**AMERICAN FOREST &
PAPER ASSOCIATION**

Recovery Boiler Program

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AF&PA Recovery Boiler Committee Meetings and Conference

Tuesday, February 5, 2013

8:30 am - 3:30 pm	Operations and Maintenance Subcommittee Meeting
10:00 am - 3:30 pm	Research and Development Subcommittee Meeting
12:00 Noon - 1:00 pm	Luncheon
4:00 pm - 5:30 pm	Steering Committee Meeting
6:00 pm	Reception - Atlanta Airport Marriott Hotel
7:00 pm	Dinner - Atlanta Airport Marriott Hotel

Wednesday, February 6, 2013

8:00 am	Continental Breakfast
8:30 am	General Assembly – Chairman's Report Karl T. Morency - Georgia-Pacific Corporation
8:40 am	Research & Development Subcommittee Report Christopher L. Verrill – International Paper Company
8:50 am	Operations & Maintenance Subcommittee Report Donald G. Flach – Georgia-Pacific Corporation
9:00 am	Report on BLRBAC Activities Leonard T. Erickson – Boise, Inc.
9:10 am	Report on Recovery Boiler Explosions and Incidents Jules V. Gommi – Gommi Tech
9:20 am	Report on TAPPI Recovery Boiler Subcommittee Activities John D. Andrews, Jr. – MeadWestvaco Corporation
9:35 am	Understanding the Recovery Boilers Smelt Run-off Phenomenon Honghi N. Tran – University of Toronto
10:15 am	Coffee Break

(Over)

Wednesday, February 6, 2013 (continued)

10:35 am	Update on Dissolving Tank Survey Thomas M. Grace – T. M. Grace Company, Inc.
11:00 am	CNCG Collection/Conditioning Systems for Incineration in Recovery Boilers L. Paul Johnson – A. H. Lundberg Gas Associates, Inc.
11:30 am	CNCG Incineration in Recovery Boilers – Burner Design, Modeling, Emissions Impact - Clark L. Conley - Metso
12:00 pm	Lunch
1:00 pm	Update on Pulp & Paper MACT and other Environmental regulations potentially Impacting Recovery Boiler Operation Michael Curtis – Georgia-Pacific Corporation
1:30 pm	Burning Dissolving Tank Gases in the Recovery Furnace John Phillips – Andritz
2:00 pm	Coffee Break
2:15 pm	Update on Study on the Relationship between Furnace Design and Explosion Damage – Thomas M. Grace – T. M. Grace Company, Inc.
2:45 pm	Enhancements and Optimization Electrostatic Precipitator Brandon Raissian – Alstom Power Inc.
3:15 pm	Metra On-Line Reduction Degree, Weak Wash & Dissolving Tank Density/TTA Measurement – Jeff Butler – Metso Automation
3:45 pm	Recovery Boiler Air System Upgrades Ishaq Jameel – Clyde Bergemann Portland
4:15 pm	Reports from Swedish and Finnish Recovery Boiler Committees Markus Nieminen – Poyry Finland Oy
4:45 pm	Closing Remarks
5:00 pm	Adjournment

reccof.6

2012 BLRBAC Incidents Summary

AF&PA Conference, Atlanta

February, 2013

Jules Gommi

- This report summarizes the previous year’s BLRBAC incidents, derived from both the Spring and Fall 2012 ESP meetings.
- The BLRBAC Meeting Reports on line contain added information. www.blrbac.org.
- Please forward new Incident Questionnaires to j.gommi@comcast.net.
- Please report all changes in company names and recovery unit operating status to j.gommi@comcast.net.

Classification of Incidents 2012

74 North American incidents (A record 55 reports in the Fall!)

1 Smelt-Water Explosion
24 Critical Incidents
46 Non-critical Incidents
3 ESP No Leak
4 Spout Failures
22 ESP'd of which
16 were Critical (73% of Criticals - Good response!)
9 Critical incidents were NOT ESP'd. 6 were in boiler, 2 were in upper furnace, and 1 was in upper economizer with a straight shot to furnace cavity.

10 International Incidents

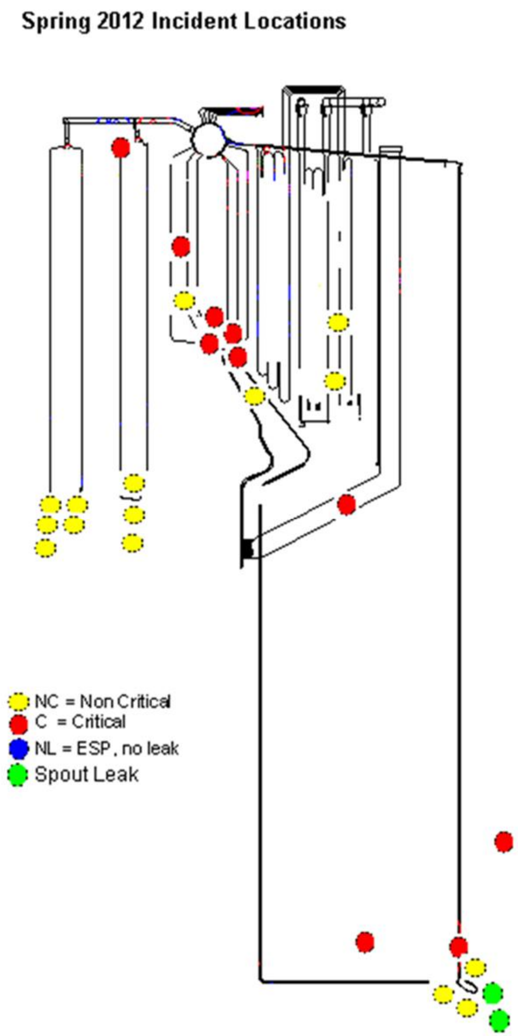
All non-critical. Included reports from Poland, Russia, South Africa, Brazil, Australia and New Zealand.

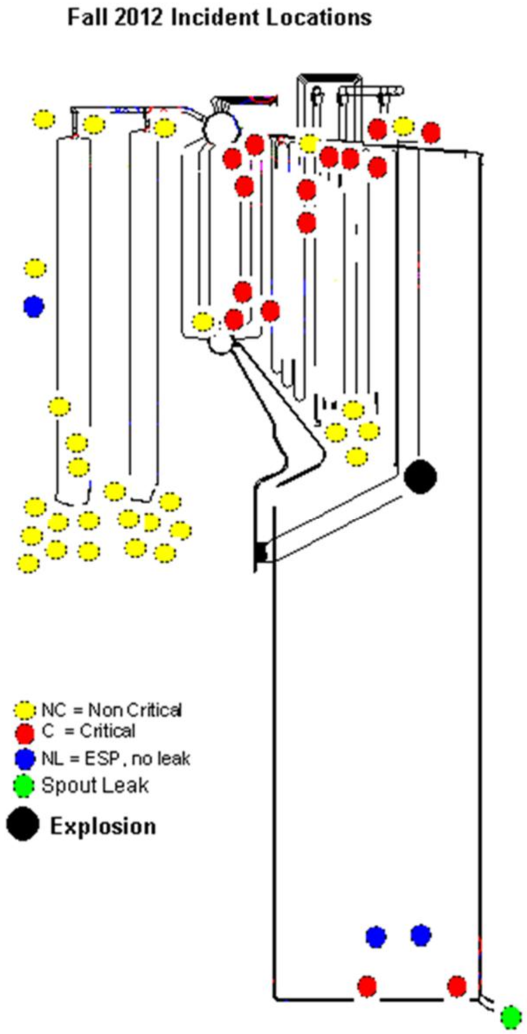
Location of leaks 2012

	Location	Spring	Fall	Total
	Econ + Handhole	11	24	**35**
	SH	2	7	**9**
	Boiler	5	7	**12**
	Screen	1	0	**1**
	Upper Furnace	2	9	**11**
	Lower Furnace	5	1	**6**
	Floor & below	0	2	**2**
	Smelt Spout	3	3	**6**
	Steam Coil Air Heater	1	0	**1**
	Dissolving Tank	0	0	**0**
	ESP No Leak	0	3	**3**
	Totals	**30**	**57**	**87**

Includes 10 International reports; Includes multiple leaks per incident.

Spring & Fall 2012 Incidents Spotted (N. America)





Root Causes 2012

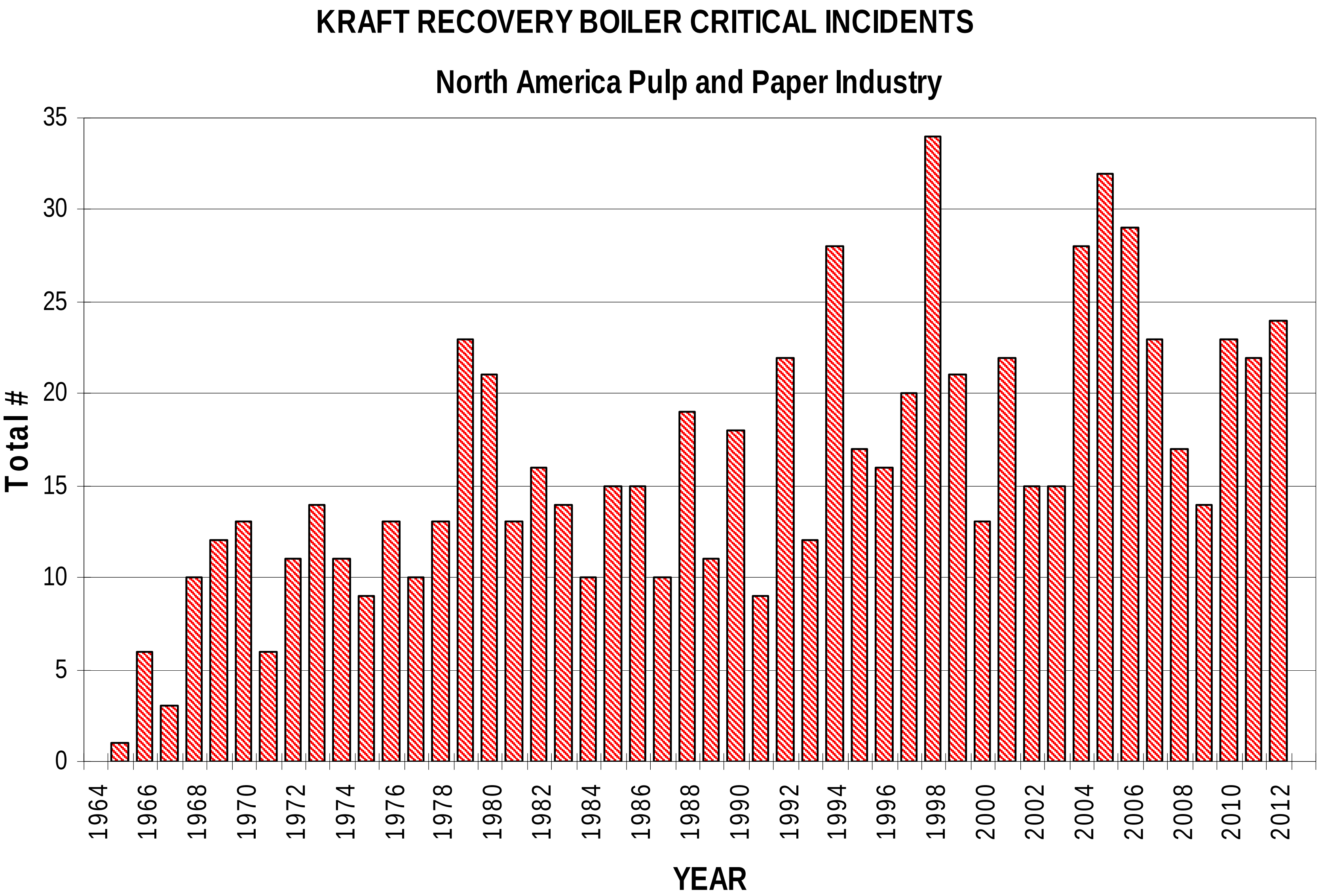
Weld Failure	12
Fatigue, Mechanical & Thermal	17
SAC/SCC/FAC	9
Thinning	17
OverHeat	6
Mechanical Damage	4
Unknown	7

Totals may exceed # of incidents, since multiple causes were reported

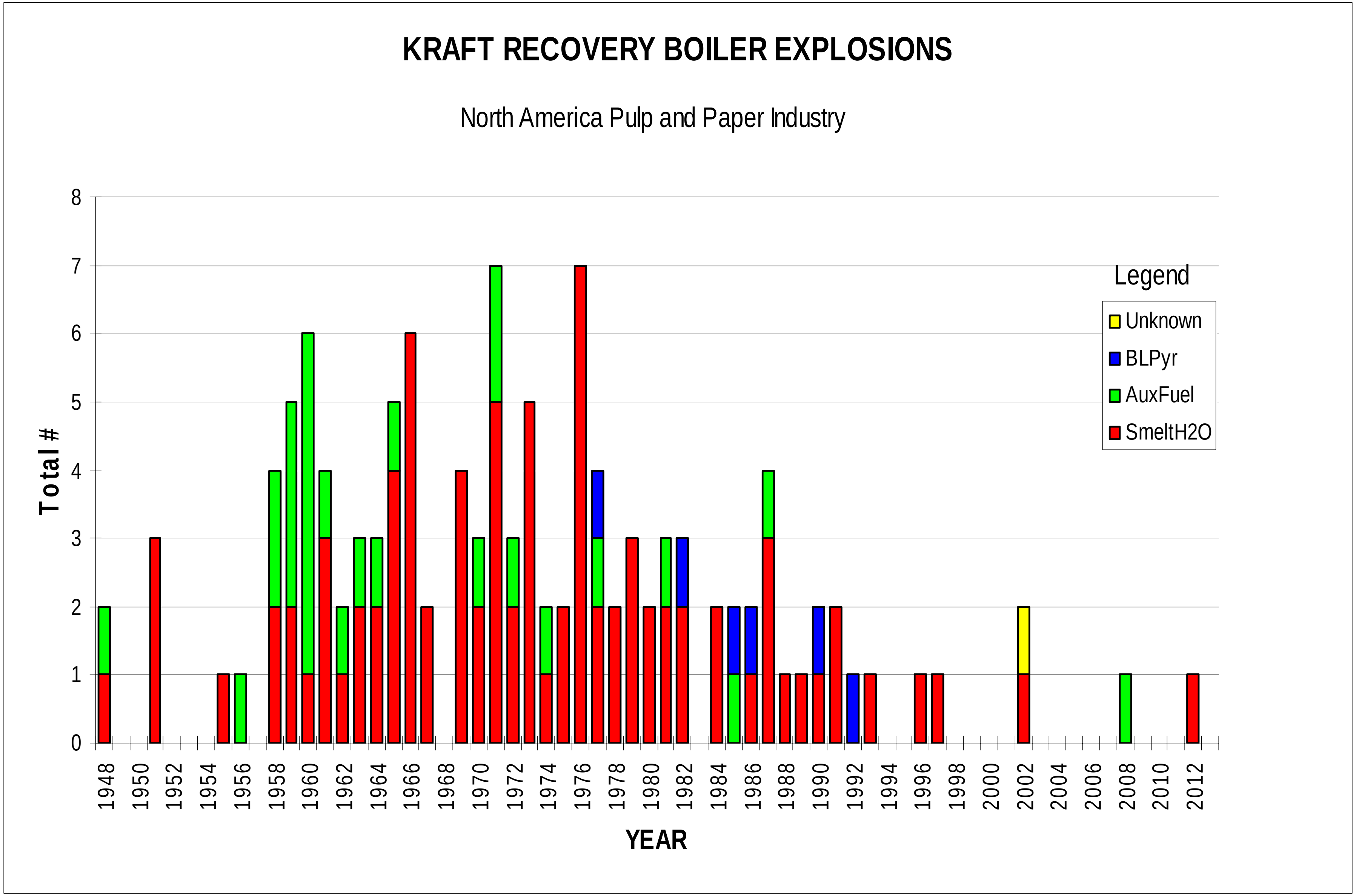
How Discovered 2012

Walk Down	51
Control Room Indications	20
Leak Detection	7
Bed Camera	-
Furnace Puff	7
SWR	1
Hydro	7

Totals may exceed # of incidents, since multiple inputs were reported.



AF&PA Report, Feb 2011



KRAFT RECOVERY BOILER EXPLOSIONS
North America Pulp and Paper Industry
Legend
Unknown
BLPyr
AuxFuel
SmeltH2O
Total #
YEAR
0
1
2
3
4
5
6
7
8
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
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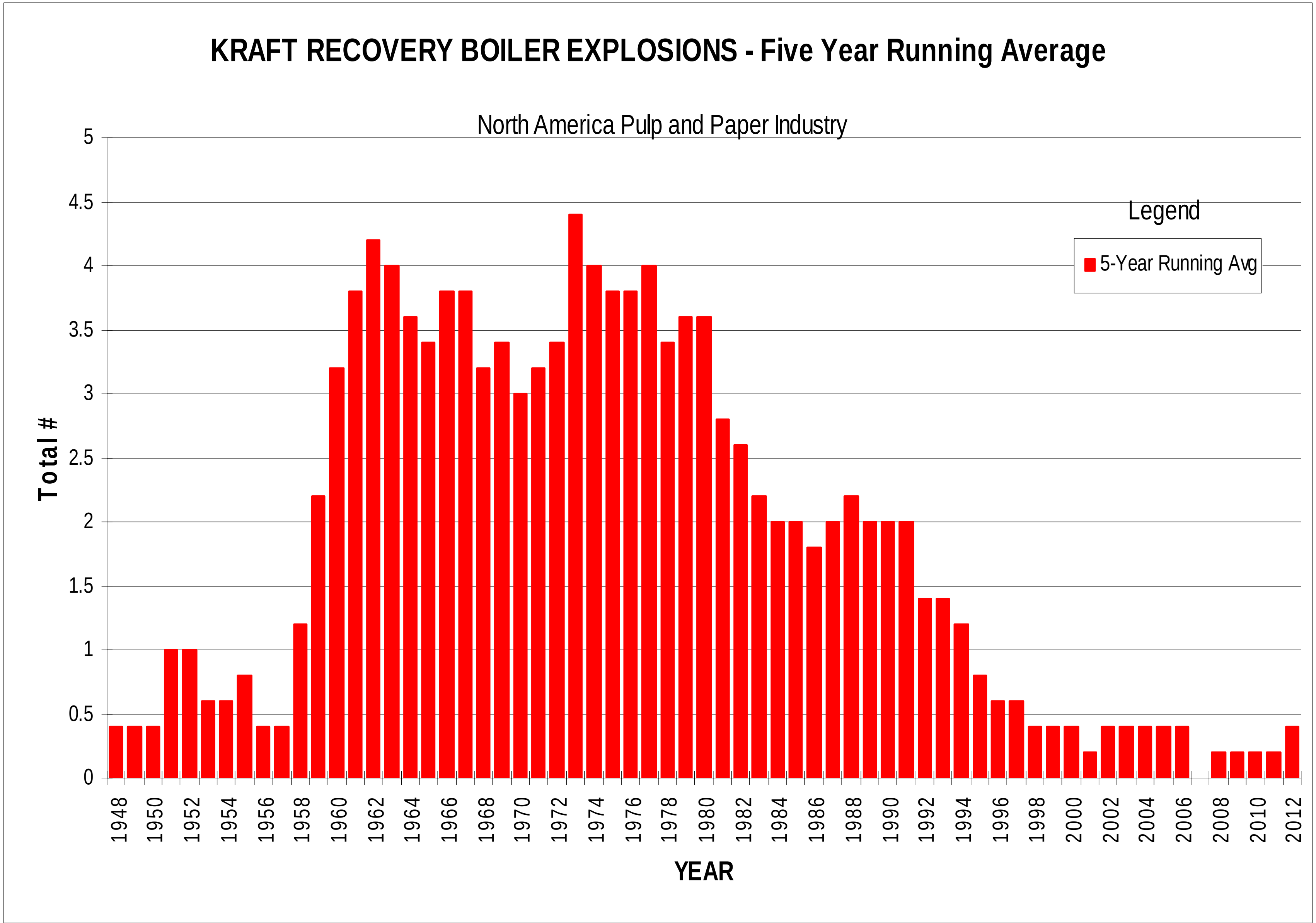
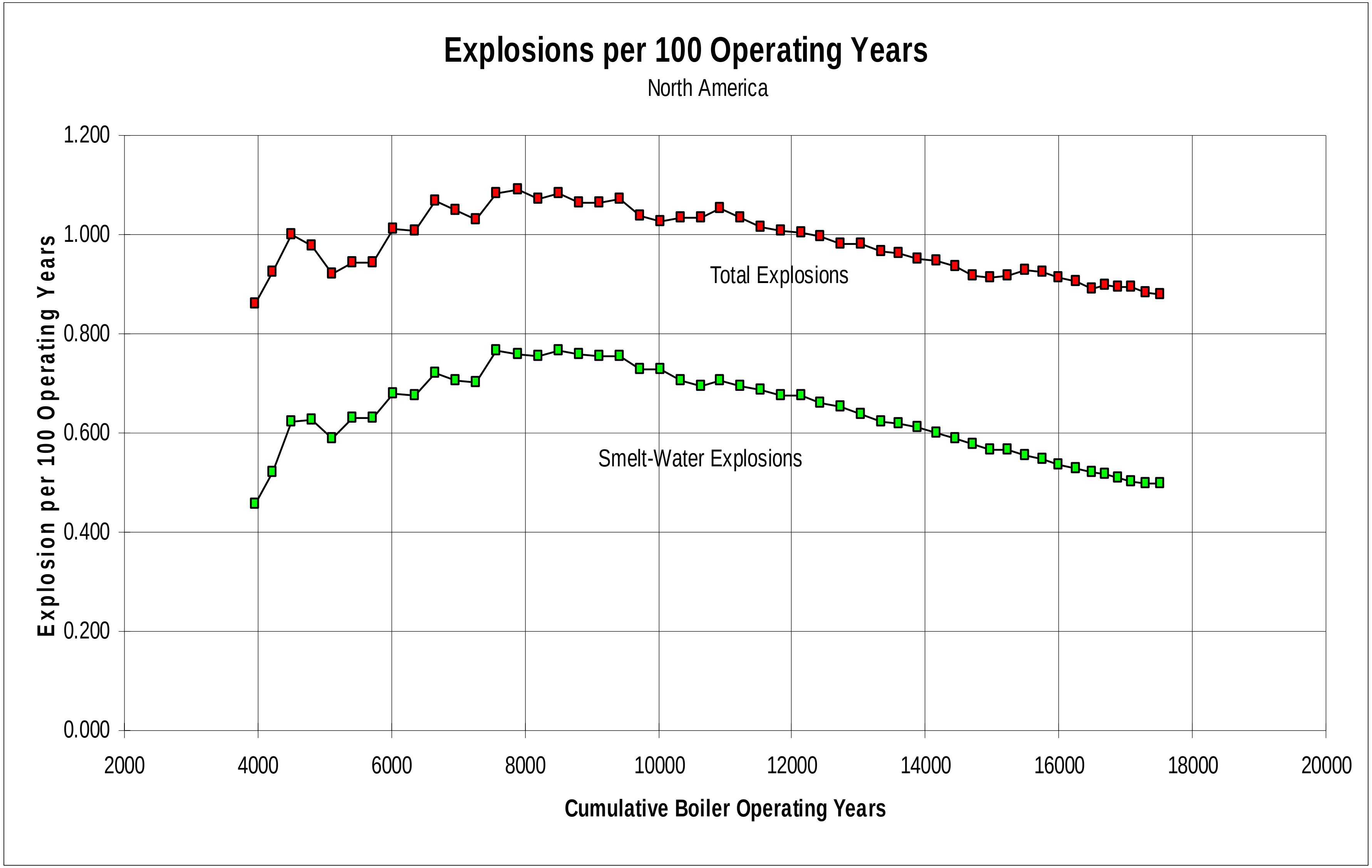
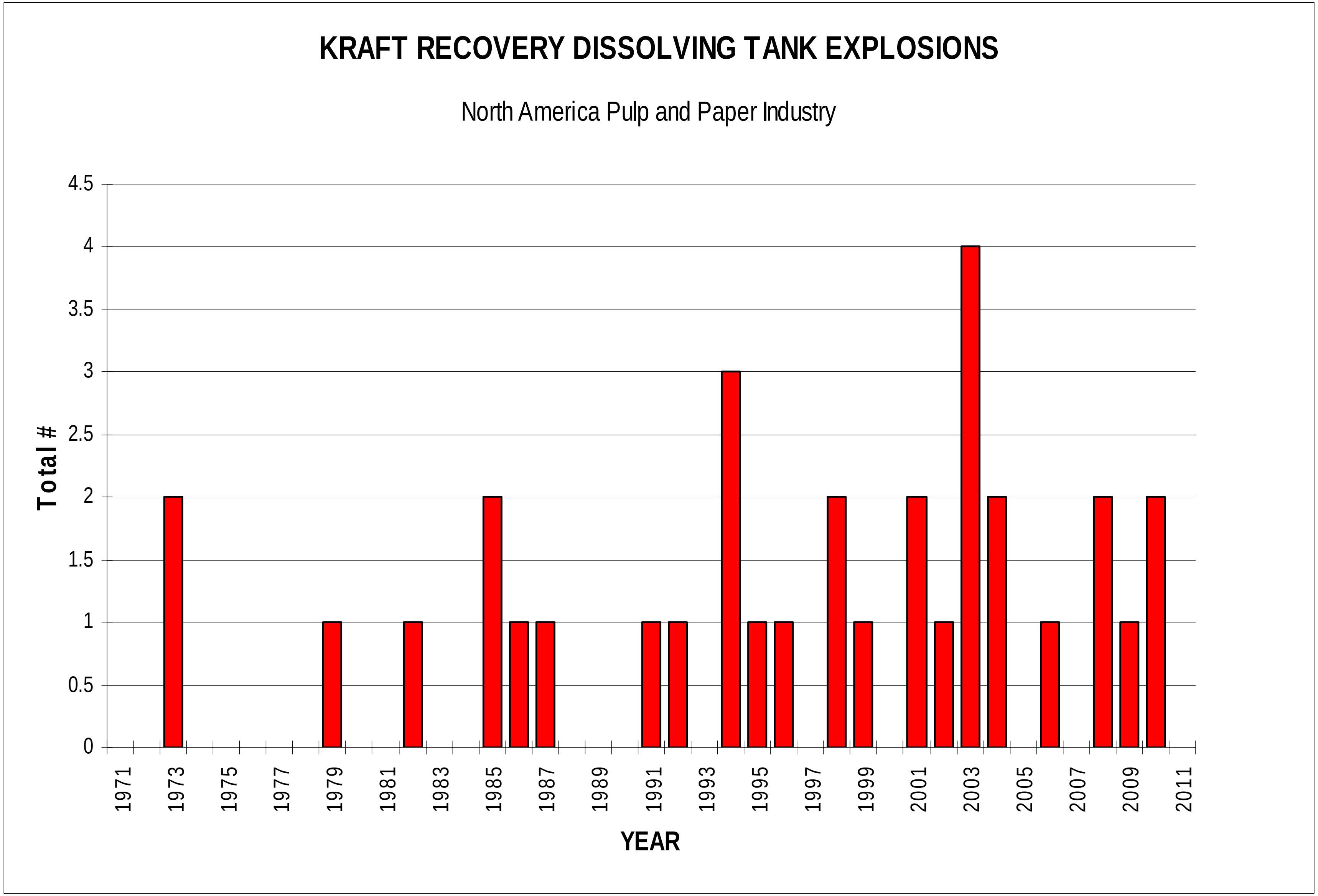
1996
1998
2000
2002
2004
2006
2008
2010
2012



AF&PA Report, Feb 2012



AF&PA Report, Feb 2011


KRAFT RECOVERY DISSOLVING TANK EXPLOSIONS
North America Pulp and Paper Industry
Total #
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
YEAR

Learnings

- Not recommended to expose leaks with pressure still on boiler
- Check for SAC at hopper attachments on sidewall of B&W units at top of nose
- Need to maintain vibration restraints
  - Watch for chaffing
- Keep weak wash off tubes
- Establish shutdown criteria for low boiler water pH

Learnings, cont'd

- Maintain dilution on Cascade after ESP to prevent tripping cascade wheel
- Contractor Safety Orientation – Notify mill if damage is caused or observed
- Plug tubes as close to drums or headers as possible to minimize tube stub
- Check for roof tube thinning if superheater sootblowers are located close to roof
- Test ESP system after any changes or additions

Learnings, cont’d

– Leak recognition and operator authority to initiate an ESP should be emphasized in training

– Supervision should “walk the talk”

– Human nature to discount leak indications

– Little history of damage after ESP

– Risk of greater damage from explosion far exceeds any risk from ESP damage

2012 ESP Subcommittee Summary of Activities

AF&PA Conference, Atlanta

February, 2013

Jules Gommi

- This report summarizes the 2012 activities of the Emergency Shutdown Procedures (ESP) Committee of BLRBAC, derived from both the Spring and Fall ESP meetings.
- The BLRBAC Meeting Reports on line contain added information. www.blrbac.org.
- Please forward new Incident Questionnaires to j.gommi@comcast.net.
- Please report all changes in company names and recovery unit operating status to j.gommi@comcast.net.

Normal Activities of the ESP Committee

- A major function of the Committee is to receive, review, classify, and share learnings from the Incident Questionnaires received from the North American community of recovery unit operators. In addition, international incidents are reviewed and shared as available.
- The ESP Questionnaire gets minor changes regularly, so be sure to get your blank from the BLRBAC website www.blrbac.org

Normal Activities of the ESP Committee

- Another major function is to develop and keep up to date the Emergency Shutdown Procedure for quickly and safely shutting down a recovery unit as soon as a known hazard is recognized.
- An extension of the Procedure deals with Testing Procedures.
- The subcommittee also interacts with other subcommittees and their recommendations to assure compatibility of efforts.

Normal Activities of the ESP Committee

- The US & Canada Units In Service update lists on the website are only as good as the input you pass on to J Gommi. Please help with all the name changes and shutdowns.

Normal Activities of the ESP Committee

Incident Definitions

- **Explosions:** Only if discernible damage has occurred. This does not include incidents where there is only evidence of puffs or blowback alone. With the new emphasis on damage, more attention will be given to the extent of damage and the amount of downtime for the damage repair (as opposed to total downtime that includes other activities).

- **Critical Incidents:** All cases where water in any amount entered or could have entered the recovery unit forward of isolating baffles (and therefore would be a similar criterion to the need to perform an ESP). This includes leaks of pressure parts of all sizes. Since small leaks often wash adjacent tubes to failure, this category is important to our learnings. This new definition will result in more entries for the Critical Incident list.

- **Non-Critical Incidents:** Those cases that did not admit water to the furnace cavity defined above.

Specific 2012 Activities of the ESP Committee

- **ESP Procedures “Dedicated” Wording**. The ESP Committee’s final wording regarding dedicated systems architecture and maintenance actions was submitted for posting after the April meeting on the BLRBAC web site for the six-month review and comment. Approval was obtained by vote at the October meeting.

Specific 2012 Activities of the ESP Committee

- **ESP Questionnaire Revision**. Questions were added to the Questionnaire. Be sure to use current version from the website.
- Some maintenance actions were not left fully compatible with ESP requirements. Added Bold words to Page 4,
- "... **Any time maintenance is done or** modifications are made to the system, the system shall be functionally tested prior to putting the unit back on line "…

Specific 2012 Activities of the ESP Committee

- **Post-ESP Guidelines.** Requirements for the fire protection of the DCE should supersede the ESP guidelines in regard to operation of fans and dampers. (Dilution water should not be shut off.) Cascade and cyclone recirculation should stay on.
- The Committee will start review for update and revision of the 2002 Post ESP Guidelines at the April 2013 meeting..
- Don’t restart tripped fans or let them seek full flow.

Specific 2012 Activities of the ESP Committee, cont'd

- **Elevator Action during ESP.** The Personnel Safety documents should reflect that elevator action should be situation-specific, to avoid opening at bottom floor facing a dissolving tank hazard.
- **ESP Reset.** Do not reset ESP system too soon where it could defeat safety features.

Understanding the Recovery Boiler Smelt Run-off Phenomenon

PULP& PAPER
UNIVERSITY OF TORONTO

Honghi Tran and Andy Jones

University of Toronto
Toronto, ON, Canada

AF&PA Recovery Boiler Program Annual Meetings and Conference
Atlanta, GA, February 6, 2013

Acknowledgements

ADITYA BIRLA AV NACKAWIC

ANDRITZ

B&W

BOISE

CarterHoltHarvey Pulp&Paper Kinleith

CENIBRA

CLYDE BERGEMANN

ELDORADO BRASIL

DMI DAISHOWA-MARUBENI INTERNATIONAL LTD. Peace River Pulp Division

ERCO Worldwide A division of Superior Plus LP

Fibria

FPInnovations

IRVING

INTERNATIONAL PAPER

KFS Combustion by design

Klabin

metso power

MWV

SUZANO PULP AND PAPER

rethink. storaenso

Tembec

TOLKO MANITOBA

NSERC CRSNG

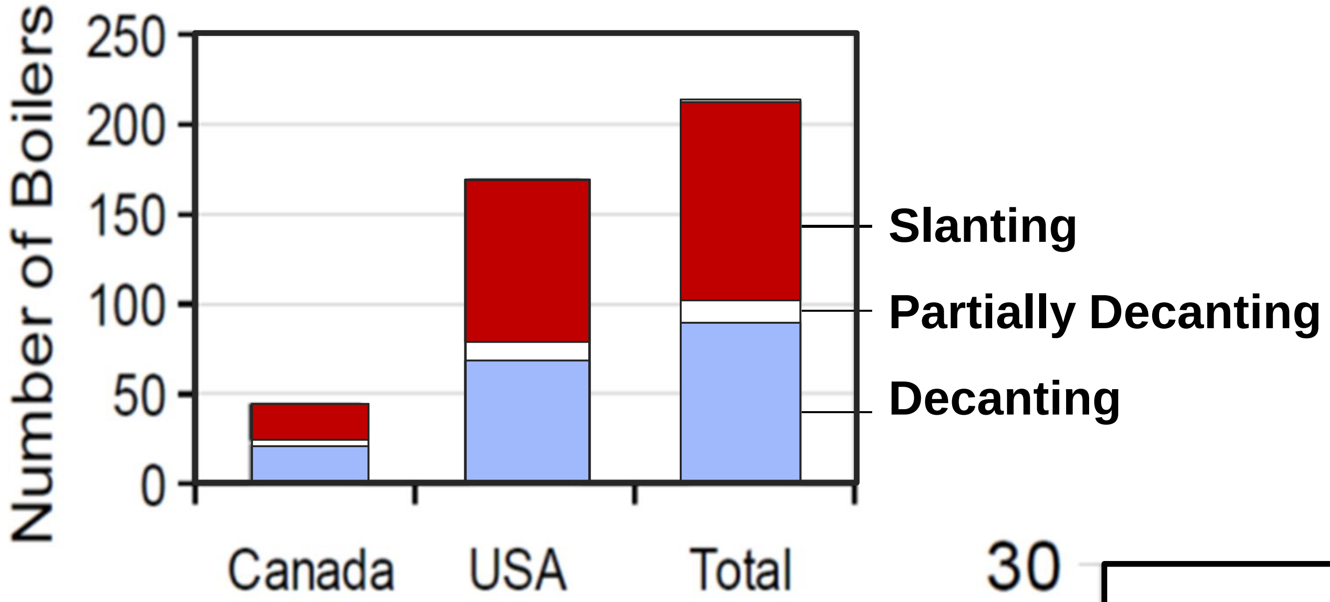
Presentation Outline

- The issues
- Mill experiences
  - Trend analysis and implications
- The runoff phenomenon
  - What triggers a runoff?
  - How long does a runoff event last?
  - What are possible causes?
  - How much smelt is needed?

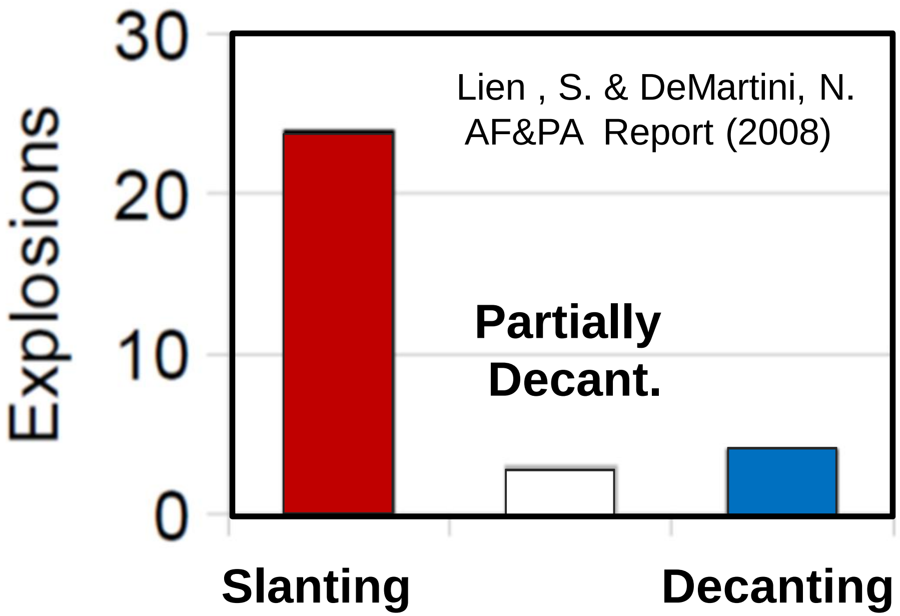
Smelt Run-off

- Occurs when a massive amount of smelt abruptly flows out of the spout
- Results in violent interaction between smelt and water in the DT
- A main problem in DT operation

BLRBAC Records

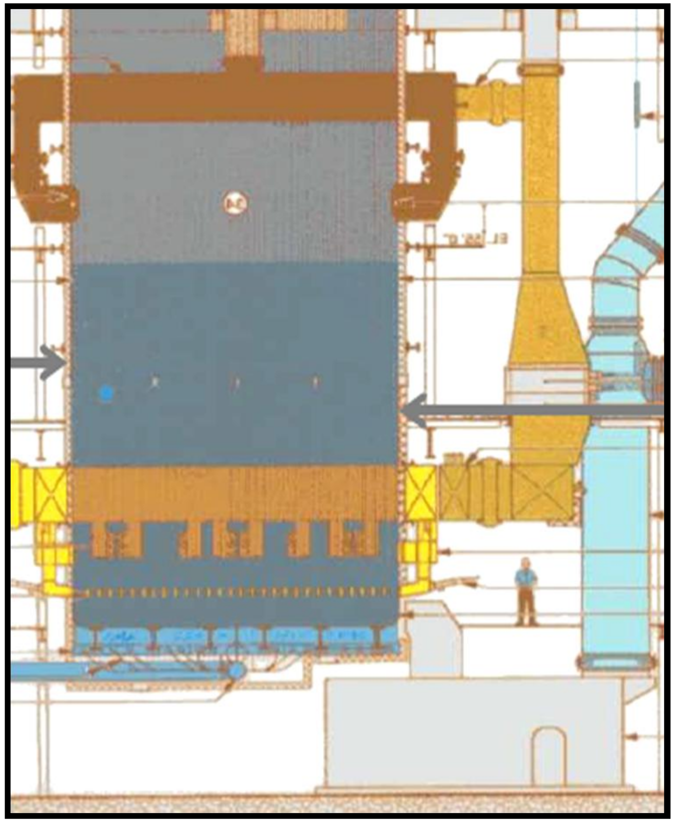


MacCallum, C.,
BLRBAC, April (2011)

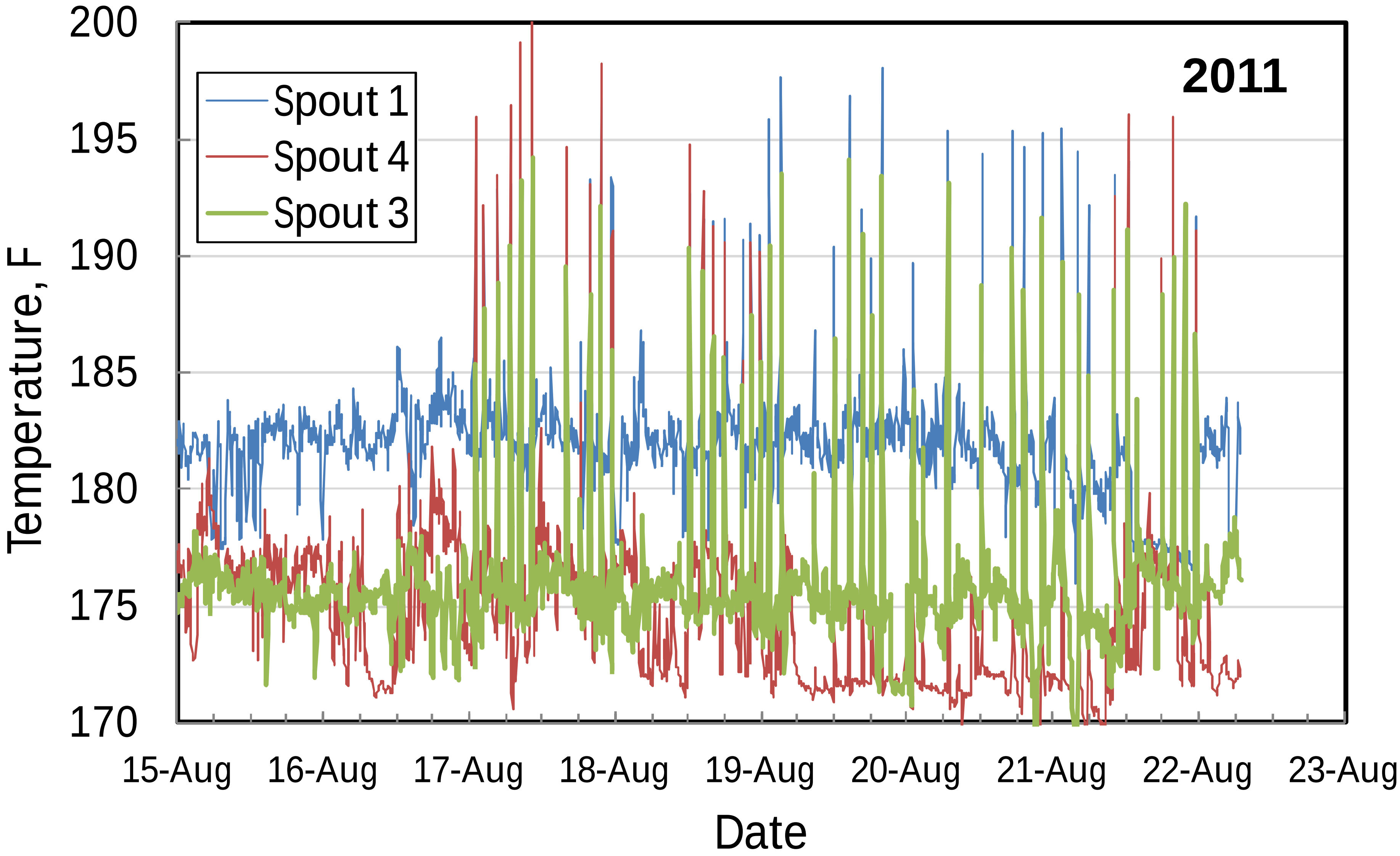


Experience at Mill A

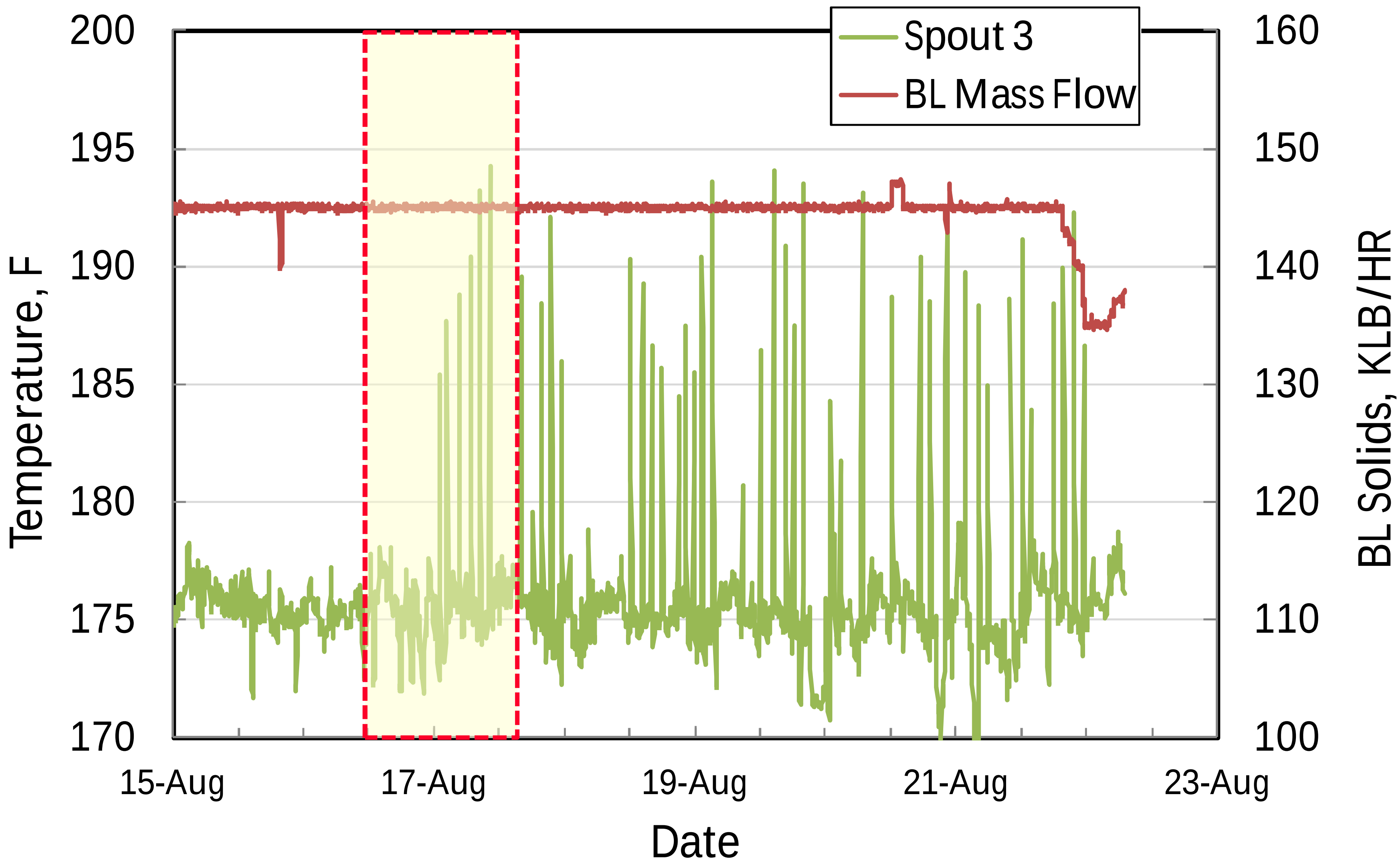
- Decanting bottom boiler
- Smelt run-off experience
  - Very severe, particularly during the 3rd week of Aug. 2011
- Use smelt spout cooling water exit temperature as an indicator



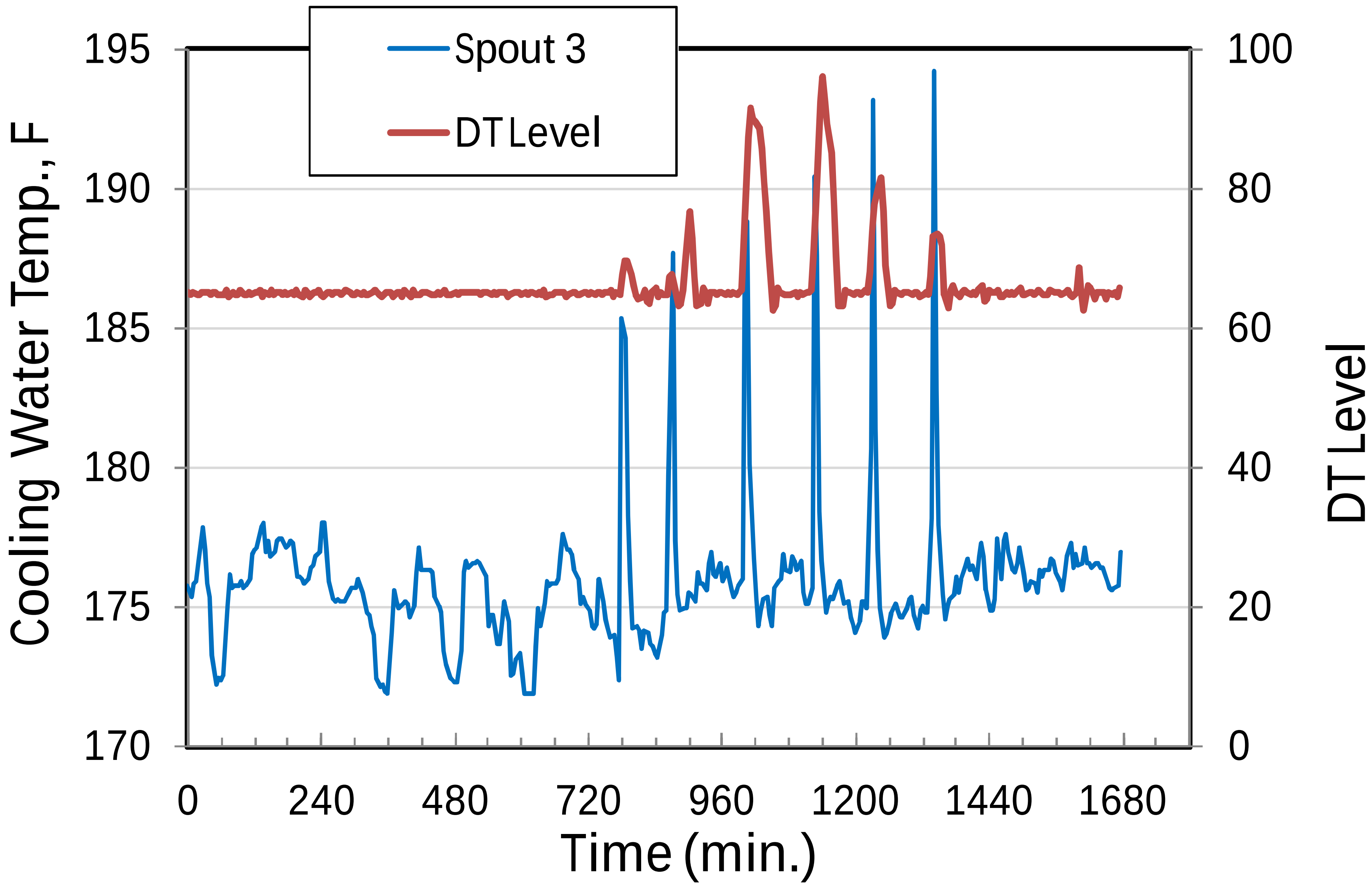
Mill A - Spout Cooling Water Temp.



