2017

AF&PA
RECOVERY BOILER PROGRAM
ANNUAL CONFERENCE

FEBRUARY 8, 2017
ATLANTA, GEORGIA

American
Forest & Paper
Association

American Forest & Paper Association
Recovery Boiler Committee

AMERICAN FOREST &
PAPER ASSOCIATION

2017
AF&PA RECOVERY BOILER PROGRAM
ANNUAL CONFERENCE
ATLANTA, GEORGIA

Atlanta Airport Marriott Hotel
Florida & Tennessee Rooms

AGENDA

Wednesday, February 8, 2017

7:00 am	Continental Breakfast
8:00 am	General Assembly – Chairman's Report & Review of the AF&PA Antitrust Policy - Karl Morency - Georgia-Pacific LLC
8:10 am	Research & Development Subcommittee Report - Christopher Verrill – International Paper Company
8:20 am	Operation & Maintenance Subcommittee Report - Donald Flach – Georgia-Pacific LLC
8:30 am	Report on BLRBAC Activities - Dean Clay – Boiler Services & Inspection, LLC
8:40 am	Effects of Added Materials on Black Liquors Combustion - Honghi Tran – University of Toronto
9:20 am	HALT – Hopper Ash Level Thermocouple System - Tim Carlier - Integrated Test & Measurement (ITM)
9:55 am	Coffee Break
10:10 am	LeakAlert Recovery Boiler Leak Indication System - Pat Terfloth - Solenis Canada ULC
10:30 am	TAPPI Energy, Recovery & Recaust Committee Report - H. Bentley Sherlock – Georgia-Pacific LLC
10:45 am	Recovery Boiler Inspection Strategy - Sandy Sharp - SharpConsultant

Wednesday, February 8, 2017 (continued)

11:25 am BLRBAC ESP Subcommittee – 2016 Incidents ESP Report
- Dean Clay – Boiler Services & Inspection, LLC

11:40 am Modeling Sootblower Jets and How They Interact with Tube Geometries.
- Markus Bussmann – University of Toronto

12:00 pm Luncheon

1:00 pm Safe-Lok Burner System
- Greg Imig - Andritz, Inc.

1:30 pm Cast Sootblower Sleeves
- Greg Imig - Andritz, Inc.

2:00 pm GL Dissolving Tank Control to Reduce Risk of Smelt Dissolving Tank Explosions
- Thanh Trung - FITNIR Analyzers Inc.

2:40 pm Coffee Break

2:55 pm Disposing of Secondary Sludge (bio-sludge) in the Recovery Boiler
- Raymond Burelle - Valmet, Ltd.

3:25 pm Recovery Line Optimization: System Benefits and Interactions
- Jeff Butler - Valmet Automation
  - Presented by: Clark Conley – Valmet, Inc.

3:55 pm Recovery Boiler ESP Power Supplies and Performance Improvements
- John Knapik - Babcock & Wilcox

4:25 pm Canadian BLRBAC
- Pat Terfloth - Solenis Canada ULC

4:35 pm Reports from Swedish-Norwegian and Finnish Recovery Boiler Committees
- Kajsa Fougher - AF, Forest Industry & Markus Nieminen – Poyry
  - Presented by: Dean Clay – Boiler Services & Inspection, LLC

5:00 pm Closing Remarks

5:10 pm Adjournment

AF&PA – Recovery Boiler Program
Attn: Wayne Grilliot
C/O: APEC, LLC
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BLRBAC

Report on 2016

Dean Clay for AF&PA Recovery Boiler Annual Conference

BLRBAC Basics

Black Liquor Recovery Boiler Advisory Committee

- Objective - promote improved safety of recovery boilers through the interchange of knowledge, experience and data.
- Meetings in April and October in Atlanta
  - **next meeting April 10 – 12, 2017, notice sent via email**
  - Be sure to check the dates of the next meeting
  - October 2 – 4, 2017, **55th Anniversary** Meeting
    - Reduced registration fee of $55 for all first time attendees and all operators.
- Members from recovery boiler: operating, manufacturing and insuring companies.
  - Only Members can vote
  - Also associate members with direct interest
- Note – BLRBAC is now incorporated.

2018 BLRBAC Meeting Dates

- 2018 Spring meeting April 9 – 11.
- 2018 Fall October 22 - 24 – a shift of approximately three weeks.
- The Fall 2016 meeting was held 3 weeks later than it has historically been held.
  - Record overall attendance, including > 50% increase in the number of operators.
  - Next opportunity to shift Fall meeting dates, due to hotel commitments, won't be until 2018.

BLRBAC Internet Site

- blrbac.org
- Guidelines and questionnaires
  - Latest versions
  - Draft revisions for review
    - Interested persons are urged to review and provide comments, before the revisions are voted on for approval.
- Articles of Association & Operating Procedures
- Meeting registration forms and information
- Meeting minutes, current and past (to 2006)
- RBs in Service, U.S., Canada
  - Help keep the lists up to date, name changes, closures

BLRBAC Internet Site, Current Guidelines

- Emergency Shutdown Procedure (Dated: October 2012)
- Safe Firing of Black Liquor in Black Liquor Recovery Boilers (Dated: April 2016)
- Materials & Welding Guidelines (Dated: April 2013)
- Safe Firing of Auxiliary Fuel in Black Liquor Recovery Boilers (Dated: February 2012)
- Fire Protection in Direct Contact Evaporators and Associated Equipment (Dated: February 2012)
- Personnel Safety & Training (Dated: February 2012)
- Application of Rotork Actuators on Black Liquor Recovery Boilers (Dated: October 2005)
- Post ESP Water Level (Dated: January 2005)
- Post ESP Guidelines (Dated: October 2002)
- Boiler Water Management Guidelines for Black Liquor Recovery Boilers (Dated: April 2016)
- Instrumentation Checklist and Classification Guide for Instruments and Control Systems Used in the Operation of Black Liquor Recovery Boilers (Dated: April 2014)
- Thermal Oxidation of Waste Streams in Black Liquor Recovery Boilers (Dated: April 2016)

BLRBAC Updated Guideline Example

- Safe Firing of Black Liquor in Black Liquor Recovery Boilers (Dated: April 2016) **CHANGES are listed at the start of the document**

- **Chapter 2 Definitions: Revised definition of "Managed System"**
  - **A documented procedure which includes a checklist of critical manual valves or devices that is completed by the operator prior to start-up and as needed throughout the operation. The checklist shall identify each valve or device and the proper position, condition or state. Any deviation from the checklist shall be controlled and documented through a jumper policy.**

- **Chapter 4.10 Refractometer Calibration:**
  - **Revised wording of refractometer calibration and refractometer standardization as presented from the Instrumentation Subcommittee on 10/6/2014. More details were provided on standardization procedure.**

- **Chapter 13 Item 9. Steam/water mixture for cooling liquor guns.**
  - **Revised wording to allow steam/water mixture to cool liquor guns as long as proper use of alarms and interlocks are in place to prevent excessive use of water that could enter the furnace.**

BLRBAC Internet Site, Documents for Review and Comments

- Personnel Safety - April 2015 Draft
- Recommended Good Practice Fire Protection in Direct Contact Evaporators and Associated Equipment - August 2015 Draft

BLRBAC Executive Committee

(*per October 2016 Meeting Election, no changes)

- ***Chairman – John Gray, Rayonier**
- ***** **Vice Chairman – Dave Slagel, International Paper**
- ***** **Operator Rep. – David von Oepen, WestRock**
- ***** **Insurance Rep. – Jim Onstead, FM Global**
- ***** **Boiler Rep. – John Phillips, Andritz**
- **Treasurer – Len Olavessen, LENRO, Inc.**
- **Secretary – Everett Hume, FM Global**

BLRBAC Subcommittees (10)

- ESP (Emergency Shutdown Procedure)
- Safe Firing of Black Liquor
- Safe Firing of Auxiliary Fuel
- Personnel Safety
- Instrumentation
- Waste Streams
- Fire Protection in Direct Contact Evaporator
- Materials & Welding
- Water Treatment
- Publicity & News

Registration

- Barbara Holich, BLRBAC Secretarial Services
- $125 Advance; $200 @ Door
  - no change in cost
  - for @ Door payment credit/debit cards are accepted.
  - Working towards online advance meeting registration using credit cards – NOT ready yet, goal is to accept for Fall 2017, check meeting notice (sent via email, or on website).
- Crowne Plaza Hotel, Atlanta Airport
  - Free shuttle to and from airport/MARTA

- Spring 2016, 190 advance, 52 @ door registrations
- Fall 2016, 210 advance, 53 @ door registrations

How to Participate in a BLRBAC Meeting

- Check the schedule for Open Subcommittee meetings, on Monday
  - Closed meeting are for subcommittee members only, to allow focus on assigned tasks.
  - Open meetings can be found in both the morning and afternoon.
- Attend an open meeting that interests you
  - Review the posted subcommittee agenda (available in the meeting schedule in the advance registration materials), and minutes from the previous meeting on the website
  - Usually they will also accept visitor questions on their guidelines, or related topics.

Participating in BLRBAC – cont'd

Examples from the Spring 2017 Meeting Registration Materials, Monday Meeting Schedule

- **1:00 pm--4:00 pm Instrumentation Subcommittee - (OPEN)**
  - Follow-up to morning session
  - Open floor session
    - Drum Level Measurement and Protection discussion
    - Assignments

- **1:00 pm--4:00 pm Safe Firing of Black Liquor Subcommittee - (OPEN)**
  - Open the meetings. Closed and Open.
  - Reviewed BLRBAC Anti-Trust statement. Both closed and open meeting.
  - Introduce members and guests.
  - Reviewed and approve the Spring 2016 meeting minutes.
  - Review any open items brought up to the subcommittee before the Fall 2016 Meeting.
  - Continue discussions from Fall 2016 meeting (Refer to minutes).
  - Add agenda items as they come in before meeting.
  - Open item discussion from members and guests.
  - Any new items will be discussed.

Participating in BLRBAC – cont'd

- Tuesday morning is ESP open meeting, all submitted incidents are reviewed.
  - Attendees have printed incident summaries.
  - Basic information, boiler leak locations and some leak photos are shown on a large screen.
  - Be prepared to take notes to share when you get back to your mill.
- Tuesday, afternoon is the Operating Problem Session, submit questions ahead of time, or go to the microphone. Please share.
- Sunday and Monday nights have supplier sponsored Hospitality events, go and meet people. Tuesday is a single, jointly sponsored, Activity Night, go and meet.

Effects of Added Materials on Black Liquor Combustion

Honghi Tran and Liming Zhao

University of Toronto
Toronto, ON, CANADA

AF&PA Recovery Boiler Program Annual Meeting and Conference
Atlanta, GA, February 8, 2017

Poor Black Liquor Combustibility

- **Require a longer time to burn, causing the char bed to build up**
- **Decrease the furnace temperature and destabilize the char bed**
- **Lead to frequent blackouts**
- **Reduce reduced boiler thermal efficiency and ultimately boiler firing capacity**

Presentation Outline

- Past studies
- Studies at University of Toronto
- Black liquor combustion characteristics
- Compared with other spent pulping liquors
- Effects of added materials on black liquor combustion

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Past Studies

- Extensively carried out studied over the past 3 decades
- Main research groups
  - IPC/IPST (USA)
  - PAPRICAN, Canada
  - Åbo Akademi University, Finland
  - University of Toronto, Canada

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Main Findings

- Combustion follows three stages:
  - Drying
  - Devolatilization (pyrolysis of organic matter and burning of pyrolysis gases)
  - Char burning (formation of smelt/ash)

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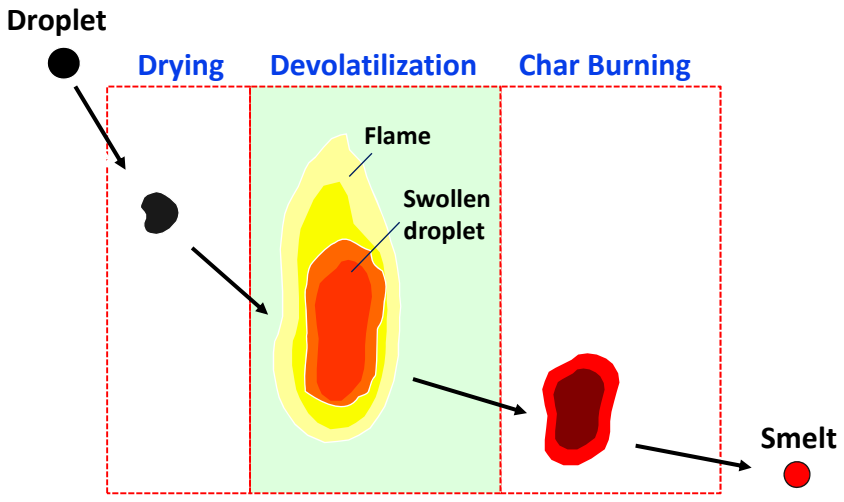
Black Liquor Combustion Stages



Studies at University of Toronto

- Combustion characteristics of various types of spent pulping liquors
- Effects of various added materials on black liquor combustibility
- Used a larger sample size

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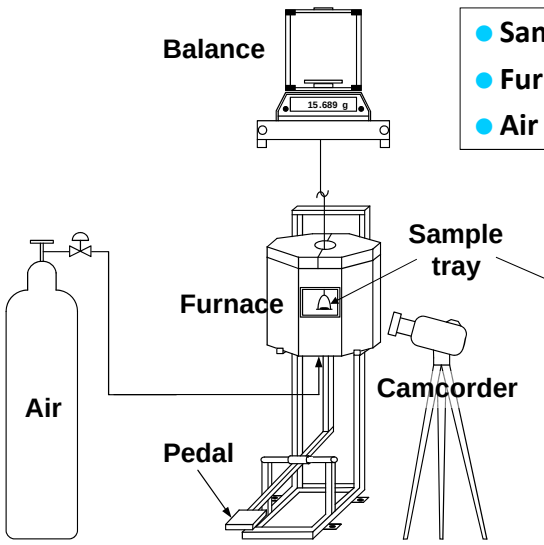
Thermogravimetric Combustor



- Sample size: 0.3 g (~7.5 mm)
- Furnace temp. : 830°C
- Air flow rate: 1 L/min

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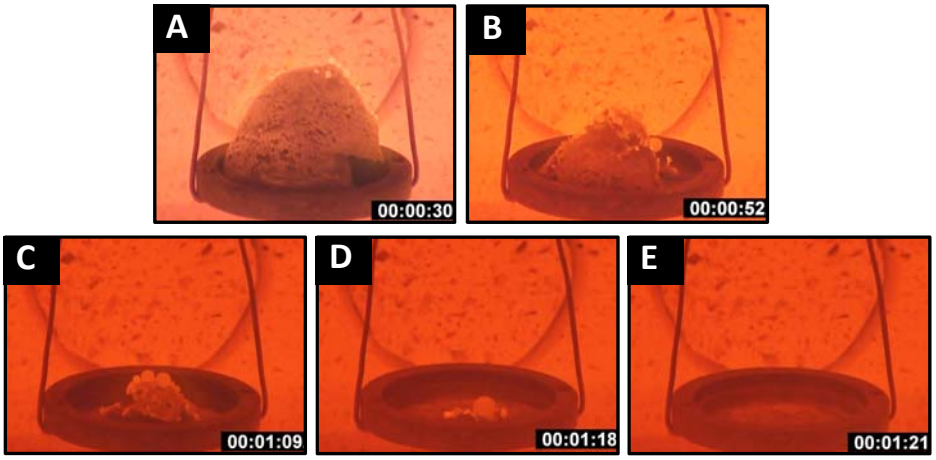
Combustion of a High Swelling Black Liquor

