

REINHOLD ENVIRONMENTAL Ltd.



2010 APC Round Table & Expo Presentation

July 18-20, 2010, in Concord, NC / Hosted by Duke Energy

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APC and AIR HEATERS





AIRHEATER CLEANLINESS

**EFFECTS ON APC
PERFORMANCE**

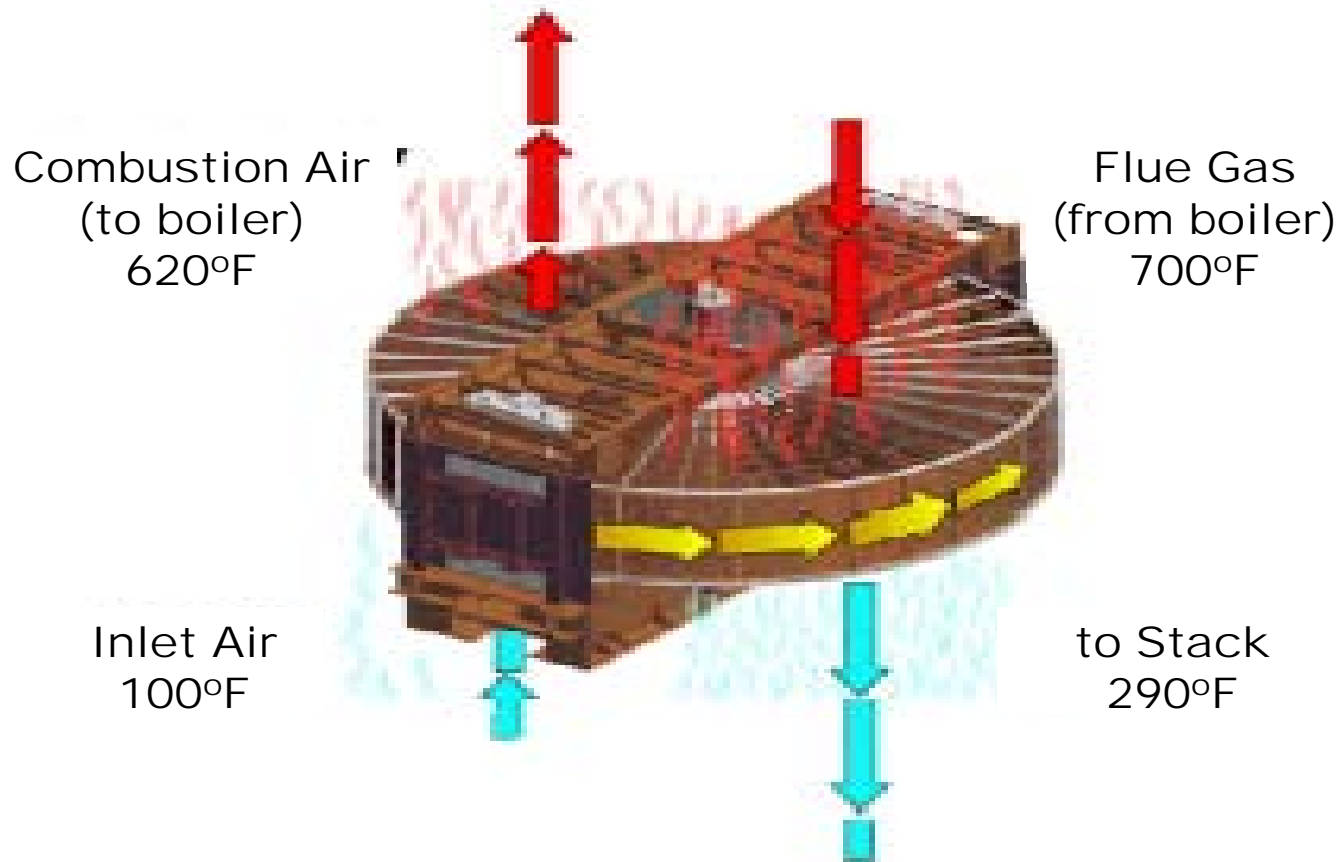
PROBLEMS AND SOLUTIONS

JOHN GUFFRE

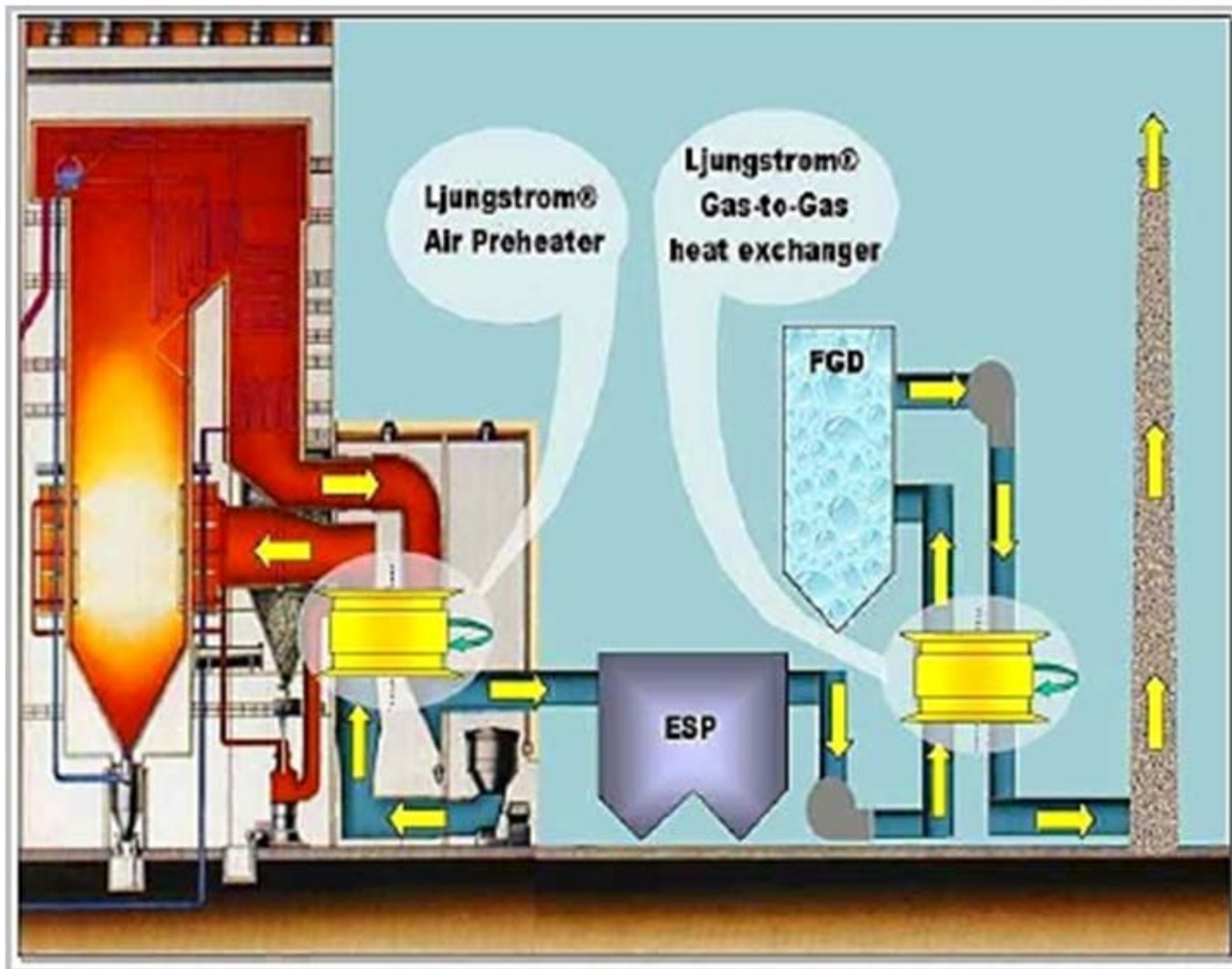
*Paragon Air Heater Technologies
23143 Temescal Canyon Road
Corona, CA 92883
951-277-8035
JGuffre@paragonairheater.com
www.paragonairheater.com*

TOPICS

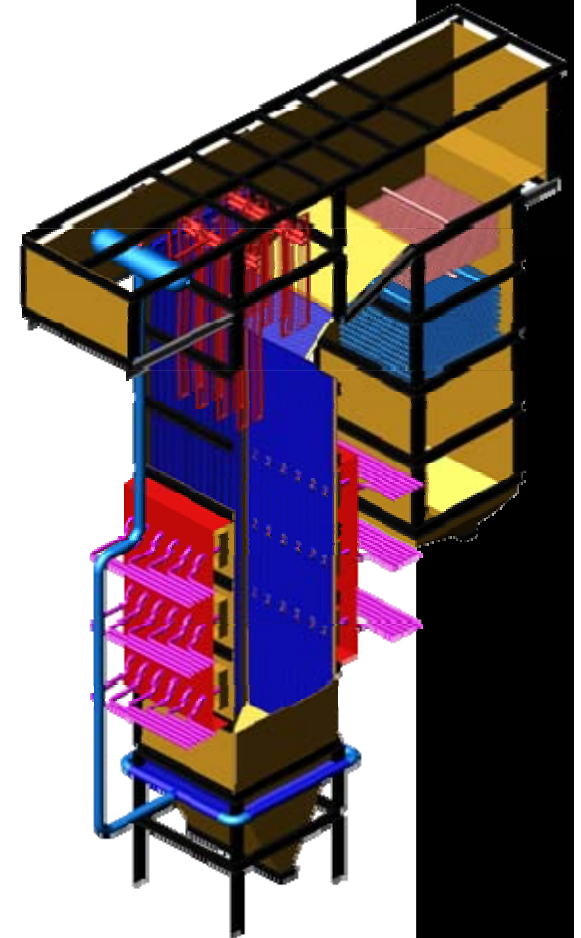
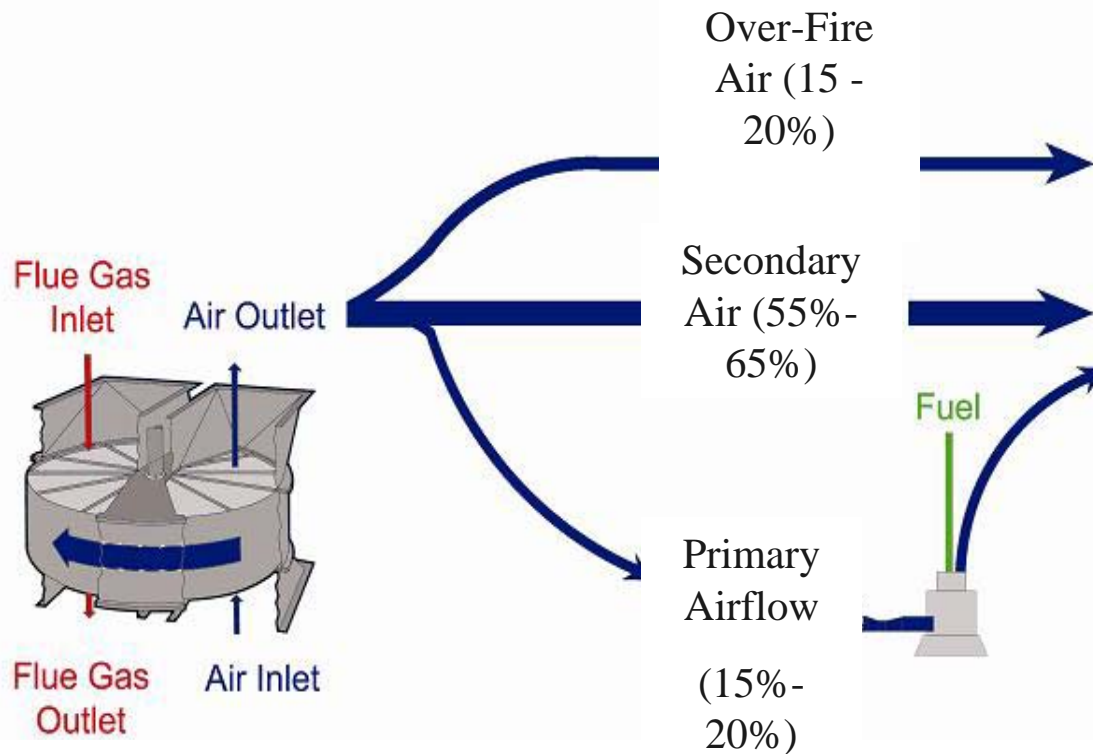
- **BASIC AIR HEATER CONCEPTS**
- **EFFECT OF THE AIR HEATER ON APC EQUIPMENT**
- **ABS FOULING AND ESP'S**
- **CURRENT APPROACHES TO AIR HEATER/ABS FOULING**
- **NEWEST SOLUTIONS**



10% to 12% of PLANT HEAT RATE



AIR HEATER AIRFLOW DISTRIBUTION



WHO OWNS THE AIR HEATER?