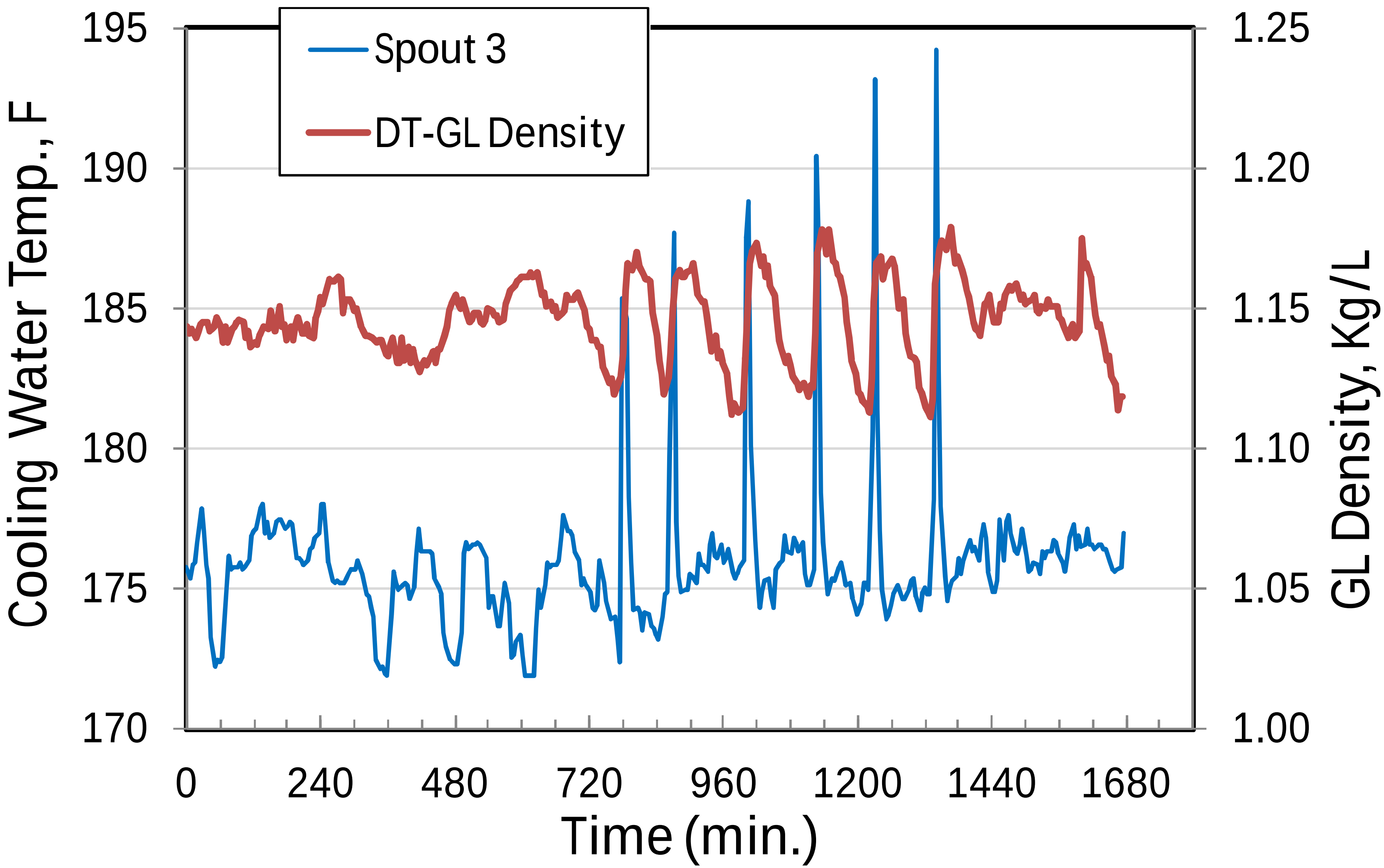
Mill A - Cooling Water Temp. vs BL Flow



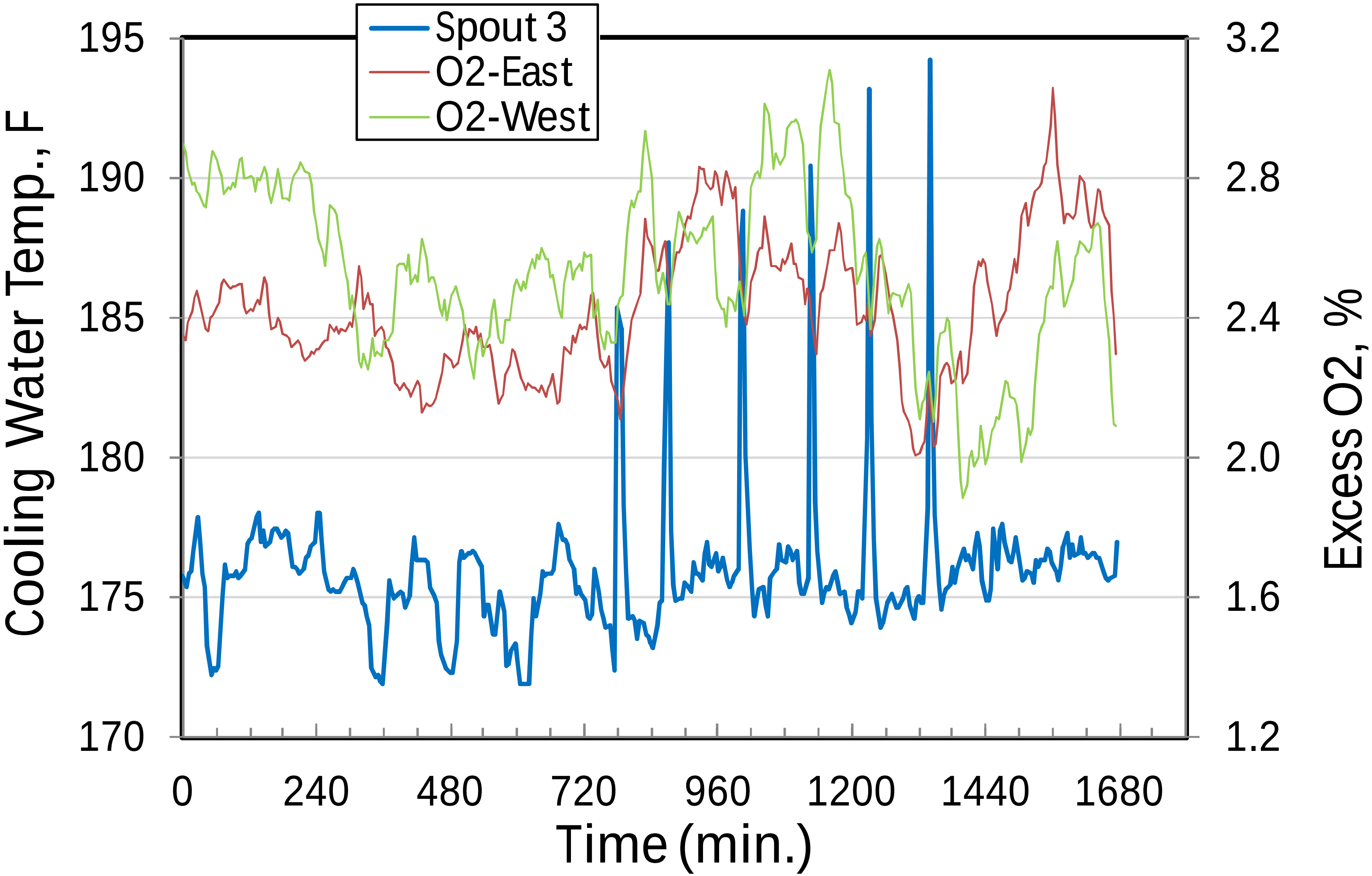
Mill A - DT Liquor Level

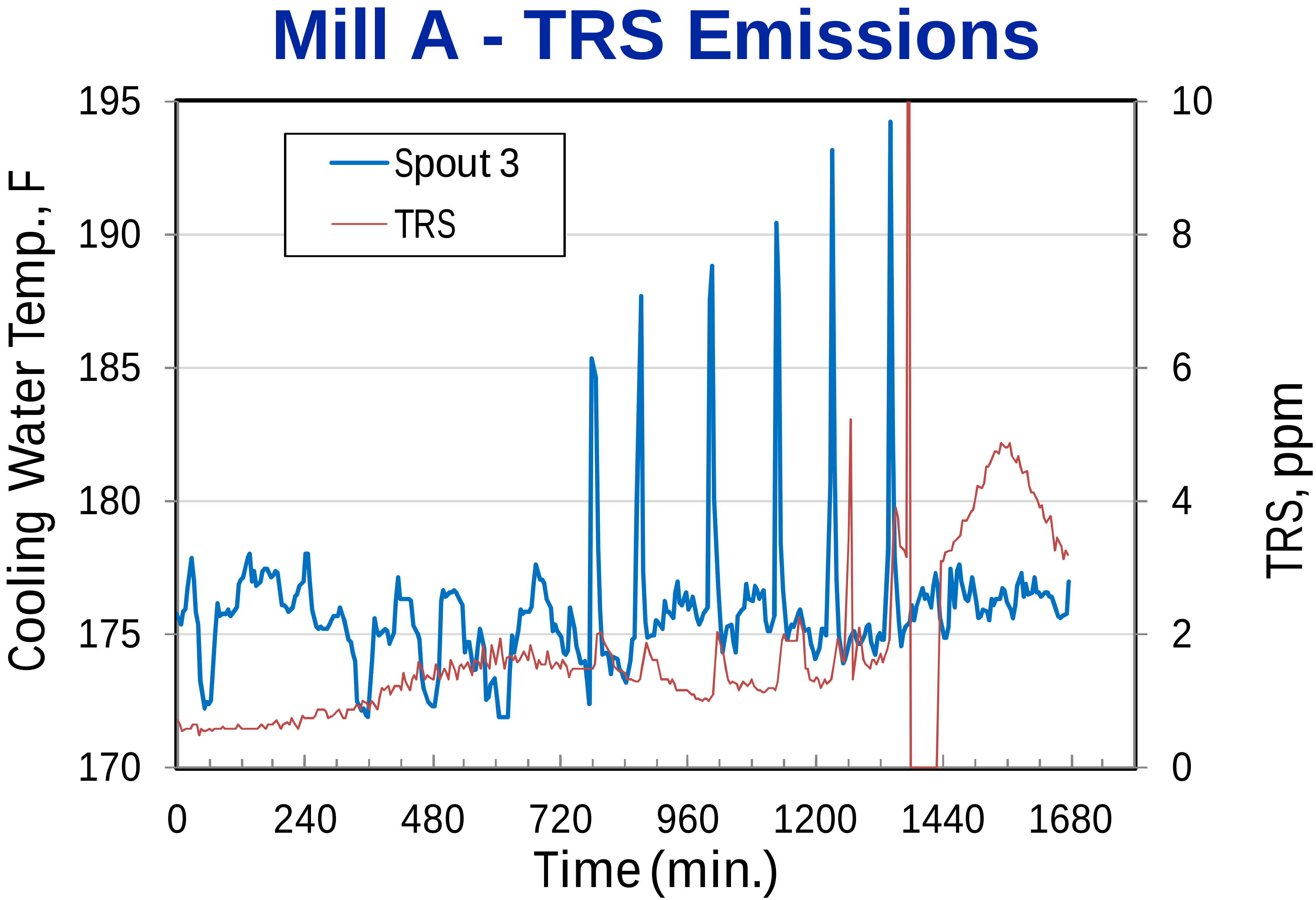


Mill A - DT Liquor Density

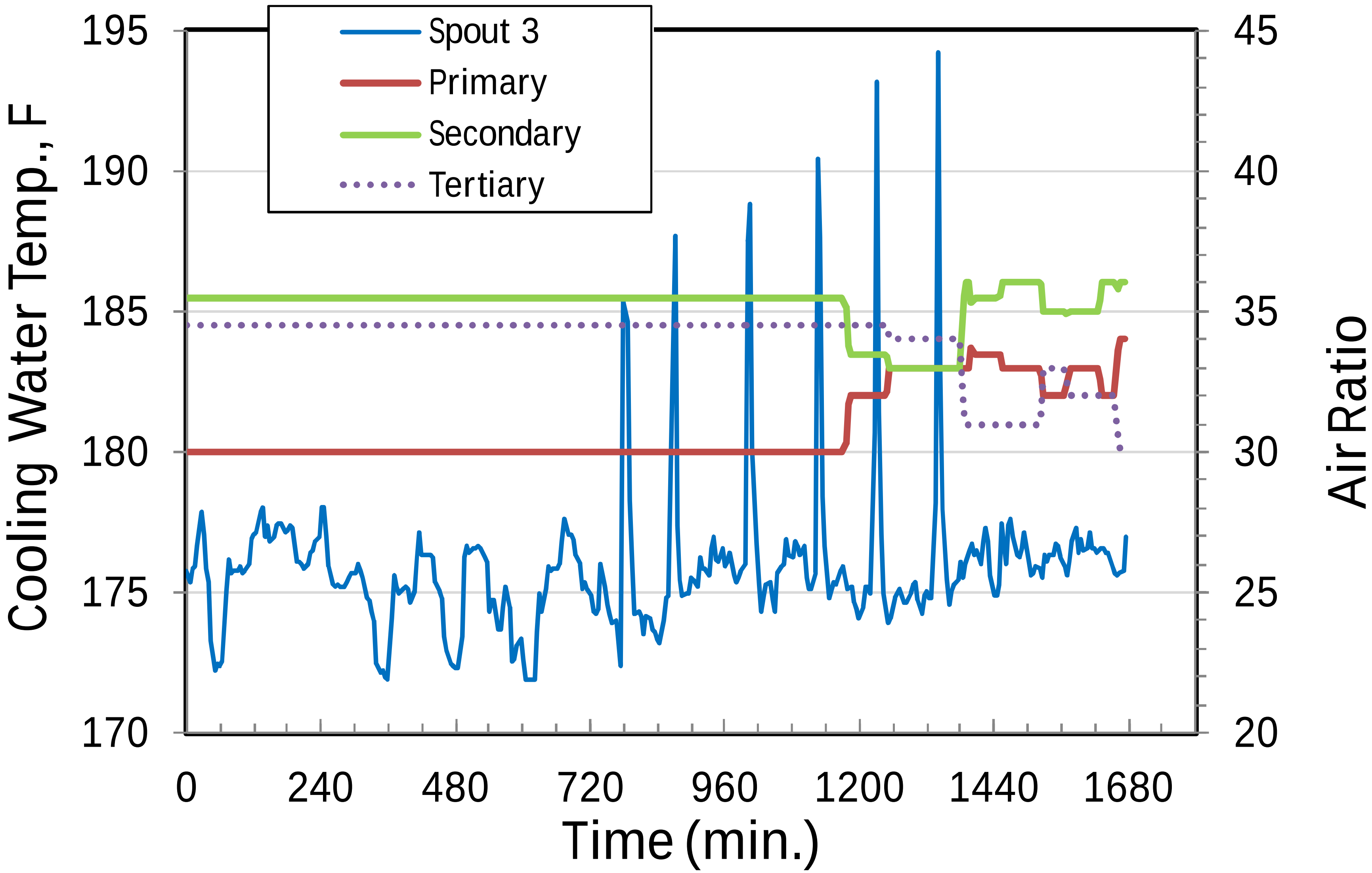


Mill A - Excess O_2

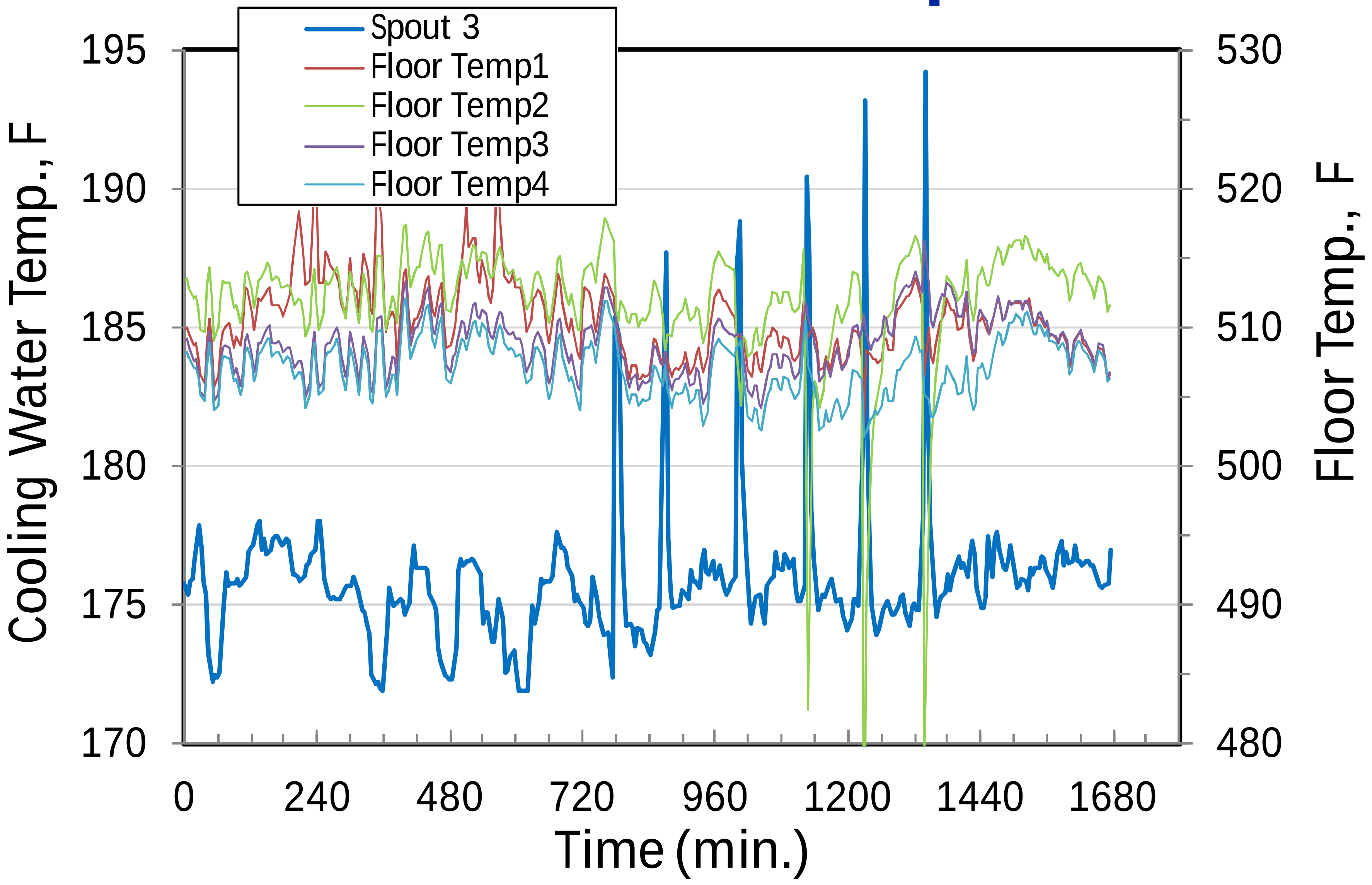



Mill A - TRS Emissions
Spout 3
TRS
Cooling Water Temp., F
TRS, ppm
Time (min.)
195
190
185
180
175
170
10
8
6
4
2
0
0
240
480
720
960
1200
1440
1680

Mill A - TRS Air Ratio



Mill A - Floor Tube Temperatures



Implications

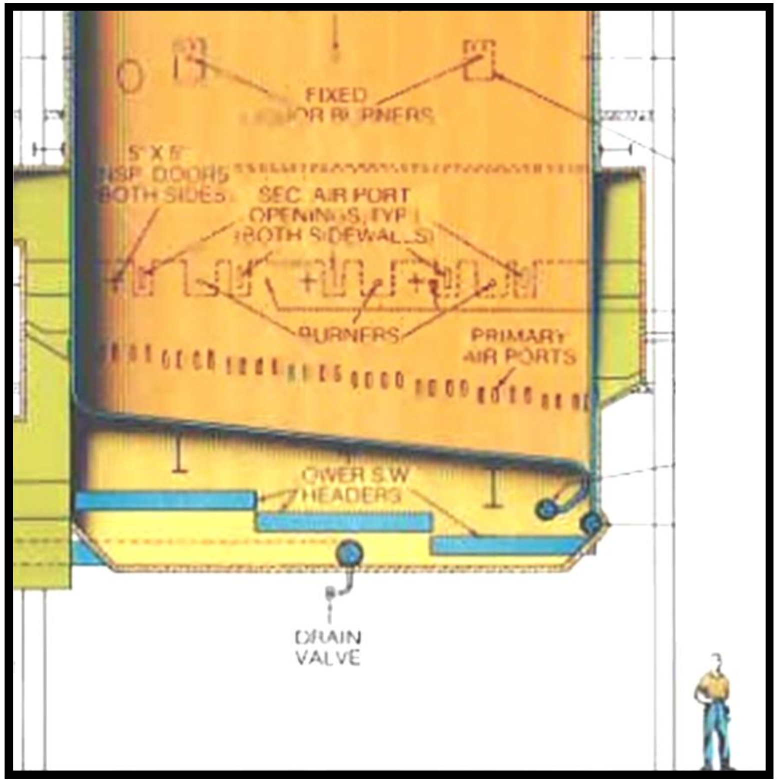
- **Excess O_2 decreased; TRS emissions increased during smelt run-offs**
  - **Caused by char bed breakup/collapse in the furnace?**
  - **Increased H_2S release from the DT?**

Implications

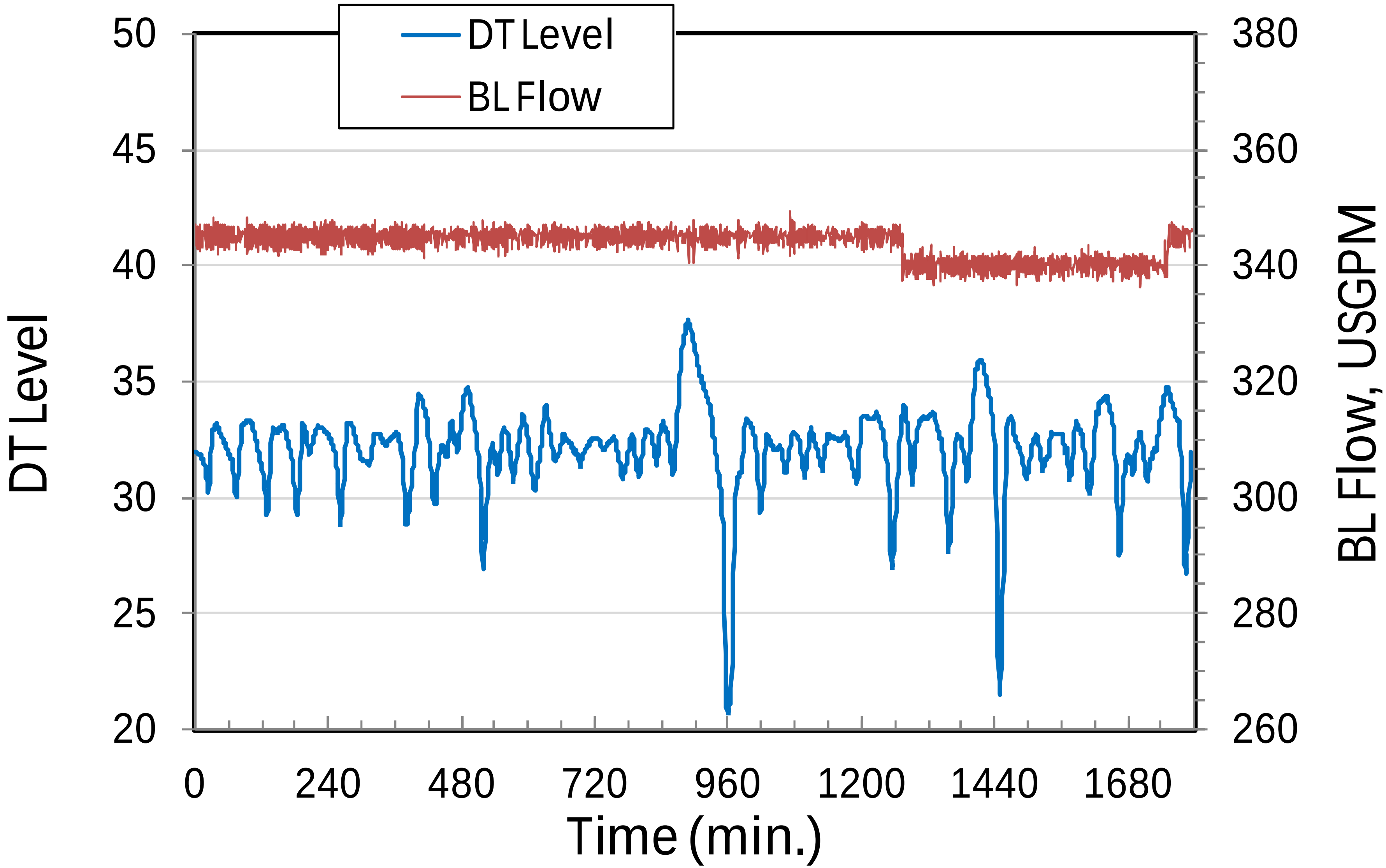
- Floor tube temperatures also decreased during smelt run-offs
  - Falling deposits covering the floor?
  - Accelerated char bed burning that increases heat flux to walls, increases driving force for circulation, and pulls more water through floor tubes where heat input is small, resulting in lower floor tube temperatures?

Experience at Mill B

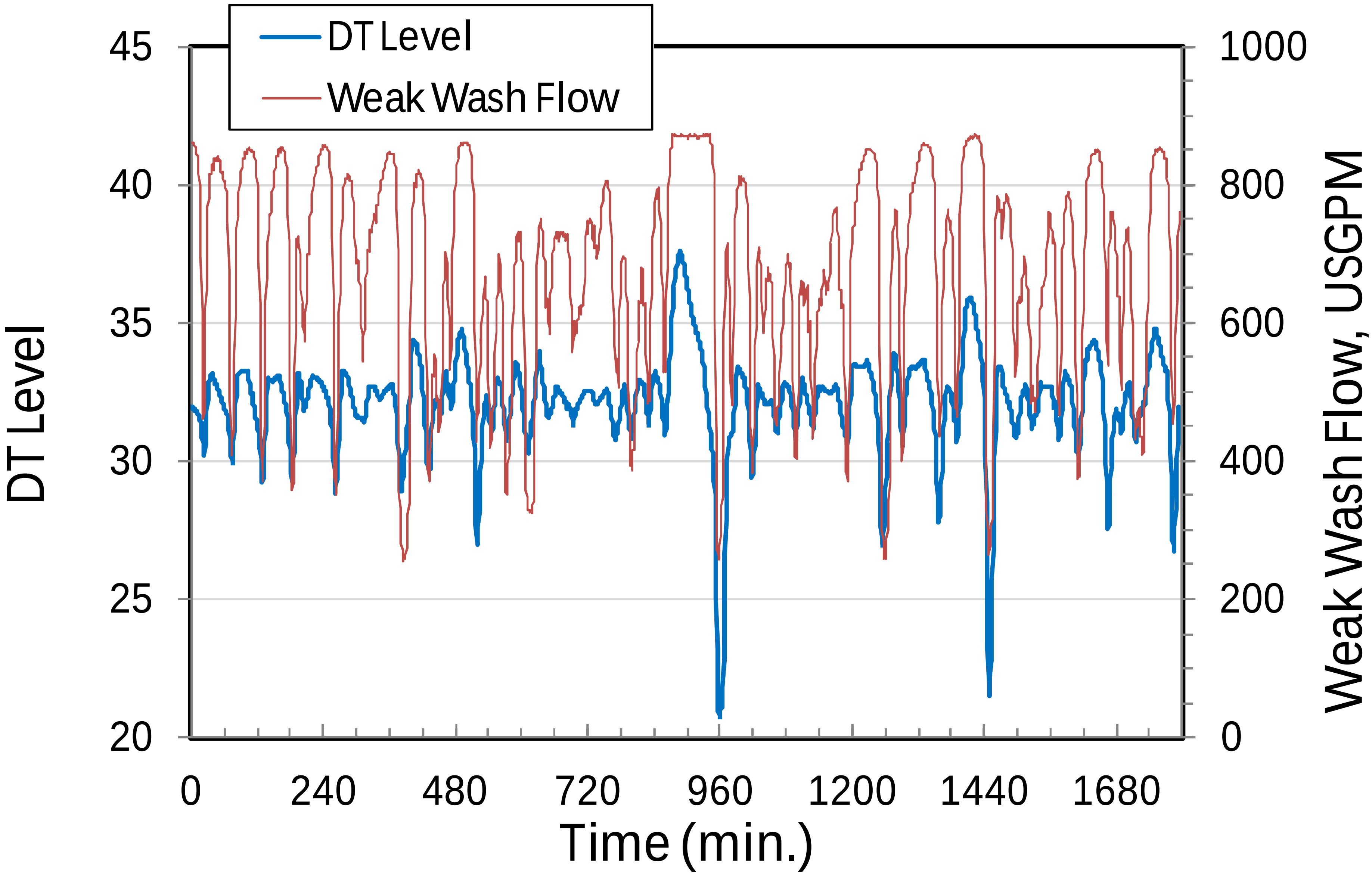
- Slanting floor boiler
- Smelt run-off problem
  - Occurred occasionally
- Use DT level as an indicator



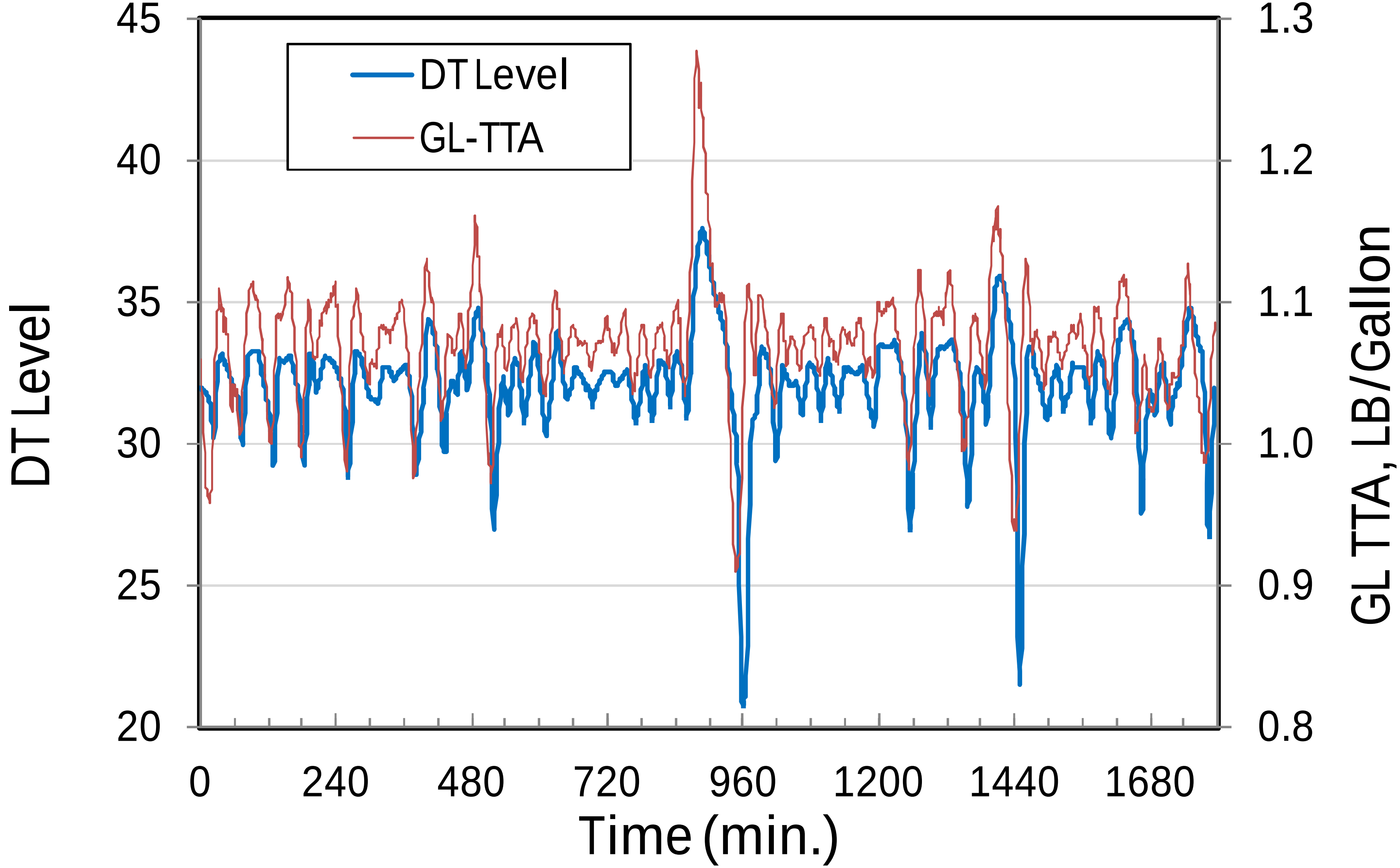
Mill B - DT Liquor Level vs. BL Flow



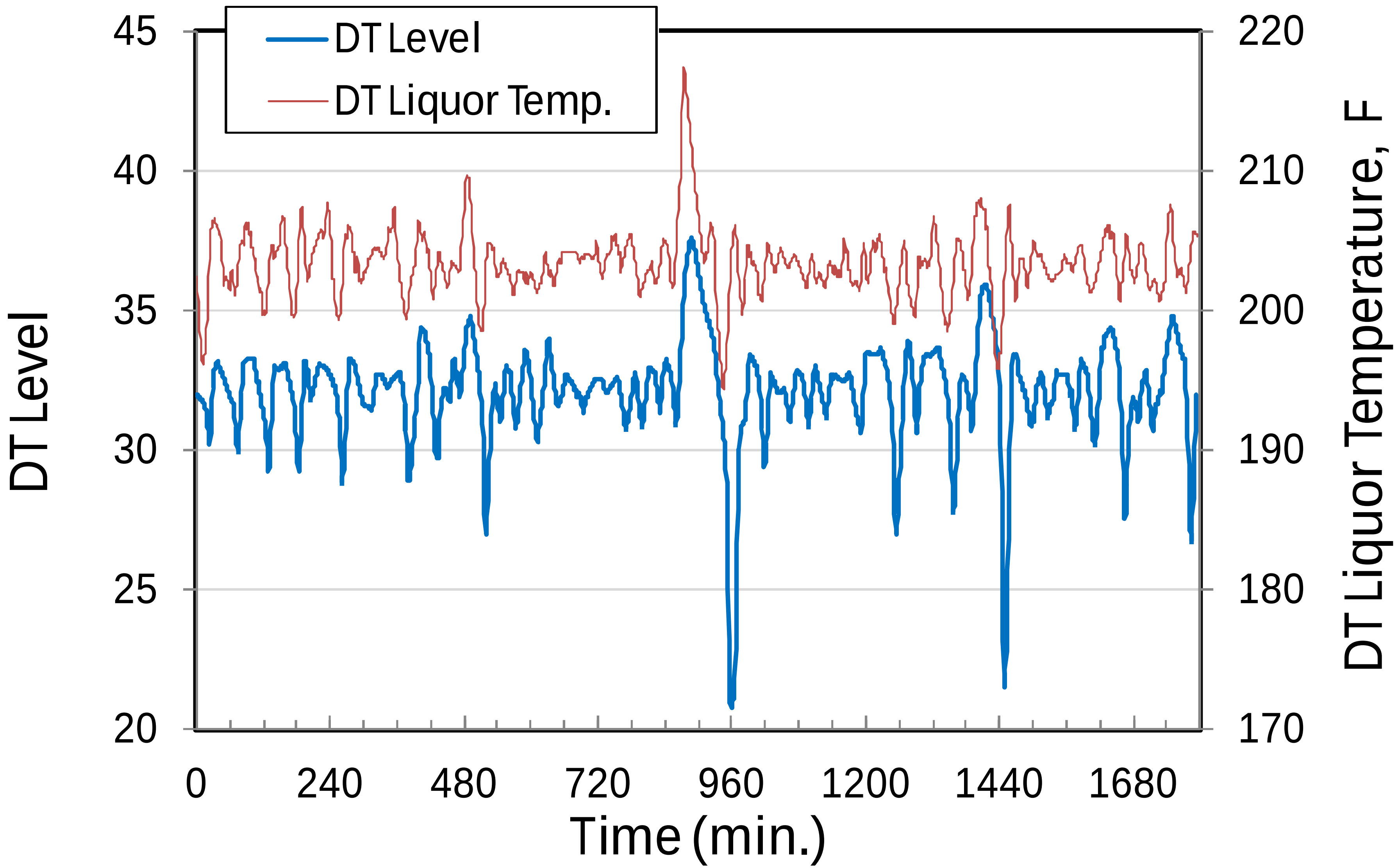
Mill B – Weak Wash Flow



Mill B – Green Liquor TTA



Mill B - DT Liquor Temperature



Smelt Run-off Indicators

- Smelt spout cooling water exit temperature
- Green liquor TTA, density and temperature
- Weak wash/green liquor flow
- DT level
- Loud noise
- Ejection of smelt/green liquor from DT
- DT vent “blast dampers” are forced open

When is a Run-off Considered a “Run-Off”?

- Operators decide to run!
- Unsafe working environment
  - Excessive fume (water vapour) and TRS emissions around the dissolving tank area
  - Green liquor/smelt ejection
  - Big bangs (explosions)
  - Building trembling

How Much Smelt is Required?

Little Flow

Weak Flow

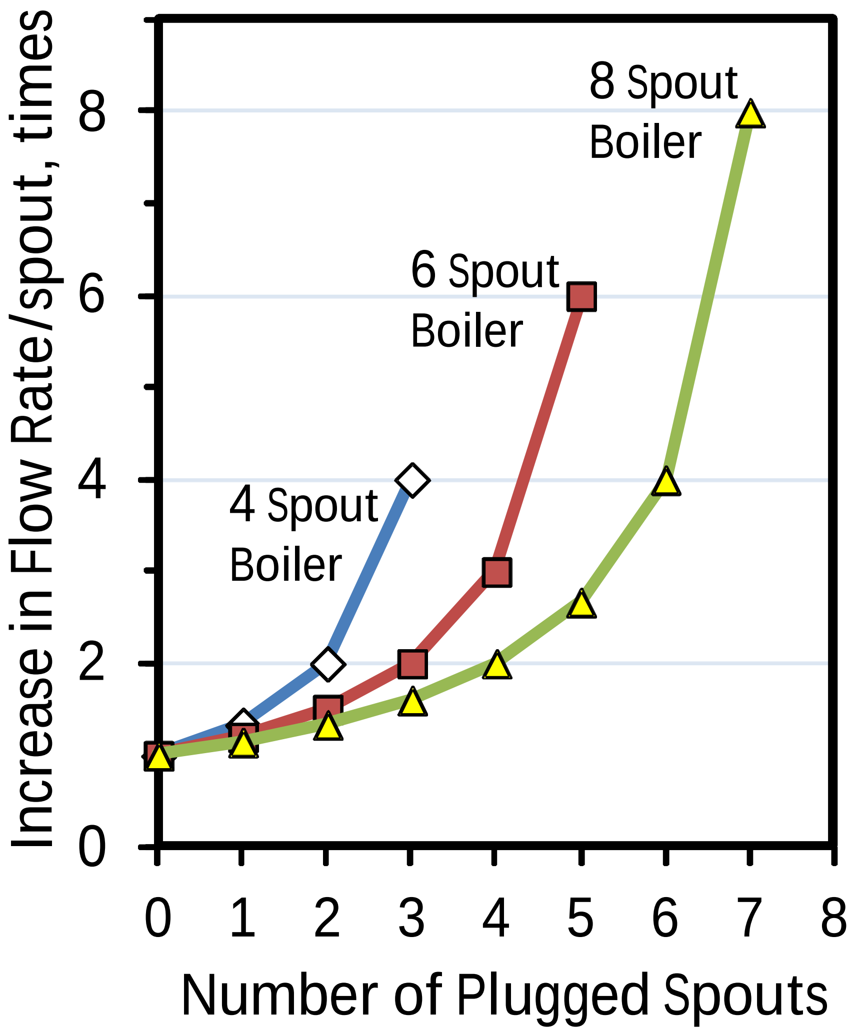
Heavy Flow

Smelt Flow Rates

Pulp production (ADMT/d)	**1000**	**1500**	**2000**
Smelt mass flow (t/d)	**640**	**960**	**1280**
Number of spouts	**4**	**6**	**8**
Smelt mass flow/spout (Kg/s)	**1.85**	**1.85**	**1.85**
Smelt volume flow/spout (L/s)	**0.97**	**0.97**	**0.97**

Effect of Plugged Spouts on Smelt Flow

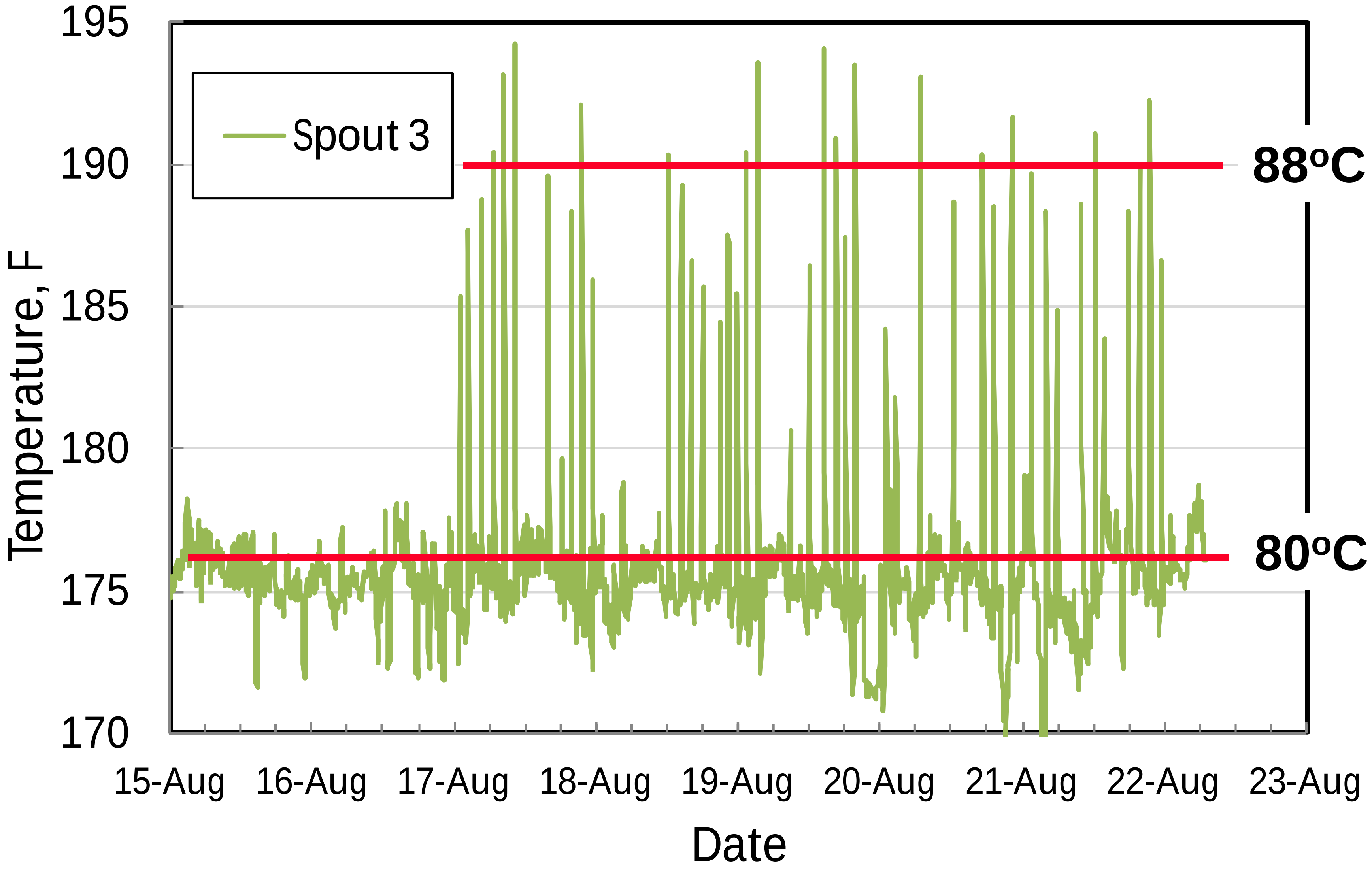
- Plugged spouts increase smelt flow through the remaining spouts
- Boilers with a fewer number of spouts are more susceptible to smelt flow change



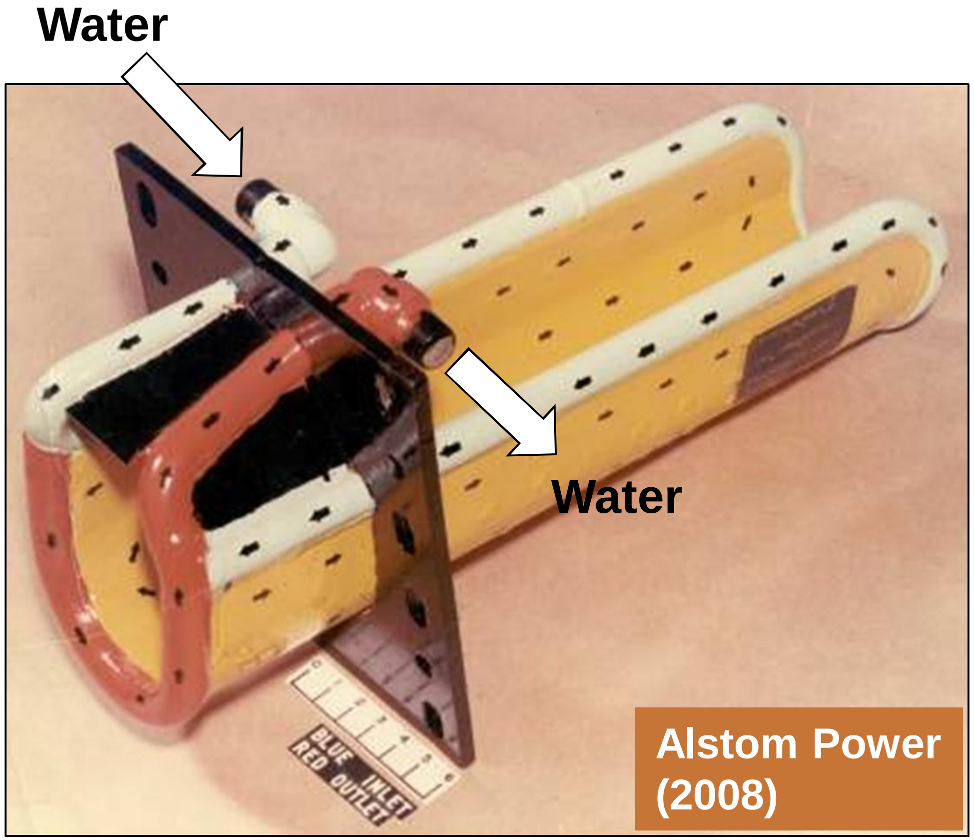
Mill Experiences

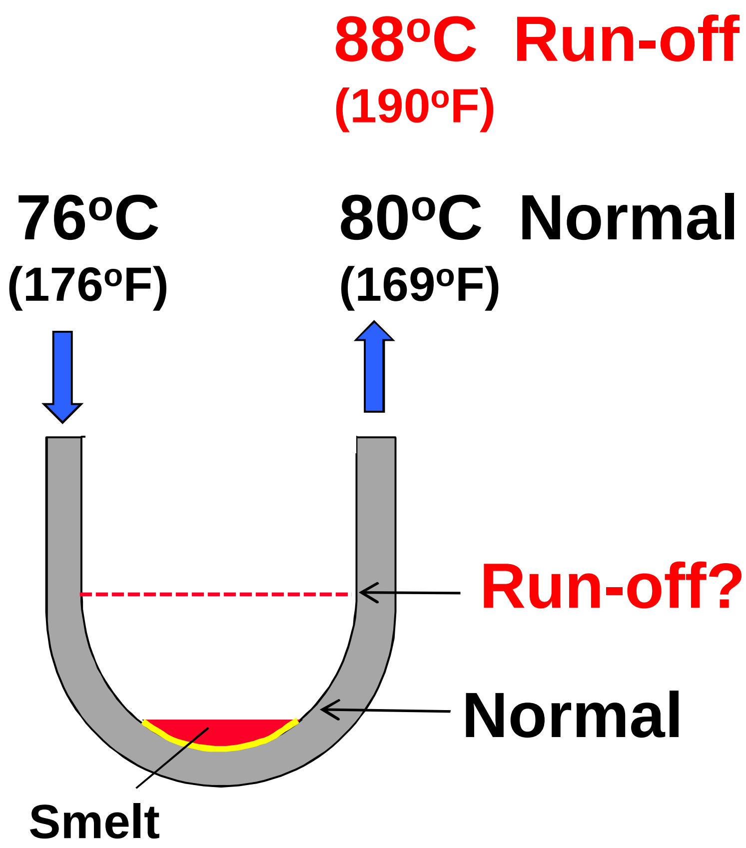
- For boilers with 4 smelt spouts, 2 plugged spouts usually do not result in smelt run-offs
  - Doubling the smelt flow rate is not the main cause
- However, a plugged shatter jet could result in big bangs even at a normal smelt flow rate
  - Proper smelt shattering is important

Mill A - Spout Cooling Water Temp.



Cooling Water Flow in Smelt Spout

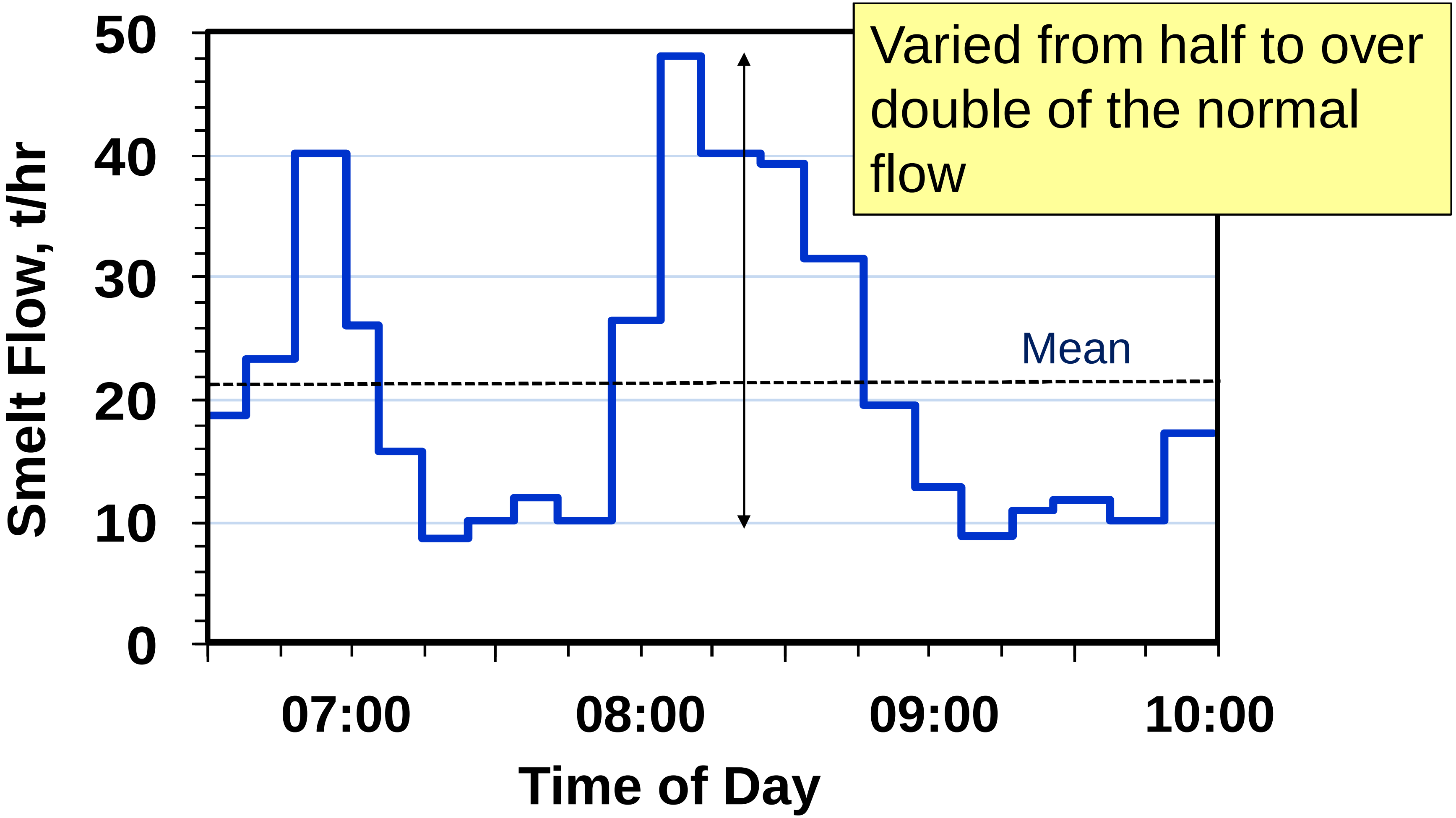




The maximum smelt flow during these severe run-offs at Mill A must have been massive (5 times?)