9

Black Liquor Smelt Formation



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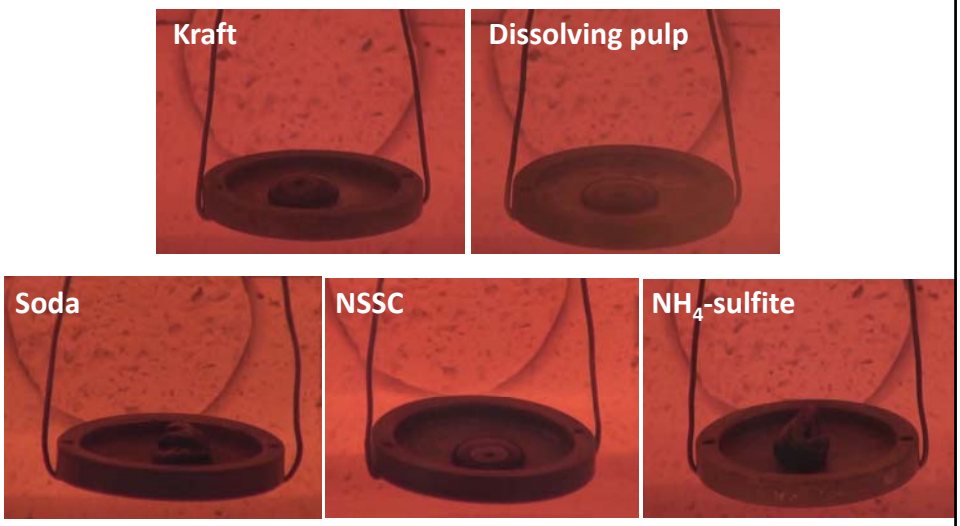
Combustion of Various Spent Pulping Liquors



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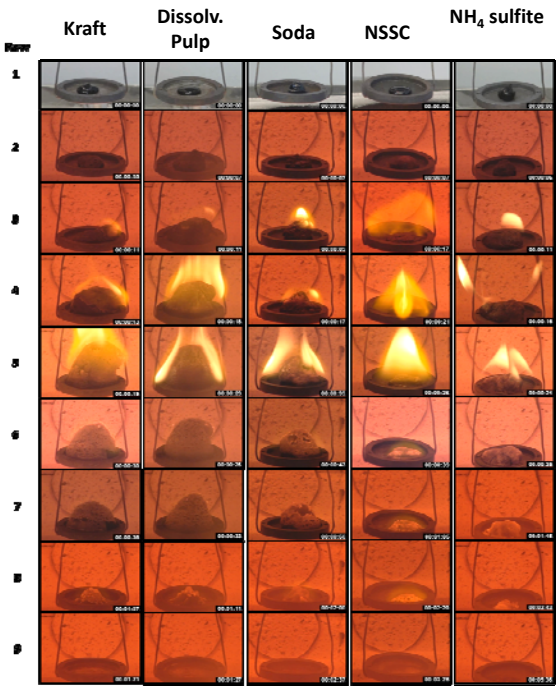
Liquor - Liquor Comparison



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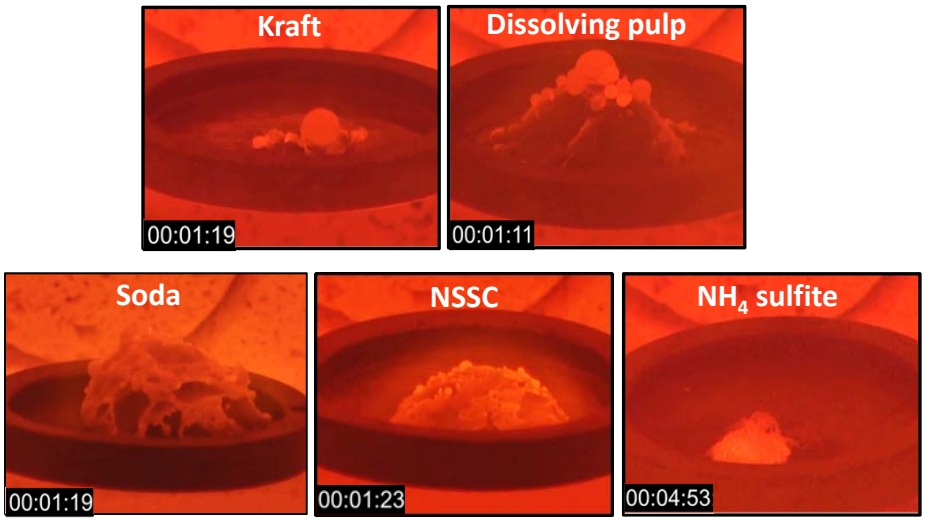
Droplet Appearance during Char Burning



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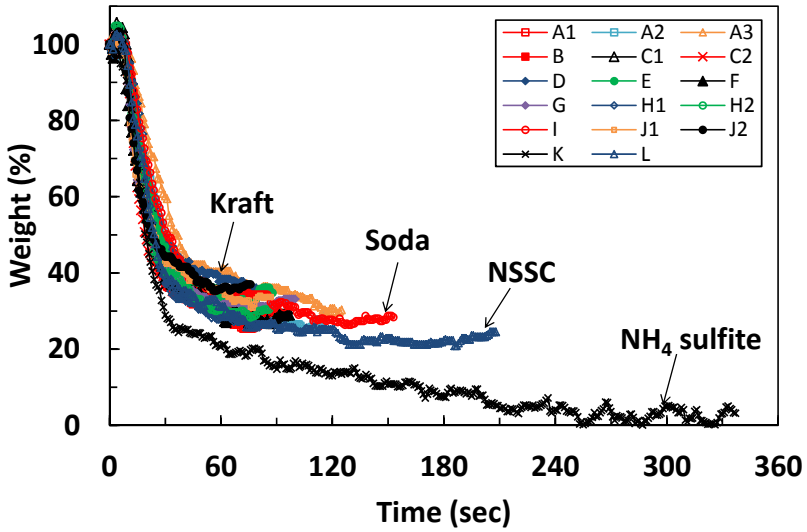
Weight Change Profiles of 17 Liquors



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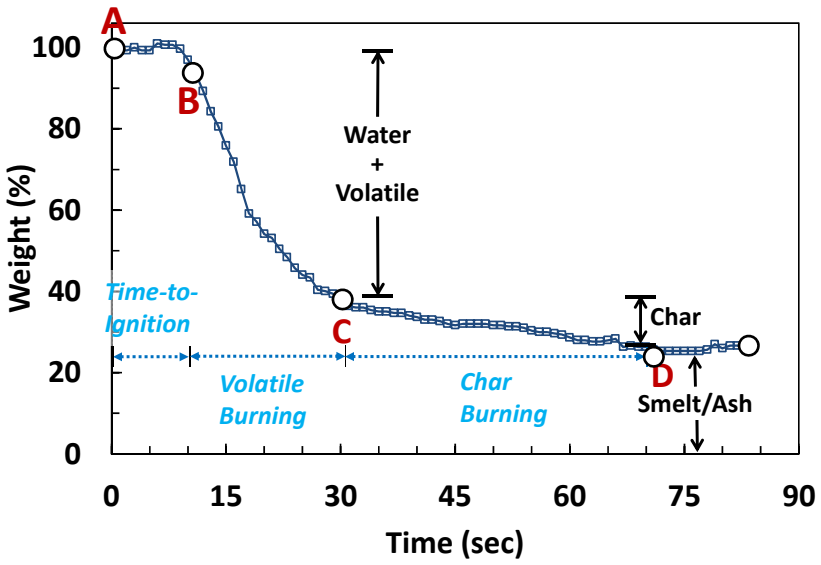
Combustion Stages



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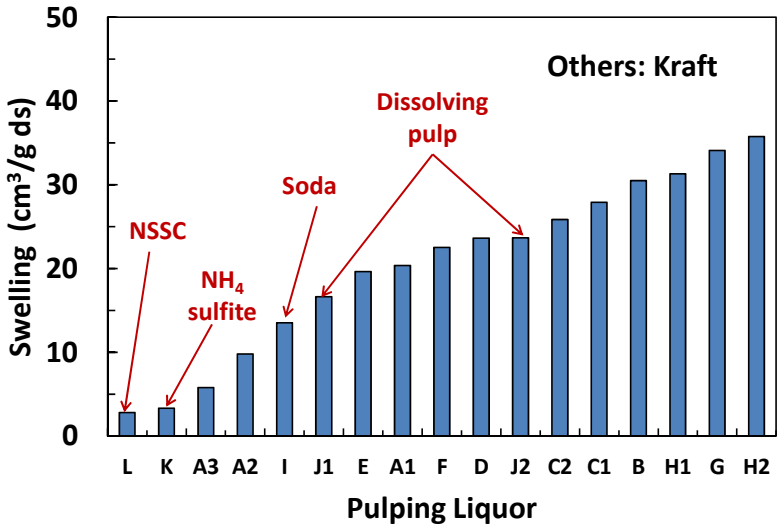
Maximum Swollen Volume



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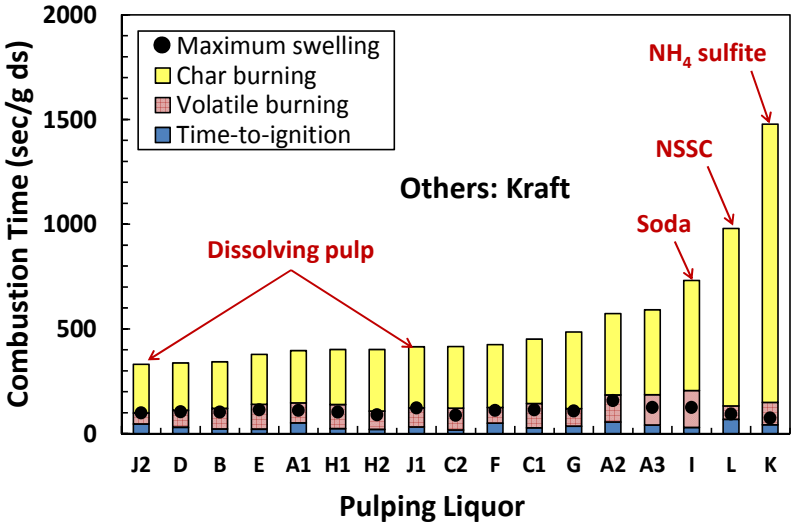
Combustion Stage Times



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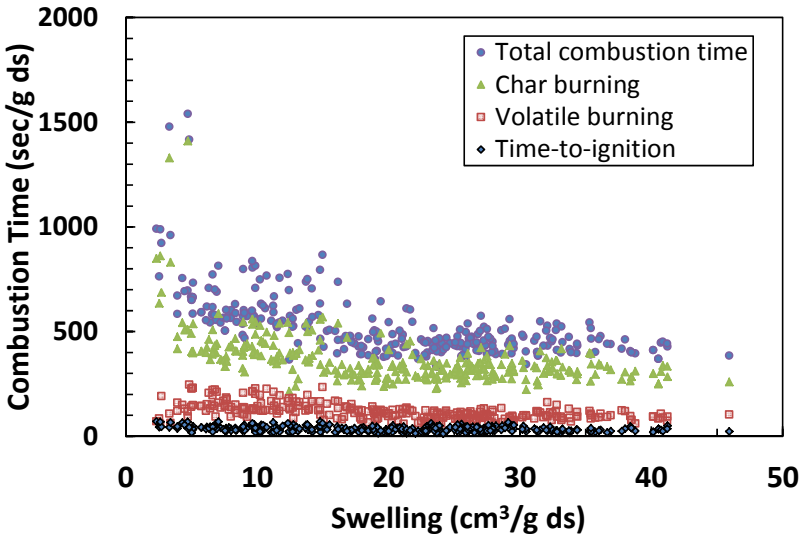
Combustion Time vs. Swelling



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Added Materials

- Prior to being burned, black liquor is often mixed with various materials to meet specific mill needs
- Added as make-up chemicals
  - Sodium sulfate (Na_2SO_4), sodium bisulfate ($NaHSO_4$), sodium sesquisulfate ($Na_3H(SO_4)_2$), and in some cases, elemental sulfur (S)
- Added as black liquor viscosity modifiers
  - Caustic: NaOH or white liquor

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Added Materials

- Added to dispose of
  - Tall oil soap
  - Biosludge
- Added to increase boiler thermal load
  - Sawdust
- Depending on the amounts, added materials may alter the liquor composition, properties, and combustion characteristics

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Black Liquors Used
(Dry Basis)

Mill	Liquor Type	Solids (wt%)	Ash (wt%)	REA (wt% as Na_2O)	Heating Value (MJ/Kg)
A	Kraft	68.3	37.8	2.8	13.2
B	Kraft	77.2	43.7	1.8	13.0
C	Kraft	77.9	44.6	3.8	13.2
D	Kraft	70.8	43.1	5.0	13.6
E	Kraft	74.5	42.5	2.3	13.4
F	Dissolving Pulp	70.9	46.6	1.4	12.4

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Added Materials

Material	Properties
Tall oil soap	From Mill B; solids content = 53.3 wt%, ash content = 27.8 wt% d.s., HHV = 18.2 MJ/kg d.s.
Caustic	NaOH, white liquor
Precipitator ash	Ash samples from several mills, Na_2SO_4, Na_2CO_3
Biosludge	From a sulfite mill; solids content = 1.4
Sawdust	Pulverized pine; particle size = < 0.8 mm

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Effect of Tall Oil Soap (Liquor B)

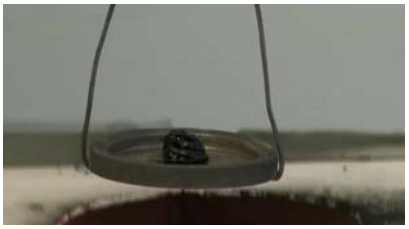
0% Soap

10% Soap

00:00:00

20% Soap

40% Soap



Effect of Tall Oil Soap (Liquor B)

0% Soap

10% Soap

00:22:18

20% Soap

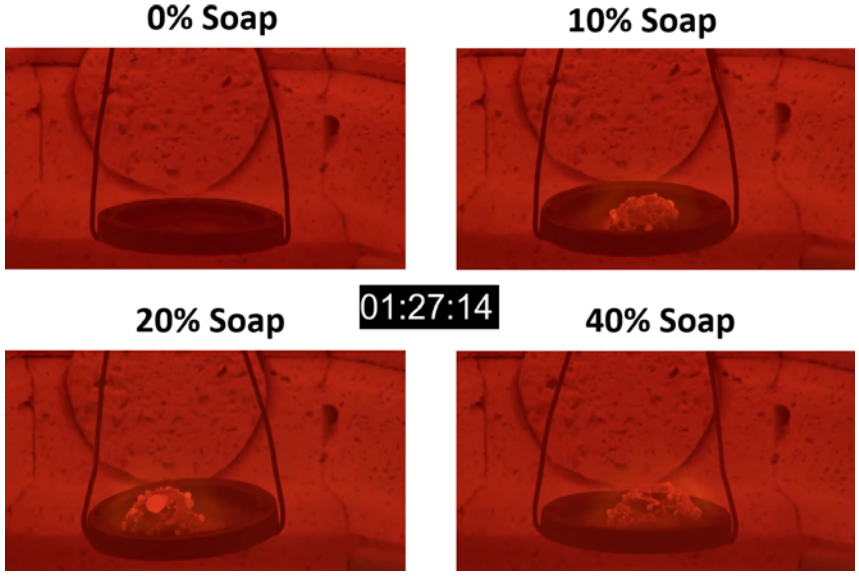
40% Soap

24

Effect of Tall Oil Soap (Liquor B)

25

Effect of Tall Oil Soap (Liquor B)