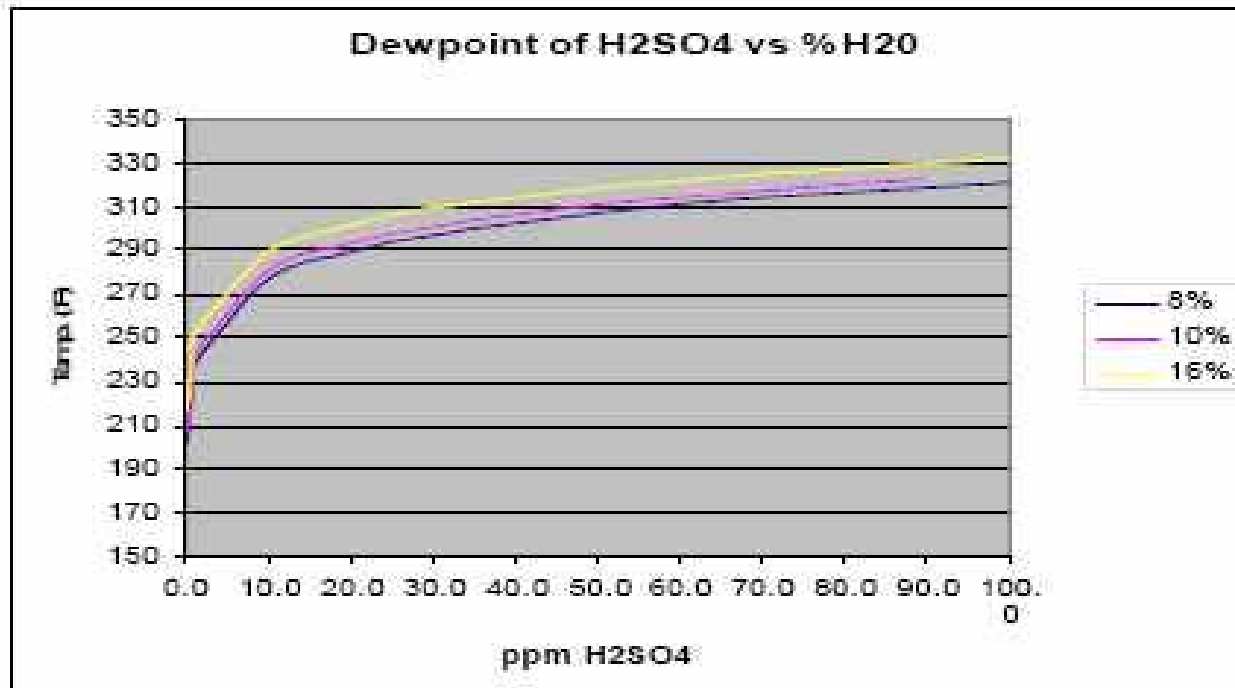
- BOILER ENGINEER?
- APC ENGINEER?
- AIR HEATER SPECIALIST?
- HEAT RATE SPECIALIST?
- **NO ONE?**

