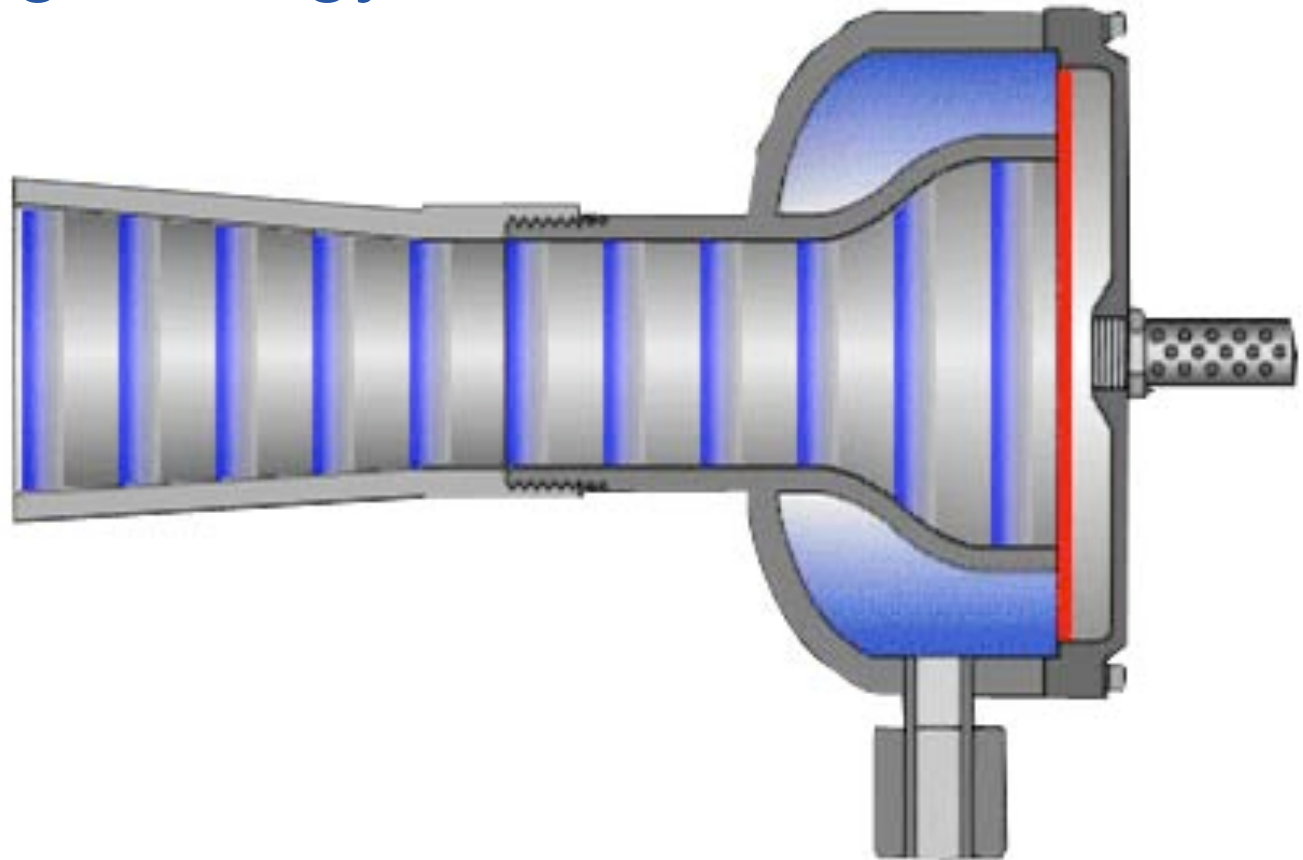
Acoustic Cleaning

Acoustic Cleaning is an alternative to some soot blower applications:

- Sound waves versus steam, air or water are used to clean heat transfer surfaces.
- Vibration versus impingement is the cleaning mechanism.
- As a result tube erosion is minimized.
- As with soot blowers, acoustic cleaning is not effective on plastic deposits.