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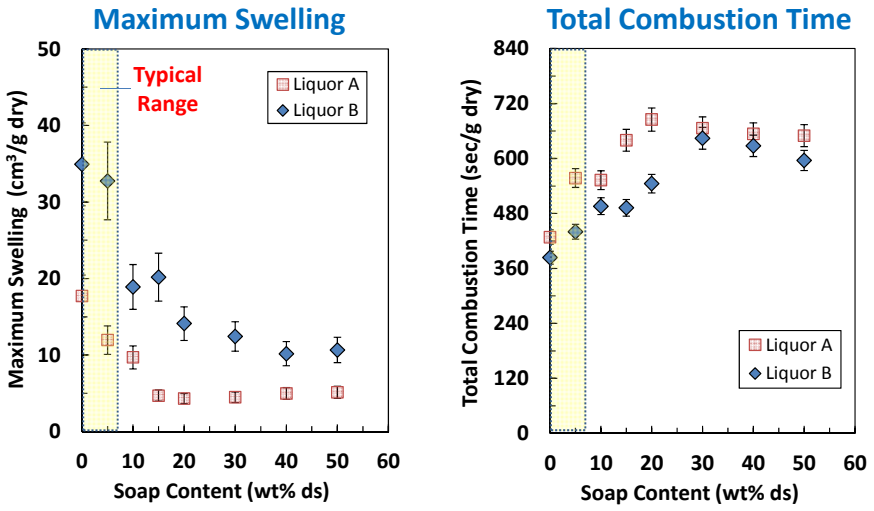
Effect of Tall Oil Soap



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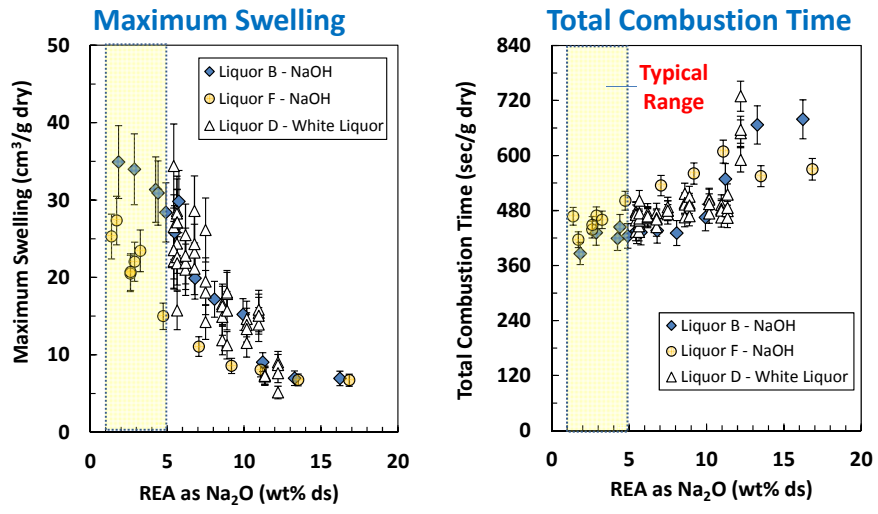
Effect of Caustic



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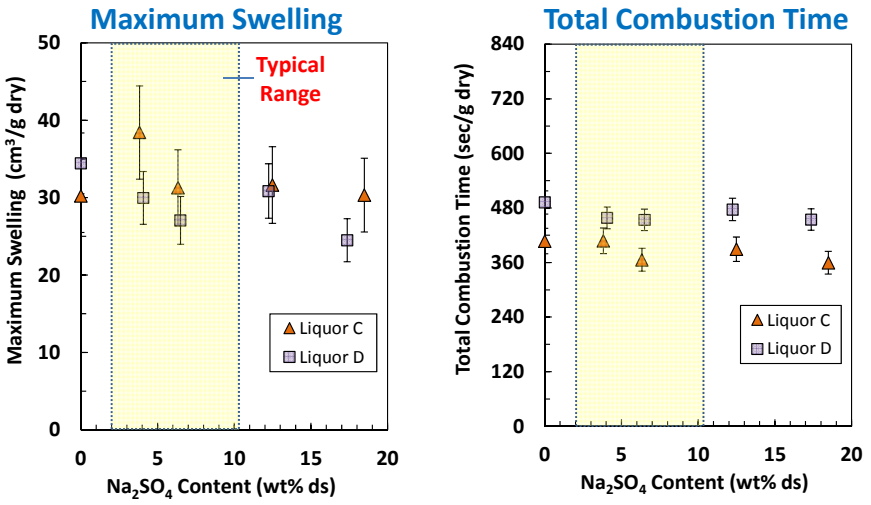
Effect of Saltcake



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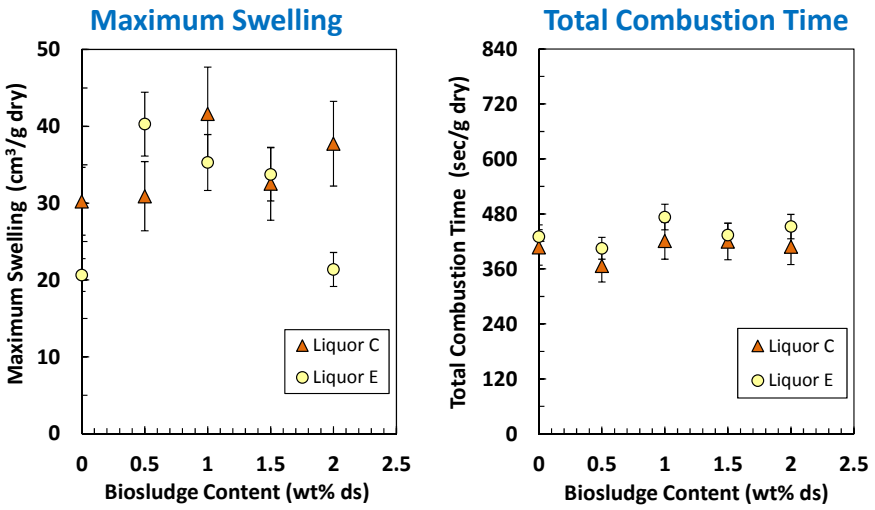
Effect of Biosludge



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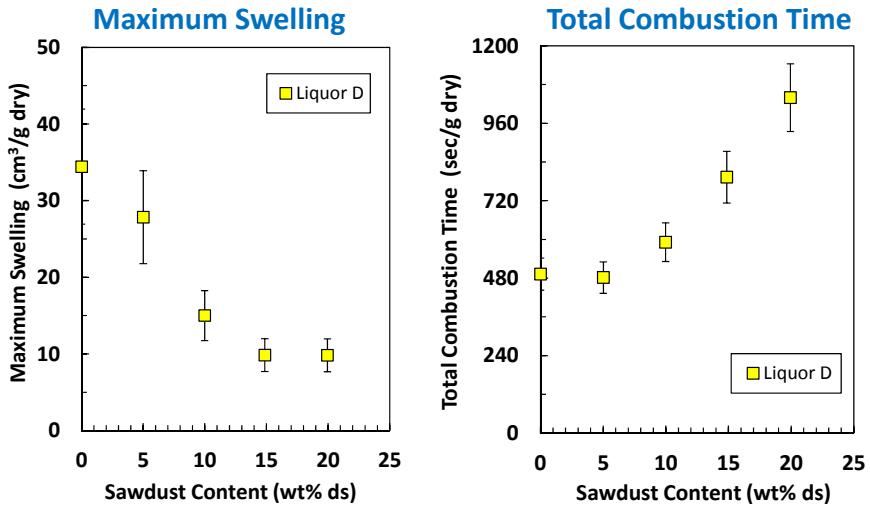
Effect of Saw Dust



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Summary

- Combustion occurs via 3 main stages:
  - Drying
  - Devolatilization/volatile burning
  - Char burning/smelt (or ash) formation
- Volatile burning rate was 10 to 50 times greater than char burning rate

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Summary

- Different liquors may swell differently
  - Black liquor swells the most and spent sulfite liquor the least
- Swelling depends greatly on liquor type, furnace temperature and gas composition
  - 20 to 50 times of initial liquor volume
- Swelling affects liquor burning rate, particularly during the char burning stage
- Liquors that swell more burn more quickly, up to a limit of 25 times of their initial volume

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Summary

- Total combustion time was determined mainly by char burning, which varied significantly from liquor to liquor.
- Adding tall oil soap (up to 20 wt%), caustic/white liquor (up to 12 wt%) and sawdust to black liquor significantly decreases the swelling of the mixed liquor, and increases the total time needed for the liquor to completely burn.

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Summary

- Under normal operation, adding makeup saltcake (Na_2SO_4) and precipitator ash to black liquor does not affect the black liquor burning behaviour
- Adding biosludge up to 2 wt% ds has an insignificant effect on the black liquor combustion

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Acknowledgements

- Andritz
- AV Nackawic
- Babcock & Wilcox
- Boise
- Carter Holt Harvey
- Celulose Nipo-Brasileira
- Clyde-Bergemann
- DMI Peace River Pulp
- Eldorado
- ERCO Worldwide
- Fibria
- FPInnovations
- International Paper
- Irving Pulp & Paper
- Kiln Flame Systems
- Klabin
- StoraEnso Research
- Suzano
- Tembec
- Tolko Industries
- Valmet
- WestRock

Natural Sciences and Engineering Research Council of Canada (NSERC)

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AF&PA - HALT

AF&PA February 2017 HALT System

Presented By: Tim Carlier, Integrated Test & Measurement

Date: 2/8/2017

Agenda

- Introduction to Integrated Test & Measurement (ITM)
- HALT – Hopper Ash Level Thermocouple System
- SuperHeater Overheat Protection(SHOP)
- Clinker Detection System (CDS)
- General Discussion

Integrated Test & Measurement (ITM)

Industrial Monitoring

- 16+ years of experience developing and installing boiler monitoring solutions

Testing Services

- In-Vehicle testing and data acquisition

Structural Testing/Analysis

- Design validation, condition monitoring, consulting services

Topics of Discussion

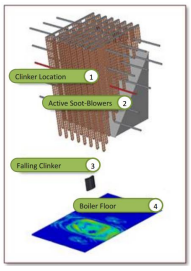
Hopper Ash Level Thermocouple System (HALT)

Ash Hopper, Level Monitoring, Personnel Safety, Process Monitoring

SuperHeater Overheat Protection (SHOP)

Boiler Startup, Tube Clear Events, Safety, Superheater overheat, Tube failures

Clinker Detection System (CDS)



Boiler floor damage, Clinkers, Safety, Smart sootblowing, Chill and blow

HALT - Overview

HALT – Hopper Ash Level Thermocouple System

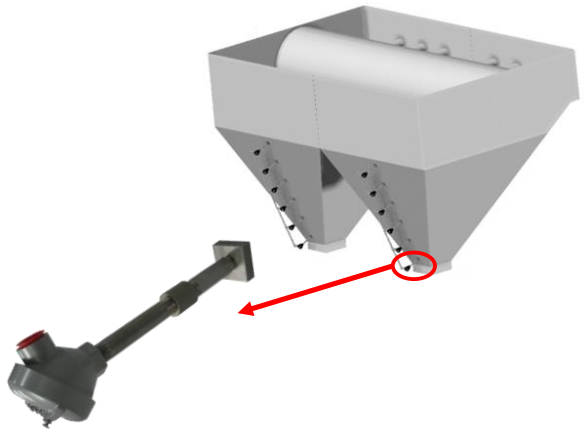
A real time preventative maintenance tool that continually monitors the level of ash within an ash hopper.

Promoting personnel safety through situational awareness.

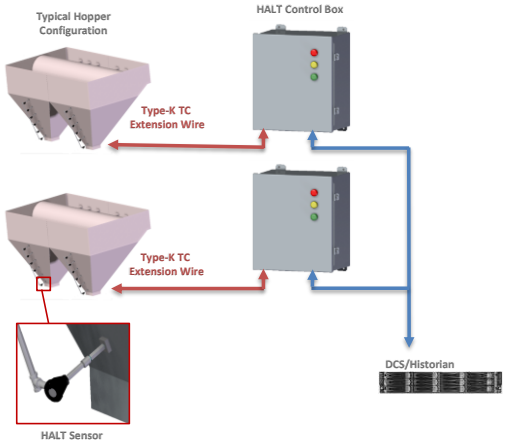
System Benefits

System Benefits

- Identify buildup in the hopper in order to:
  - Alert the operator that remediation may be required
  - Promote operator safety
- Optional closed-loop control of your hopper remediation systems (e.g. rappers, vibrations, etc.)



System Topology



System Features

- Seven (7) sensors per duct (standard)
  - Six (6) Flange, One (1) Surface
- Type K Thermocouples
- Stainless Steel Assembly
- Flange Welded to Hopper Wall

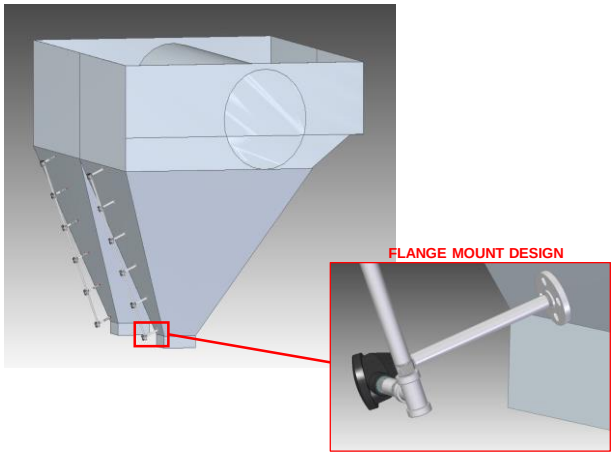
IO Features

- Stainless Steel NEMA4X
- Industrial Real-time Controller
- Standard 16-channel Capacity
- Local Status Indicator Lights
- Integrates with DCS and/or PI System via Industry standard interfaces
- Option for controlling ash remediation (e.g. vibrators, rappers, etc.)

Communication Interface Options

- OPC-DA
- OPC-UA
- Ethernet IP
- MODBUS TCP

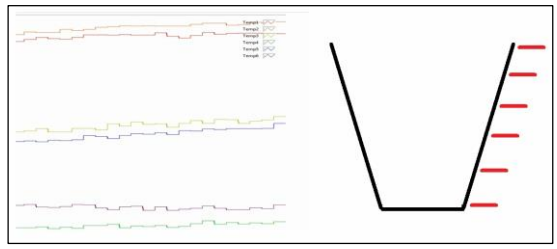
Thermocouple Installation



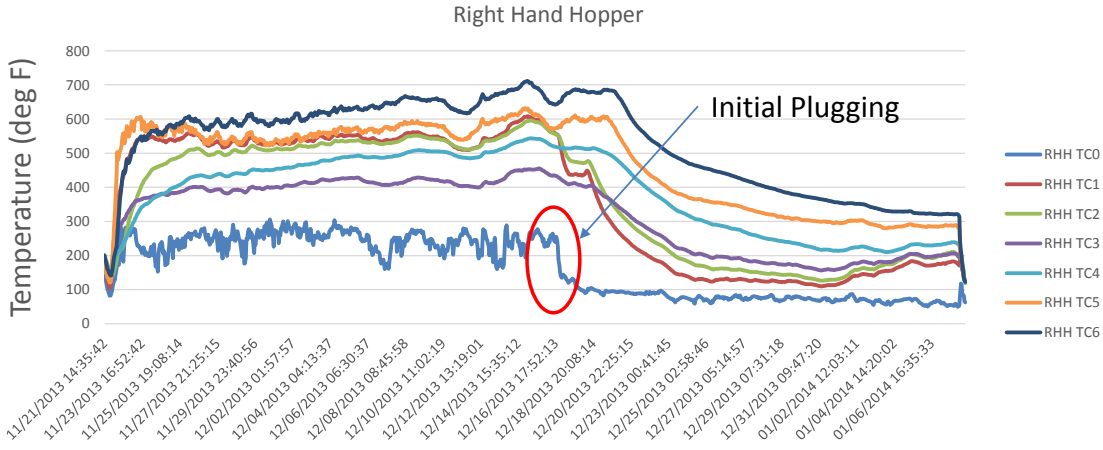
System Behavior

System Description

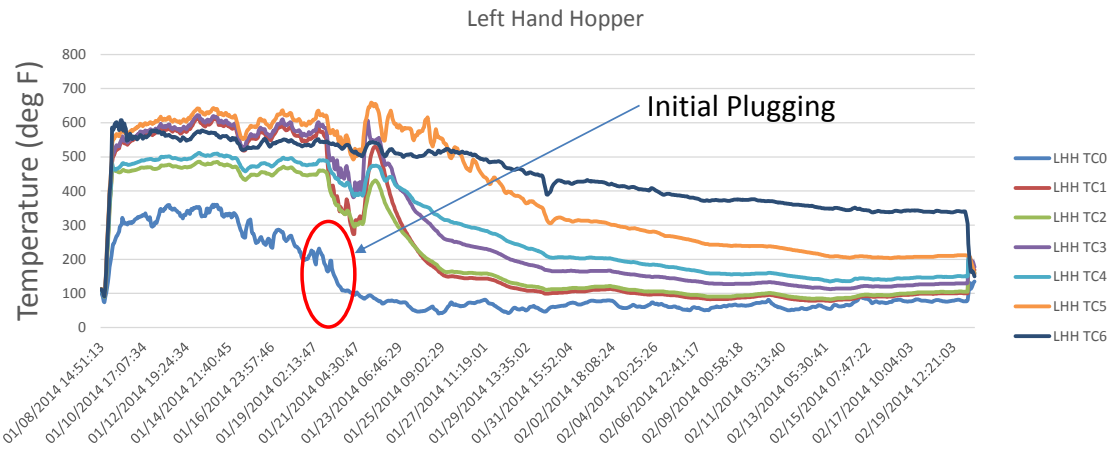
An industrial controller housed in a stainless steel enclosure acquires and analyzes temperature data from ruggedized thermocouples positioned at key locations along the hopper walls.



