

# Furnace Erosion Presentation

**ChevronTexaco**  
**Pascagoula Refinery**

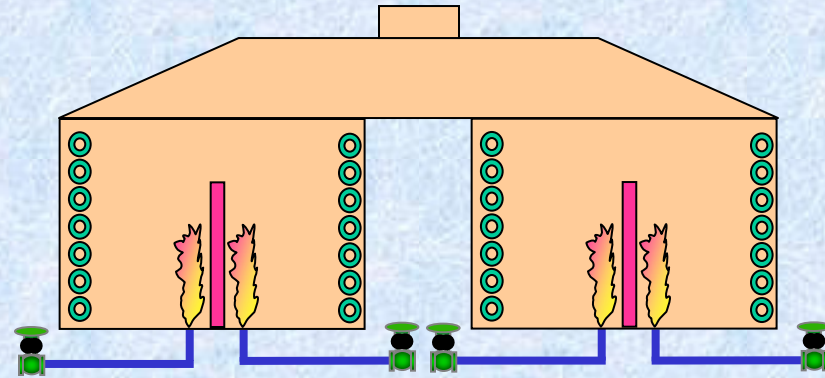


- **Furnace Process Design**
- **Furnace Cleaning Methods**
- **Furnace Erosion and Lessons Learned**
- **Furnace Outlet Thermowell Location and Lessons Learned**

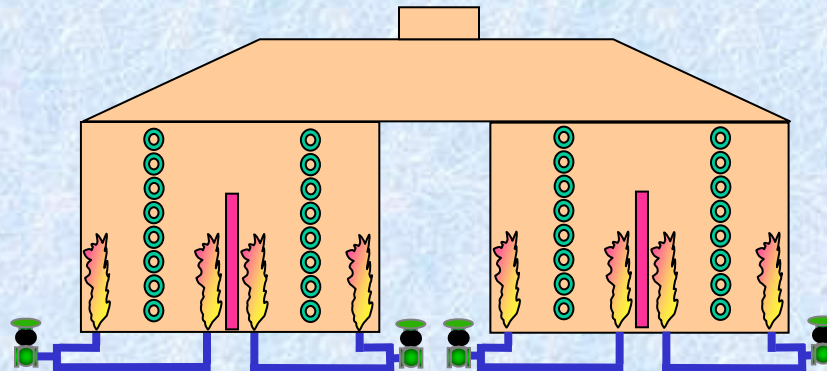
**Presenter: Les Osborne**

# Types Of Coker Furnaces

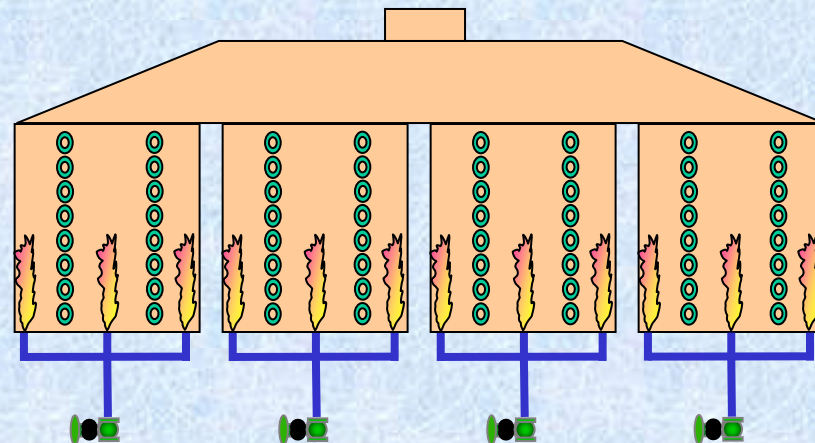
- **Single Fired**



- **Doubled Fired**



- **Triple Fired**



# **Common Factors For All Furnace Designs:**

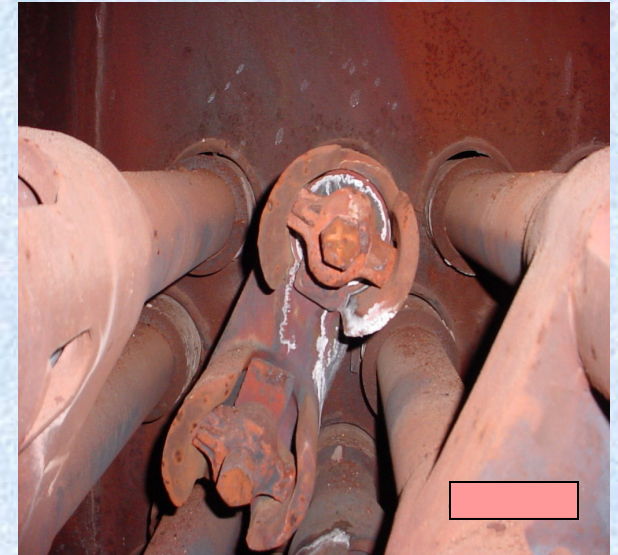
- Typical Outlet Temperatures 850-950 F.**
- Large Fuel Gas Consumers**
- Coke Fouling Impacts Performance and Efficiency**
- Coke Fouling Requires Periodic Cleaning**
- Today's Market Conditions Require Cokers To Feed Heavier, High Metal, High Sulfur Feeds To Be Profitable**
- Erosion affects Safety, Reliability, and Profitability**



