Fuel Qualities Important to Combustion

Securing Supply and Quality Control
Making Wood Work Workshop
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Why is Fuel Quality Important?

- Fuels cause 95% of operational and maintenance problems and unscheduled outages in boilers.
- In small systems fuel problems cause high labor costs not offset by fuel savings.
- Fuel problems can be reduced or avoided.

Some Consequences of Poor Fuel Quality

	SIZE	MOISTURE	ASH
HEATING VALUE		REDUCED	REDUCED
GRATE	ENTRAINED	ENTRAINED	CLINKER
BOILER TUBES			FOULING
COMBUSTION AIR	INCREASED	INCREASED	CONTROL
EMISSIONS	INCREASED	CO, PIC, PM	PM
OPERATION	DUST	EFFICIENCY	STOPPED
	EQUIPMENT FAILURE		EQUIPMENT FAILURE
LABOR	INCREASED	INCREASED	INCREASED

FUEL SIZE

- Oversize
  - Fuel handling and feeding
  - Slows rate of combustion
  - Cause air imbalance
- Undersize
  - Fines cause imbalance in airflow
  - Dry fines require more secondary air control (Hi CO).

Troublesome Fuel Sizes

Stringy Bark

Wet fines


CATERPILLAR


CHIPS DISCHARGE TO VIBRATING SCREEN
ACCEPTS DISCHARGED TO MOVING BELT DRYER


West Salem Equipment
www.westsalem.com

Typical Boiler Fireside Problems

- Ash removal problems
- Large deposits on refractory surfaces
- Deposits on refractory but not on tubes
- Spalling, slagging, viscous slag
- Accumulation around air tuyeres and refractory
- Fuel feeder blockage from slag
- Slag at hot spots from afterburning
- Blockage of gas passages
- Erosion of transitions in gas ducts

Slagging and Fouling are caused by Combinations of

- Fuel
  - Properties
- Boiler Design
- Boiler
  - Operation

Benefits of Reduced Slagging

- Safety
- Reduced Maintenance
- Reduced Outages
- Improved Plant Efficiency and Capacity
- Extended or Expanded Fuel Supply
- Reduced Corrosion

Typical Boiler Convection Pass Problems

- Bridging and blockage of convection passes
- Loss or attenuation of steam/HW capacity
- Erosion
- High temperature bonded deposits in crossover ducts or superheaters
- Corrosion in superheater, air heater and economizer

Fuel Factors

- Ash composition: potassium (K), sodium (Na), chlorine (Cl), sulfur(S), silicon (Si), Aluminum (Al)
- Total Ash
- Fuel Moisture