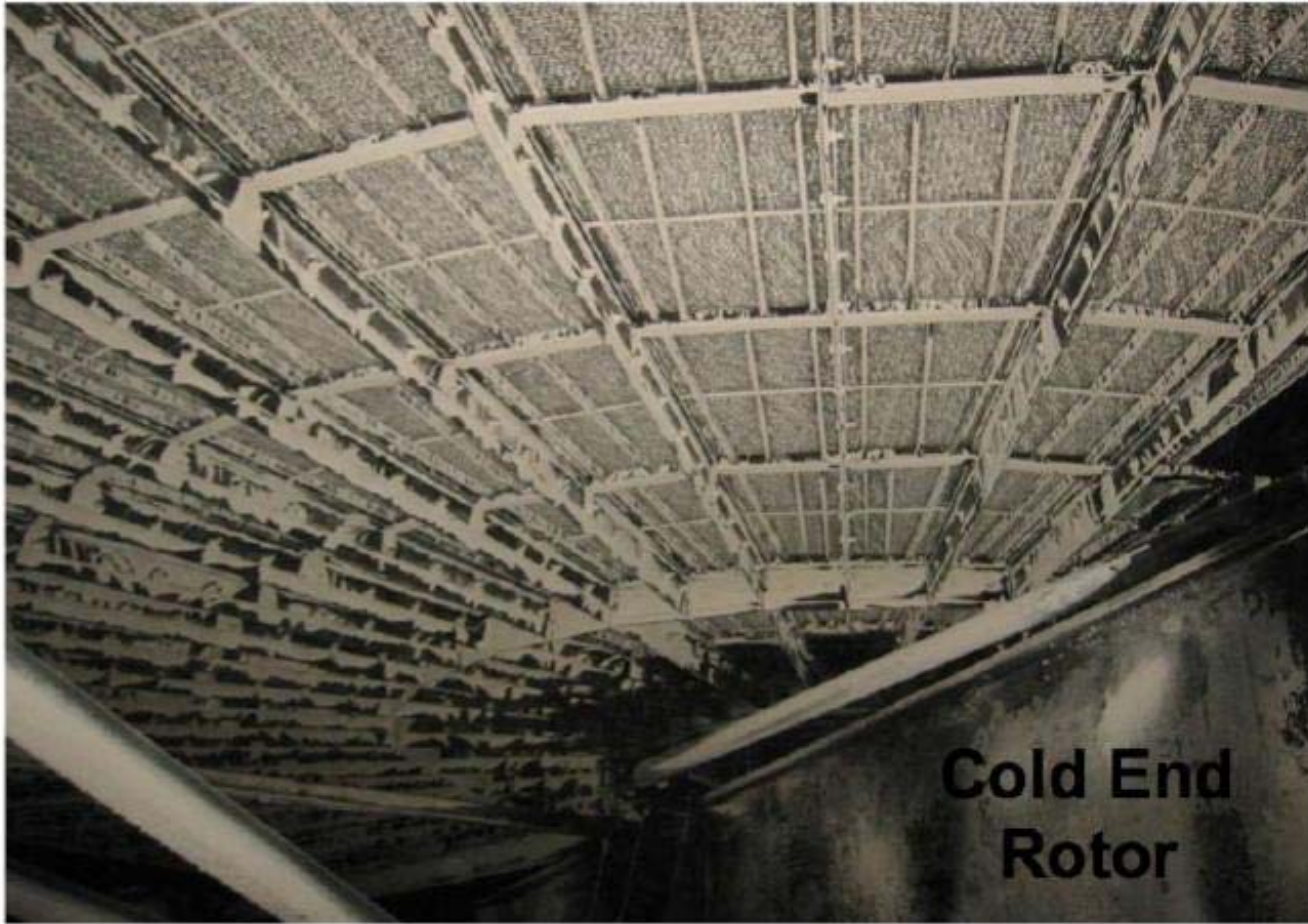
MINIMIZE GAS OUTLET TEMPERATURE

-20F = - 3% FLOW

-20F = + 1/2% EFFICIENCY

-20F = - \$400,000/yr COAL





CONDENSATION DEPOSITS



TWO ABS ELEMENT STYLES

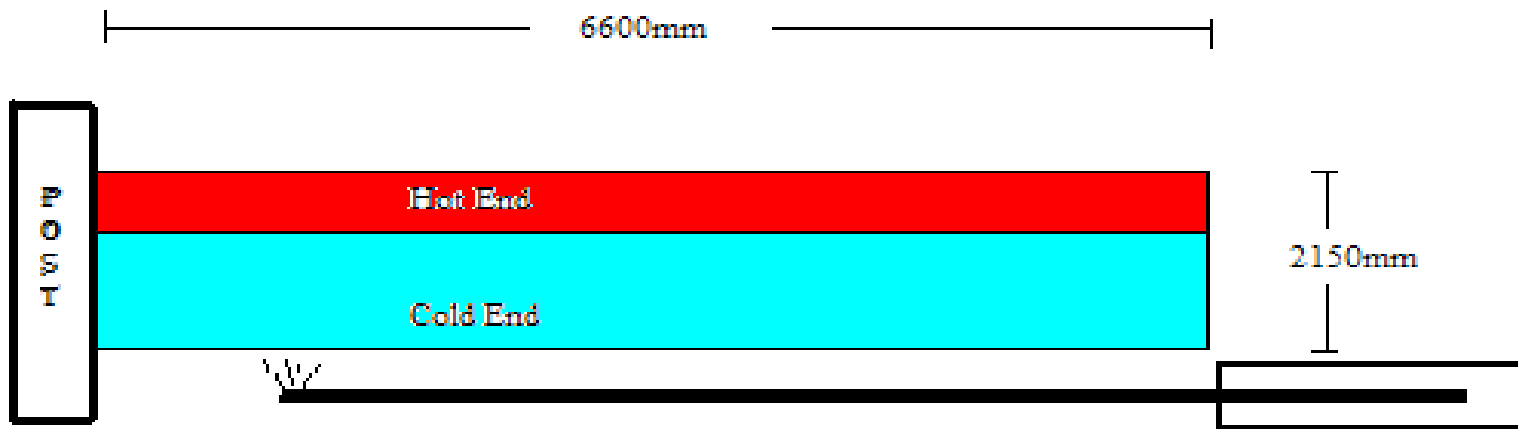


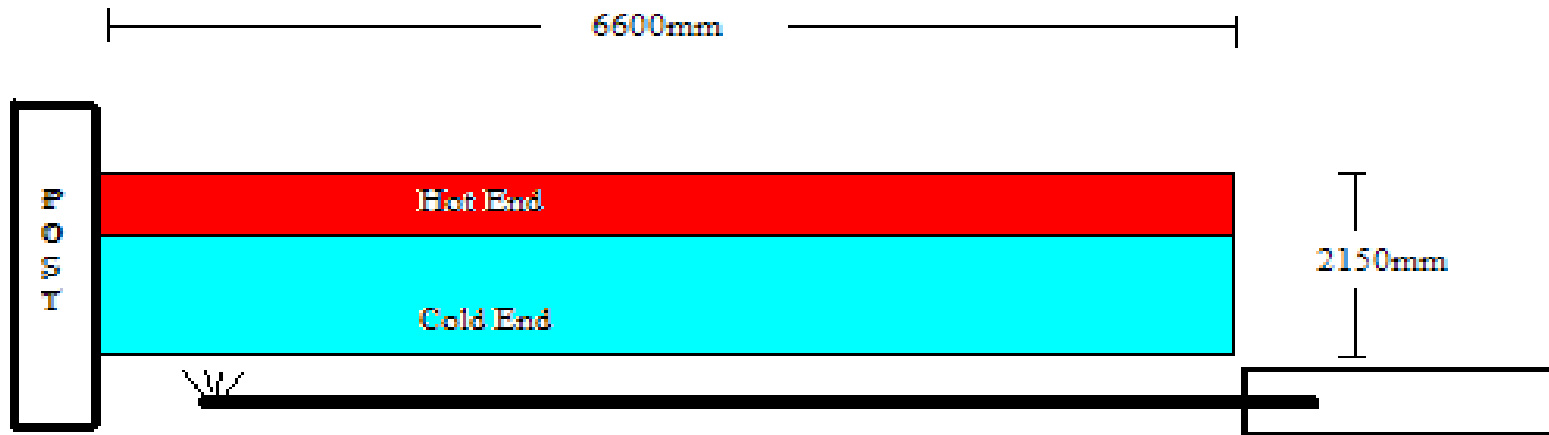


SWING ARM AH SOOT BLOWER







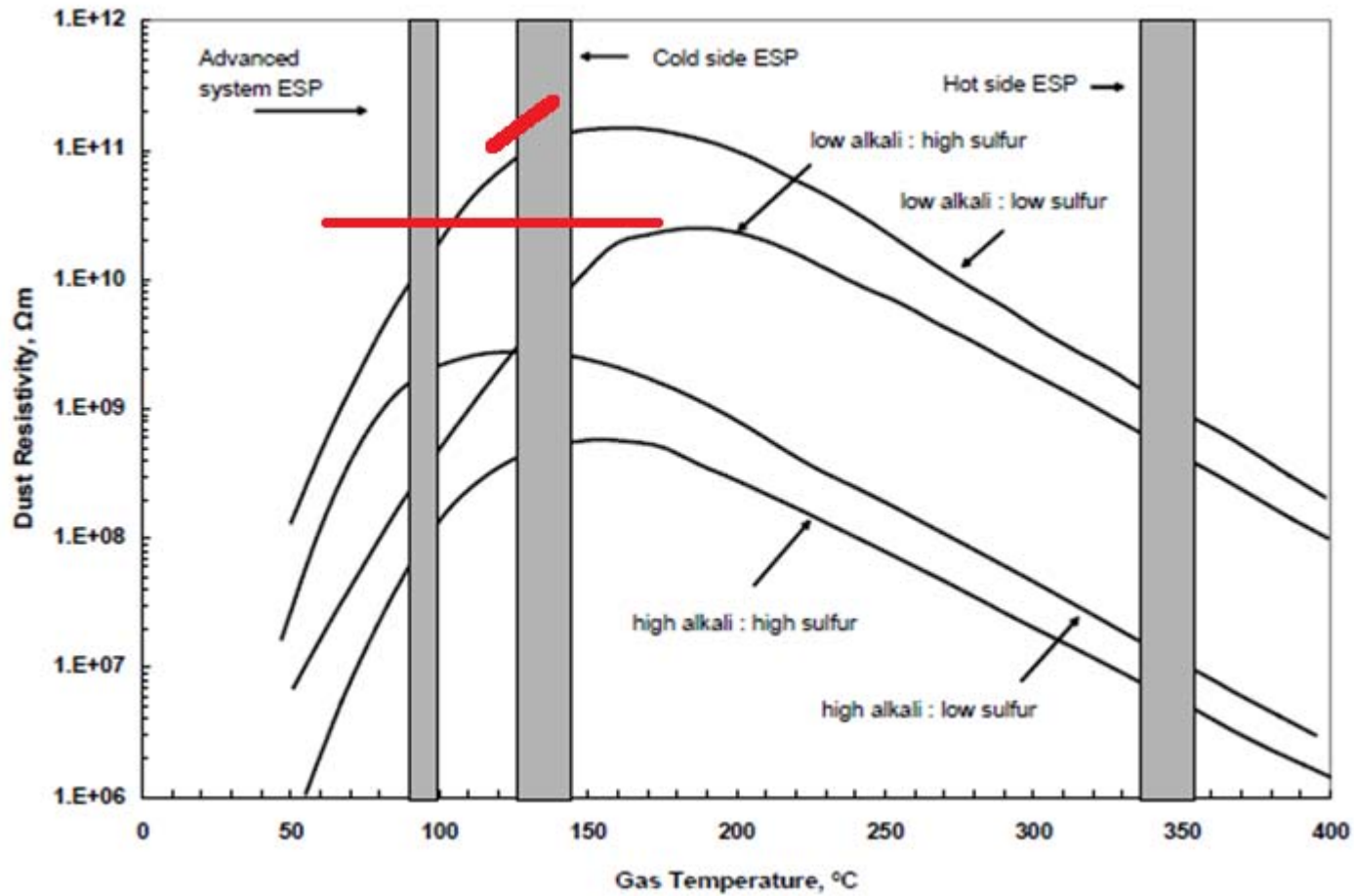


AIRHEATER CLEANLINESS

APC EFFECTS

- **FLYASH RESISTIVITY**
- **FLOW VOLUME - SCA**
- **PRESSURE DROP – BAG LIFE**
- **OUTAGES FOR WASHING - ABS**

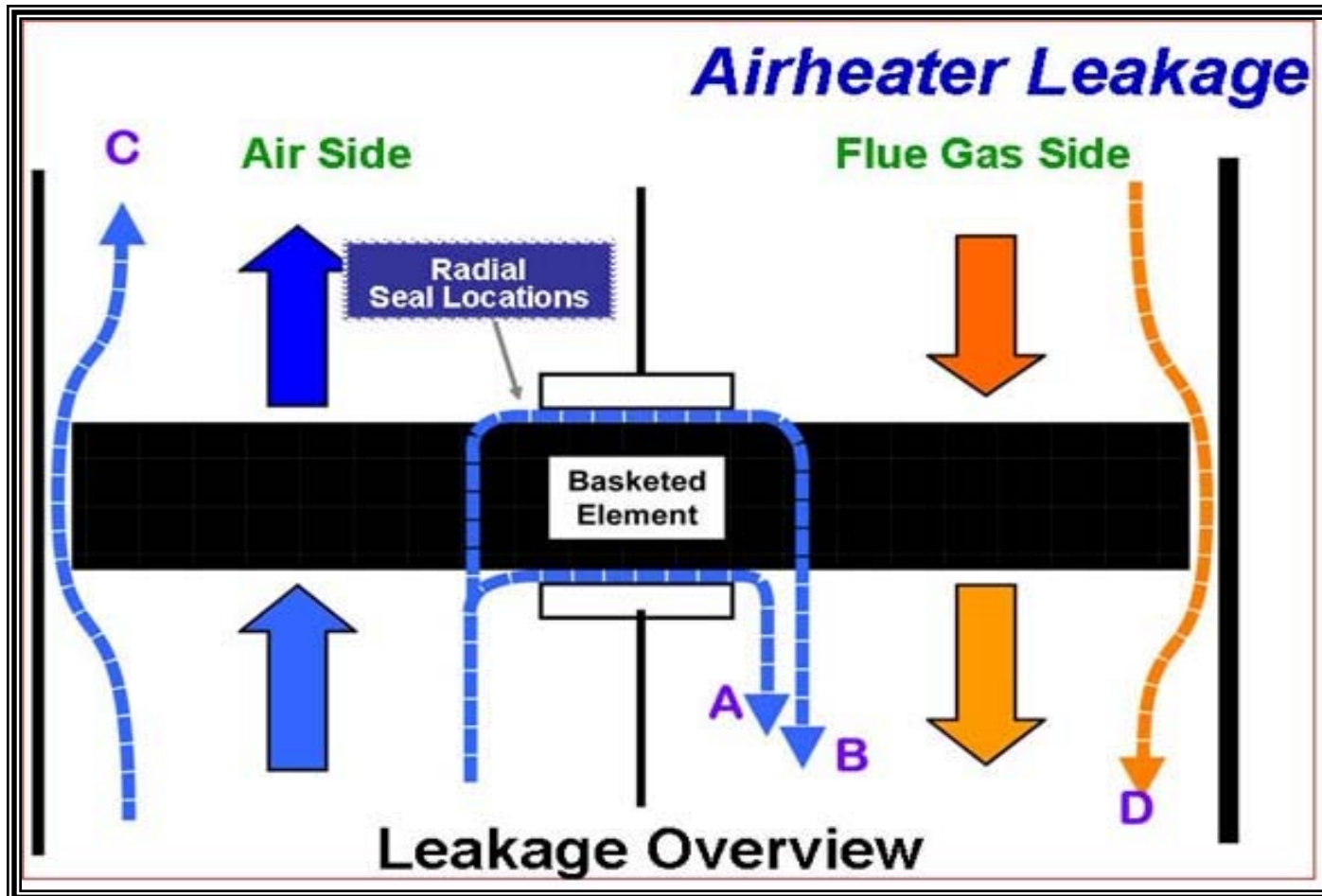
AIR HEATER TEMPERATURE AND FLYASH RESISTIVITY



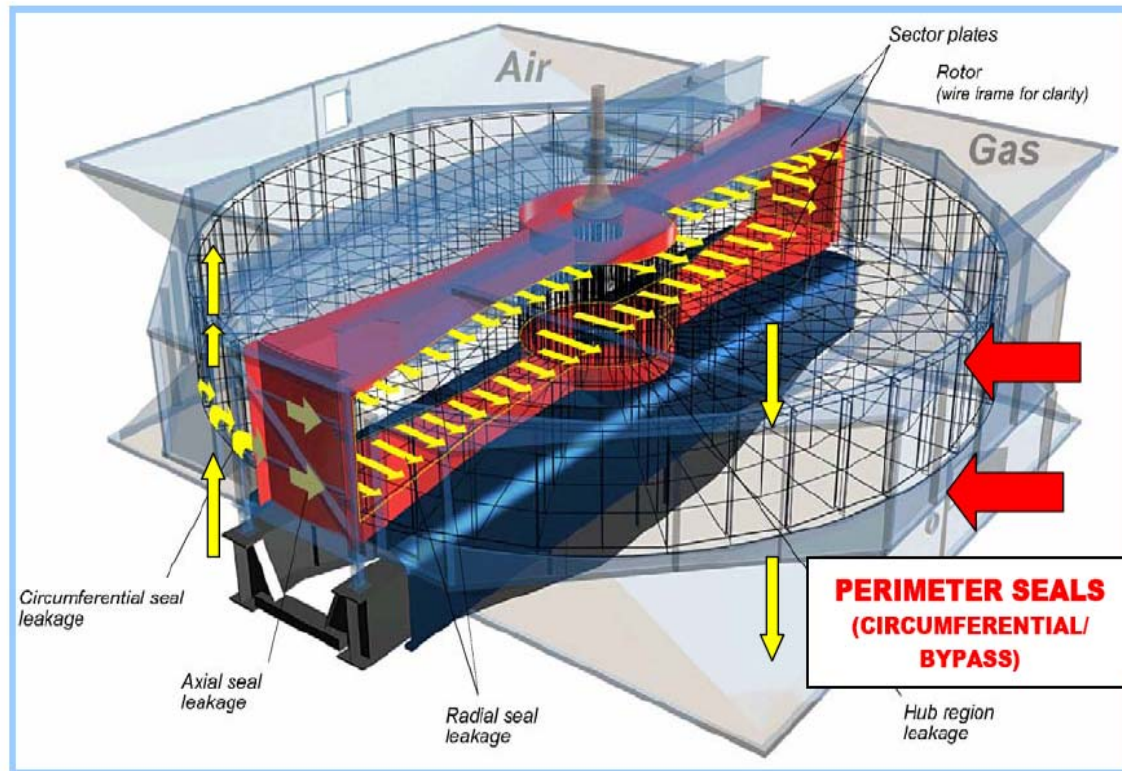
MINIMIZE LEAKAGE

- INCREASED ESP SCA
- MORE UNIFORM INLET
FLOW AND TEMPERATURE
- REDUCED BAGHOUSE ΔP
- REDUCED FAN HORSEPOWER

LEAKAGE PATHS IN THE AIRHEATER

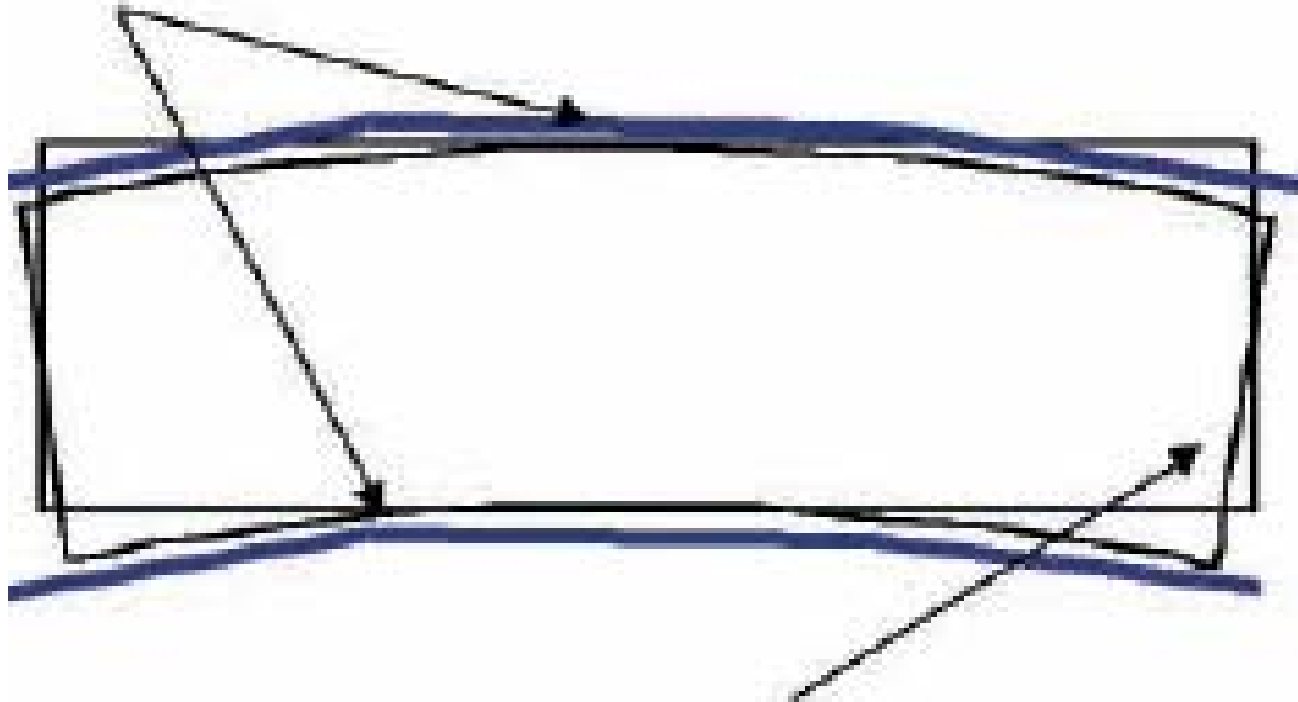


What is leakage ?