Trend: Right Hand Hopper



Trend: Left Hand Hopper



HALT Overview Video

SuperHeater Overheat Protection(SHOP)

SuperHeater Overheat

- Thin-lipped bursts in superheater tubes occur when steam flow is insufficient, when deposits restrict flow, or when tubes are blocked by water due to a rapid firing rate during boiler start-up.

* US Patent 14/202,242

SuperHeater Overheat Protection(SHOP)

Cost of Failure

- Superheater tube failure has a significant negative impact on unit safety as there is a risk of these failures creating a critical exposure due to secondary failure of screen and water wall tubes.
- Superheater tube failure during startup can cost in excess of $500k in lost production.

Key Features

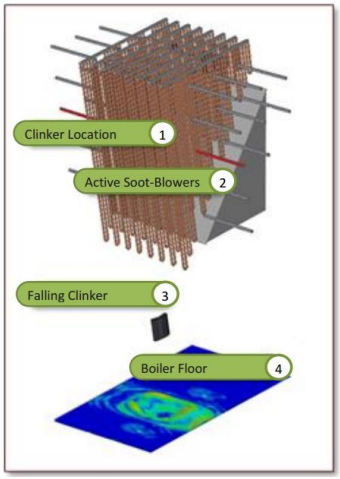
- Supervisory solution for managing tube clearing during boiler startups.
- Autodetection of Tube Clear Events (TCE)
- Data historian and analytics to assist in identifying which tubes to inspect

Clinker Detection System (CDS)

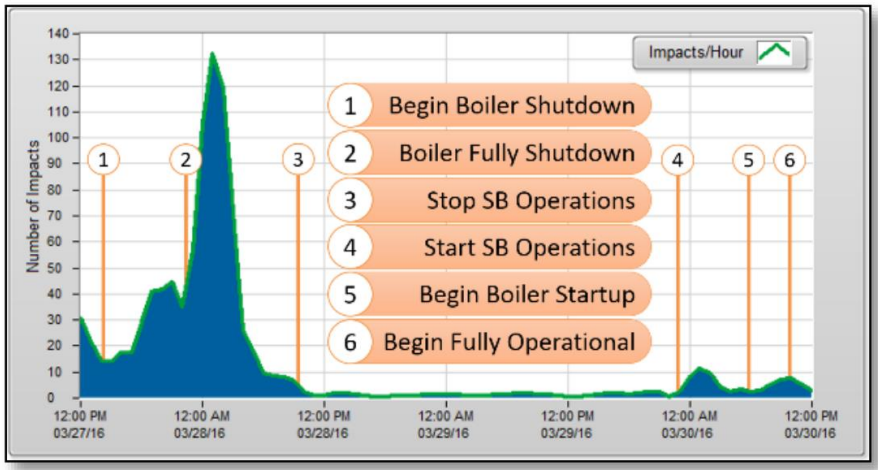
CDS Benefits

- Determine location of superheater fouling
- Optimize soot-blower operation
- Identify damaging clinkers
- Shorten duration of chill and blow events

* Patent Pending



CDS – Chill & Blow Optimization



CDS-Video

Comments, Questions, Suggestions?

Thank you for your time.

Comments, Questions, Suggestions?

844.837.8797
Tim.Carlier@iTestSystem.com

http://www.iTestSystem.com/BMS

SOLENIS™
Strong bonds. Trusted solutions.

OnGuard™ *i* Controller with Leak Alert

SOLENIS

IDEAL RECOVERY BOILER LEAK INDICATION SYSTEM

- Sensitive enough to detect small leaks
- Minimal false alarms
- Indicates where in the boiler the leak is occurring, ESP?
- Low cost
- Minimal maintenance

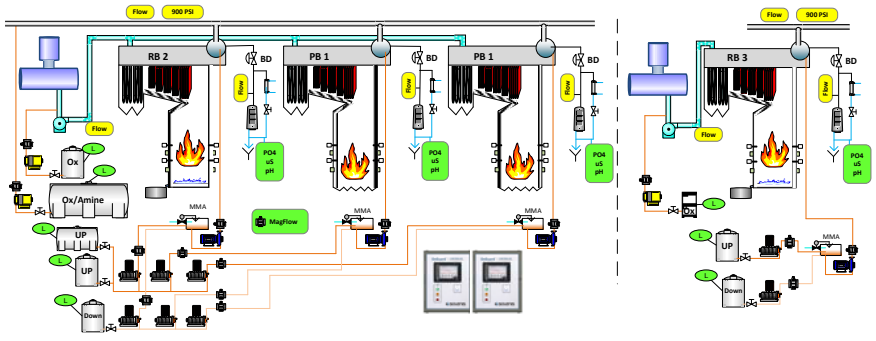
OnGuard™ *i* Controller – The Heart of Leak Alert

Intelligent Performance Based Control System = RESULTS NOT RESIDUALS

- The most advanced, stand alone, chemical control system ever developed
- Extraordinary processing power
- Capable of controlling multiple systems
- Touch screen and internet access

ONGUARD I CONTROLLER CAPABILITIES

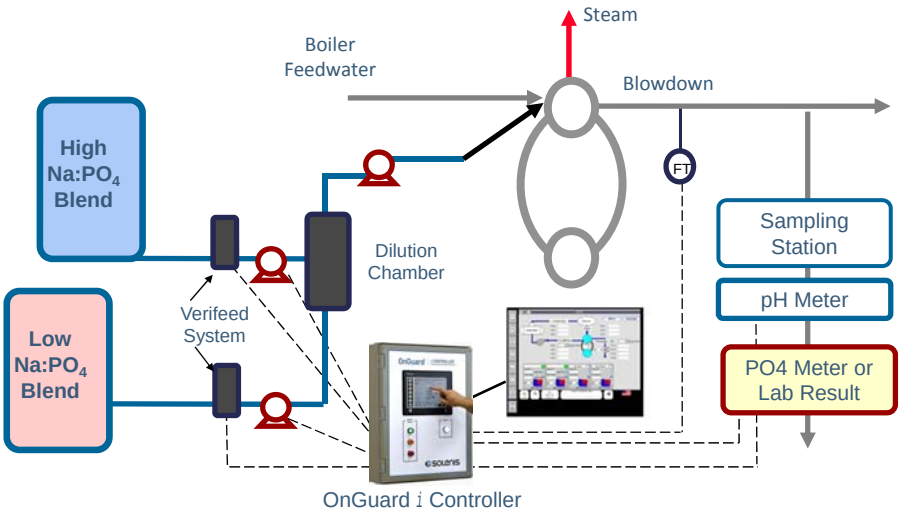
EG. CONTROL MULTIPLE BOILERS



SOLENIS

KNOWLEDGE BASED CONTROL FOR BOILER WATER

BPPC: BOILER PH PHOSPHATE CONTROL

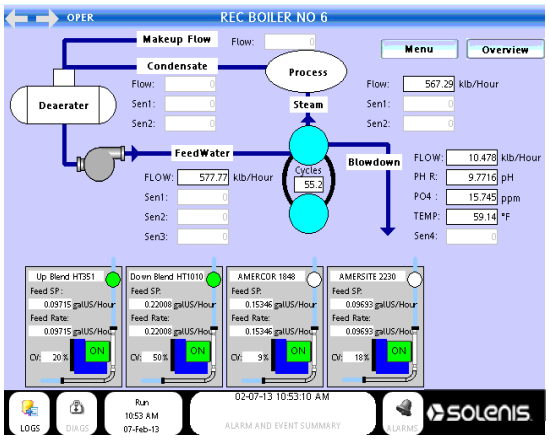


5 Confidential and proprietary.

SOLENIS

OnGuard™ *i* controller

BPPC Application

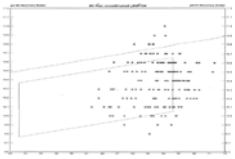


- Controls oxygen scavenger, up/down pH:PO4 blends, amine feed
- Maintains precise pH:PO4 ratio (In the Box) control
- Provides precise blowdown measurement and/or control
- Feed-forward/feed-back control loops

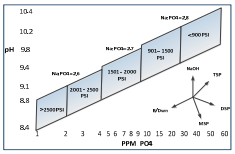
6 Confidential and proprietary.

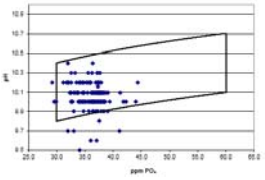
OnGuard™ *i* controller
Recovery Boiler BPPC Application

BPPC CONTROL - EVOLUTION OF "IN THE BOX"

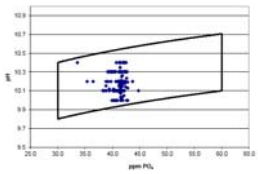


100% Manual
Operator control
45 to 85% TIB
c 1990





90% Automation
PaceSetter control
90-95% TIB
c 2005

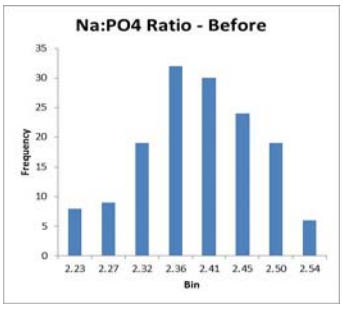


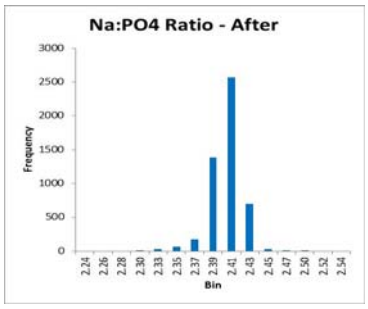
100% Automation
OnGuard *i* control
98 - 100% TIB
c 2015

SOLENIS

CASE#1: IMPROVED CONTROL / REDUCED RISK

OnGuard *i* controller



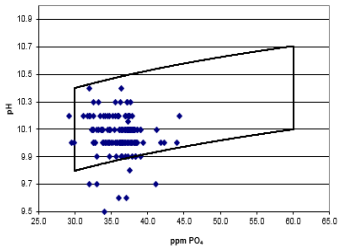


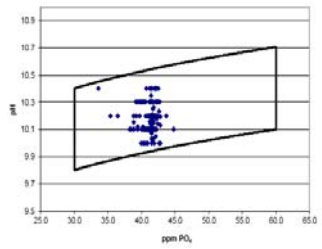
REDUCED PROCESS VARIABILITY – 62%
FEWER UNDERSHOOTS – REDUCED CORROSION RISK
FEWER OVERSHOOTS – REDUCED RISK OF CAUSTIC ATTACK

SOLENIS

CASE #2: OPERATING COSTS REDUCED 18.2%

OnGuard *i* controller





TIGHTER CONTROL
MONTHLY COST PER MILLION POUNDS OF STEAM

CASE #3: CONTROLLING SODIUM INTERFERENCE

Background:

- Long time Solenis pulp mill account
- 850# (58 bar) congruent PO4/pH control
- Sodium spikes from the evaporator condensate made TIB difficult due to shifts in the Na:PO4 ratio.

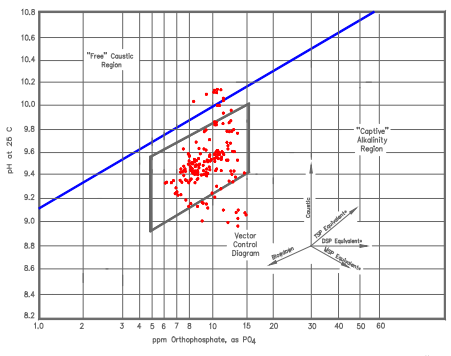
Solution:

- Replace Pacesetter with OnGuard i controller
- Utilize Knowledge Based control through the BPPC program

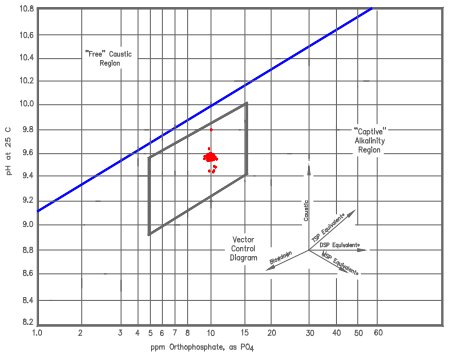
Result: 100% in control

CASE #3: CONTROLLING SODIUM INTERFERENCE

Pacesetter Control



OnGuard *i* Control



CASE #7: DYNAMIC LOAD SWINGS

Background:

- Pulp Mill
- 650# (45 bar) congruent PO4/pH control
- Recovery boiler used to manage load swings

Solution:

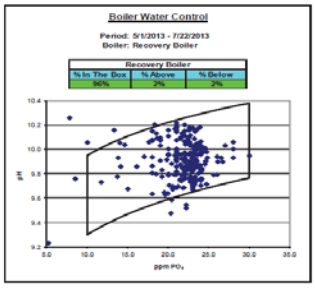
- Replace heritage equipment with OnGuard *i* controller
- Utilize Knowledge Based control through the BPPC program

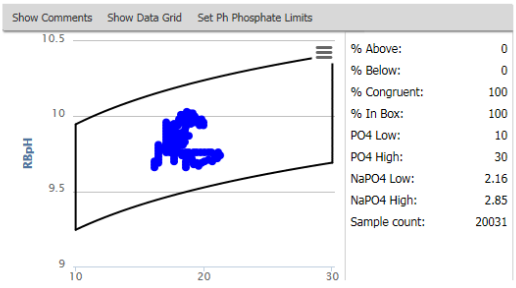
Result: >99% in control

CASE #7: DYNAMIC LOAD SWINGS

2 month performance prior to OnGuard *i*

Mill requires > 95% TIB





OnGuard™ *i* controller
LeakAlert

LEAKALERT ADVANCEMENTS

Solenis LeakAlert

- Everything needed is within the OnGuard *i* controller
- All required capabilities directly available on OnGuard *i* controller
- LeakAlert is self calibrating
  - calibrations are always up to date.
- Can specify expected false alarm rates.
- 4 – 20 mA/digital and call out via text, email

OnGuard™ *i* controller
With LeakAlert

LeakAlert uses both water and/or chemical mass balance

- Water balance is based on metered inputs and outputs
- Chemical balance is based on measurements of non-volatile chemical or tracer chemical

The percentage difference between measured and mass-balance-predicted values is monitored.