Smelt Flow During “Normal” Operation

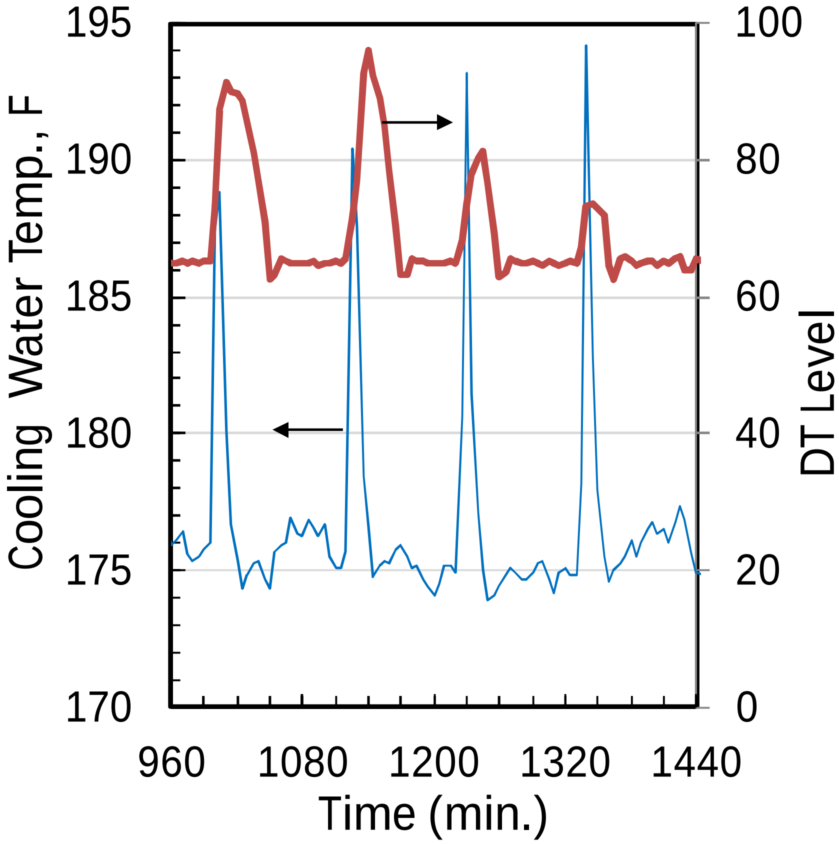
(based on DT mass balance for a 780 t/d pulp mill)



Wiklander, G., BL Recovery Boiler Symposium, Helsinki, Finland, (1982)

Semi-quantitative Analysis

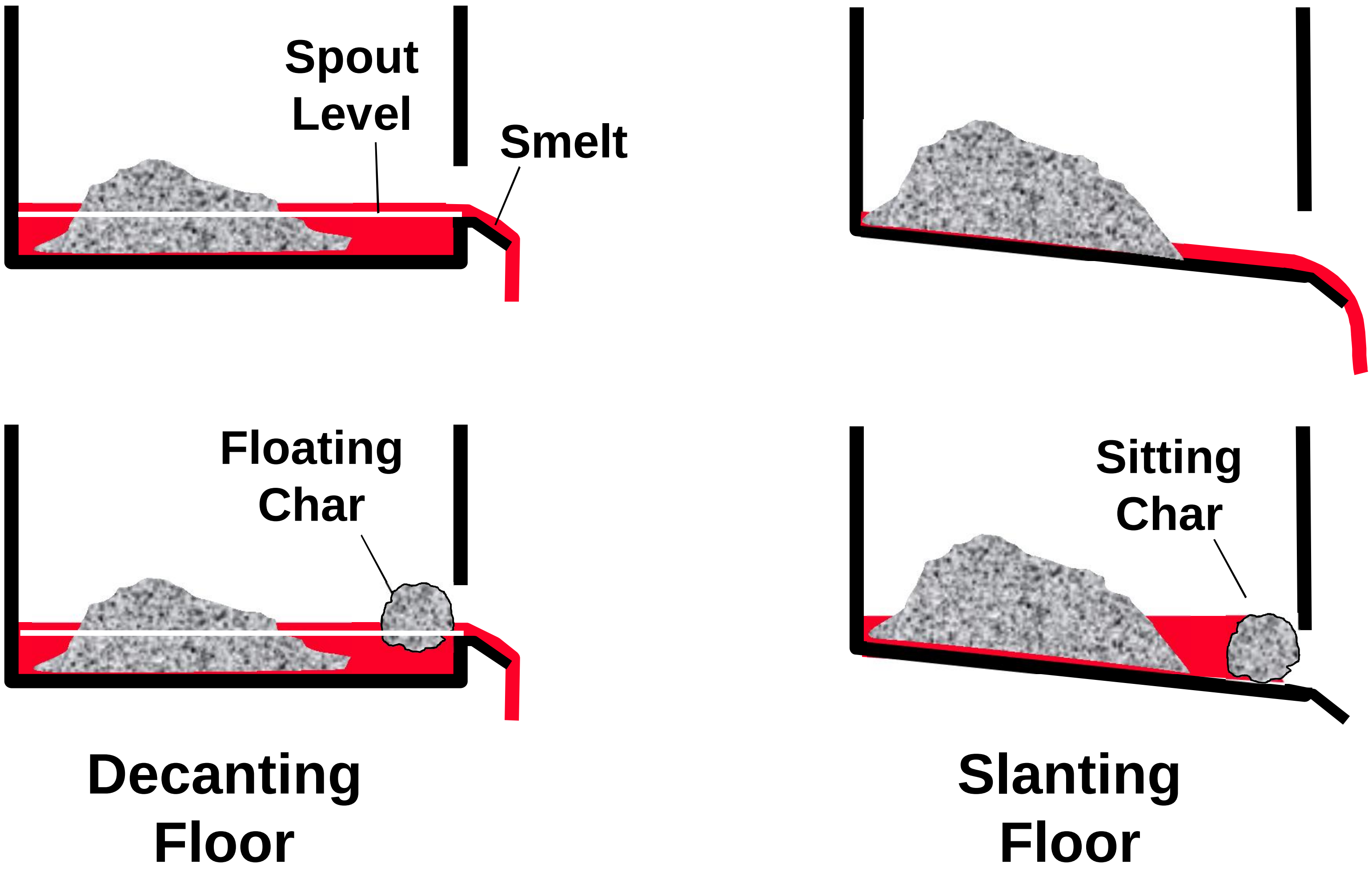
- A smelt runoff event lasts about 30 minutes, but its effect may last more than 1 hour
- The smelt flow rate at the peak of a runoff may be as much as 5 times of the normal flow rate



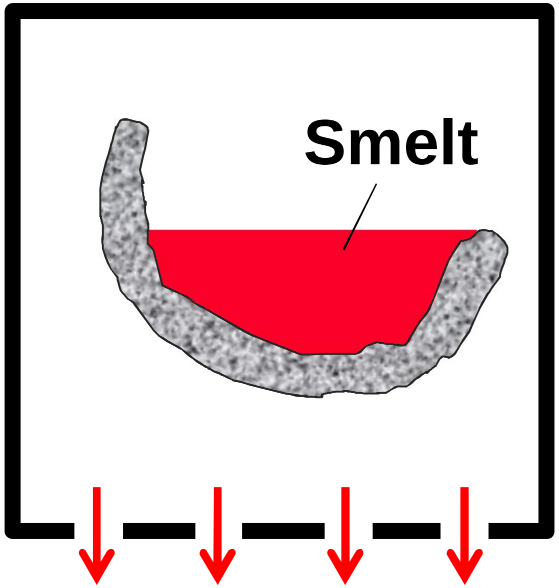
Two Basic Requirements for a Smelt Runoff

- Smelt Collection
  - Behind dams (char bed and/or large deposits)
  - In char bed craters
  - Behind plugged spouts
- Smelt Release triggered by
  - Bed collapsing
  - Bed burned down
  - Falling deposits
  - Spout cleaning

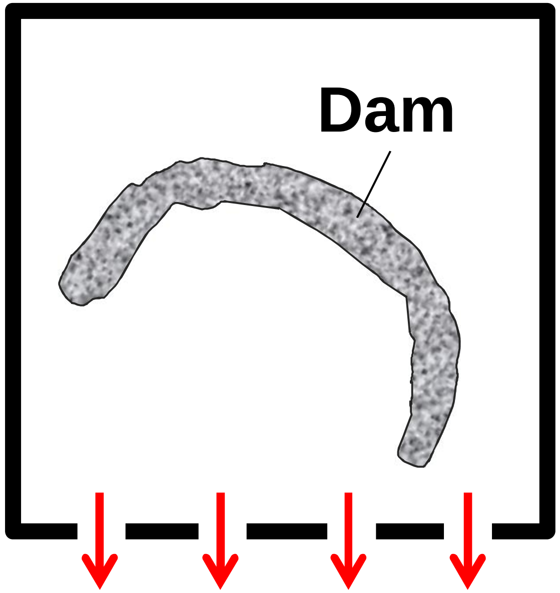
Slanting floor boilers are more susceptible to smelt accumulation



Dam Shape vs. Smelt Accumulation

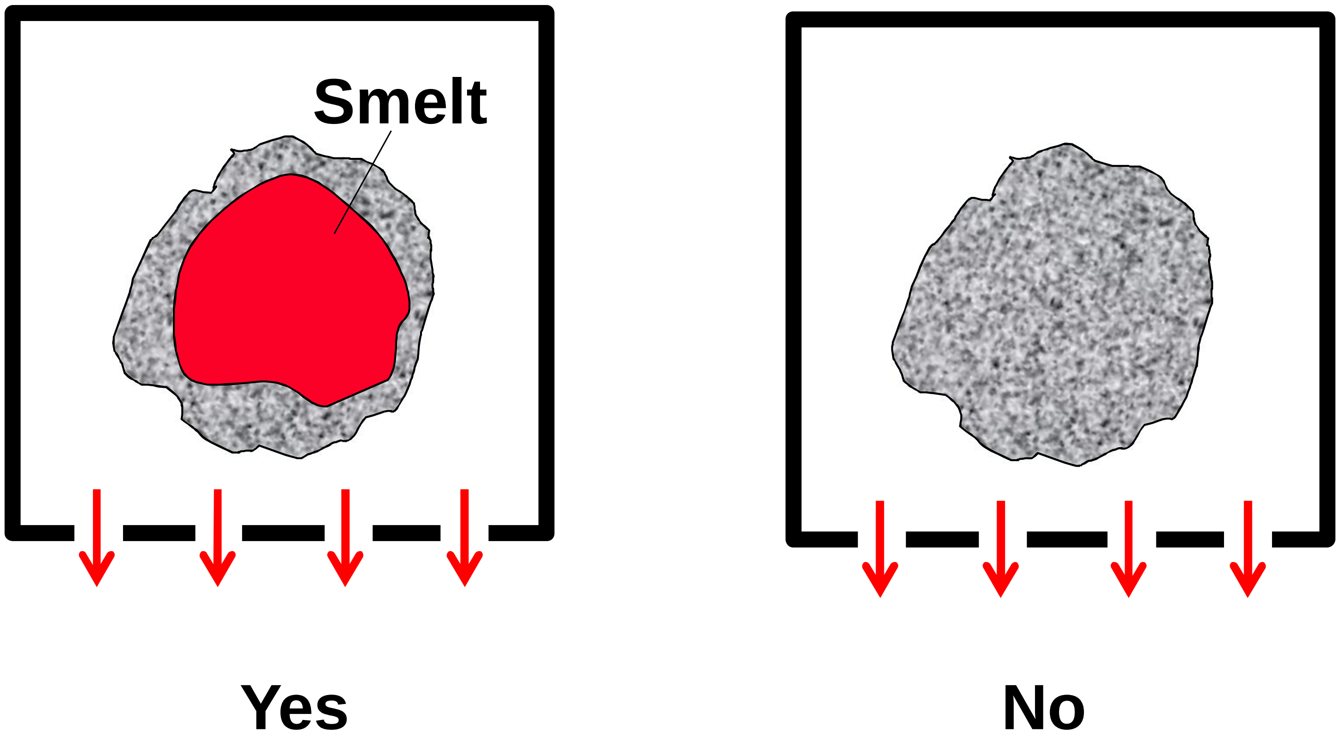


Yes - particularly for slanting floor boilers



No

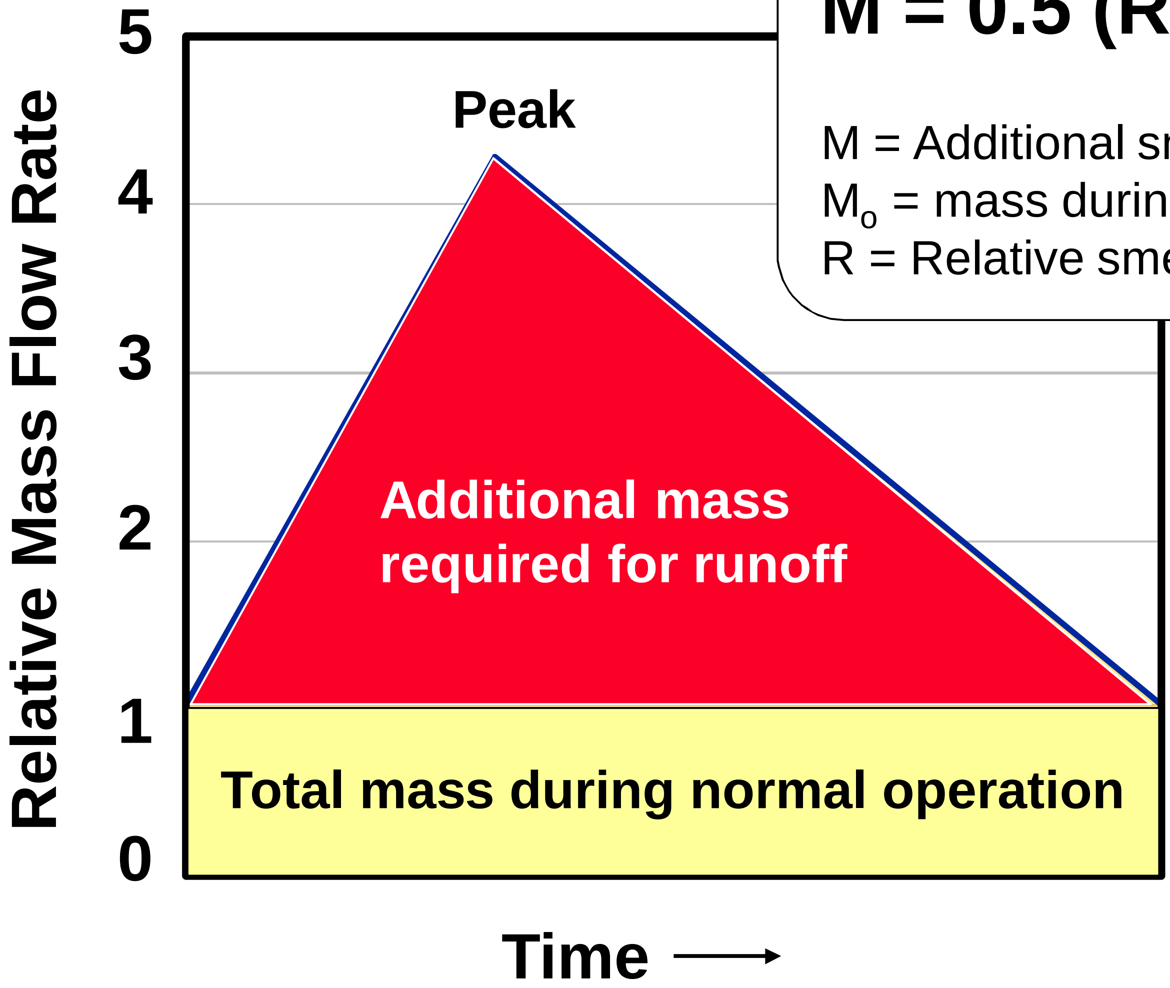
Crater Shape vs. Smelt Accumulation



Effect of Falling Deposits

- Smelt spout blockage
- Dam and crater formation
- Smelt surge
  - Char bed breakup
  - Volume displacement
- “Jellyroll” smelt formation
  - Char bed and smelt cooling
  - Deposits contain sulphate (not sulphide), greatly increasing the “local” smelt freezing temperature

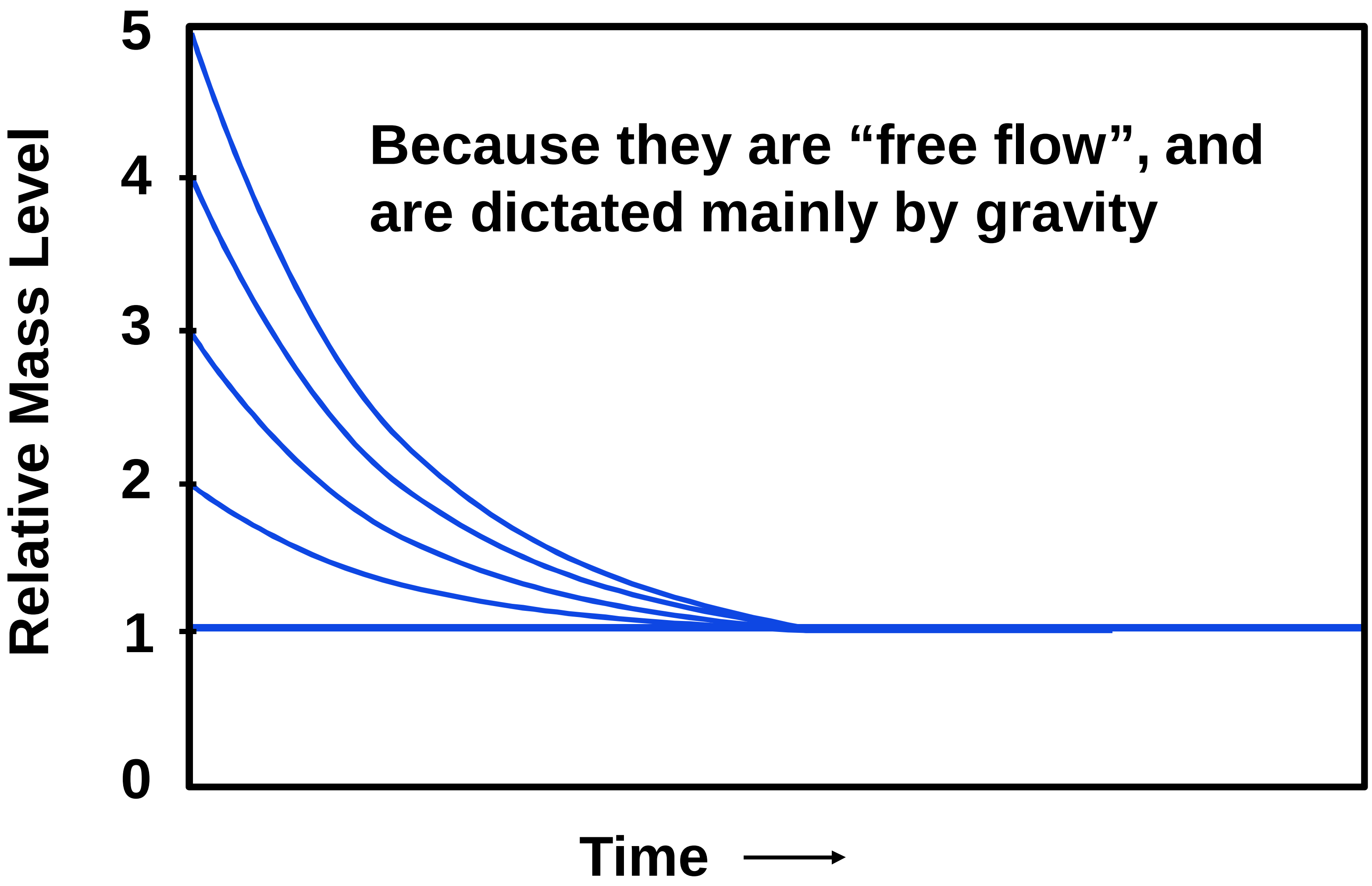
Smelt Mass Required for a Runoff



$$M = 0.5\ (R_{Peak}-1)\ M_o$$

M = Additional smelt mass needed for runoff
M_o = mass during normal operation
R = Relative smelt flow rate at peak

Why Are All Runoff Durations almost the same (about 30 minutes)?



Summary-1

- A smelt runoff event
  - Lasts 25 to 30 minutes at a peak flow rate 2 to 5 times higher than normal
- Smelt runoffs may be detected by
  - Spout cooling water exit temperature
  - DT level, liquor TTA, density, temperature, weak wash flow and GL flow
- Smelt flow can be calculated based on material and heat balances around the DT

Summary-2

- At high smelt flow rates, DT explosions may be avoided if smelt is properly shattered
  - This may be limited by shatter jet designs
- On the other hand, DT explosions can occur at a normal smelt flow rate if smelt is not shattered
  - Shatter jet malfunction
  - Nozzle is plugged
  - Jellyroll smelt

Summary-3

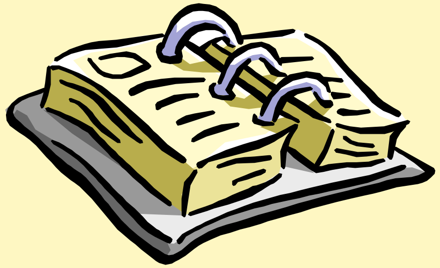
- Boilers with a larger number of spouts are less susceptible to runoff problems
- Boilers with a slanting floor are more susceptible to runoff problems
  - Allowing smelt to accumulate
- Char bed size and shape, falling deposits and smelt freezing temperature can all contribute to smelt runoff problems

CNCG Collection/Conditioning Systems for Incineration in Recovery Boilers

2013 AF&PA Recovery Boiler Committee Meetings and Conference

Paul Johnson
(paul.johnson@lundbergassociates.com)
Lundberg - Bellevue, WA

Agenda



1. Introduction
2. CNCG Properties
3. RB burning of CNCG in Perspective
4. Collection, Transport, Conditioning
5. Operation and Safety Interlocks
6. RTR Considerations

Introduction

NCG :

Non-Condensible Gas

Kraft mill odorous gases

- sulfur compounds (TRS)
- organics (methanol, terpenes)
- water vapor and air

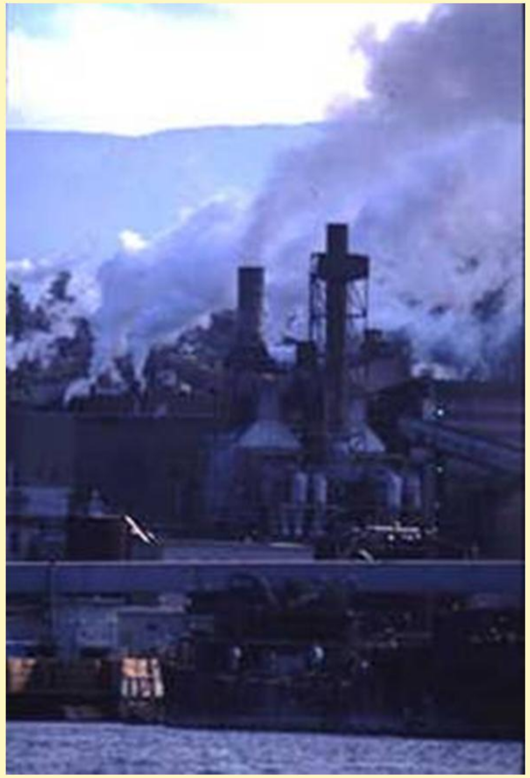
Introduction

Kraft mill odorous gases contain sulfur compounds originating from:

- digesters
- evaporators
- turpentine systems
- stripping systems
- brown stock washers
- filtrate tanks
- liquor storage tanks

Introduction

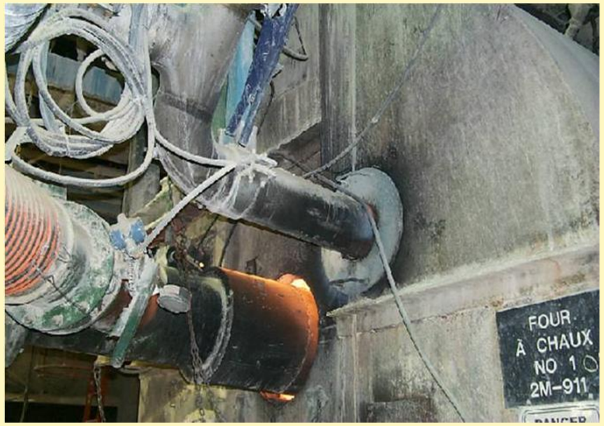
- NCG vented to atmosphere can cause
  - Injury
  - Environmental damage
  - Nuisance odor



- Stringent environmental regulations require
  - Collection
  - Incineration (Destruction)

Traditional “Weapons of Gas Destruction”

Lime Kiln

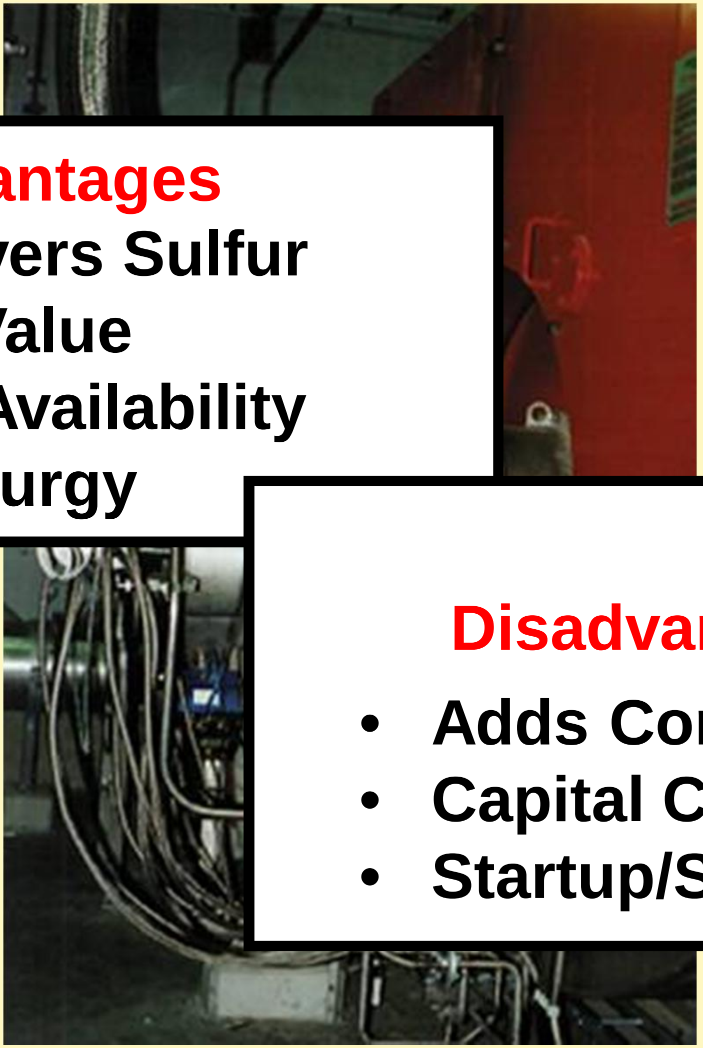


Dedicated Incinerator

Power Boiler

Regenerative Thermal Oxidizer

Recovery Boiler



Advantages

- Recovers Sulfur
- Fuel Value
- High Availability
- Metallurgy

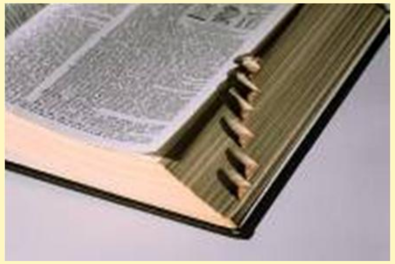
Disadvantages

- Adds Complexity
- Capital Co$t
- Startup/Shutdown

NCG Properties determine:

- Safe Collection and Transport Practices
- Conditioning Requirements
- Safe Incineration Methods

NCG Properties

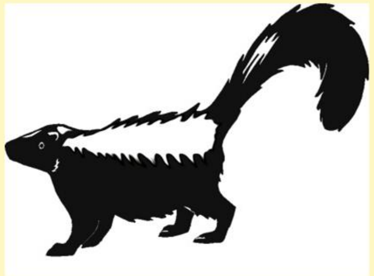


TRS: Total Reduced Sulfur

- Kraft mill odorous sulfur compounds
  - Hydrogen sulfide H_2S
  - Methyl mercaptan CH_3SH
  - Dimethyl sulfide $(CH_3)_2SH$
  - Dimethyl disulfide $(CH_3)_2S_2$

NCG Properties

NOXIOUS



CORROSIVE

TOXIC

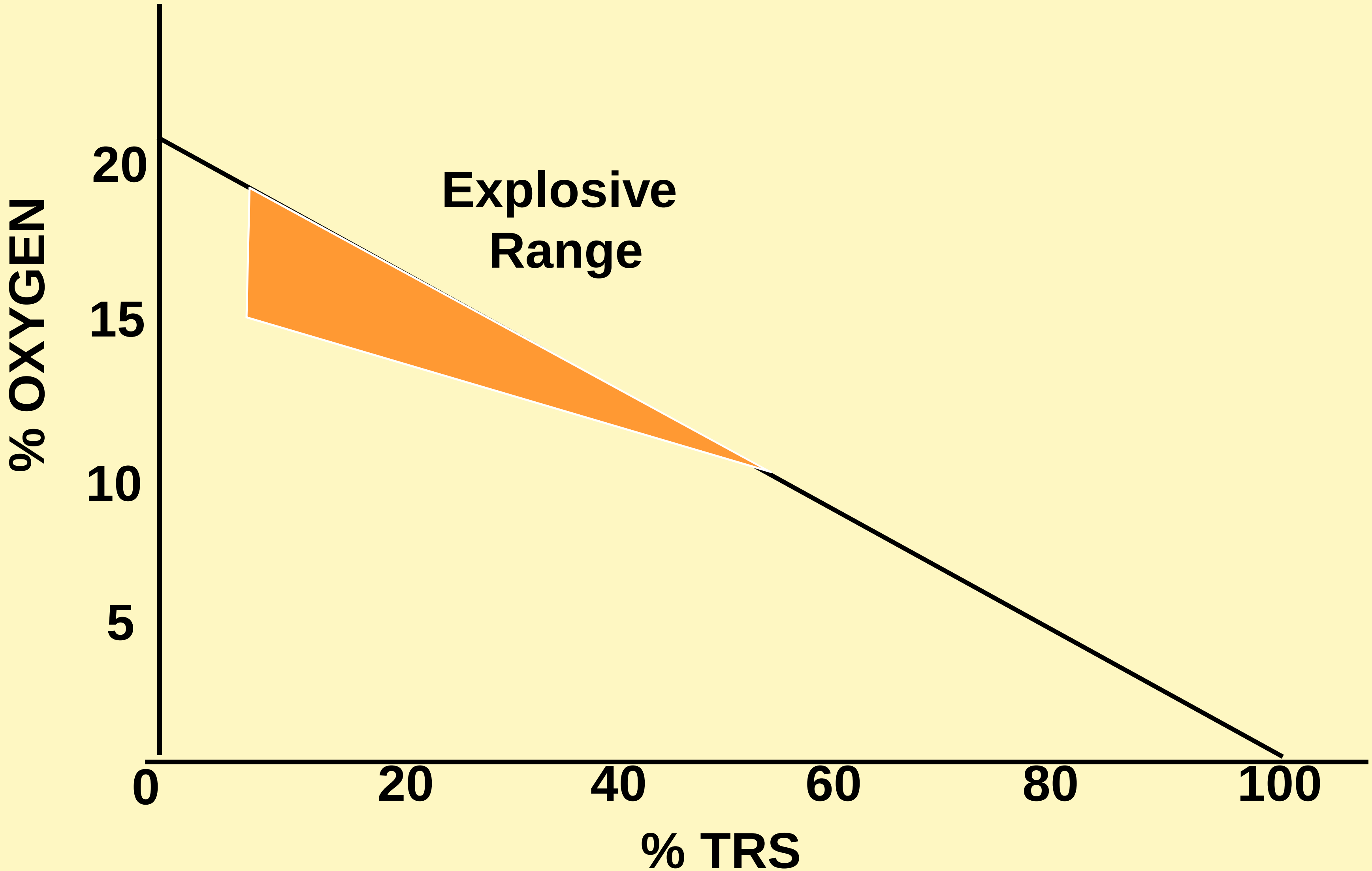
EXPLOSIVE

Combustion Properties

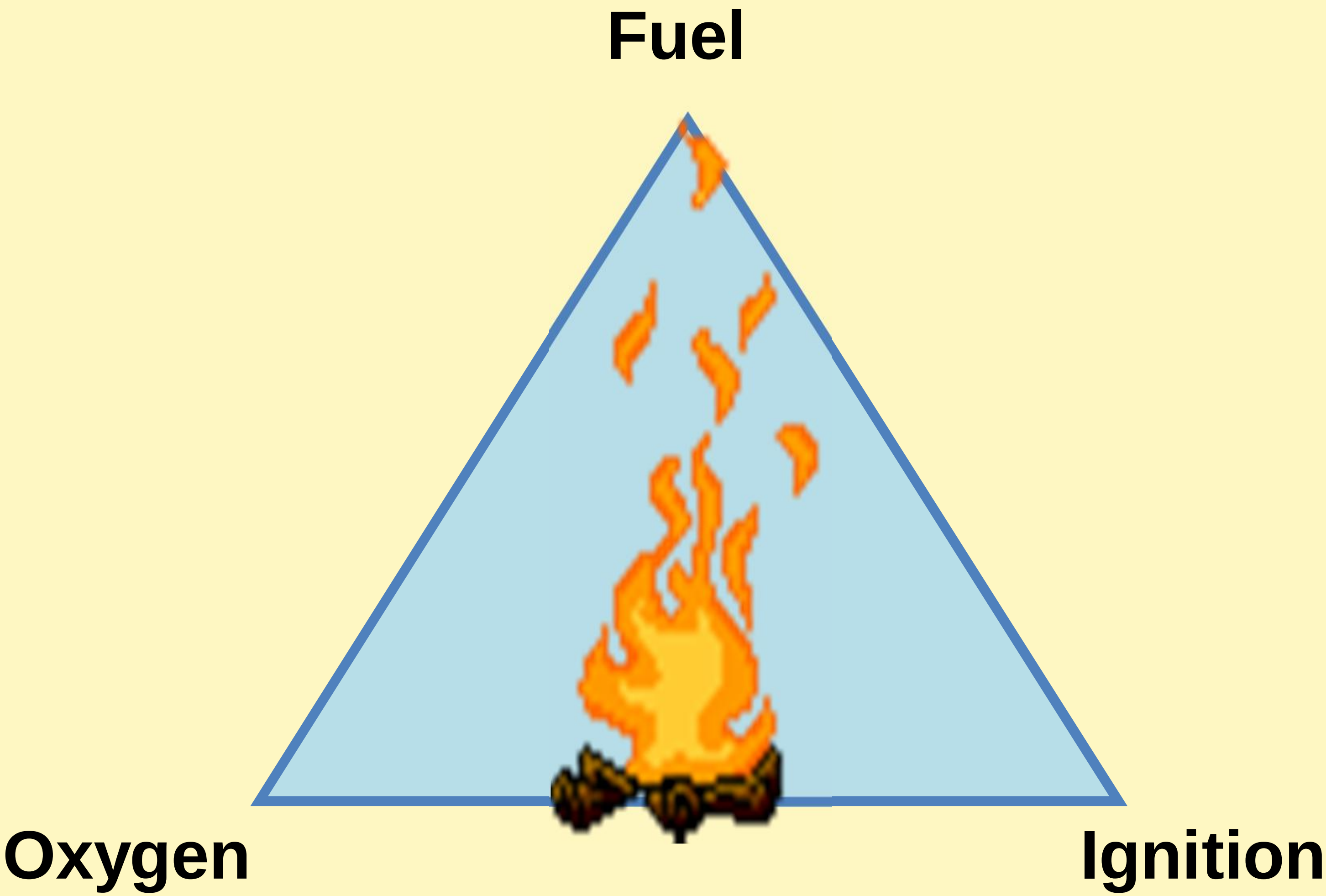
Flame Propagation Speed	(feet/second)
TRS, methanol	2
Terpenes	100-500

Explosion Limits	Lower (vol%)	Upper (vol%)
Combustibles	2	50

Explosive Range of NCG



Requirements for Fires



Types of NCG Systems

- Concentrated (CNCG)
- Stripper Off Gas (SOG)
- Dilute (DNCG)
- Chip Bin Gas (CBG)

Firing of NCG in Recovery Boilers

Treated as Fuel – Added through Burners

- Concentrated (CNCG)
- Stripper Off Gas (SOG)

Treated as Air – Added to Air Systems

- Dilute (DNCG)
- Chip Bin Gas (CBG)

Types of NCG Systems

CNCG: Concentrated Non-Condensable Gas

- Low Volume High Concentration (LVHC)
- Digester and evaporator areas
- TRS, wood organics, trace air and water vapor
- High in combustibles, low in oxygen

Types of NCG Systems

SOG: Stripper Off Gas

- Stripper product vapor
- Methanol, water vapor, TRS, terpenes, organics
- "Very Condensable Gas"
- Target concentration:
  - 50 wt % combustibles
  - 50 wt % water vapor

CNCG in Recovery Boiler

For a 1000 TPD Kraft Mill:

Typical CNCG flow to incineration

- 500 ACFM @ 168 F
- 20% TRS compounds
- 50% Nitrogen, some oxygen
- 30% moisture, saturated

➢ 6 inch diameter stainless steel line

CNCG in Recovery Boiler Mass Perspective

For a 1000 TPD Kraft Mill:

- 1500 TPD BLS (dry) (Elephant)
- 10 TPD CNCG (dry) (Labrador)
- 1 TPD Sulfur in CNCG (Chihuahua)

CNCG in Recovery Boiler Furnace Volume Perspective

For a 1000 TPD Kraft Mill:

- BLS burning requires a Recovery Boiler the volume of a building several stories high
- CNCG can be burned in an incinerator the volume of a Chevy Suburban

CNCG in Recovery Boiler Moisture Perspective

For a 1000 TPD Kraft Mill:

- 583 TPD moisture with liquor@72% solids
- 4 TPD moisture with CNCG (sat'd @ 168 F)

  (Hot tub full of water)

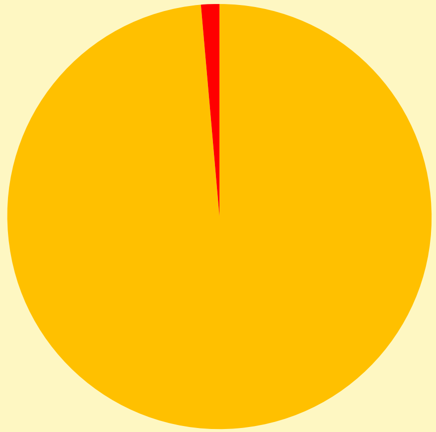
  (Pitcher of sweet tea)

- 1 TPD moisture with CNCG (sat'd @ 120 F)
- 5 TPD moisture with SOG (50 wt% methanol)

CNCG in Recovery Boiler Chemical Perspective

For a 1000 TPD Kraft Mill:

- 70 TPD sulfur in black liquor
- 1 TPD sulfur in CNCG
- (negligible sulfur in SOG)



Typical CNCG: 2 lbs sulfur/ton of pulp

(1/4 to 2/3 of mill sulfur makeup)

CNCG in Recovery Boiler Energy Perspective

For a 1000 TPD Kraft Mill:

- BLS 5400 BTU/lb (dry), 680 MMBTU/hr
- CNCG 2600 BTU/lb (dry), 2 MMBTU/hr

(One more cup of gas in a 20 gallon gas tank!)

- SOG 9000 BTU/lb (methanol), 4 MMBTU/hr

CNCG Specialized Equipment

Safety
- Flame Arresters
- Rupture discs

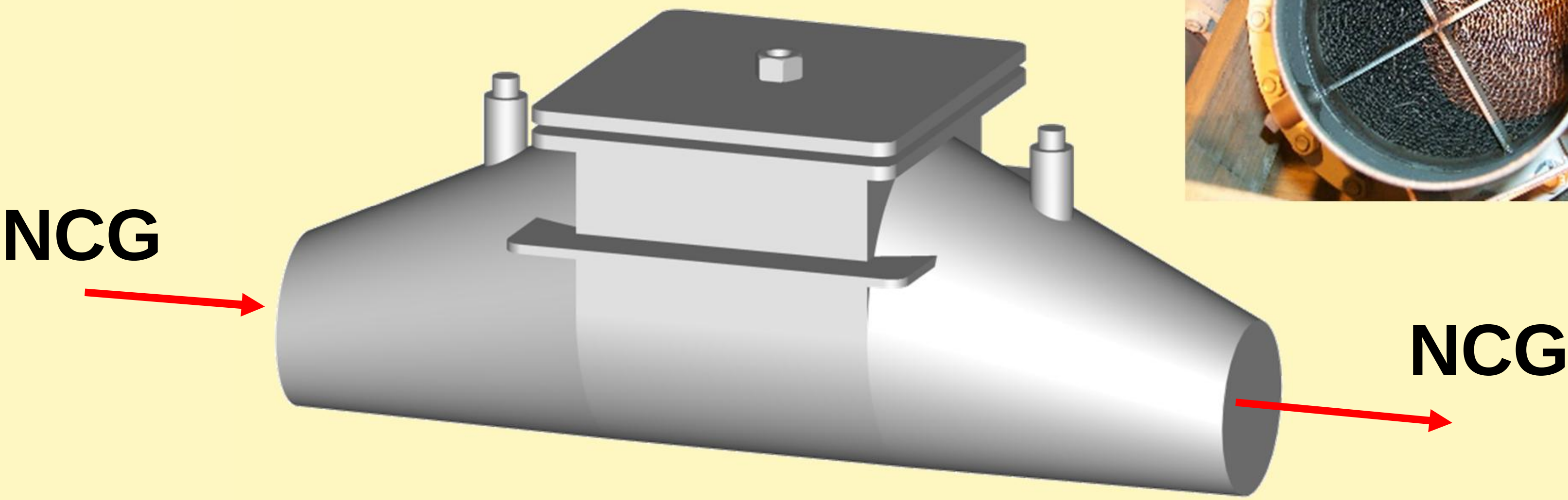
Transport
- Steam ejector

Conditioning
- Gas Cooler
- Gas Reheater
- TRS Scrubber
- Entrainment Separator

Flame Arresters

- In-line devices designed to protect against flame propagation or burn-back

- Located at each source and at each incineration point

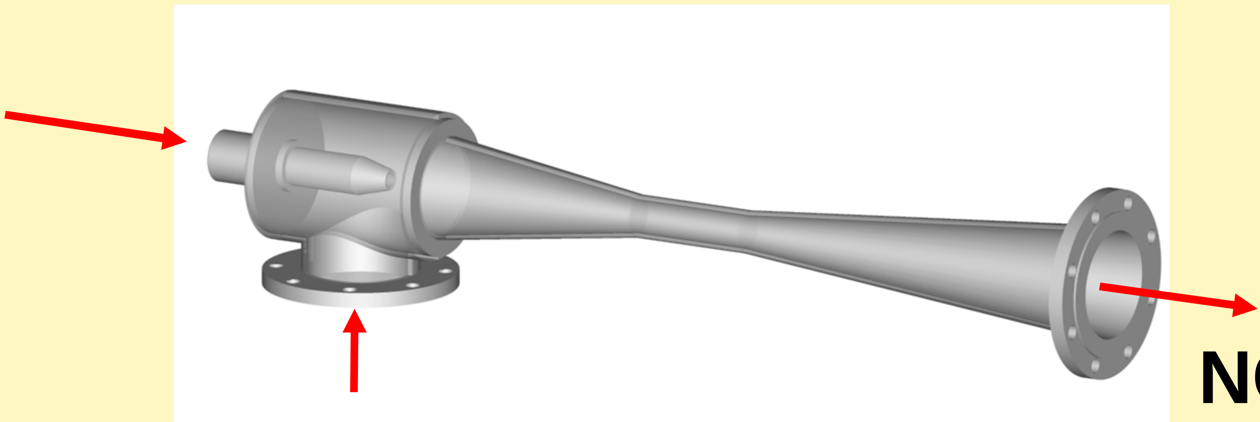


Rupture Discs

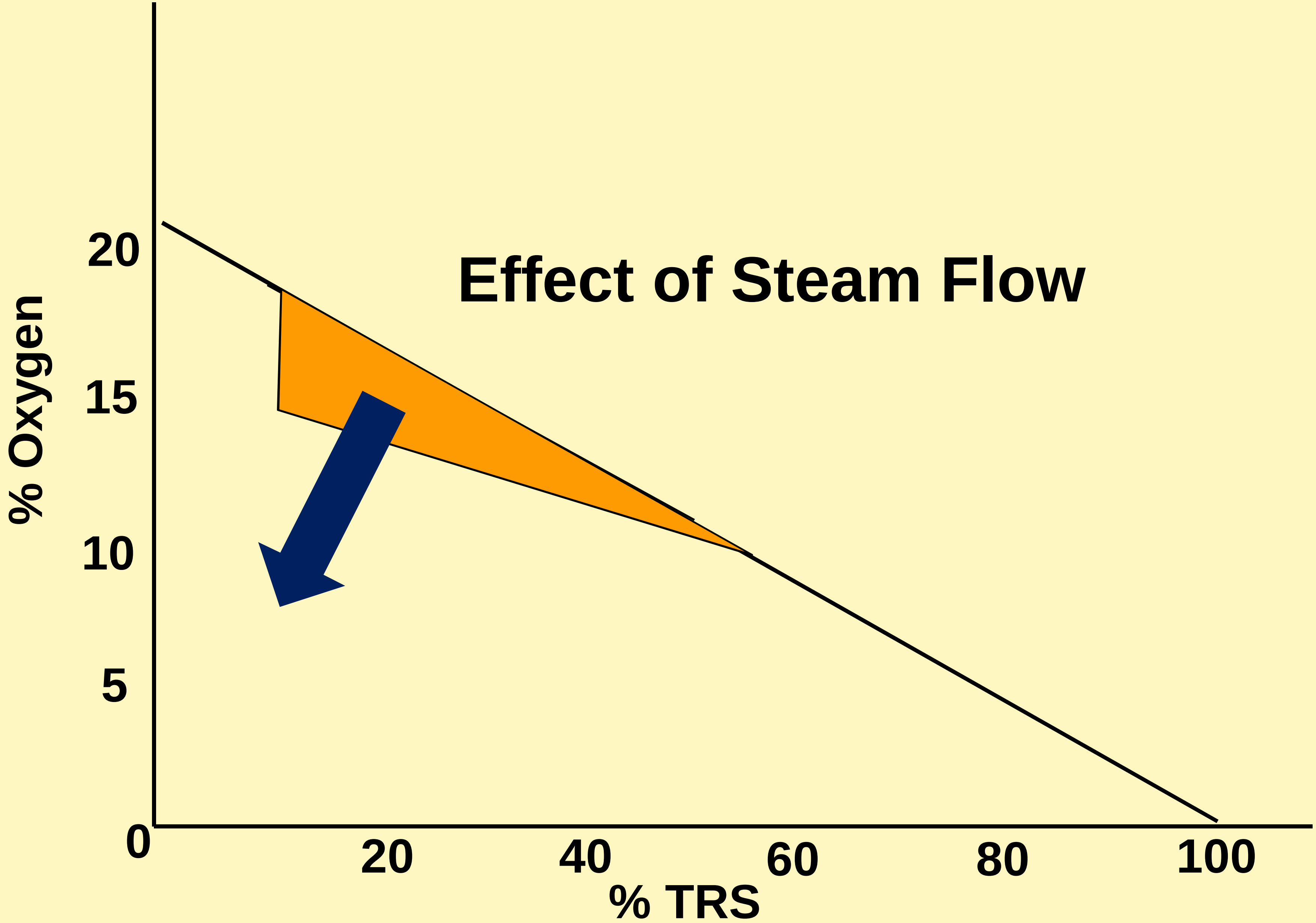
- Protect NCG line against overpressure
- Carbon (graphite) or stainless steel
- Located at sources and burning points
- Full line size

Steam Ejector

- Motivates the NCG
- Keeps collection system under vacuum
- Maintains safe NCG velocity
- Steam suppresses flammability

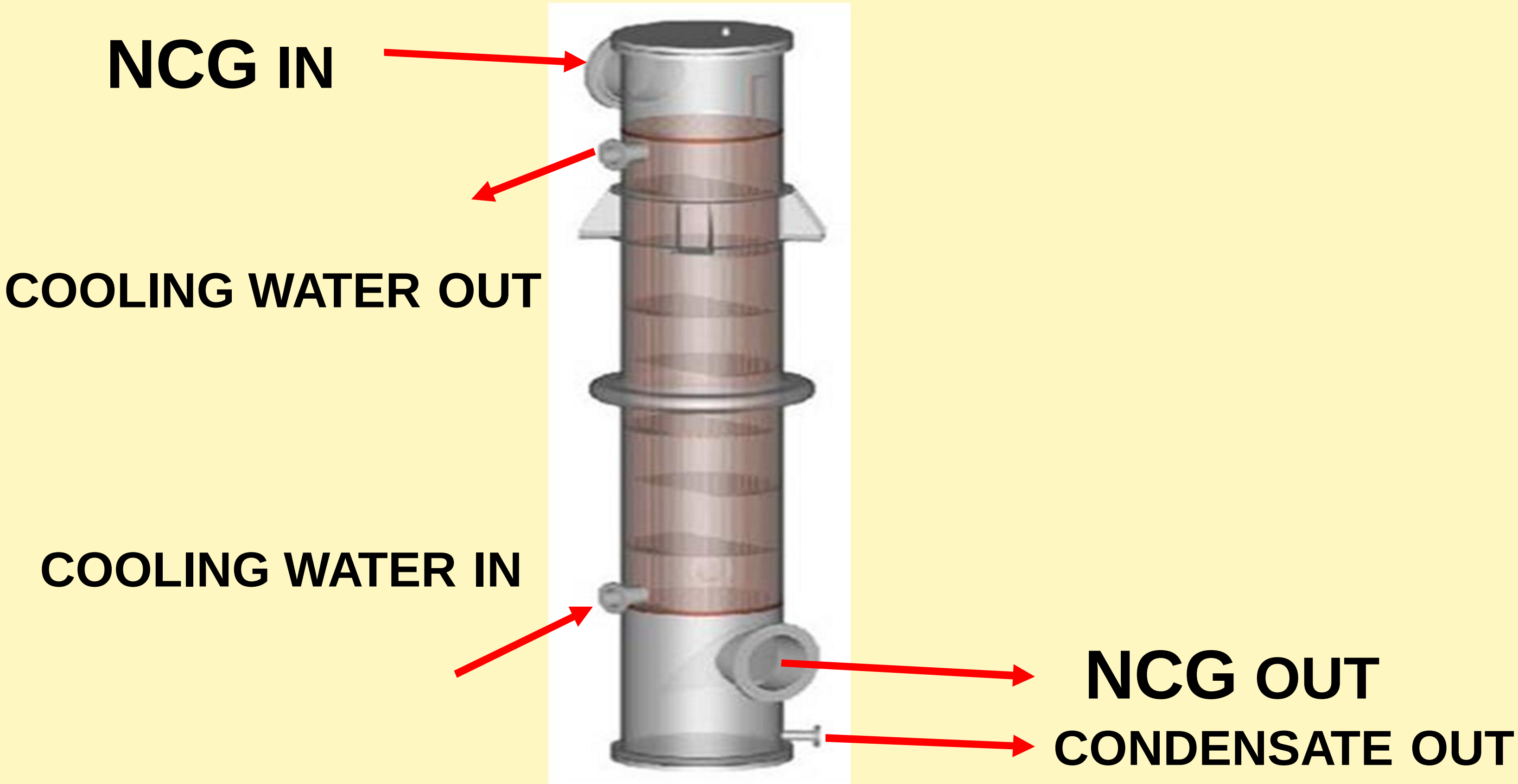


Explosive Range of NCG



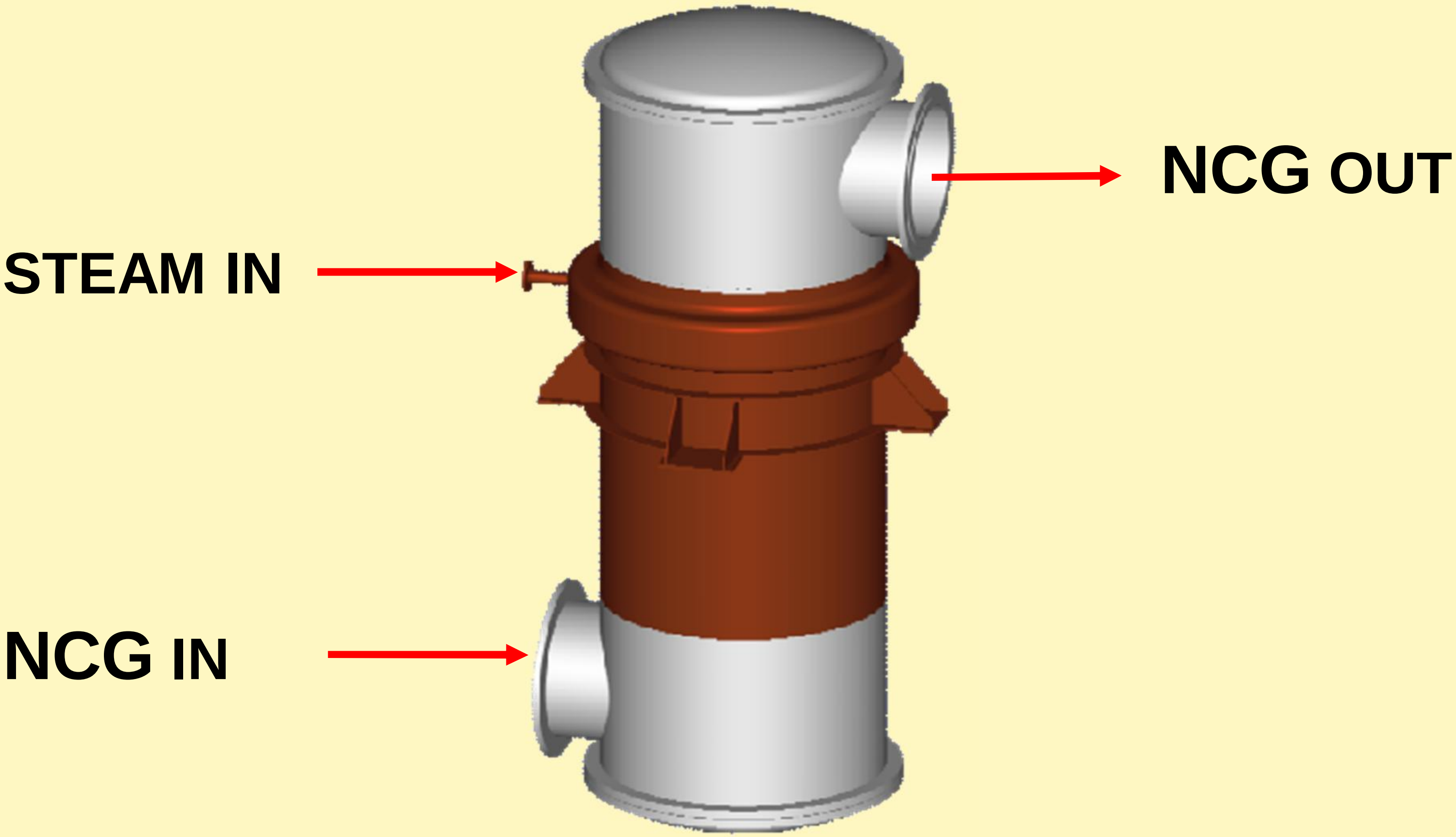
NCG Cooler

- Reduces moisture and volume of NCG
- Removes condensable organics
- Condensing occurs inside the tubes