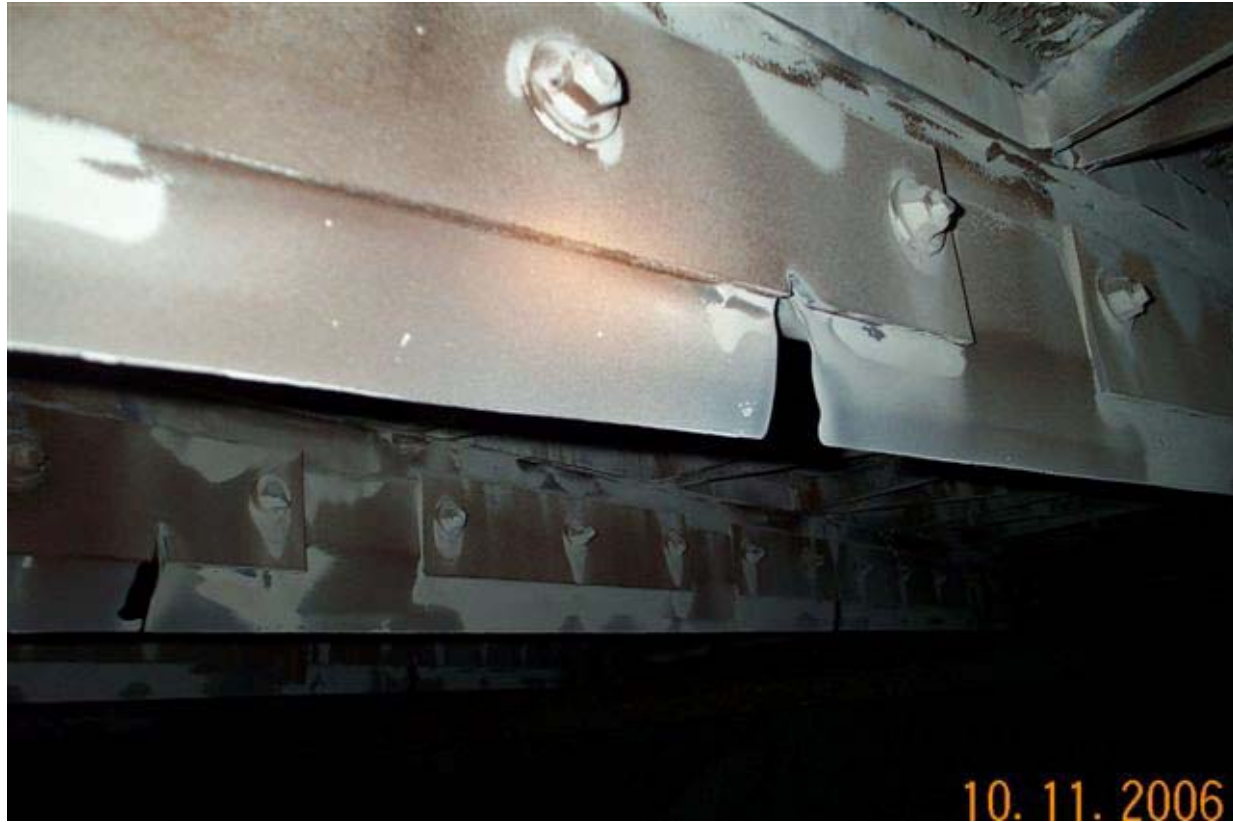


APPENDIX 1
FIGURE 1

Radial sealing plates

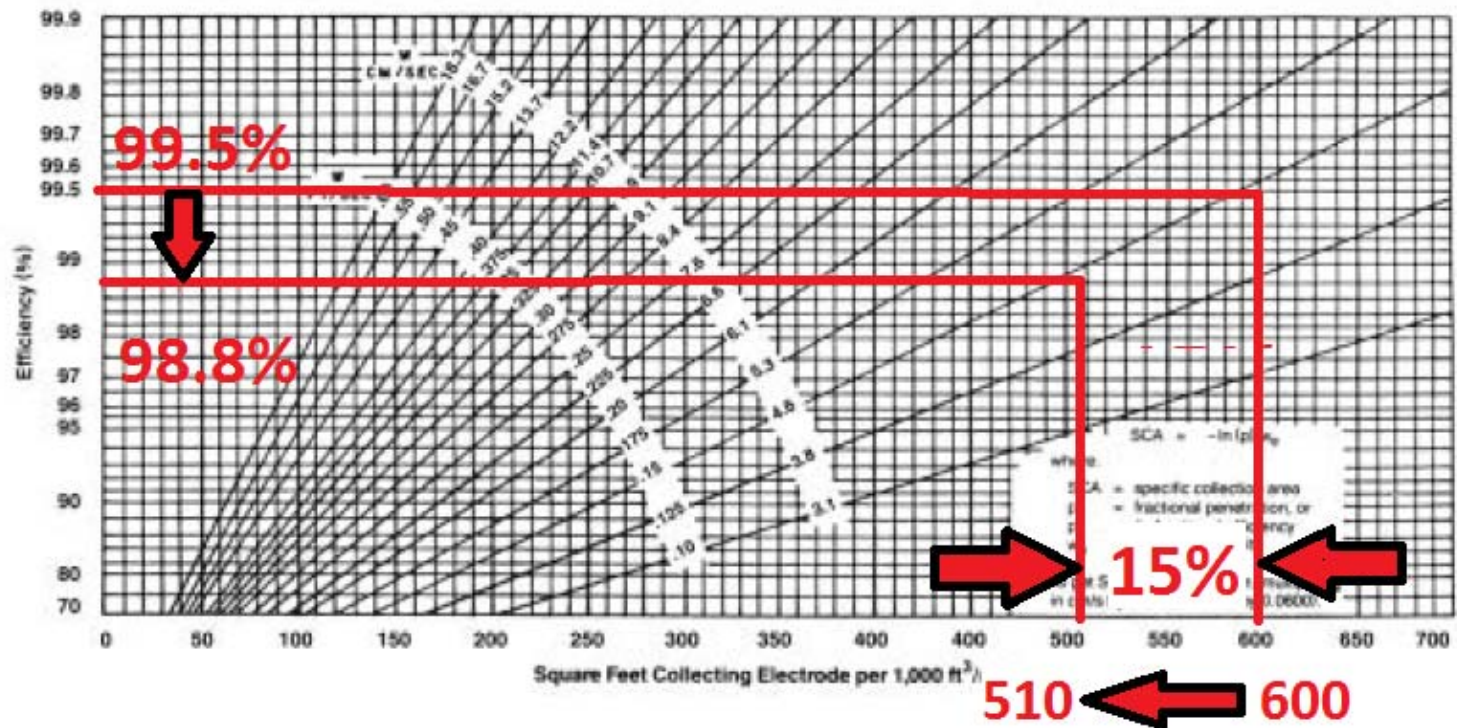


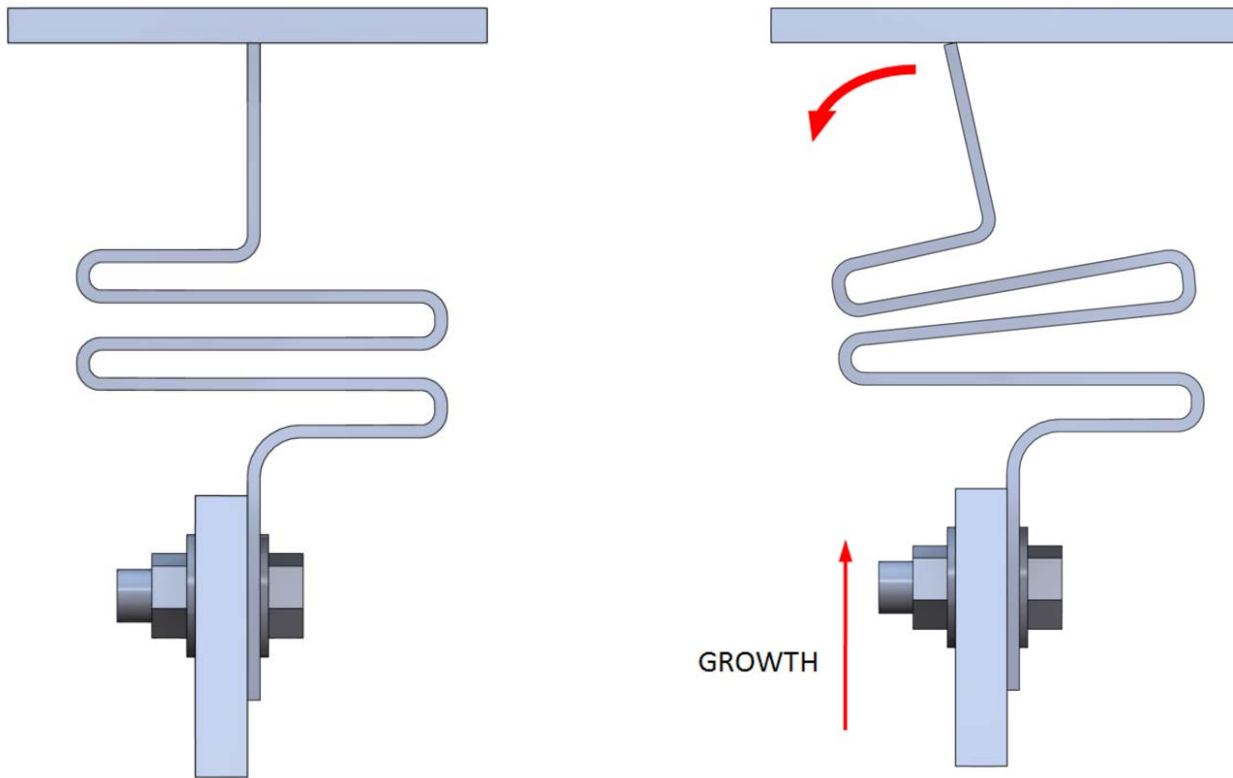
Thermally deformed rotor



HIGH VELOCITY RADIAL SEAL LEAKAGE

GAS VOLUME EFFECT ON SCA AND ESP COLLECTION EFFICIENCY





DuraMax™ Radial Seal



Before Contact



**Contact with
Sector Plate**

ACTUAL FAN POWER SAVINGS FROM REDUCED LEAKAGE

FAN	Before (AMPS)	After (AMPS)
3A ID FAN	572	459
3B ID FAN	691	468
3A FD FAN	131	125
3B FD FAN	128	113

SEVERE ELEMENT FOULING



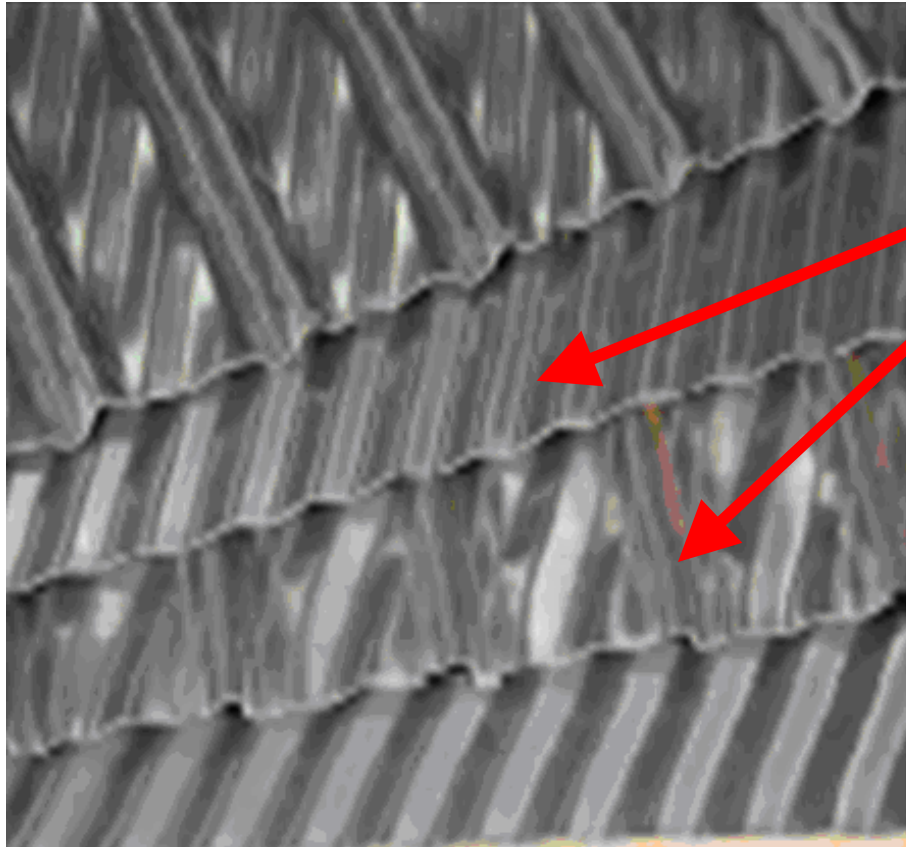
**CONCRETION IN CHANNELS
REDUCES EFFICIENCY AND
RAISES GAS TEMPERATURE**



INCREASED GAS OUTLET TEMPERATURE - VOLUME ASH AND ABS BUILD-UP

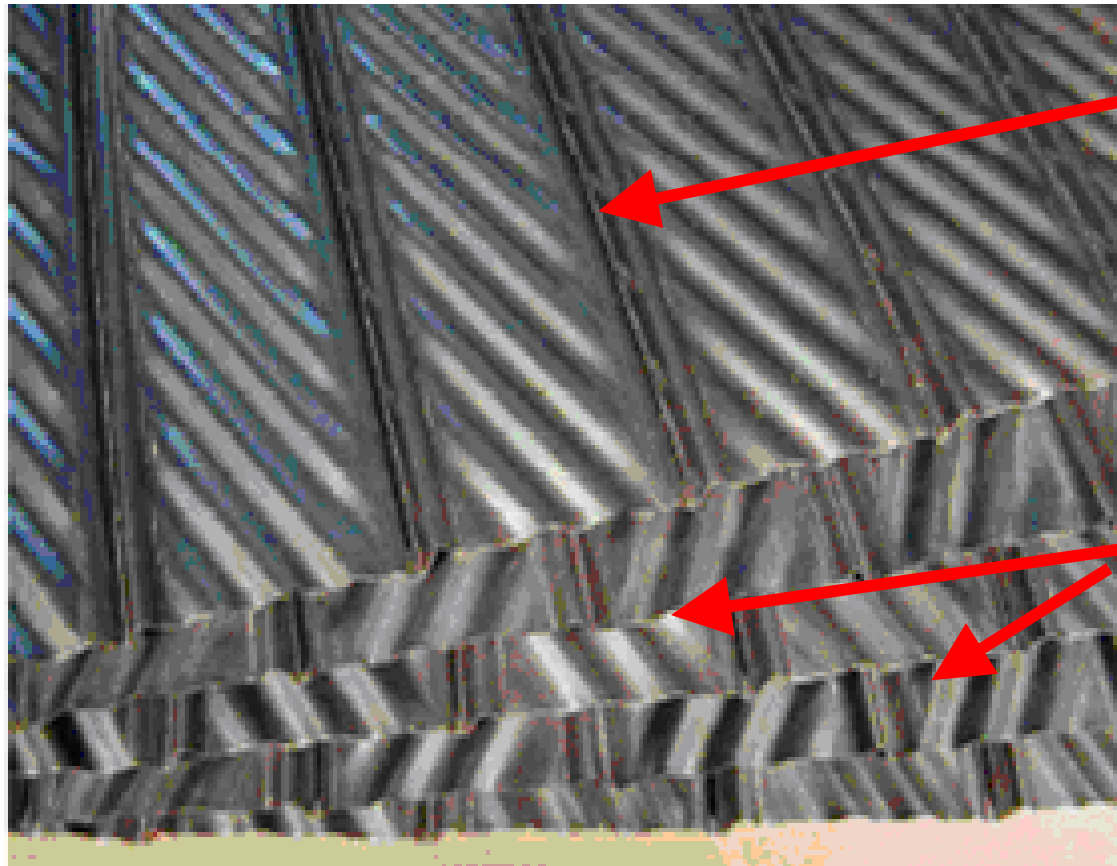
- INSULATES HEAT TRANSFER SURFACE**
-
- BRIDGES THE ELEMENT SURFACE AND
REDUCES TURBULENCE FOR CONVECTION**
- NARROWS GAS PASSAGES AND INCREASES
GAS VELOCITY THROUGH ELEMENT
PASSAGES**

ORIGINAL DU ELEMENT



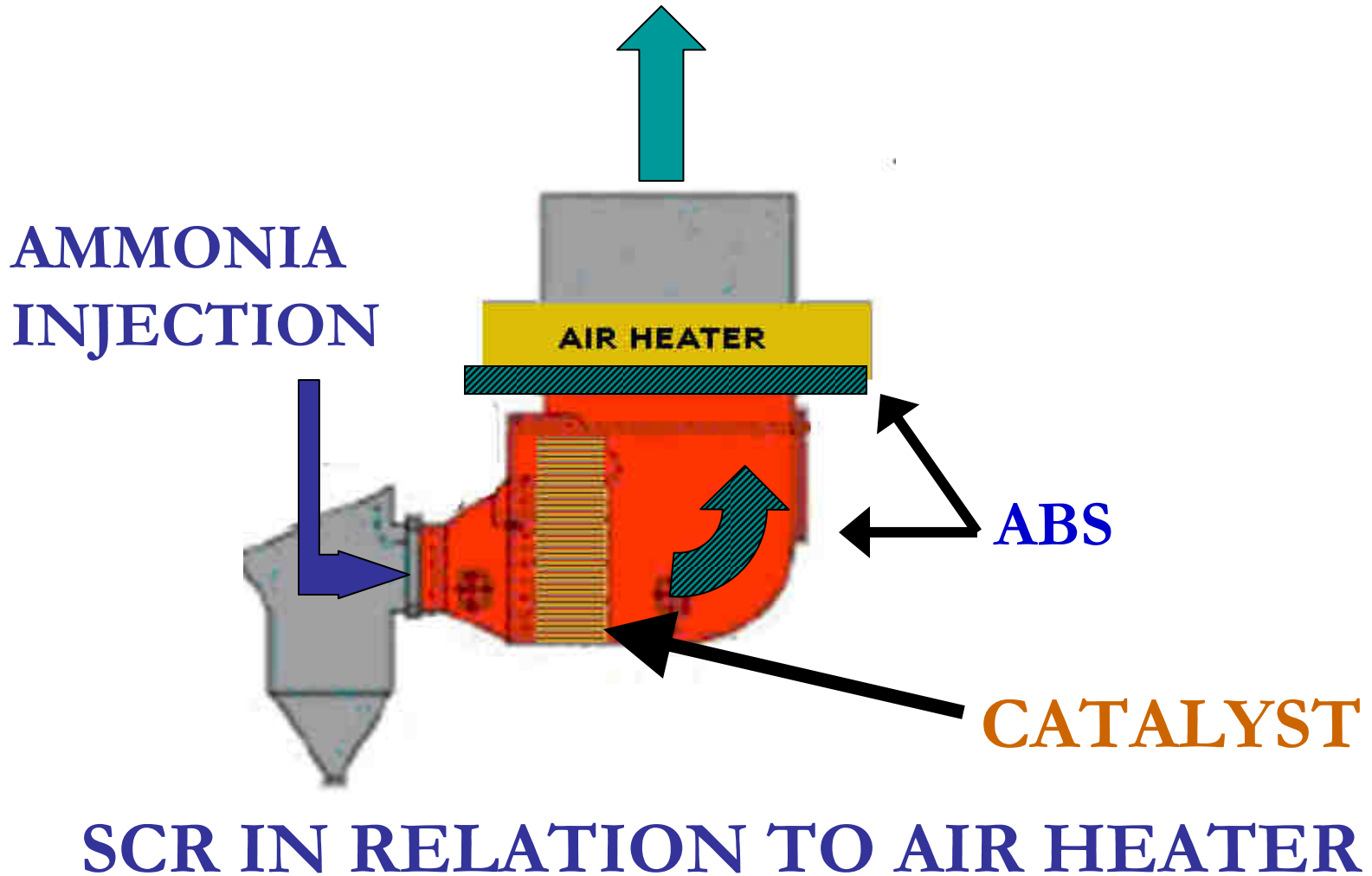
**Undulations
in Same Direction**

NEWER DU ELEMENT STYLE



**Deeper
Notches**

**Undulations
Opposite
Directions**



FORMATION OF AMMONIUM BISULFATE



ABS BUILD-UP AT PRECIPITATOR INLET



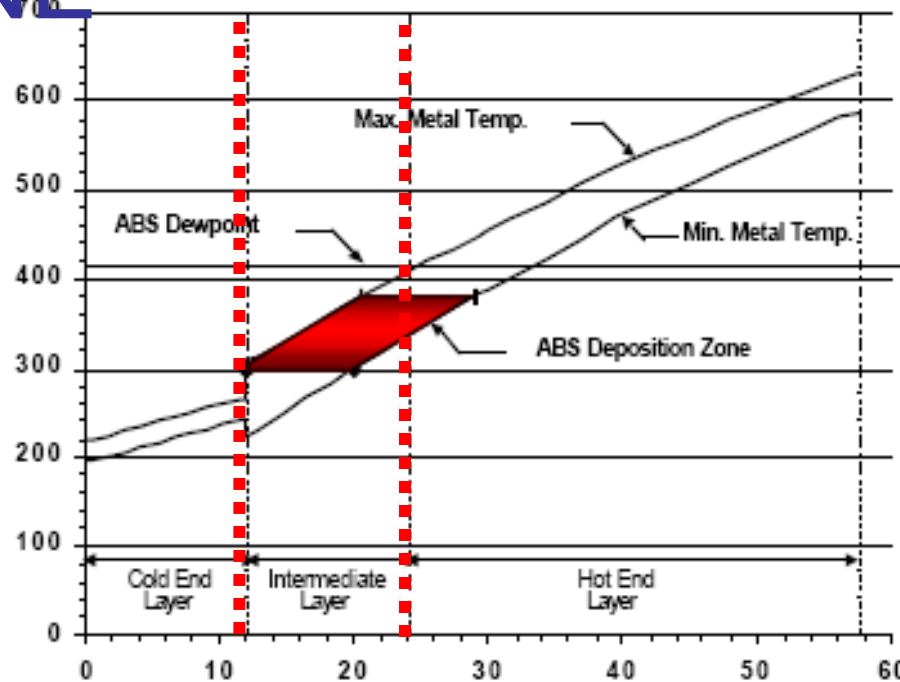
DEALING WITH ABS

- ENAMELED ELEMENT
- TWO LAYER DESIGN
- NEW ELEMENT CONFIGURATIONS
- SOOT BLOWING AND ABS
- CATALYZED AIR HEATER BASKETS
- NEWEST NANO ENAMEL
- CARBIDE COATED ELEMENT