# Furnace Designs

- **Mule Ears**

- A) Reliable Design- Erosion Resistant
- B) Cause High DP Across Furnace
- C) Subject To Leaking
- D) Easy To Access Furnace Tubes



- **U-Bends**

- A) Less Erosion Resistant
- B) Lower DP Across Furnace
- C) Do Not Leak
- D) Cannot Access Furnace Tubes



# **Current Methods To Remove Coke**

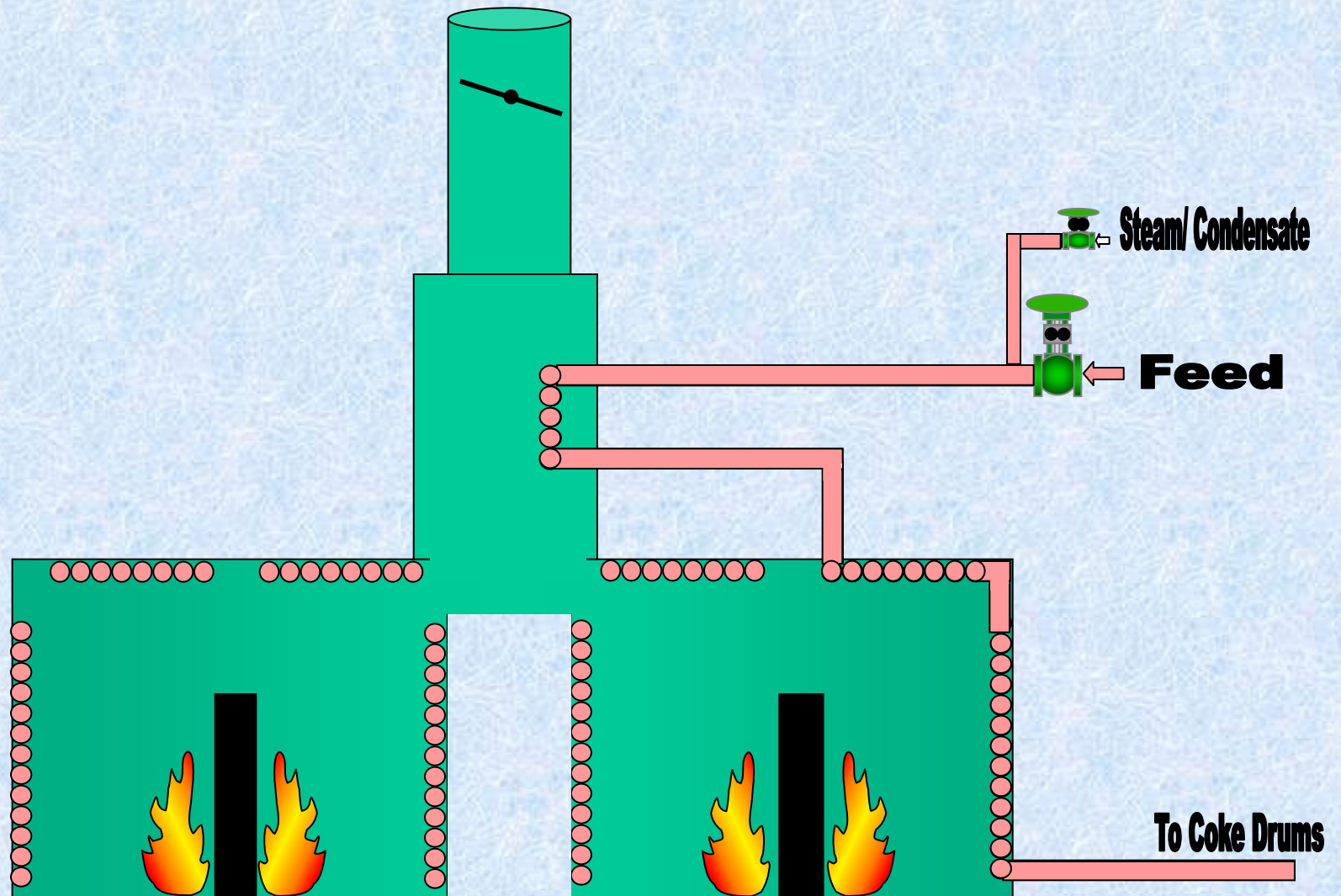
- **On-Line Cleaning:**
  - » **A) Spalling With Condensate Injection**
  - » **B) Spalling With Steam Injection**
  - » **Advantage- Minimum Feed Interruption**
  - » **Advantage- Increases Time Between Decokes**
  - » **Disadvantage- Increased Erosion**

# **Current Methods To Remove Coke**

- **Off- Line Cleaning**
  - » **A) Steam/ Air Decoke**
  - » **B) Pigging**
  - » **C) Steel Shot Circulation**
  - » **Advantage- Less Erosion**
  - » **Disadvantage- Usually Requires Outside Contractors**
  - » **Disadvantage- Loss of Feed Throughput During Procedure**



# Typical Single-Fired Coker Furnace





The diagram illustrates a cross-section of a header box area. A large, light blue rectangular region is labeled "Header Box Area". Inside this region, a bundle of tubes is shown. The tubes are represented by thick pink lines with black outlines. A U-tube bundle is the central feature, with its horizontal legs extending to the left and its curved section on the right. To the left of the U-tube, there are four vertical orange rectangular blocks, each positioned between the horizontal legs of the U-tube. To the right of the U-tube, there is a single vertical orange rectangular block. At the bottom of the header box area, there is a horizontal pink tube that extends to the right, passing through a vertical wall. This wall is represented by a thick black line. To the right of the wall, the tube continues horizontally. The tube has a flange-like structure at the wall, with several small black rectangular blocks on either side of the tube. The background of the entire diagram is a light blue textured pattern.