Troublesome Fuels

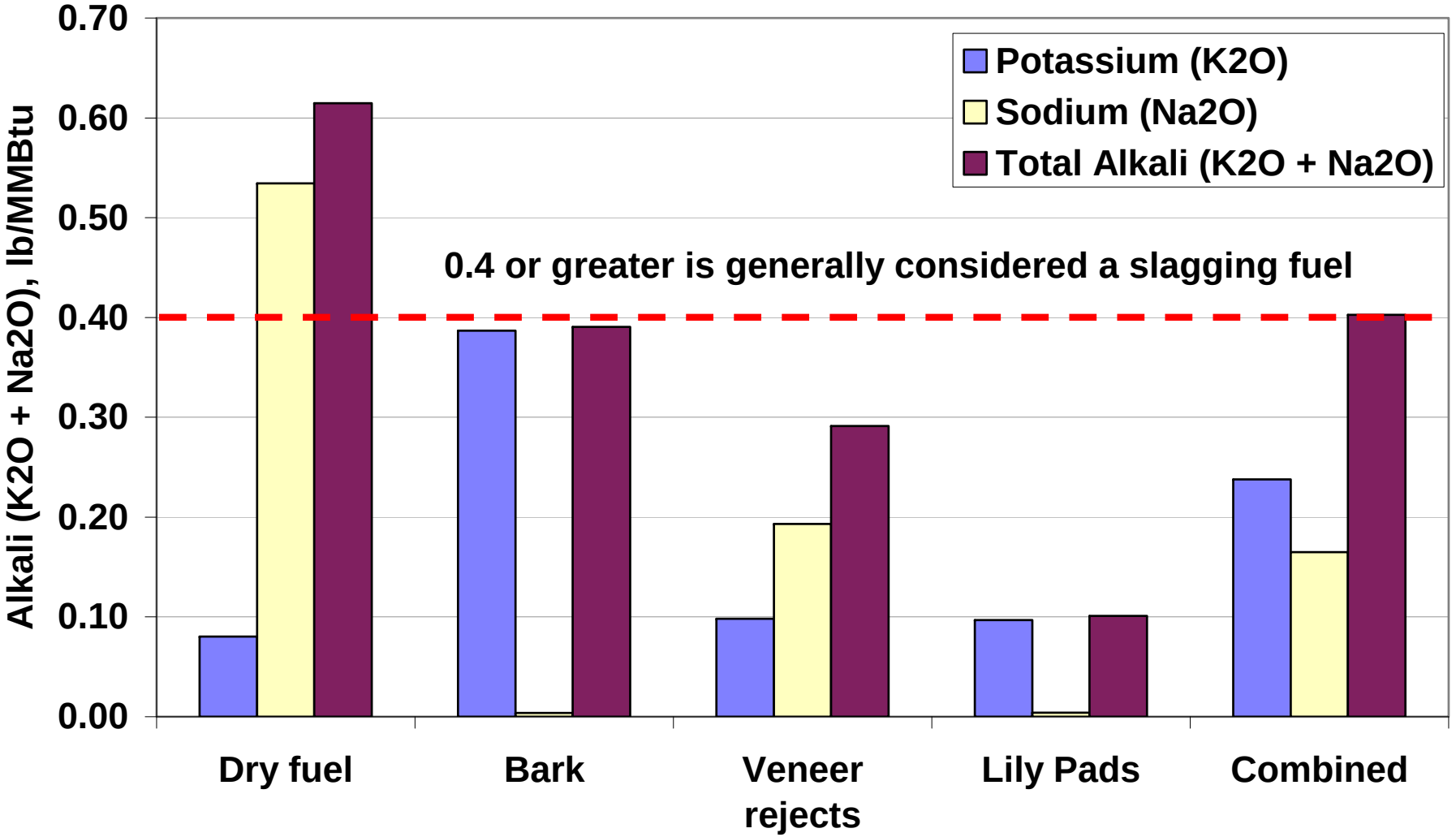
- Dirty hog fuel, bark
- Tree trimming, landscape prunings
- Hardwoods: aspen, poplar on alkali soils
- Resinated wood, MDF or particleboard trim

Potassium is a Principal Cause of Slag and Clinkers.

- Associated with annual growth.
- Found in bark (cambium), leaves, needles, and juvenile wood.
- Potassium and sodium salts can also be found in resins from board products – sander dust, trim, waste
- Potassium and sodium behave in the same way in a boiler: they vaporize at low temepratures.

Alkali content of fuel

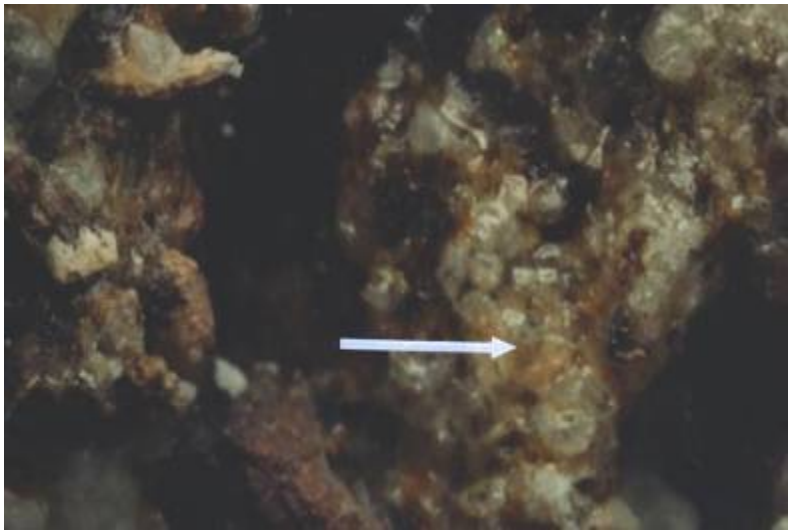
(April 2006 samples)