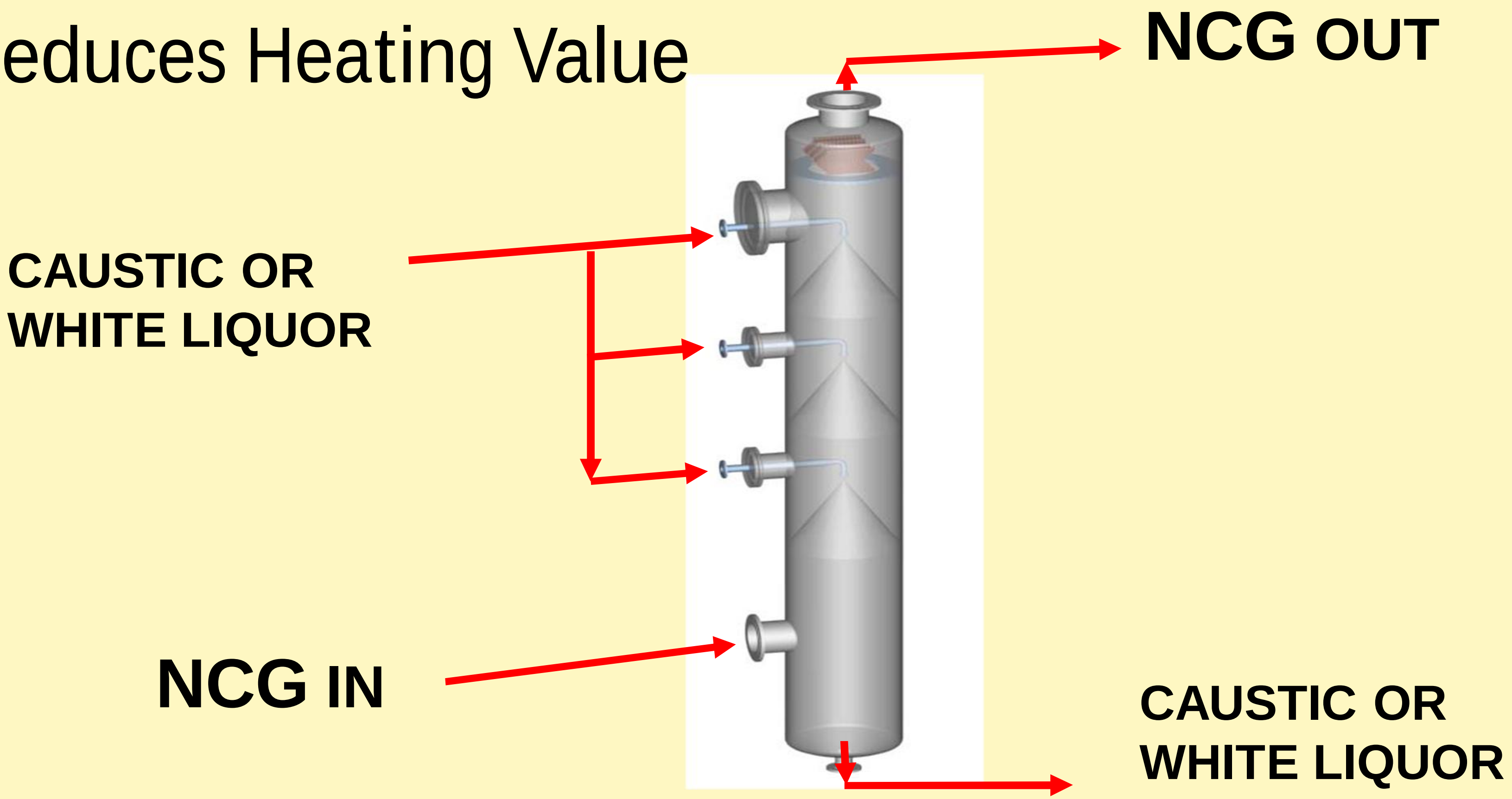
NCG Re-heater

- Superheats NCG to below 50% RH
- Required on DNCG, not on CNCG



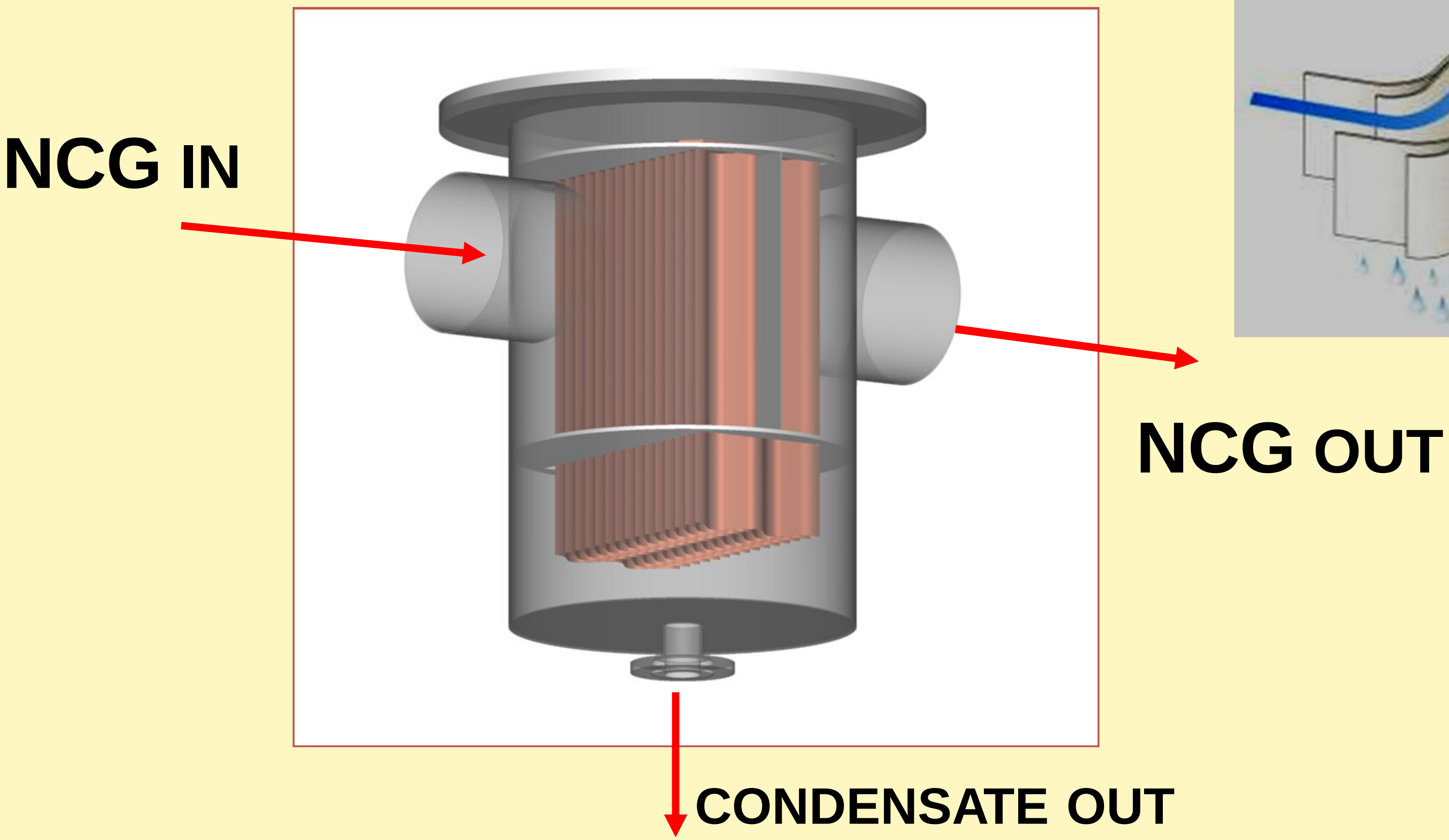
TRS Scrubber

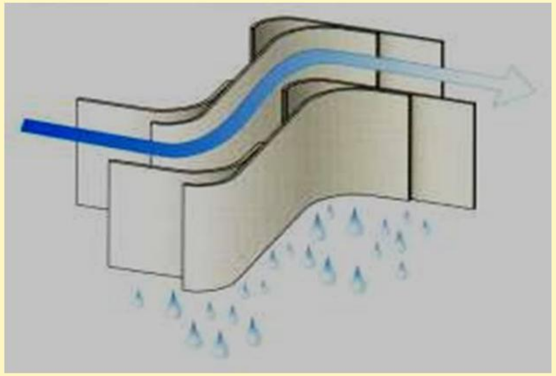
- Caustic or white liquor
- Reduces sulfur content by 50-60%
- Reduces TRS during venting
- Reduces Heating Value



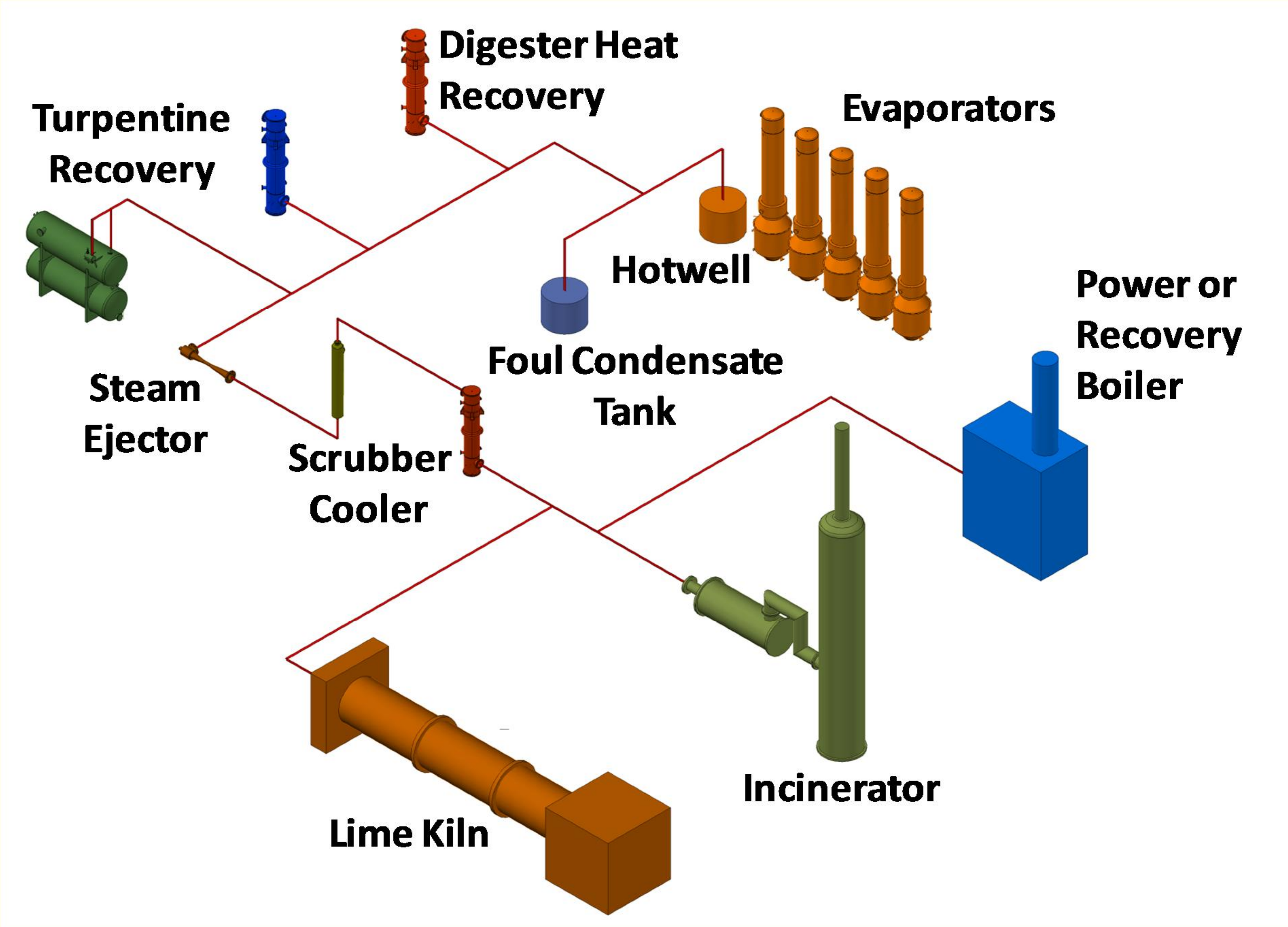
Entrainment Separator

- Removes water droplets before incineration
- Normally chevron demisters with vanes





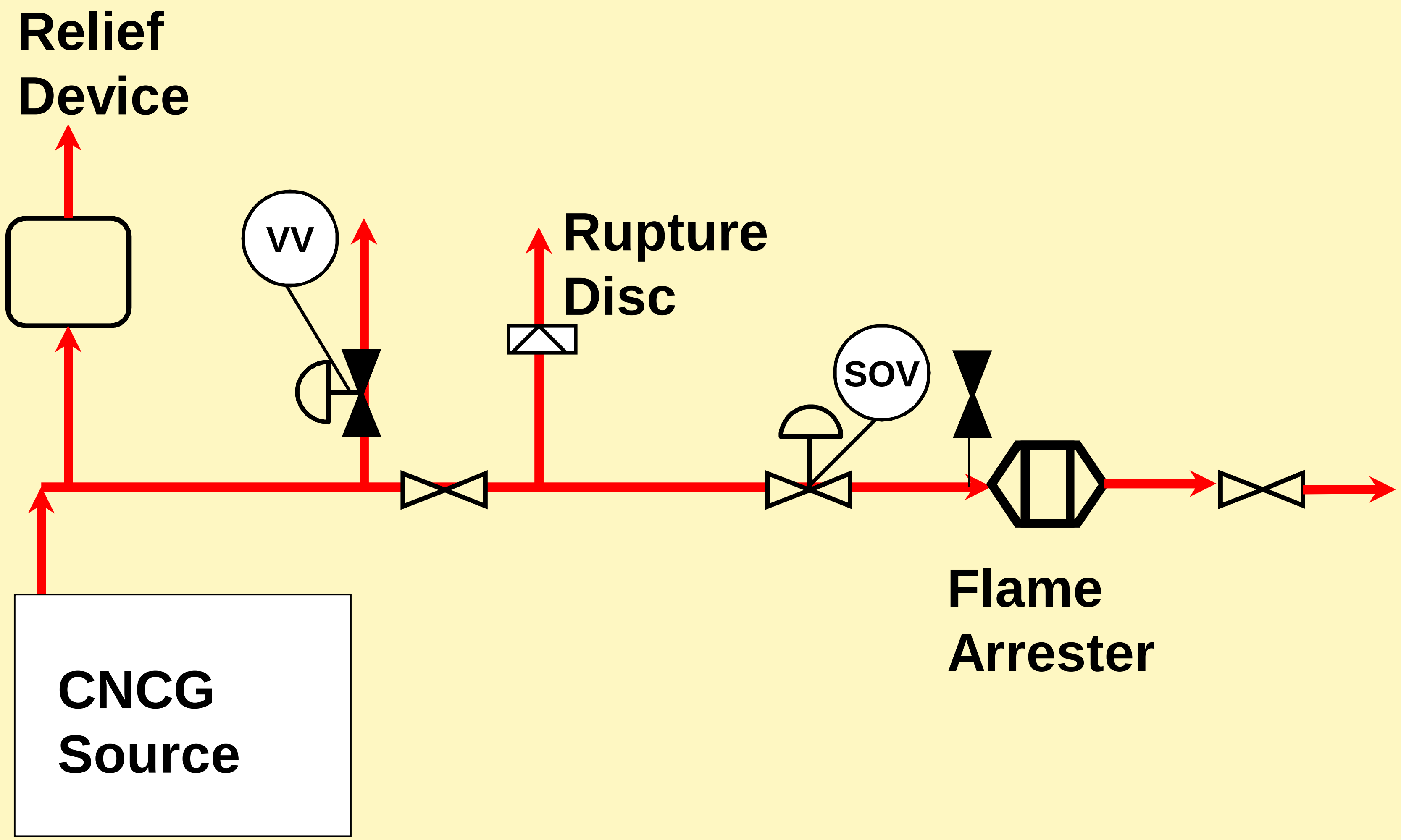
CNCG Collection & Transport



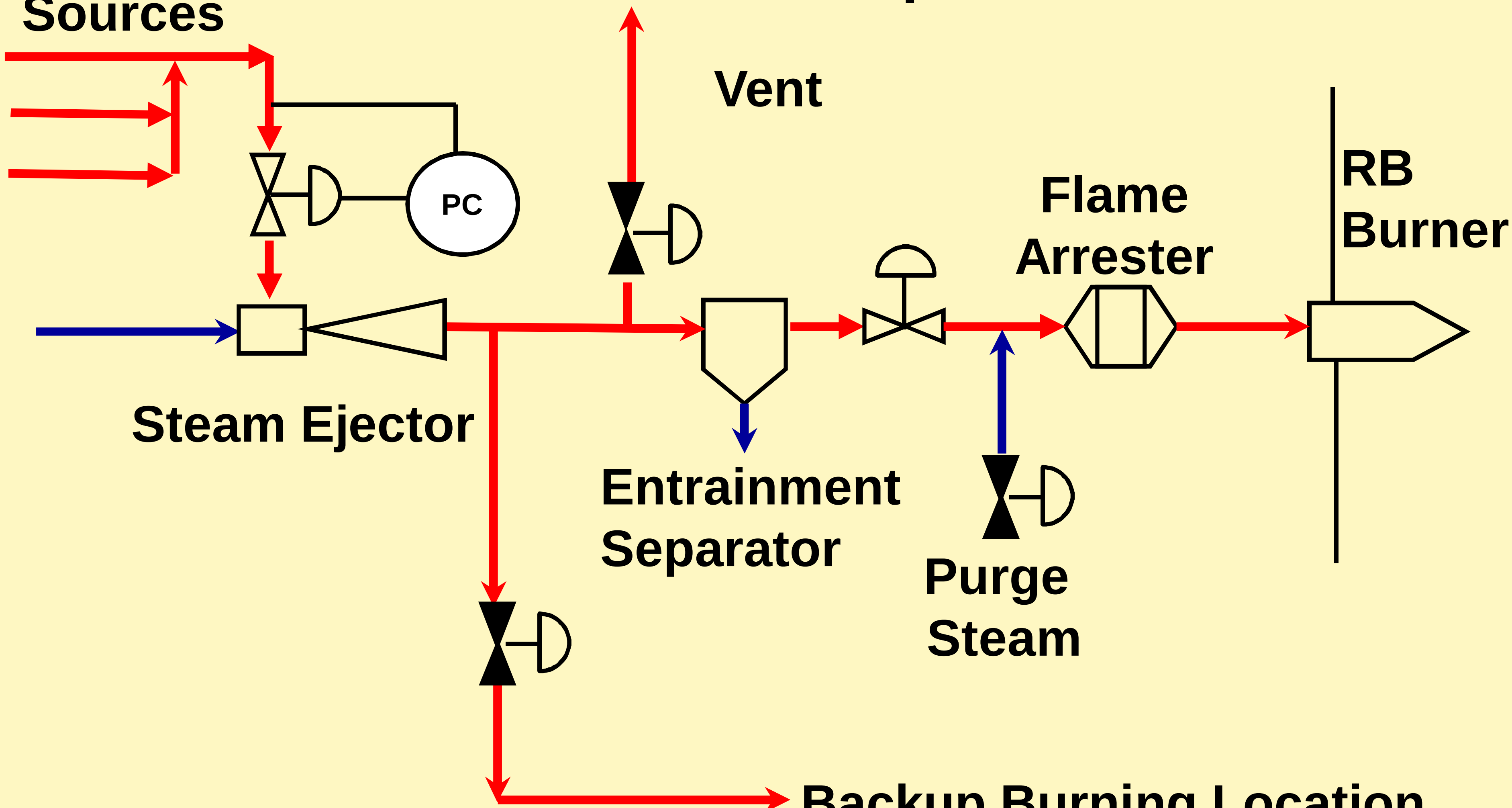
Safe Operation

1. Good Condensing at CNCG Sources
2. Keep Air Out
3. Drain Condensate
4. Eliminate Ignition Sources
5. Protect Piping and Equipment
6. Maintain all Safety Interlocks

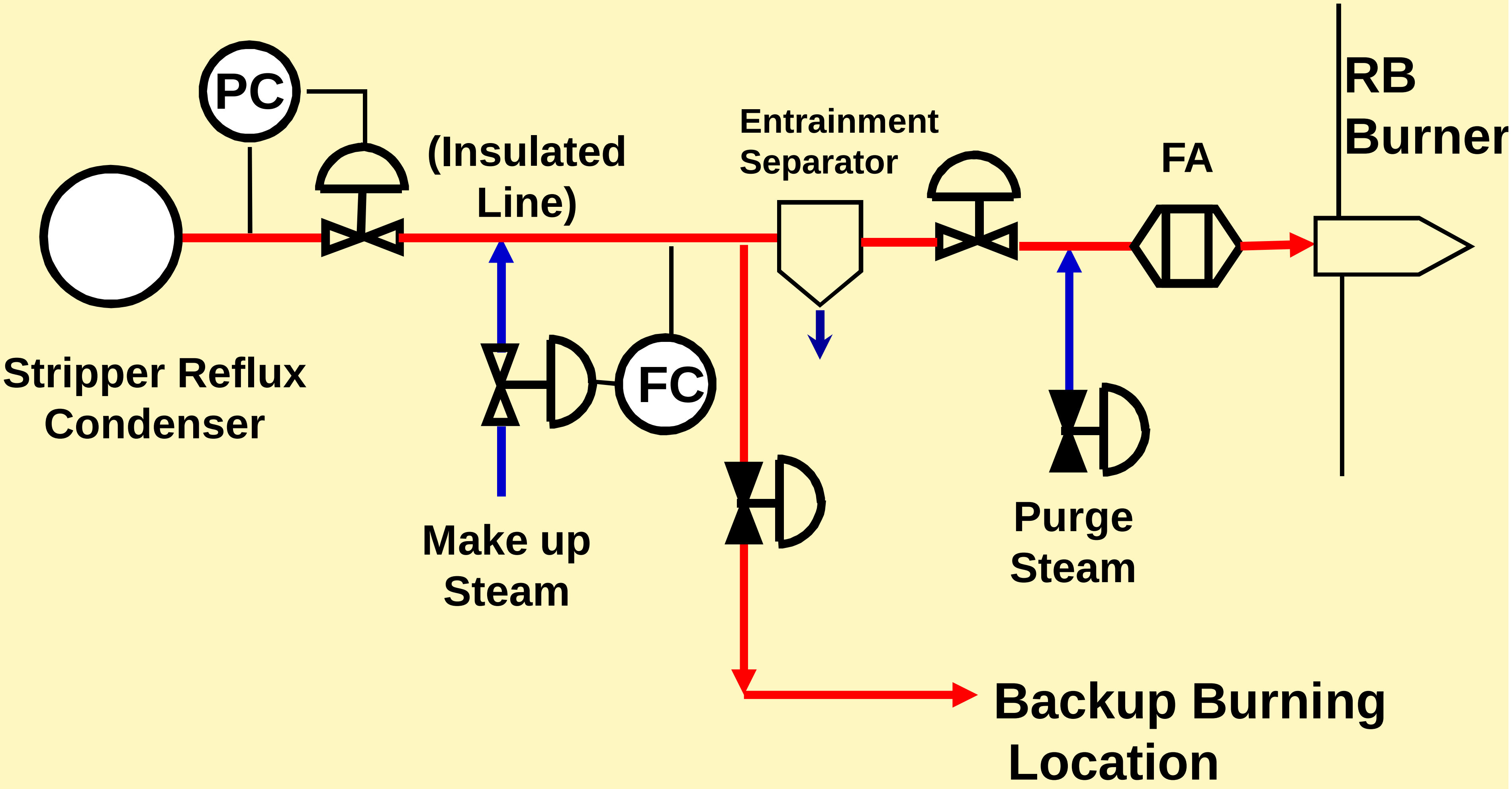
CNCG Source Collection



CNCG Transport



SOG Collection and Transport



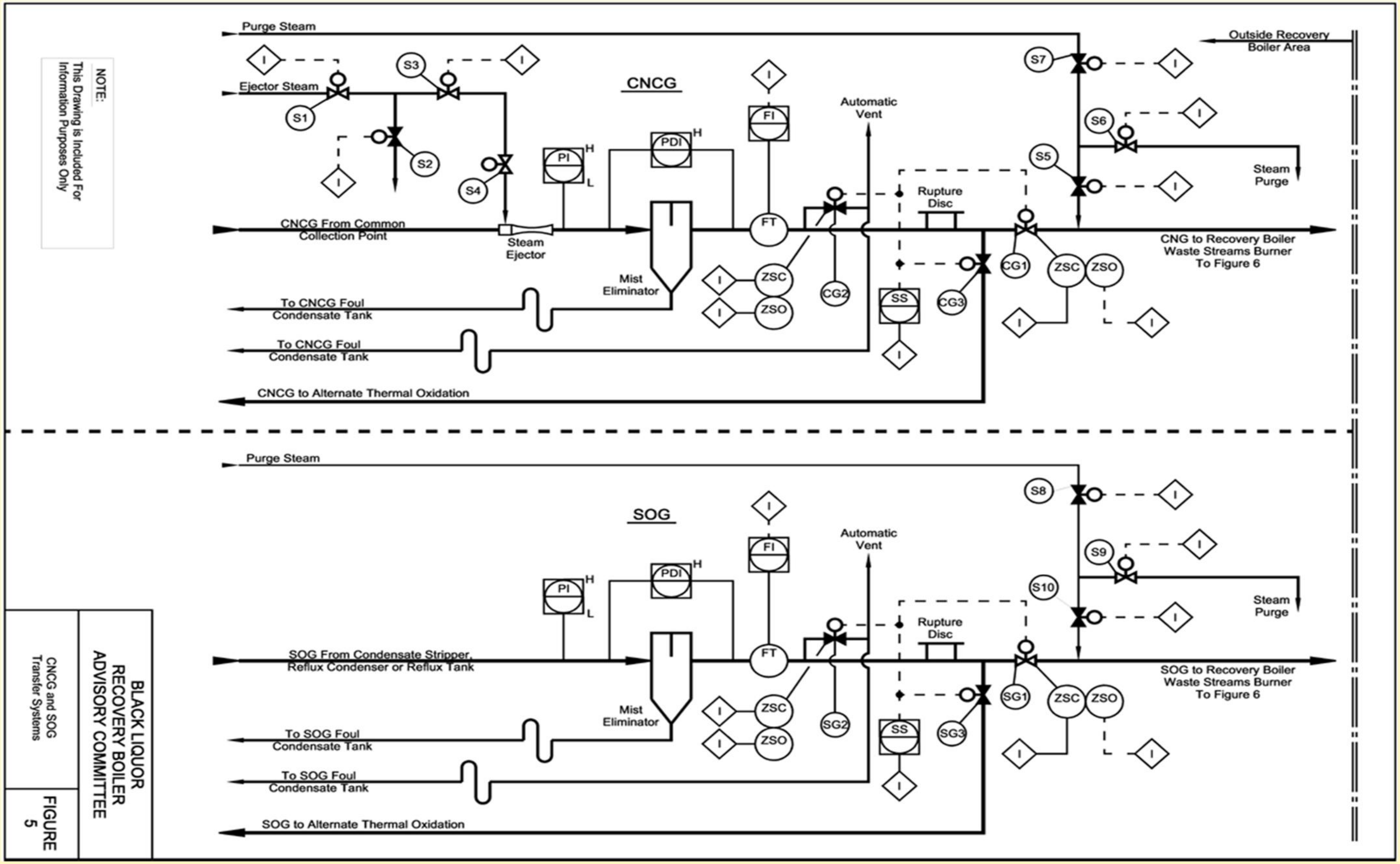
Basic CNCG Safety Interlocks

– High temperature at burning point
– Low NCG velocity at burning point
– Loss of incineration device permissive
– High pressure at any rupture disc
– Loss of NCG ejector

Additional Interlocks at the Recovery Boiler

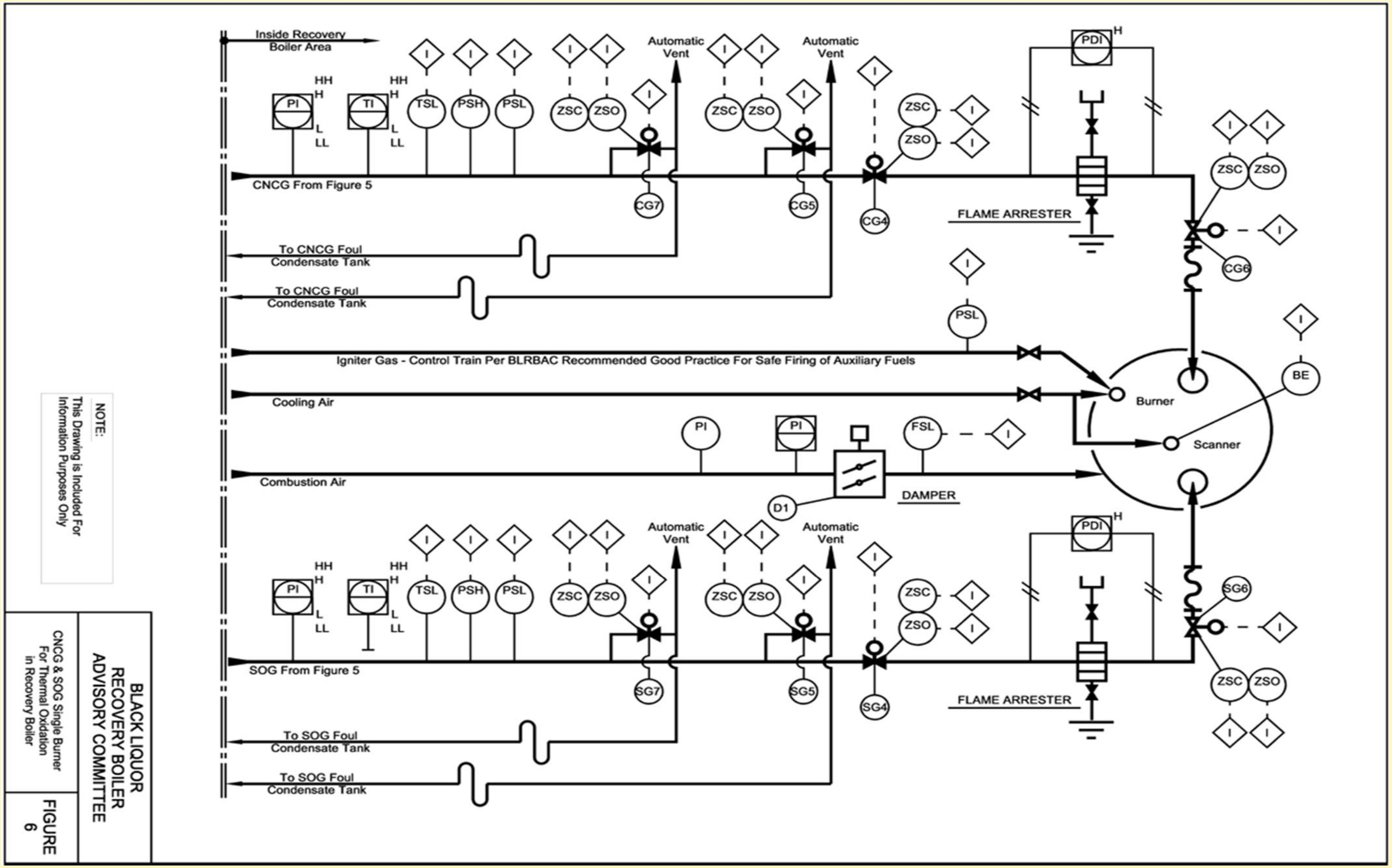
- Interlocks are required to avoid liquid condensate entering the boiler
- BLRBAC has outlined these in detail
- CNCG is treated as a fuel in a dedicated burner with a continuous igniter

BLRBAC (Ch. 5) Guidelines for Burning CNCG and SOG



http://blrbac.org/sites/default/files/Waste%20Streams%20(February%202012).pdf

BLRBAC (Ch. 5) Guidelines for Burning CNCG and SOG



http://blrbac.org/sites/default/files/Waste%20Streams%20(February%202012).pdf

EPA’s Risk and Technology Review of Cluster Rules

New rules in effect from “9-11”, 2012

EPA's RTR Consequences

No vent time allowances for startup, shutdown, or malfunction (SSM)

EPA's RTR Consequences

Collect and burn NCG during startup and shutdown of mill processes

- The NCG burning point is forced to startup first, shutdown last on outages
- If the RB starts first and shuts down last there may be extended downtime

24-36 hours?

EPA's RTR Consequences

Vent time allowances of 1% for CNCG and 4% for DNCG and 10% for condensate stripping remain, but are subject to further revision…

- <88 hrs/year for CNCG

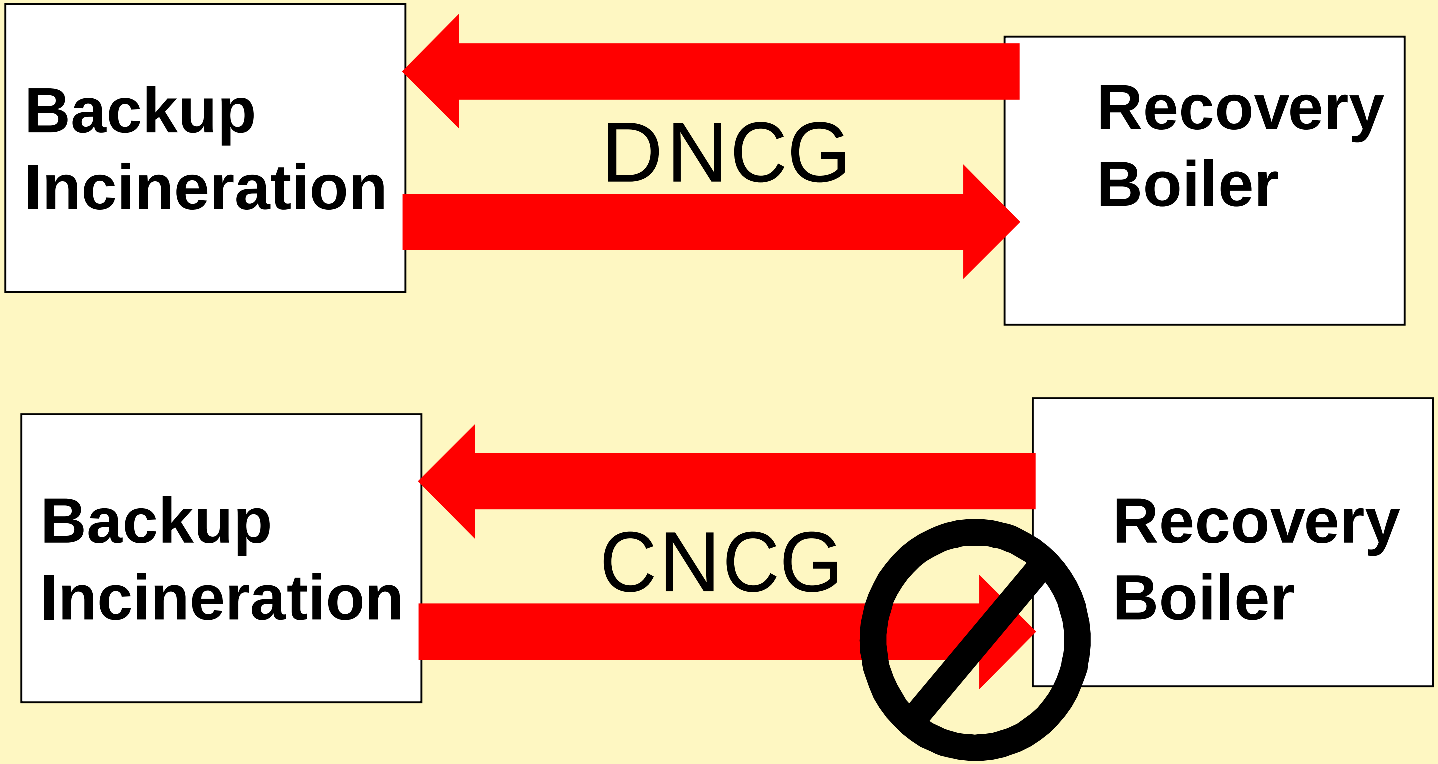
  <350 hrs/year for DNCG
- Some companies already targeting

  <2 hrs/year venting for CNCG and DNCG

EPA's RTR Consequences

Automatic transfer between burning points becoming necessary to minimize venting

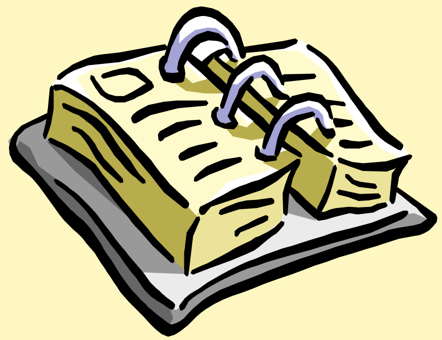
BLRBAC guidelines:



EPA's RTR Consequences

- Backup NCG burning locations a necessity
- The high availability of RB's make them more attractive burning locations
- Liquefaction of SOG can provide some flexibility in handling of stripper product
  - Storage in a surge tank
  - Blending with heavy black liquor
  - Methanol purification and reuse

Summary



- ✓ CNCG Properties
  - determine how it must be handled
- ✓ RB burning of CNCG in Perspective
  -CNCG effect is small vs. RB size and BLS quantity
- ✓ Collection, Transport, Conditioning
  -requires specialized equipment
- ✓ Operation and Safety Interlocks
  -critical and well defined by BLRBAC
- ✓ RTR Considerations
  - more recovery boilers will be burning CNCG

2013 AF&PA Recovery Boiler Meeting

Burning NCGs in RBs

February 6, 2013

Clark Conley

Field Services Manager, North America

metso

Non Condensable Gases (NCG)

	Weak gases, DNCG (Diluted Non Condensable Gases)	Strong gases, CNCG (Concentrated Non Condensable Gases)
Characteristics	Below lower explosion limit	Above upper explosion limit
Volume flow	10.000 – 100.000 m^3/h	300 – 5.000 m^3/h
Sulfur content	0,1 – 0,5 kg S/ton pulp	2 – 4 kg S/ton pulp without superconc. 12 – 14 kg S/ton pulp with superconc.
Sources	Tanks Washers	Evaporator plant Superconcentrators Strippers Liquid Methanol Systems Digester
Treatment	Recovery boiler Scrubber	Recovery boiler Standalone incinerator Lime kiln Power boiler

metso

Odorous Compounds from Kraft Pulp Mill

	Explosion interval, % v/v (wet gas)
Hydrogen sulfide (H_2S)	4 – 44
Methylmercaptan (CH_3SH)	3,9 – 21,8
Dimethylsulfide (CH_3SCH_3)	2,2 – 19,7
Dimethyldisulfide ($CH_3S_2CH_3$)	1,1 – 16,1

Odorous Compounds from Kraft Pulp Mill

FOUL SMELLING	**Detection limit**	**2 ppb**
TOXIC SUBSTANCE	**Deadly dose**	**700 ppm**
EXPLOSIVE	**Explosion interval**	**4 – 40% in air**

CNCG to the recovery boiler

Benefits:

- High availability of the boiler
- Production of high pressure steam
- No separate incinerator
- Low investment cost

Boiler operation experiences

- No SO_2 emission increase
- No NO_X emission increase
- Maintained reduction efficiency
- No abnormal corrosion have been observed at heating surface tubes

NCG Treatment System - Safety

Safe operation is considered during the design

- **Separate systems for DNCG and CNCG**
- **Equipment is furnished with safety features such as:**
  - **Water seals**
  - **Flame arrestors**
  - **Steam ejectors for gas transport**
  - **Rupture discs**
  - **Droplet separators**
- **Special material for corrosion resistance**
- **Fully automated safety sequences**

NCG Treatment System – Operational Reliability

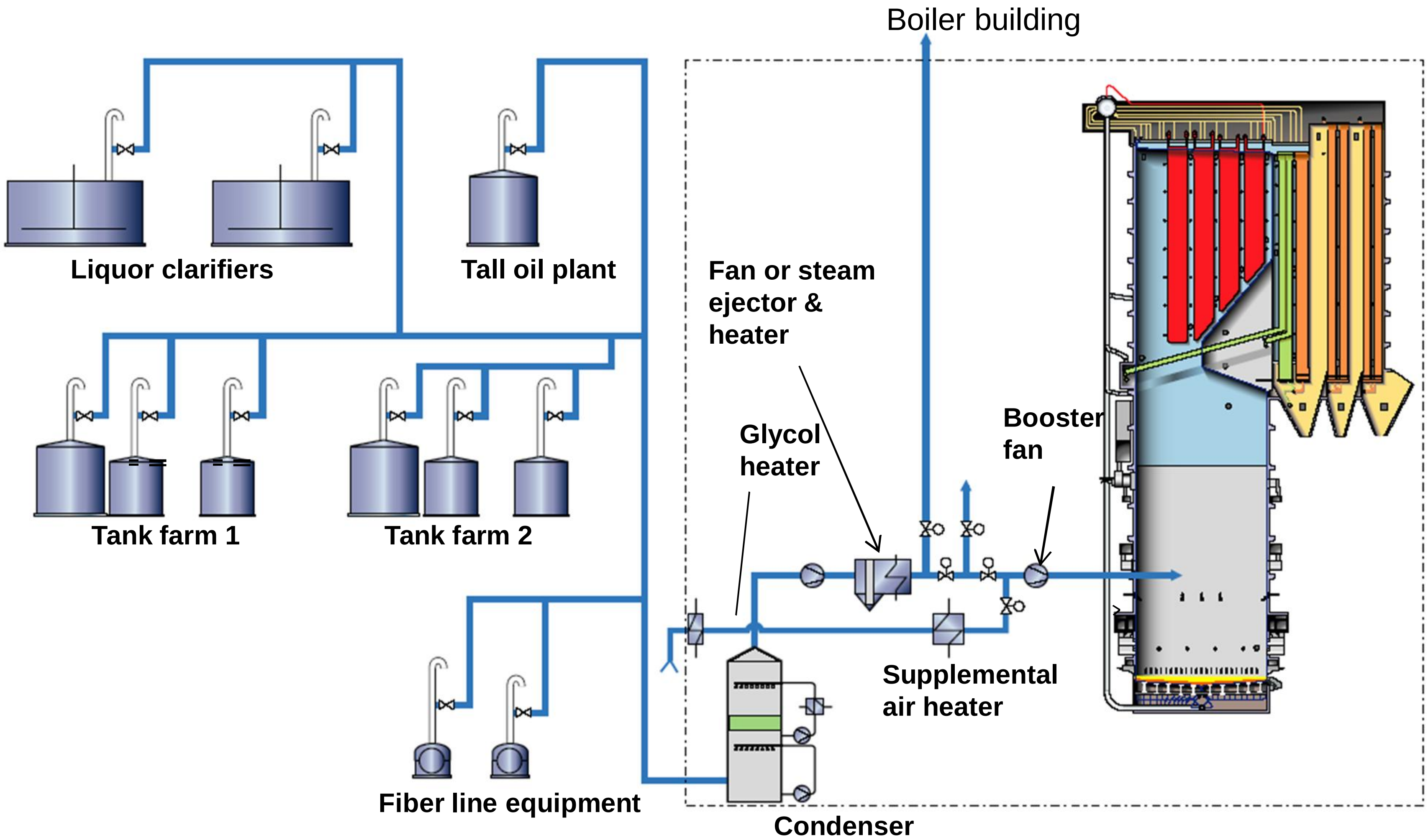
Minimized risk of corrosion

- Pressure and flue gas temperature of the recovery boiler are high
- The incinerator and the inlet connection of the SO_2 washer are made of special material
- Pump, droplet separators, flame arrestors and scrubbers are made of acid-resistant steel

Fully automated and secure

- Both incinerator and stand-by incinerator have a valve center of their own
- The incinerator is furnished with three combustion temperature measurements and two flame detectors
- Quantities of all substances to be burned are measured
- Refractory or air-cooled combustion chamber of incinerator stands high temperatures

DNCG (HVLC) Treatment System



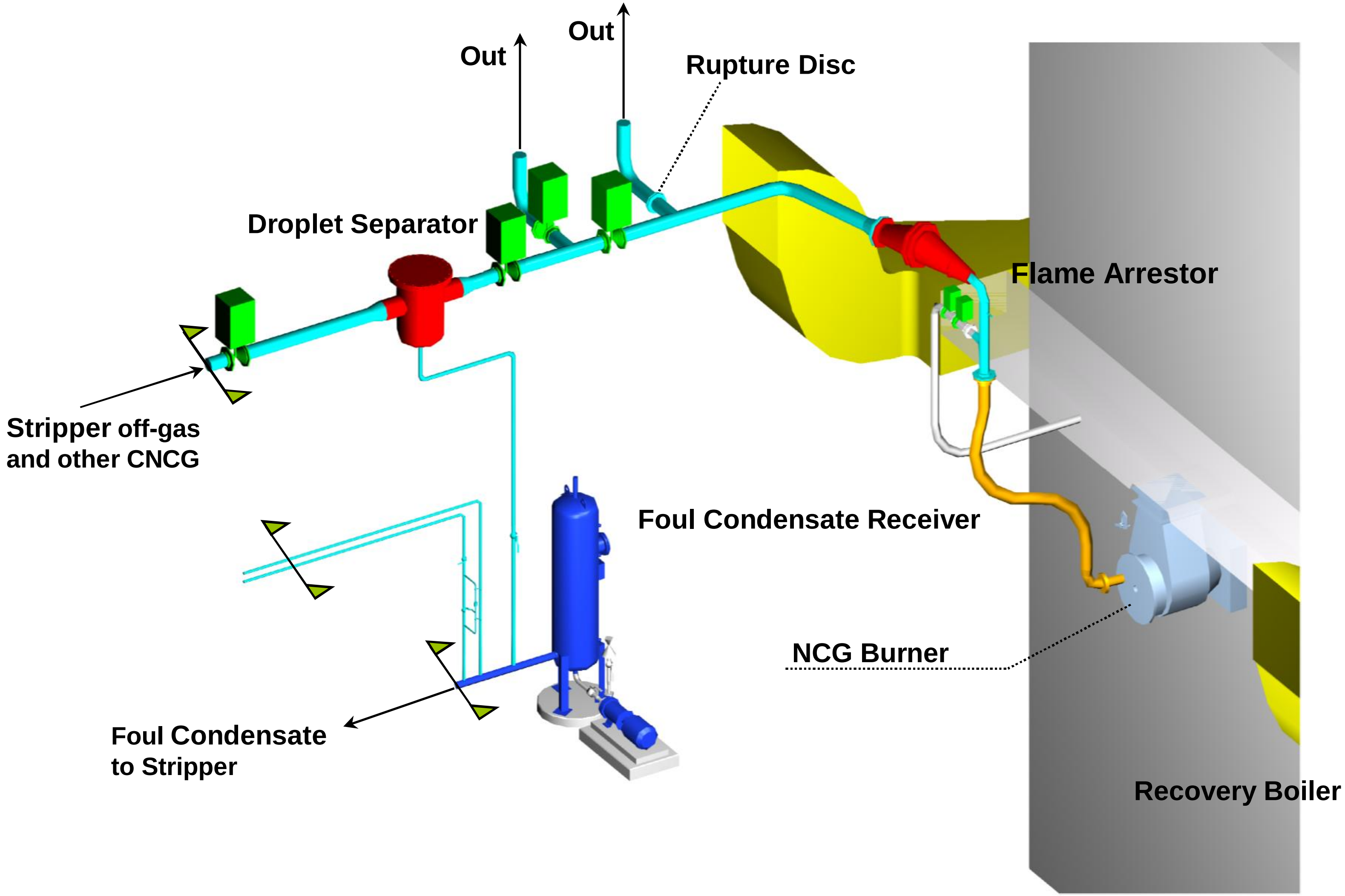
DPP32_2007

DNCG Treatment System

DNCG nozzles in secondary or tertiary air registers

DPP32_2016

CNCG System for Recovery Boiler

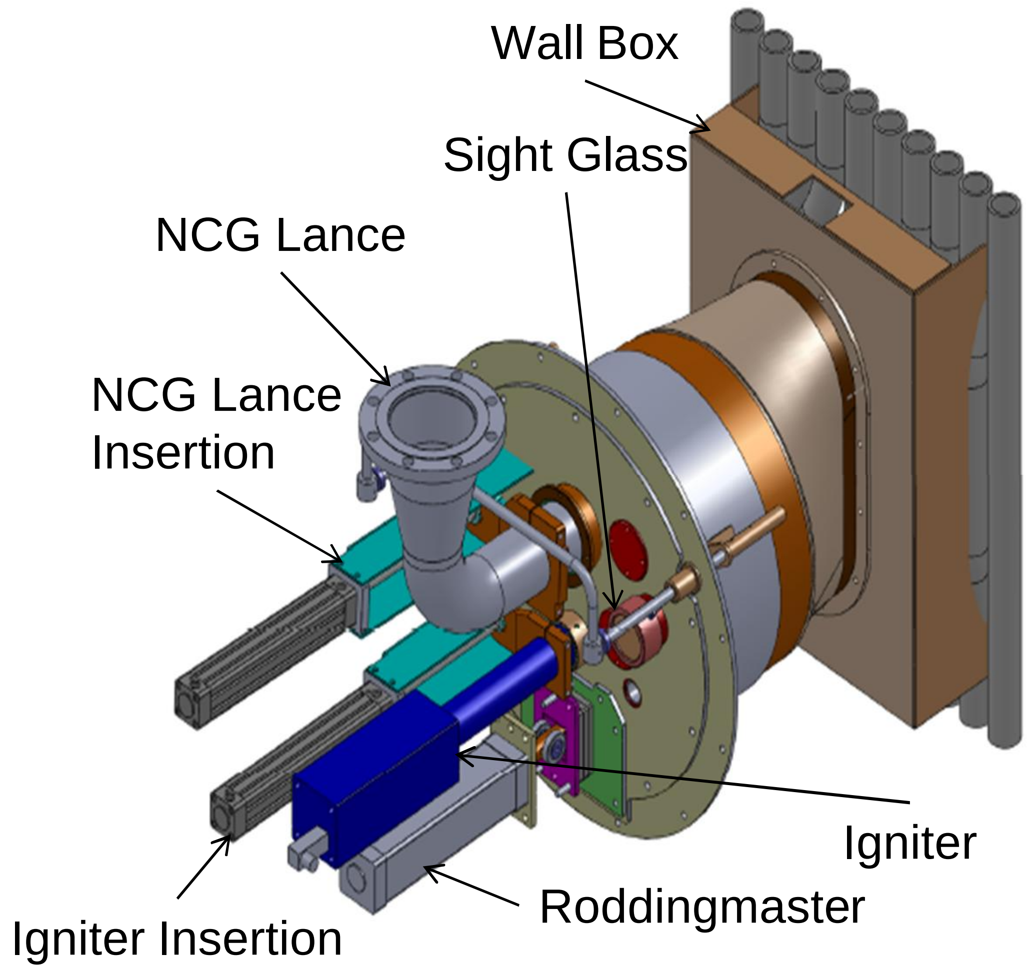


DPP32_2009

metso

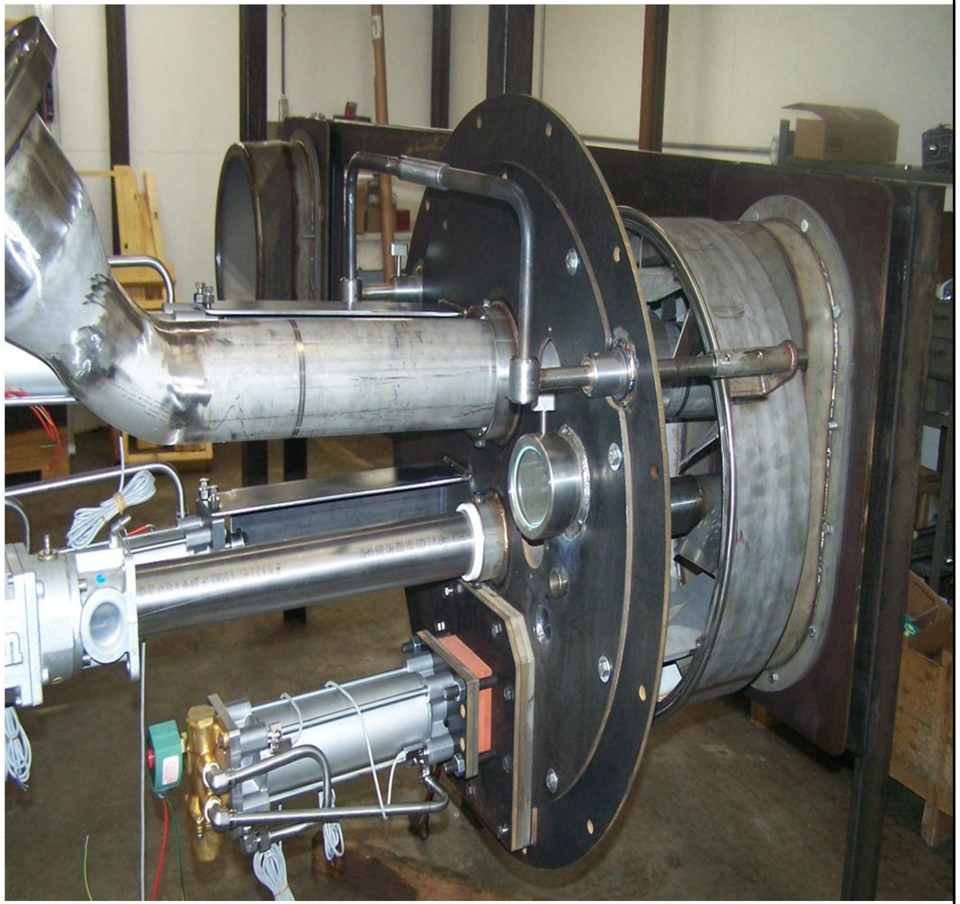
Metso RB CNCG Burner Assembly

- Location verified by CFD
- Typically at or near 2° level
- Below liquor firing level
- Class 1 Igniter (BLRBAC) – 10% heat input
- Combustion air is 2°
- Casting to protect opening tubes
- Supplied with valve rack
- Minimum combustion air requirements

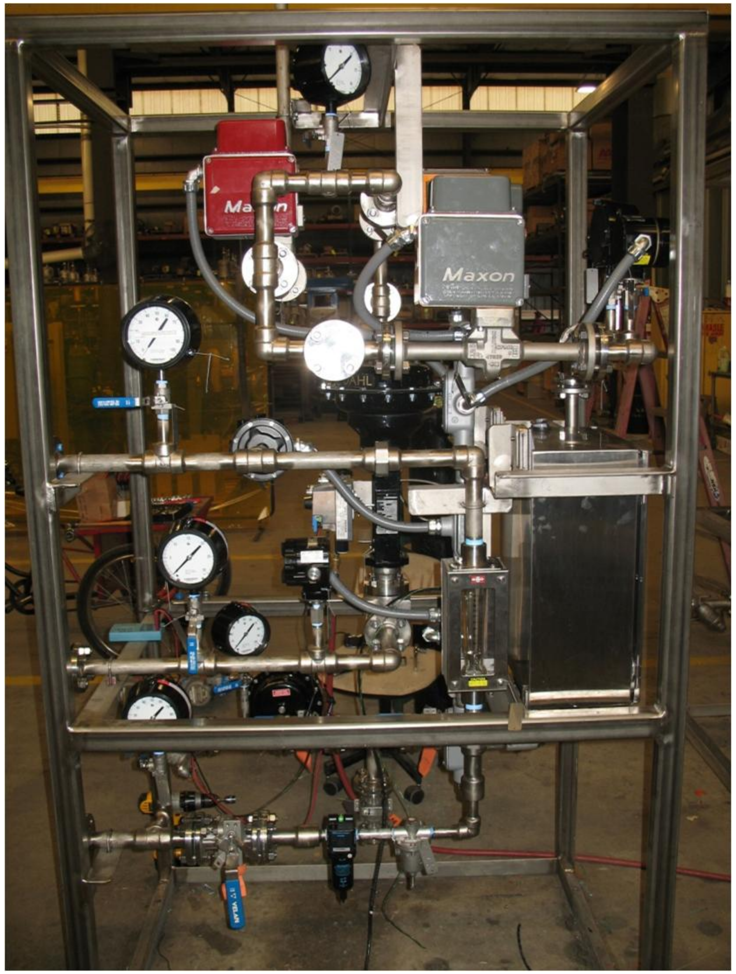


Metso RB CNCG Burner Installation

- Modern North American design
- Small footprint allows easy retrofits
- Port rodder keeps opening and lance cleaner
- Large sight glass allows operators to monitor flame
- Automatic insertion and retraction of CNCG lance and igniter
- Minimal impact to air setup



Valve Rack



Considerations for CNCG burning

High char bed temperature

- **Enough Na_2CO_3 in the ash (approx. 5 – 15%)**
- **High dry solids content (> 70%)**
- **Low SO_2 level**
- **pH of ash**

Location of burner

- **Preferred location of the burner is below liquor sprayers. This will maintain low SO_2 level**

Other Considerations

- Low point drains should be designed into piping just prior to introduction into RB.
- Methanol can be injected through a separate lance in the CNCG burner assembly or can be added to the black liquor prior to the solids meters.
- If the mill has a current sulfur deficit, the sulfur from the NCG will close the gap.
- Business analysis must weigh the reduction in makeup chemicals against the Class 1 igniter fuel.

