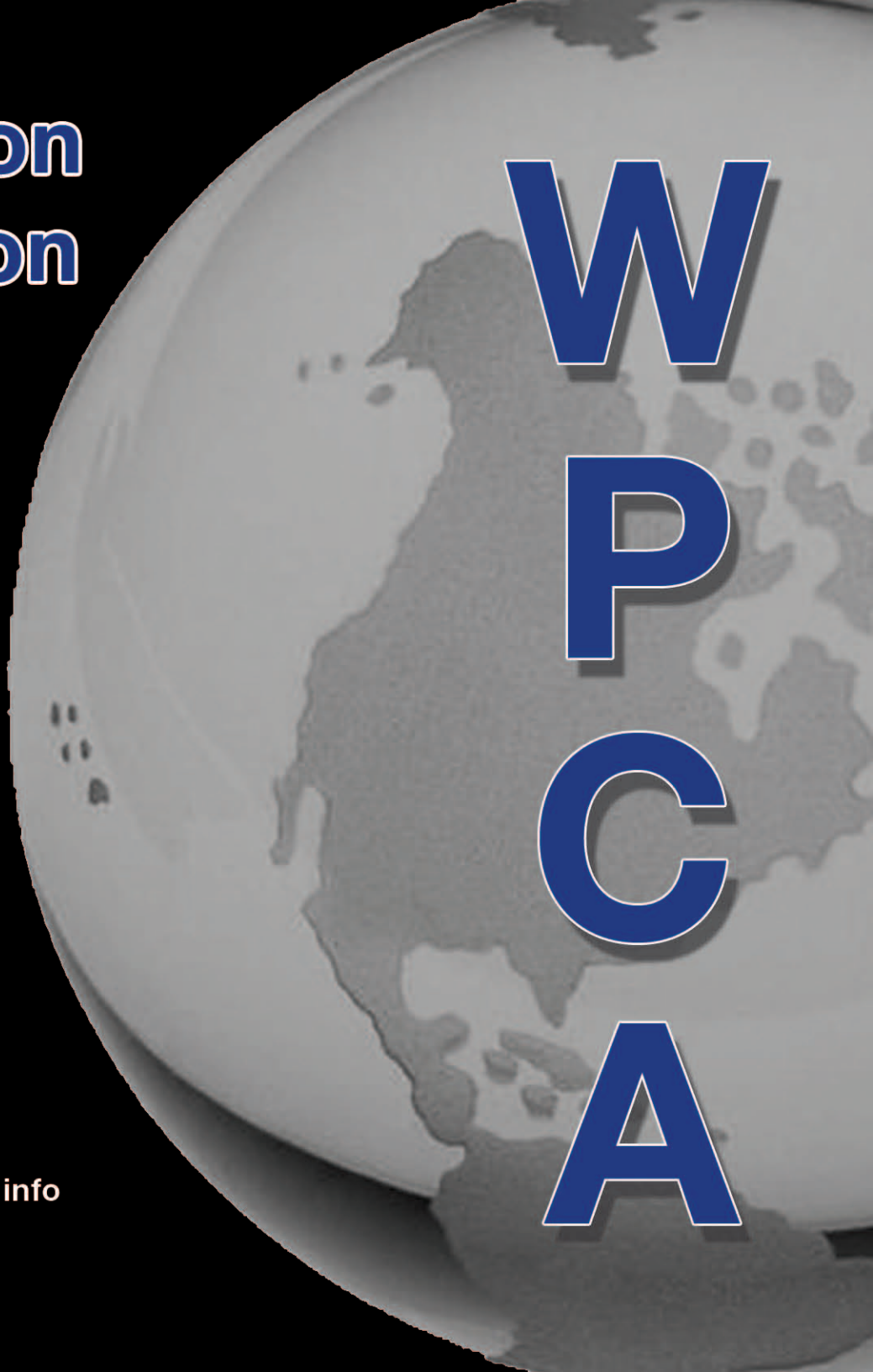
Worldwide Pollution Control Association



Dry Scrubbing O&M Training

APC/PCUG Conference
July 12-16, 2009
The Woodlands, TX

WPCA

Visit our website at www.wpca.info

power generation group

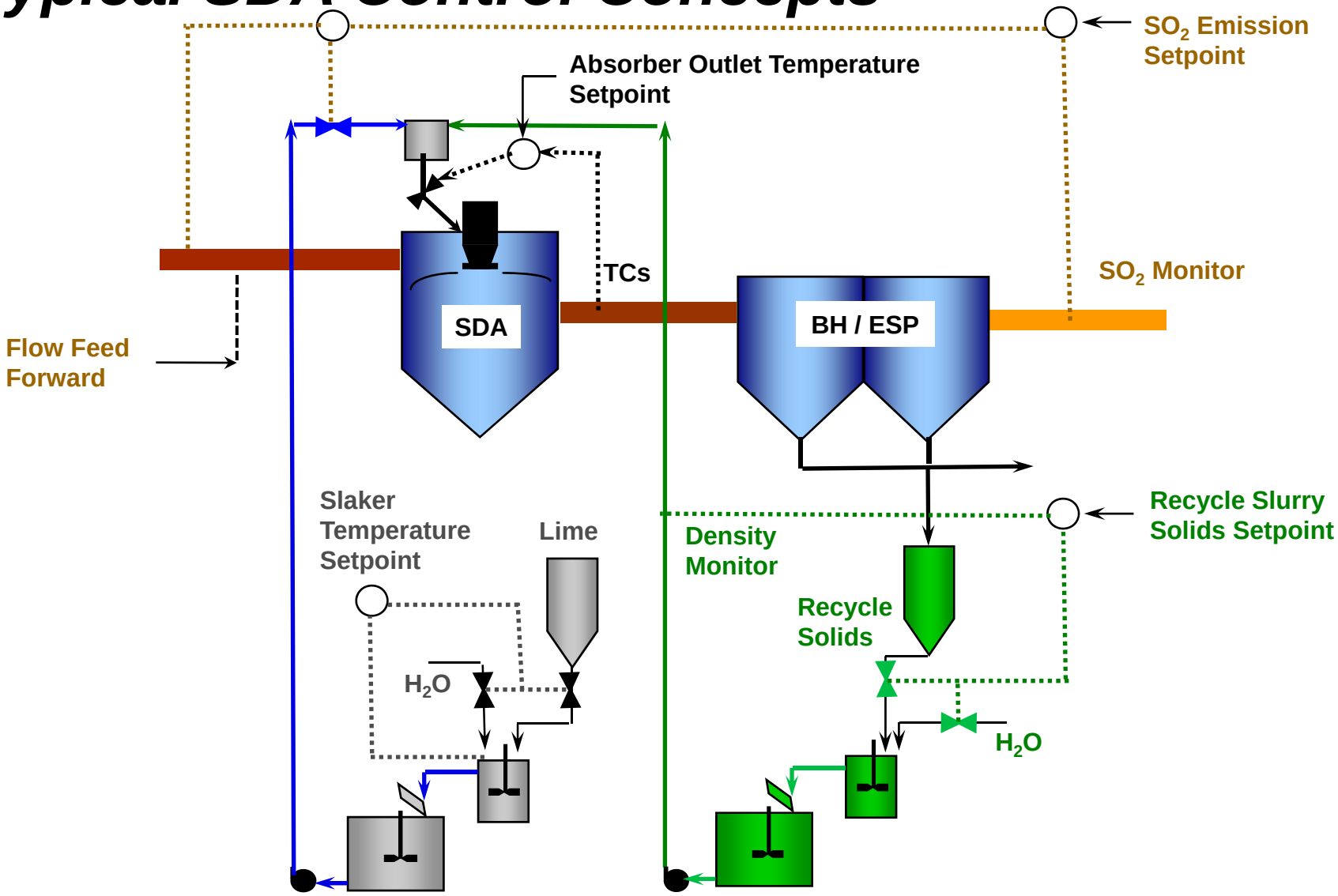
Spray Dryer Absorber O&M Considerations

WPCA Dry Scrubbing O&M Seminar
The Woodlands, Houston, TX
July 12, 2009

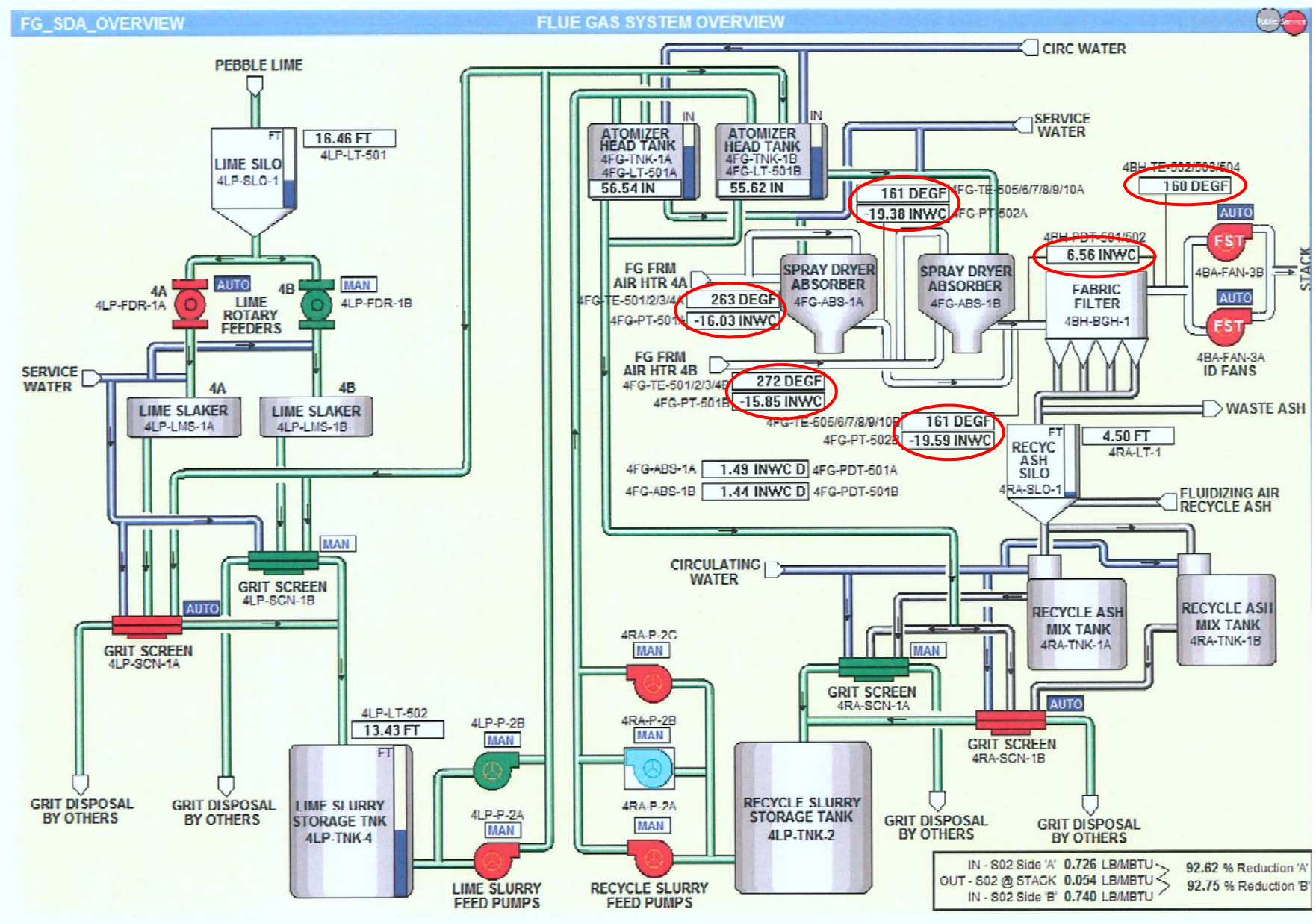
SDA Operations & Maintenance

- Key SDA Operating Considerations
- Boiler Load Following and Ramping
- SDA Byproduct Properties
  - Fly Ash Pre-Collection Impacts
- SDA Byproduct Handling Systems
- Process Upsets
- Troubleshooting Tools and Experience

Typical SDA Control Concepts

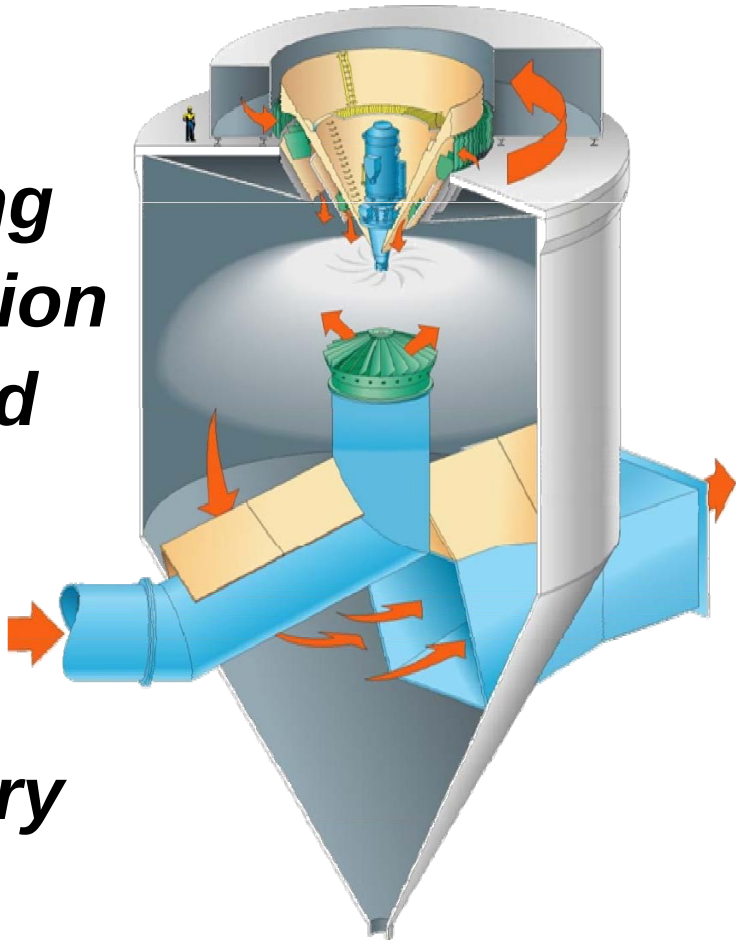


Instrument verification is critical for optimal performance



Important Control Considerations

- ***SDA outlet temperature response time***
- ***Safe operating temperature is function of slurry solids loading***
- ***Maintain margin above saturation***
- ***"Chemistry" generally not used for process control***
  - ***Byproduct moisture***
  - ***Cl in byproduct***
  - ***Conductivity of recycle slurry***



What Determines SDA Consumables?

Lime Use

Inlet conditions, lime and water quality and required performance

Pressure Drop

Flue gas flow and conditions, arrangement, SDA selection, FF design and operation

Power Consumption

Gas flow and temperature, slurry solids loading and flow

Water Use

Gas flow and temperature, spraydown

Typical Lime Specification

- *High calcium quicklime (CaO)*
- *Particle Size*

  ¾ inch x 0 with no more than 50% less than 10 mesh
- *Availability*

  90% CaO or greater per ASTM C25
- *Reactivity*

  40° C temperature rise or greater in 3 minutes