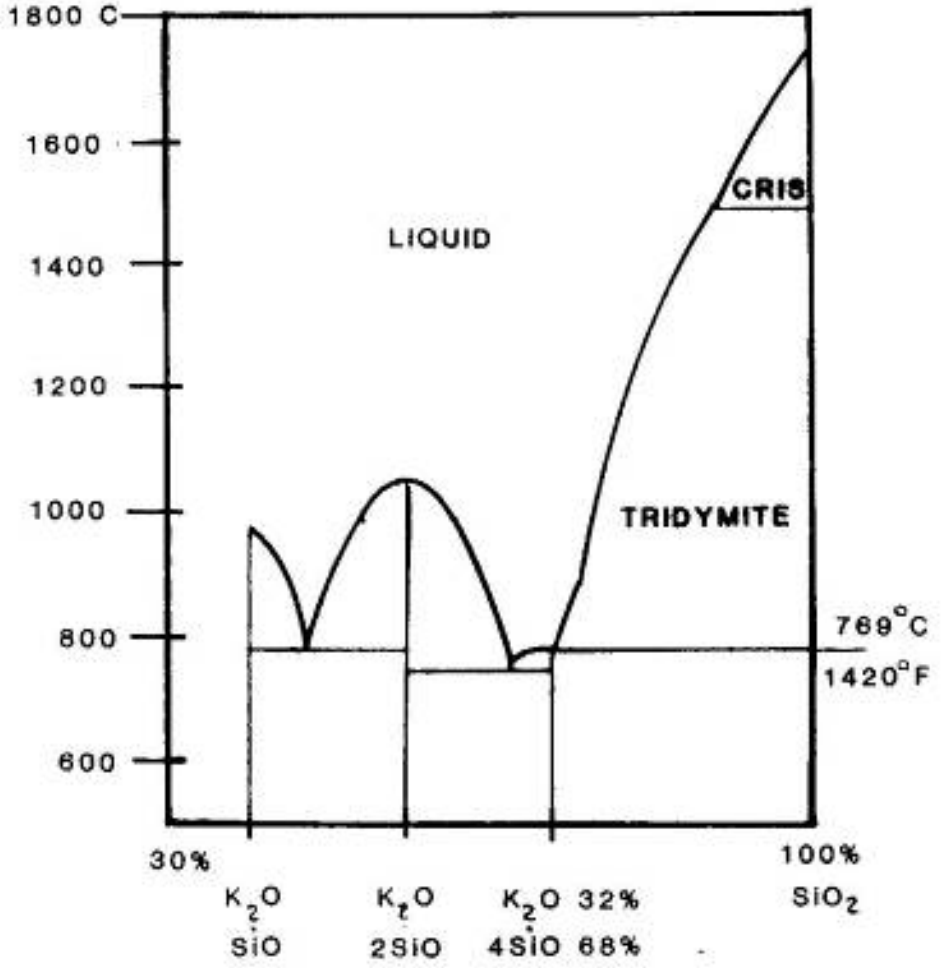


Clinkers Often Form Where Local Temperatures Are High

- On grate
- At air jets
- At flame impingement points
- From char carryover or afterburning
- When boiler/furnace is hot, economizer or convection passes plugged, low gas flow and low cooling in boiler