- As these percentages become more statistically significant, the likelihood that they have a specific, possibly leak-induced, cause increases.

OnGuard™ *i* controller
With LeakAlert

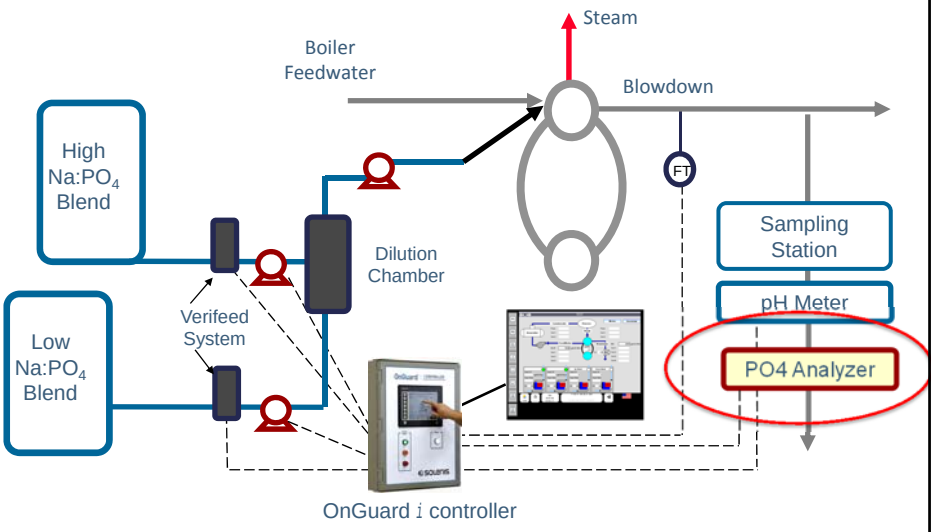
Does not require external periodic calibration - LeakAlert calibrates itself based upon data inputs from each boiler.

Allows you to explicitly set the expected alarm rate

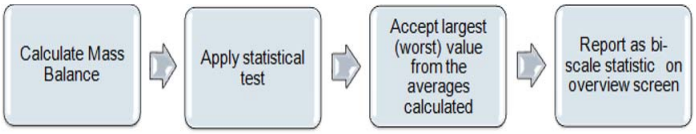
- Automatically adjusts the sensitivity to produce a specified alarm rate consistent with the background variability.

Proprietary data filters to avoid load swing triggered false alarms.

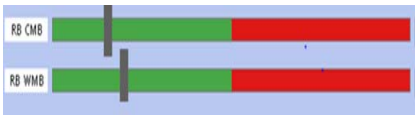
BOILER AUTOMATED CHEMISTRY CONTROL
WITH LEAKALERT SYSTEM



STATISTICAL PROCESS



OPERATOR VIEW

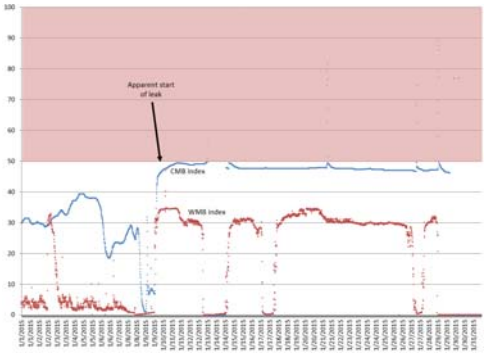


LEAKALERT CHEMICAL MASS BALANCE DRILL DOWN CHART

LEAKALERT DETECTION MATRIX

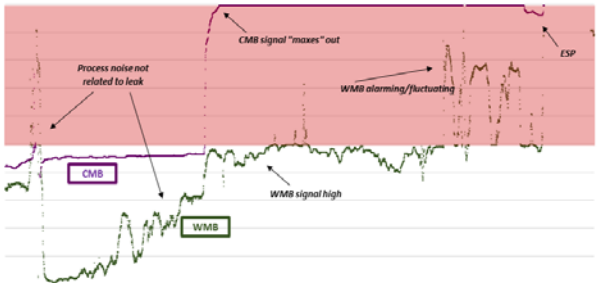
Water Mass Balance Indication	Chemical Mass Balance Indication	Potential Conclusion
No Indication	No Indication	No water or chemical loss.
Indication	Indication	Water loss in cycled part of boiler
No Indication	Indication	Water loss in cycled part of boiler (but not large enough to be seen by water balance) Chemical loss upstream of boiler after chemical measurement. Chemical loss within boiler
Indication	No Indication	Water loss in economizer or superheater Water loss in cycled part of boiler but not yet seen by chemical mass balance system due to time delay.

CASE ONE – LEAKALERT



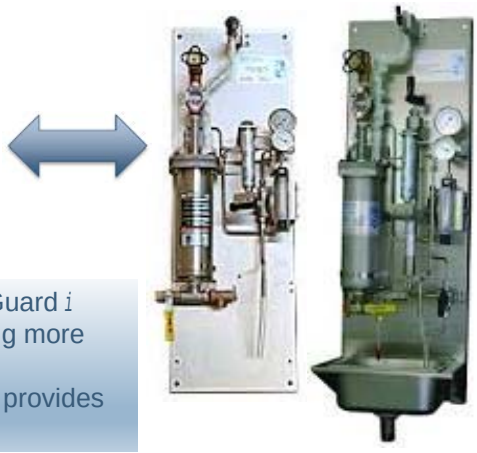
Both WMB and CMB identified a change in status (potential leak), however due to interference in data, LeakAlert failed to hit trigger point (red). Mill was notified on January 9th when shift occurred, investigated but unable to locate leak until later failure.

CASE TWO - LEAKALERT



CMB identified and notified the mill of a change in status (potential leak), which instigated a rigorous inspection of the recovery boiler, but the leak was too small to identify location. Due to large level of interference in WMB data from leaky valves identified in the investigation, the WMB did not alarm until the tube leak caused a larger failure.

NOTE: SAMPLE PANEL IS CRITICAL



With the exception of the OnGuard *i* controller itself, there is nothing more important than a well built and maintained sample panel that provides clean water at a reliable rate.

SIGNALS NEEDED FOR ONGUARD *i* OPERATION WITH LEAKALERT

Water mass balance:

- Steam Flow
- Blowdown Flow
- Feed water Flow
- Any other flows, such as Soot Blower and Attemperation steam, required to form a complete mass balance

SIGNALS NEEDED FOR ONGUARD *i* OPERATION WITH LEAKALERT

Chemical mass balance:

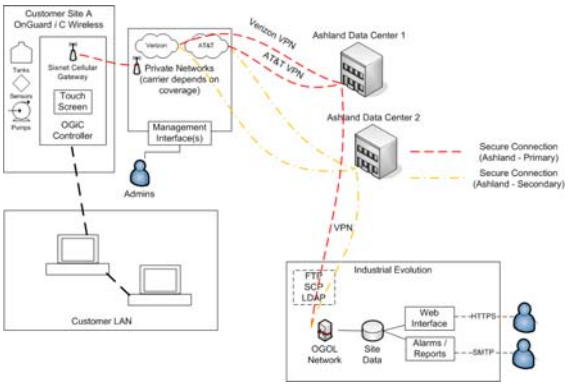
- Phosphate or other non-volatile blowdown concentration
  - Sample preparation is critical!
- Blowdown Flow
- Chemical feed rate, concentration and specific gravity
  - LeakAlert can obtain this information directly from BPPC feed loops

COMMUNICATIONS OPTIONS

DCS / LAN
- **Modbus**
- **Data Historian**

VPN – Sixnet
- **WIFI**

Cellular
- **Modem**
- **Smart Phones**
- **Tablets**



OnGuard™ *i* controller
OnGuard OnLine

LEAKALERT BOILER LEAK INDICATION SYSTEM

- ✓ Sensitive enough to detect small leaks
- ✓ Minimal false alarms
- ✓ Indicates where in the boiler the leak is occurring, ESP?
- ✓ Low cost
- ✓ Minimal maintenance

TAPPI

ENERGY, RECOVERY & RECAUST COMMITTEE REPORT

AMERICAN FOREST & PAPER ASSOCIATION
RECOVERY BOILER PROGRAM
2017 ANNUAL CONFERENCE & MEETINGS
FEBRUARY 6 – 8, ATLANTA, GEORGIA

TAPPI

MISSION STATEMENT:

TAPPI FOSTERS THE VITALITY OF THE GLOBAL FOREST PRODUCTS, PULP, PAPER, TISSUE, PACKAGING, AND ASSOCIATED INDUSTRIES BY DELIVERING UNSURPASSED TECHNICAL KNOWLEDGE, VALUABLE NETWORKS, AND PROFESSIONAL GROWTH FOR OUR MEMBERS (from tappi.org)

ENERGY, RECOVERY & RECAUST COMMITTEE

FORMERLY KNOWN AS THE STEAM & POWER/ENERGY MANAGEMENT COMMITTEE

TAPPI ENERGY, RECOVERY & RECAUST COMMITTEE

- POWER AND RECOVERY BOILERS SUBCOMMITTEE
- ENERGY MANGEMENT SUBCOMMITTEE
- WATER TREATMENT SUBCOMMITTEE
- KILNS AND CAUSTICIZING SUBCOMMITTEE
  - NEW IN 2016
  - DEVELOPED AS A RESULT OF A NEED IDENTIFIED BY ASKING MILLS

TAPPI TECHNICAL PROGRAM SUPPORT

PEERS

ICRC

TAPPI TECHNICAL INFORMATION PAPERS (TIPS)

TAPPI TECHNICAL INFORMATION PAPERS (TIPS) ARE DOCUMENTS CONTAINING SPECIALIZED INFORMATION (E.G., DATA, SOFTWARE, CALCULATIONS) USED IN THE MANUFACTURE, EVALUATION AND DESCRIPTION OF PULP, PAPER, AND RELATED PRODUCTS, WRITTEN IN A STANDARDIZED FORMAT WHICH IS READILY USEABLE BY THE INDUSTRY. (from tappi.org)

TAPPI TECHNICAL INFORMATION PAPERS (TIPS)

- WORKING GROUP
  - WORKING GROUP CHAIR (WGC)
  - TWO OR MORE WORKING GROUP MEMBERS
  - THREE OR MORE TAPPI MEMBERS
  - WGC AND AT LEAST TWO GROUP MEMBERS MUST WORK FOR DIFFERENT COMPANIES
- PUBLISHED GUIDELINES FOR WRITING TIPS

NEW TIPS PUBLISHED IN 2016

- 0416-08 "GUIDELINES FOR REPLACEMENT OF GENERATING BANK TUBES WITH EXPANDED JOINTS IN TWO-DRUM BOILERS", WGC = MICHAEL LYKINS
- 0416-11 "RECOMMENDED TEST PROCEDURE FOR BLACK LIQUOR EVAPORATORS", WGC = CHRIS VERRILL
- 0416-15 "CHLORIDE AND POTASSIUM MEASUREMENT AND CONTROL IN THE PULPING AND CHEMICAL RECOVERY CYCLE", WGC = ANDREW JONES
- 0416-25 "NITROGEN OXIDE EMISSIONS CONTROL FROM BIOMASS AND KRAFT RECOVERY BOILERS IN THE PULP AND PAPER INDUSTRY", WGC = JOHN LA FOND
- 0416-26 "BEST PRACTICE FOR RECOVERY BOILER INSPECTION (OPTIMIZING INSPECTION SCOPE)", WGC = CHRIS JACKSON

TIPS UP FOR REVIEW IN 2017

- 0416-16 "RECOVERY BOILER ENERGY EFFICIENCY IMPROVEMENTS", WGC = ANDREW JONES

IDEAS FOR NEW TIPS

- DISSOLVING TANK OPERATION IN RESPONSE TO UPSET CONDITIONS
  - LIKELY A SUMMARY OF RESULTS OF RESEARCH IN PROGRESS
- SMELT SPOUT SELECTION, OPERATION AND CARE
  - LIKELY A CONSOLIDATION OF FROM SPOUT SUPPLIERS AND BLRBAC GUIDELINES

UPCOMING EVENTS

- COMMITTEE MEETING FOLLOWING BLRBAC
  - WEDNESDAY, APRIL 12, 2017, IN ATLANTA, GEORGIA
- PEERS AND IBBC
  - NOVEMBER 5-8, 2017, IN NORFOLK, VIRGINIA

Recovery Boiler Inspection Strategy

- new approaches offer new benefits

Sandy Sharp
(Columbia, MD, USA)

AF&PA Annual Conference and Committee Meetings, February 7-8, 2017, Atlanta

Introduction

- We inspect RBs because in-service damage cannot yet be modeled or predicted
- Many RB inspections are ineffective
  - Undiscovered in-service cracking/thinning causes ~70% of RB leaks and explosions

Outline

- Limitations of current inspection strategies
- New strategies for planning inspections
- New strategies for evaluating inspection data
- Recommendations for RB inspections

2

Why don't inspections find damage that creates risks? (1)

1. Scope of most RB inspections is based largely on tradition
   - While reducing staffing, most mills have unconsciously passed responsibility for scope of RB inspections to their NDT contractors
     - Conflict of interest
       - Contractor: Increase scope and retain business
       - Mill: Minimize long-term costs

3

Why don't inspections find damage that creates risks? (2,3)

2. Most mills ignore new strategies developed to increase cost-effectiveness of inspection/maintenance in chemical process industries

3. Most mills continue to evaluate corrosion and cracking using fabrication standards (ASME B&PV), rather than the strength of the damaged tube, e.g.:
   - evaluate a locally-thin tube as if the whole tube were as thin as the thinnest measurement
   - cut out all tubes containing SAC fissures

4

What about strategies used elsewhere?