Questions

Thank You

?

FEDERAL ENVIRONMENTAL REGULATORY UPDATE – PULP AND PAPER MILLS

Mike Curtis
Director, Technology Support
Georgia Pacific Corp.
February 6, 2012

Review of Applicable Regulatory Structure

- Clean Air Act requires emission standards be developed and reviewed on a routine basis.

  - National Emission Standards for Hazardous Air Pollutants (NESHAPS) are stationary source standards for hazardous air pollutants. Hazardous air pollutants (HAPs) are those pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. The NESHAPs promulgated after the 1990 Clean Air Act Amendments are found in 40 CFR Part 63. These standards require application of technology based emissions standards referred to as Maximum Achievable Control Technology (MACT). EPA is required to complete a one-time residual risk assessment 8-years after the promulgation of the MACT. EPA is also required to complete a technology review every 8-years to determine if technology advancement justify a more restrictive emissions limits. These are know as RTR reviews. Pulp Mills is Subpart S and Chemical Recovery is Subpart MM.

  - Section 111 of the Clean Air Act authorized the EPA to develop technology based standards which apply to specific categories of stationary sources. These standards are referred to as New Source Performance Standards (NSPS) and are found in 40 CFR Part 60. The NSPS apply to new, modified and reconstructed affected facilities in specific source categories. Pulp Mill NSPS is Subpart BB. These standards are review every 8 years to determine if updates are necessary.

Issues to Discuss

Final NESHAP Subpart S – Residual Risk and Technology Review: Pulping Sources	Completed 7/2012
Upcoming NSPS Subpart BB: review and modification of current rule.	Proposal: 5/2013 Final: 3/2014
Venting Allowance for Pulp Mill Sources	Expected: mid-2013
Upcoming NESHAP Subpart MM – Residual Risk and Technology Review: Chemical Recovery Sources	Late 2013 / early 2014

NESHAP: Subpart S Residual Risk and Technology Review

- Final Subpart S RTR was issued on July 2012. Risk modeling of emissions from Subpart S regulated sources found the emission did not have an unacceptable impact on the public.
- SSM allowances were removed from the rule.
- Venting allowances and stripper downtime was retained while being evaluated. EPA attorneys belief the venting allowance is not allowed by the Clean Air Act. (more later)
- Rule requires miscellaneous retesting once every 5-years.
- Emissions test needs to be reported to EPA via the electronic reporting system.

DONE FOR NOW – TECHNOLOGY REVIEW AGAIN IN 8-YEARS

NSPS - Subpart BB Review

- EPA was sued by the Center For Biological Diversity, Greenpeace, and Port Townsend AirWatchers. EPA settled the suit and agreed to:
  - Sets deadline of May 15, 2013 for proposed determination that either:
    - Proposes revisions to Subpart BB under section 111(b)(1)(B) OR
    - Determines "review is not appropriate in light of readily available information on the efficacy" of the current NSPS
  - Sets a deadline of March 14, 2014 to either complete the rulemaking OR determine that the NSPS does not need to be revised OR a combination of actions.

NSPS - Subpart BB Review (cont.)

PM NSPS Limits (and MACT)

Source	PM Limits NSPS	New PM MACT	Controls/Comments	EPA NSPS options
Recovery Furnace	0.044 gr / dscf	0.015	ESP	0.025-0.03 OR keep; separate new at 0.015
Lime Kiln Gas	0.066 gr / dscf	0.01	ESP and / or scrubber	0.064 (MACT) ; separate new std. at 0.01
Lime Kiln Oil	0.13 gr / dscf	0.01	ESP and / or scrubber	No differentiation between gas and oil.
Smelt Tank	0.2 lb / TBLS	0.12	Various types of Scrubbers	0.1 - 0.12 for new but maybe existing as well; most likely change

Current Opacity with Allowances in NSPS (and MACT)

Unit	Limit	Allowed Exceedances per quarter	Comments	EPA options
Recovery Furnace-Existing	35%	6%	6 minute average; excluding SSM	20%; 1-6%; no SSM; maybe an opacity cap or longer averaging period
Recovery Furnace-New	20%	6%	same	Same except tighter %
MACT RF – new only	20%	6%	same	
NSPS Lime Kiln	none			20%; 1-4%
MACT Lime Kiln-Existing/New	20%	6%	COMS common, permit level	

NSPS - Subpart BB Review (cont.)

TRS Limits in NSPS

Source	TRS Limits	Allowance	Controls	EPA Options
Recovery Furnace	5 ppm vd @ 8% O2	1% based on 6 min average	NDCE, improved combustion air	<1% allowance; 2-3 ppm but perhaps KEEP @ 5 ppm
Lime Kiln	8 ppm vd @ 10% O2	None	Mud washing	Keep @ 8 ppm
Smelt Tanks	0.033 lb / TBLS		scrubber	Looking at fresh scrubber water, need to review latest NCASI info
Digesters, BSW, Evaporators, Stripper	5 ppmvd @ 10% O2		combustion	No change

Estimated Range of Costs to Lower PM Limits

Total Cost	EPA Est. Number Modified	Min total annual cost	Max total annual cost	Min total capital cost	Max total capital cost	Min $/ton	Max $/ton
Recovery Furnaces	6	$2,400,000	$13,500,000	$18,000,000	$120,000,000	$10,005	$57,354
Lime Kilns	2	$1,250,000	$1,250,000	$4,000,000	$10,000,000	$7,444	$18,123
Smelt Tanks	6	$120,000	$2,640,000	$3,000,000	$24,000,000	$1,158	$59,708
Total	14	$3.77 M	$17.4 M	$25 million	$154 million	No 1.5 or 3x adjustment	No 1.5 or 3x adjustment

NSPS - Subpart BB Review (cont.)

Incremental costs for PM reductions for NSPS sources												
Source	Control Improvement for Lower Emissions	Level of Control Improvement	Total Annual Cost	Typical Production or Flow		Current NSPS (gr/dscf or lb/TBLS) or lower current emission level	Alternate NSPS for modified (based on data)	Tons PM reduction from current	$/ton	Alternate NSPS = MACT new	Tons PM reduction from current	$/ton
recovery furnaces	upgrade ESP - smaller unit	moderate	$394,384	75,000	dscf m	0.044	0.03	39.42	$10,004.66	ESP upgrade not likely to get to 0.015 from 0.044		
recovery furnaces	upgrade ESP/combusti on air - larger unit	moderate	$943,357	175,000	dscf m	0.044	0.03	91.98	$10,256.11	ESP upgrade not likely to get to 0.015 from 0.044		
recovery furnaces	replace ESP - smaller unit	significant	$2,260,892	75,000	dscf m	0.044	0.03	39.42	$57,353.94	0.015	81.66	$27,688.11
recovery furnaces	replace ESP - larger unit	significant	$2,260,892	175,000	dscf m	0.044	0.03	91.98	$24,580.26	0.015	190.53	$11,866.33
lime kilns	add ESP in advance of scrubber if not present - smaller unit	significant	$625,973	20,000	dscf m	0.066	0.02	34.54	$18,123.44	0.01	42.05	$14,887.11
lime kilns	add ESP in advance of scrubber if not present - larger unit	significant	$625,973	40,000	dscf m	0.066	0.02	69.08	$9,061.72	0.01	84.10	$7,443.55

EPA is considering providing alternative standards for New and Modified Sources

Update from EPA on Subpart BB

- Internal briefings but no political reviews set – changing leadership
- EPA not as focused on TRS or PM limits for RF and LK or BS washers
- EPA is focused on opacity, percent allowances for PM and TRS (6 and 1%), and SDT PM and TRS limits. Keep 20% action level for LK at this point but reduce action level for RF to 20% like Subpart MM
- EPA will eliminate SSM provisions and use affirmative defense for malfunctions; no separate standards for S&S so fold into allowances like done for Subpart S RTR.
- EPA still looking at whether to distinguish between new and existing/modified units; not applicable to existing NSPS units.

Venting Allowance – Subpart S

- As noted earlier in the Subpart S – RTR review, EPA deferred a decision on venting allowance.
  EPA believes either a numeric or work practice standard needs to apply at all times.
- Industry has requested that EPA accept a 97% destruction allowance for LVHC (98% control and 1% venting) and 94% for HVLC gases (98% control and 4% venting). EPA is considering this option.
- An alternative work practice is being proposed for the 10% stripper collection and destruction obligations. The alternative WP would be to transport the condensates to a biological treatment system via an uncontrolled sewer system. This alternative is estimated at providing 85% destruction of the methanol vs. the stripper requirement of 92%.
- This issue is currently be worked by EPA is a proposal expected in the summer of 2013.
- A wrong decision by EPA would be extremely costly to our industry and immediately place most of our mills in non-compliance.

NESHAP - Subpart MM RTR Review

- EPA is behind on the Risk and Technology Review. A draft rule is currently not expected until at least the end of the year, unless they are sued to accelerate.
- Risk modeling of this subpart has been completed and is not expected to be an issue.
- Technology reviews have not been completed and will be our greatest risk.
  - High PM standards for Recovery Furnaces.
  - HCl controls from RF
  - DCE vs NDCE
- SSM will go away.
- Opacity exceedence allowances will be challenged.

Eliminating Recovery Boiler Dissolving Tank Emissions

John Phillips
Andritz, Inc.

Recovery Boiler Dissolving Tank Vent Gas Cooler

- **The vent from the dissolving tank is the only visible plume and a major emissions point for TRS in a modern recovery boiler**

- **TRS emissions from vent stack are often 5 to 10 times more than in the flue gases**
  - **Many TRS compounds are difficult to scrub out with caustic**

Recovery Boiler Dissolving Tank Vent Gas Cooler

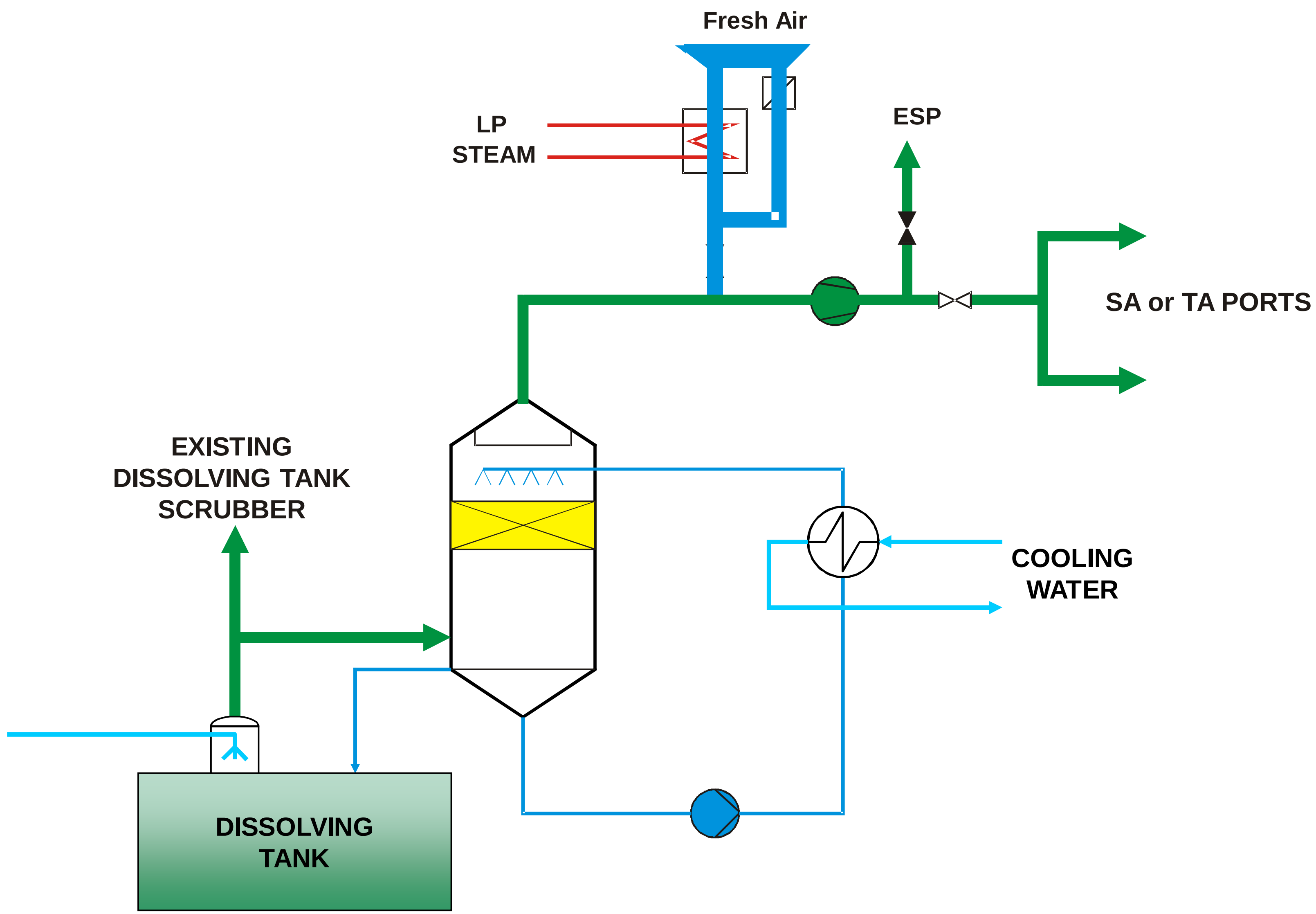
- **Dissolving tank vent is very difficult to treat**
  - **Relatively high flow**
  - **High particulate content**
  - **High TRS content**
  - **High moisture content, about 50% water**
  - **“Sticky” gas can plug ductwork**

- **Dissolving Tank Vent Cooler technology conditions the vent gases**
  - **Moisture and particulates are removed**
  - **Vent gases can then be used as combustion air in the recovery boiler**

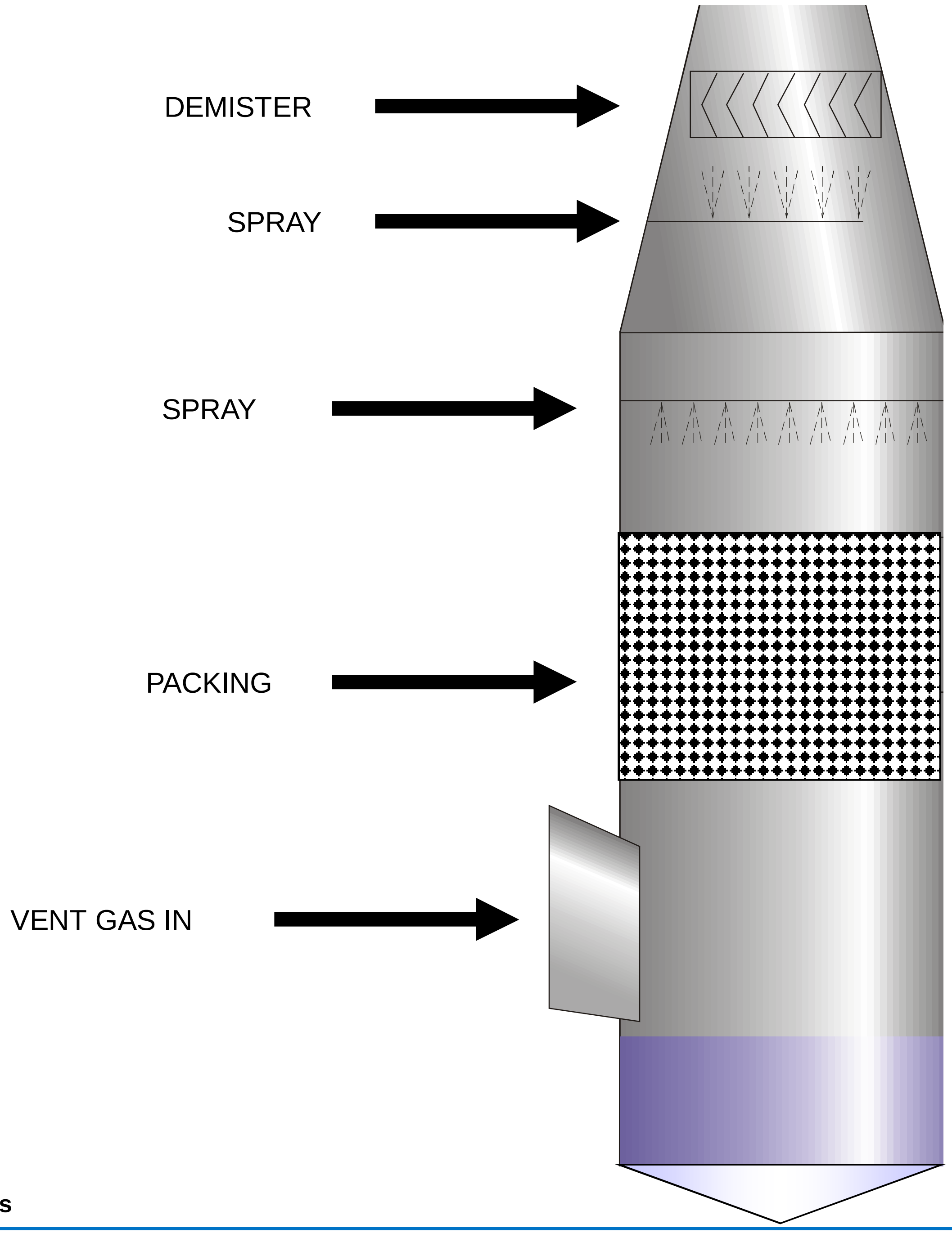
Recovery Boiler Dissolving Tank Vent Gas Cooler

- **Vent gases are cooled down to reduce moisture content**
  - **At the same time gases are scrubbed to clean them**
  - **Forced flux condensation effectively removes particulates**
- **Vent gases are then used at the secondary or tertiary air elevation**
  - **Extremely well suited for boilers with modern staged combustion air system**
- **Mix tank gases can be handled in the same system**
- **The whole system is designed to handle difficult gases**

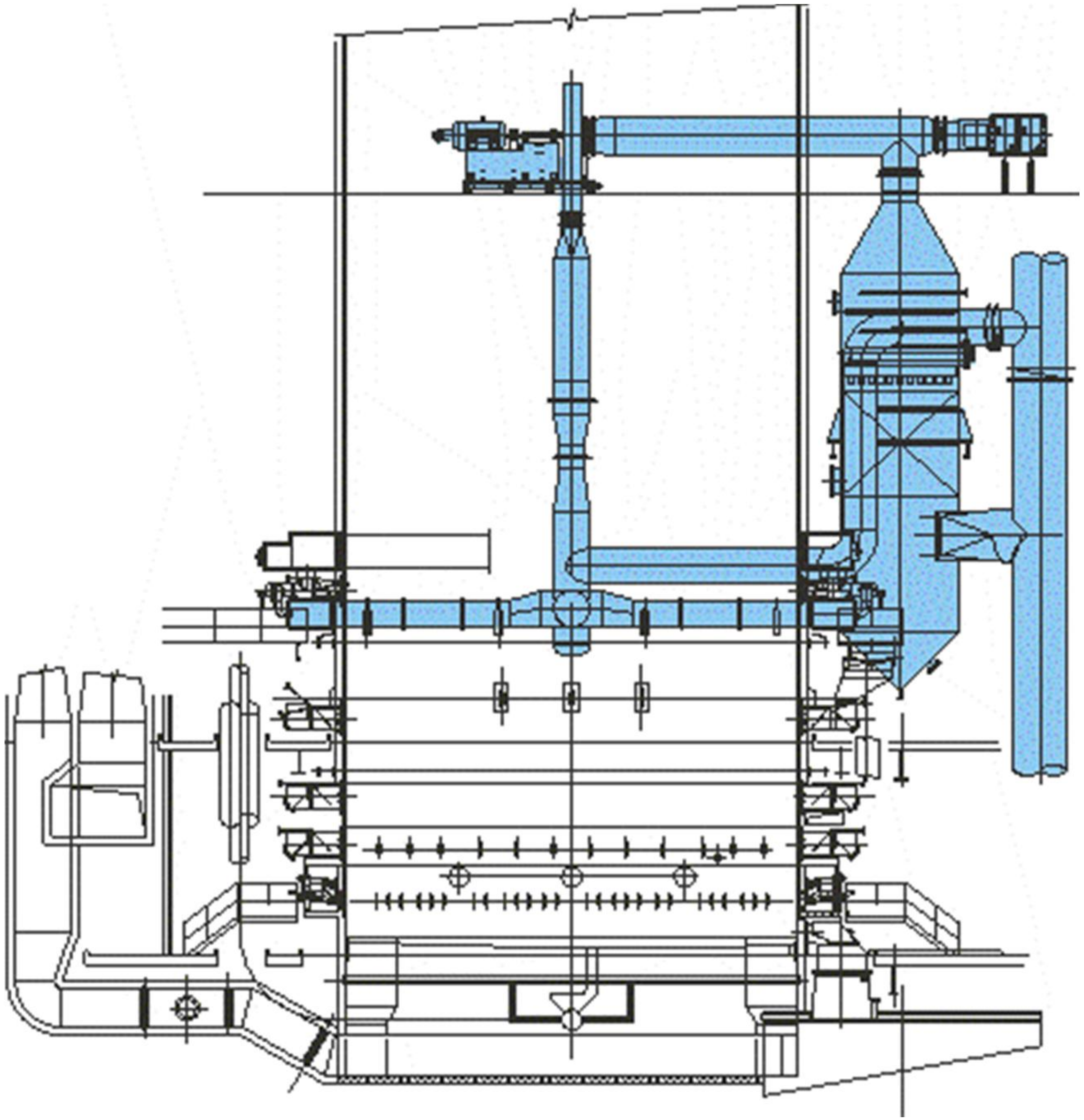
Recovery Boiler Dissolving Tank Vent Gas Cooler Retrofitted System Flowsheet



Recovery Boiler Dissolving Tank Vent Gas Cooler Retrofitted System Flowsheet

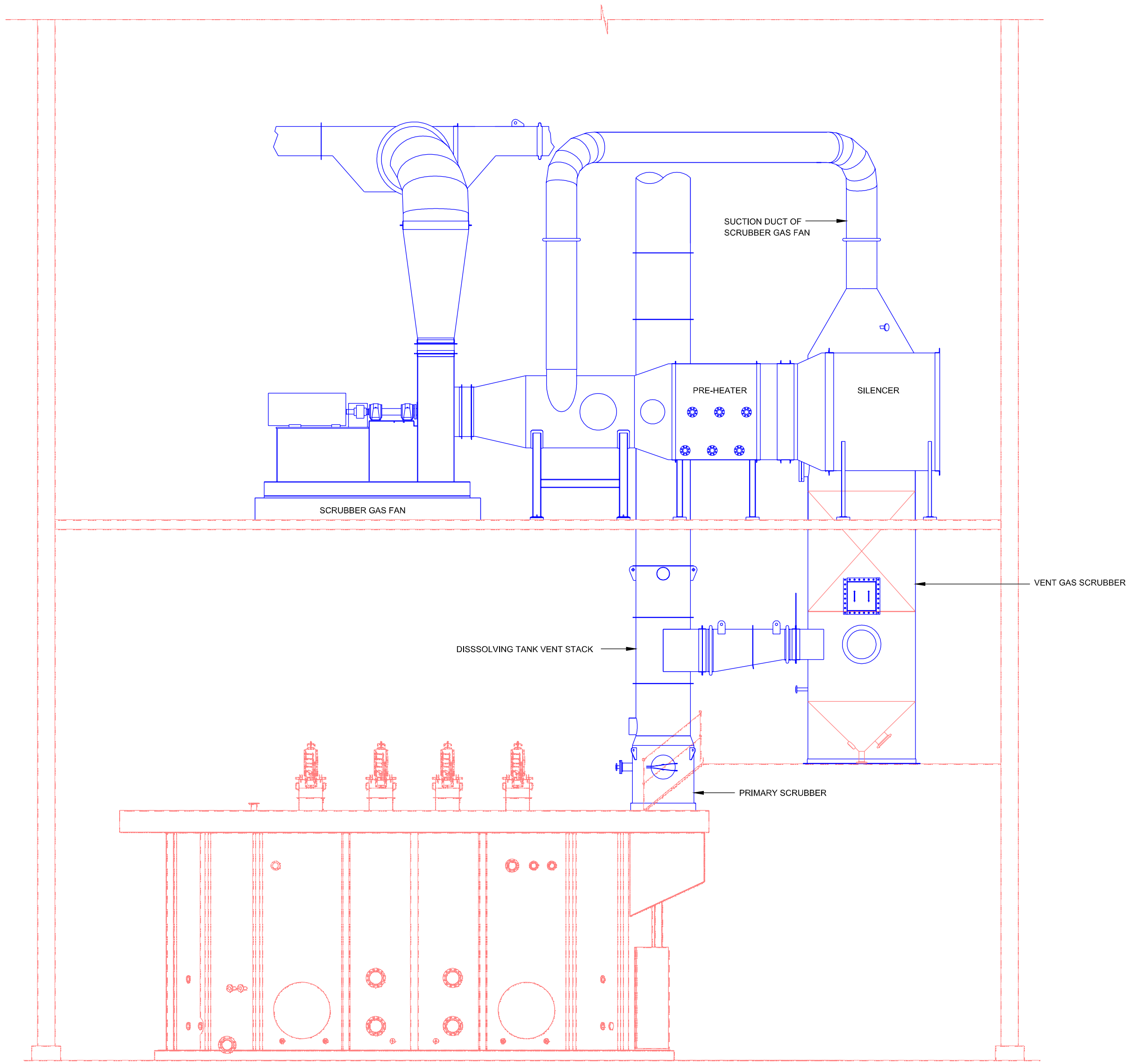


Recovery Boiler Dissolving Tank Vent Gas Cooler Retrofitted System Layout



Recovery Boiler Dissolving Tank Vent Gas Cooler Retrofitted System Installation

Recovery Boiler Dissolving Tank Vent Gas Cooler Retrofitted System Layout



Recovery Boiler Dissolving Tank Vent Gas Cooler
Features and Benefits

- **Eliminates TRS and particulate emissions**
  - **All gases are oxidized in the recovery boiler and go through the precipitator**

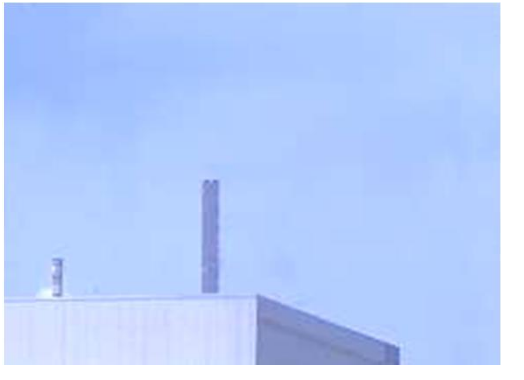
- **Eliminates the need of scrubbing chemicals**
  - **Costly caustic makeup is eliminated**

- **Eliminates the dissolving tank vent plume**
  - **The only visible vent from a modern recovery boiler**

Recovery Boiler Dissolving Tank Vent Gas Cooler Features and Benefits (cont'd)

- **Recovers 400,000 to 650,000 Btu/Ton Pulp of otherwise wasted thermal energy in the form of warm water**
  - **Generates 105 °F to 125 °F warm water**
  - **Benefit for northern mills**

- **Proven technology with multiple references**
  - **Complies with BLRBAC regulations for DNCG firing**



Recovery Boiler Dissolving Tank Vent Gas Cooler Operating References

- **Rosenthal (Germany) 1999**
- **Varkaus (Finland) 1999**
- **Aracruz (Brazil) 2000**
- **Kuusanniemi (Finland) 2001**
- **Varo (Sweden) 2003**
- **Soporcel (Spain) 2004**
- **Ruzomberok (Slovakia) 2004**
- **Suzano (Brazil) 2005**
- **Valliant (USA) 2006**
- **Campti (USA) 2008**
- **New Bern (USA) 2009**
- **Valdosta (USA) 2010**
- **Kamloops (Canada) 2010**

REVIEW OF 2001 FURNACE DAMAGE VS. DESIGN STUDY

Thomas M. Grace

Recovery Boiler Committee Annual Meeting

Background Information

- Study looked at the relationship between the damage experienced in recovery boiler explosions and furnace design factors
- Study was carried out by J. L. Clement and T. M. Grace
- Study completed and results presented in 2001

Reason for Study

- The study followed a multiple-fatality explosion in Brazil in 1998 where people were exposed to steam and hot water from a corner tube torn open by explosion

- It was recognized that exposure to hot water and steam from opened pressure parts is the biggest hazard to personnel in an explosion

- The study wanted to understand the role played by boiler design factors on the damage sustained.

Two Phases to the Study

- Phase I
  - Review explosions on BLRBAC explosion list and select specific incidents for detailed review
    - Relevance to current recovery boiler population
    - Involvement of significant issues
    - Availability of detailed information
    - Availability of design information
- Phase II
  - Detailed investigations of the selected incidents
  - Incorporating design information in damage assessment
  - Determination of relationships between design and damage
  - Report the results

What Was Done

- Selected 20 recovery boilers that had a total of 24 damaging recovery boiler explosions
  - Involved boilers from five different suppliers
    - Alstom Power Inc.
    - Andritz-Ahlstrom Corporation
    - The Babcock & Wilcox Company
    - Kvaerner Pulping Oy (Tampella)
    - Kvaerner Pulping AB (Gotaverken)
- Reviewed type and extent of explosion damage experienced with different designs – interacted with manufacturers in this step
- Prepared and analyzed a data base

Output of Study

- Conclusions supported by analyzed information
  - Results intended to be used by Recovery Boiler Committee and Manufacturers to make recommendations regarding boiler design and personnel safety
- Phase II, Volume 1 report to AF&PA Recovery Boiler Committee summarizing all of the results of the study
- Phase II, Volume 2, A B and C reports containing confidential design information and having limited distribution
- Paper presented at TAPPI Engineering Conference in either 2001 or 2002 summarizing results of study

Major Focus Areas

- Furnace corners
- Buckstays, tiebars, and end connections

- Floor support
- Junction of floor and spout wall
- Junction of floor and sidewalls

- Junction of nose arch and sidewalls
- Junction of roof and sidewalls

Corner Design

- All suppliers have a different and unique approach to the design of “explosion corners” and “normal corners”
- General practice is to use weak corner construction in a designated vertical section of one to four corners
  - Designated section is above air port levels and extends from starting level to the roof
  - Most common on front wall corners at nose arch & superheater
  - Other corners use a more robust design
- Seven different explosion corner seal designs identified in the 20 boilers investigated in the study
  - These may not represent suppliers latest designs
  - Study was done over 10 years ago

Corner Experience

- Corners normally open during explosions
  - Corners opened on 17/24 explosions
    - 7/17 had all four corners open to some extent
  - Corners did not open on 6/24 explosions
  - No information on corners in 1 explosion
- Relief of the pressure wave in a large explosion is not confined to the explosion corner – all may open
- Mixed results with weaker explosions
  - Weak corners only ones to open sometimes
  - Sometimes only normal corner opened
- Extent an explosion corner opened often greater than the designated length
- Corner may open in a different location than where the explosion corners are

Explosion Corner Experience

- All suppliers design with weak corners
- Explosion pressure relief is random
- Furnace corners opened on 70% of explosions
- All four corners opened on 7
- No pattern with number of explosion corners
- Some seal designs more likely to result in torn tubes

Tearing of Tubes at Corners

- More rigid corner seal construction generally contributed to tube tearing
  - In some cases tearing was adjacent to the “weaker” seal that should have torn
  - Dependence on size of weld is not reliable – weld size difficult to control
- Considerable differences in tube tearing experience with different corner constructions
  - Need to refer to report or paper for more detail on this
- Tearing is more a function of corner seal design than tiebar arrangement

Issue – Tearing of Corner Tubes

- Extensive tearing open of corner tubes can occur during recovery boiler explosions

- Strong relationship exists between corner seal construction and tearing of corner tubes
  - A subset of boilers with increased risk of such a failure can be defined
  - The Phase II report should be consulted for details

- No apparent correlation between the number of “explosion corners” and torn tubes

Interdependence of Corner Seal and Tiebar/Buckstay Connections

- Case 1: minor explosion broke explosion corner shear pins at 4 buckstay elevations
  - No permanent deformation of buckstays or walls
  - Buckstay clips were broken adjacent to corner
  - Insulation and lagging were bulged
- Case 2: Major explosion with minimal opening at corners
  - Buckstay deflection up to 12 inches – some buckled & twisted
  - Wall panel bowed up to 4 ft
  - Buckstay interconnection at corner remained intact
- Need to define the purpose of the tiebar and buckstay

Issue – Value of “Explosion Corners”

- No definitive conclusion could be reached regarding whether or not “explosion corners” resulted in less damage by allowing the explosion pressure wave to be vented

- There is no guarantee that the boiler will open at the designated weak-corner location
  - Explosions occurred where the boiler opened up and tore tubes, while the designated weak corners remained intact

Issue – Furnace Floor Design

- Certain designs prone to floor bowing design
- Floor integrity related to:
  - Floor support beam attachment
  - Floor-to-wall seals
- Severe floor deformation likely to tear open supply tubes or downcomers
- Severe floor deformation constitutes a major hazard to personnel

Experience with Floor Design

- Basically two distinct designs – sloped and decanting

- Sloped floor, 9/20 boilers
  - Generally damaged
  - 2 hinged down, 3rd appeared close to hinging

- Decanting bottom design, 11/20 bottoms, 15 explosions
  - Integrity generally unaffected by explosions
  - Floor may be dished down in areas

Different Floor Support

- Sloped floor
  - Relatively few support beams installed
  - 6/9 boilers – beams dislodged from sidewall supports
  - Seal at low point of floor at wall

- Decanting bottom
  - More closely spaced support beams
  - Effective restraint of sidewalls by end connections
  - Seal is under floor

Other Issues

- Seals at Nose Arch and Roof
  - Opened in 60% of explosions – each location
  - Frequent tearing of tubes at seal
    - 2 edges of seal welded to tube
    - Tube wall is weakest point
  - Opportunity to design the seal to fail without tearing tubes
- Air and flue gas ductwork bulging
  - Only observed in 3 of the 24 explosions analyzed
  - Furnace corners did not open in one case – lack of venting probably contributed to ductwork bulging
  - Corners did open in other 2 cases –venting did not prevent duct from bulging
  - No firm conclusions drawn

Final Remarks

- The Phase II Report(s) to AF&PA Recovery Boiler Committee contain a great deal of information on the types of damage occurring in recovery boiler explosions and its relationship to boiler design
- The report(s) were intended to be used by AF&PA Recovery Boiler Committee, boiler manufacturers, or appropriate BLRBAC Subcommittees to make recommendations regarding boiler design and personnel safety
- No new recommendations in this regard should be made without a thorough review of the information from this study

Enhancements and Optimization of Electrostatic Precipitators

AF&PA Recovery Boiler Committee and Meetings 2013

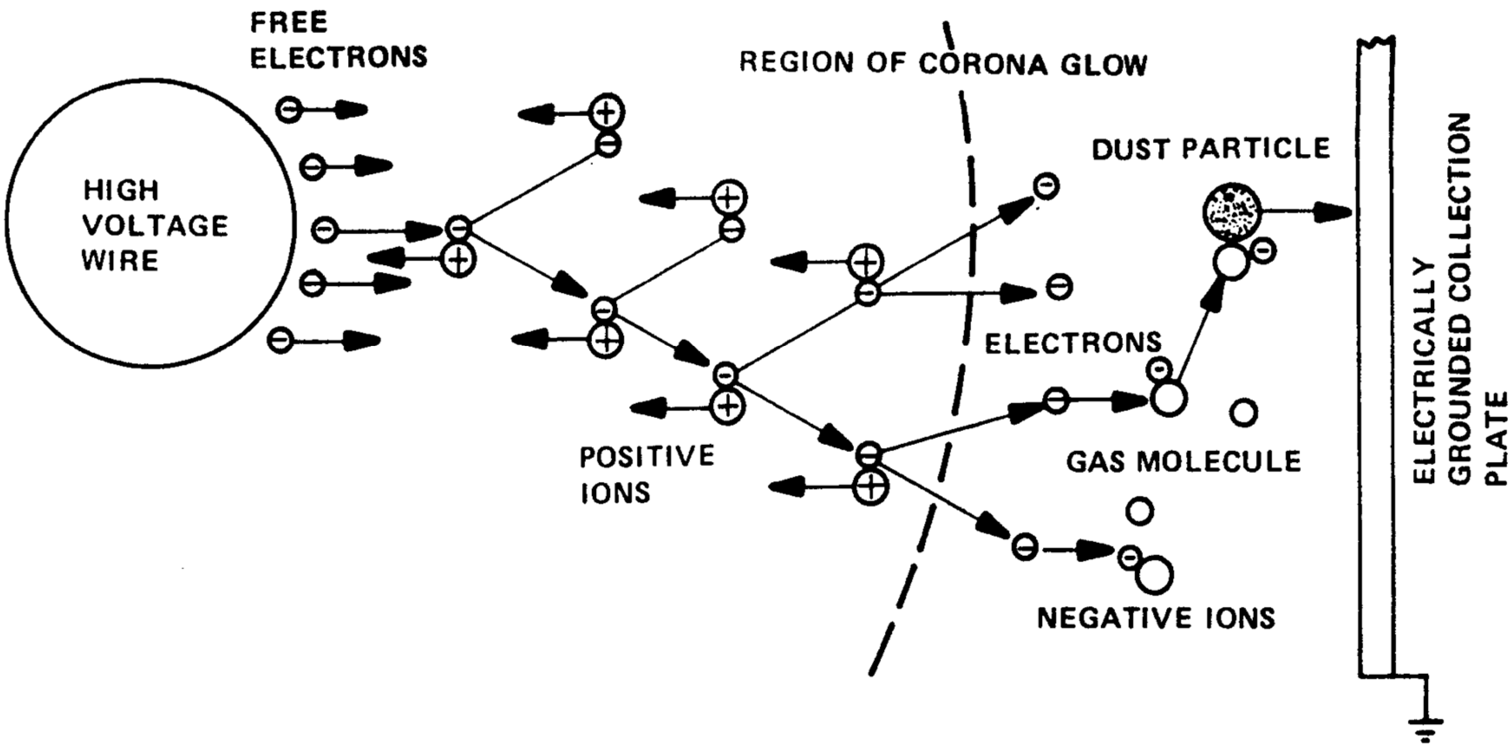
I. Samuelsson, D. Levesque, C. Mauritzson, V. van Hattem, B. Raissian

Agenda

- Concepts and Fundamentals
- Precipitator Problems and Potential Solutions
- Case Studies

Concepts and Fundamentals

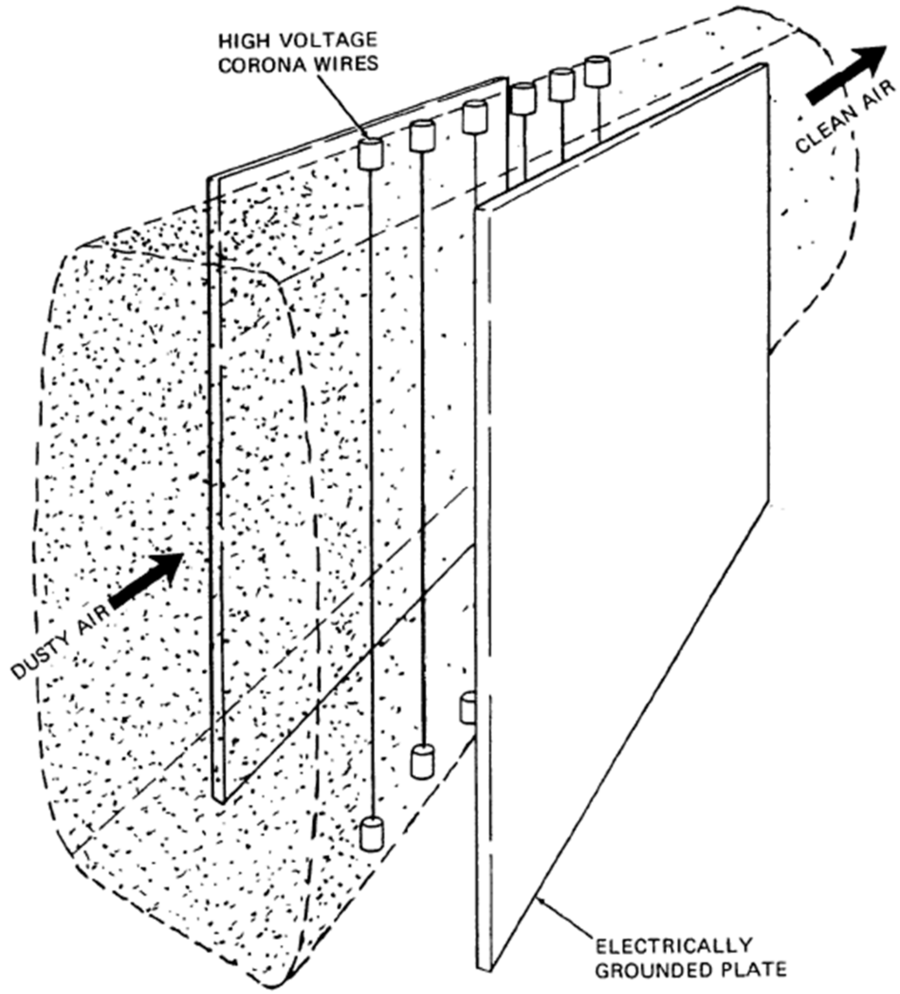
Electrostatics



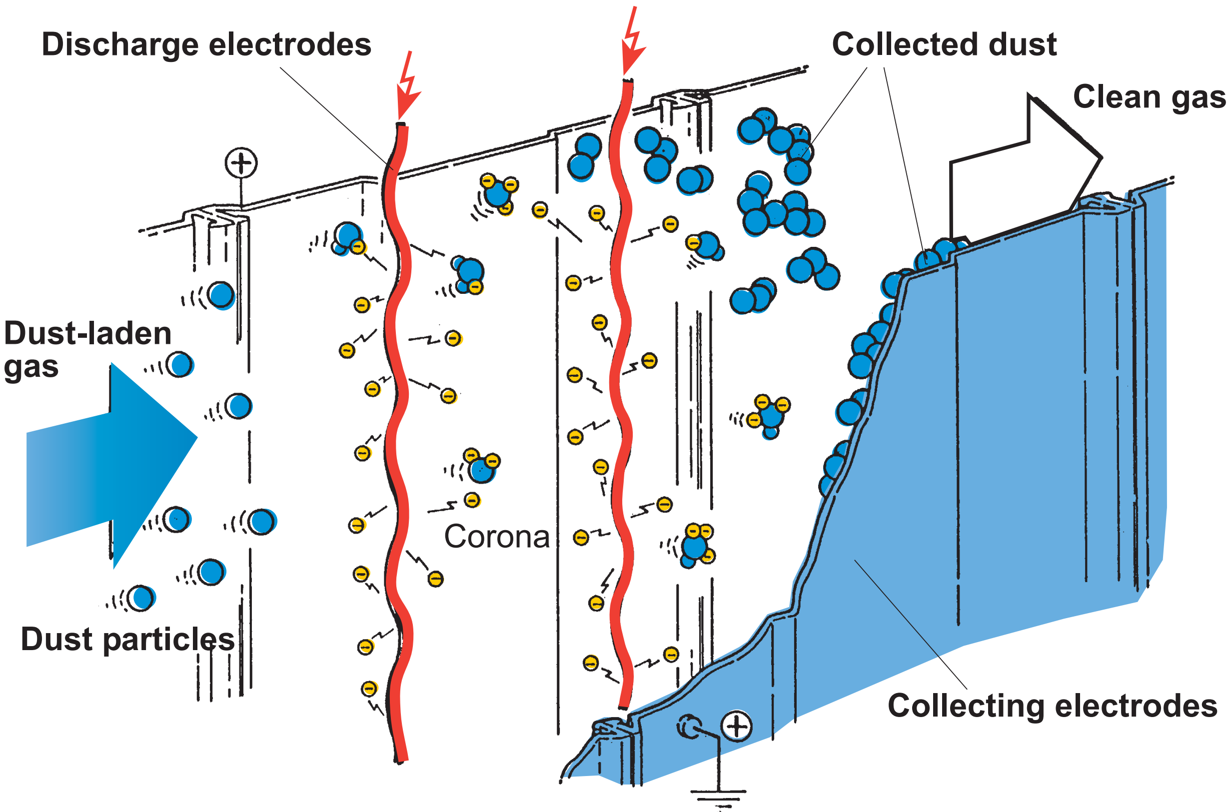
- A high voltage (typically 30,000 – 100,000 volts for industrial/utility applications) is applied to the electrodes.

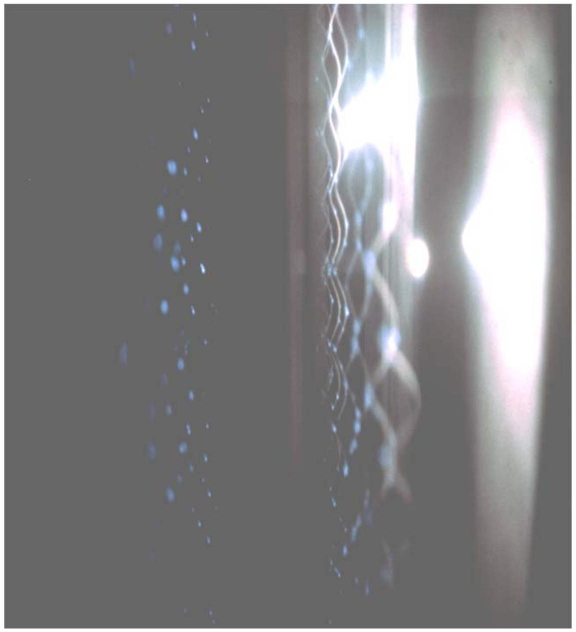
Electrostatics

- Here’s how these basic electrostatic principles are applied in an electrostatic precipitator.