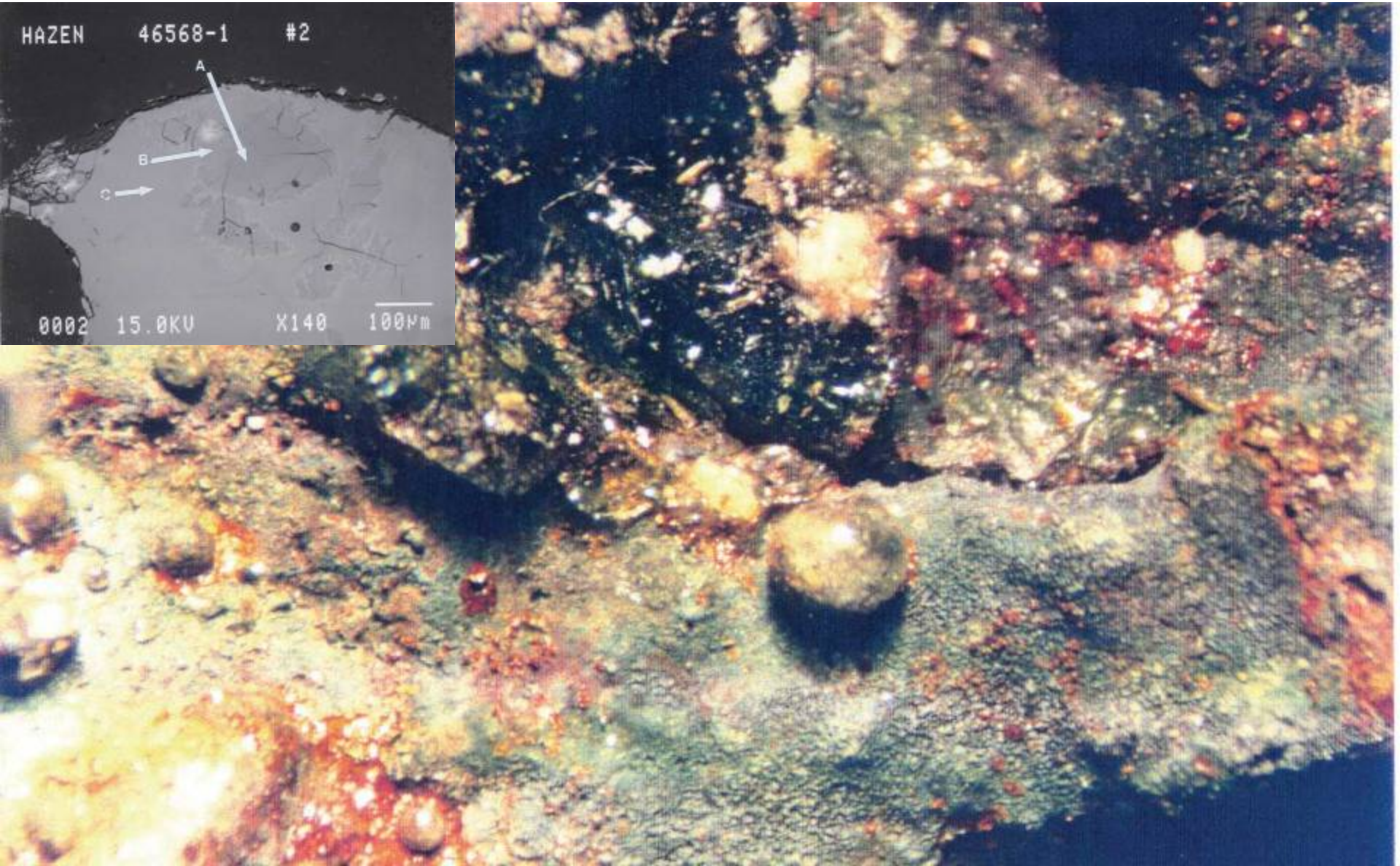
Fuel Ash: Melted Potassium and Sodium React With Silica to Cause Slag