- Refineries and petrochemical plants face similar inspection challenges:
  - Aging equipment
  - Risks from combustible gas explosions and fires
- Their trade assoc. (API) began study of cost-effectiveness of inspection strategies in 1993
  - API RP 581: *"Risk-Based Inspection (RBI) Technology"* published 1996, 2002, 2015
  - API RP 579 *"Recommended Practice for Fitness-for-Service,"* published 2000

5

What is Risk-Based Inspection (1)

- RBI minimizes costs and failures by focusing inspection/maintenance resources on types of damage that present greatest Risks

Risk = Likelihood x Consequence

- Likelihood (events per year) involves
  - size and propagation rate of each potential type of damage
  - probability of detection of damage with proposed inspection methods,
- Consequence (cost per event) involves
  - probable size of leak/rupture at failure
  - probable leak duration and destination
  - potential for injury and cost of clean-up

6

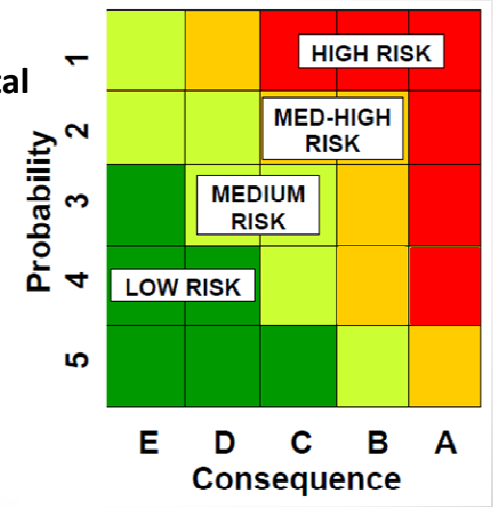
What is Risk-Based Inspection (2)

- RBI can be applied at three levels of diligence.
- Level 1 RBI (~ qualitative approach used by most P&P mills), focuses resources on equipment that contains corrosive or flammable liquids or operates at high temperatures or pressures
- Level 2 (semi-quantitative RBI) shows how to classify likelihood and consequence of each type of damage
  - Likelihood: (1, Very high; 2, High; 3, Moderate; 4, Low; 5, Very low)
  - Consequence: (A, Catastrophic; B, Very serious; C, Serious; D, Significant; E, Minor)

7

Level 2 Risk-Based Inspection (3)

- RBI software classifies risks and calculates total annual cost of risks
- Each damage mechanism belongs in one of the boxes
- RBI increases scope and/or frequency of inspection when seeking damage that presents higher risks



8

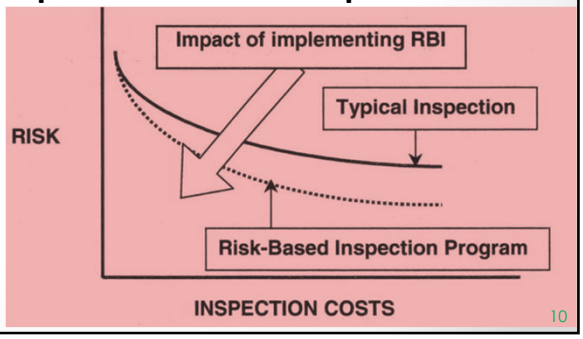
Level 2 Risk-Based Inspection (4)

- RBI reduces total annualized cost of risk in an RB by
  - Planning inspections to reduce uncertainty regarding damage
  - Making repairs, improving process conditions and upgrading materials of construction to extend equipment life.
- Example of a Level 2 RBI study in a mill: *Sharp, Alavi and Lunn, "New tools for the rapid assessment and reduction of safety risks in newly-acquired mill equipment," 10th Intl. Symp. on Corr. in P&P Industry, 10 (1), 9-25, 2001.*

9

Level 3 Risk-Based Inspection (4)

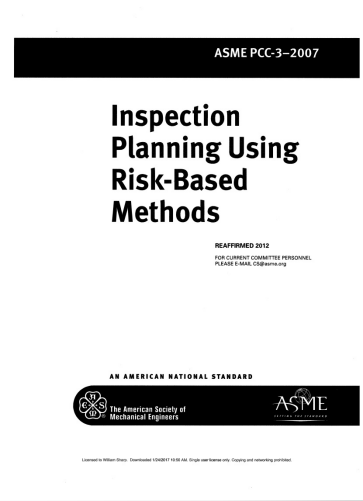
- Level 3 RBI quantitates likelihood and consequence
  - Enables a mill to
    - measure and monitor annualized cost of risk
    - calculate impact of proposed inspection/ maintenance activities on annualized cost of risk
  - Significant start-up costs to collect required data
  - Typically reduces insp/ maintenance costs by 30-50% at constant risk



10

Isn't RBI written specifically for petrochemical plants?

2007/2012 ASME PCC-3, "Inspection Planning Using Risk-Based Methods" shows how to use API 581 methods to plan risk-based inspections of pressurized equipment in other industries



11

If RBI is so cost-effective in other industries, why don't mills use it?

1. **Continuous reduction of maintenance budgets eliminates cost-saving initiatives that have high up-front costs**
2. **Most RB superintendents are isolated from other chemical process industries, ∴**
   - ❑ **unaware of RBI**
   - ❑ **don't have time to evaluate it**
   - ❑ **doubtful they should risk "less" inspection.**
3. **NDT companies typically propose scope of RB inspection same as previous year:**
   - ❑ **easier to price**
   - ❑ **Implied threat that "less inspection may increase risks"**

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Background to understanding inspection results (1)

- Early 1950s: Major research effort to understand catastrophic failures of new jetliners (caused by metal fatigue)

- Computers were used to solve partial differential equations describing complex local stresses

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Background to understanding inspection results (2)

- Since 1950s computer power has enabled analysis of actual stresses within individual parts (e.g. aircraft, dams, ships) and whether they will propagate characterized defects
  - Divide component into small chunks (finite elements) that transmit stresses to adjacent chunks
  - Combine partial differential equations that model individual chunks into systems of equations that model the entire component
  - Use numerical methods to derive approximate solutions to the partial differential equations by minimizing an error function

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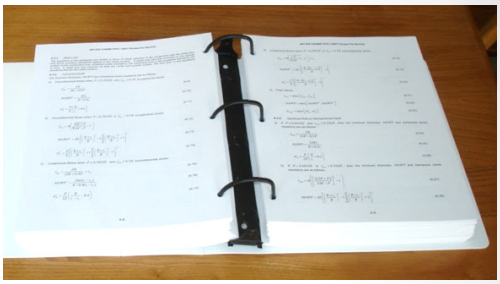
Understanding inspection results

- 2000: API RP 579 "Recommended Practice for Fitness-for-Service," described consensus methods for calculating FFS of refinery equipment containing characterized defects
- 2001: PCC of ASME and API 579 committee began working together to develop a FFS code for P&P, chemicals, utilities. National Board, and overseas organizations involved also.
- 2007: "API 579-1/ASME FFS-1: Fitness-For-Service" code: consensus methods for determining FFS

16

11 types of damage can be evaluated using the methods in FFS-1



- Brittle fracture
- Local metal loss
- General metal loss
- Pitting corrosion
- Hydrogen embrittlement
- Weld misalignment and shell distortion
- Crack-like flaws
- Operation in the creep range
- Fire damage
- Dents and gouges
- Laminations

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Using FFS-1

- RB tube with one of 11 types of damage can be evaluated with 3 levels of rigor
  - Level 1 is conservative screening: minimum operator skill, inspection data, component information
  - Level 2 requires inspection data and straightforward calculations by engineers
  - Level 3 requires detailed component data. An engineer familiar with FFS calculations calculates margin of safety using FEA

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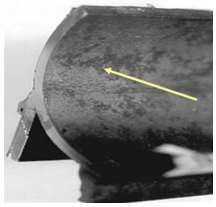
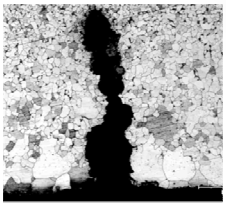
Using FFS-1 in RBs (SAC example)





1. ASME and NBIC say cut out SAC fissures
   - But research shows SAC has little effect on burst strength *("The strength of recovery boiler tubes containing stress-assisted corrosion", Sharp, Proc. 11th Intl. Symp. on Corros. in the P&P Industry, TAPPI , 2004*)
   - FFS-1 calculates whether or not SAC fissures will propagate
2. Determine maximum safe size of defects before an inspection begins

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Using FFS-1 in RBs (Near-Drum Corrosion example)

- ASME and NBIC say plug generating bank tubes where Near-Drum Corrosion violates ASME design thickness
  - 2016 example of Level 3 FFS in a RB
    - *Sharp and Jones, "Evaluation of near-drum thinning data in recovery boiler generating bank tubes," TAPPI J, 15 (7), 491-500, July 2016.*
- Four SharpConsultant Level 3 RB FFS projects each saved the respective client several millions of dollars

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Recommendations for planning Risk-Based RB Inspections (1)

- Take back responsibility for inspection scope from NDT contractor
- Plan an inspection to address all potential damage mechanisms (consult OEM, inspection specialists)
  - Take advantage of low cost of pre-startup inspections, which enable thinning rates to be calculated after first in-service inspection. Note that new tubes are typically thicker than their specified/nominal thickness.

Planning Risk-Based Inspections (2)

- Develop a multi-year inspection plan
  - Because different types of damage progress at different rates
- Use a rolling 6-year inspection plan to combine inspections that require scaffolding and to combine inspections that require more time

Excerpt from a 6-year inspection plan

Part to be inspected	Inspection guidelines	Previous condition	2009 inspection	2010 inspection	2011 inspection	2012 inspection	2013 inspection	2014 inspection
Carbon steel floor tubes	Every 6th year 100% visual, TMLs on every 5th tube every 4' (crown, +45°, -45°)	Nominal 0.200"; 2004 min 0.196"; t_{min} 0.072".	No action	No action	No action	Remove bed by smelt pumping and hydroblasting. TMLs on every 5th tube every 4' (crown, +45°, -45°).	No action	No action
Carbon Steel wall tubes at smelt line	TMLs on every 5th tube at the smelt line around the walls (crown, +45°, -45°).	Nominal 0.200"; 2004 min 0.194" 2005 min 0.180" 2007 min 0.185" t_{min} 0.072".	No action	TMLs on every 5th tube at the smelt line around the walls (crown, +45°, -45°).	No action	Scan every wall tube across smelt line to locate smelt line (thinnest reading). Crown and 45° each side on each tube.	No action	No action
Spout opening tubes	TMLs on each tube beside each spout opening at center of opening and at the center of upper and lower bends. Within bend areas move UT transducer, to find minimum thickness. At center height of opening, move UT transducer to find the lowest thickness direction on each tube beside the opening.	Nominal 0.200"; 2004 min 0.199" 2006 min 0.148" 2007 min 0.172" t_{min} 0.072".	Carefully remove smelt in front of each spout and 4 tubes on either side w/o damaging any tubes. TMLs at 3 elevations on 4 tubes on each side of opening (crown, + 45°, -45°). Scan inside of bottom bend and front of innermost tubes for smelt washing and smelt line thinning. Record thinnest readings.	Remove bed in front of spout tubes only if 2009 scanning showed localized thinning there. TMLs at 3 elevations on 4 tubes on each side of opening (crown, + 45°, - 45°). Scan inside of bottom bend and front of innermost tubes. Record thinnest readings.	Remove bed in front of spout tubes only if 2009 scanning showed localized thinning there. TMLs at 3 elevations on 4 tubes on each side of opening (crown, + 45°, - 45°). Scan inside of bottom bend and front of innermost tubes. Record thinnest readings.	Remove bed in front of spout tubes only if 2009 scanning showed localized thinning there. TMLs at 3 elevations on 4 tubes on each side of opening (crown, + 45°, - 45°). Scan inside of bottom bend and front of innermost tubes. Record thinnest readings.	Remove bed in front of spout tubes only if 2009 scanning showed localized thinning there. TMLs at 3 elevations on 4 tubes on each side of opening (crown, + 45°, - 45°). Scan inside of bottom bend and front of innermost tubes. Record thinnest readings.	Remove bed in front of spout tubes only if 2009 scanning showed localized thinning there. TMLs at 3 elevations on 4 tubes on each side of opening (crown, + 45°, - 45°). Scan inside of bottom bend and front of innermost tubes. Record thinnest readings.

Planning RB Inspections (4)

- Refine the rolling 6-year inspection plan following each inspection using RBI principles, i.e.
  - Reduce inspection intensity (scope and/or frequency) where
    - damage is consistent and statistically predictable
  - Increase inspection intensity where
    - damage involves cracking or is localized
    - damage rates are unknown or unpredictable
    - previously-unexplored types of damage may have occurred
- Learn about new damage mechanisms reported at BLRBAC, TAPPI C&ME, NACE STG 38

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Calculate remaining life based on measured rates of thinning (1)

- Can calculate how many TMLs are required to establish statistically-reliable corrosion rates and predict outliers in each part of the RB
- Standard error in UT measurements typically 0.005-0.007" > thinning rate, so optimize precision and accuracy of tube thickness measurements, e.g.:
  - Pre-qualify NDT technicians (TAPPI TIP 0402-21)
  - Precisely-locate TMLs
  - Repeat measurements if calibration drifts
  - Check outlier readings (90% will be wrong)

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Calculating remaining life based on measured rates of thinning (2)

- Do not rely on thinning rates calculated as difference between consecutive measurements at single TMLs are not reliable, because standard error of each measurement > thinning rate
- Instead, use trending software to calculate remaining life
  - Typically needs ≥ 4 data sets at ≥ 100 TMLs that belong to the same statistical population

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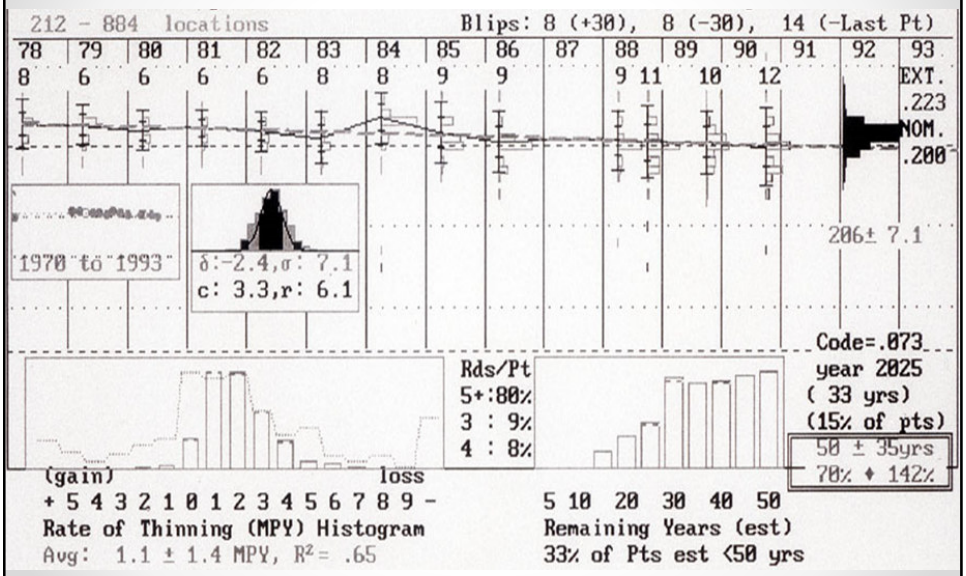
Trending programs need not be fancy



Waterwall tubing at front wall primary airports

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Calculating remaining life based on FFS-1 calculations (3)

- FFS-1 is typically used to show whether characterized defects will propagate under operating stresses
  - It provides a sound basis for decisions to run as-is until a scheduled inspection, to monitor, repair, alter or retire the equipment

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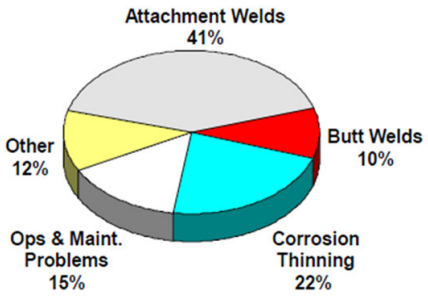
Don't believe the myths!

1. Tube thickness surveys will identify the tubes most likely to leak or rupture

Bauer and Sharp, "Inspection of Recovery Boilers to detect critical leaks," TAPPI J. 74 (9), 92-100, 1991.