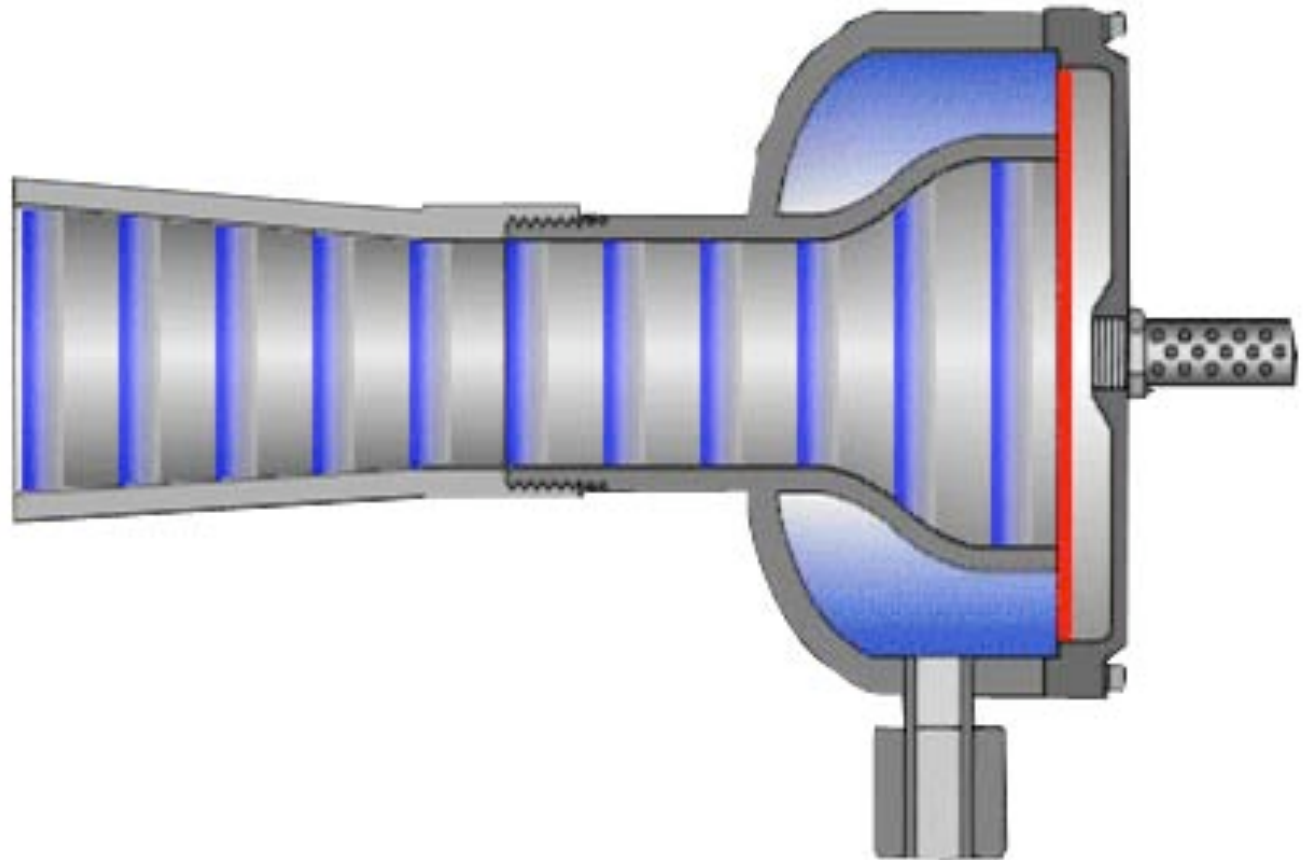
Acoustic Cleaners

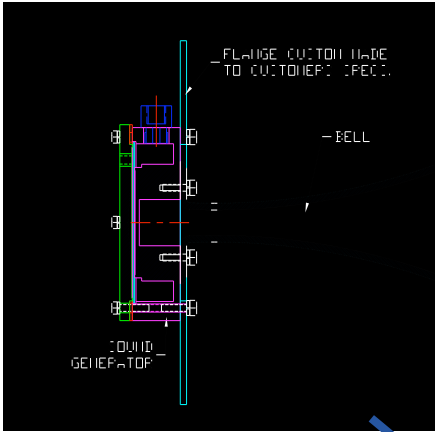
Air operated horns that produce low frequency, high energy sound waves.