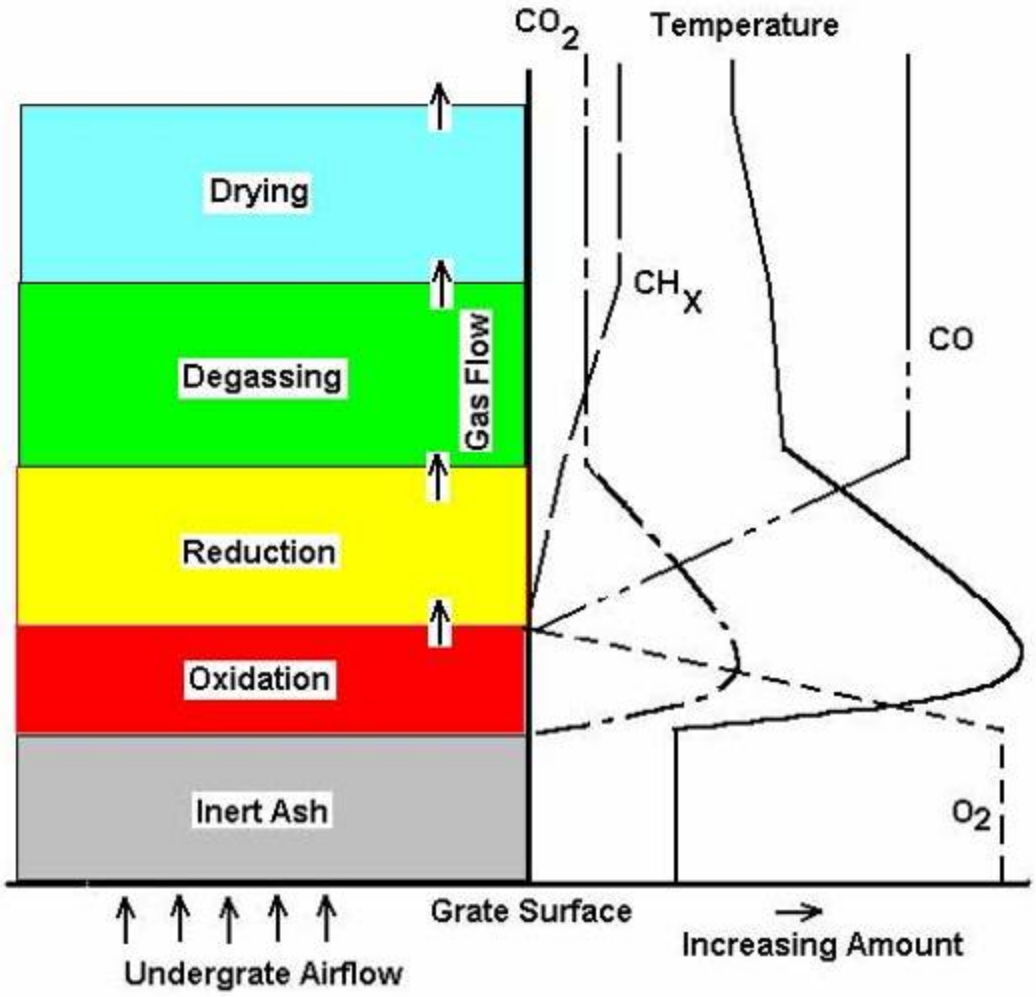
PHASE DIAGRAM FOR K_2O-SiO_2

Grate Clinkers Are Often Fused Potassium and Silica Compounds



Sintered Clinker from Grate Formed at Rear Boiler Wall, Spreader Stoker Travelling Grate

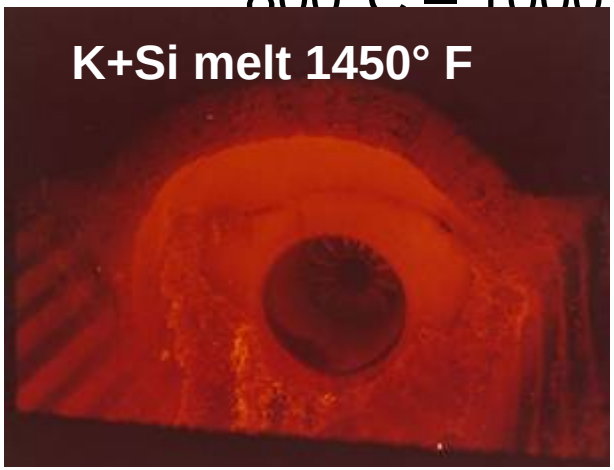
Slag Forms In Deep Bed With Too Much Undergrate Air: Alkali Released During Char Oxidation When O2 is at Particle Surface

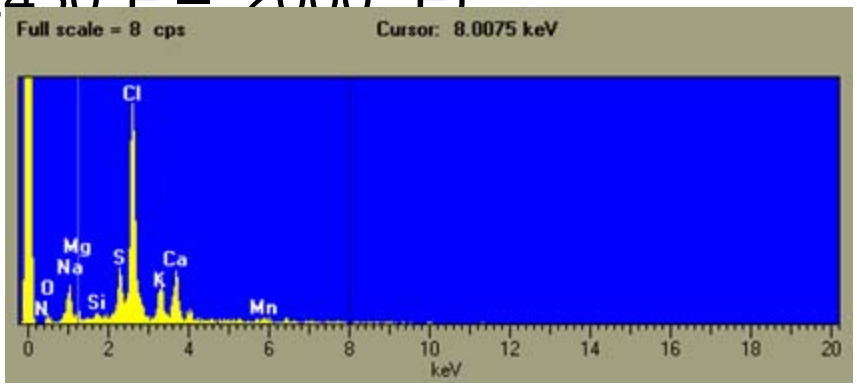


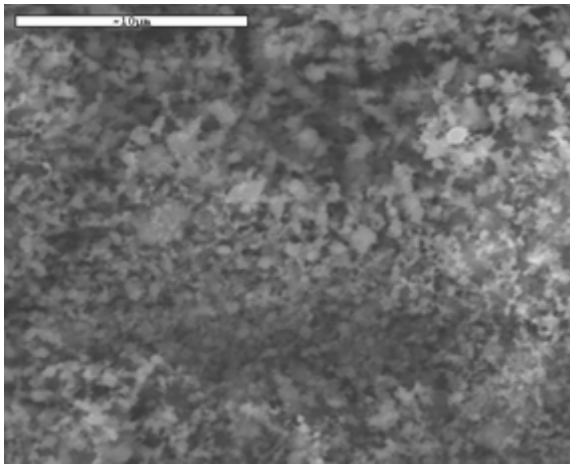
Potassium, Chlorine and Sulfur Vaporize and Condense to Form Fine Sticky Particles