(1948-1990)



2. Measuring tube thickness at more locations will identify the thinnest tubes
3. NDT technicians will report visual indications of corrosion or cracking while working in a RB

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Conclusions

Mills should use RBI and FFS codes (ASME PCC-3 and ASME FFS-1)

- **to make RB inspection and maintenance more cost-effective**
- **to evaluate their inspection programs by monitoring the annualized cost of defect-related risks in RBs**
- **to evaluate the FFS of tubes containing defects, using technically reliable, globally-accepted procedures**
- **to schedule tube replacement based on statistically-reliable estimates of remaining life**

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BLRBAC ESP Subcommittee

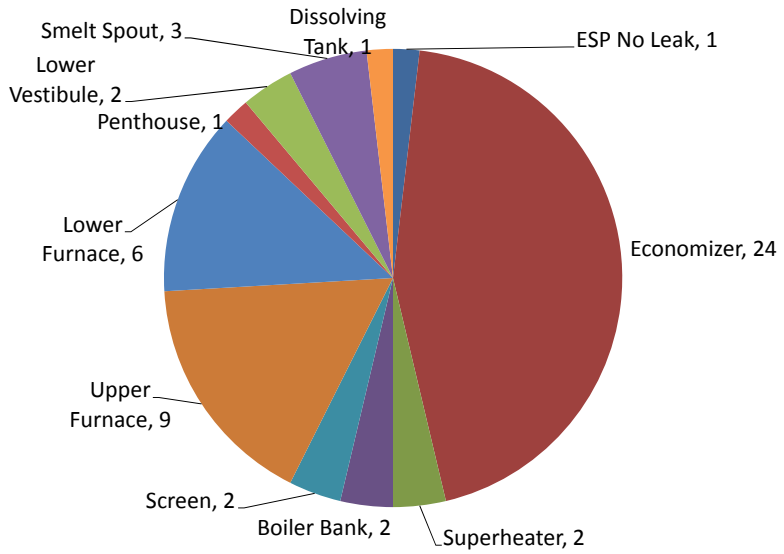
2016 Incidents ESP Report,
covering Spring and Fall Meetings
for AF&PA
Wednesday February 8, 2017

Dean Clay, taken from J. Andrews BLRBAC ESP reports

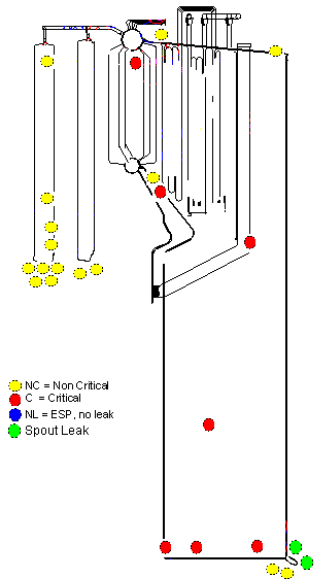
Incident Questionnaire Review

- 54 North American incidents
  - -NO Smelt Water Explosions
  - -1 Dissolving Tank Explosion
  - -20 Critical
  - -32 Non-critical
  - - 1 ESP – No Leak
  - - 3 Smelt Spout Leak
  - – 14 ESP'd
    - 11 Critical
    - 55% of Critical that Should ESP
- 11 International Incidents

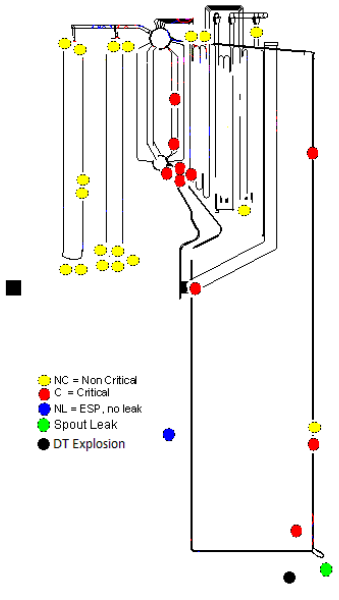
Incident Locations



Leak Locations S 2016



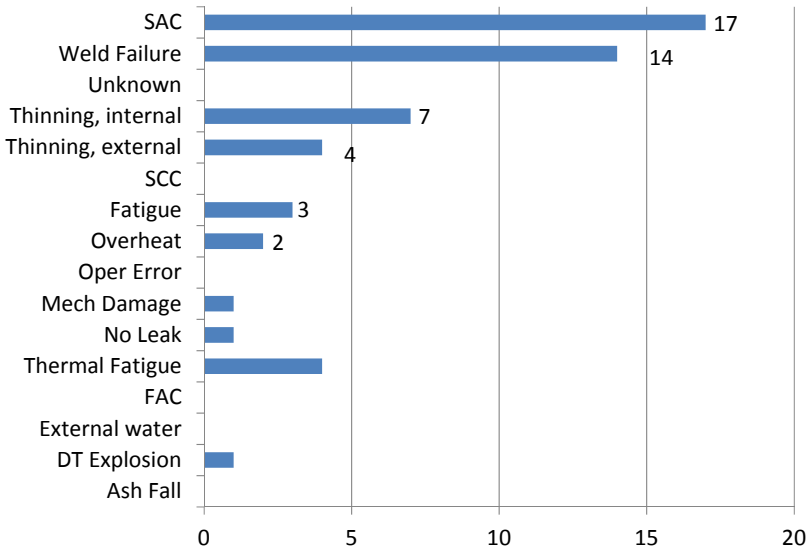
Fall 2016 Incident Locations



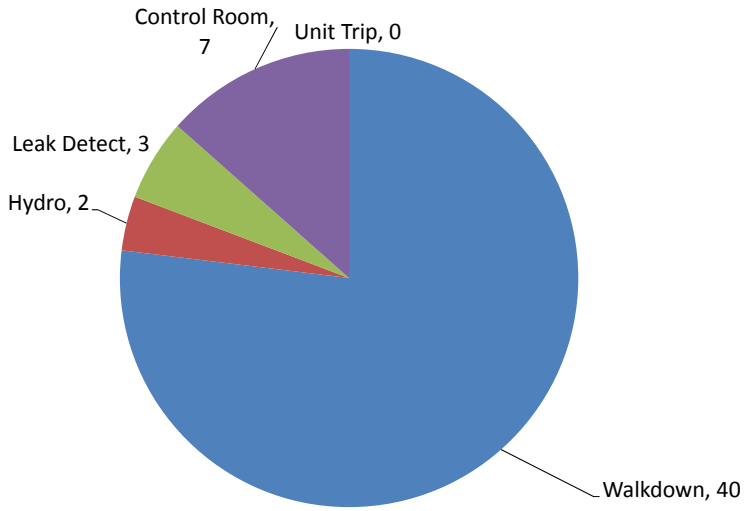
Leaks by Boiler Type

- Drums
  - 1 - 15
  - 2 - 39
  - 3 - 0
- Back End
  - Large Economizer - 45
  - Cascade - 5
  - Cyclone - 4

Leak Cause



How Discovered



Leak Detection Systems

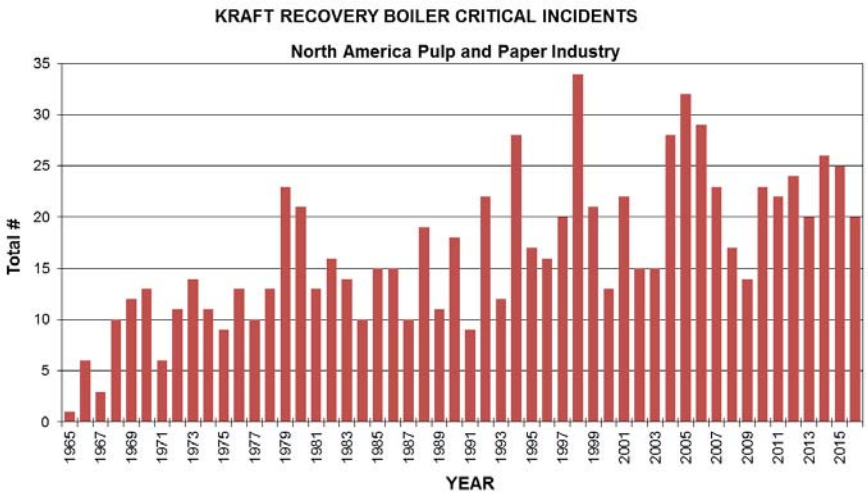
- Leak Detection Systems installed – 38
- 70% said had LDS (38/54)

- Identified leak – 3
- Confirmed leak - 7

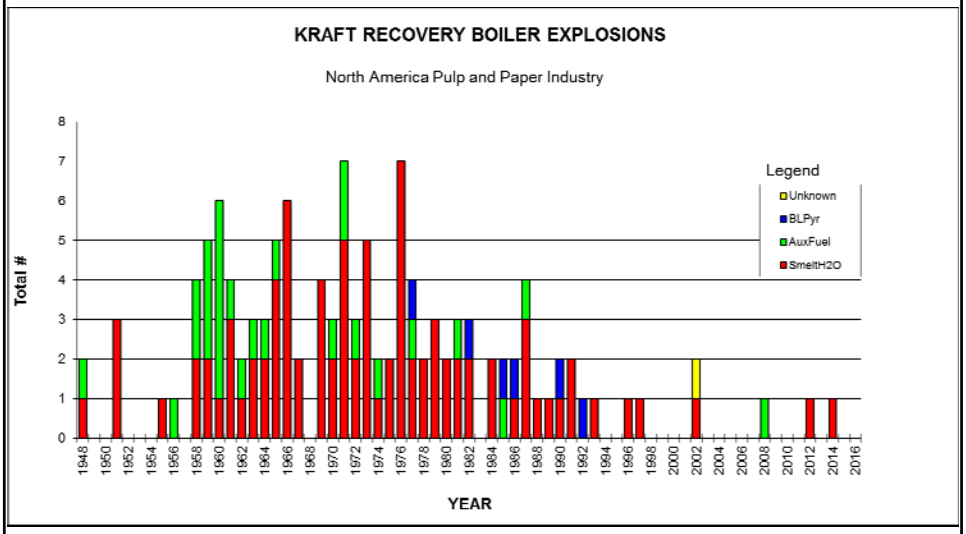
Initiation of ESP

- Spring Meeting Only, Ranged from 5 minute to 5 days
- Half 10.5 hours or less

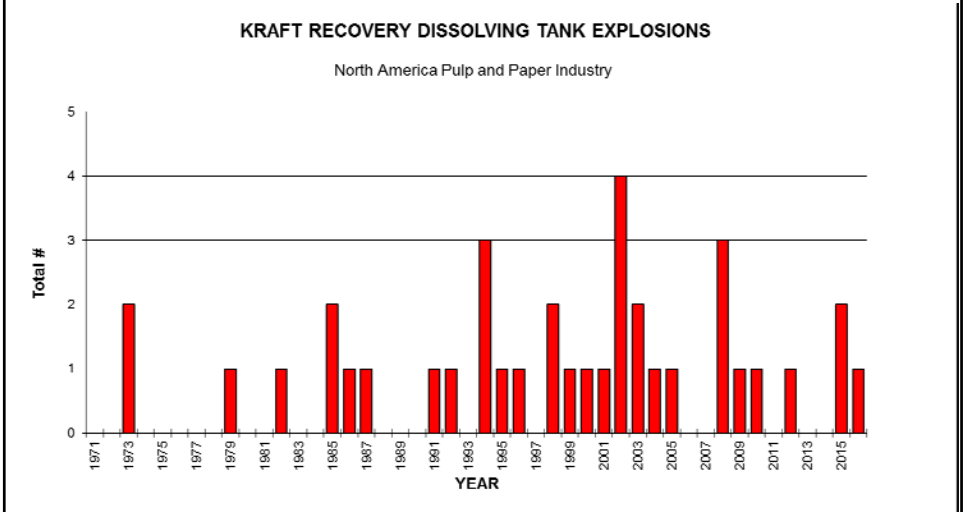
Critical Incidents to Date



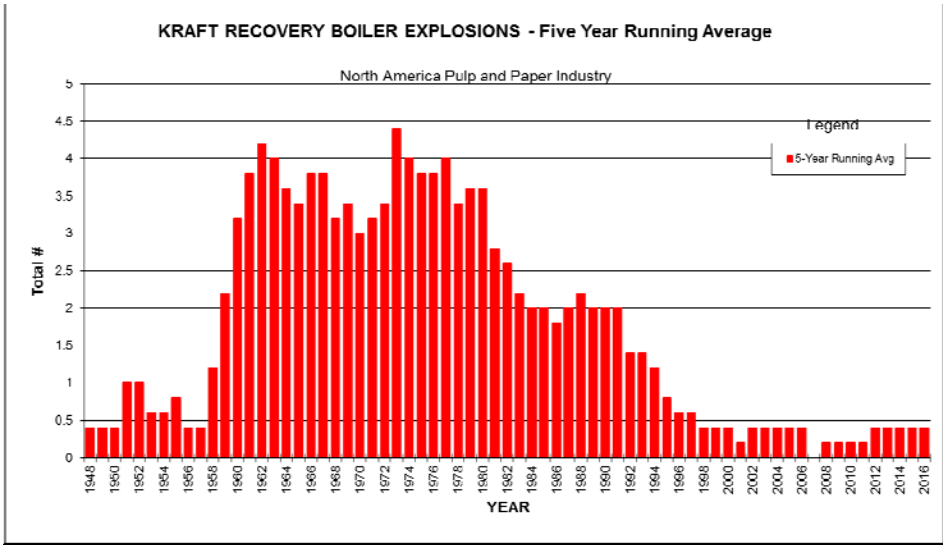
Boiler Explosion History



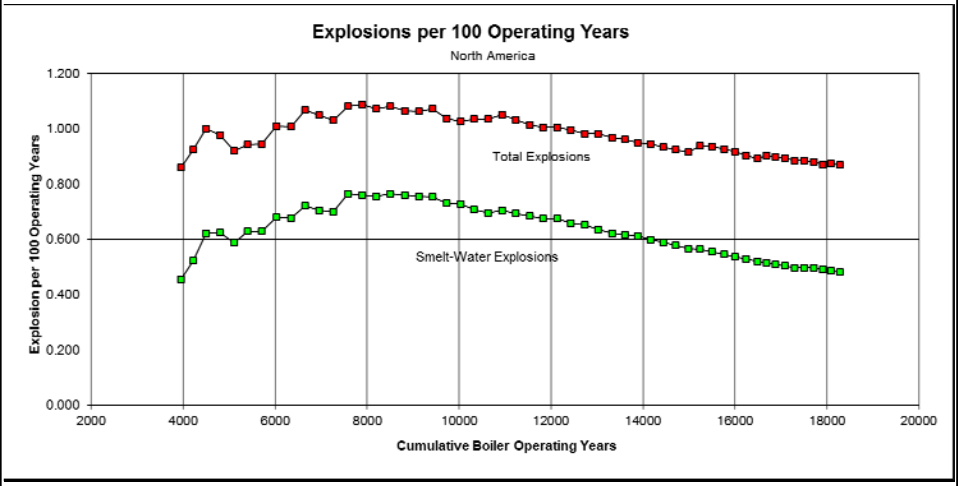
Dissolving Tank Explosions



Explosion History - Five Year Avg.



Explosion History per 100 Oper Yr



Learnings

- Clean saltcake buildup from economizer headers to reduce corrosion from wet saltcake during outages.
- Infrared Imaging guns may be useful to identify hot spots in the bed for further probing and temperature measurement but the indicated temp from IR should not be the final criteria. You are measuring the surface temperature and there may be molten pockets of smelt below the frozen surface.
- It is not recommended for operators to observe leaks through open mandoors to see if they are getting worse. Tube ruptures or even fan problems can cause blowback.

Learnings

- Critical alarms should be set up to come back on if they are acknowledged but the problem continues. In the middle of a crisis it is easy to forget about an acknowledged alarm.
- Steam cooled sidewall panels need to be drained during startup to remove any condensate that has collected and allow steam to circulate to cool the panel.
- Check short radius riser tubes in the penthouse for cracking either internal Stress Assisted Corrosion or external fatigue cracking. Riser tubes that do not completely vent to the drum (rise up from the header and go back down to enter the drum) may have internal thinning issues from steam blanketing.

Learnings

- There were two incidents reviewed that had leaks due to Copper Contamination Cracking. Both were from automated welding machines where the welding head struck the tube and melted the copper head into the tube metal.
- Localized deposits can cause tube thinning either external from overheat or internal from under deposit corrosion. We have had several incidents reported where the boiler was thought to be clean based on DWD readings from what was thought to be the high heat areas of the unit. Many of these deposits have been found at tube bends at airports and burner openings.