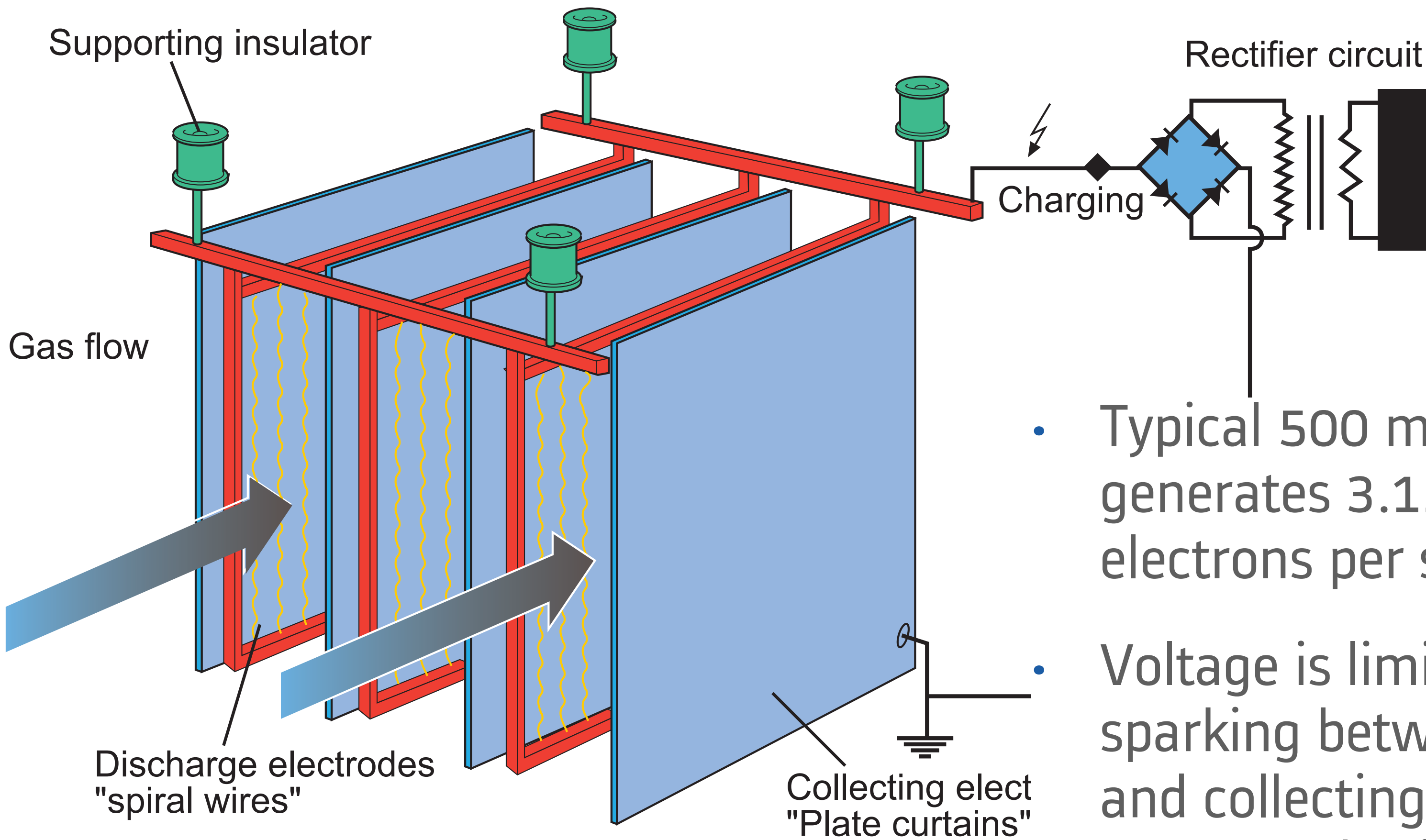
Principles of Dust Collection





- Ionization
- Charging
- Transport
- Collection
- Dislodgement

Principal Design of Electrostatic Precipitator



- Typical 500 mA field generates 3.12 quintillion electrons per second
- Voltage is limited by sparking between emitting and collecting electrodes: 10,000 volts/inch or 500 V/mm in dry air

Precipitator Fundamentals

1. Good Gas Distribution
2. Ability to Generate Optimized Corona
3. Ability to clean collected particulate from collecting plates and discharge electrodes
4. Ability to remove dust from precipitator

All fundamentals must be in proper order to maximise collection efficiency

Factors affecting Precipitator Performance

- ESP characteristics, and hence the collection efficiency of the ESP, depend on the following:
  - Flue gas composition
  - Flue gas temperature
  - Flue gas pressure
  - Electrode and collecting plate geometry
  - Power supply
  - Particulate properties
  - Particulate loading
  - Amount of build-up on internals

Precipitator Problems and Potential Solutions

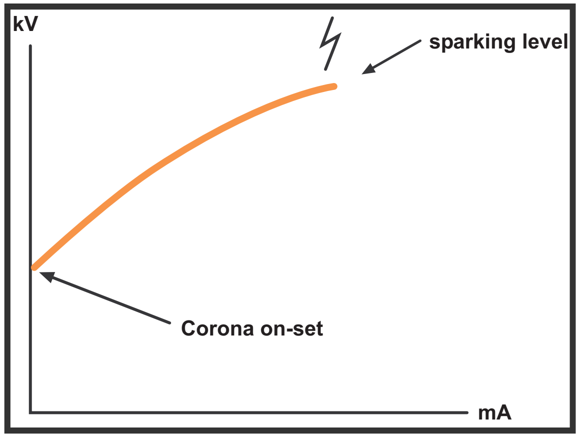
Typical Problems affecting Performance

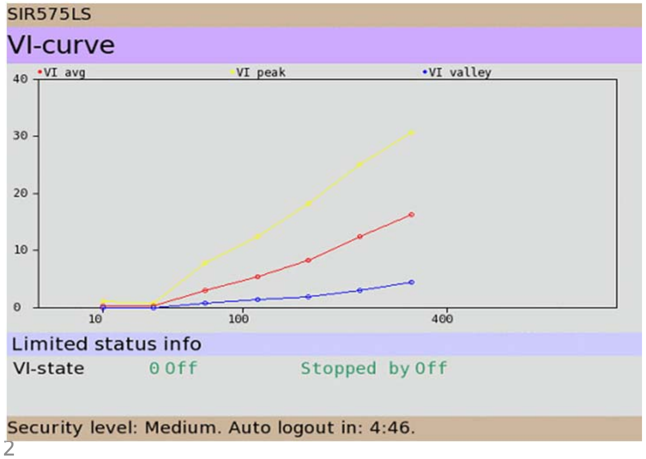
- Poor Power Input
  - Mechanical Deficiencies
  - Space Charge Effect
- Dust Build-up Issues
  - Adhesive Salt Cake
  - High Resistivity Ash
- Gas Flow Issues
  - Gas distribution
  - Sneakage
  - Inleakage of air
- Overload Conditions
  - Increased Mill Production

Poor Power Input - VI Curves

Voltage-Current (VI) Curve is a diagnostic tool used to evaluate precipitator performance and troubleshoot

- Gives a distinct signature for each bus section for the actual operating conditions
- Excellent for remote troubleshooting if normal operation V x I curves available for comparison
- Curve profiles should remain identical (with time) assuming continuing mechanical integrity and the same process conditions





Poor Power Input: Mechanical Deficiencies

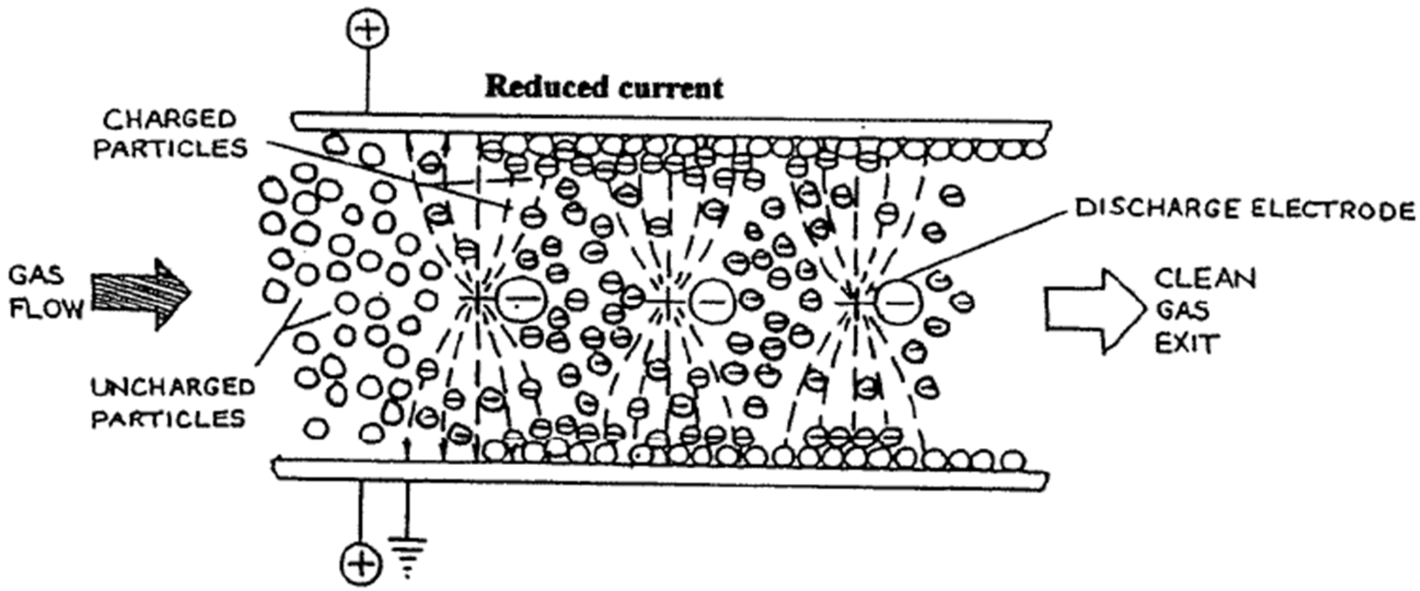
- Problem
  - Reduced distance between emitting and collecting electrodes
  - Reduced spark-over voltage

- Solution
  - Maintaining internal alignment is critical

Poor Power Input: Space Charge Effect (corona quenching)

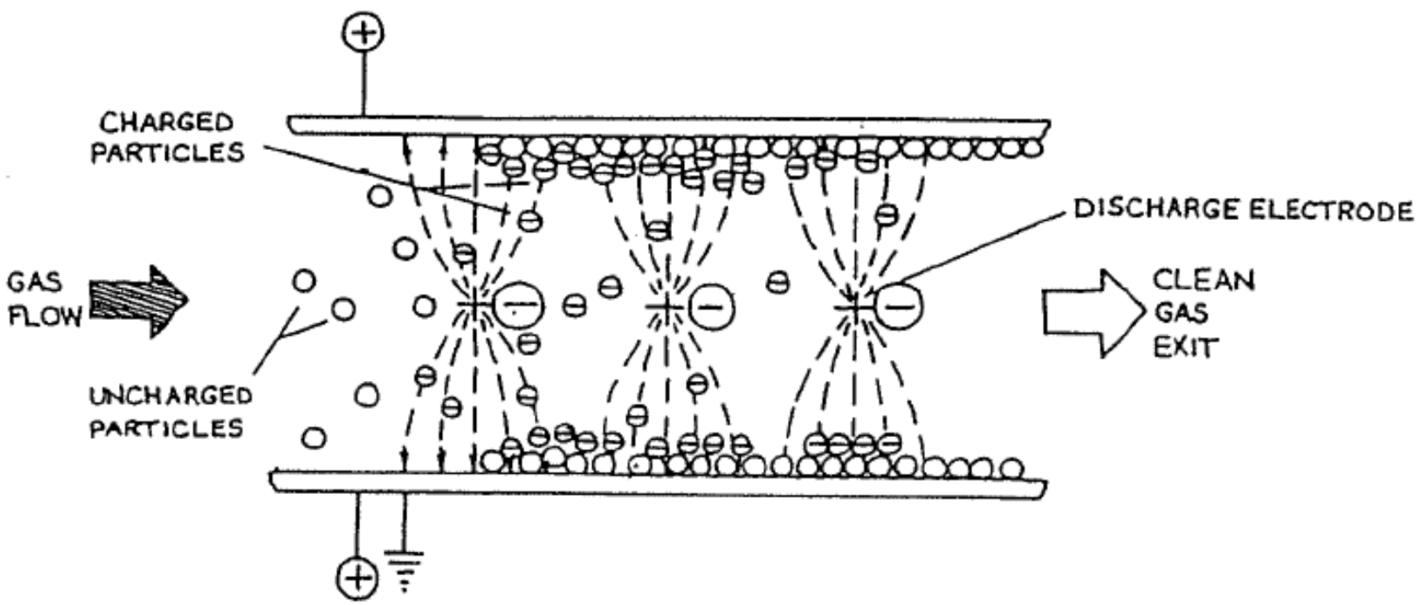
- Problem
  - Presence of fine dust in large quantity
  - Shielding effect on electrical power input
  - Higher secondary voltage required to attain same current level
  - In extreme conditions, corona current onset close to spark-over voltage

Poor Power Input: Space Charge Effect



High Inlet Particulate Loading:
Lower current, reduced collection efficiency

Poor Power Input: Space Charge Effect



High current: improved collection efficiency

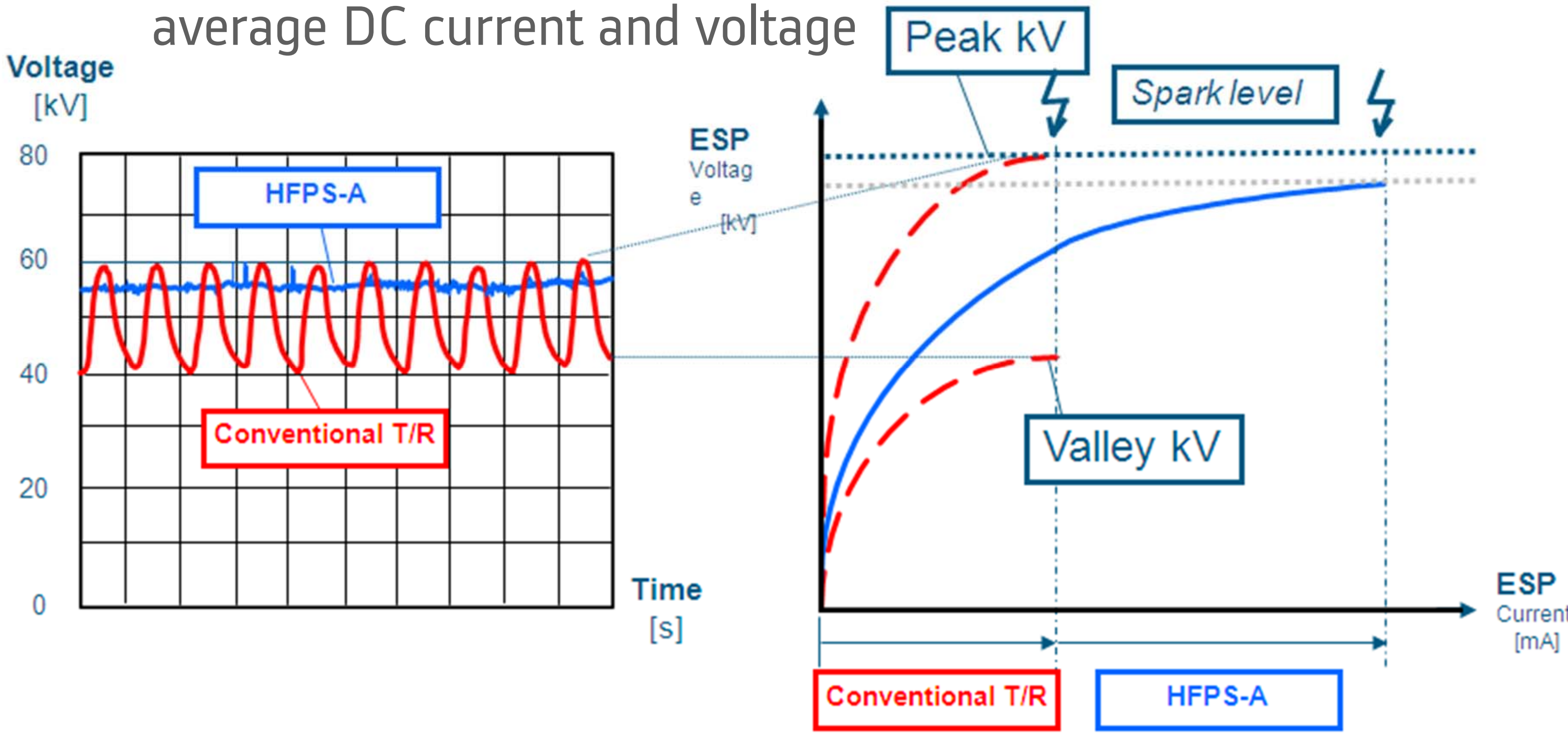
Poor Power Input: Space Charge Effect

- Solutions
  - Optimised T/R controls (EPIC)
    - Allows T/R to operate as close to spark-over voltage as possible
  - Peaked discharge electrodes
    - Low corona onset voltage

Preferred Design

Poor Power Input: Space Charge Effect

- Solutions
  - High frequency transformer rectifiers (SIR or HFPS-A)
    - Higher voltage frequency
    - Secondary voltage to ESP has a much smaller ripple, increasing average DC current and voltage



Poor Power Input: Space Charge Effect

- Solutions
  - High frequency transformer rectifiers
    - This technology can as much as double the current in the first field of an overloaded ESP.
    - This solution can sometimes replace the need for additional collecting area in the ESP to meet emissions.

Dust Build-up Issues: Adhesive Salt Cake

- Problem
  - Low pH dust conditions eventually generate hard, crusty accumulations
  - Combustion conditions can cause high dust carryover and stratification in boiler cause moist sticky ash
  - Trace amounts of hygroscopic elements such as hydroxides and sulphides is a reason for plugging distribution panels and discharge electrodes

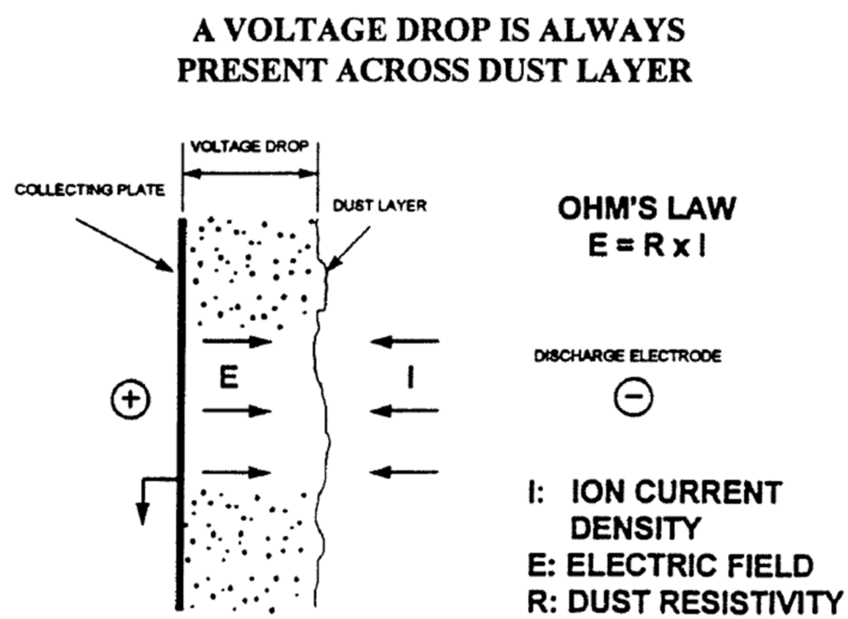
- Solution
  - Optimise rapping
    - Increase rapping intensity and frequency in key areas
  - Avoid horizontal surfaces as much as possible
  - Improve recovery boiler operating conditions (ideally)

Dust Build-up Issues: High Resistivity Ash

- Kraft recovery boiler ash resistivity is typically quite low
- Also, high presence of moisture in flue gas enhances conductivity of particulates.
- Mills with high degree of closure or mills using logs having been transported in the ocean are prone to high levels of alkalichlorides
- Problem
  - Higher resistivity ash creates voltage drop across dust layer
  - High resistance means high holding forces based on Ohm's Law, where E=RxI

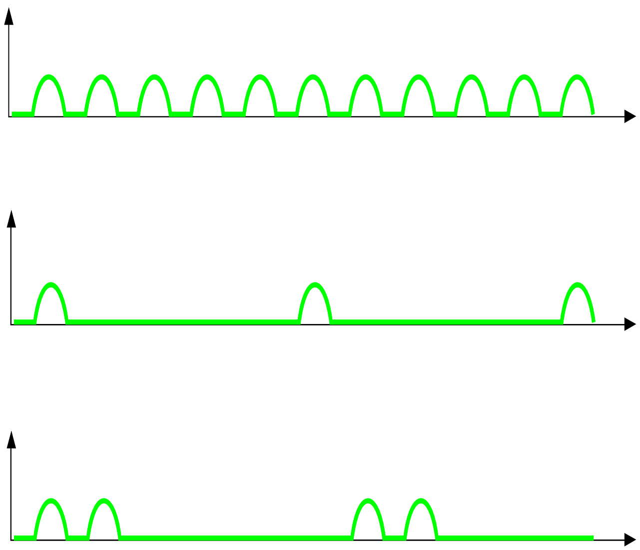
Dust Build-up Issues: High Resistivity Ash

- Affects the holding forces or voltage drop across the particulate layer on the collecting plate and can be best described by OHM's Law:
  - **E = R x I**
  - where E represents the "force" holding the particulate to the collecting plate.
- Low resistivity dust is easily removed through rapping
- High resistivity dust is difficult to remove. Over time, dust is accumulated on the collecting plates, resulting in a gradual decay of ESP performance.



Dust Build-up Issues: High Resistivity Ash

- Solutions
  - Purge ESP ash (thus reducing chlorides)
  - Semi pulse charging
    - Conventional charging
      - CR=1/1
    - Semi pulse
      - CR = 1/5
    - Semi pulse
      - CR = 2/6



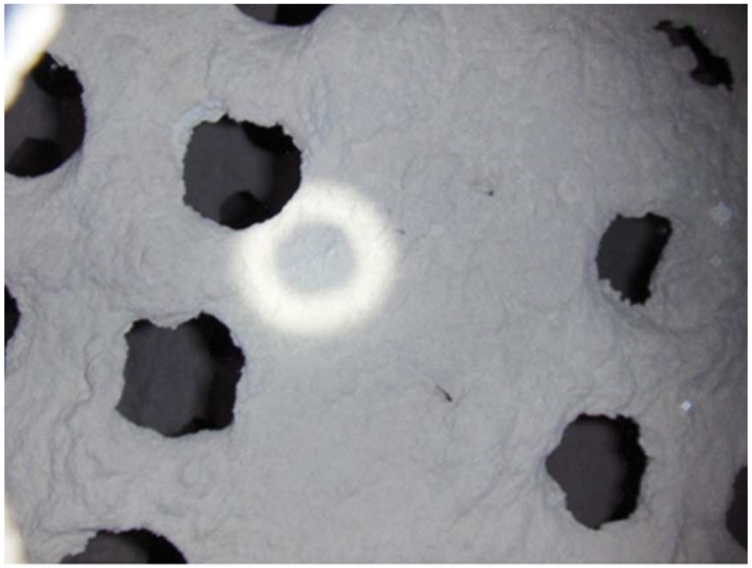
Dust Build-up Issues: High Resistivity Ash

- Solutions
  - Spiral (wire) discharge electrodes
    - More even current distribution

Preferred Design

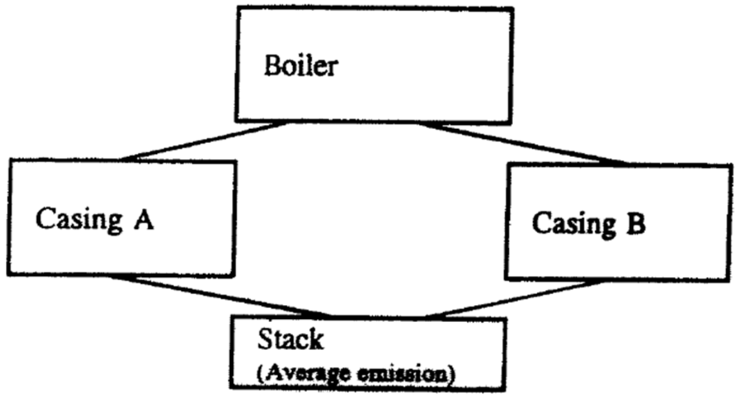
Gas Flow Issues: Gas Distribution

- Problem
  - Uneven gas distribution across the ESP will cause loss of efficiency
  - Poor distribution may be caused by poor design, dust build-up
  - Sticky ash accumulations



Gas Flow Issues: Gas Distribution

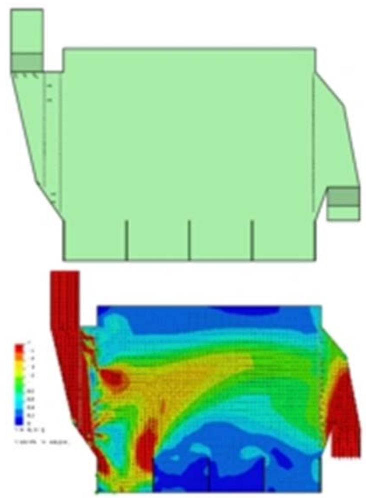
- It's very important to maintain even flue gas flows (i.e., a 50%/50% split) between parallel precipitator casings.
- Deviations result in increased stack emissions.
- The effect of uneven flow splits becomes much greater if the actual flue gas flow is <u>greater than design</u>.



(% of total flow) Casing A/ Casing B	Emission after casing A (mg/Nm3)	Emission after casing B (mg/Nm3)	Average emission in the stack (mg/Nm3)
50/ 50	50	50	50
55/ 45	78	30	56
60/ 40	113	16	74
65/ 35	155	7	103
70/ 30	206	2	145
75/ 25	263	1	197

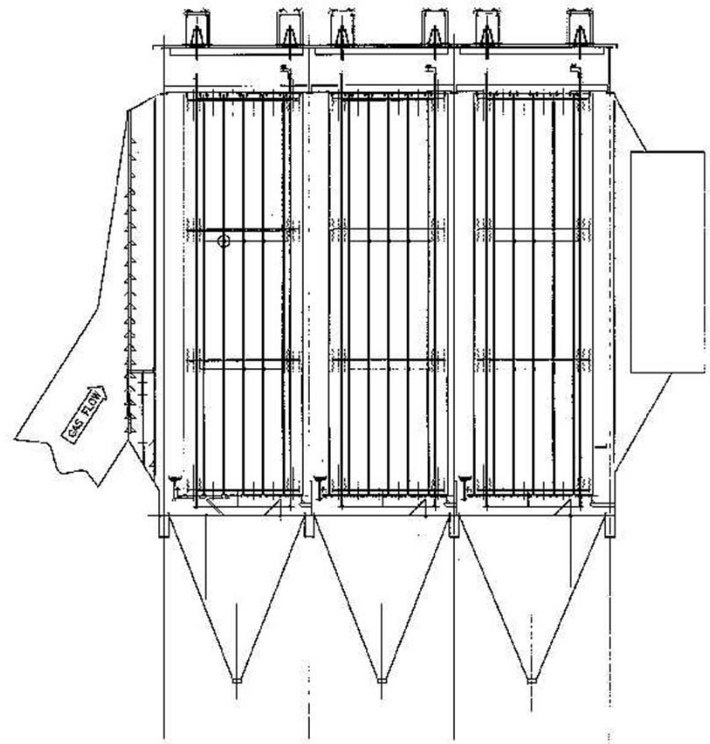
Gas Flow Issues: Gas Distribution

- Solutions
  - Perform internal inspection
  - Perform flow distribution test or a model study



Gas Flow Issues: Sneakage

- Problem
  - Flue gas is bypassing the collecting area
  - For 1% sneakage with inlet concn of 20 g/Nm^3, min outlet concn is 200 mg/Nm^3



- Solution
  - Sneakage must be found and corrected
  - Baffling can be installed

Gas Flow Issues: Inleakage of Air

- Problem
  - Air inleakage increases flue gas volume to ESP, which increases velocity through ESP
  - Air inleakage causes stratification of the flue gas, and results in uneven dust loads over the cross section of the ESP

- Solution
  - Examine equipment and casing for leaks
  - O_2 measurements at several locations can help identify sources of inleakage

Overload Conditions

- Problem
  - Increased mill production has resulted in overloaded ESP
- Solution
  - Improving performance without extension
    - Possible solutions include improved T/R controls, High Frequency T/Rs, peaked discharge electrodes, and efficient rapping
  - Improving performance by extension
    - If above solutions are not adequate for load increase, then additional fields can be considered. Parallel ESP is also a possibility.
    - When flue gas velocity exceeds critical value, cross sectional area must be increased

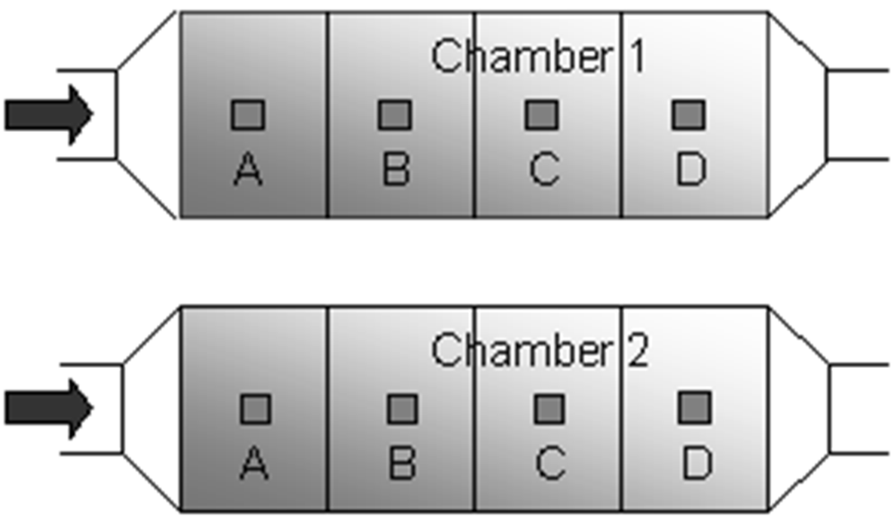
Case Studies

Results on Soda Recovery ESP: Brazil

- Recovery boiler upgraded from 2200 t/d BLDS at 70% dry solids to 3000 t/d BLDS at 75% DS. ESP was not upgraded.
- After Boiler Upgrade
  - Significant build-up was present on the ESP internals
  - Emission levels were measured as high as 1000 mg/NDm^3. Guarantee level was 50 mg/NDm^3.
- Diagnosed Causes
  - Higher resistivity due to high amount of alkalichlorides in the dust
  - Space charge effect

Results on Soda Recovery ESP: Brazil

- Solutions Implemented
  - HFPS-A on A and B-fields
  - Power Control Rapping
  - Larger hammers
  - Increased speed of ash conveyor



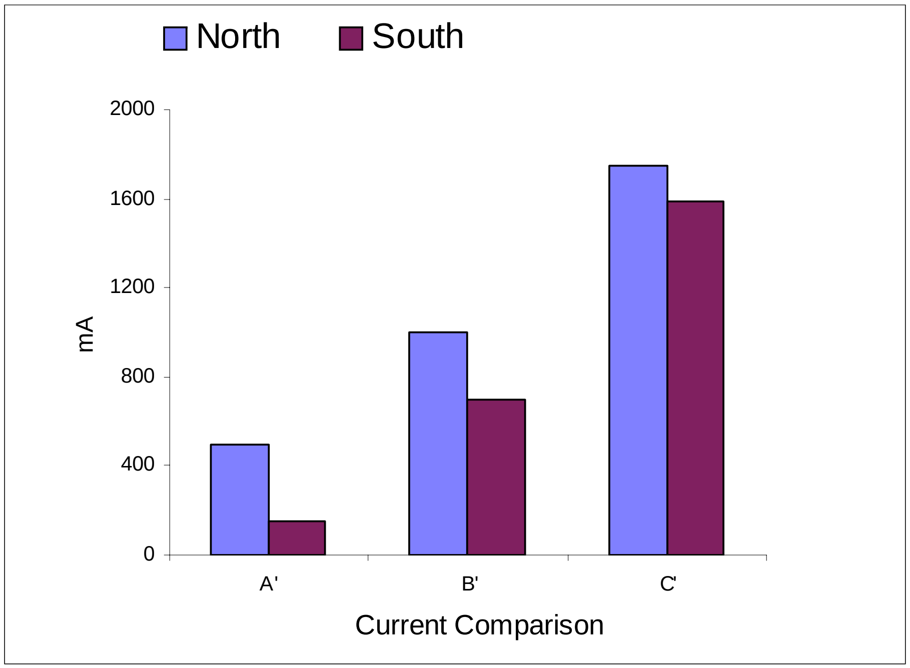
Results on Soda Recovery ESP: Brazil

- After the solutions were implemented, the unit was able to attain guarantee levels.

Field	Pre-Boiler Upgrade			Post-Boiler Upgrade		
	kV	mA	spm	kV	mA	spm
A	65-70	100-300	50-200	65	90	35-200
B	65-70	600-1100	30	55	170	55-200
C	55	1400	0	50	180	55-200
D	48	1400	0	70	110	0-30

Field	kV	mA	spm
A	60-64	175-250	200-300
B	66-69	400-500	0-2
C	57-58	1200-1400	0
D	54-55	1400	0

Results from HFPS-A installation on Soda Recovery: Canada

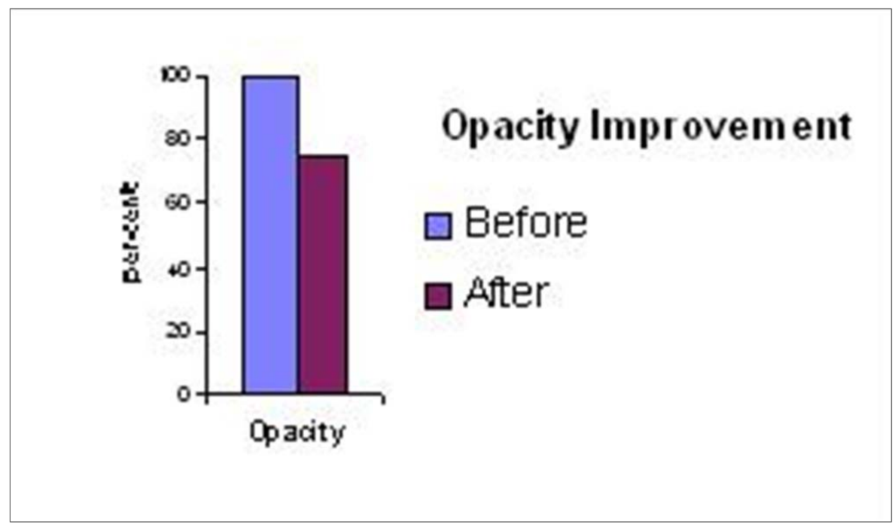


Mill #1

* Original design was for 3.0mmlbs/day

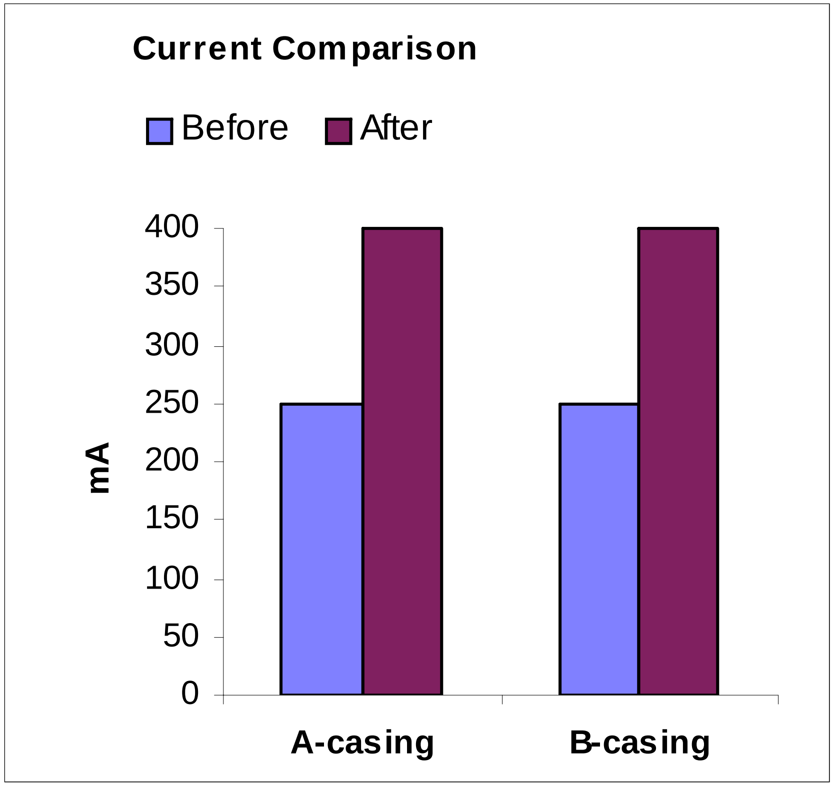
* Currently overloaded by 50% and running at 4.5mmlbs/d blds @ 72%DS

* 25% improvement in opacity

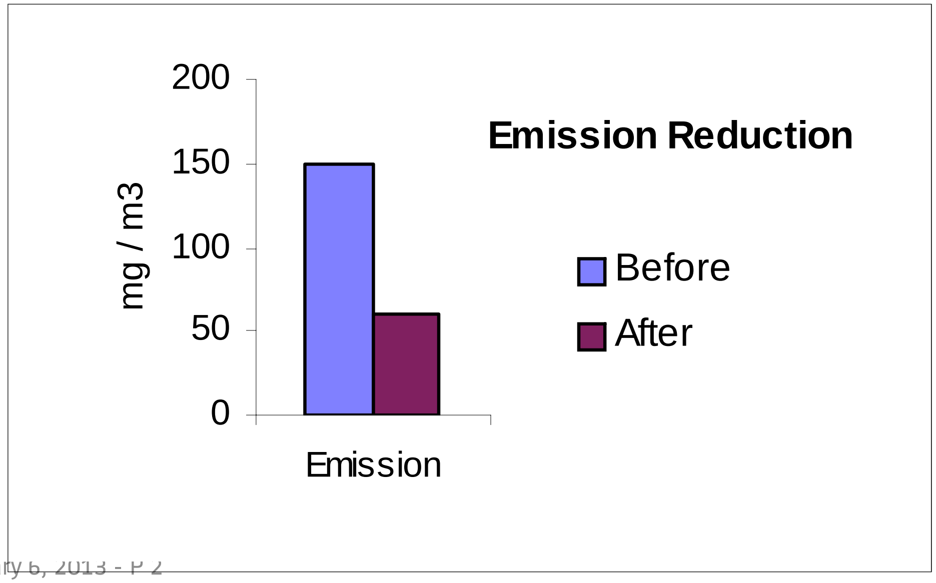


- Precip with 6 Fields (2 chambers)
- One HFPS-A installed in one of two 1st fields (north)

Results from HFPS-A installation on Soda Recovery: Canada

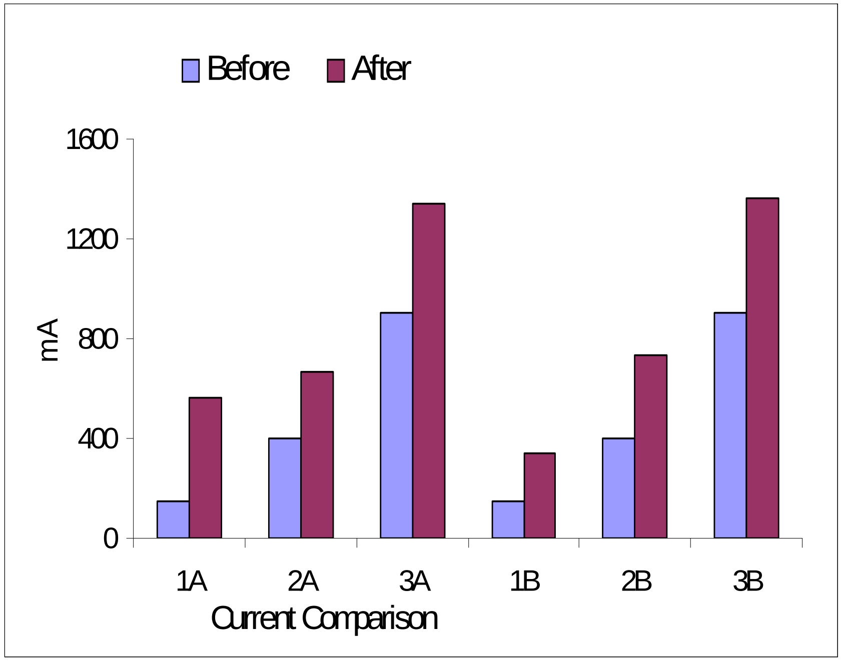


Mill #2
* Recovery unit was running at 800,000lbs/hr @65%DS
* Boiler had an air system upgrade and increased load to 1,045,000 lbs/hr @71% DS
* 66% decrease in emissions!

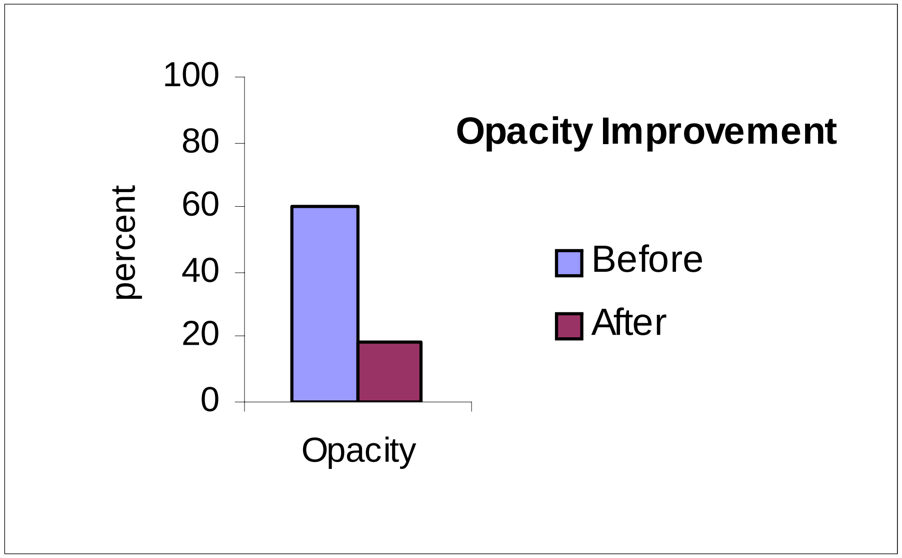


- Precip with 2 Fields
- Two HFPS-A's installed

Results from HFPS-A installation on Soda Recovery: Canada



Mill #3

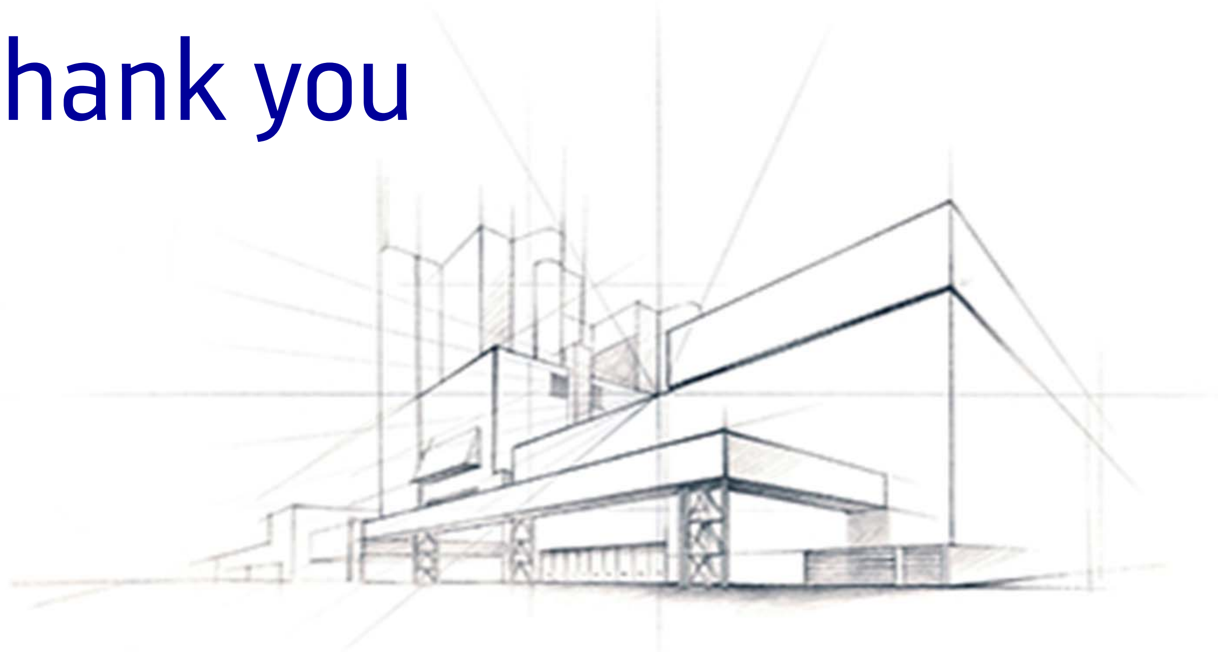


- Precip with 6 Fields (2 chambers)
- Two HFPS-A's installed in first fields

Summary

- Poor ESP performance can be grouped into 4 major categories
  - Poor power input
  - Dust build-up issues
  - Gas flow issues
  - Overload conditions
- Proper evaluation and application of available technology has the potential to alleviate the need for additional collecting area.

Thank you



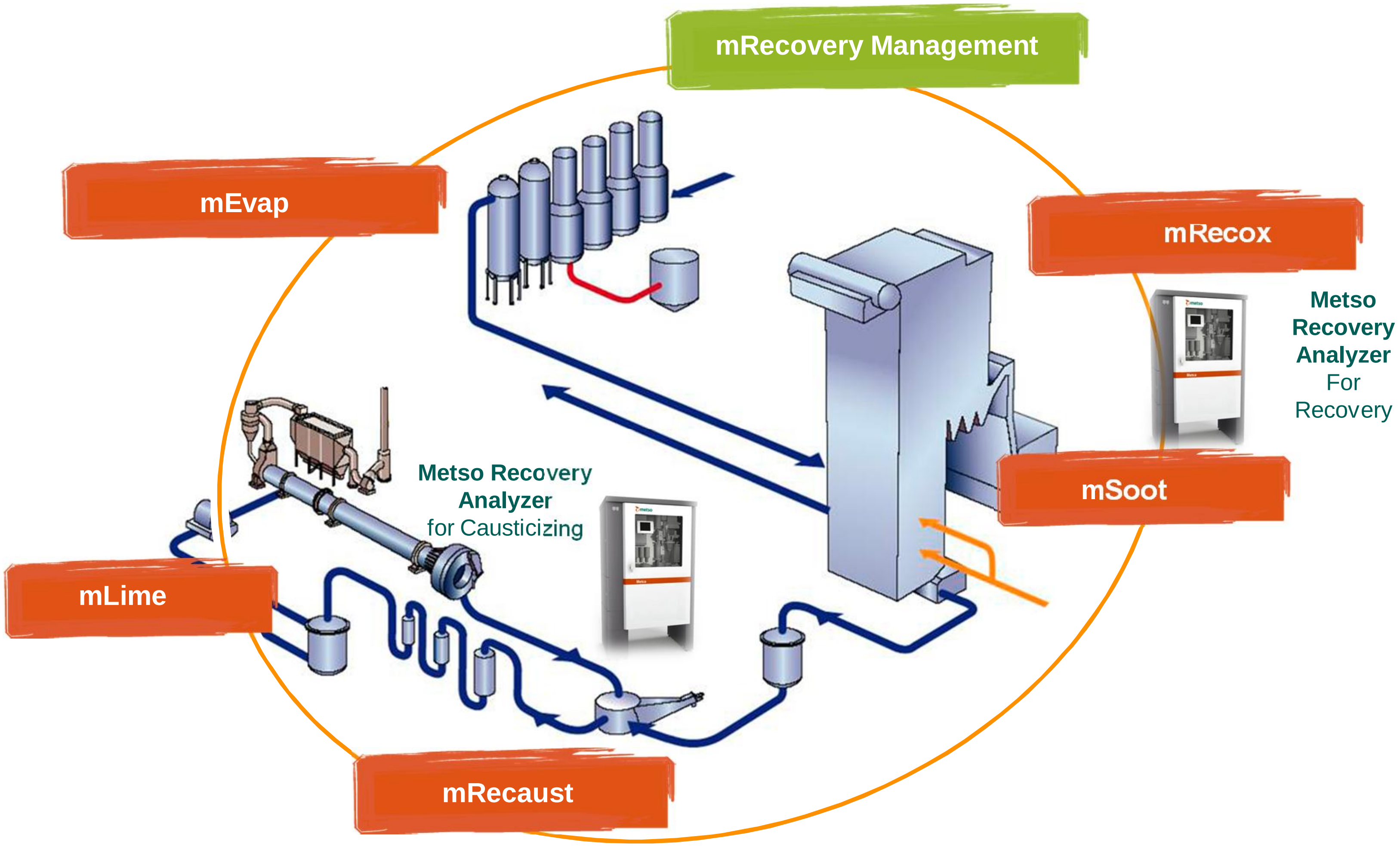
Recovery Boiler Optimization Utilizing On Line Recovery Analyzer Measurements

Jeff Butler

Product Manager – Pulp Solutions

metso

Advanced Process Controls for Recovery Line Management



Recovery Analyzer
On Line ABC Titrator

Recovery Analyzer

- Introduces the Metso modular analyzer concept for recovery process
- On line, multipoint, modular analyzer for recovery process management
- Dissolving tank green liquor TTA
- Weak Wash TTA
- NEW: Reduction degree measurement
- Flexibility and expandability in measurement capacity when needs grow, with more speed and capacity
- User-friendly interfaces and supporting tools for life cycle services
- Cost effective installation
- Safe, automatic sampling - less manual work in risky environment

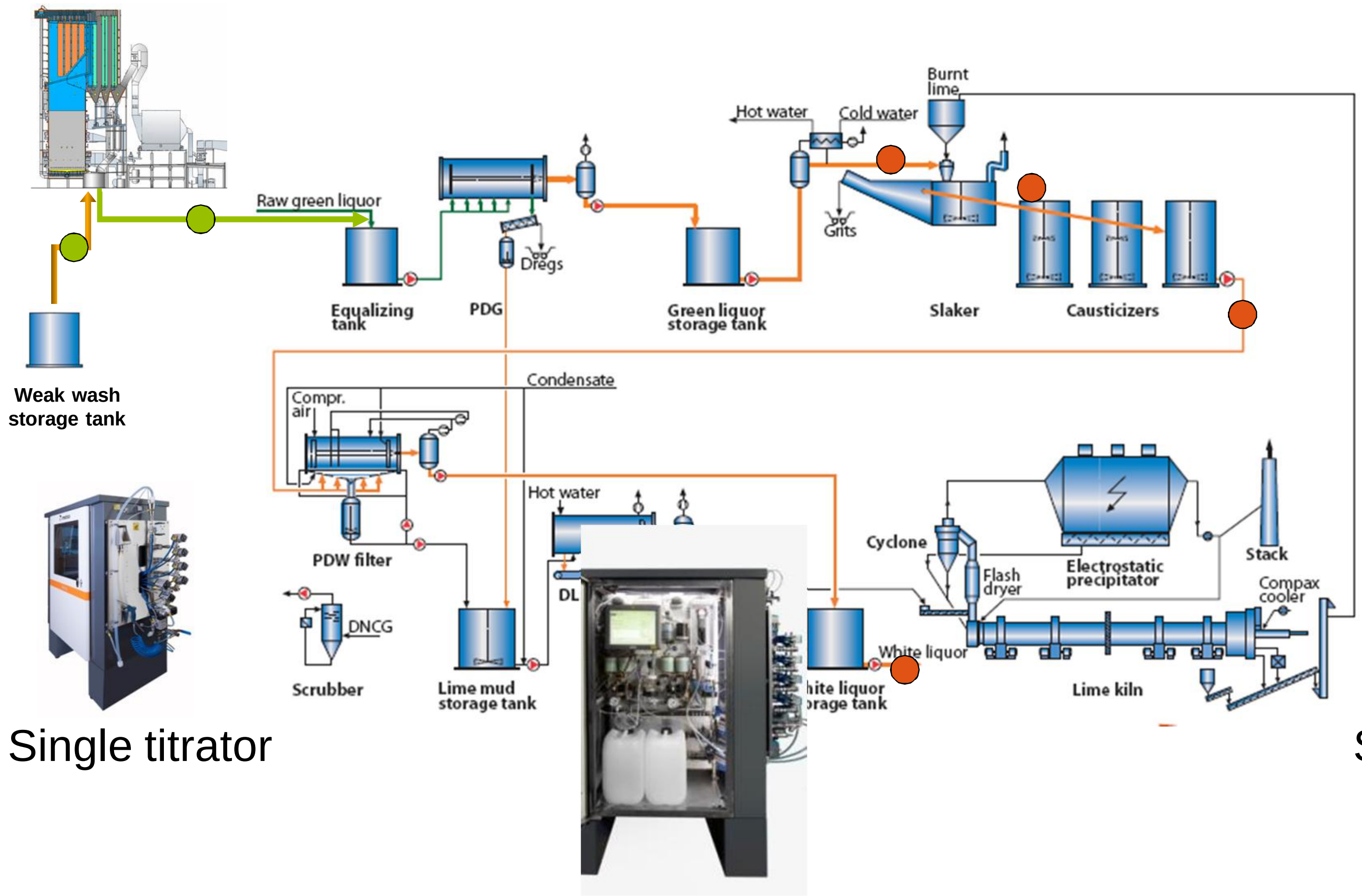
Recovery and Recaust Analyzer
- online measurements available from day one

- Provides actual liquor chemistry titration results (ABC-titration/SCAN 30:85)
- No calibration required – online measurements available from day one
- No sensor removal and cleaning needed
- Alkali components' conductivity changes do not affect measurement results
  - Chemical Absolutes!
- Can be used to measure liquor manual samples
- Rugged design ensures high uptime and low maintenance
- Large titrator reference base and field proven controls

New analyzer features

- Flexible analyzer platform and sample line structure
  - Single or dual titration module
  - Sampling points from 1 up to16
- New sample handling unit
  - Smaller sample amount
  - Faster sedimentation time
  - New multi burette dozing system
- New measurement
  - reduction degree
- New electronics platform with enhanced features
  - Modern communication tools via Ethernet
  - Visually advanced and easy interfaces
  - Intelligent selfdiagnostics
- New sampling device options
  - Faster control and sample line flushing management. Flushing possibilities back to process or mill sewer system

Versatile product concept



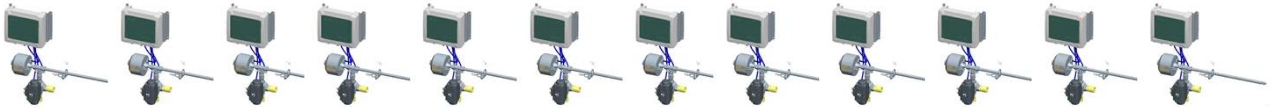
Single titrator

Single titrator

Dual titrator

Concept and performance features

Expandability for customer needs



Alkali Analyzer	Measurements	Single cabinet model	Dual cabinet model	Single or dual cabinet with safety house
Sample handling and measurement unit	NaOH,Na_2CO_3,Na_2S & EA,AA,TTA,CE%S%	1-8 sample point	1-16 Sample point	1-16 sample point
Reduction degree(Optional)	Reduction degree	1	1	1
Speed		8-10 min/measurement 12-14 min/measurement	5-7 min/measurement	
Description		•Dedicated analyzer for recovery boiler measurements •For Single causticizition line measurements	•Faster analyzer for single causticizing line measurements •Dual causticizing line measurements	Safety cabinet for harsh environmental conditions

Minimal maintenance

2 (2)

metso
Expect results

Metso Metra

C. Once a year (~ 8 hours)

First check all items listed under

Sample unit	
19.	Check and service the was
20.	Check and service the so
21.	Acid-clean the sample li
Titration unit	
22.	Replace the pH elect
23.	Clean and service t
24.	Clean the analyze
25.	Check and updat

metso
Expect results

1 (1)

Metso Metra — Maintenance check list

A. Once a week (~ 30 minutes)

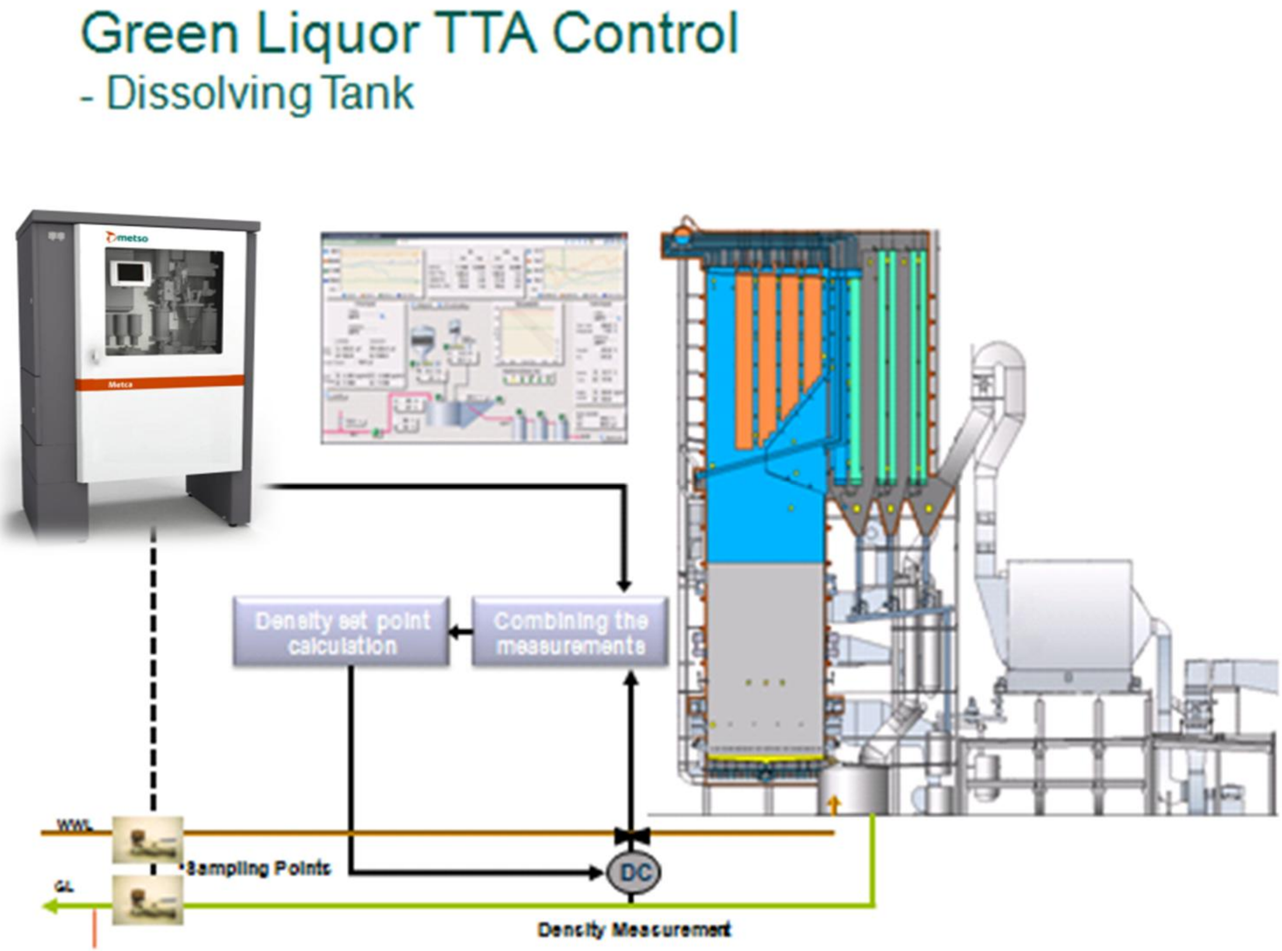
Sample unit		
1.	Make sure that all the connections of the sample unit and samplers are tight.	☐
2.	Make sure that compressed air pressure is the same than in start-up, 4–6 bar (58–87 psi).	☐
3.	Make sure that the pressure of sample unit washing water is the same than in start-up, 4–8 bar (58–116 psi) or at least 2 bar (29 psi) higher than the highest process pressure at the sampling point if the sample line is flushed in to the process.	☐
Titration unit		
4.	Fill the HCl, $BaCl_2$ and IPA tank if needed ($BaCl_2$ and IPA only with reduction measurement). Remember to add Triton X-100 to the HCl tank: ratio 1 mL / 20 L of HCl (0.006 fl oz/1 US gal HCl).	☐
5.	Check that the burette operates correctly and does not suck air in.	☐
6.	Check the water level in the analysis cup.	☐
7.	Check the sample, water and chemical tubes and their connections.	☐
8.	Check any error messages from diagnostics. If repeated errors are observed, find out what causes them.	☐

B. Once a month (~ 2 hours)

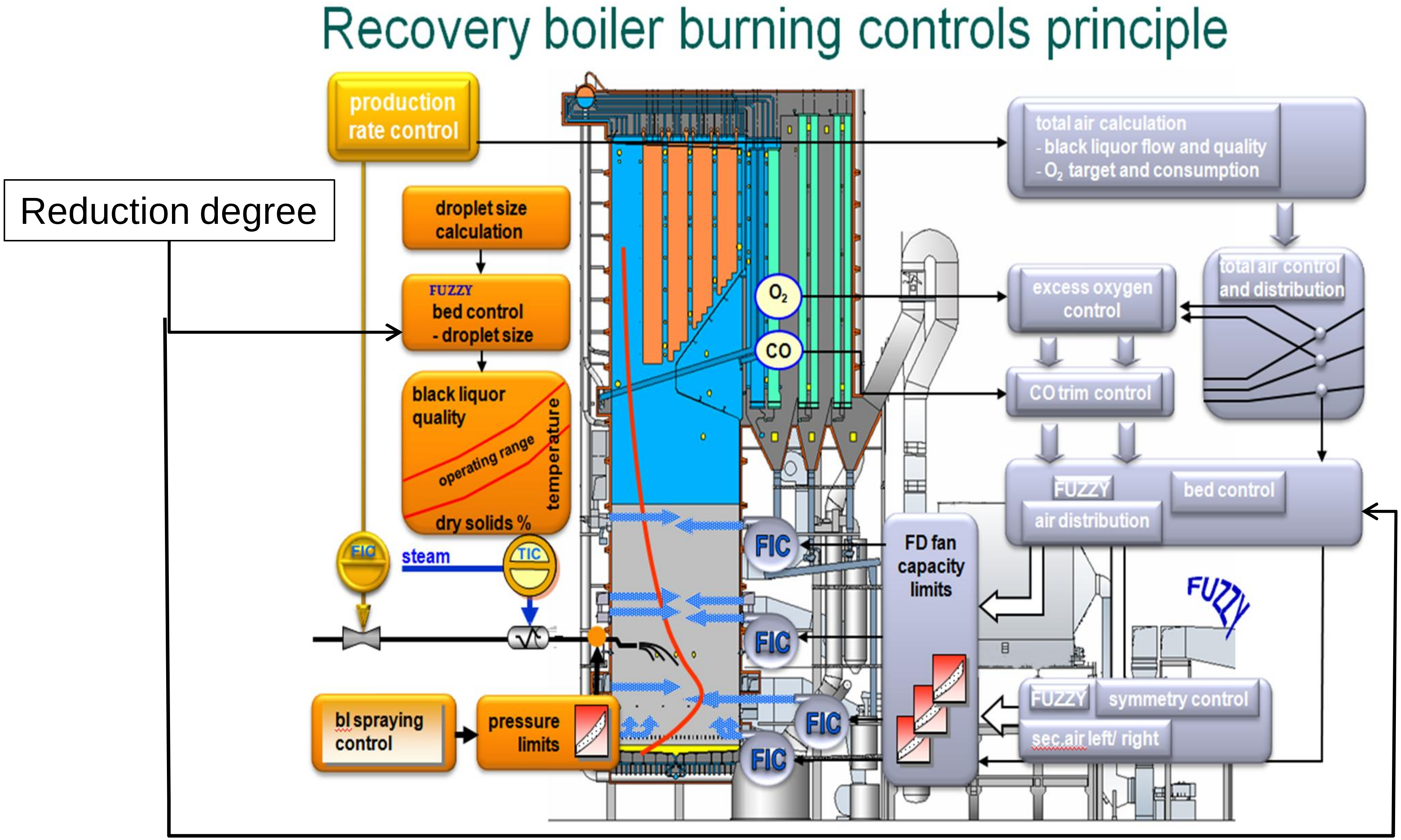
Recovery Boiler measurement applications

Recovery Boiler Optimizer
Green Liquor TTA Control – Dissolving Tank

- Alkali analyzer measures TTA and correlates result to density. Density setpoint is sent to existing denisty controls
- Alkali analyzer measurement is modeled against Mill's on line density measurement
- Manipulated Variables
  - Weak Wash Flow
- Control Variables
  - Green Liquor Density
  - Green Liquor TTA



Using Reduction Degree Measurement for Liquor Burning and Air Optimization,

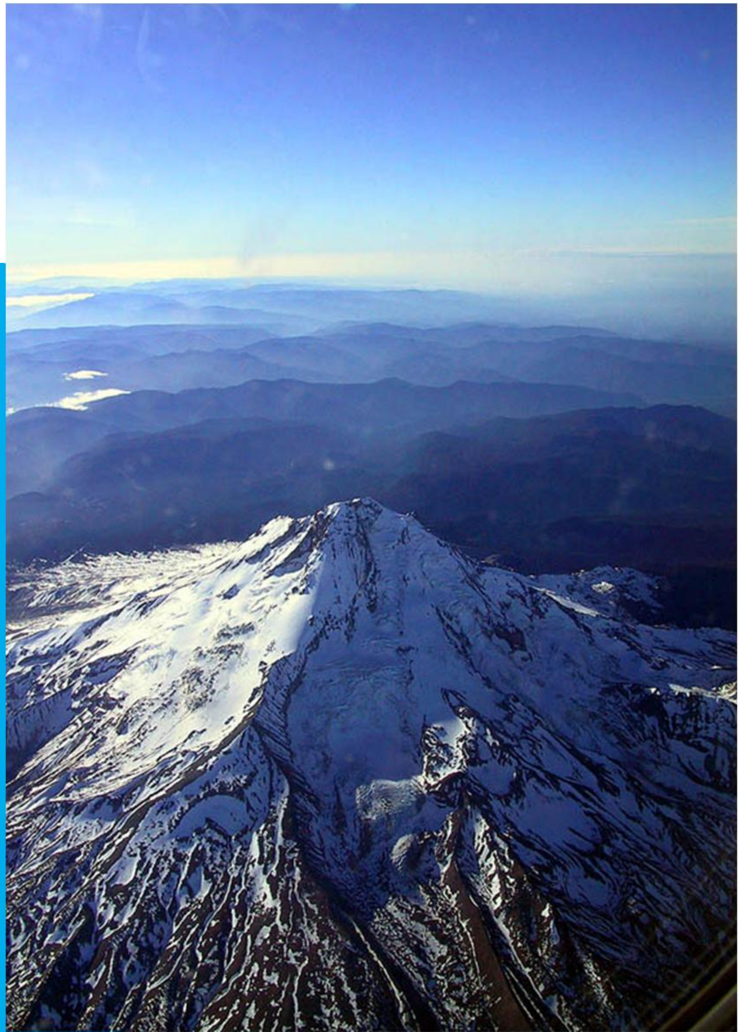


Summary of Benefits

- In Recovery Boiler Area:
  - Reduction degree increase 1-3 % units (potentially more)
  - Reduction degree deviation decrease up 30 %
  - Excess oxygen level decreases 10 %
  - Oxygen standard deviation decreases 30 %
  - Flue gas final temperature decreases up to 5 degrees
  - Combustion supporting fossil fuels not needed
  - Dry solids throughput increase 1-5 %
  - Steam production increase 1-5 %
  - Reliable and accurate dissolving tank density measurement and control
  - Emissions decrease 10 - 20 %
- Reliable chemistry based measurement results can be used in process start-ups to shorten the ramp up time to normal production
- Absolute measurement provide solid foundation for process management and control even during process disturbances — problems can be identified fast and their impact to the process minimized
- Automated laboratory testing according to a standard method provides repeatable real time process information 24/7/365

Thank You!!!