  Total temperature rise in 10 minutes max

  ASTM C110
- *Chemical Analysis*

CaO	*90 – 98 wt.%*
MgO	*0.5 – 1.5 wt.%*
Inerts	*10% max*
LOI	*1.5% max*

Pebble Lime Handling Considerations

- *Design for minimizing particle break-up in transport*
  - *Minimize transport distance*
  - *Long sweep elbows*
  - *Silo target box design*
- *Size slaker feed for expected particle size distribution at feeder rather than delivered lime specification*
- *Provide for slaking water heating to optimize slaker performance*

Load Ramping

- *Increasing load – increase lime slurry flow in manual control ahead of load*
- *Automatic control - feed forward*
  - *Stack gas flow or MW output - too late*
  - *Flue gas temperature - too variable*
  - *"Compensated" coal flow recommended*
- *Avoid "valves wide open" operation*
- *Rapid load drop*
  - *May see solids drop out in SDA w/o a solids handling system under SDA*
- *Emissions averaging period considerations*

SDA Byproduct Considerations

- *No "byproduct quality control" step in the SDA FGD process as incorporated in WFGD gypsum production*
- *Trace elements from coal, flue gas, lime and process water streams end up in byproduct*
- *Byproduct quantity and composition does not vary widely over normal anticipated range of SDA operating conditions*

Byproduct Generation Rule-of-Thumb

Ratio of lb byproduct solids / lb SO_2 removed

2.5 to 3.0

- ***Excluding fly ash***
- ***2.5 is good first estimate for Western coals***
- ***0.2 to 1.0 % S in coal***
- ***90 to 94% SO_2 reduction***

SDA Operation Impact on Byproduct Solids

Increase SO_2 removal by increasing lime use

% Removal	Byproduct Solids	% $Ca(OH)_2$
80	-2.5%	0.09
85	-1.3%	0.16
90	Base	0.27
95	+1.5%	0.50