**Header Box Area**

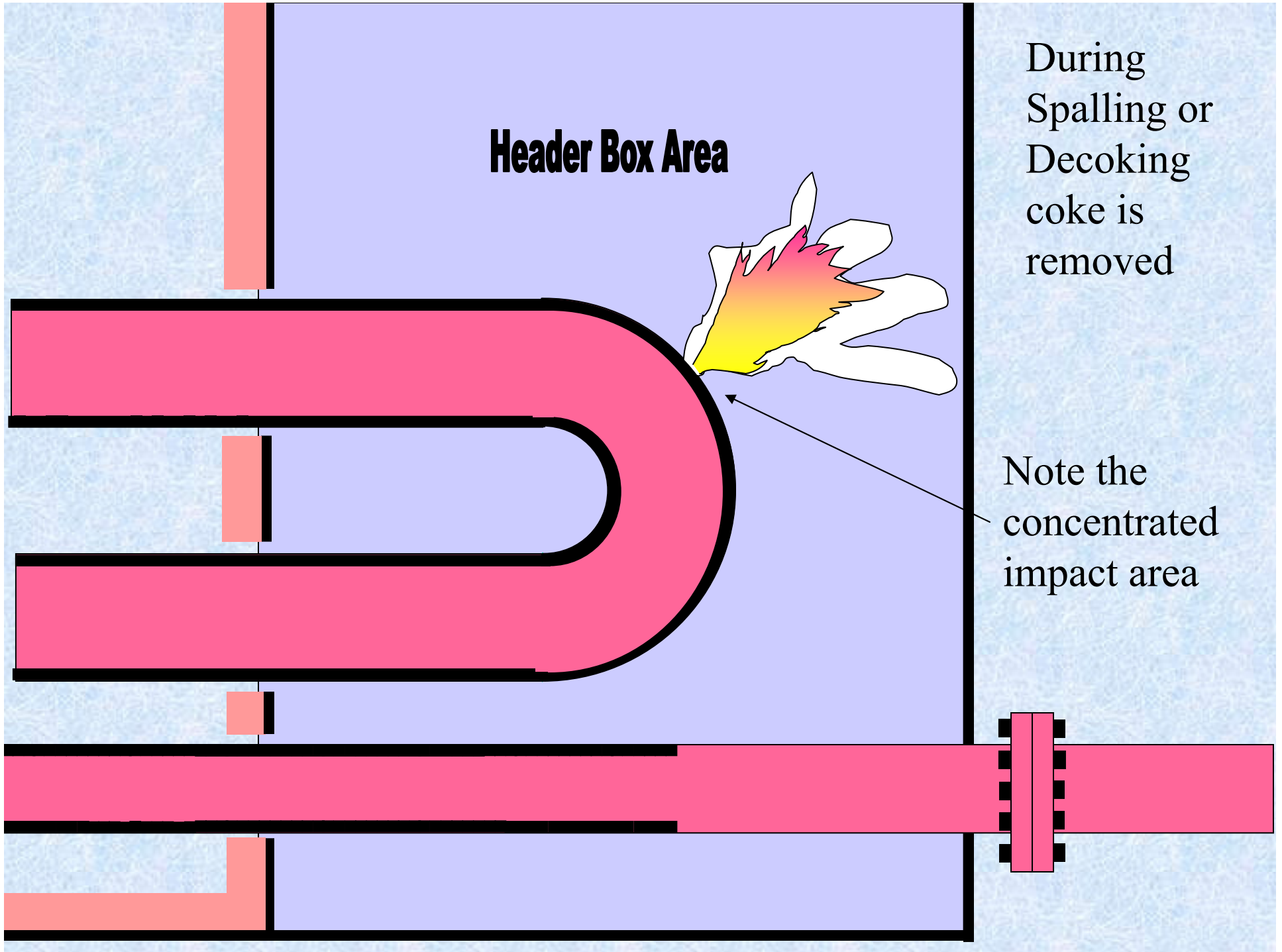
**During feeding, coke is being laid down on tube walls which insulates them, decreasing heat transfer**



**Header Box Area**

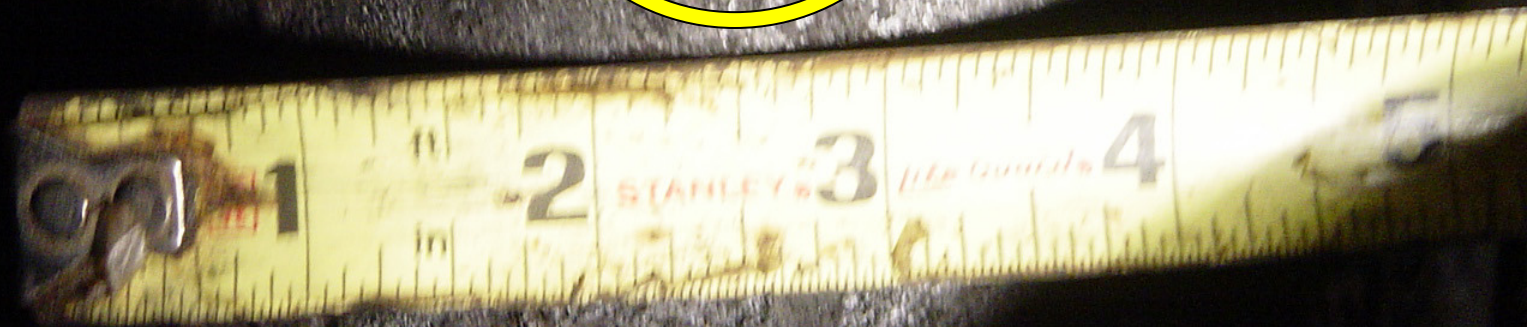
During  
Spalling or  
Decoking  
coke is  
removed