??Questions??



A STACKED AIR SYSTEM FOR IMPROVING COMBUSTION IN A RECOVERY BOILER

AF&PA Meeting, Atlanta

Ishaq Jameel PhD

02/06/2013

Outline

- Overview of RB Fouling
- Overview of Stacked Air System
- Case I: Increase in Load
- Case II: Reduction in Emissions
- Potential Benefits
- Concluding Remarks

If the leading soot blowers look like this…

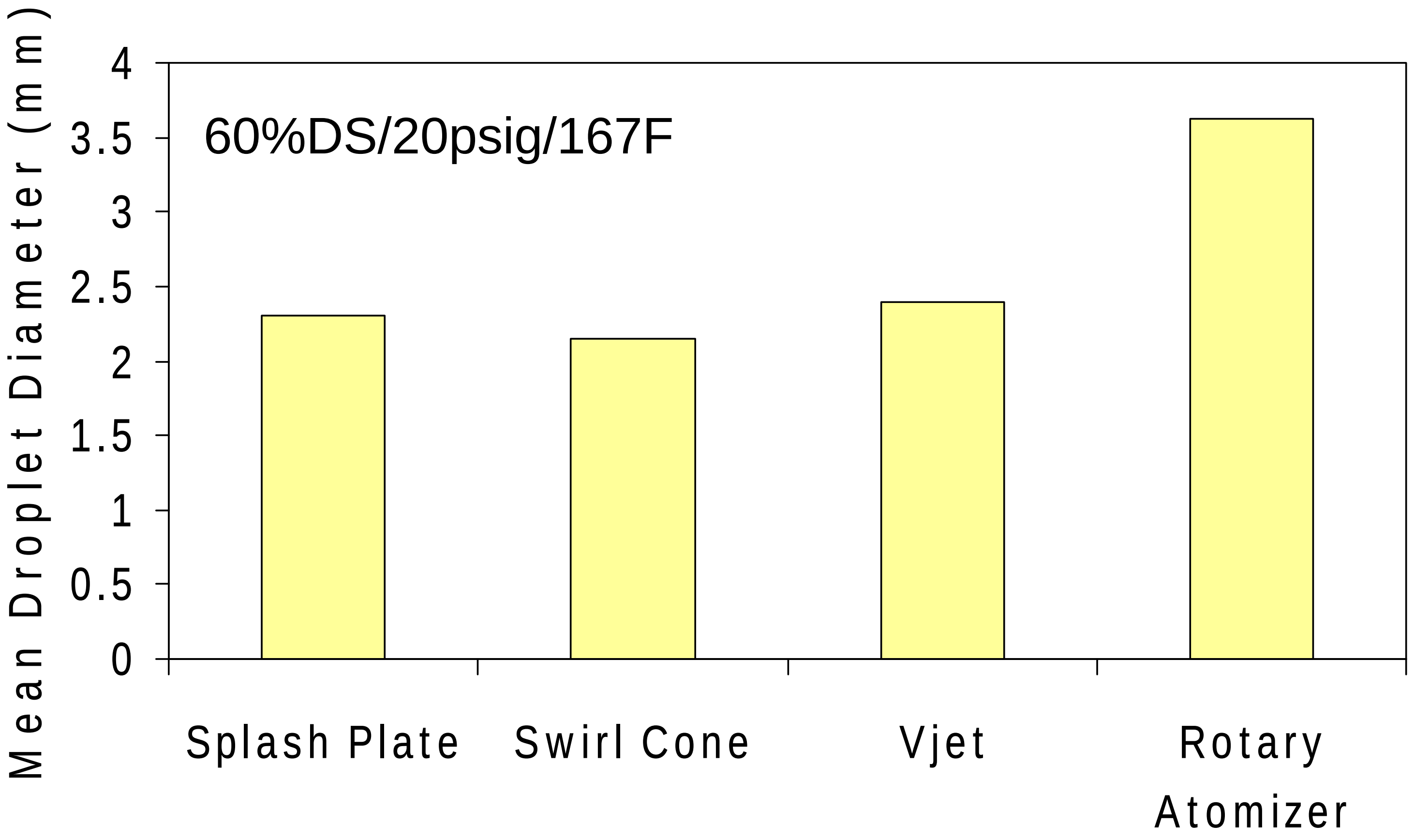
Stacked Air will improve
ash deposition & cleaning capability

Factors Affecting RB Fouling

Fouling

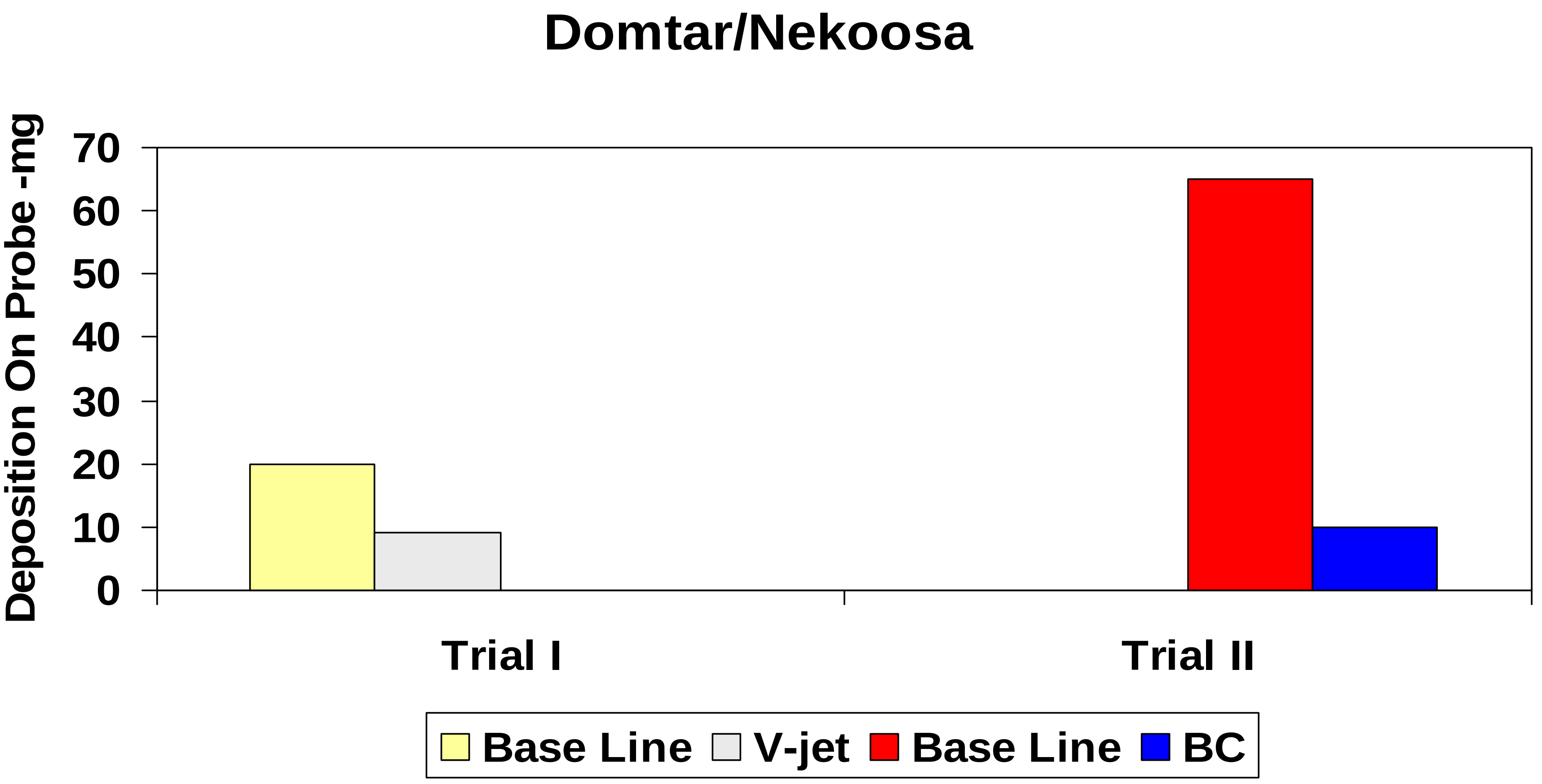
- Ash Loading
  - Firing Rate
  - BL Spray
  - Air System
- Stickiness of Ash
  - Chemistry
  - Temperature
- Soot blowing

Liquor Spraying



Empie, H.J.,S. Lien, D. Samuels, Black Liquor Delivery Systems, Annual Research Review, IPST, April 1993.

Carry Over Test



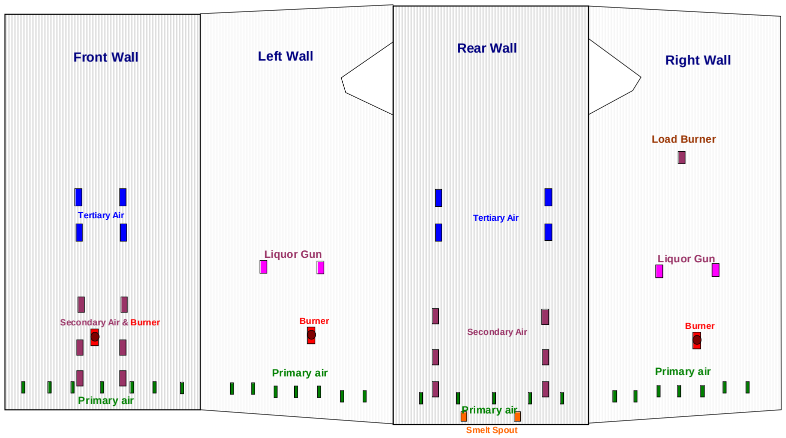
CB Beer Can Nozzle

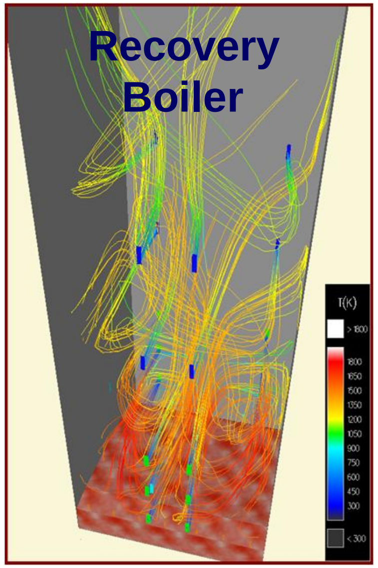
- Variable Orifice Beer Can*.
- Corrosion resistant casting.
- Better control of the bed & smelt flow.
- Reduced carryover.

*US Patent US 2008/0006725
Swedish Patent SE 534 983 C2

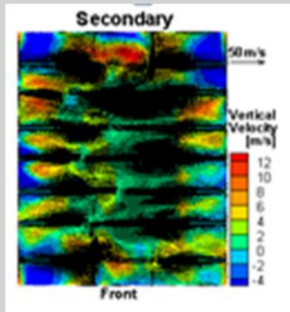
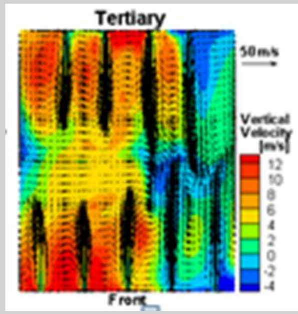
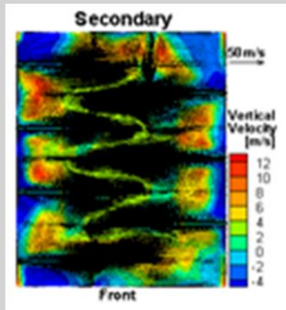
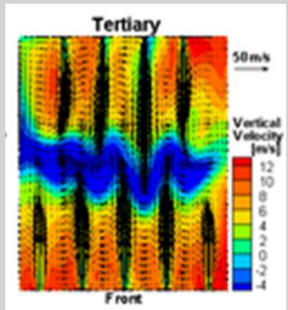
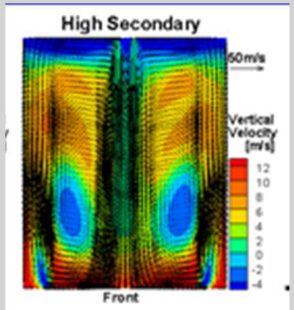
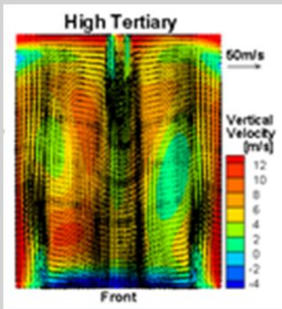
What is "Stacked Air"

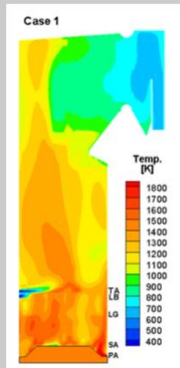
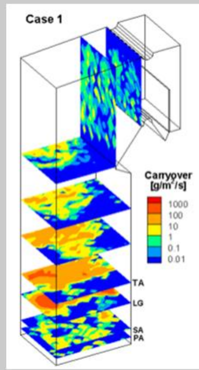
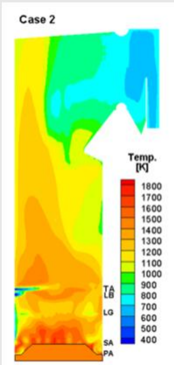
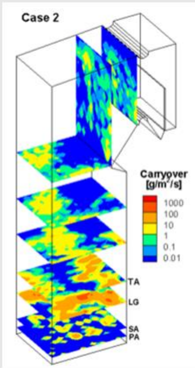
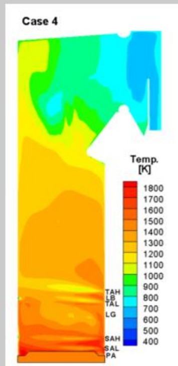
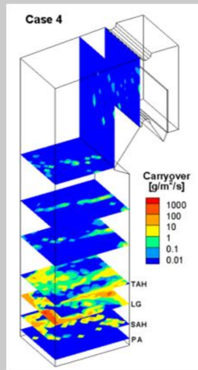
- Multi-Level "*stacked*"
- Ports vertical aligned
- Same air pattern
- Lower pressure





Air Distribution

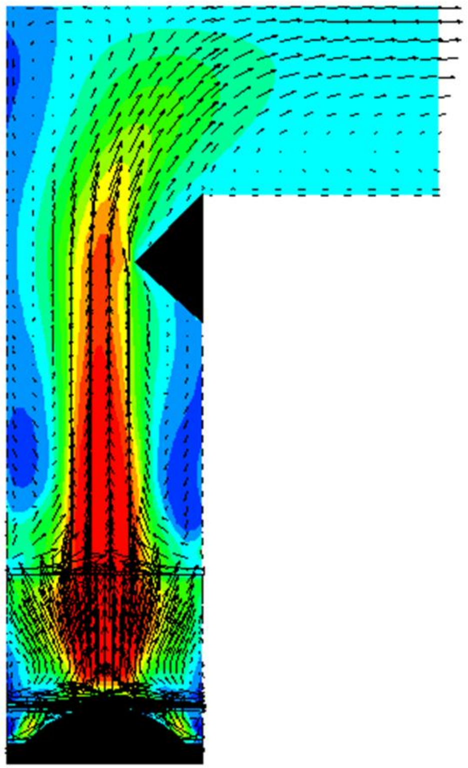
Background	Case	2RY	3RY
• ALSTOM '76 • Load = 2070t/d (4.6MMlb/d) • 68.7% DS • Steam Flow 281t/h (619KPPH) • Final Steam 62bar /463C (900psig/865F)	1		
	2		
	3		

Case #	FG Temp.	Carryover	Results Summary
1			Load=2070t/d Carryover 164kg/h (0.2% DS) FEGT = 959C FGT above bed = 1020C Energy release = 93MW Residual O2 = 2.7% CO = 791ppmv
2			Load=2070t/d Carryover 157kg/h (0.18% DS) FEGT = 898C FGT above bed = 1136C Energy release = 91MW Residual O2 = 2.5% CO=535ppmv
4			**Load=2313t/d** Carryover 3kg/h(~0% DS) FEGT = 873C FGT above bed = 1214C Energy release = 131MW Residual O2 = 2.1% CO = 4ppmv

Benefits from Stacked Air System

- Superior mixing
- Full use of the furnace volume.
- Elimination of high temperature core
- Reduction in upward velocity
- Hotter lower furnace & char bed
- Lower FEGT
- Reduction in emissions
  - SO2 and TRS
  - Carryover
  - NOx production
  - Unburned hydrocarbons & CO

Combustion System for Recovery Boiler

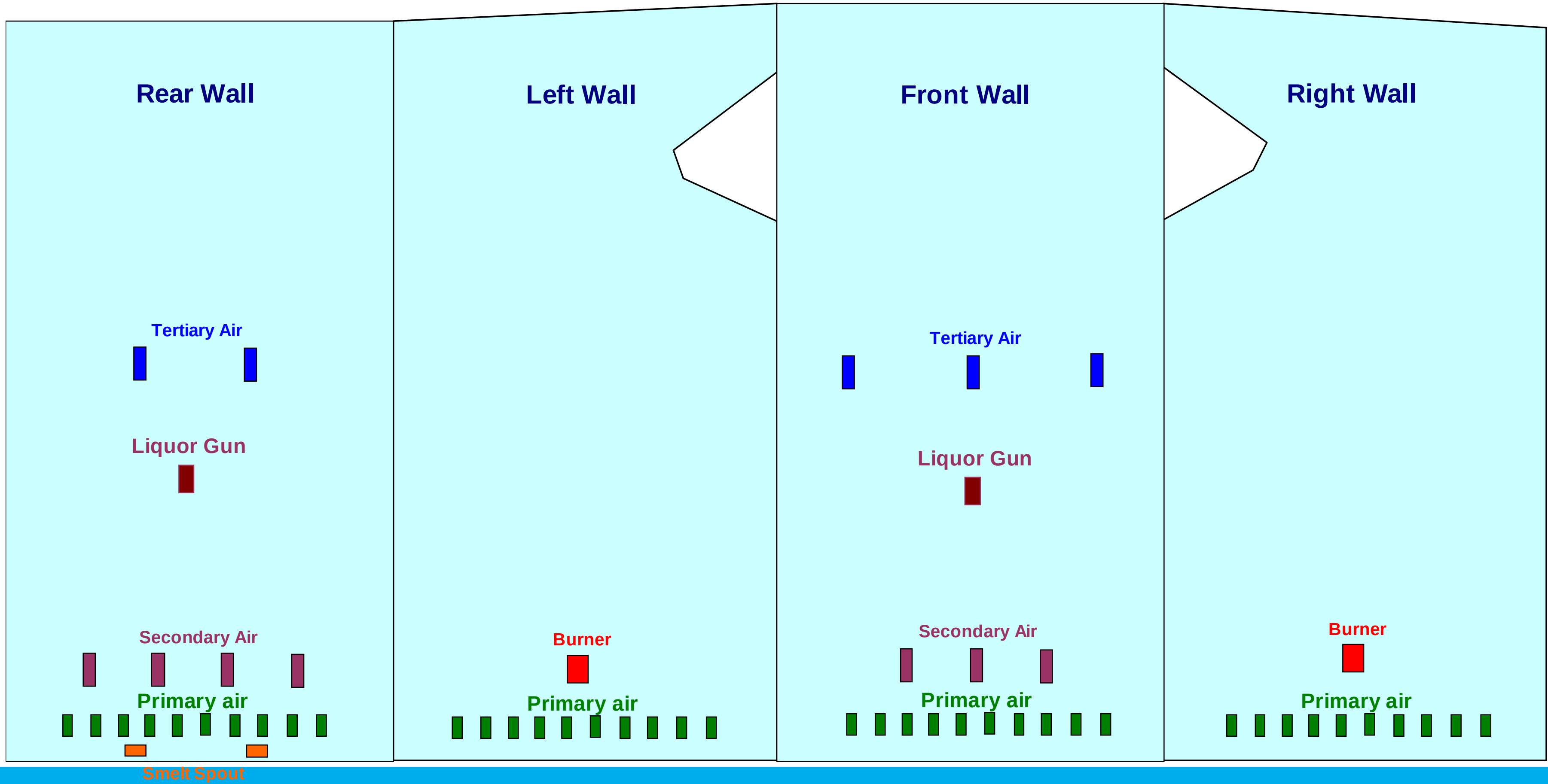


Case I – Reduce Fouling

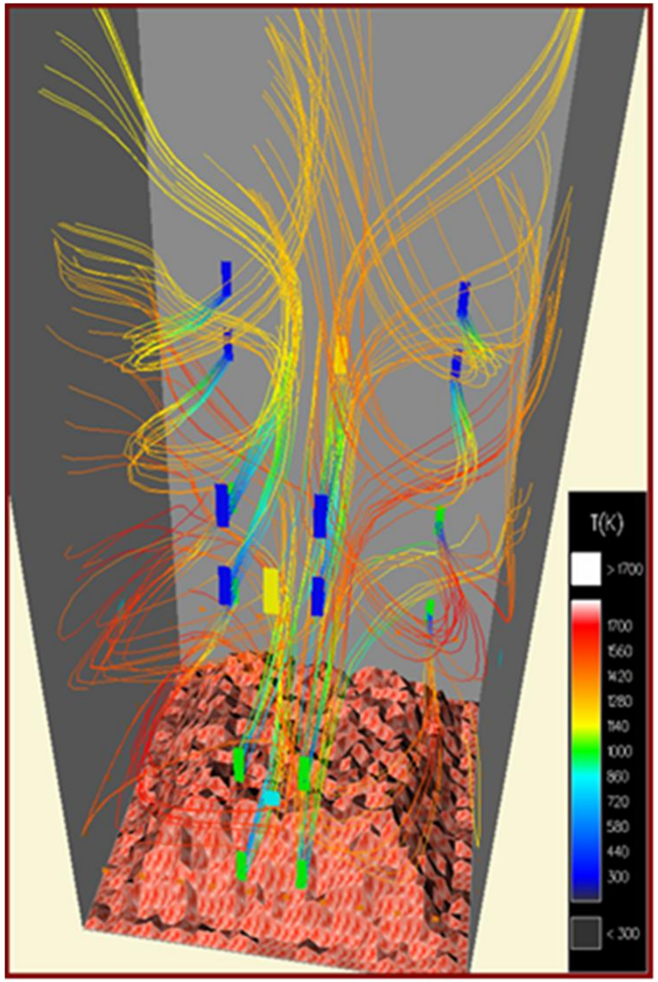
- Soda Boiler/Thailand
- Originally rated at 225 TDS/day
- Eucalyptus + CTMP liquors (low S)
- Air system modified in 2001, 1X/4x3 2RY & 1X/3x2 3RY
- High smelt melting temperature
- Continuously burned fuel oil
- Airports and spouts are hard to clean
- Running at 280t/d & Plugging <u>weekly</u>

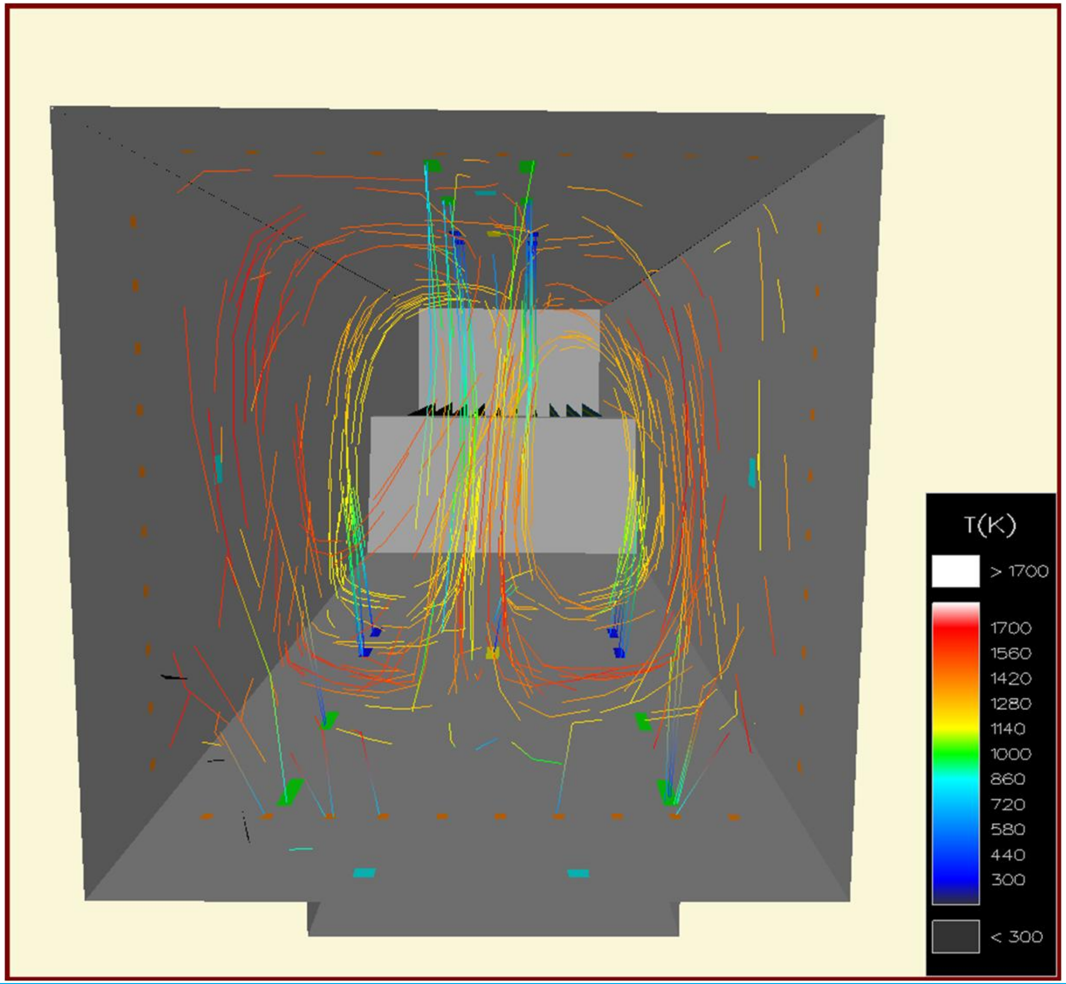
Project Goals

- Increase runtime
- Eliminate oil co-firing
- Increase load rate (370 TDS/day target)



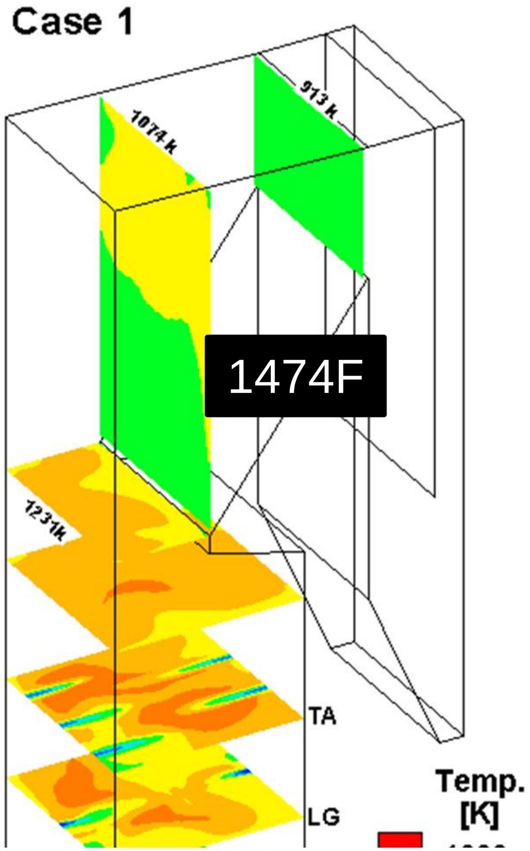
Secondary and Tertiary



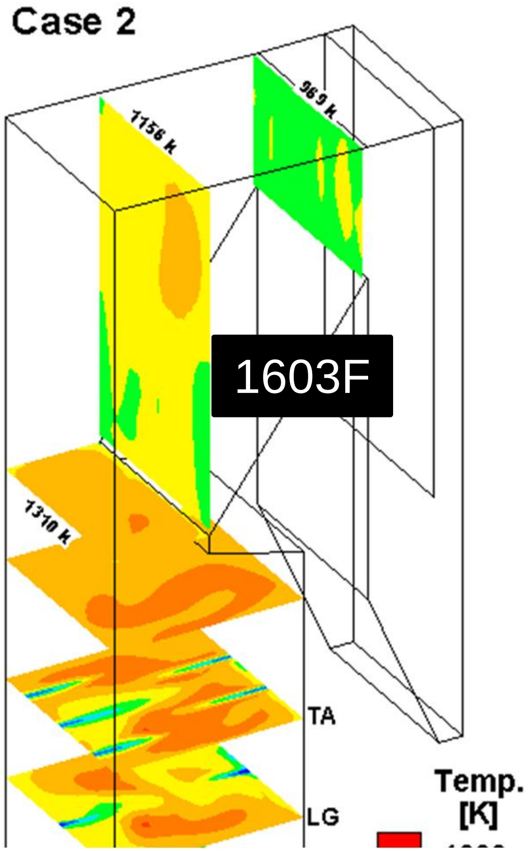


Requirements

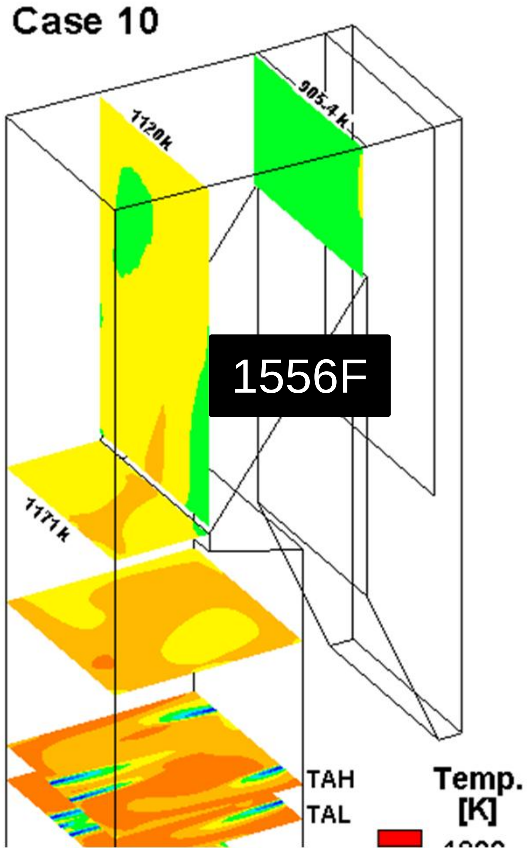
- Reduce upper furnace gas temperature



Existing System-280t/d



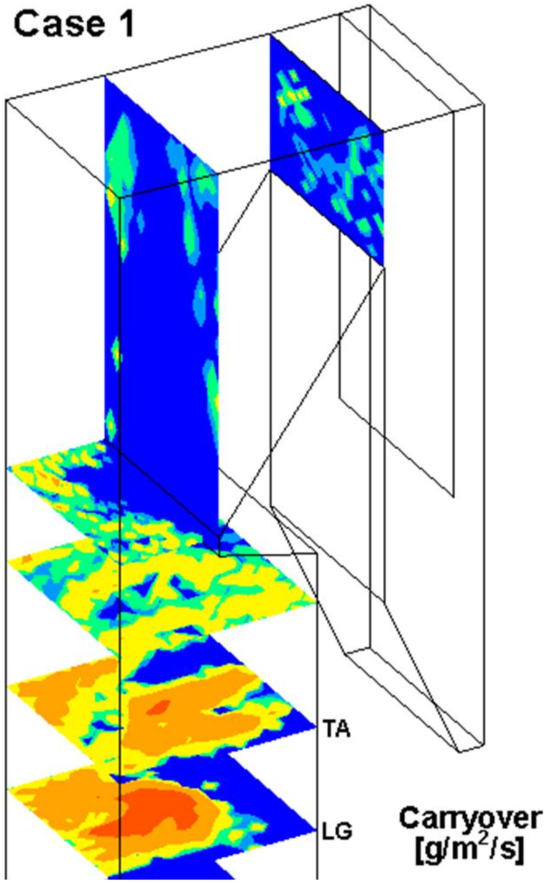
Existing System-370t/d

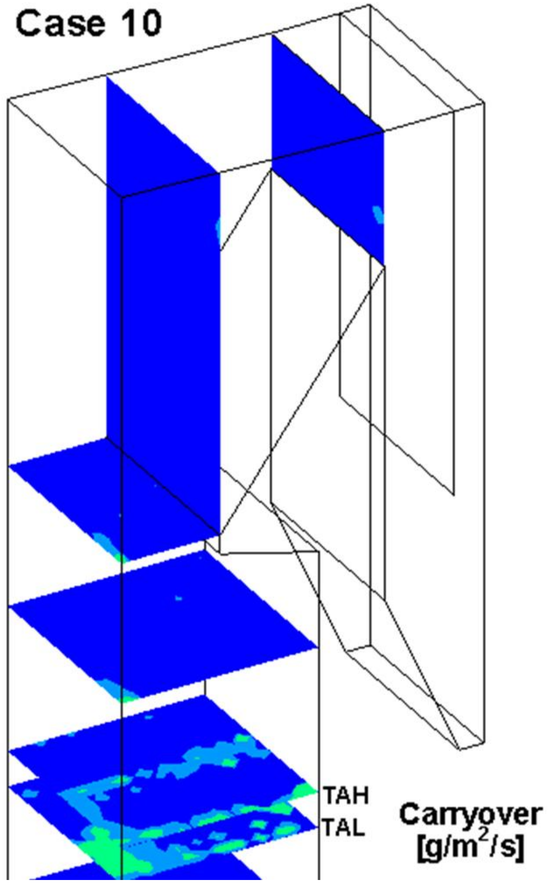


New System 336 t/d

Requirements

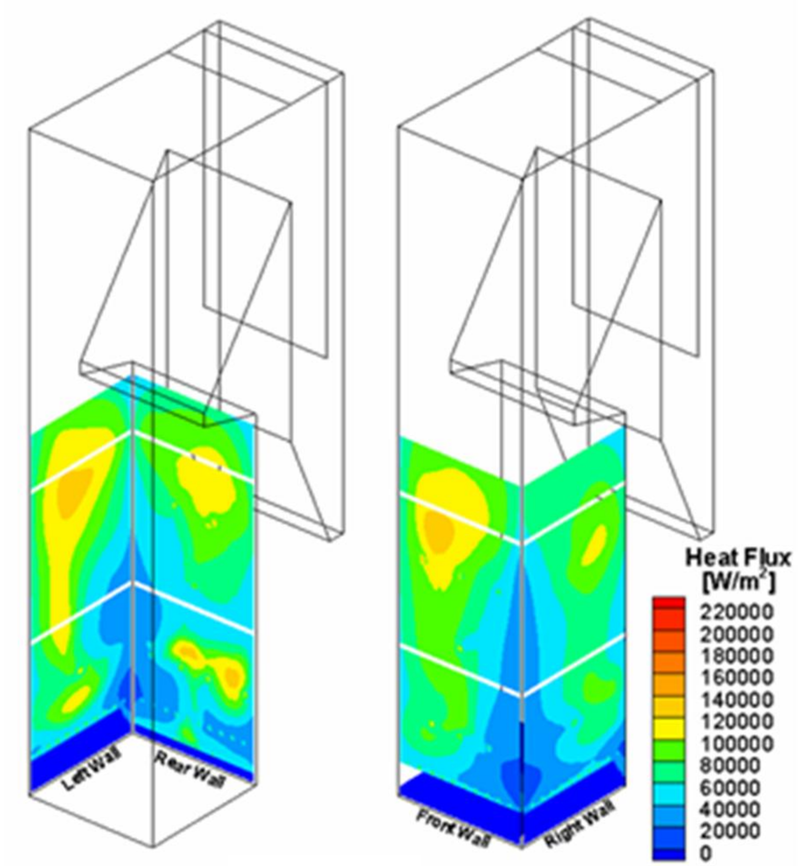
- Reduce rate of ash accumulation



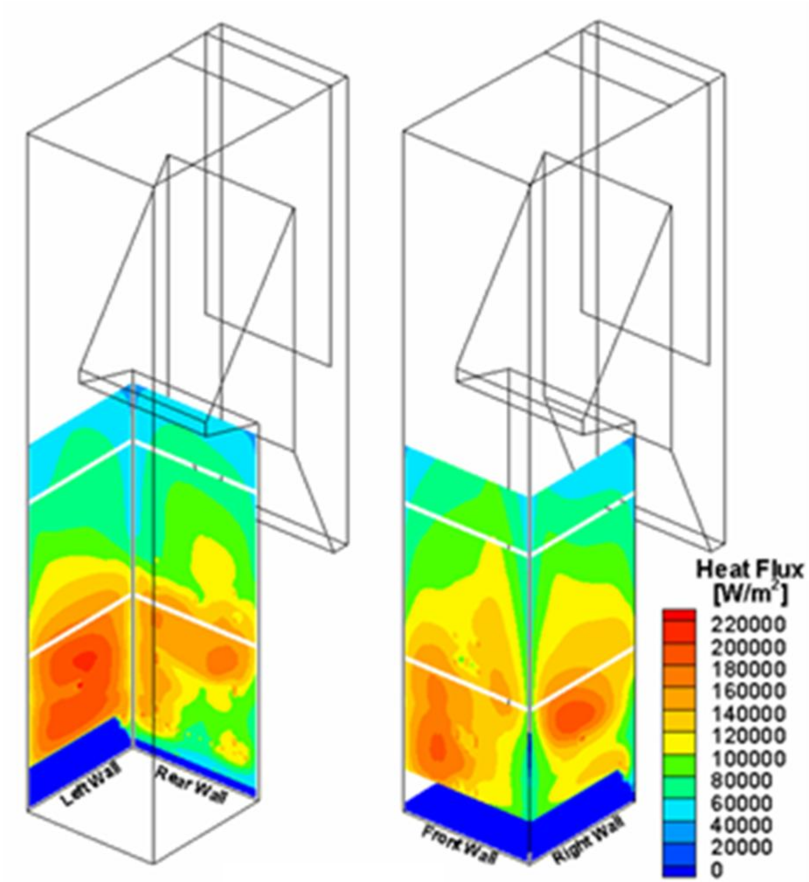


Requirements

- Increase heat release in lower furnace



Case 1



Case 10

Summary

- Increase rate of ash removal
  - ➔ Replaced 2 critical soot blowers with RS type
  - ➔ Installed CFEIII nozzles on 3 existing blowers
- Improve lower furnace operation
  - ➔ Increase heat release
  - ➔ Reduce 1RY air flow
  - ➔ Modify 2RY and 3RY air systems

- Boiler restarted August 2006
- 12% / 63% / 25% air splits
- Load increased to 320t/day*
- Runtime, 1wk → 3 months
- Eliminated burning oil
- Improved smelt flows
- Less operator intervention required

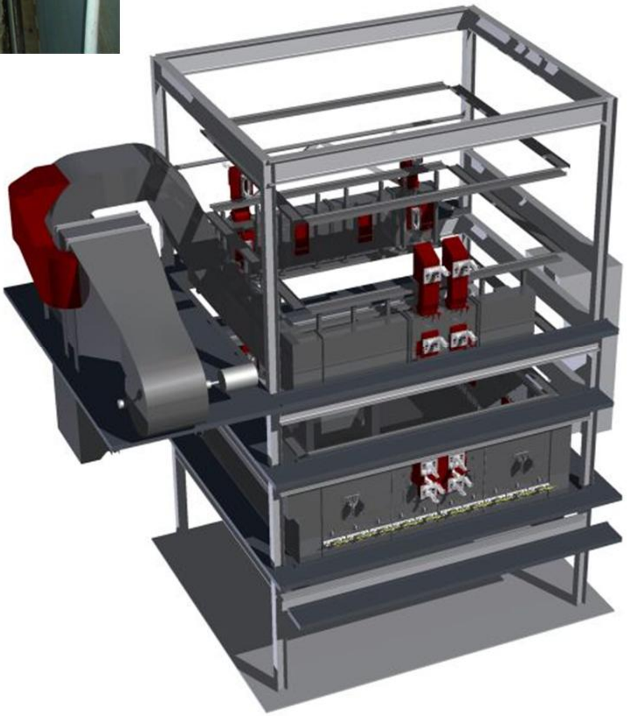
**bottle neck was digester*

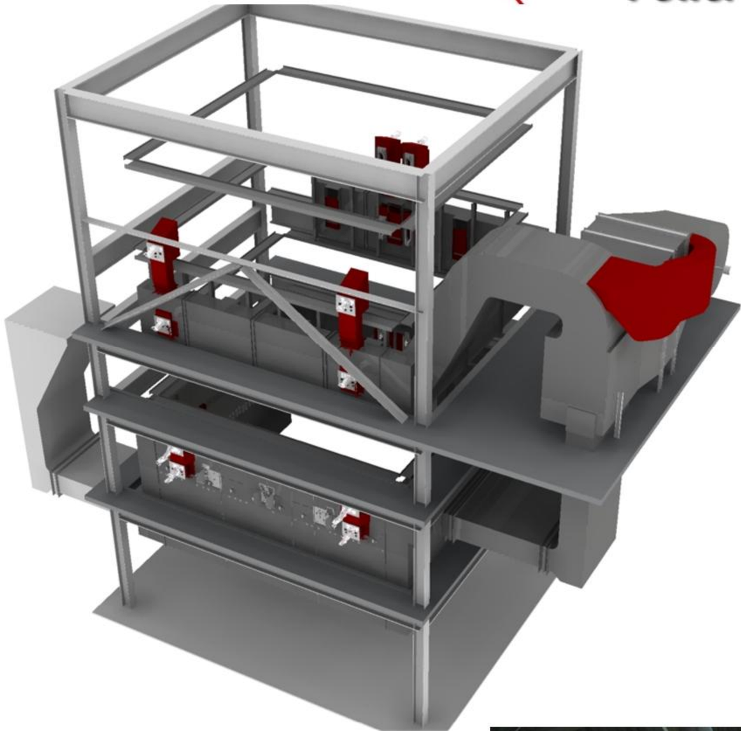
Case II – Emissions Reduction

- B&W Boiler- sloped floor
- Load: 1452tDS/d, 63%DS, 113C
- Steam Capacity 6531t/d
- Final Steam: 45bar(g)/404C

- 4xSplash Plates
- 4X, 4 wall 2RY
- 4x3, 2 wall 3RY
- Dedicated 1RY fan
- Single fan for 2RY & 3RY
- Heated 1RY, 2RY & 3RY (151C)

Combustion Air System





2RY Air Ports

3RY Airport

Results

	BEFORE	AFTER
Load (tDS/d)	1452	1452
Deposit Probe (g)	59	11
STACK TEST		
O2 (%)	4.9	5.0
CO (ppm)	19	<4.3
NOx (ppm)	85	74
SO2 (ppm)	**49**	**<1.8**
TRS (ppm)		<13

35% reduction in 1RY ports
2 levels 2RY & 3RY ports

Ambient 3RY air
4 beer can nozzles

Typical Range

Production increase	8 – 20%
Decrease soot blowing	10 – 50 %
Thermal efficiency increase	1 – 3 %
Chemical reduction increase	2 – 6 %
Reduction auxiliary fuel use	Up to 100%
Reduction in SOx	Up to 90%
Reduction in NOx	8 - 14%

Where to Find SAS?

- **> 35 Successful Installations**:
  - ➔ Japan (2)
  - ➔ Thailand*
  - ➔ Taiwan (2)
  - ➔ USA (16)
  - ➔ Brazil, Canada, Chile, Spain, Colombia*, Romania & France

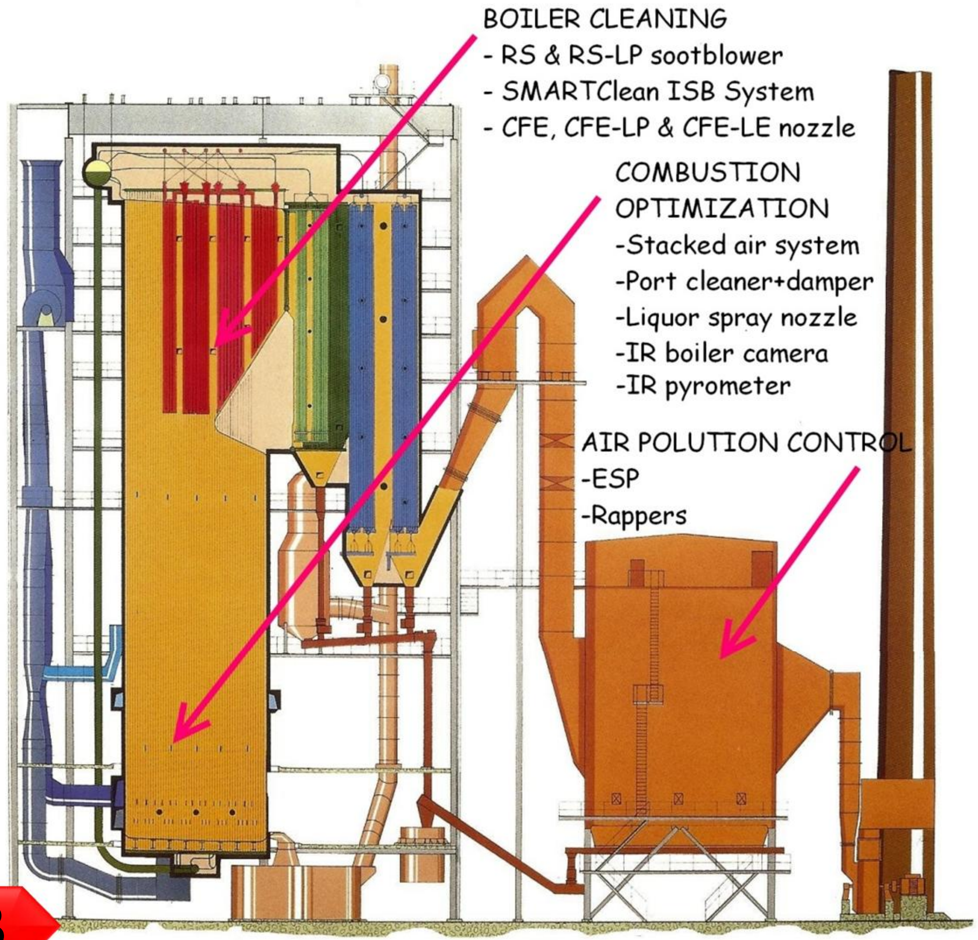
** Soda liquor*

CLYDE BERGEMANN Power Group

www.cbpgus.com

What are your Objectives?

- Increase runtime
- Increase load
- Lower emissions
- Increase efficiency
- Mitigate SH corrosion
- Reduce soot blowing steam



Complete Solution for Your RB

Finnish Recovery Boiler Committee

Markus Nieminen

Content

- Overview to recovery boiler committee
- Overview to finnish recovery boilers
- Incident statistics in Finland
- Incidents in Finland 2012
- Current projects

Overview to Finnish recovery boiler committee

Introduction

- The Finnish Recovery Boiler Committee (FRBC) has promoted safe, economic and environmentally friendly operation of recovery boilers and closely related processes since 1964.
- The Committee collects information about incidents involving recovery boilers and provides details of these to its members. The Committee publishes guidelines, recommends practices and arranges conferences and meetings. The Committee conducts and supports research projects related to safe operation and improved economy of recovery boilers.