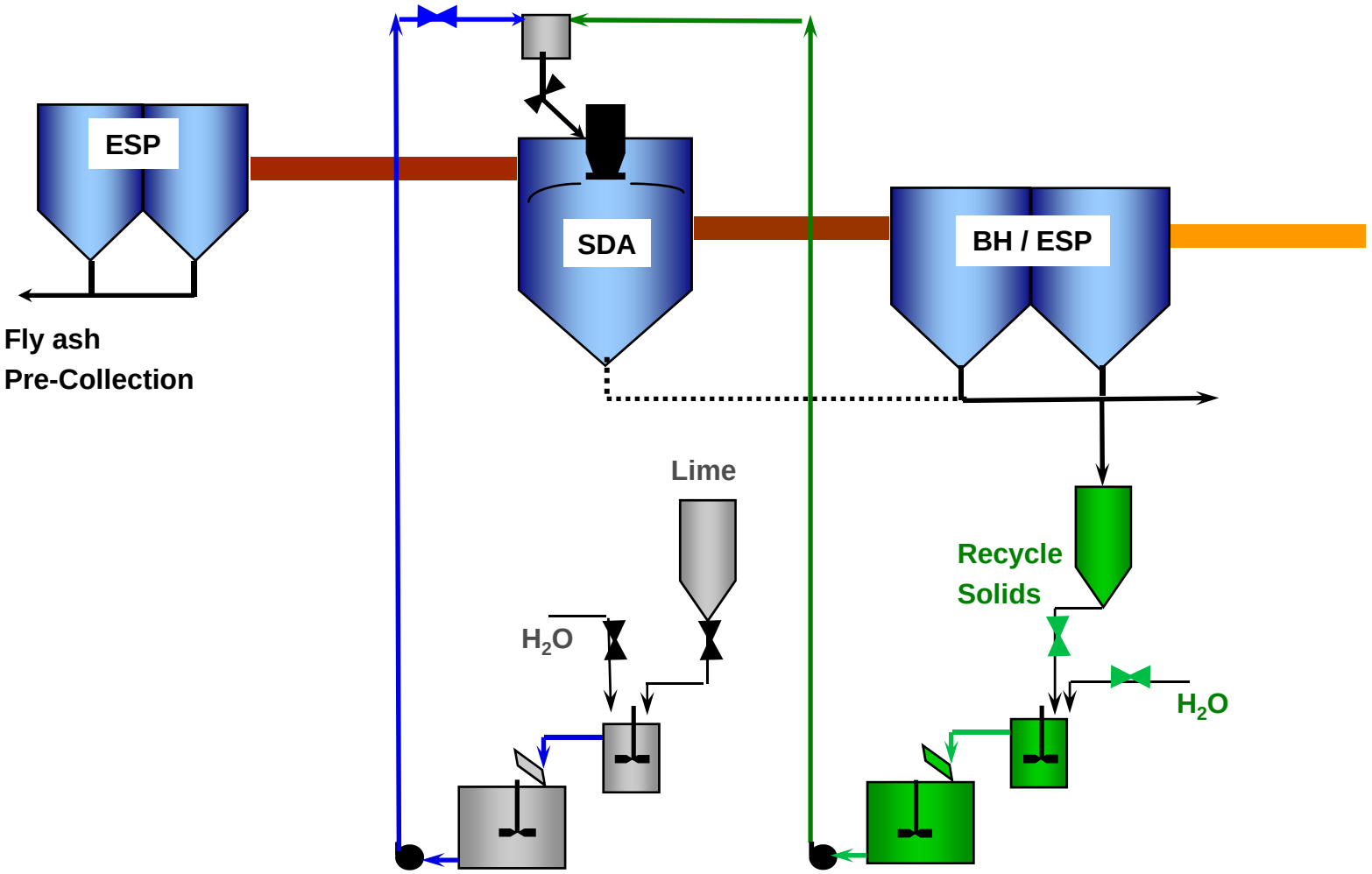
35 F Approach Temperature

Reduce lime use by lowering temperature

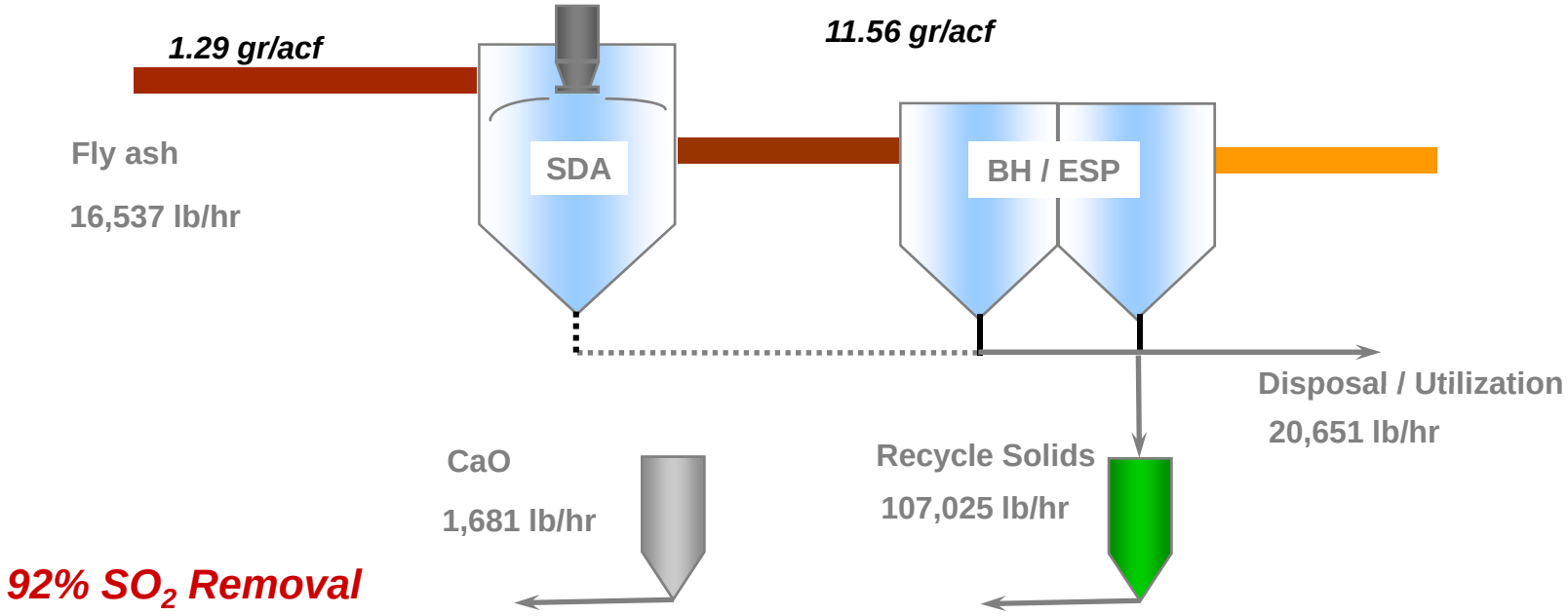
Approach Temperature	Byproduct Solids	% $Ca(OH)_2$
25	-0.3%	0.14
30	-0.2%	0.20
35	Base	0.27
40	+0.2%	0.37
45	+0.4%	0.47
50	+0.6%	0.60

90% SO_2 Removal

Fly Ash Pre-Collection



Solids Mass Balance w/o Pre-Collection

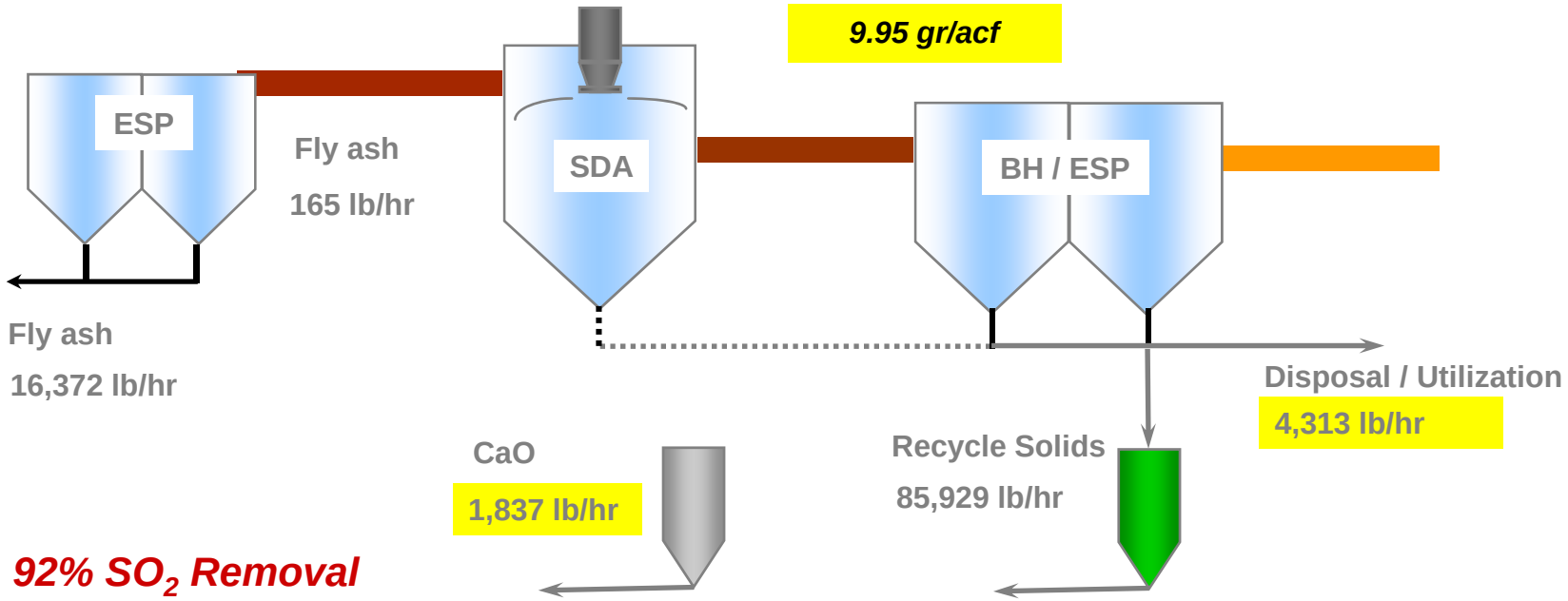


92% SO_2 Removal

By-product / Recycle Solids Composition (wt. %)