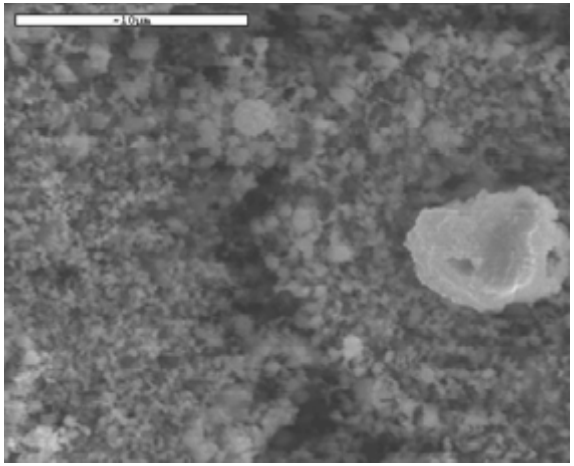
60% -80% released at Combustion Temperatures

800°C – 1000°C (1450°F – 2000° F)

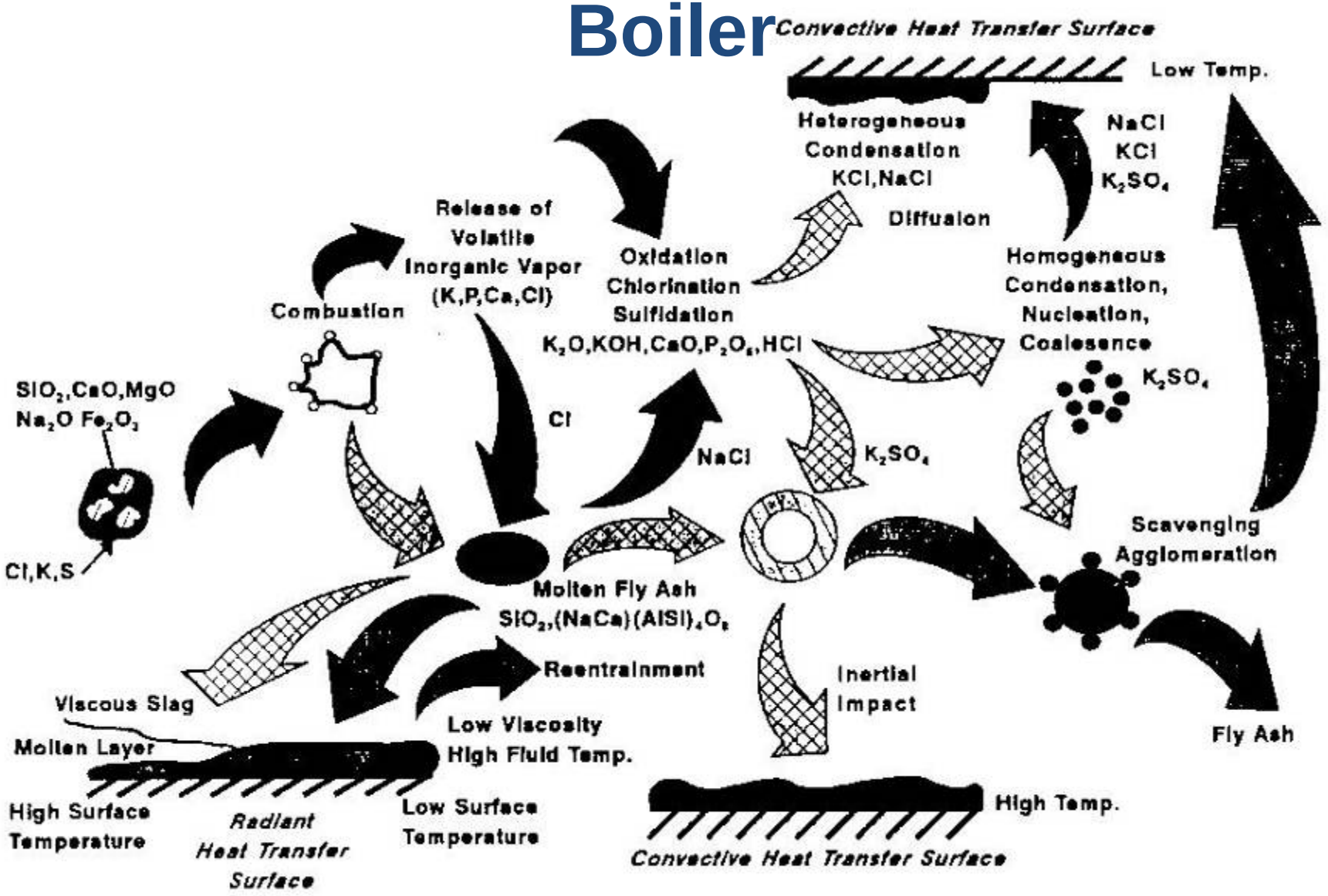




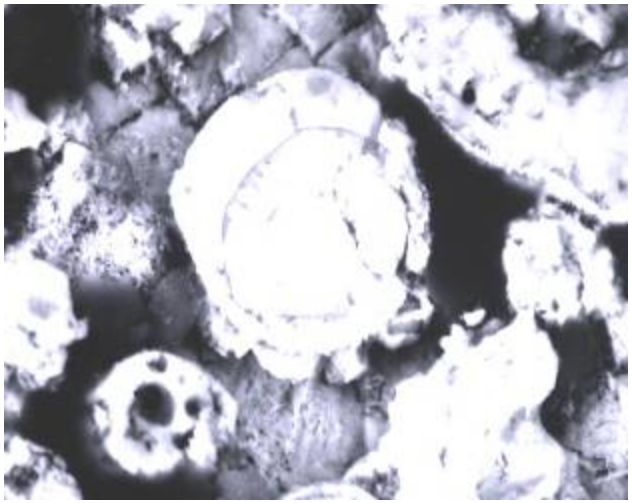


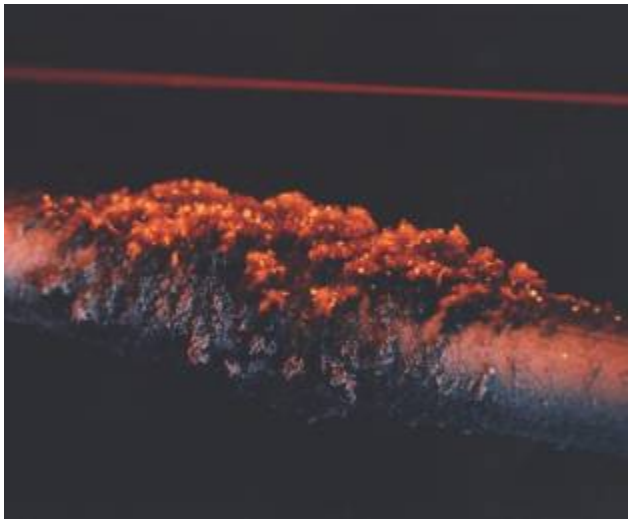


Combustion and Cooling Modify Fuel Chlorine, Potassium and Sulfur in the Boiler



Hit and Stick: Deposits Form By Impact of Sticky Particles



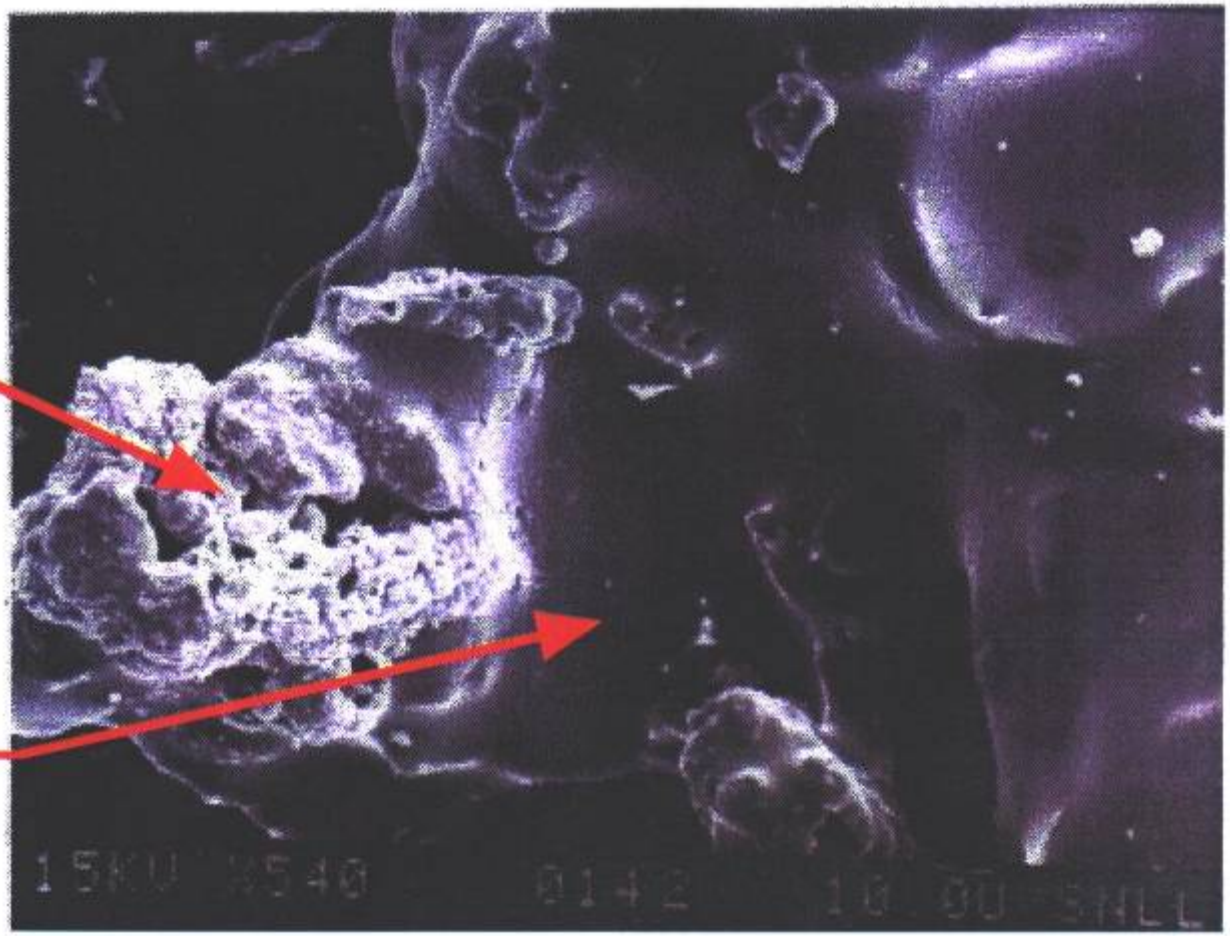


Potassium Concentrations in Clinkers Can Increase and Melt With Time

MFC Sample of Rice Straw Deposit

Principally Silica (Si:K ≈ 27:1)

Principally Potassium Silicate Si:K ≈ 3.6:1)



Furnace Operations Affecting Slagging and Fouling