ABS TEMPERATURE ZONE



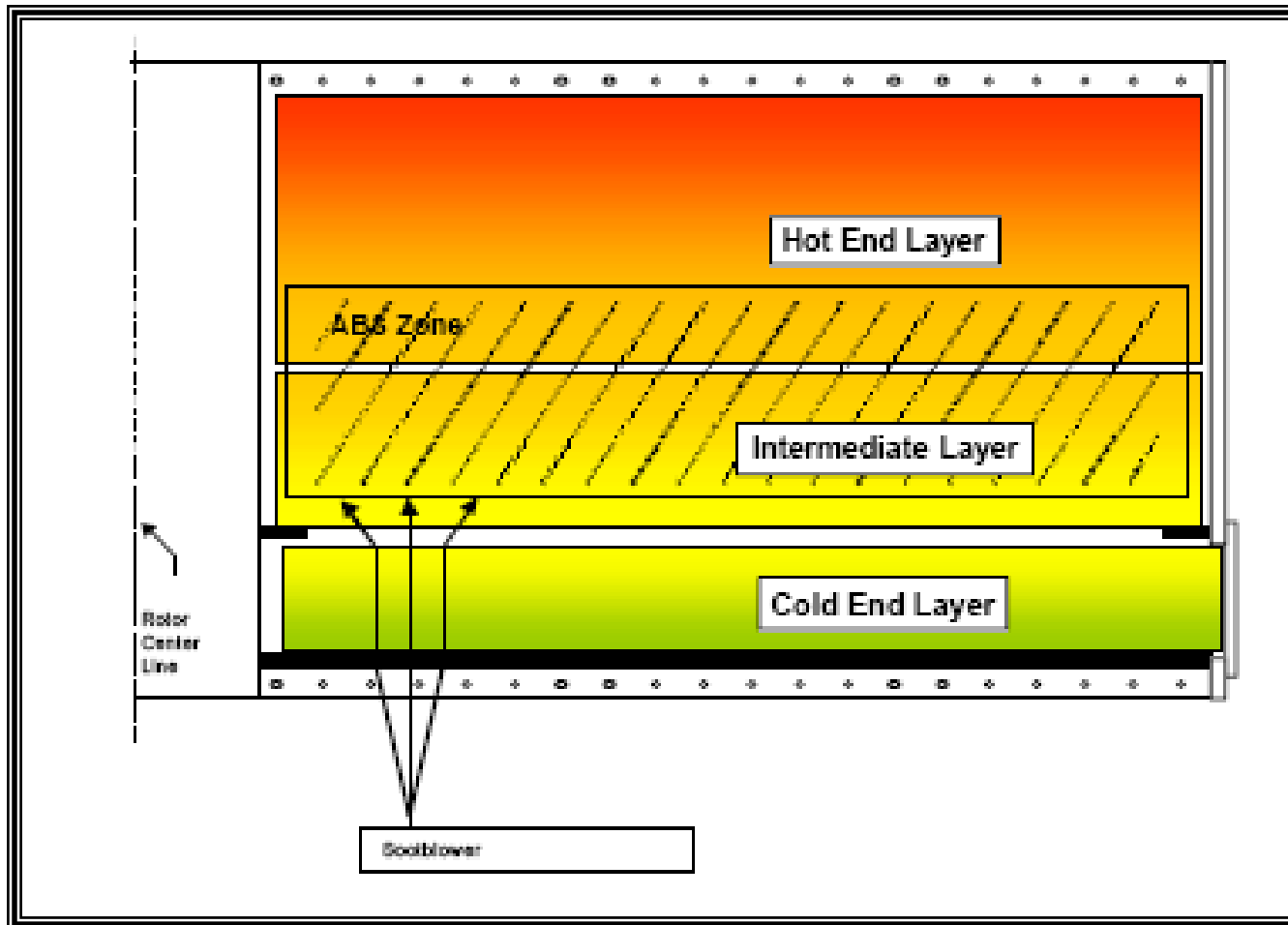
DEPTH OF ELEMENT

ABS

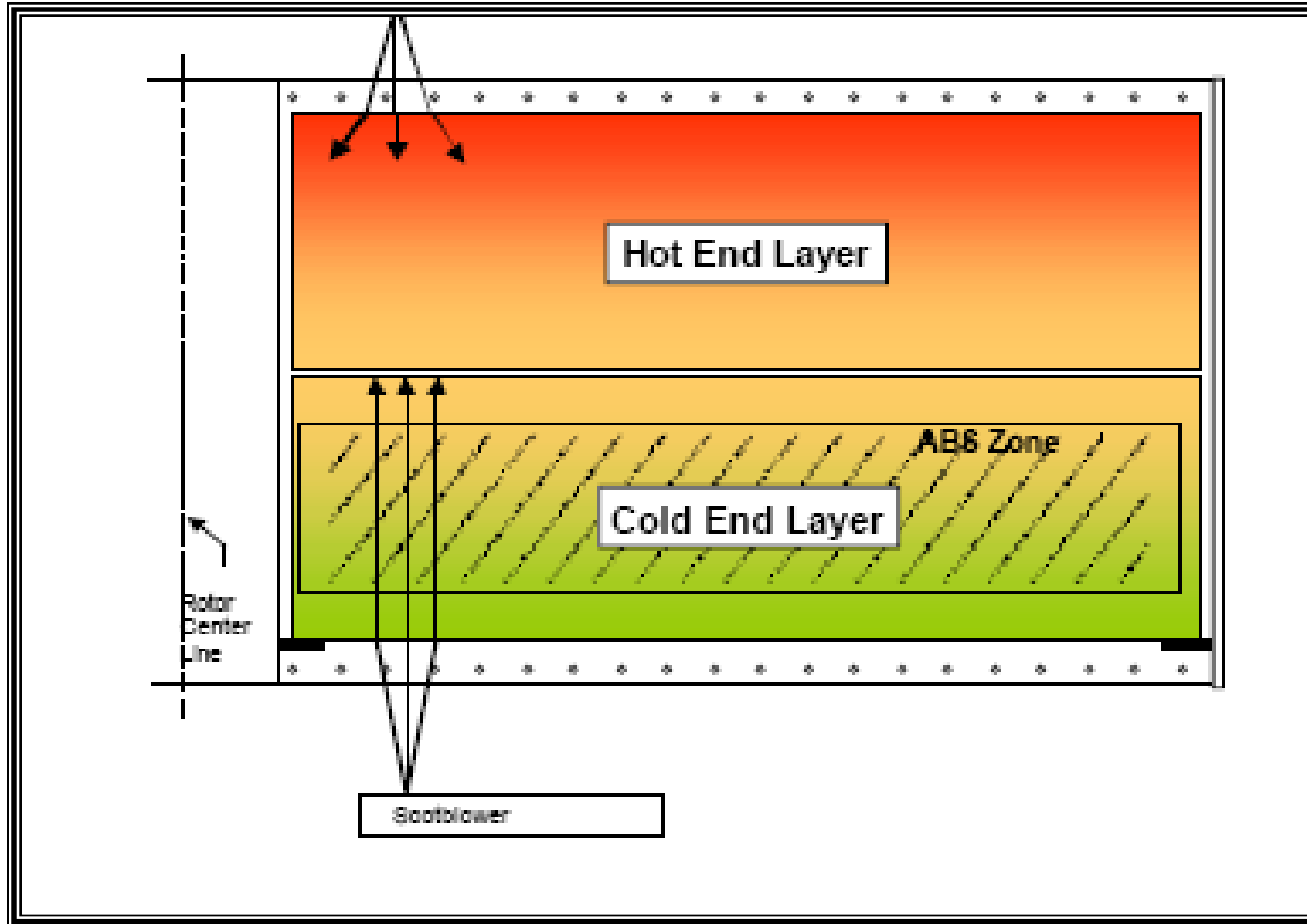
**12
INCHES
TO 30
INCHES**

**300°F
TO 390°F**

MULTILAYER AIR HEATER



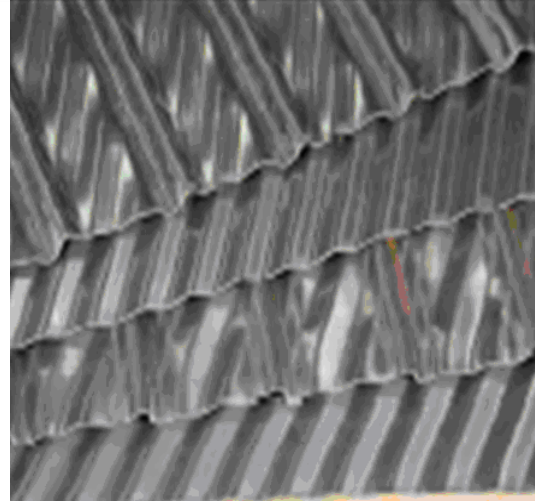
TWO LAYER ABS CONVERSION



CLOSED CHANNEL



**STANDARD
HOT END**



**ABS STYLE
COLD END**





SWING ARM AH SOOT BLOWER



TWO LAYER COLD END DAMAGE

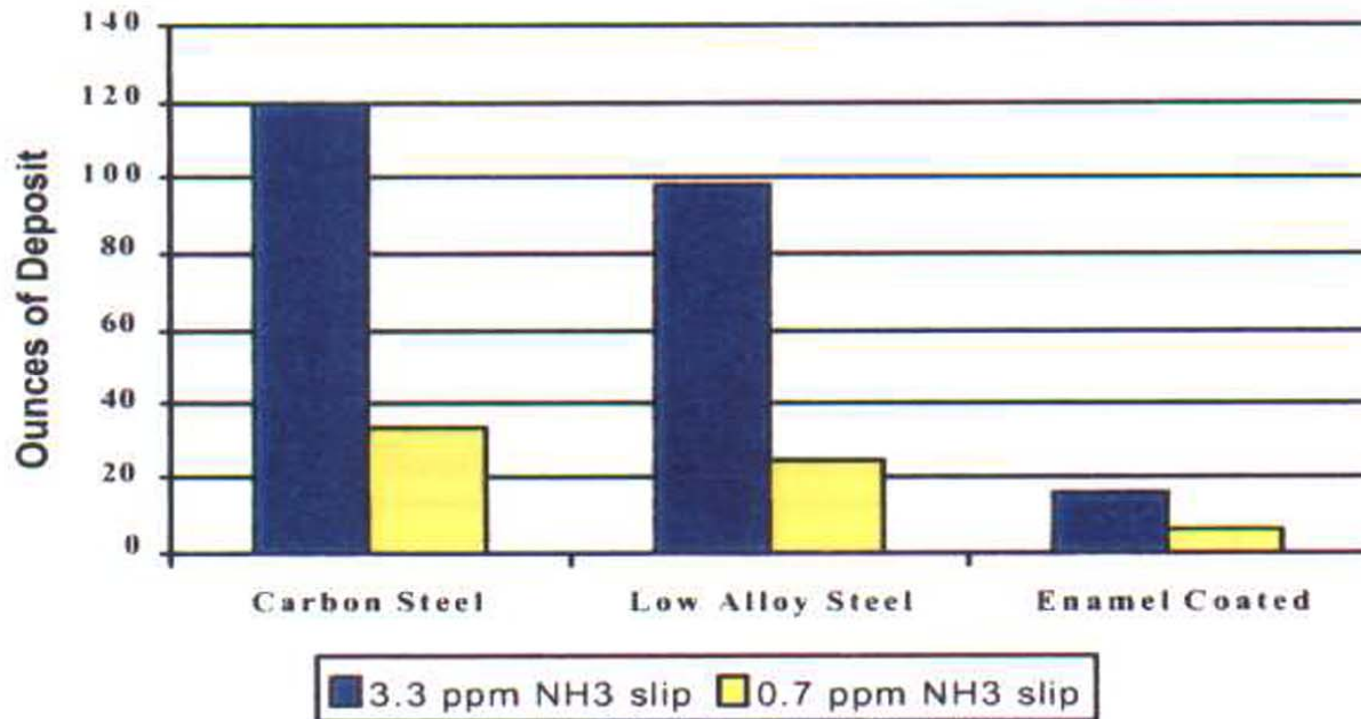


TWO LAYER COLD END DAMAGE

**CONFIGURATION CHANGES
FOR ABS REQUIRE CAREFUL
ATTENTION TO SOOT
BLOWING METHODS AND
PRESSURE**

WHAT ABOUT ENAMEL?

Enamel Coated Element for ABS



RESISTANCE TO ABS BUILDUP

Problems with Current Coating Systems

BRITTLENESS

- Enamel class coatings are mostly glass
- Enamels crack easy under stress
- Compression of basket assemblies leaves micro-cracks.
- Stresses in Rotation of Horizontal units cause additional cracking
- Micro-cracks leave paths for acids to attack substrate.