Fly Ash	*79.75*	*Inerts*	*0.62*
Free Water	*1.00*	*Crystal Water*	*1.77*
$CaSO_3$	*13.25*	*$CaSO_4$*	*2.73*
CaF_2	*0.00*	*$Ca(OH)_2$*	*0.34*
$CaCl_2$	*0.16*	*$CaCO_3$*	*0.38*

Solids Mass Balance with Pre-Collection

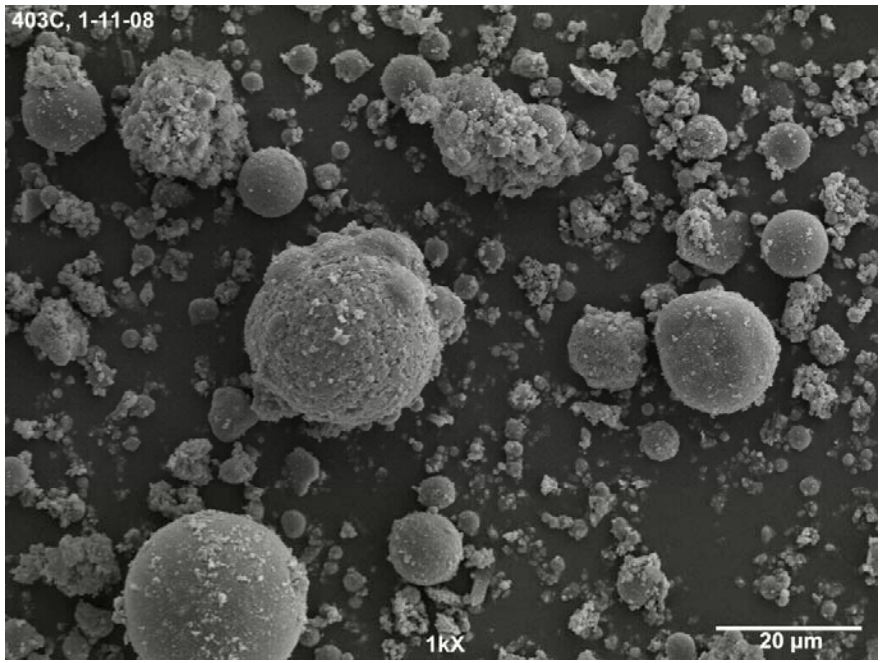


92% SO_2 Removal

By-product / Recycle Solids Composition (wt. %)

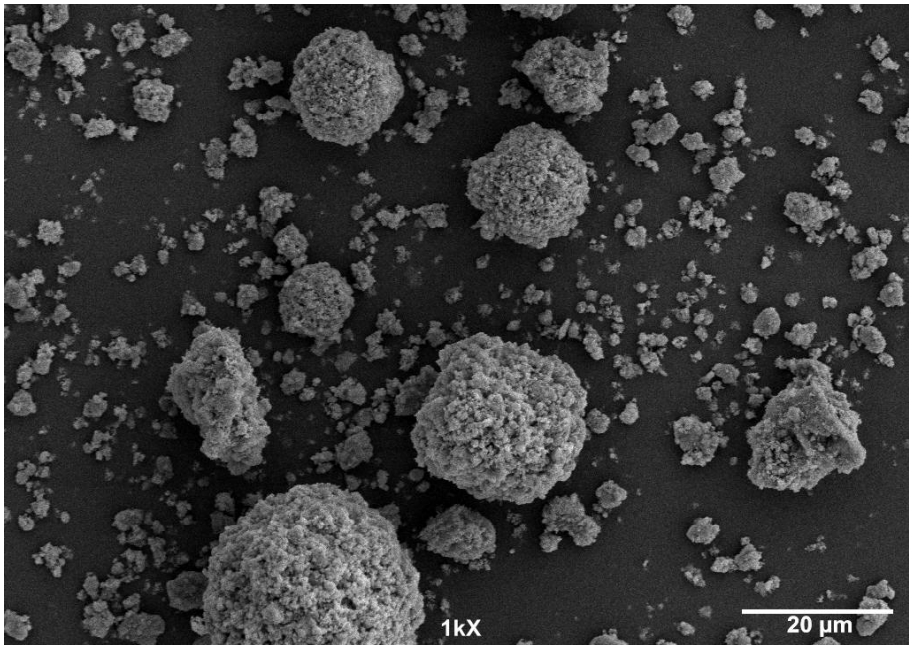
Fly Ash	4.28	Inerts	4.55
Free Water	1.00	Crystal Water	8.37
$CaSO_3$	62.70	$CaSO_4$	12.91
CaF_2	0.00	$Ca(OH)_2$	3.91
$CaCl_2$	0.76	$CaCO_3$	1.53

SDA Byproduct Solids



Without Ash Pre-collection

With Ash Pre-collection



SDA Byproduct - Key Material Properties

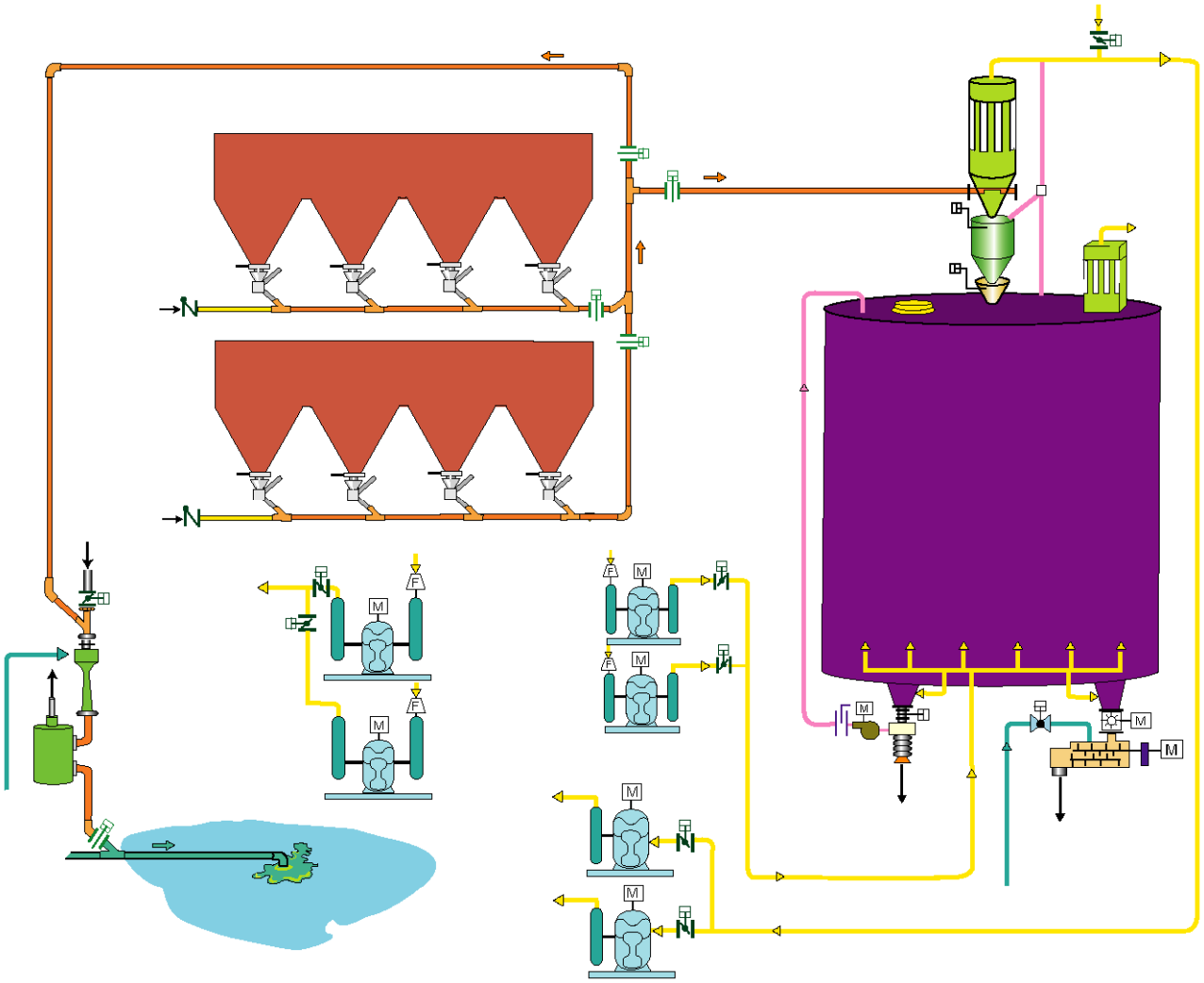
	No pre-collection		Fly ash pre-collection
	Range	Average	Average
Particle Size, D90 µm	34 – 71	47	7
Particle Size, D50 µm	3 – 16	6	2
Particle Density, bulk density lb/ft^3	37 – 42	39	30
Particle Density, tap density lb/ft^3	61 - 71	64	44