Note the  
concentrated  
impact area






Erosion Failure Area







Note the bulged area of  
the header box



Header box





**Note the severe sooting and build up on furnace tubes**

**Inside view  
of firebox**







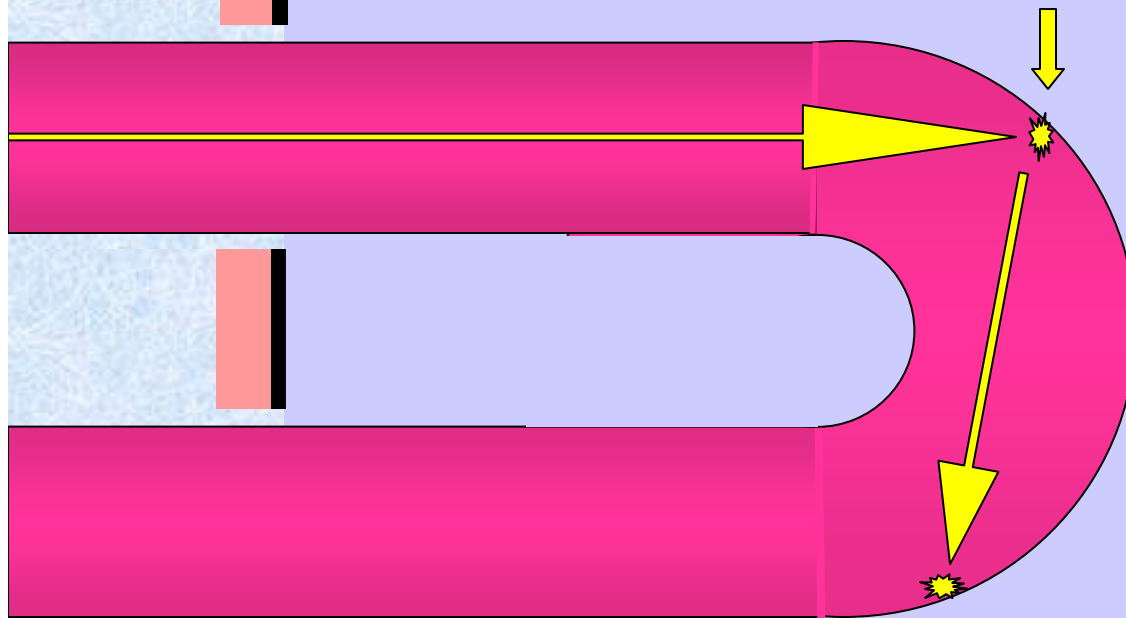
**Inside view of  
failed U-bend**



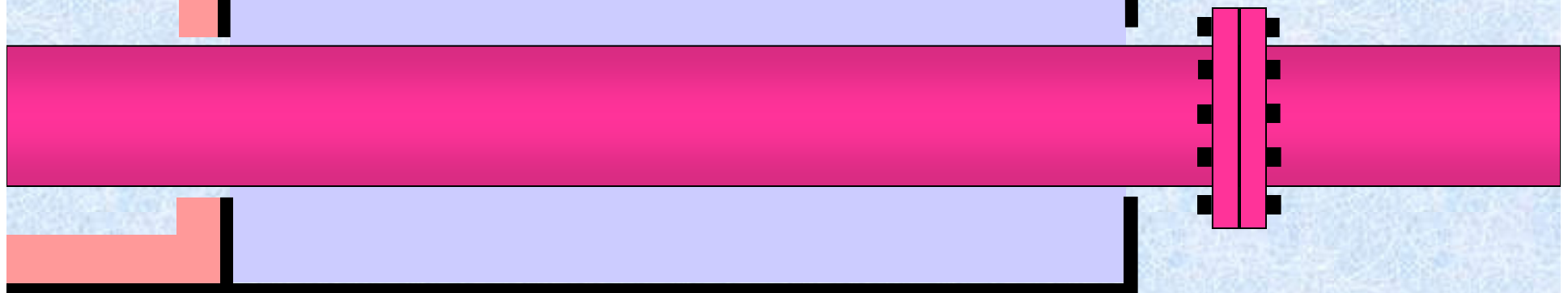