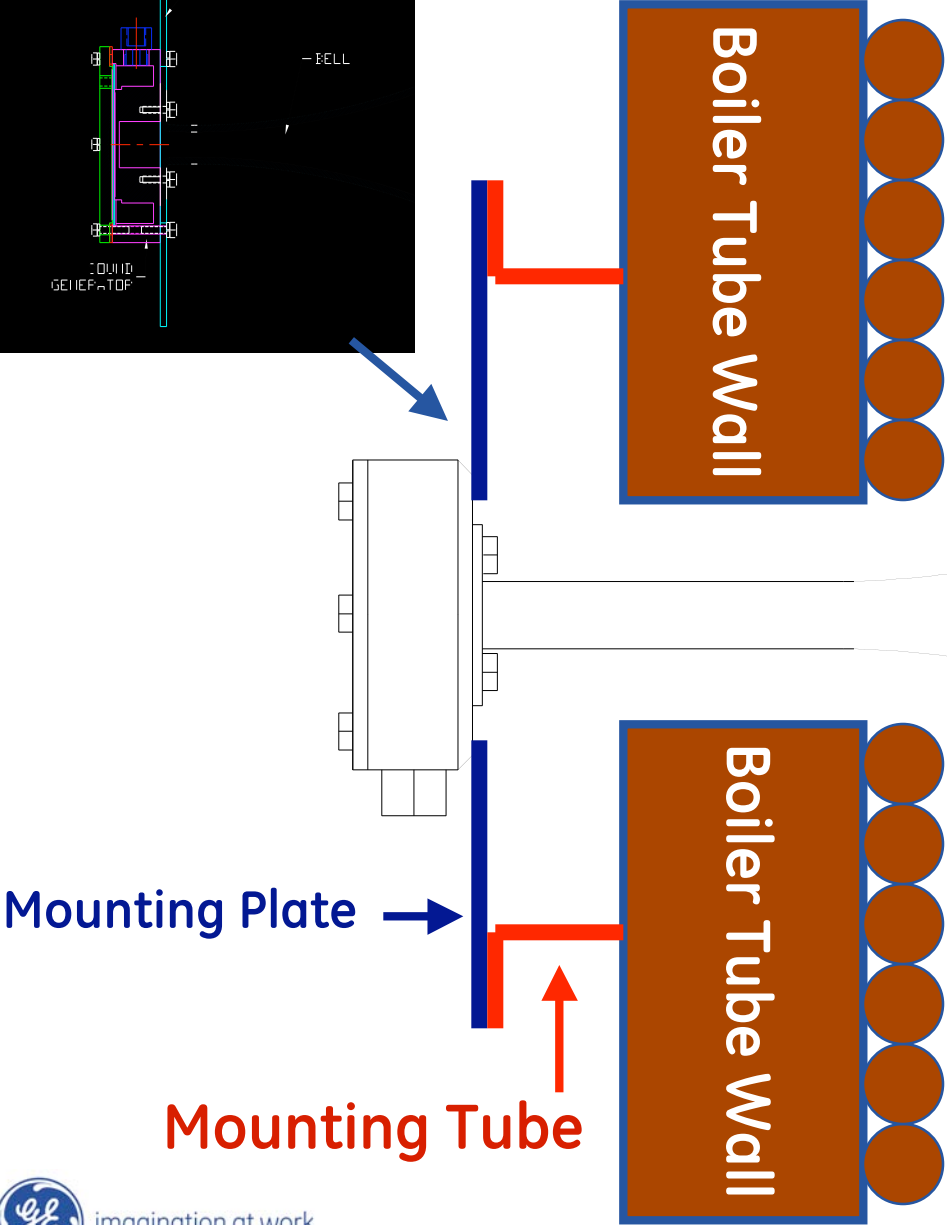
Acoustic Cleaners

The sound waves cause particulate deposits to resonate and dislodge from heat transfer surfaces.