Comparison based on limited fly ash pre-collection sample data

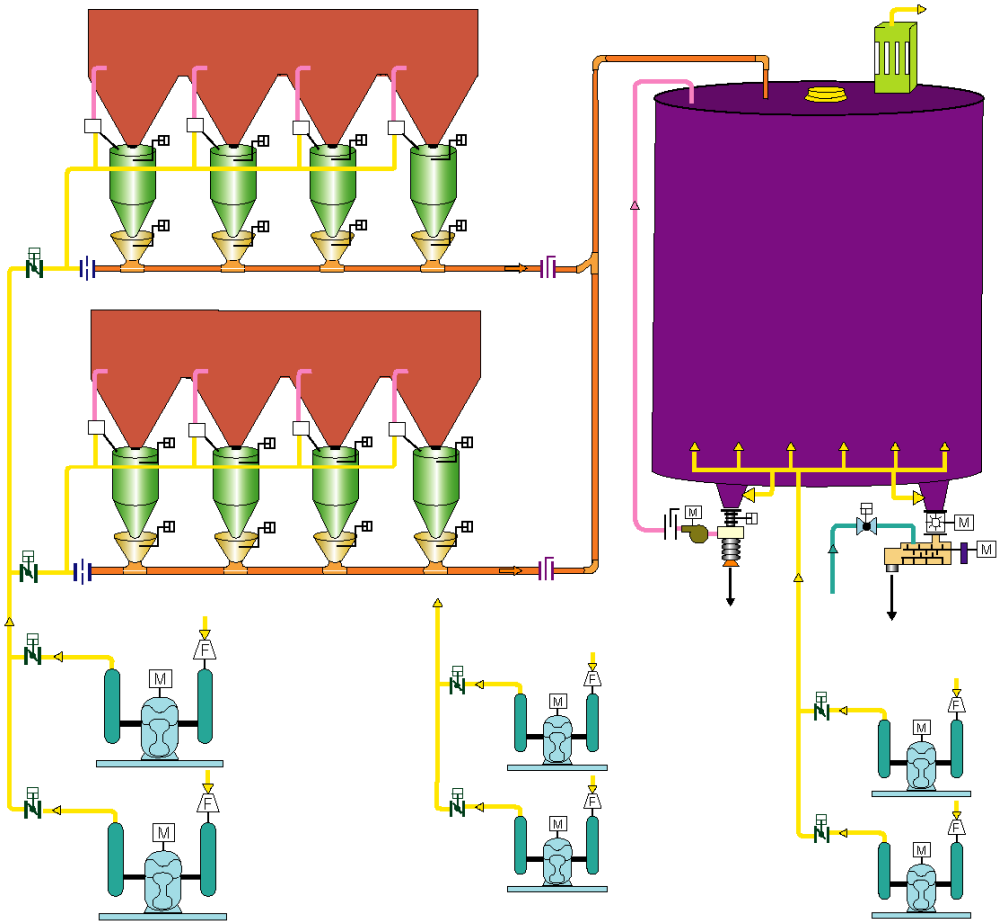
Fly Ash Pre-Collection Impacts

- ***Need byproduct handling system flexibility***
  - ***Capacity with pre-collector out of service***
  - ***Range of material properties expected***
- ***Changes nature of the solids***
  - ***Composition – relatively higher $Ca(OH)_2$ and $CaCl_2$***
  - ***Shape – irregular shapes result in higher void fraction and more interlocking***
  - ***More tendency to cake, but fluidizes easily on aeration***

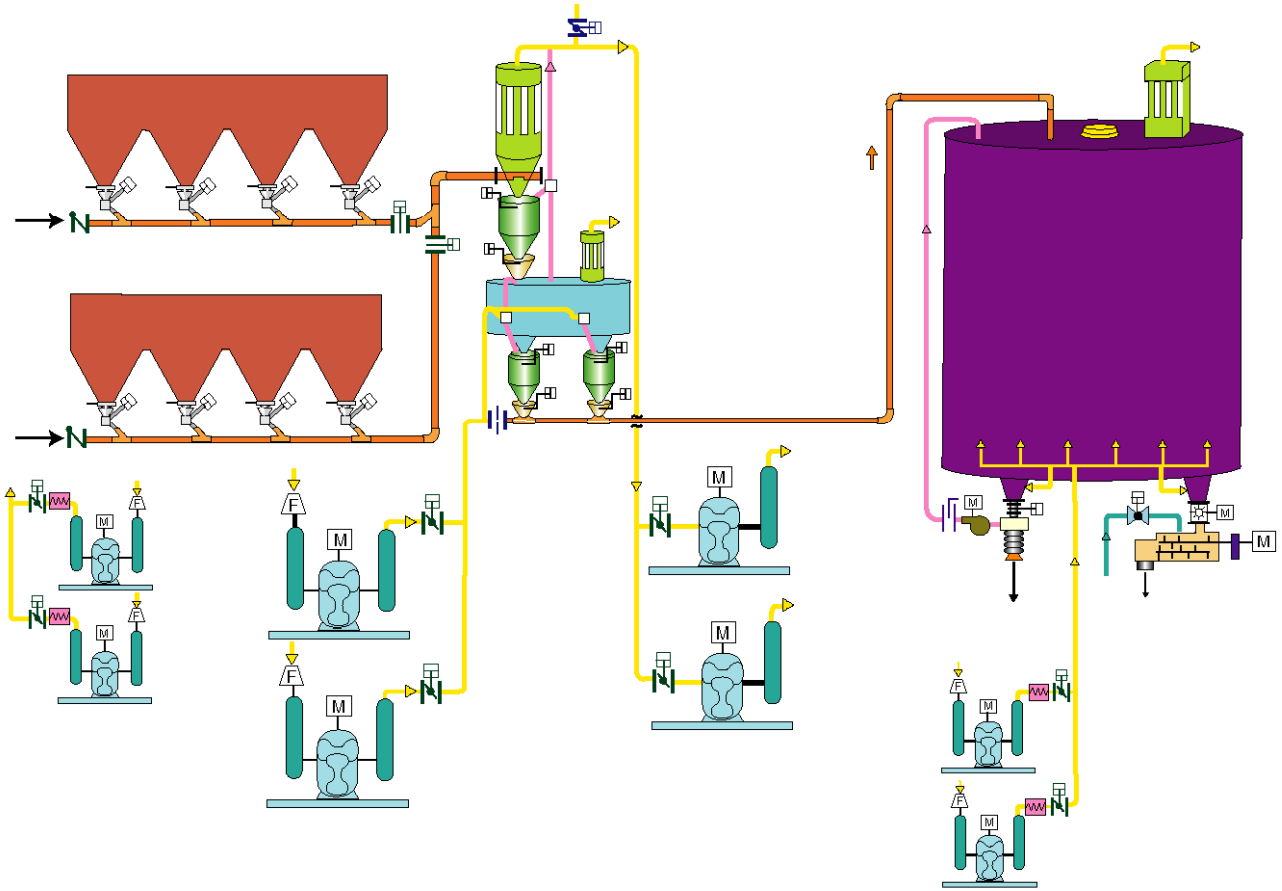
Byproduct Handling – Vacuum System



Byproduct Handling – Pressure System



Byproduct Handling – Vacuum/Pressure System



Byproduct Handling System Comparison

System Feature — Preferred System Design

	Vacuum	Vacuum/Pressure	Pressure
Lower hopper area headroom Required	☑	☑	
Long ash material transport distance		☑	☑
Lower initial cost	☑		
Less hopper area housekeeping	☑	☑	
Higher ash loading capacity			☑
Simplified silo/collection Equipment			☑
Fewer moving parts, less life cycle maintenance	☑		

Byproduct Handling System Considerations

- *Conveying velocity 10 to 20% higher than fly ash system*
- *Good experience with straight drop through valves*
- *Pre-heat conveying lines – maintain warm lines when not transporting solids*
- *Rubber elbows in transport lines can help prevent build-up*
- *Consider insulating transport lines*

Byproduct Disposal

- ***Pug mill conditioner***
  - ***Water added at 12 to 25% by weight with free lime a factor in determining optimal moisture***
  - ***With fly ash pre-collection – may need to add ash back in to the mix to stabilize***
- ***Non-stick surfaces to reduce build-up***

Process Upsets You May Encounter

- ***Low recycle slurry solids***
  - ***Adjust SDA operating conditions to maintain good drying***
- ***Loss of recycle slurry feed***
  - ***Design for lime only operation***
- ***Low SDA inlet temperature***
  - ***May limit ability to add sufficient reagent***

Troubleshooting Tools and Experiences

- Tools to verify operating conditions
- Use of thermal imaging
- Temperature distribution mapping