# New Lesson Learned

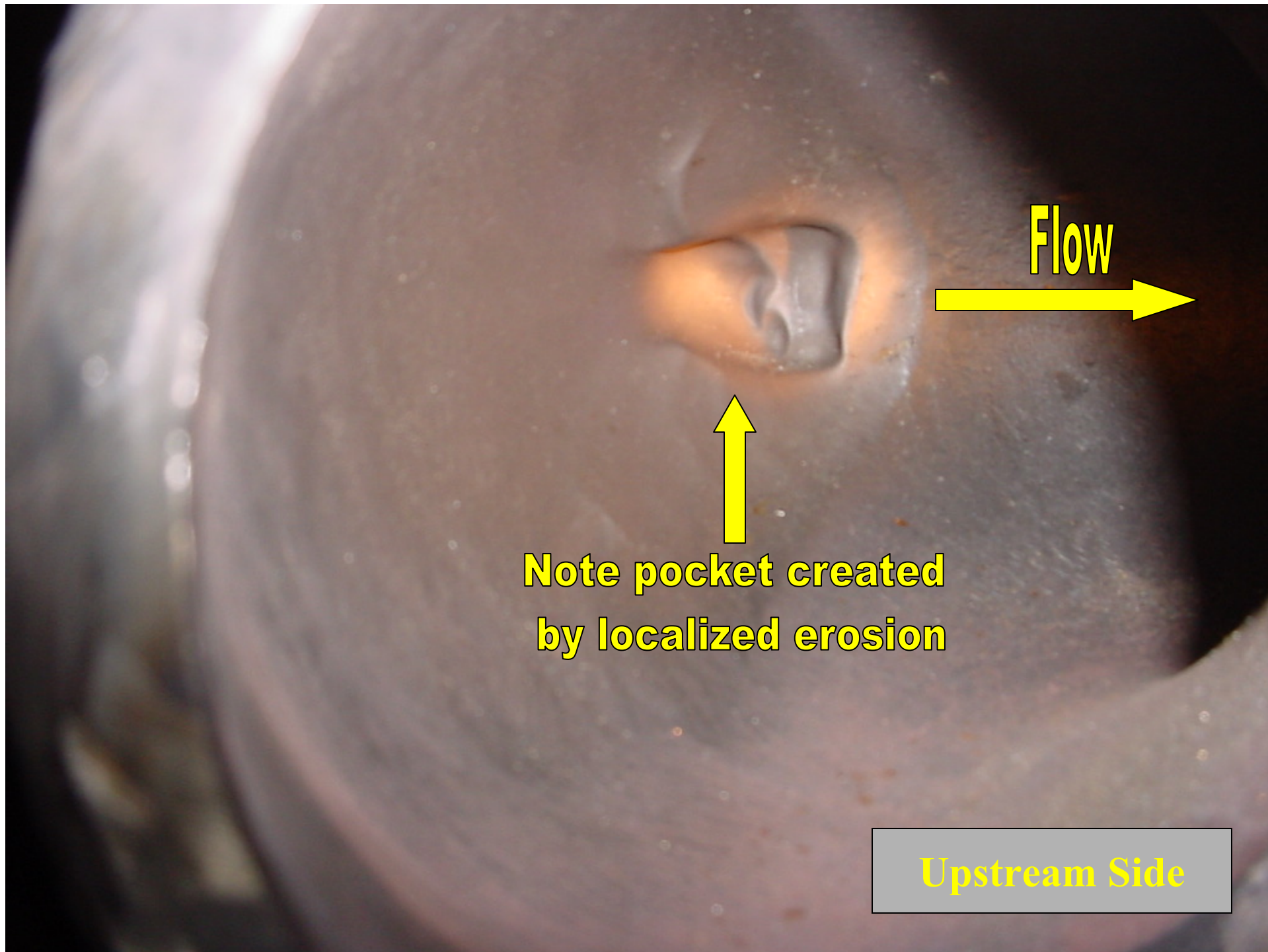
## Header Box Area

Specific impact erosion zone  
creates an intense jetting effect



*Coke that breaks loose from the tube walls during spalls/ decokes can accelerate to velocities of 200-500 ft/ per second before impacting the ends of the tubes due to the tube lengths in furnaces*