Members

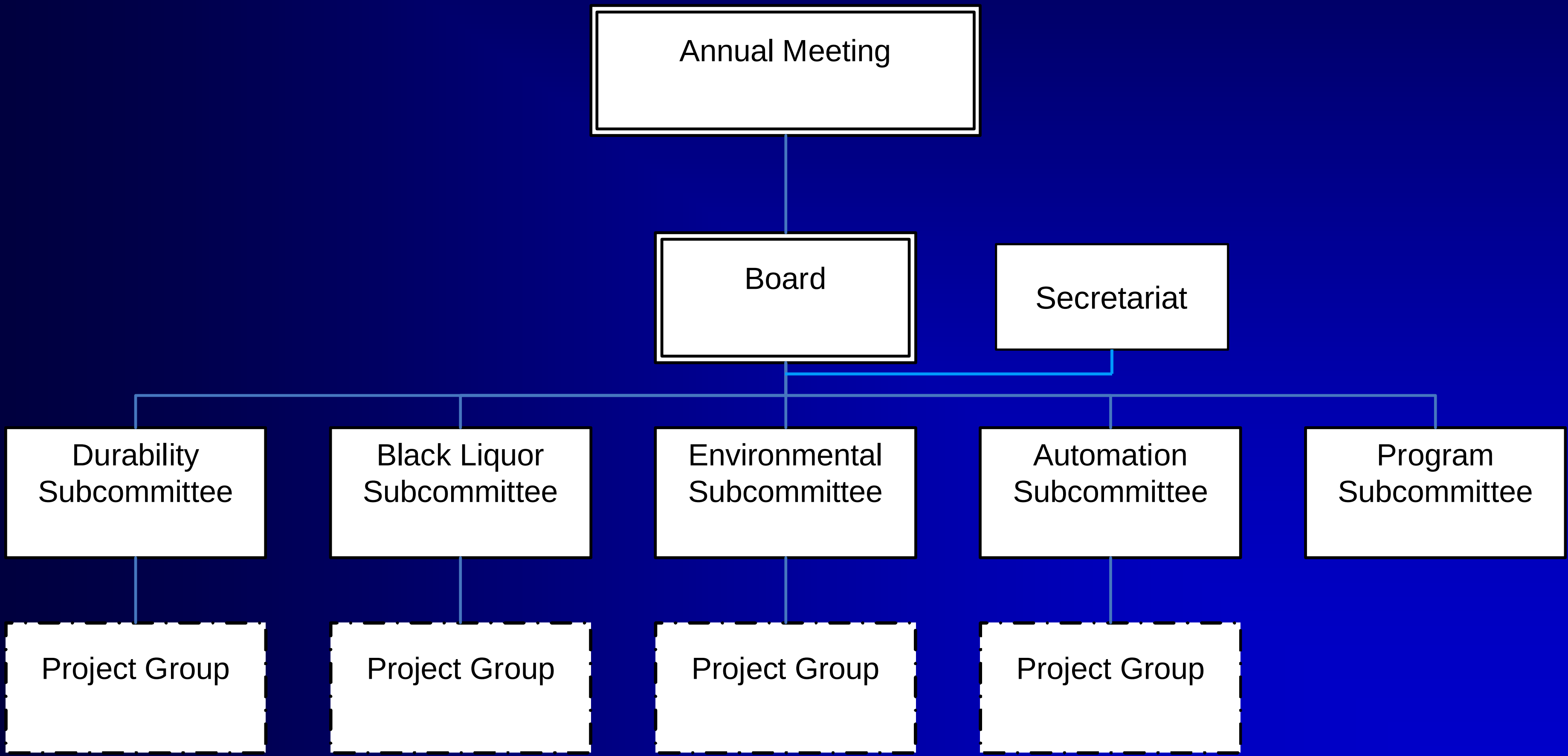
- The members of the Committee include pulp mills, recovery boiler manufacturers, a number of insurance companies, engineering companies, research organisations and universities in Finland.

- Total 27 members, including 15 pulp mills
- There is a yearly member fee

Decision making

- The highest decision-making body of the FRBC is the Annual General Meeting which appoints the Executive Board every year in April.
- The Executive Board controls the budget and supervises sub-committees projects
- There are five sub-committees
  - the Durability / ESP Sub-committee
  - the Black Liquor Sub-committee
  - the Environmental Sub-committee
  - the Automation Sub-committee
  - the Program Sub-committee

Organisation

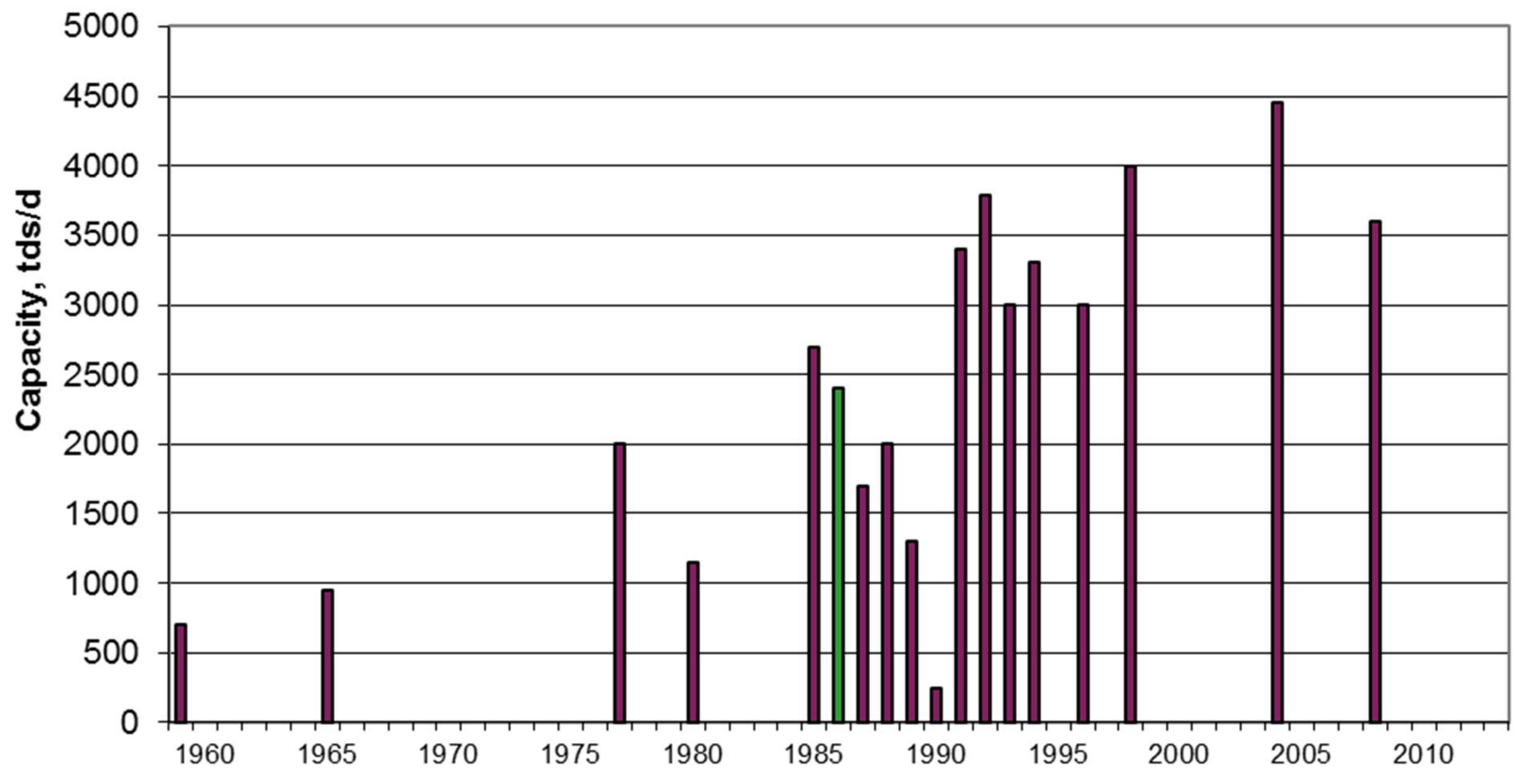


FRBC 50 years and ICRC 2014

- In 2014, FRBC celebrates its 50th anniversary
- International Chemical Recovery Conference (ICRC) will be held between 9.6. – 12.6.2014 in Tampere, Finland

Overview to finnish recovery boilers

Finnish Recovery Boilers



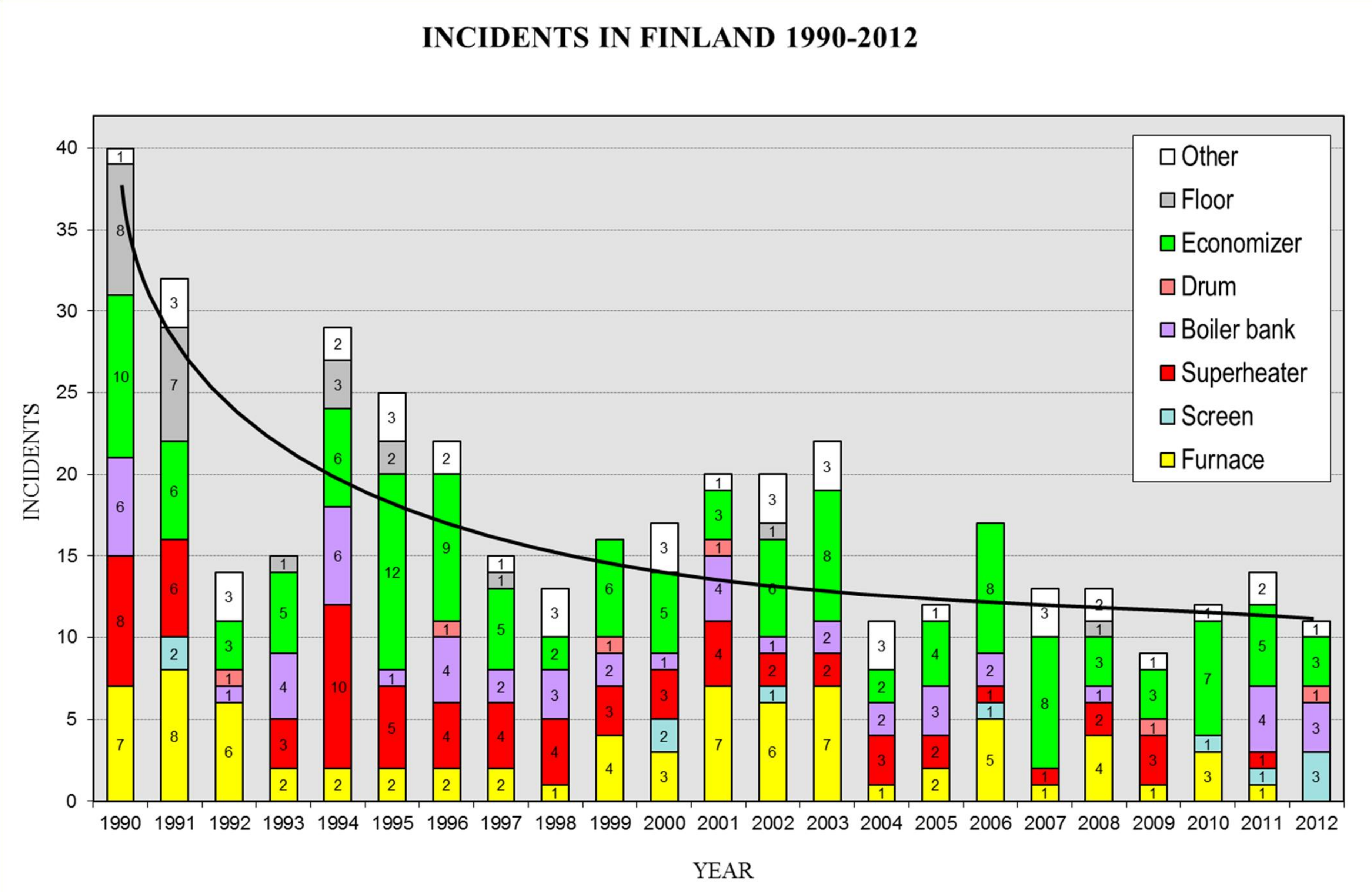
Finnish recovery boilers

• No. of recovery boilers	17 pcs
• Number of mills	15 pcs
• Average boiler age	24 yrs
• Capacity weighted age	19 yrs
• Average boiler size	2400 t ds/d

  – 2 mills operate more than one RB

Incidents statictics

SUOMEN SOODAKATTILAYHDISTYS
FINNISH RECOVERY BOILER COMMITTEE



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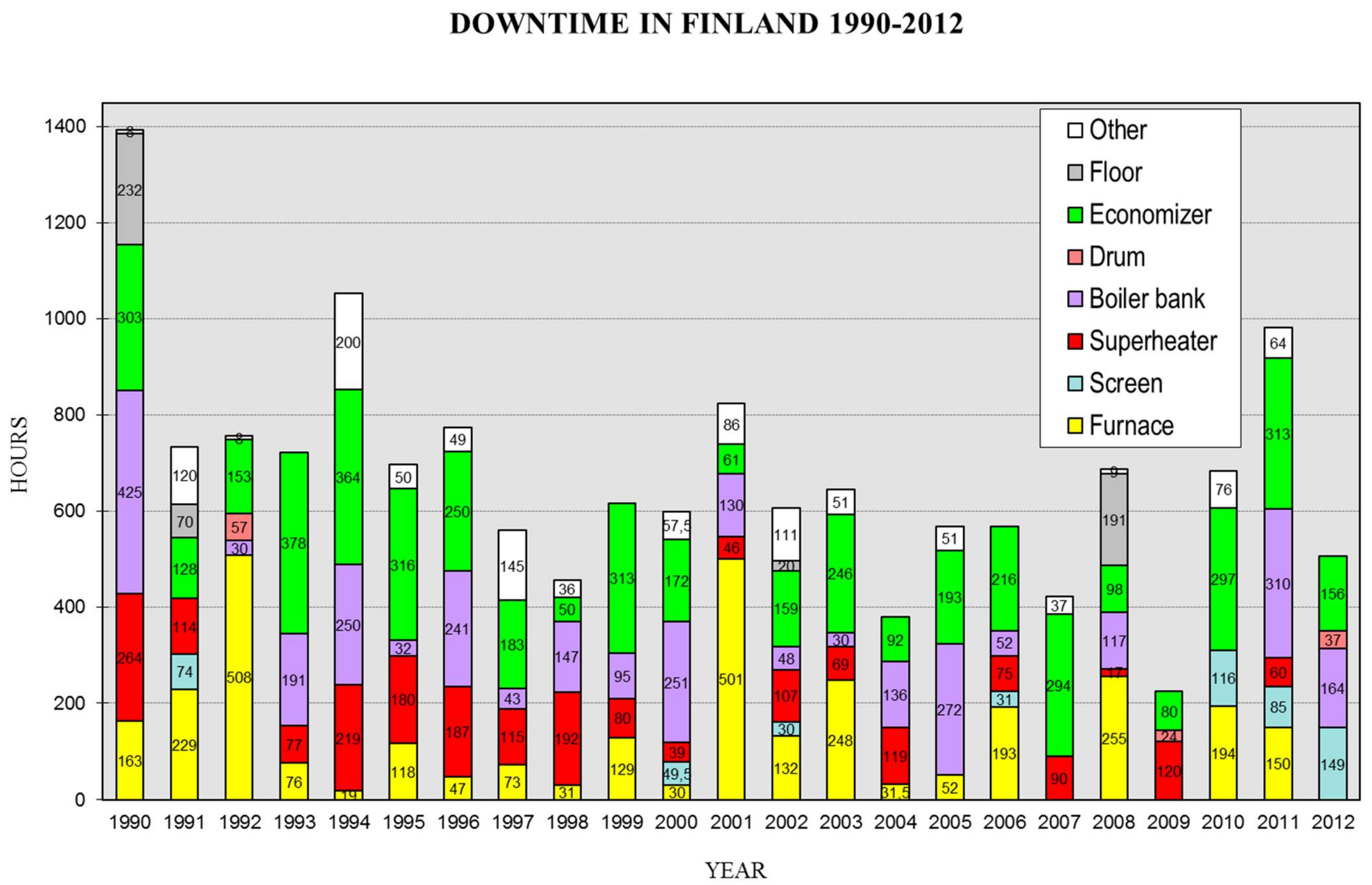
FINNISH RECOVERY BOILER COMMITTEE



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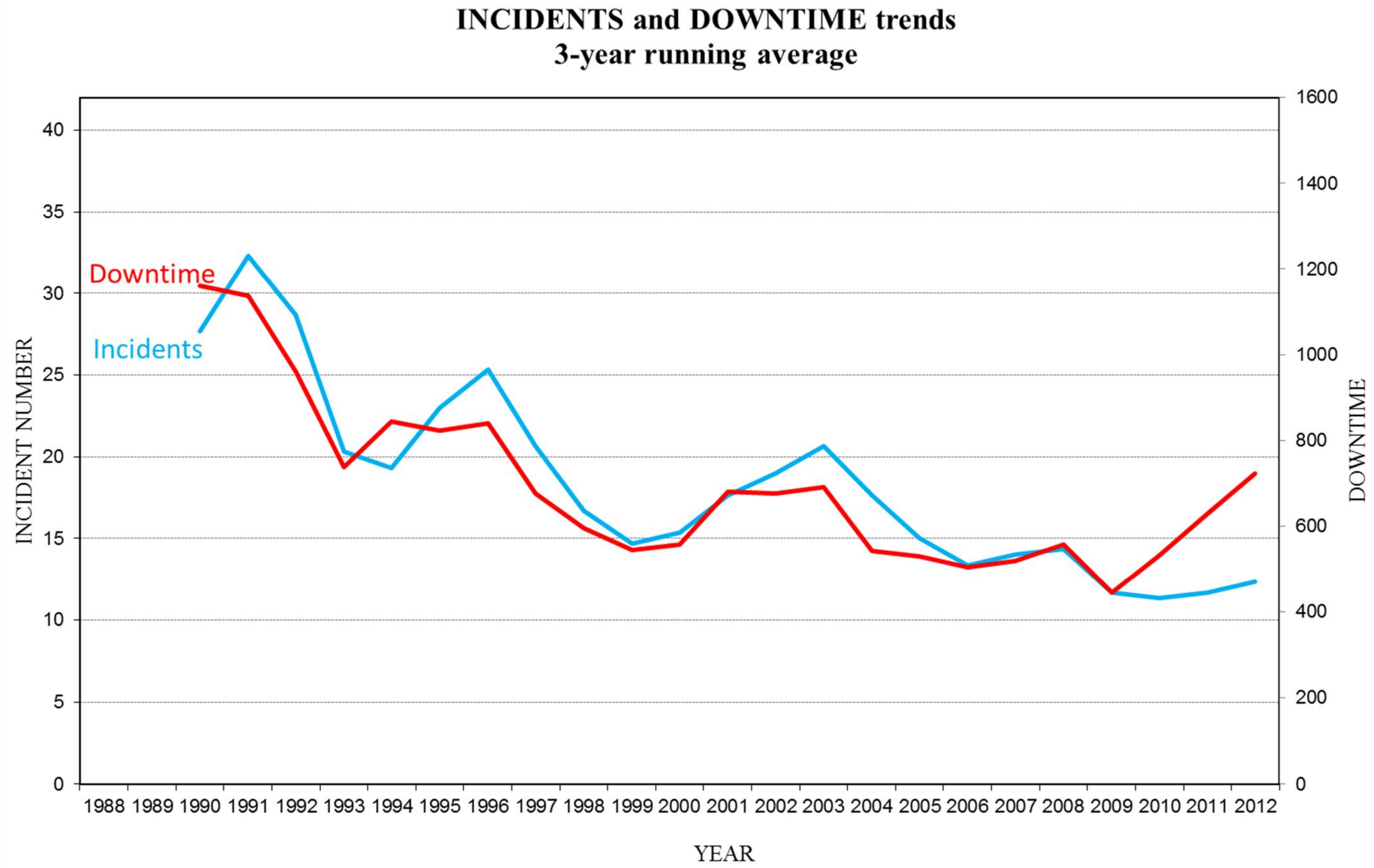
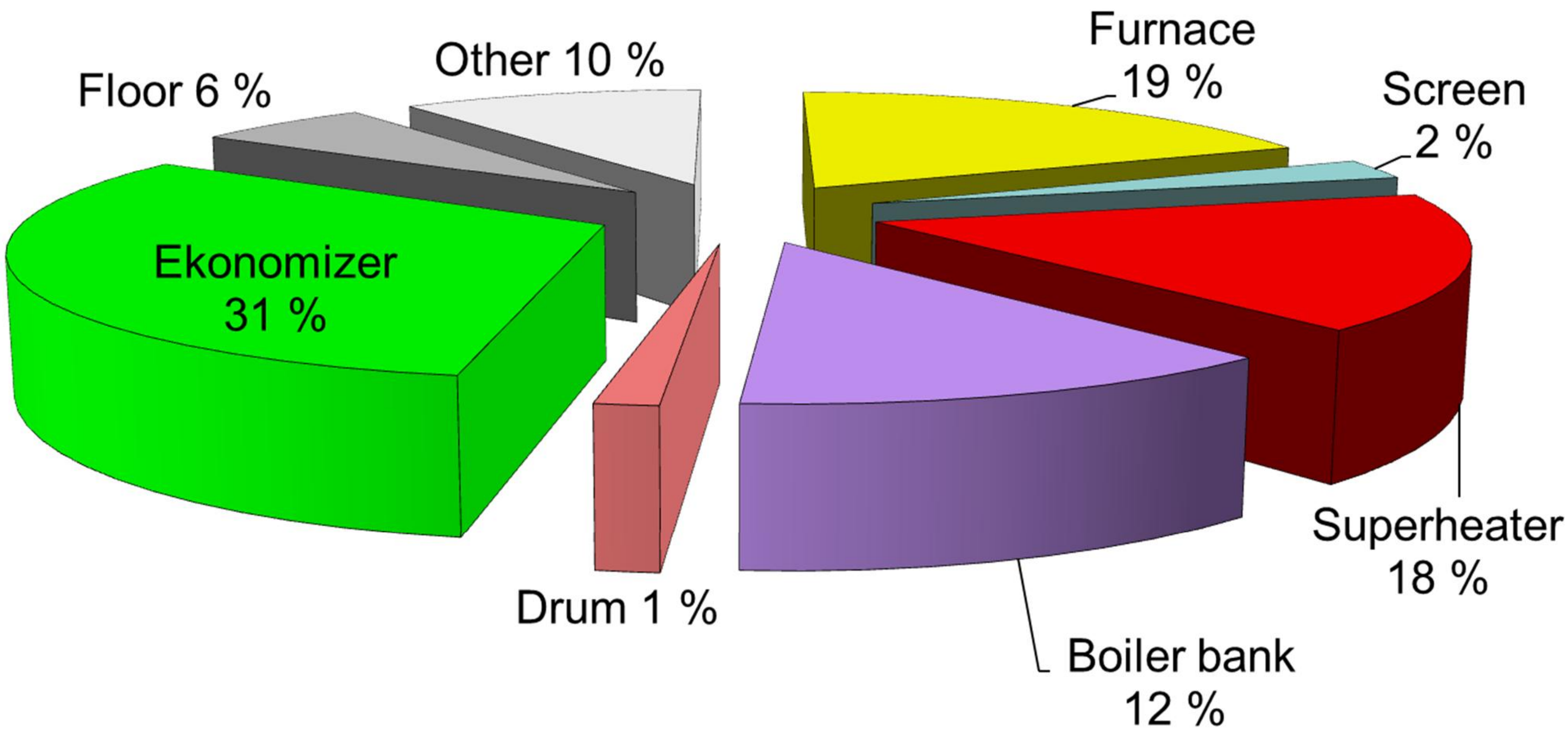


SUOMEN SOODAKATTILAYHDISTYS
FINNISH RECOVERY BOILER COMMITTEE

INCIDENTS PER AREA 1990-2012



Incidents 2012

Incidents reported 2012

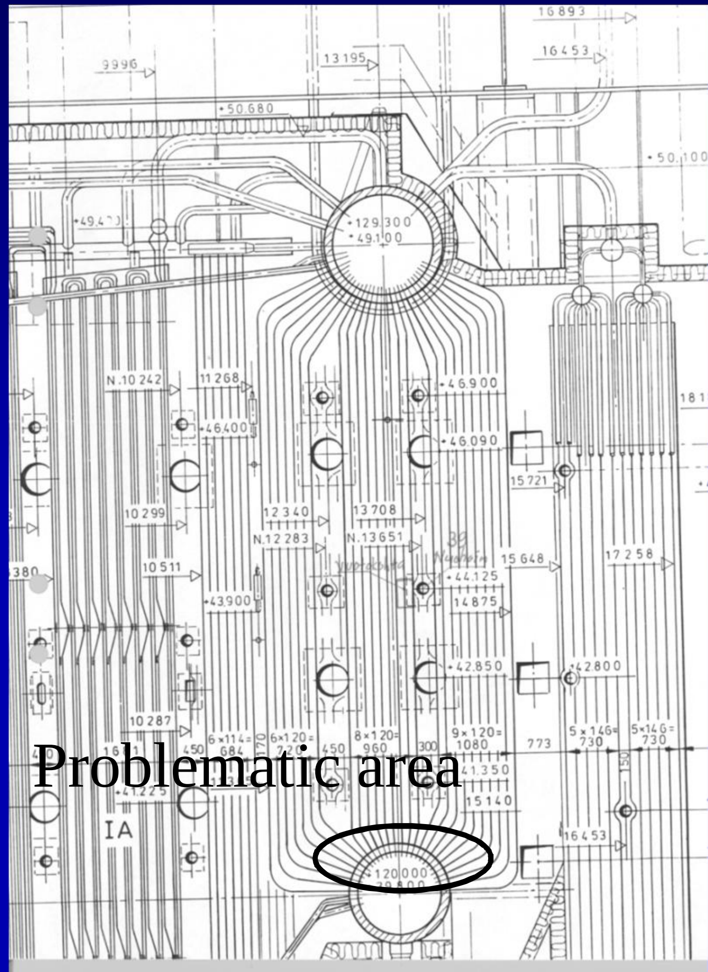
No	Incident headline	Down time	
12-1	Steam drum, manhole seal leak	37 h	
12-2	Boiler bank, tube thinning	24 h	Boiler B
12-3	Screen, tube leak	101 h	
12-4	Screen, tube leak	48 h	
12-5	Boiler bank, tube leak	70 h	Boiler A
12-6	Boiler bank, tube leak	70 h	Boiler A
12-7	Other, smelt spout shatter jets	24 h	
12-8	Economizer, tube leak	96 h	
12-9	Economizer, tube leak	26 h	
12-10	Screen, tube damage	0 h	
12-11	Economizer, tube leak	34 h	
	TOTAL	506 h	

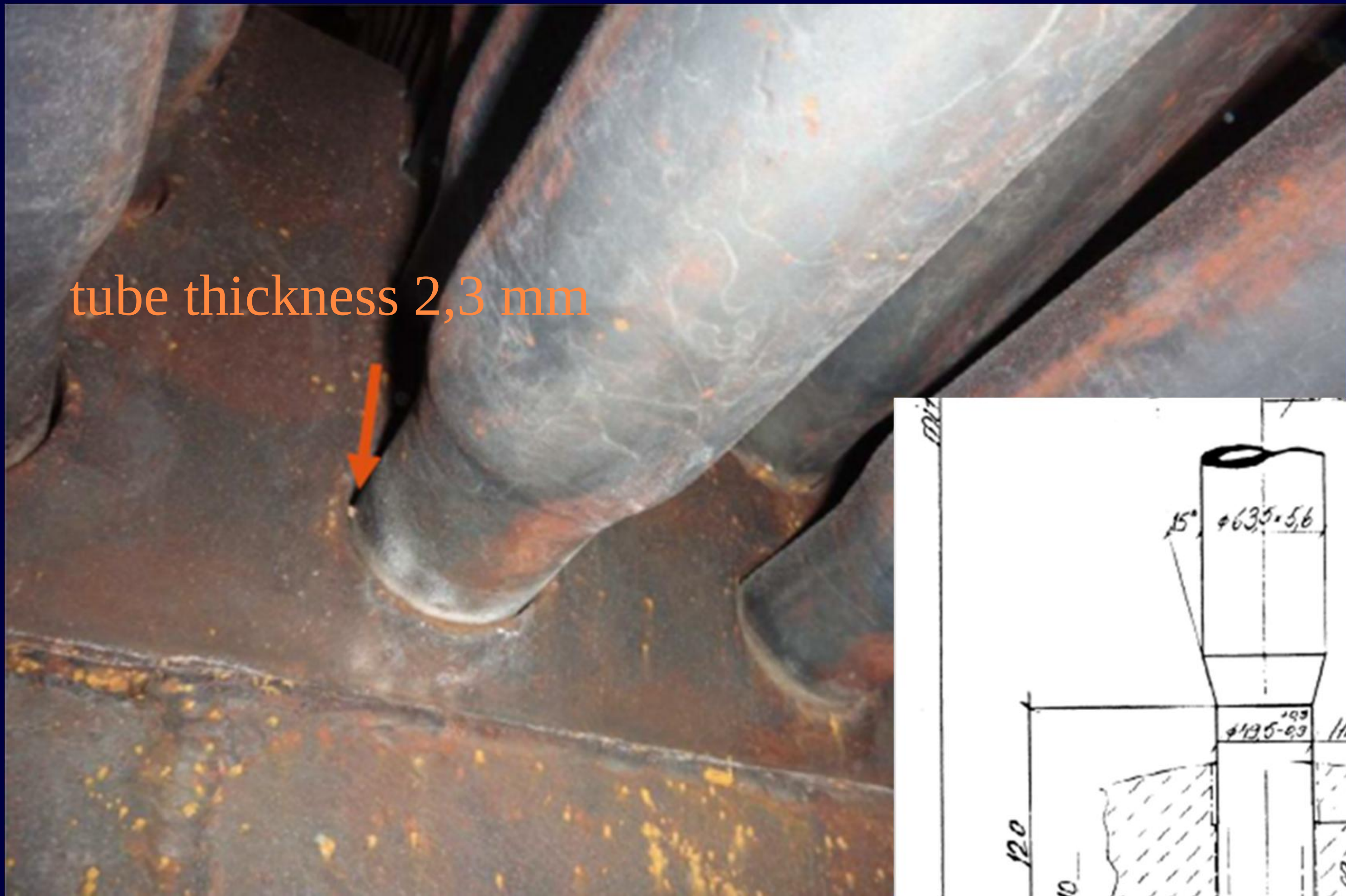
Boilerbank leaks (two drum boiler)

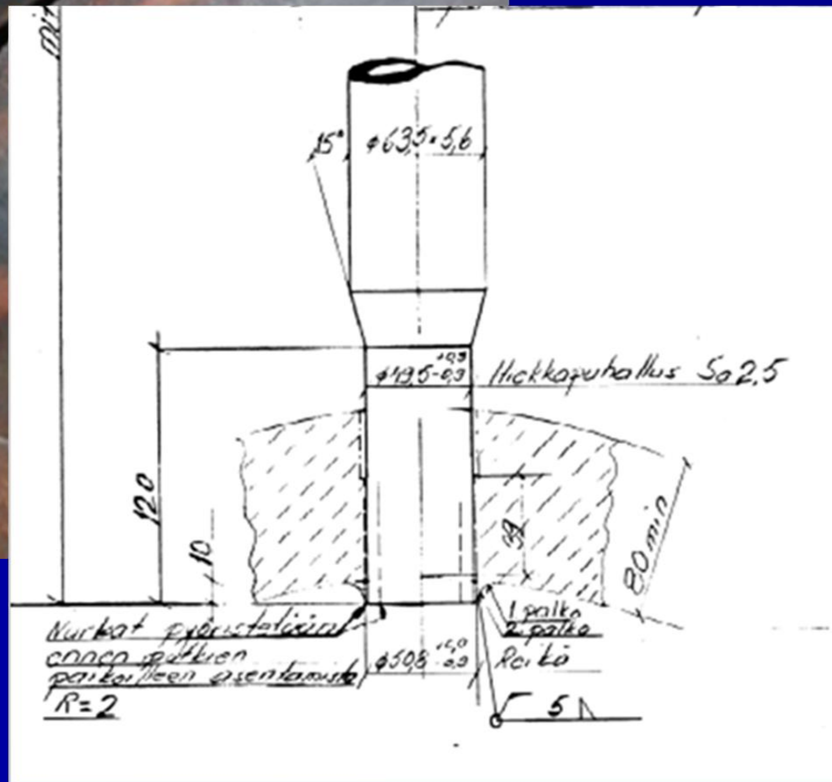
- Boiler A:
  - Two-drum recovery boiler from AA started 1987
  - 1700 tDS/d (3,7 MM lbs /day), 85 bar (1200 psig), 480 °C (900 °F)
  - Several unplanned shutdowns due to boiler bank tube leaks near lower drum during 2011-2012, total downtime about 450 hours
  - Leaks also 1990´s and 2000's (several hundred tubes repaired or plugged)
- Boiler B:
  - Same design and steam values, started 1985
  - 2700 tDS/d (6 MM lbs /day)
  - Extensive inspection during annual shutdown -> the thinnest were 2,3 mm
  - About boiler bank 100 tubes (3 mm or thinner) were plugged
  - In addition 120 tubes (which couldn't be measured) were plugged

Boilerbank leaks (two drum boiler)

- Near lower drum thinning
  - Most of the leaking tubes were in the center section of near lower drum
  - Sootblowing causes vibration especially to the center section of boiler bank -> vibration restraints
  - Tube plugging changes temperature profile -> increases movement
  - Deposits (acidic sulphates) accumulate on the drum interface

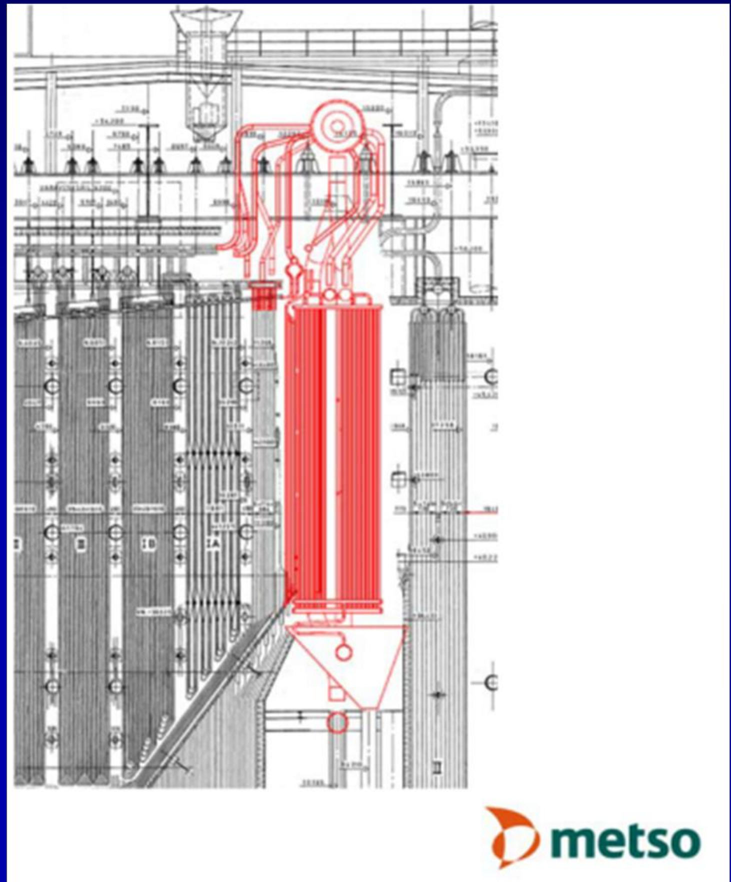



tube thickness 2,3 mm


15°
ϕ63,5×5,6
Hiekkapuhallus Sa 2,5
120
10
80 min
R=2
5

Boilerbank leaks (two drum boiler)

- Single-drum conversion
  - Boiler A autumn 2012 by Metso
  - Totally 5 weeks shutdown
  - For boiler B the conversion is under planning
  - In Finland 2 more boilers have same kind of boiler bank structure



Projects

Current projects

- Updating: recommended procedure for incineration of non-condensible gases
- Recommendation for recovery boiler UPS systems
- Ammonia recovery from stripper gases
- Reduction of TOC from recovery boiler make-up water

SUOMEN SOODAKATTILAYHDISTYS
FINNISH RECOVERY BOILER COMMITTEE

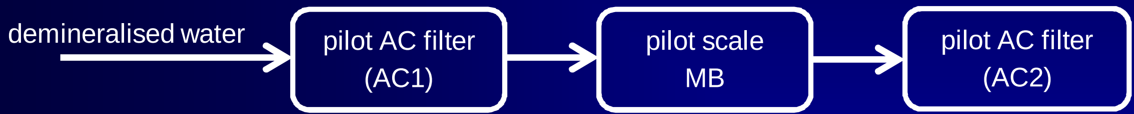
Project background

- Decomposition products of organic compounds, mainly organic acids with carbon dioxide, are related to recovery boiler waterside corrosion
  - Especially air preheaters made from carbon steel
- Organic acids cause pH to drop -> Accelated dissolution of magnetite
- Organic compounds in the make-up water originate from:
  - raw water (mainly natural organic matter, NOM)
  - organic internal water treatment chemicals
  - impurities (lubricants, degraded ion exchange resins etc.)

TOC reduction project

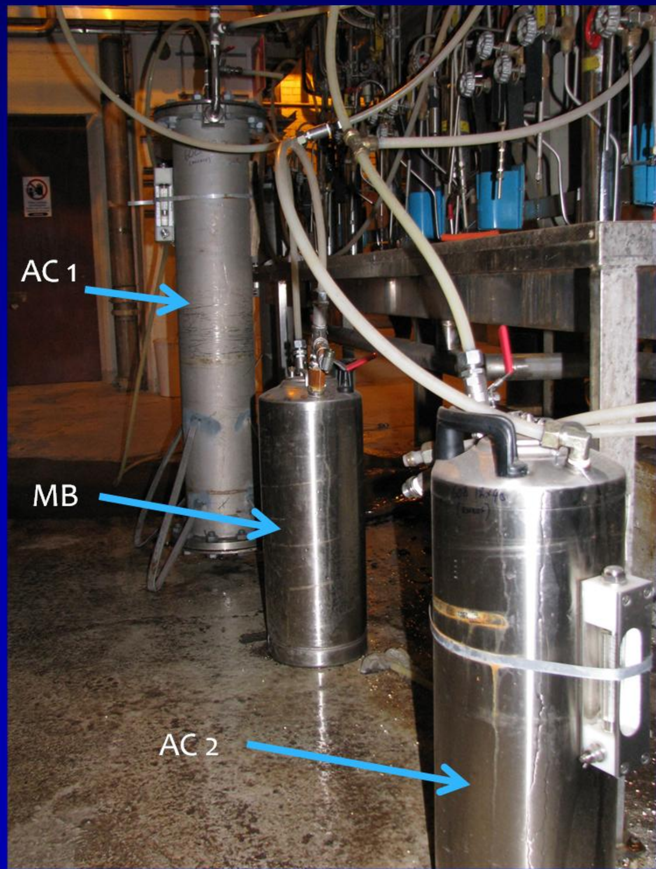
- Ways to prevent air preheater corrosion:
  - Stainless steel preheaters
  - Improve the effectiveness of make-up water treatment (reverse osmosis, active carbon, UV)
  - Change raw water source from surface water to groundwater
- TOC removal field tests
  - Active carbon in pilot and full scale

Active carbon: Field test



Test scheme of pilot scale AC filters.

Test scheme of full scale AC filters.



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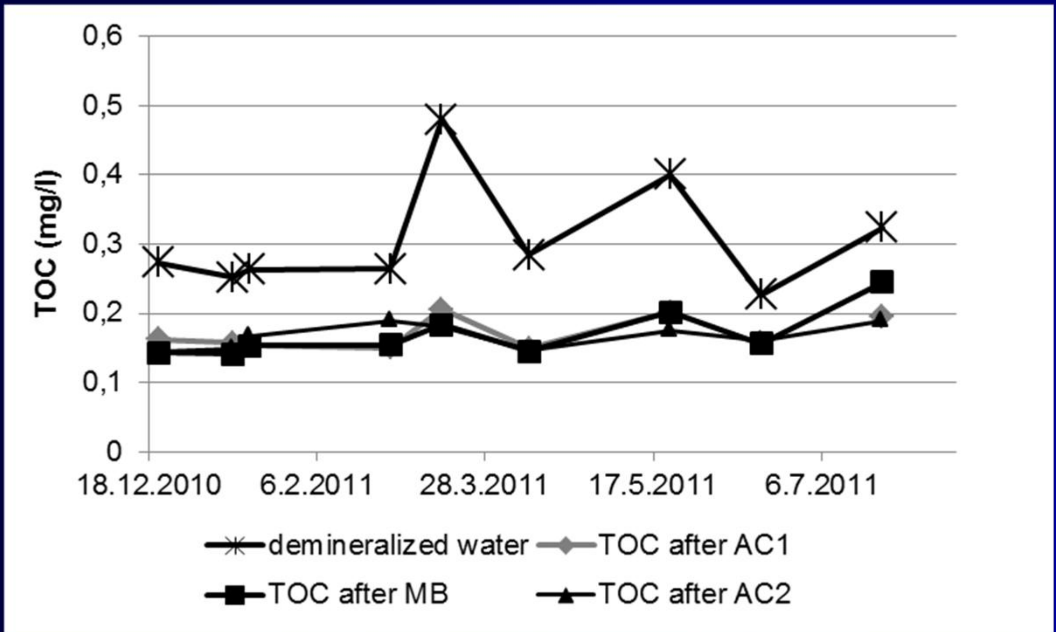
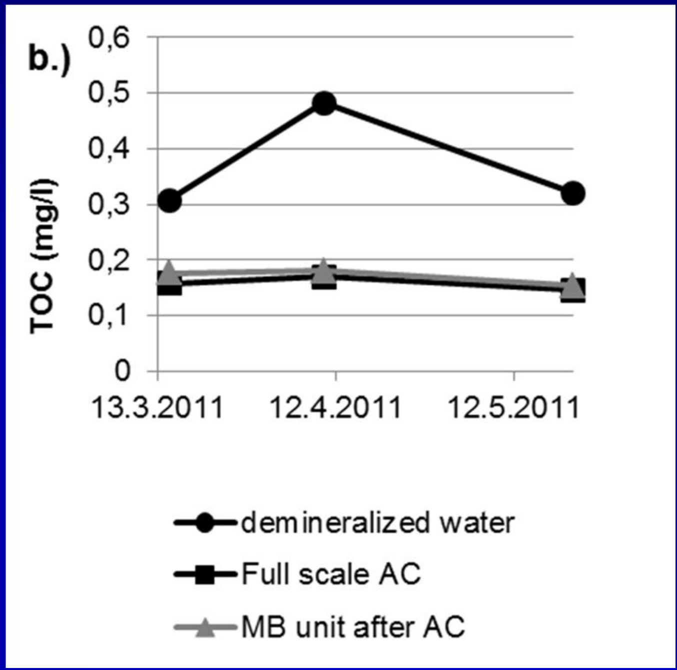
Active carbon: TOC reductions

Pilot scale AC filters



Residual TOC removal 38 – 57 %

Full scale AC filters



Residual TOC removal 40 – 65 %

Conclusions AC

- Active carbon can remove up to 40 - 60 % of residual organic material (TOC)
- AC bed lifetime before regeneration is at least 10 months -> pilot scale test
- Non-acid washed was as effective as acid washed active carbon
- Subsequent MB is needed to remove elevated conductivity and silica
- AC works fine in full scale

Thank you!

Annual Report from the Swedish-Norwegian Recovery Boiler Committee, 2012

Urban Andersson, ÅF
Secretary of the Swedish-Norwegian Recovery Boiler Committee

Sodahuskommittén
The Swedish Norwegian Recovery Boiler Committee

Activity during the year

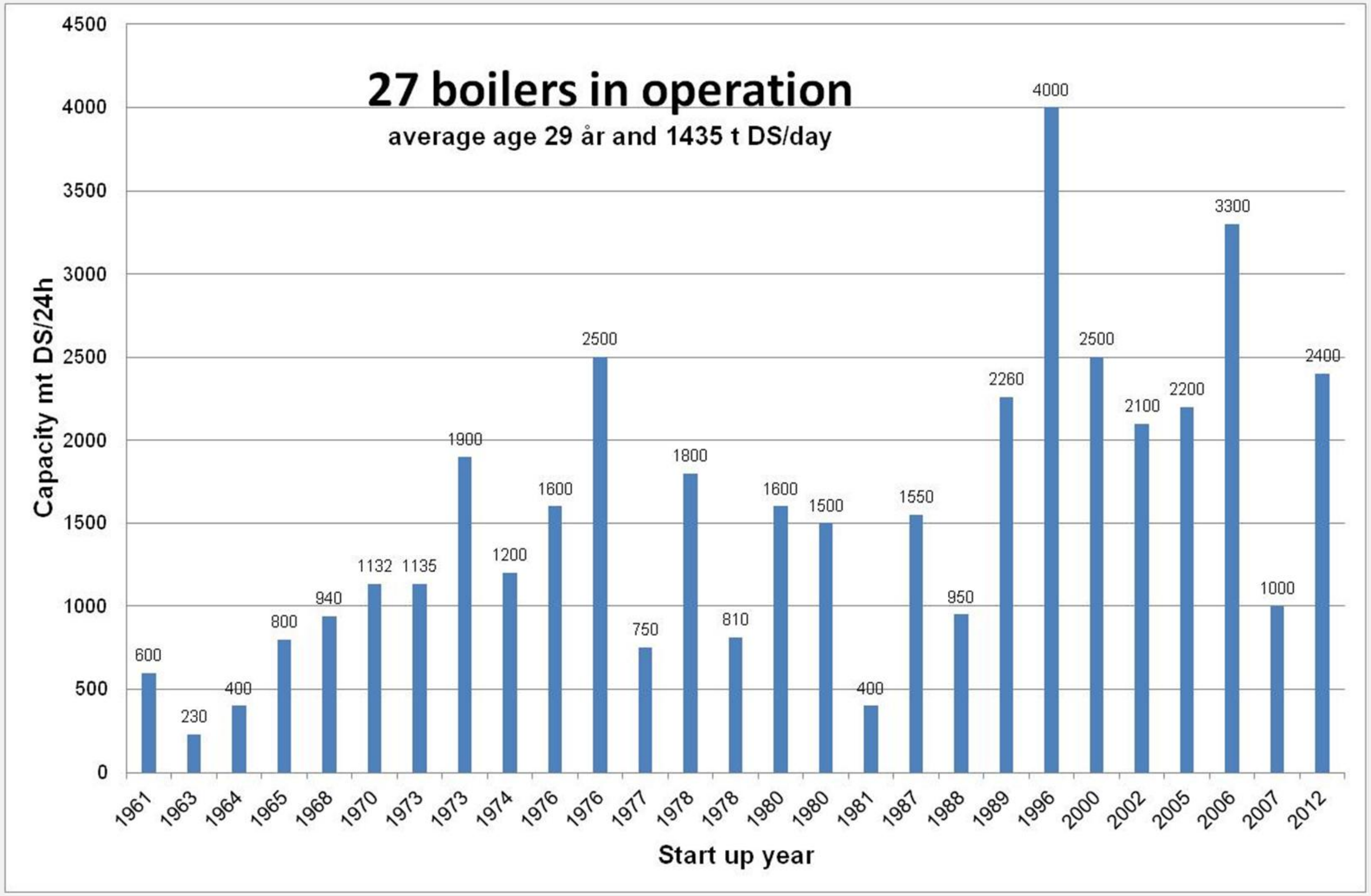
- Organization and Board
- Recovery boilers in Sweden and Norway
- Recovery Boiler Committee 3 years program
- New recommendations
- Injury trends
- Education
- Recovery boiler meeting
- SNRBC internationally

Organization / board

The Board of the SNRBC
Chairman: Per Utterström, Korsnäs Gävle
Secretary: Urban Andersson, ÅF
18 members (13 voting)

- **Recommendations Subcommittee**
  Secretary: Lars Andersson, ÅF
  3 members
- **Incidents Subcommittee**
  Secretary: David Good, ÅF
  11 members
- **Edjucation Subcommittee**
  Björn Lundgren, Billerud Gruvön
  7 members

The boiler park in Sweden and Norway



SNRBC 3 years program 2010-2012

Theme year 1. Chemical cleaning of recovery boilers on the water side.
The final report is accept.

Theme year 2. Problems and issues related to control and secure power supply. Work will continue in 2013.

Theme year 3. Combustion and melt handling. A day for operators and factory people to exchange experiences and discuss safety issues have been arranged. A report from this meeting summarizing ideas and proposals is in progress..

Recommendations

A - Technical definitions

B - Construction and equipment

C - Operation and disturbances

D - Inspection and maintenance

E - Training of staff

F - Safety conditions

Recommendations

During the year the following recommendations approved

No new approved so far this year

Recommendations

The following recommendations are circulated for comments

B6/B7: Revision and merging B6 and B7. (The reason for this is that B6 and B7 overlap and therefore it is better if it is only one recommendation).

B6: Recommendations for disaster protection and float switches for recovery boilers

B7: Recommendation on the design and supervision of the equipment for remote monitoring of water levels in recovery boilers (new title for the combined recommendations is not ready)

Recommendations

Audit of the following recommendations are in progress

B1: Recommendations regarding recovery boilers construction and equipment

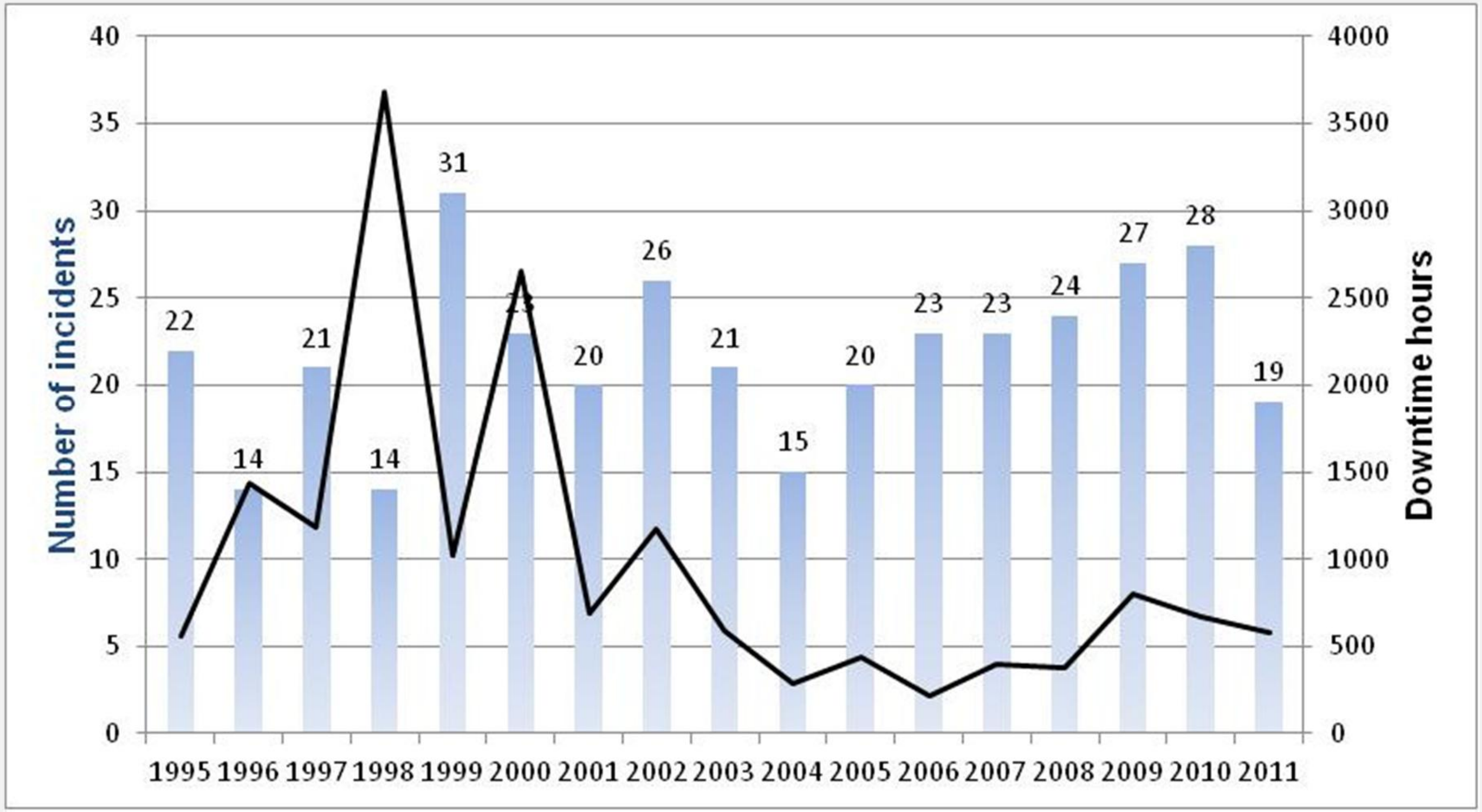
B17: Recommendations concerning the design and operation of liquor evaporation – soda house

D1: Instruction regarding water washing of recovery boilers gas side (based on the approved report)

B16: Guidelines concerning equipment for disposal-firing in the recovery boiler (continued revision due to the incident in Värö)

Incidenter

19 incidenter rapporterades under 2011



Sodahuskommittén

The Swedish Norwegian Recovery Boiler Committee

Education in change

- From start has over 800 operators been trained
- In 2011, 12 people were certified
- 2012 participates 14 people in training for certificate

Education in change

- The first part of the training will be a base for all certification in chemical recovery
- "Sulphate Factory basics" are reviewed
- The topic “energy efficiency” is introduced
- Increased training in control and regulation technology
- Lesson time is increased from 108 hours to 120 hours
- Project work comprising 10 to 20 working days are introduced
- The regular factory supervisors will be mentors for the entire course

Recovery boiler meeting

This year's recovery boiler meeting was held at the Smurfit Kappa Kraftliner Piteå May 8

Projects: Soda Boiler Conversion, iron bar robot and soot blowing control.

Study visit at Chemrec in Piteå

SNRBC Internationally

- Exchange of information with its Finnish counterpart in Helsinki
- The activities has also been reported to AF & PA's recovery boiler comity in Atlanta
- The Swedish Norwegian Recovery Boiler Comity is also represented in European standardization body CEN boiler via SIS.

International cooperation in standardization area

SNRBC is involved in writing the common standard for the manufacture of boilers for use in the European Union.

The standard is called EN 12952, Water Tube Boilers, and includes a chapter on recovery boilers.
The working group issued last year a proposal for a revised edition of the equipment standard, Part 7 Equipment, which is out on the ballot.

The working group processes presently the revision of the general part.

Our representative in CEN working groups WG1 and WG3 and the SIS sister committee TK285 is Fredrik Bruno.

Thank you for your attention