Model D-230 1 Piece Bell



The bell of the acoustic cleaner is backed through a small opening. The opening can be as small as 4" (100 mm) I.D.

Powerwave[®] Acoustic Cleaners for Cleaning Heat Transfer Surfaces



Acoustic Cleaning

- Acoustic horns must be properly located to be effective.
- Potential for additional water penetrations to obtain suitable coverage.
- Acoustics can be operated more frequently compared to soot blowers without causing erosion.
- Operating and maintenance cost for an acoustic horn is low relative to soot blowers.

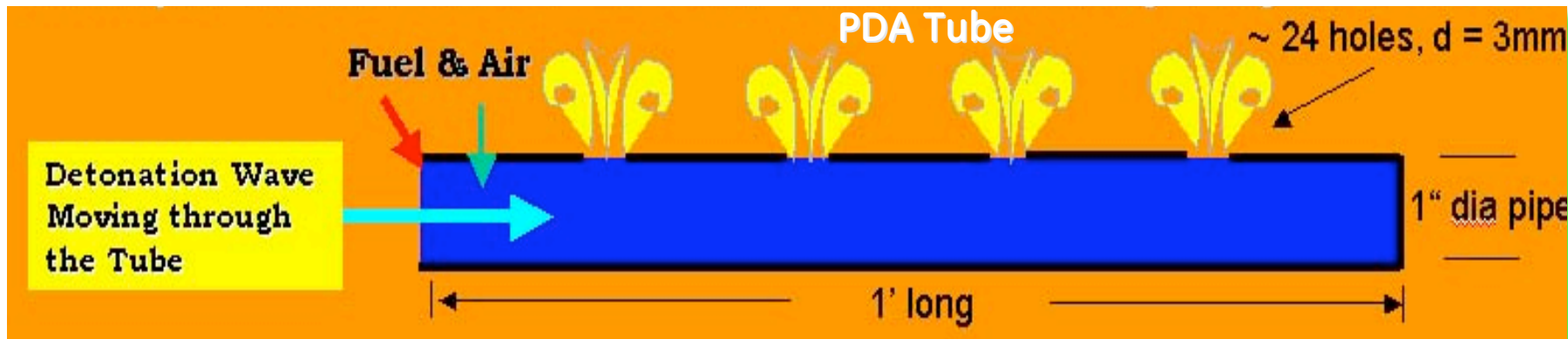
Dynamiting

- Dynamiting used to eliminate fused build up inside boilers.
- This is an extreme measure used to recover boiler performance.
- Small charges are placed strategically in the fused mass to “blast” them free of heat transfer surfaces.
- Large deposits at the top of the boiler can drop free and damage lower surfaces.