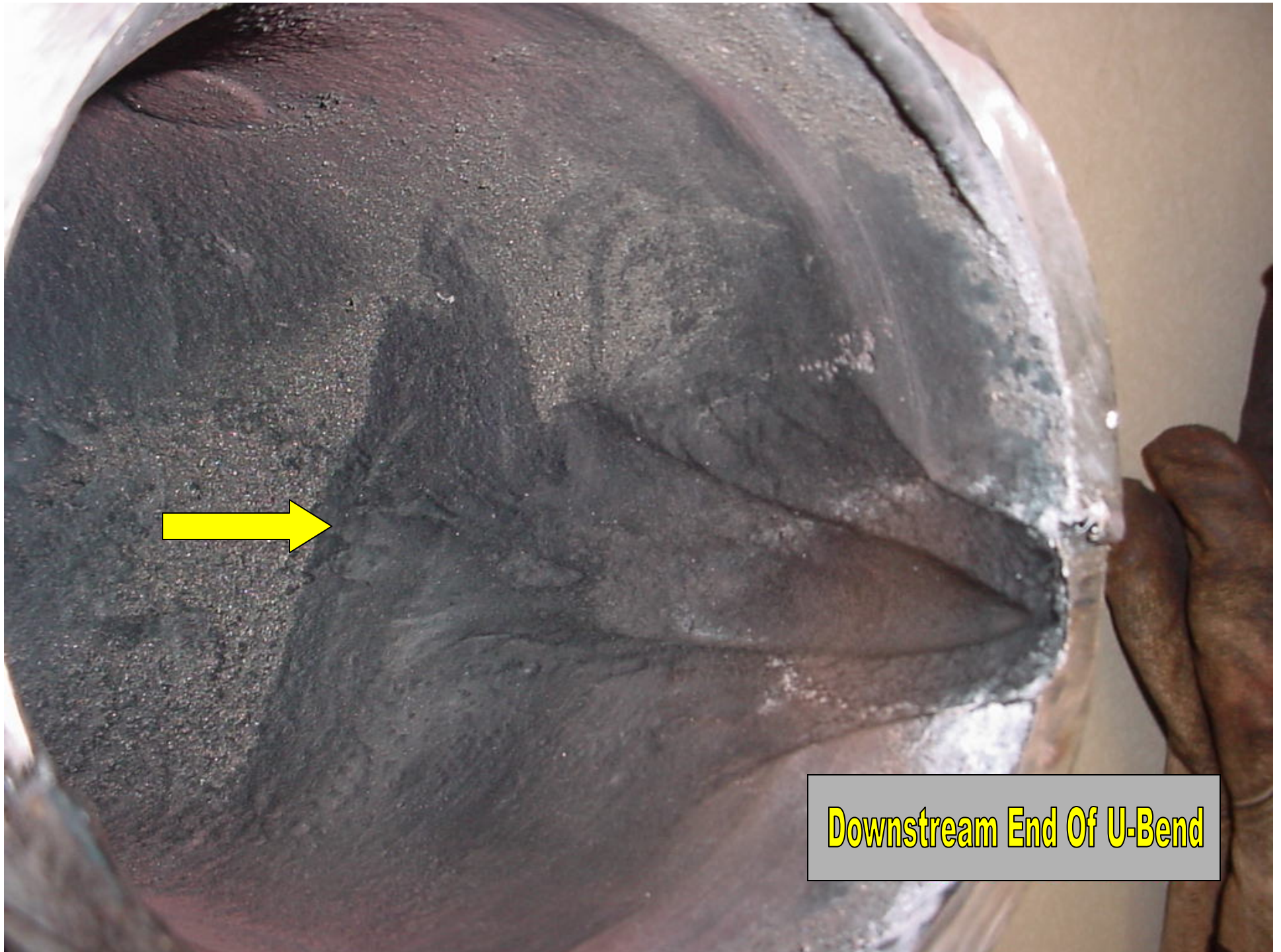


**Flow**

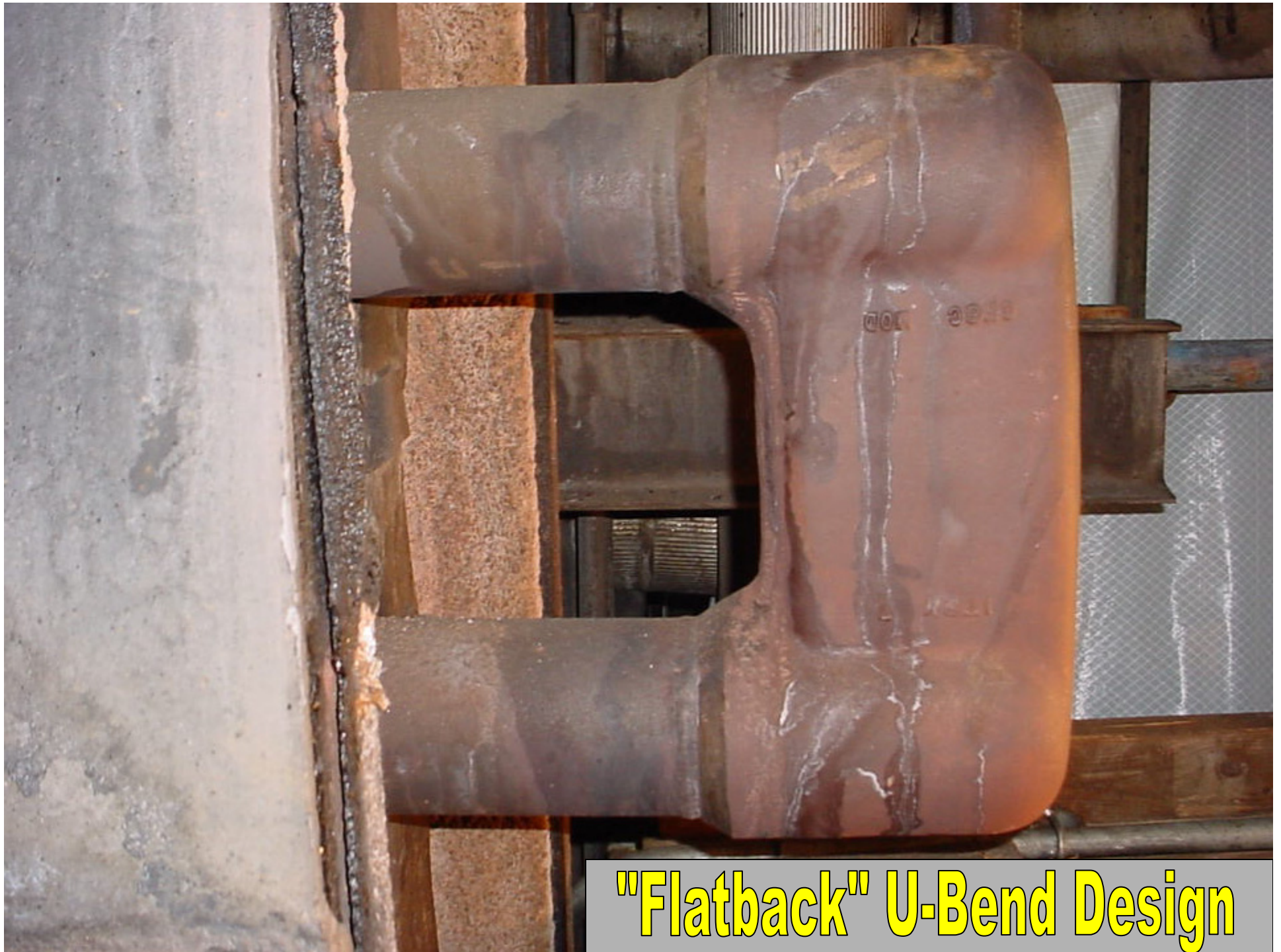
**Note pocket created  
by localized erosion**