- **High Temperature**
  - At the grate
  - At air Jets
  - At furnace exit
- **Poor Fuel Distribution (piling)**
  - Causes reducing conditions (Hi CO)
  - Concentrates high ash components
- **Infrequent Boiler Cleaning Enhances Buildup**
  - Slag removal
  - Soot blowing

Boiler Operation to Reduce Slagging

- Maintain low temperatures at the grate with air control and uniform fuel load
- Control boiler for lower target furnace exit temperature
- Avoid high peak temperature excursions due to changes in fuel, load,
- Use frequent mechanical cleaning
- Avoid over-heating fouled ducts

Fuel Management to Control Slagging

- Eliminate worst acting fuel components
- Dilute “dirty” fuel with clean fuel
- Screen to remove fines
- Schedule worst fuels just prior to scheduled outages
- Schedule fuels in a known “firing sequence” or blend
- Ash chemical analysis: monitor fuels for chemical content (Na, K, total chemical content (Na, K, total salt, Chlorides)
- Blend fuels based on potassium, sulfur, chlorine and silica content

FUEL QUALITY RECOMENDATIONS

- Size fuel with hammermills and screens
- Know the best moisture content for the boiler
- Blend fuels for uniform density.
- Screen or separate ash, dirt and foreign matter form fuels. Avoid leaves and needles from annual growth.