Slurry Solids Moisture Balance

Moisture Balance Uses

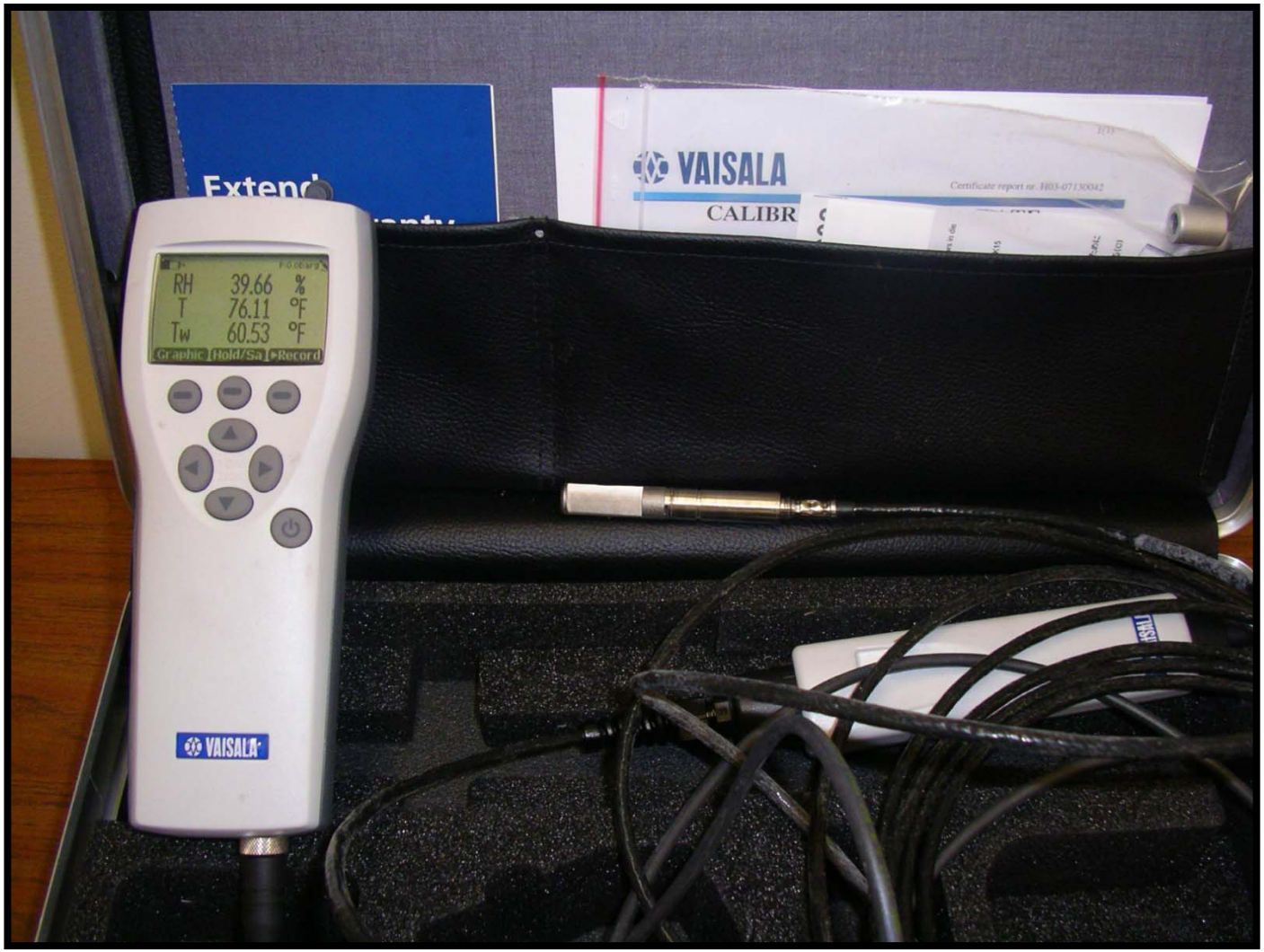
Dry & Weigh Scale

- Confirm lime slurry solids (105C, < 1mg/60sec)
- Confirm recycle slurry solids (85C, < 1mg/60sec)
- Measure slurry and water TDS
- Measure recycle ash moisture content

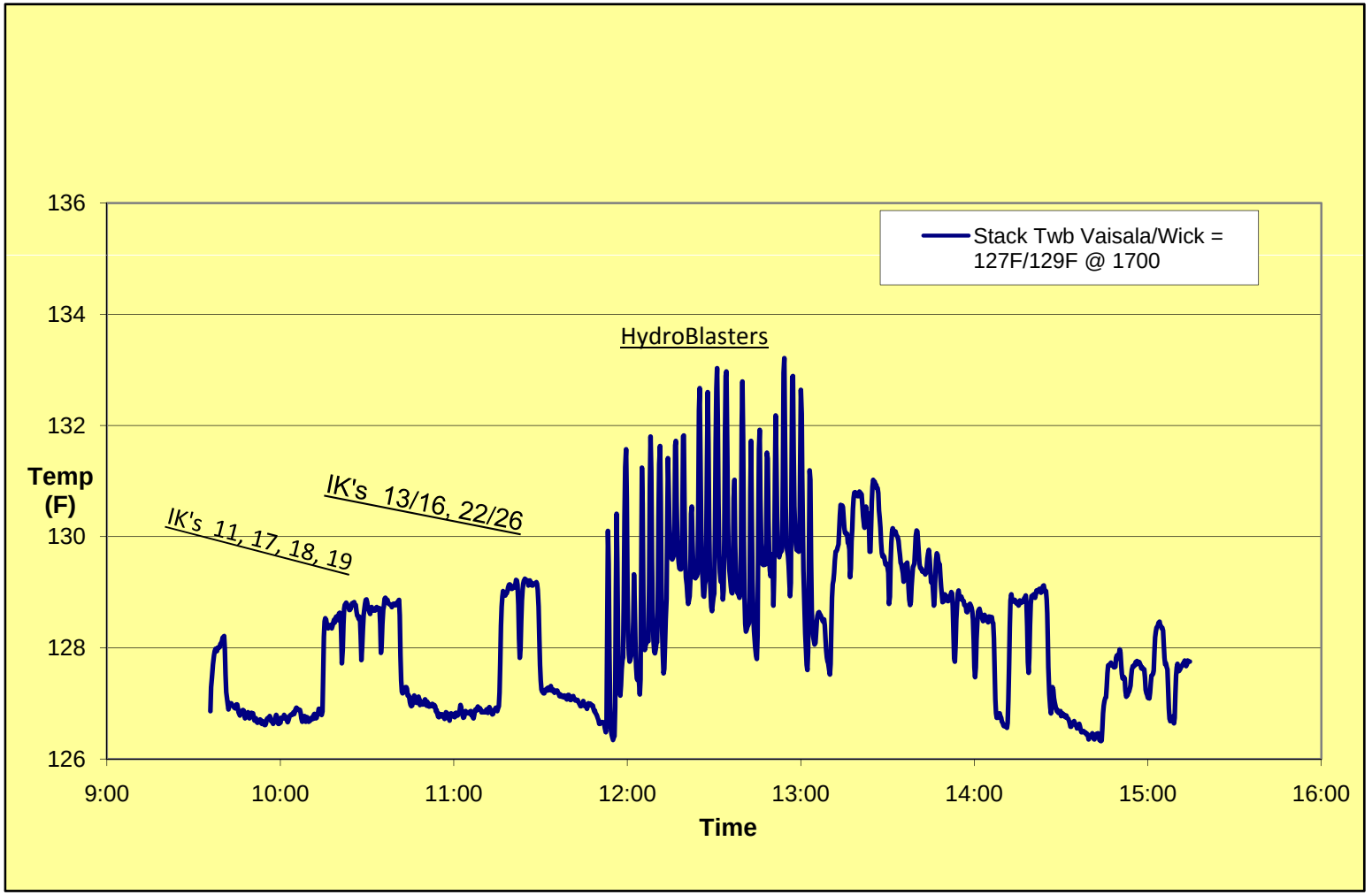
Weigh Scale

- Check slurry density measurement.
- Confirm solids specific gravity constants programmed into density monitor