CORROSION

- Enamel class coatings are melted onto substrate at 1500+F
- At 1500F carbon in steel will burn and produce CO₂ bubbles – causing voids
- Enamel is used over a specific steel called Enameling Iron with almost no carbon
- Enameling Iron corrodes very rapidly in sulfuric acid
- Enameling iron is brittle after forming – stress cracking failures can occur

“NEWER” COATING



ELEMENT CRACKING FAILURES MOST LIKELY DUE TO
CORROSION UNDERMINING THE COATING AND
NON-DUCTILE METAL SUBSTRATE FATIGUE FAILURES

FAILED COATED ELEMENT SHOWING SUBSTRATE FAILURE



**THE USE OF A FORMABLE CORROSION RESISTANT
SUBSTRATE IS CRITICAL TO SUCCESS**

ENAMELED ELEMENT FAILURES RELATED TO ABS BUILDUP



CURRENTLY AVAILABLE ENAMEL



**CONCRETION IN CHANNELS
REDUCES EFFICIENCY AND
RAISES GAS TEMPERATURE**



ENAMELING FUTURE

Recent advances on enameled elements



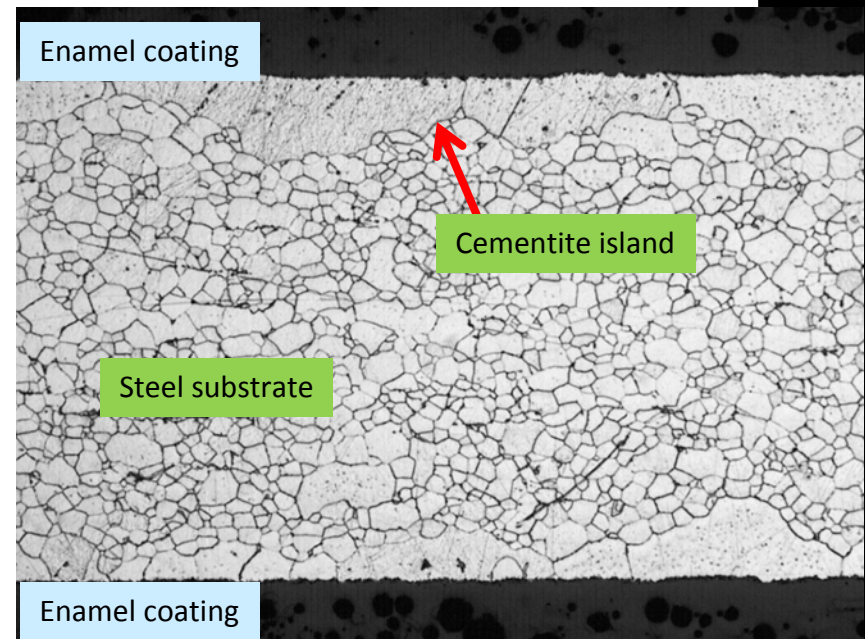
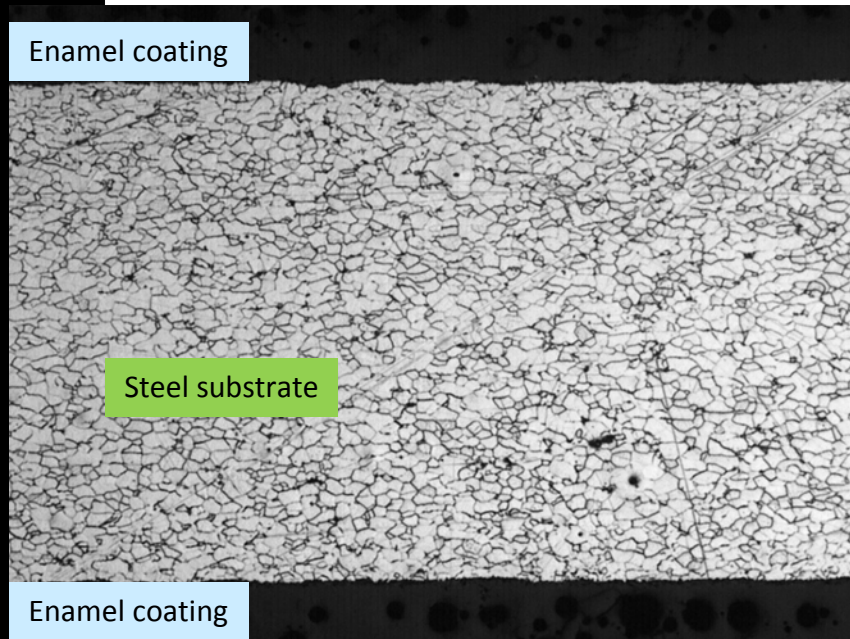
- **SELF-REPAIRING**
- **NANO SURFACE**
"Non Stick"
- **ADVANCED METALS**

METALS FOR VITREOUS ENAMELING PROCESS

Steel structure:

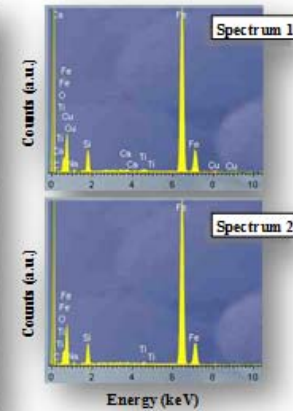
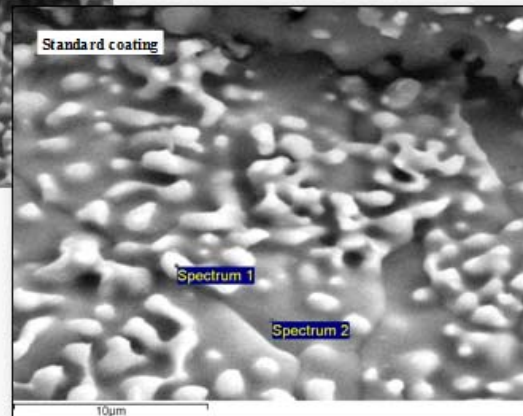
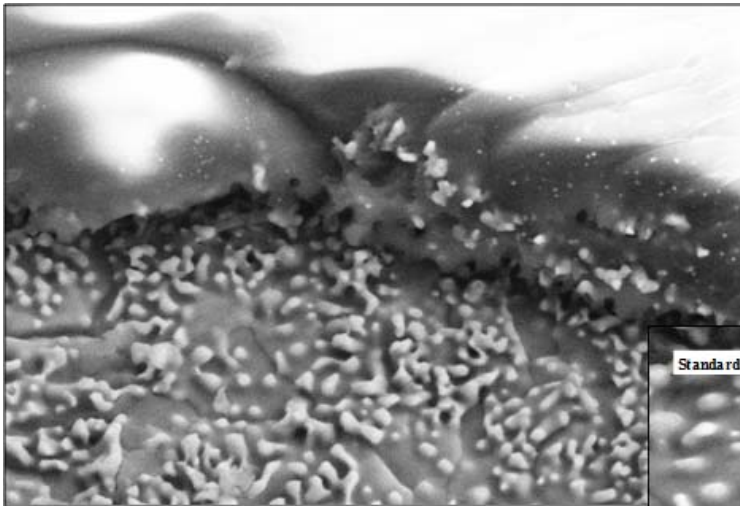
Good microstructure and good interface quality

Bad microstructure and bad interface quality

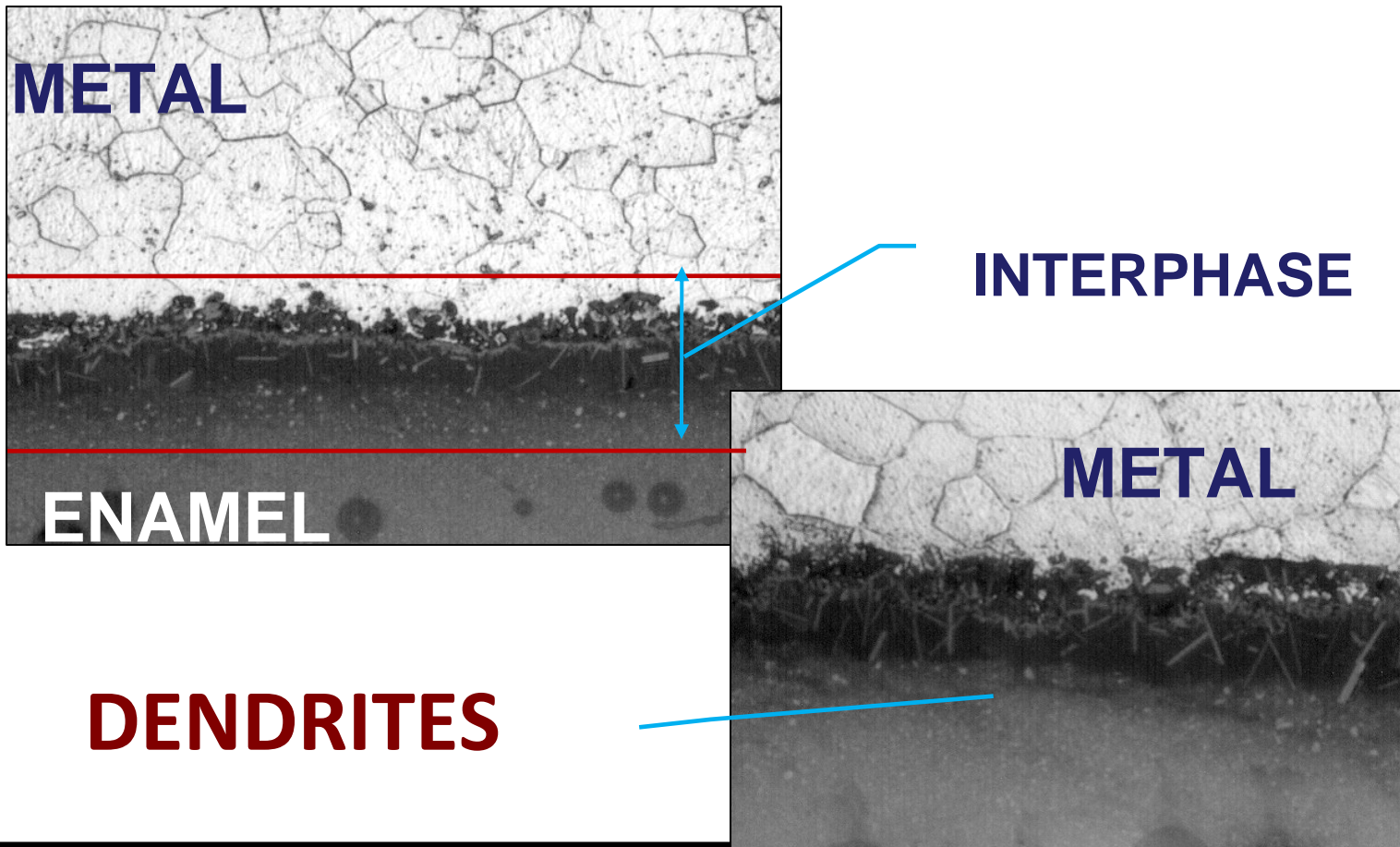


ENAMEL – STEEL INTERACTION DURING FIRING

DENDRITES



ENAMEL – STEEL INTERACTION DURING FIRING



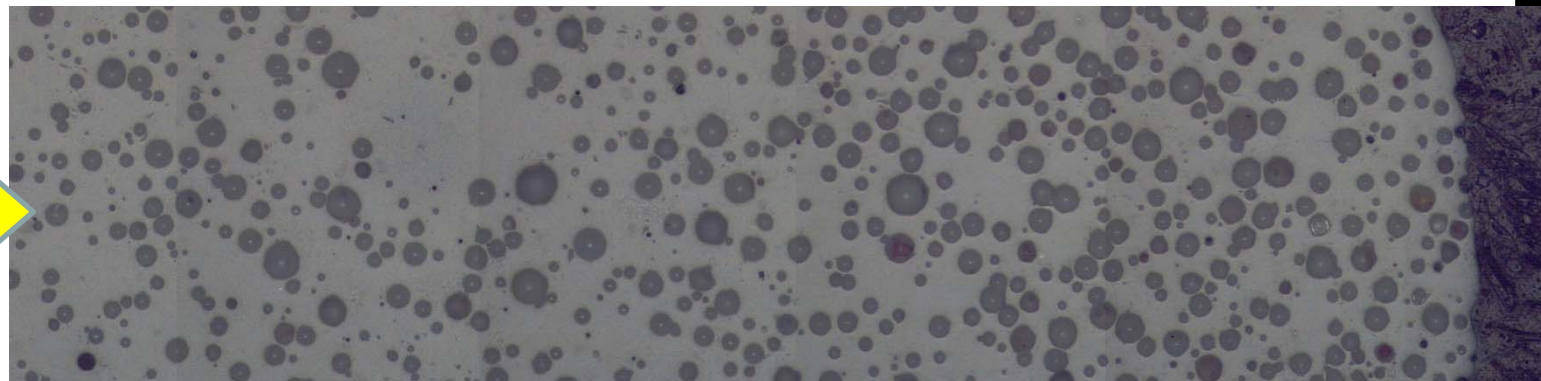
Enamel

ENAMEL – STEEL INTERACTION DURING FIRING

Enameled steel: a functionally graded material

Steel

Enamel coating

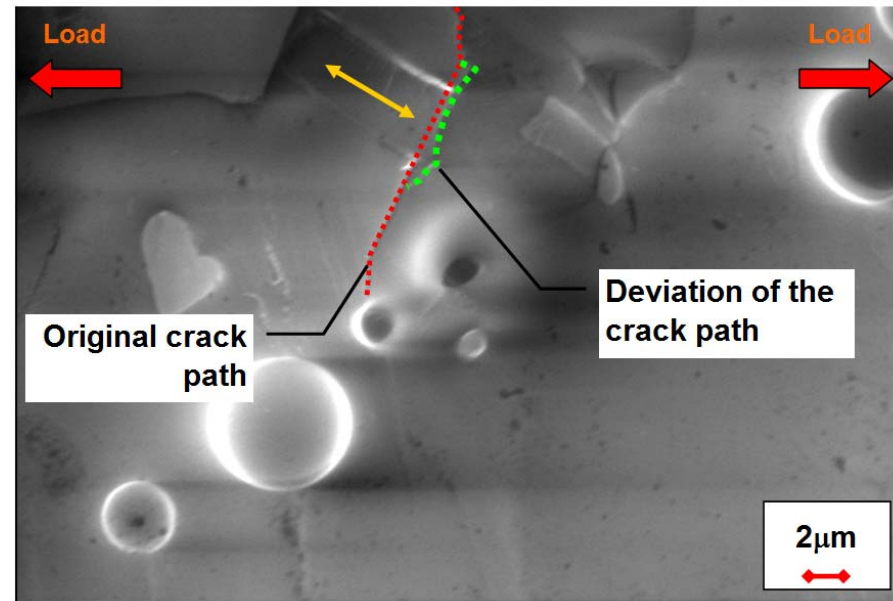
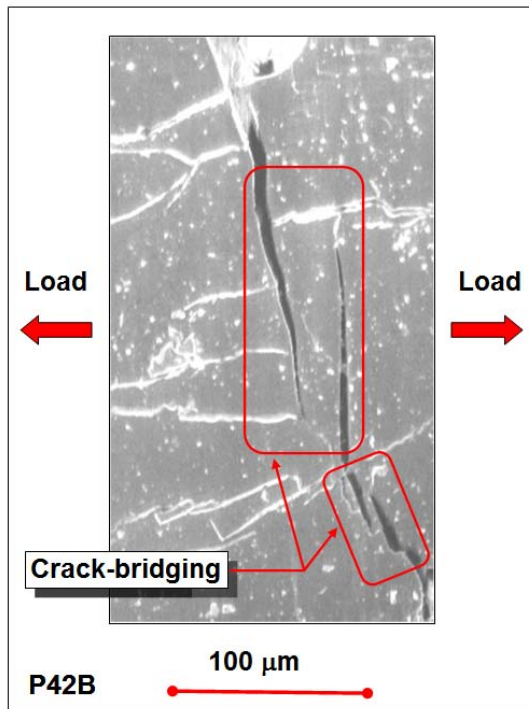