**Upstream Side**

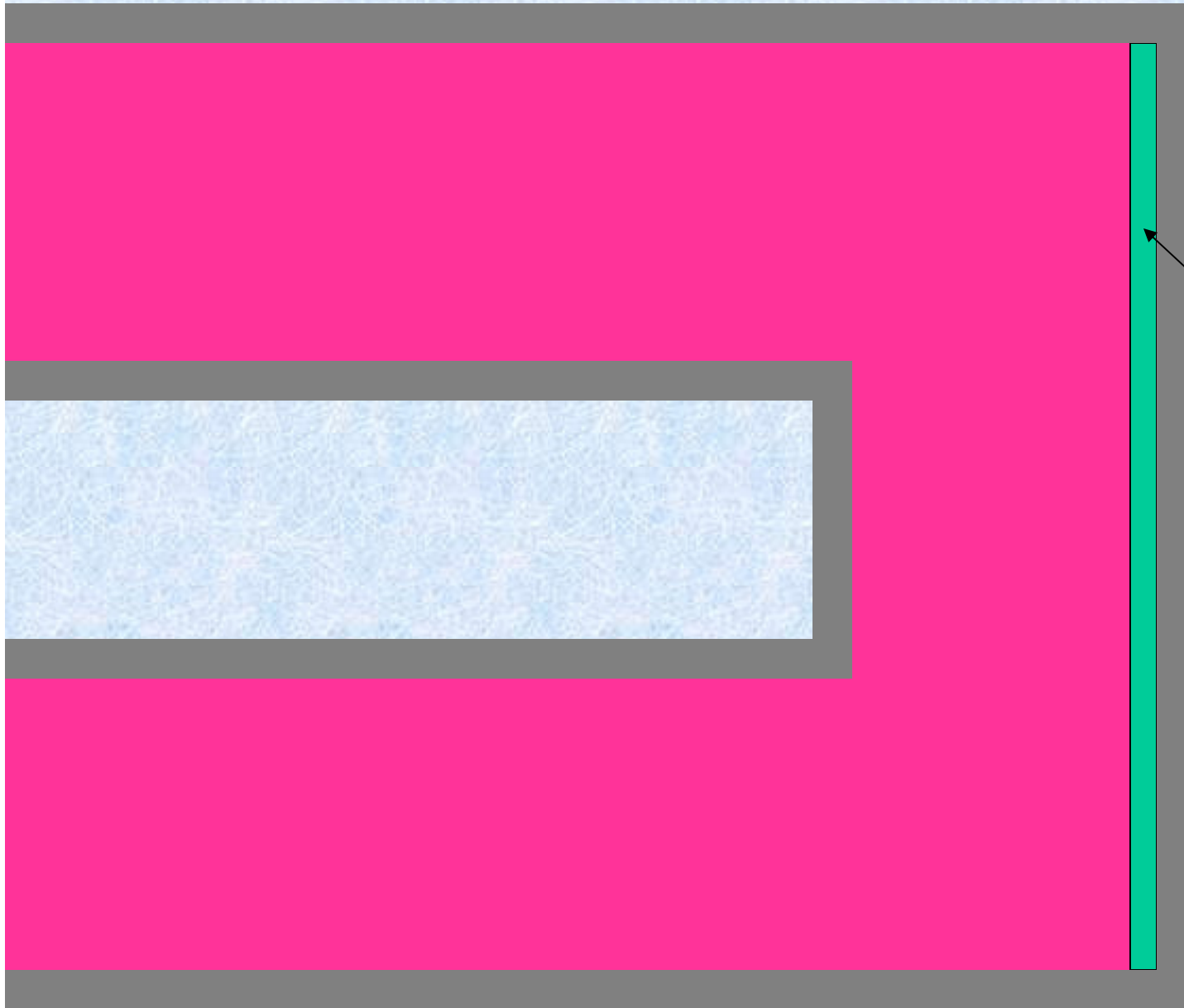








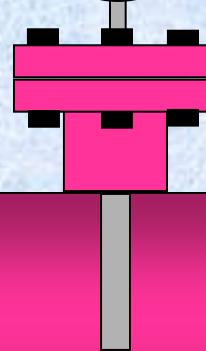
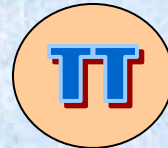
## Theory Behind “Flatback” Design