Wet Bulb Temperature Measurement

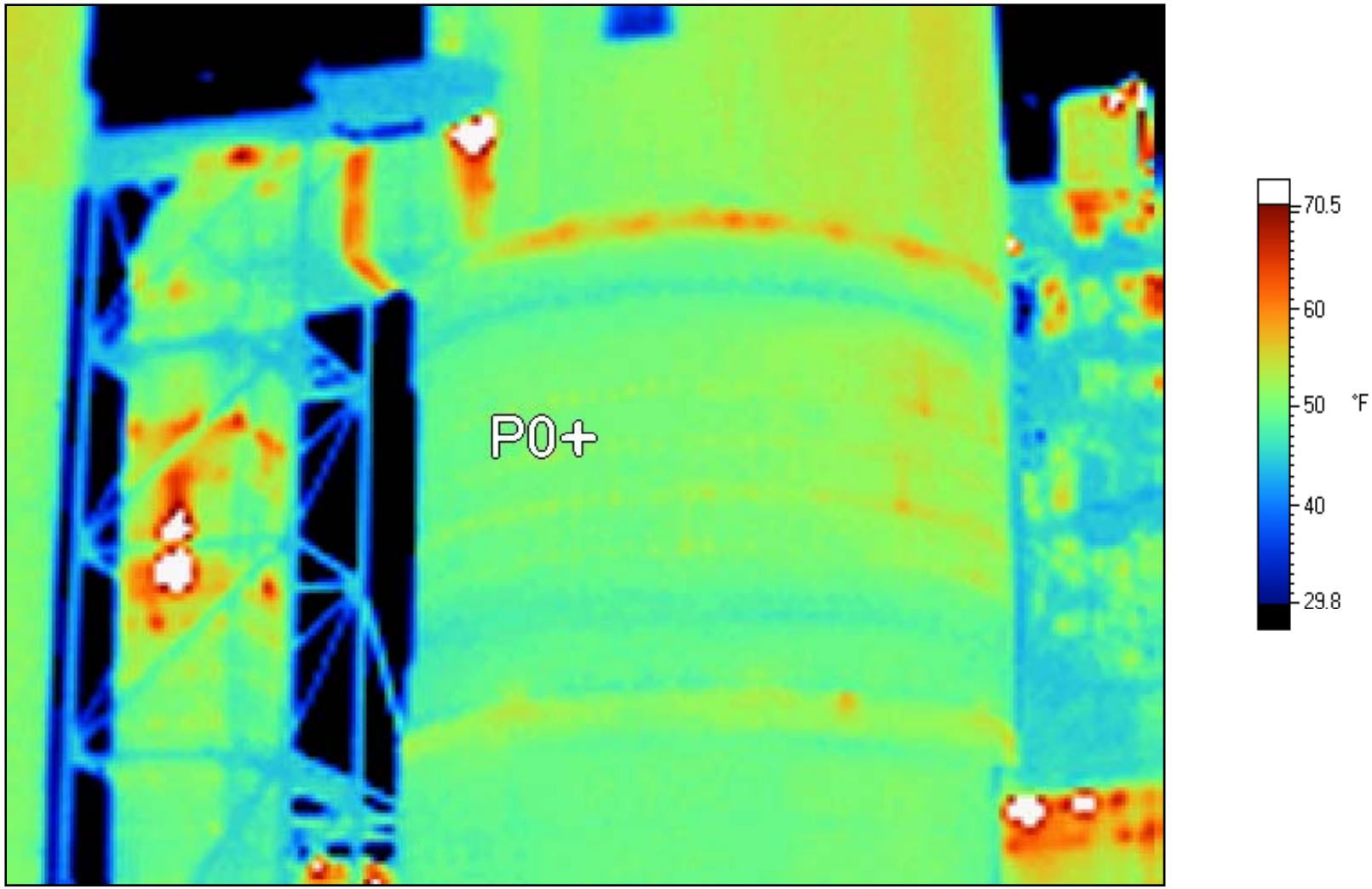


Wet Bulb Temperature Variability

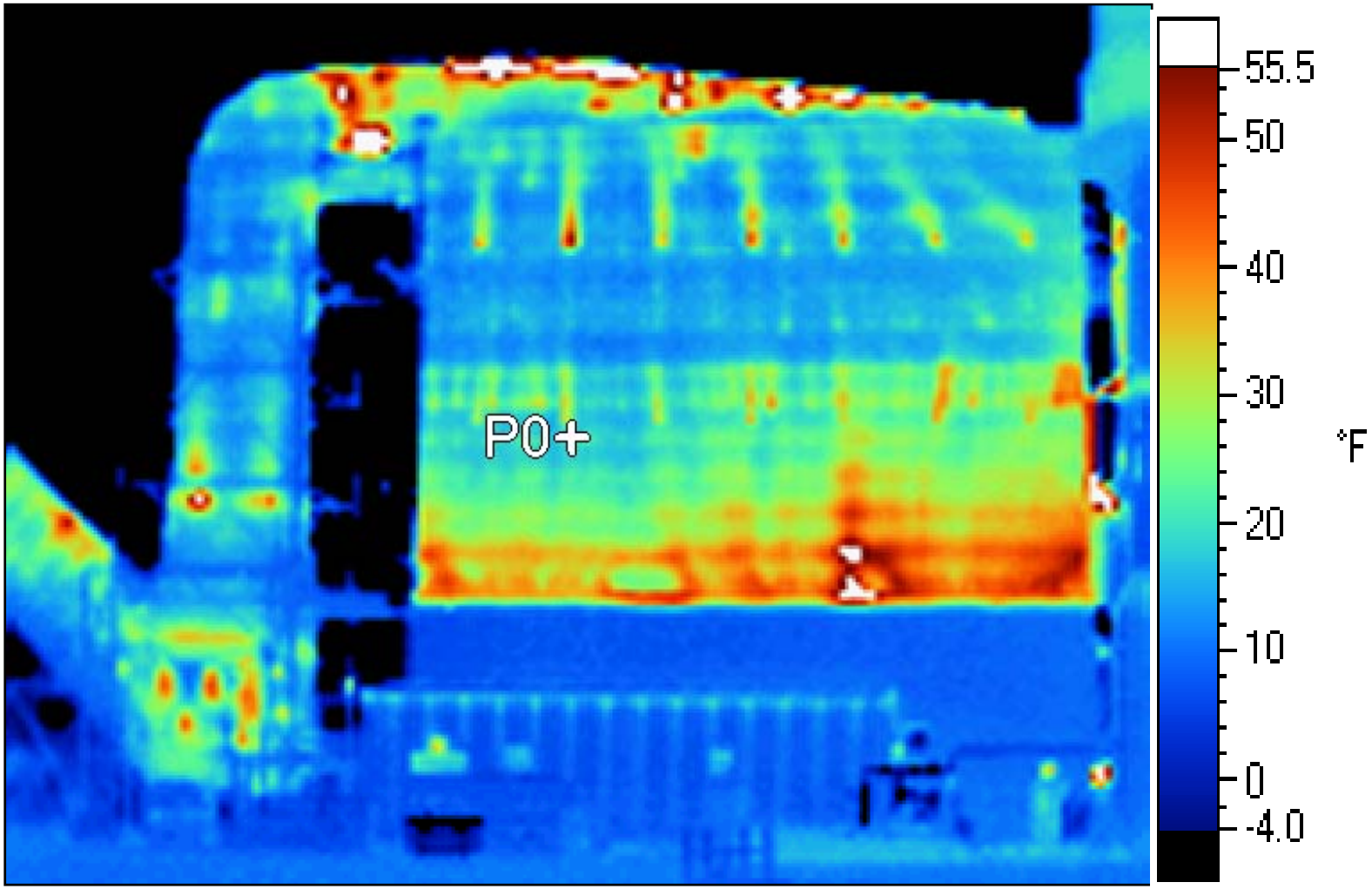


Infrared Thermography

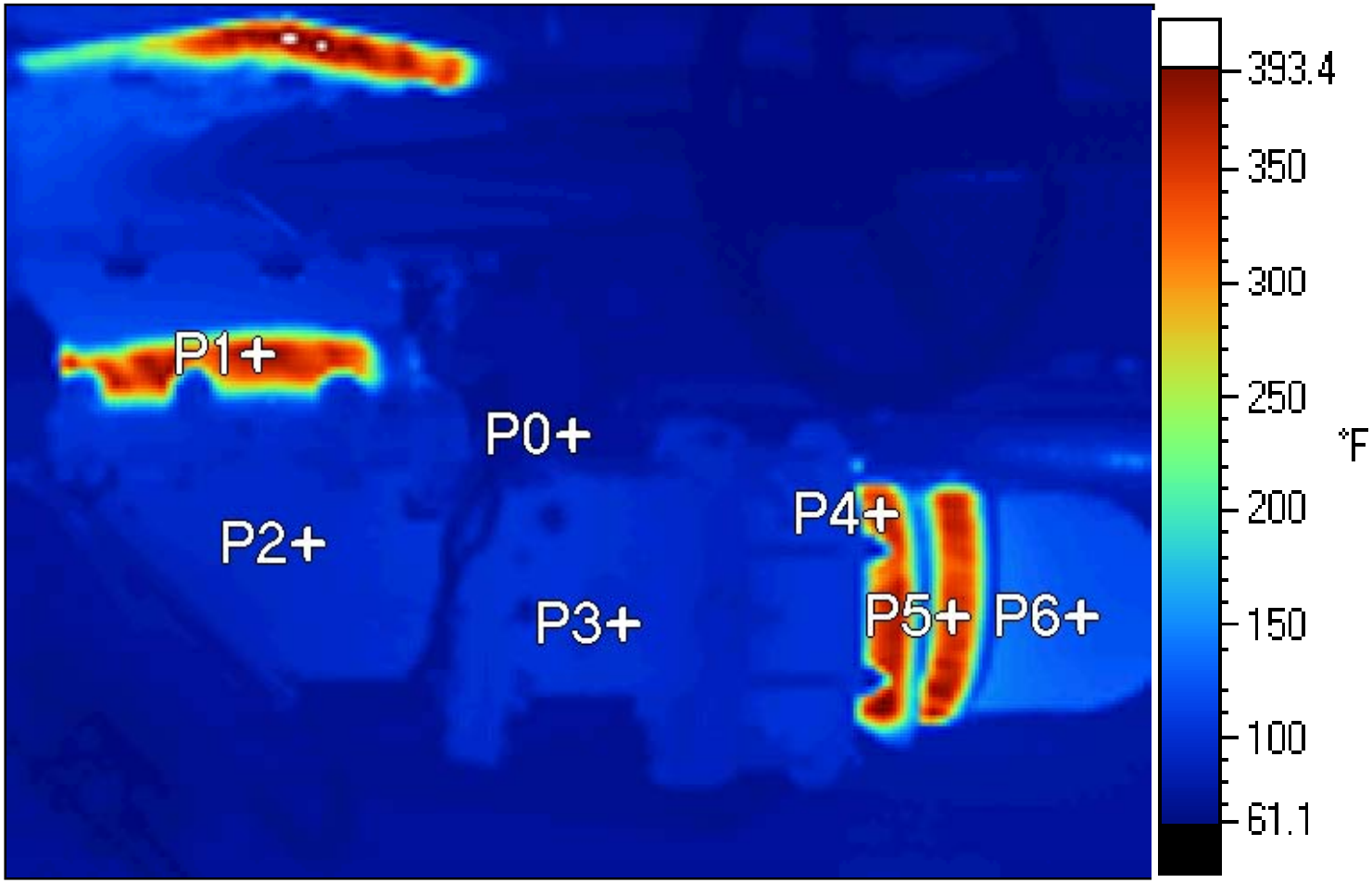
SDA Spray Chamber



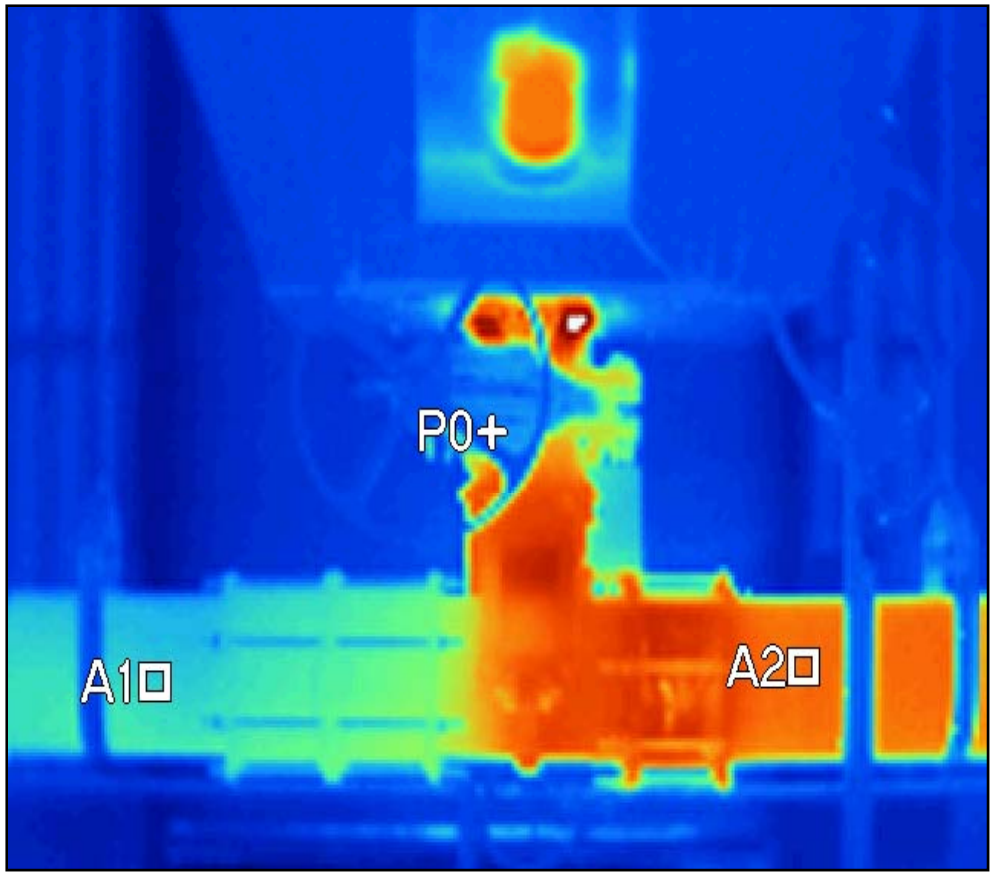
Baghouse Following SDA

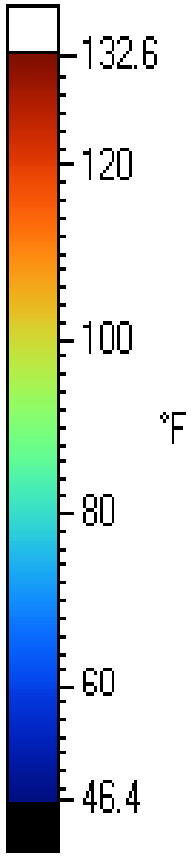


Baghouse Ash Valve Heat Tape



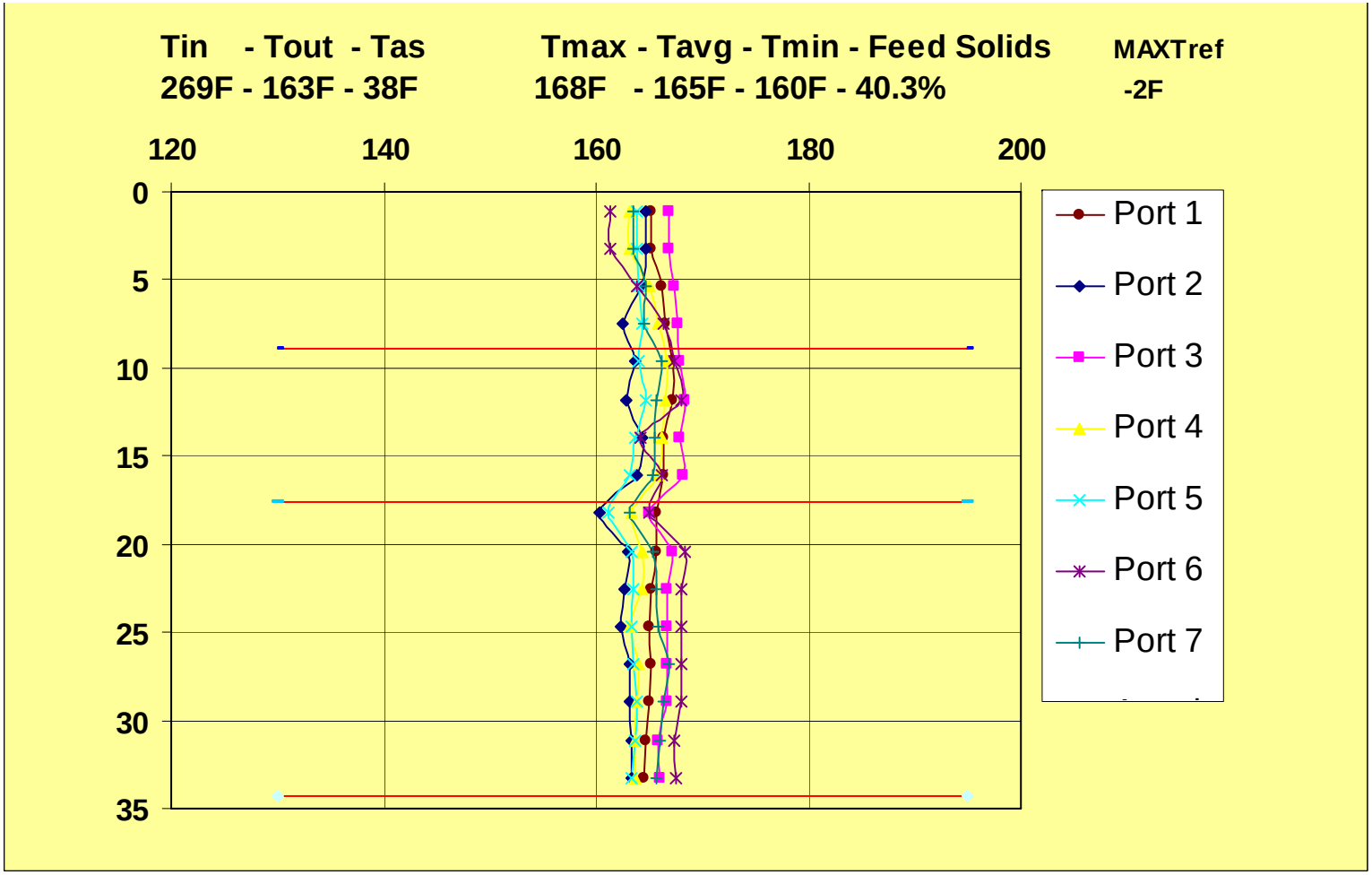
Baghouse Ash Valve and Transport Line





Po =69F
A1 = 79F
A2 = 112F

Confirm SDA Vessel Drying Profile



Things That Can Sneak Up On You

- *Change in water quality*
  - *Strainer, cooler and cooling water line pluggage*
  - *Screen blinding*
- *Fuel change*
  - *May need to modify operations if significant change in Cl*
- *Difficulty in maintaining slurry solids*
  - *Leaking flush valves*
  - *Excessive screen wash or loss of nozzle*
- *Excessive flushing*
  - *Longer and higher pressure flushing is not necessarily a good thing*
- *Instrument calibration*

Key Spare Parts to Consider

- Atomizer assembly
- Miscellaneous key atomizer components
  - Rotary - gear set, spindle, bearings, wheel, nozzles
  - Dual Fluid – end cap, mix chambers, nozzles
- Slurry tanks
  - Agitator gear box
  - Agitator shaft
- Slurry feed
  - Critical hoses and connections

SDA O&M Summary Comments

- *O&M costs – EIA Data – about $1.00/MWhr(net)*
- *Atomizer PM*
  - *Rotary - 1 to 3 month cycle typical*
  - *DFN – weekly inspect and clean*
- *Practice good atomizer parts tracking to optimize spare parts inventory and avoid unplanned maintenance*
- *Experiences and practice with slurry train swapping varies widely*
- *Take advantage of each outage to inspect internals and piping*
- *Establish a long-term corrosion monitoring plan*


Thank You !
Kevin Redinger
B&W