Enamel coating

External face

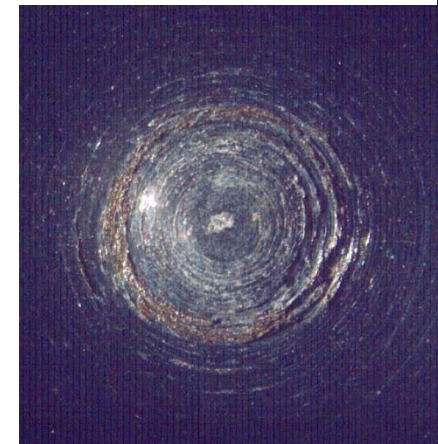
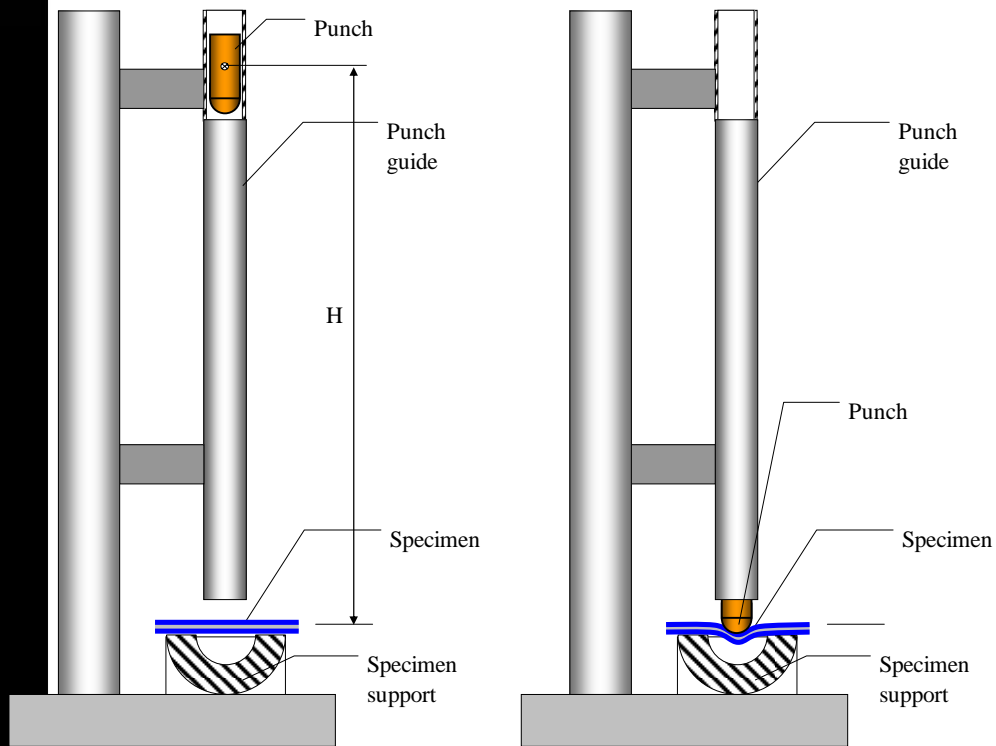
SELF-REPAIRING MECHANISMS:

CRACK BRIDGING



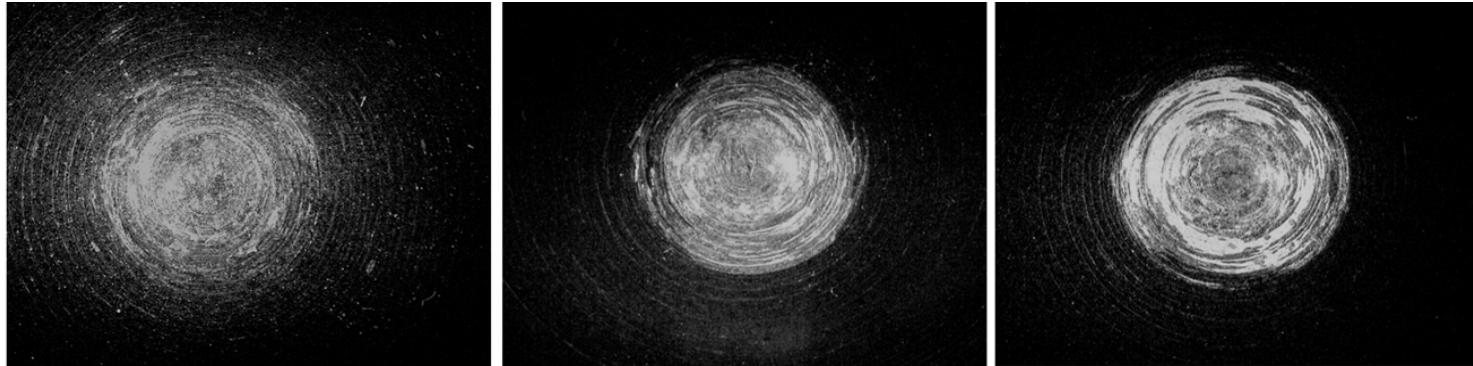
CRACK SHIFTING

ADHERENCE OF ENAMEL TO THE METAL SUBSTRATE

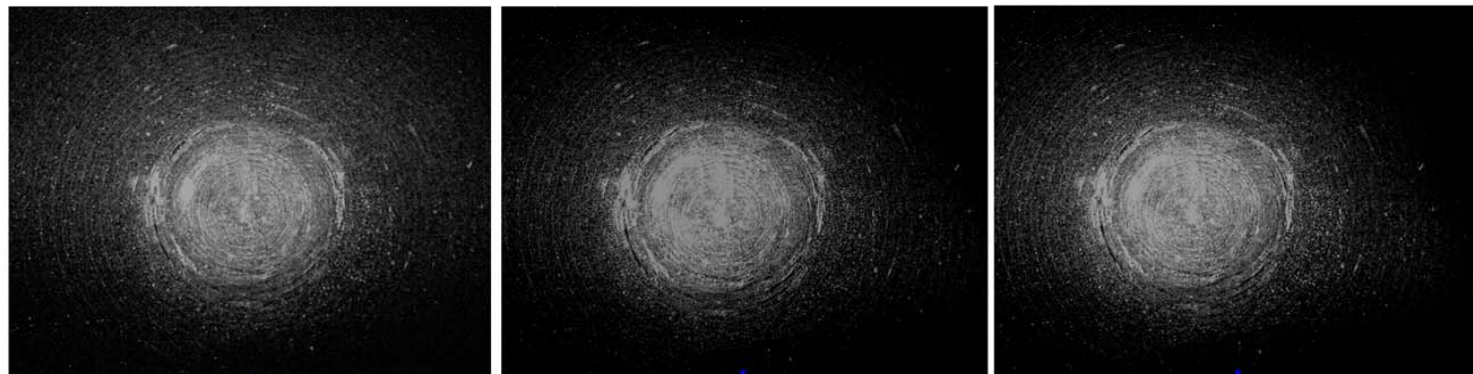


SELF-REPAIRING ENAMEL

S
T
A
N
D
A
R
D



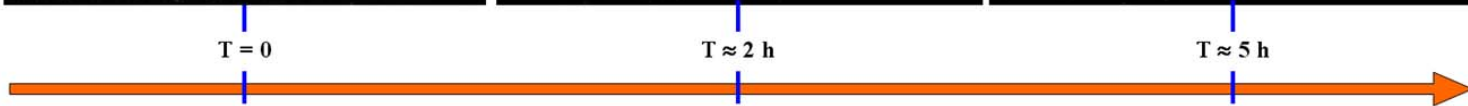
N
A
N
O
M
O
D
I
F
I
E
D



T = 0

T ≈ 2 h

T ≈ 5 h



ADHERENCE TEST

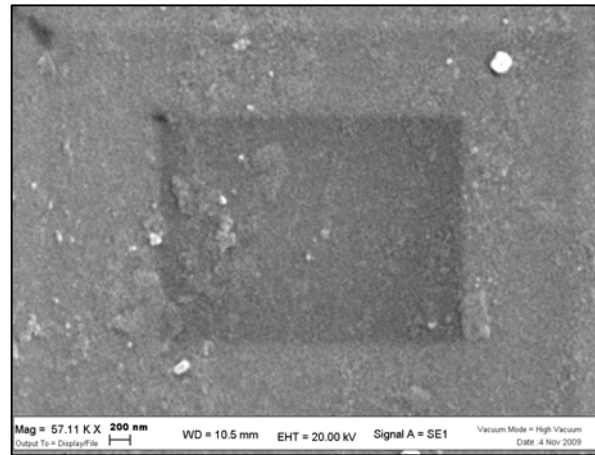
NEW NANO-ENAMEL COATING SURFACE IS LESS WETTABLE

STANDARD ENAMEL



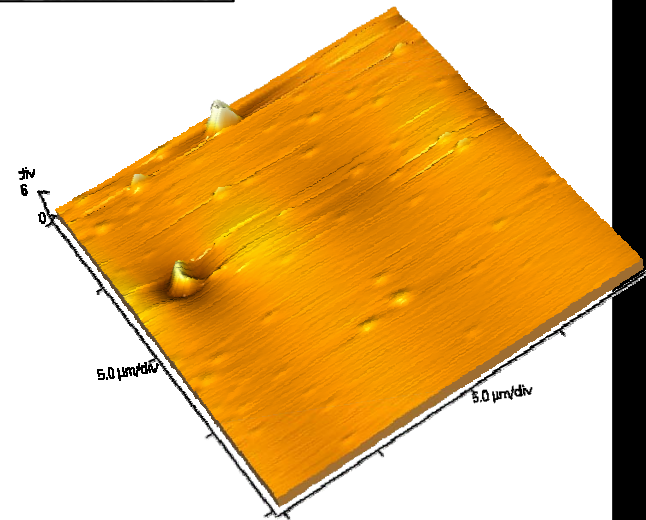
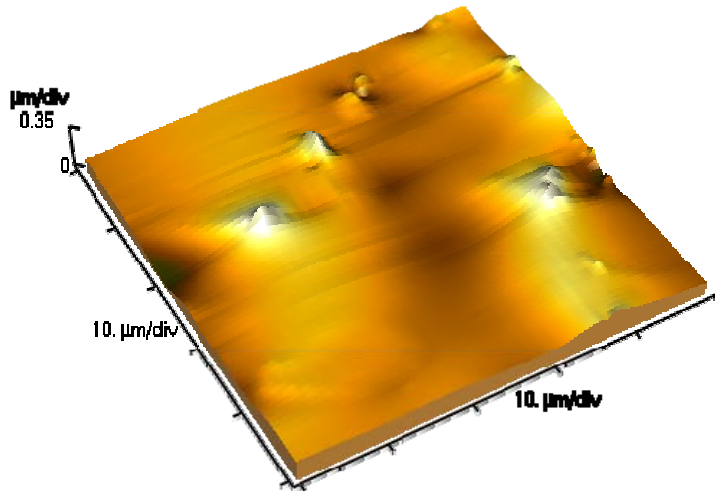
NANO-ENAMEL



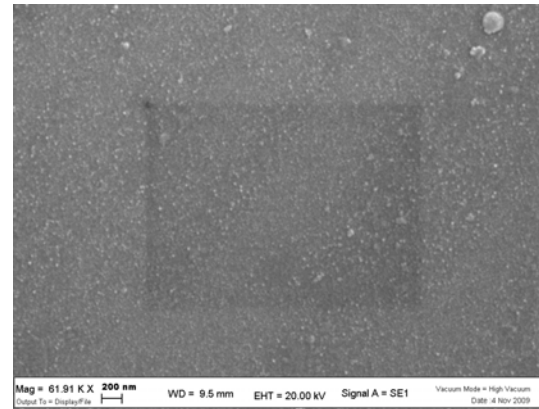


STANDARD ENAMEL SURFACE

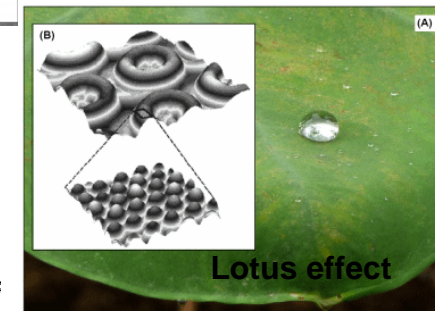
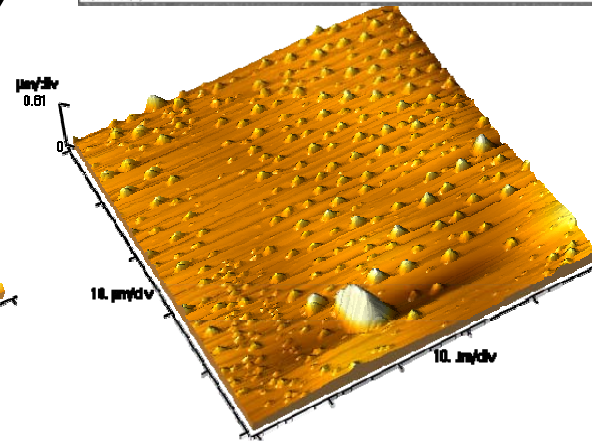
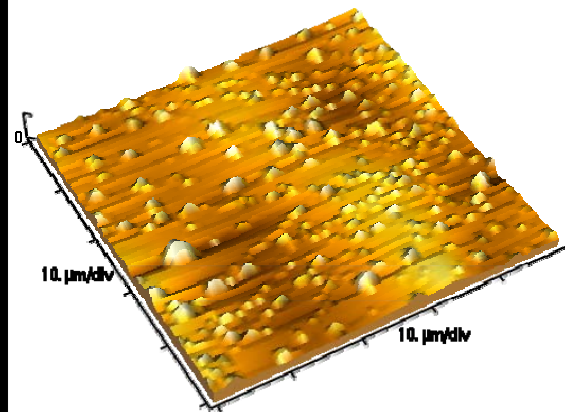
SCANNING
ELECTRON
MICROSCOPE