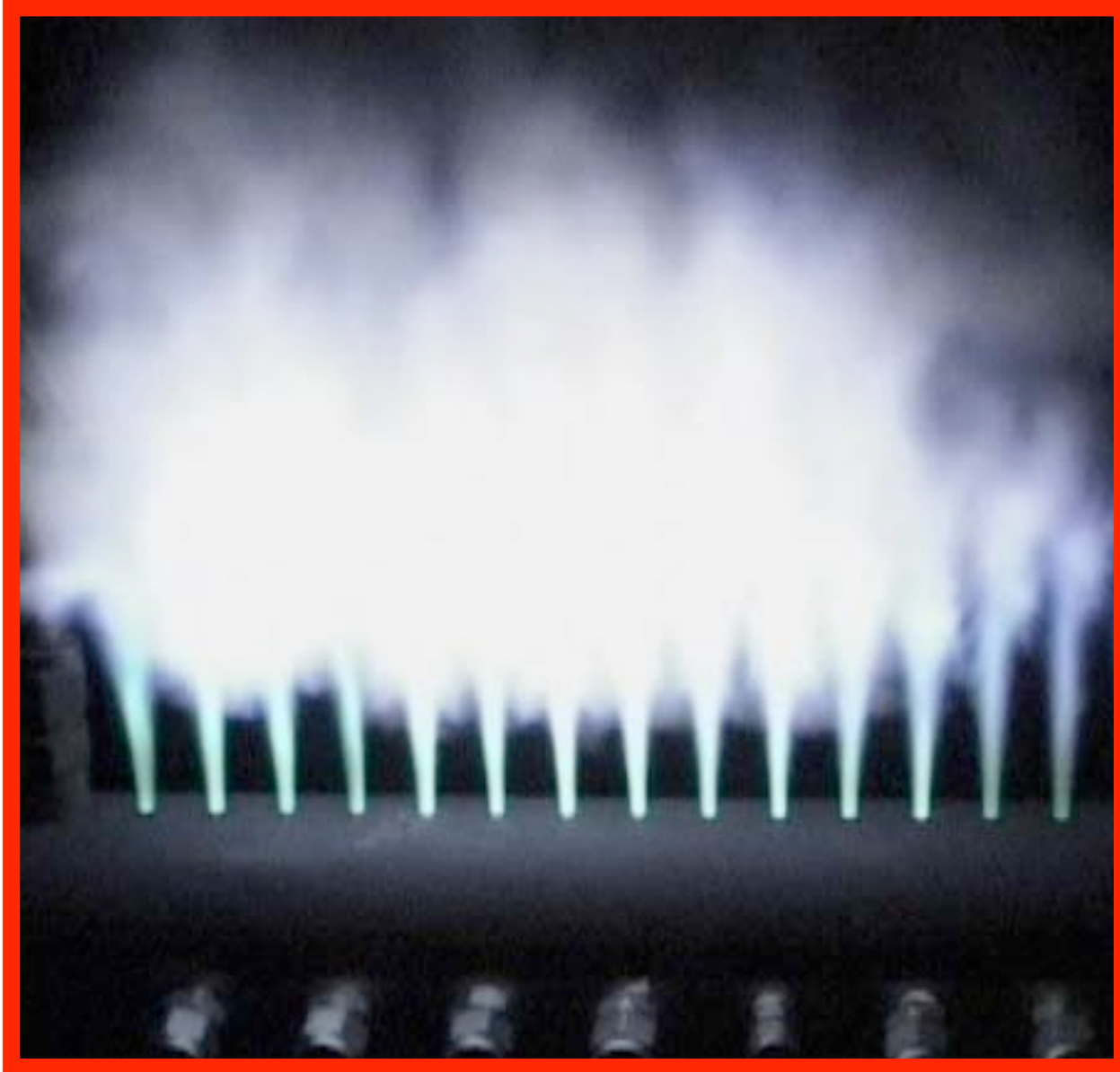
Pulse Detonation

- New technology intended to bridge the gap between soot blowers and dynamiting.
- Permanently installed devices utilized in a similar fashion to acoustics.
- Controlled detonations create shock waves which are transmitted into the boiler shell.
- Vibrations are the cleaning method.
- Test installations indicate effectiveness on plastic deposits without erosion associated with water blasting.

Pulse Detonation Actuator (PDA)



Pulse Detonation Actuator (PDA)



Pulse Detonation

- Additional demonstrations will occur in 2006 to commercialize the pulse detonation device.
- Current field data indicates the PD Device will provide improved cleaning ability without the maintenance costs associated with soot blowers.

Summary

- It is essential to keep heat transfer surfaces clean in a boiler.
- The correct pattern and sequence is site specific.
- Ash characteristics and furnace temperature will dictate potential for fouling and slagging.
- Soot blowers are the most common mechanism for accomplishing this.
- Acoustic horns can be effective cleaning non radiant sections of the boiler as well as air heater sections.
- Pulse detonation is a technology which will be available during the 2006 time frame.