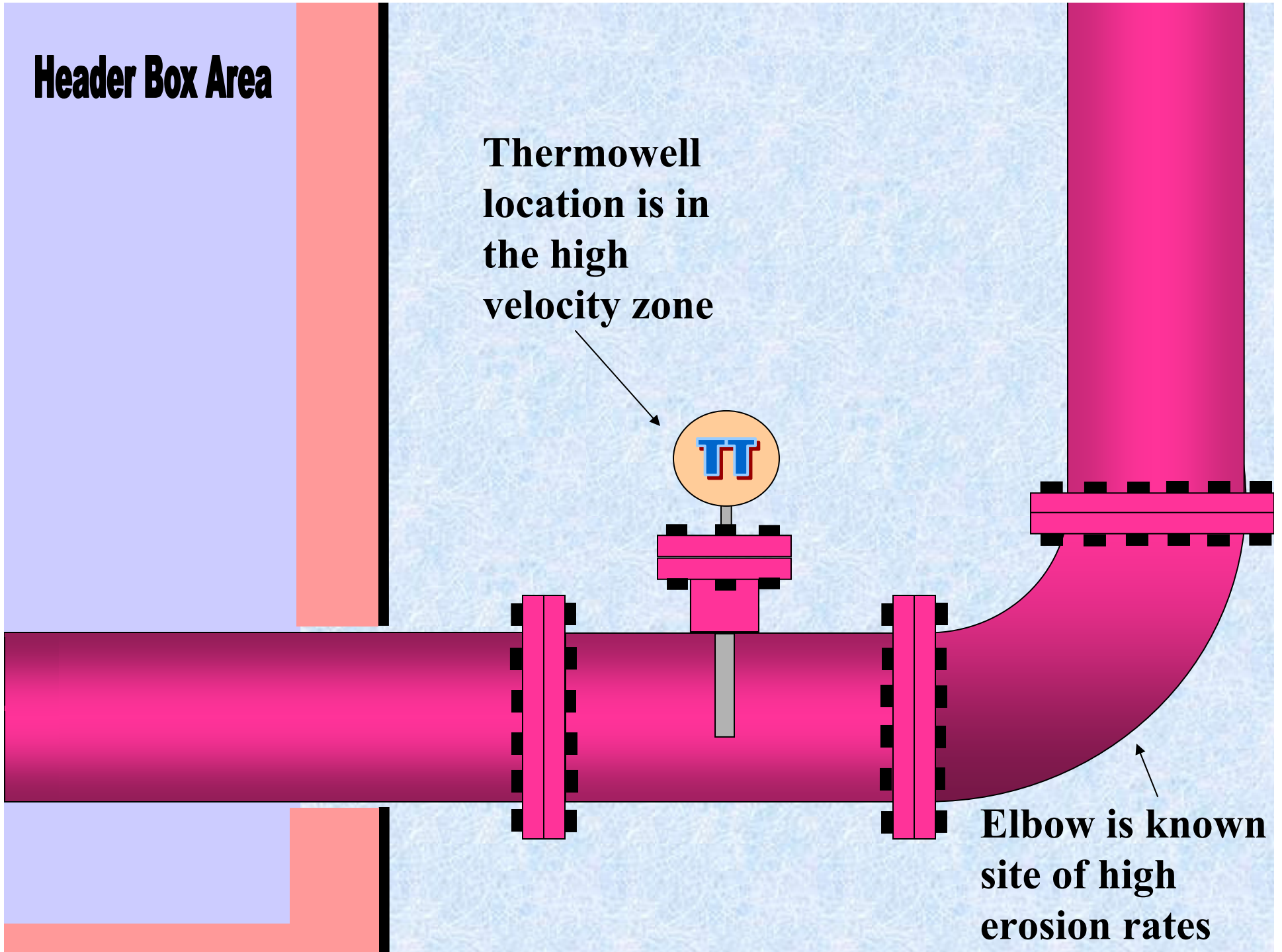
Green Area  
Denotes  
“Protective”  
Liquid Layer  
That Absorbs  
Impacts

**Header Box Area**

**Thermowell  
location is in  
the high  
velocity zone**



**Elbow is known  
site of high  
erosion rates**







Erosion has penetrated thermowell



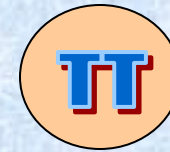


**Note penetration by erosion**

**Header Box Area**

# Lesson Learned

**Relocating the  
TW takes it out  
of the high  
velocity zone**



**Hardfaced or  
stellited elbow**





# Furnace Outlet Elbows

**Typical Outlet Elbow**



**Stellite Hardfaced Interior**





# Summary

- **Furnace Tube Lifespan:**
  - A) Erosion Monitoring
  - B) Creep/ End Of Life Analysis
- **U-Bend Design**
  - A) Type U-Bends
  - B) Erosion Monitoring
- **Outlet Thermowell Location**
  - A) Hardfacing
  - B) Relocate to Low Velocity Area
  - C) Erosion Monitoring/ Inspection
- **Outlet Piping/ Elbows**
  - A) Hardfacing
  - B) Metallurgy Research/ Review
  - C) Erosion Monitoring/ Inspection

# Conclusions

- **In normal furnace operation there is always a certain amount of erosion taking place.**
- **Spalling/ Decoking Procedures accelerate the erosion processes in the furnace due to the coke on the tube walls being stripped from the tube walls and those coke particles impacting areas downstream.**
- **Modifying your Spalling or Decoking procedures to reduce velocities can help to slow erosion process.**
- **Opportunity inspections with non-destructive monitoring techniques such as UT and X-ray can determine erosion rate if baseline thicknesses were taken at beginning of service life.**
- **Improving furnace design can help control and minimize the erosion rates.**