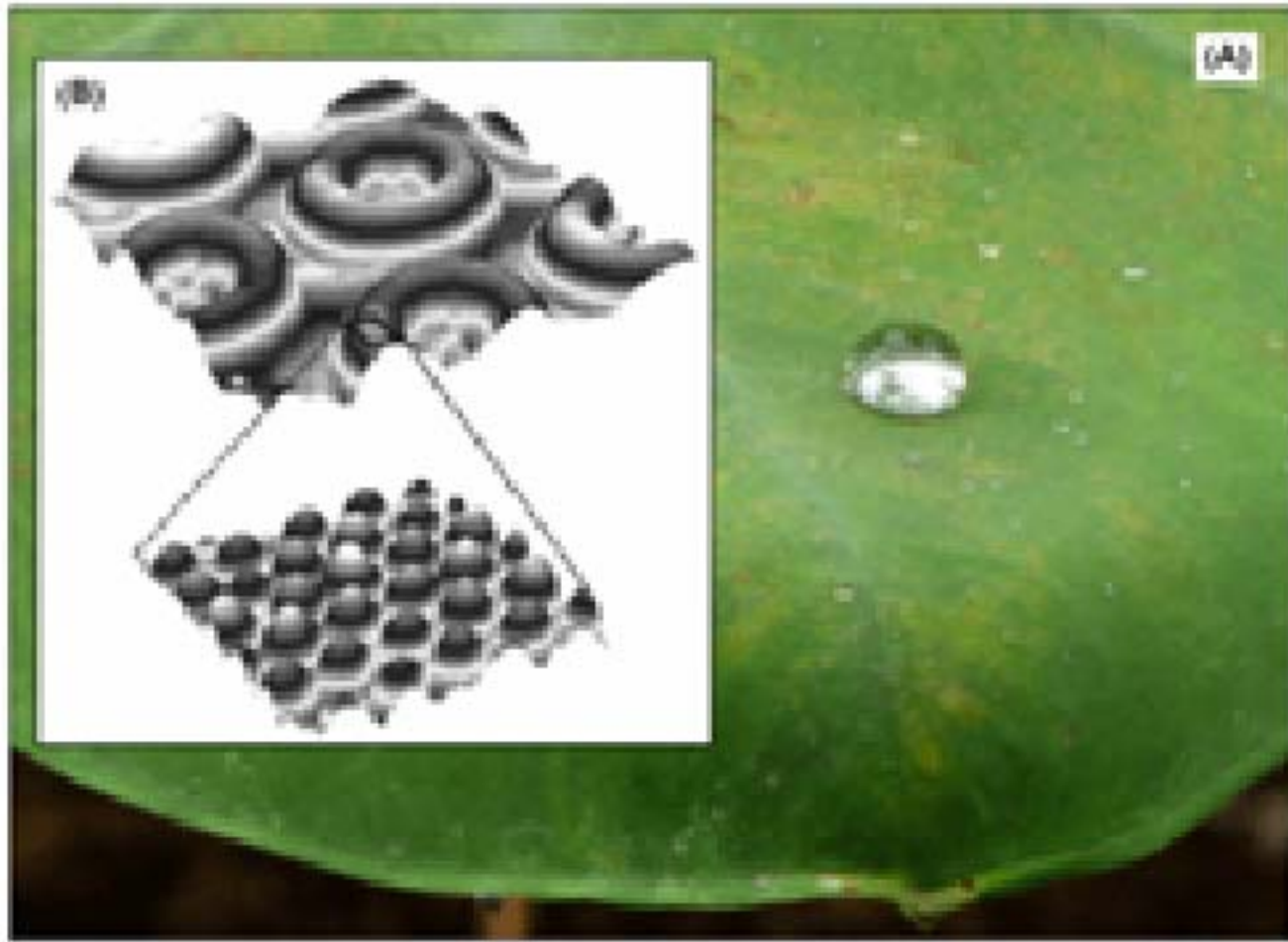
NANO-ENAMEL SURFACE MICRO AIR LAYER PREVENTS FULL CONTACT



SCANNING
ELECTRON
MICROSCOPE
(SEM) ANALYSIS



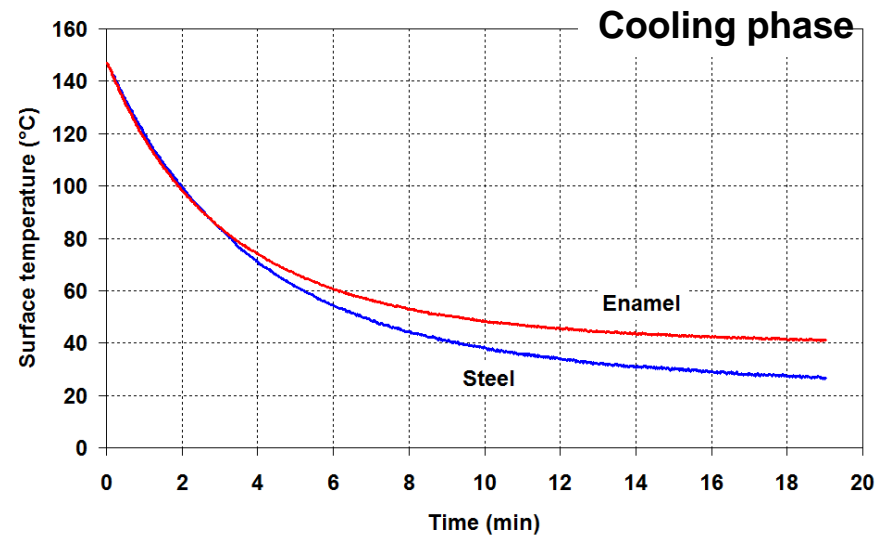
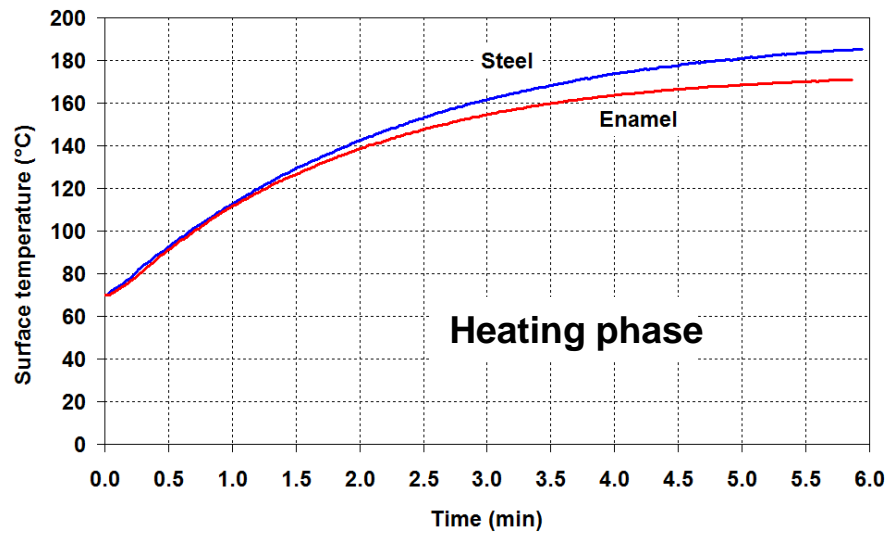
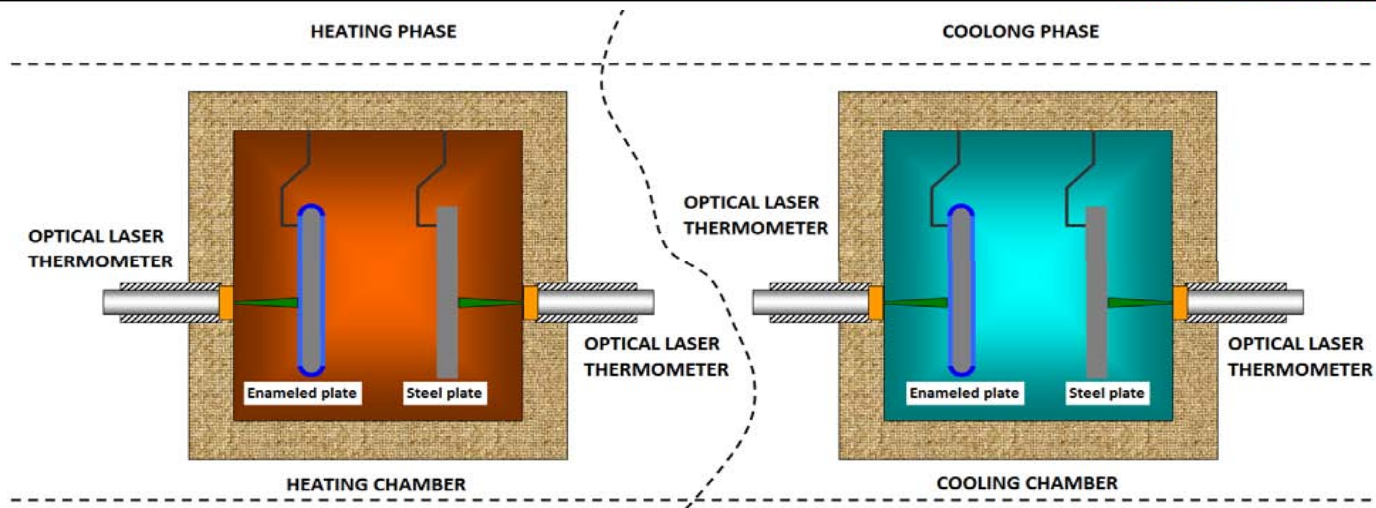
Lotus effect



LOTUS PETAL

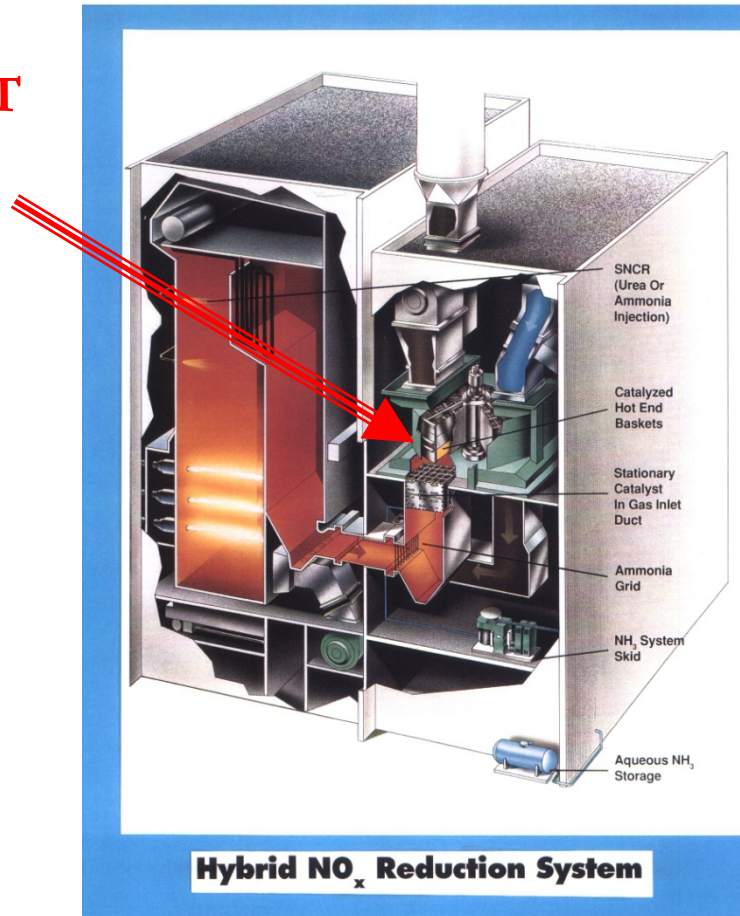


SILICONE CARBIDE

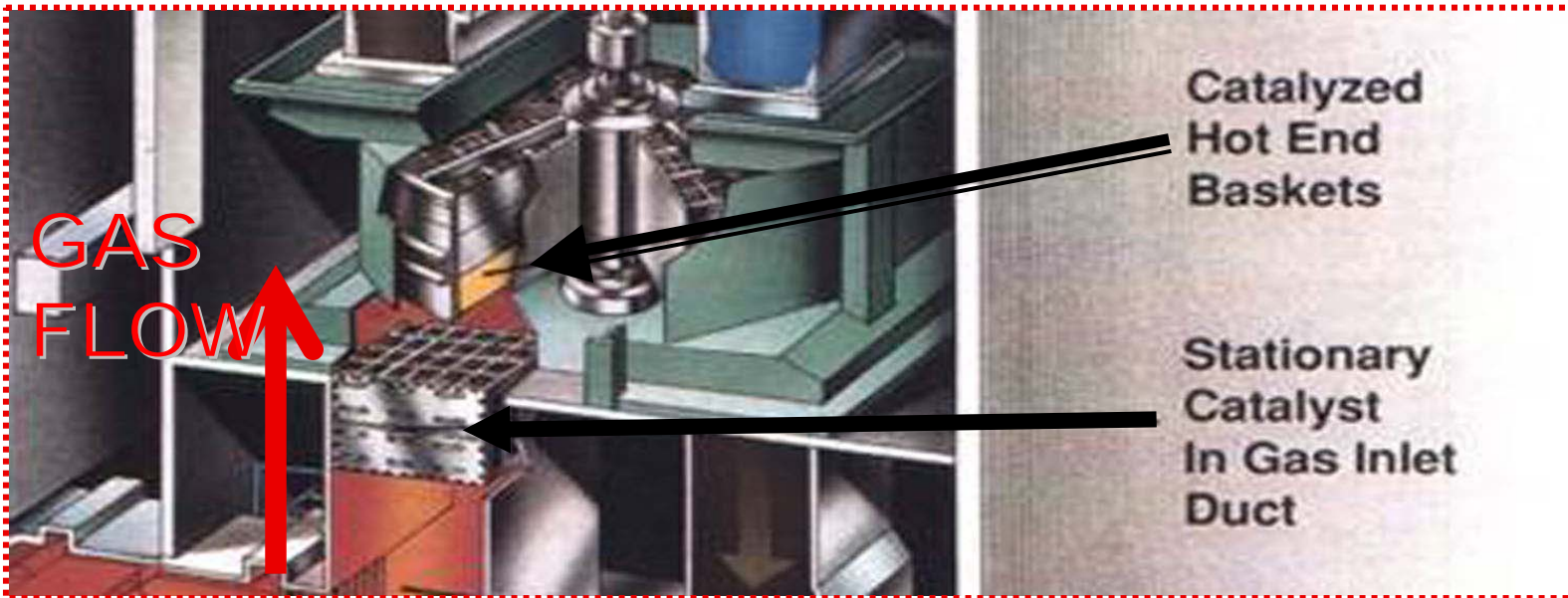


Catalytic Air Heater

**CATALYST
LAYER**



Catalyst in Airheaters



COST PENALTY ATTRIBUTED TO ABS AIR HEATER BUILDUP –500 MW COAL UNIT

Parameter	Quantity	Annual Penalty
Increased Pressure Drop	4 inches H ₂ O	\$ 198,000
Gas Outlet Temperature Increase	0°F	\$ 440,000
Water Wash Outages	9 days/yr	\$ 1,500,000
Increased Leakage in Radial Seals	3%	\$ 63,000
Increased Circumferential Seal Leakage	5000 ACFM	\$ 95,000
TOTAL PENALTY		\$2,073,000