Learnings

- If a spout water cooling leak is discovered, the recommended action is to cut off the cooling water and plug the spout. It is not recommended to continue operation of the unit with a known spout leak.
- When installing plugs in tube stubs, keep the stubs as short as possible to minimize the potential for accumulating deposits, forming steam pockets, etc.
- In the event of an inadvertent ESP, follow the post-ESP procedures to ensure no un-safe conditions are created.

Learnings

- Check ESP systems to ensure all functions are energize to activate so that loss of power to the inputs or loose or broken wire from ESP buttons does not initiate an inadvertent ESP.
- Consider installing an ORP (oxidizing, reducing potential) meter to monitor feedwater quality – dissolved oxygen, pH, conductivity.
- Periodically shut off oxygen scavenger to check deaerator performance (<10 ppb)
- Consider chemically cleaning economizer w/ balance of the boiler to remove internal deposits, eliminate under-deposit corrosion, and passivate any O2 corrosion cells.

Learnings

- Smelting out a bed should start at the spout wall to minimize potential for smelt pool forming behind a salt cake dam.
- Work with sootblower supplier to establish blowing pressures for each area of the boiler and check periodically. Follow management of change process before exceeding established pressures to minimize risk of fatigue failures

Changes Under Consideration

- Combining ESP and Post ESP Guidelines into one document
  - Include DCE Fire Suppression Medium as specific exclusions to “Stop All Water and Steam Supplies”
  - Wording to clarify that all motor protection interlocks should be bypassed with ESP
  - Clarify “Alternate Means to Initiate ESP”

Boilers in Service

- North American Total - 191
-

	US	Canada
– Number	149	41
– Avg Age	38.8	38.7
– Max Age	64	69

- Oldest
  - Kruger Three Rivers, PQ
  - 1947 Alstom
- Contact Dean Clay with any Corrections or Updates

Incident Questionnaires

- Obtain Up to Date Questionnaire from website www.blrbac.org
- Submit to Dean Clay at dclay@fuse.net
  - Or to dclay@bsimail.com
  - Please use Word .doc or .docx files, not .pdf
  - Please use .jpg illustrations
- Look for confirmation of receipt from Dean

Modeling Sootblower Jets and How They Interact with Tube Geometries

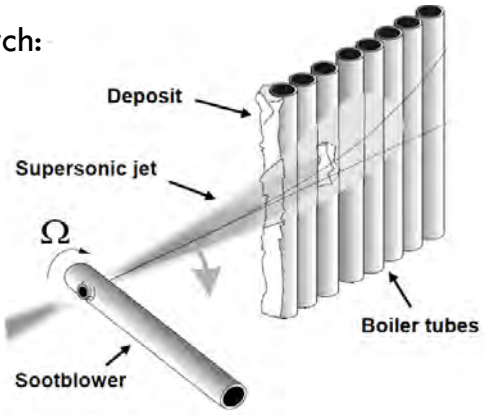
Markus Bussmann, Shahed Doroudi, Honghi Tran, Danny Tandra

PULP& PAPER
UNIVERSITY OF TORONTO

UNIVERSITY OF TORONTO

Sootblowing

- Use 3 – 12% of boiler's high pressure steam!
- Sootblowing effectiveness is hard to measure
- Two aspects of research:
  - Maximizing deposit removal forces
  - Minimizing steam consumption

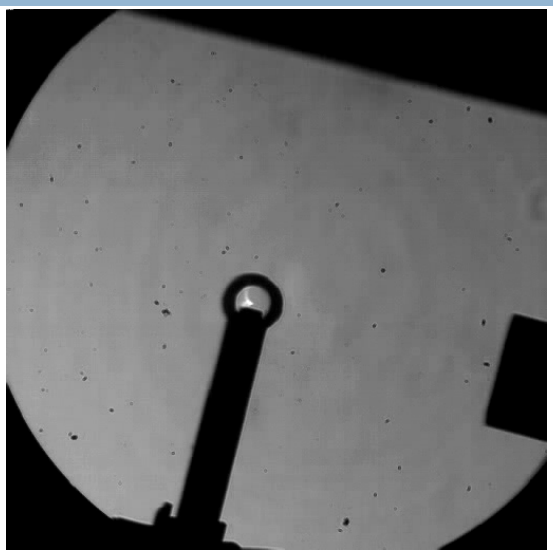


Pophali, "INTERACTION BETWEEN A SUPERSONIC JET AND TUBES IN KRAFT RECOVERY BOILERS"

Sootblowing

¼ scale Experimental Sootblower model

Schlieren Visualization by Pophali



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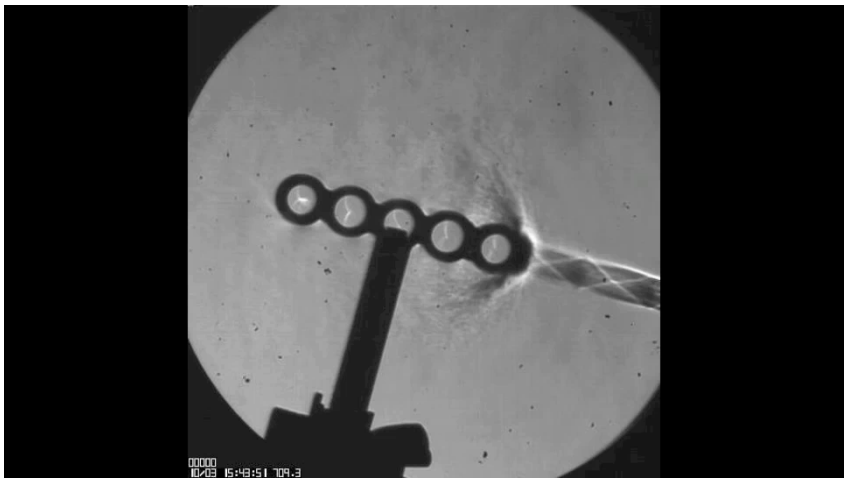

Why Computational Fluid Dynamics (CFD)?

7

- **Complement to Experiments**
- **Complete Flow Field**
  - **Pressure, Velocity, … everywhere**
- **Once validated, run "virtual" experiments**

Free Jet Model with Nozzle

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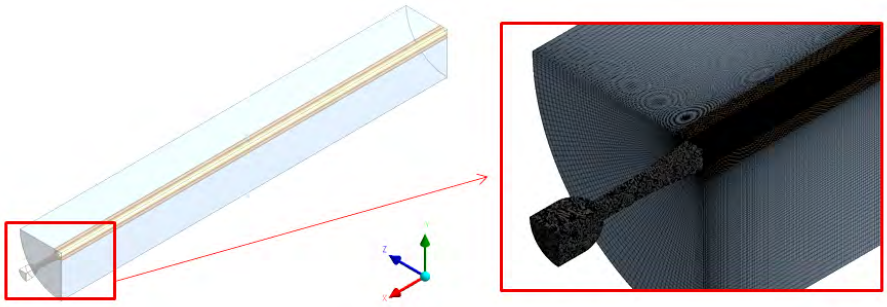
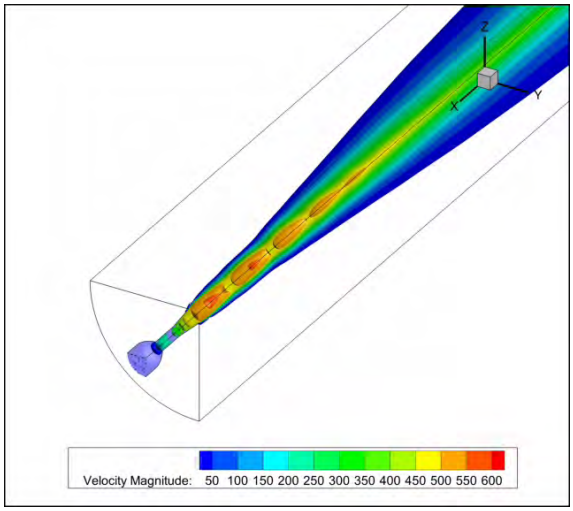
- begin with an underexpanded free jet
- cylindrical quarter model (axisymmetric flow)

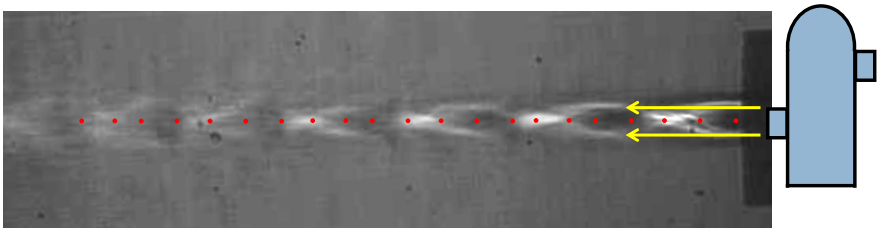


Free Jet – Velocity Contour



Free Jet Simulation

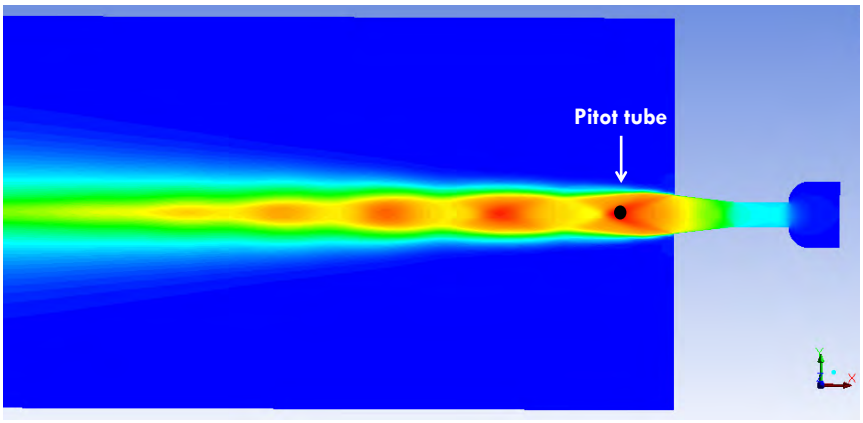
- Centerline Pitot Tube (PIP) measurements available



Pophali, "INTERACTION BETWEEN A SUPERSONIC JET AND TUBES IN KRAFT RECOVERY BOILERS"

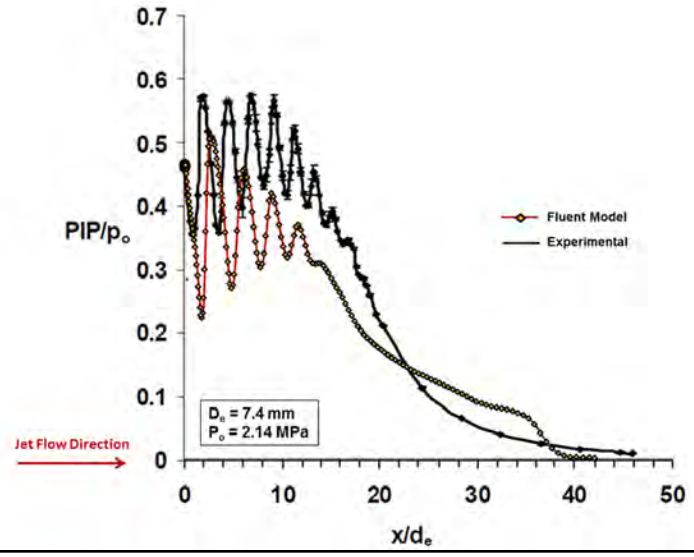
Peak Impact Pressure (PIP)

- Pressure a sootblower jet can exert on an obstacle
- A measure of sootblower effectiveness



Free Jet Centerline PIP

CFD vs Experimental Comparison



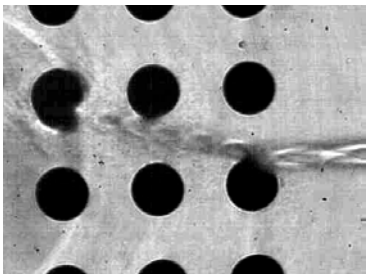
Schlieren Visualization

by Ameya Pophali

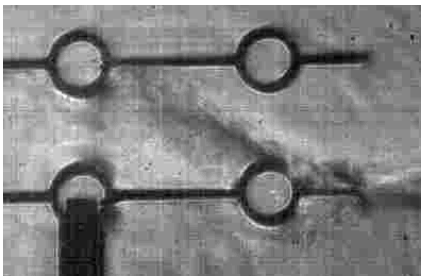
15

- ¼ Scale Sootblower Flow
- Key Measurement → PIP (Peak Impact Pressure)

Generating Bank

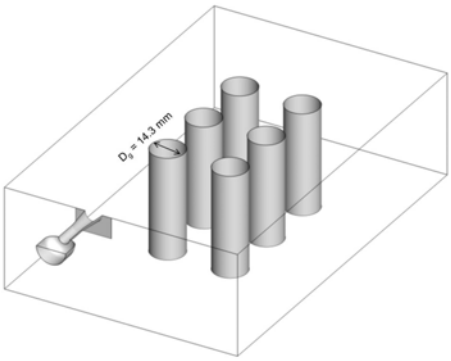


Economizer

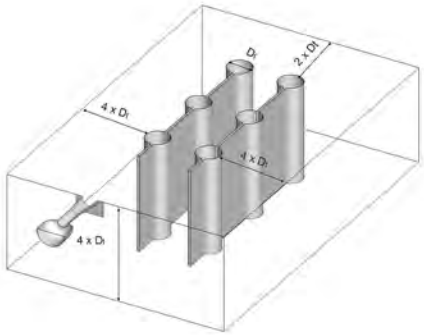


New Domains

Generating Bank



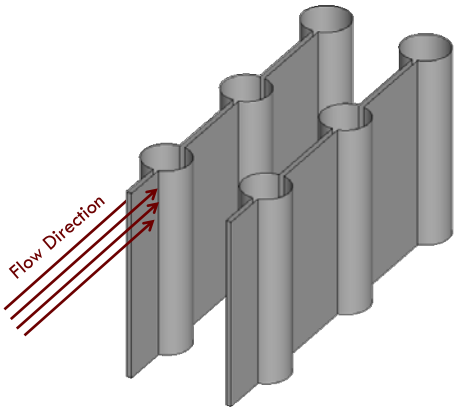
Economizer



Economizer

17

- Complex Flow onto Finned Tubes

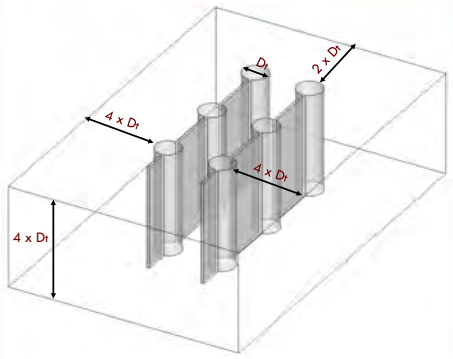


3D Domain of Economizer

18

- Insert Finned Tubes into Domain
- Domain Size based:

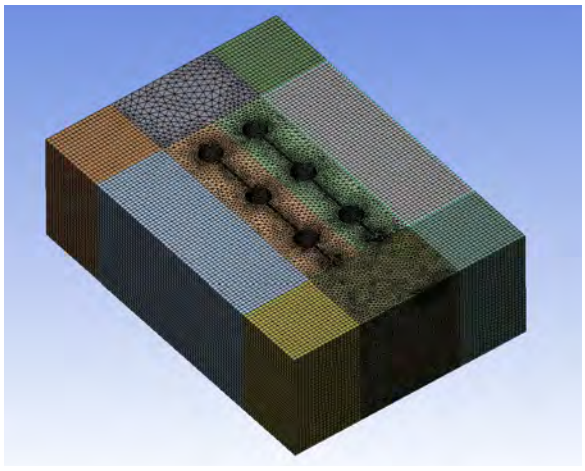
  D_t = 11 mm / 0.43 Inches (Tube Diameter)



Unstructured Mesh with Refinement

19

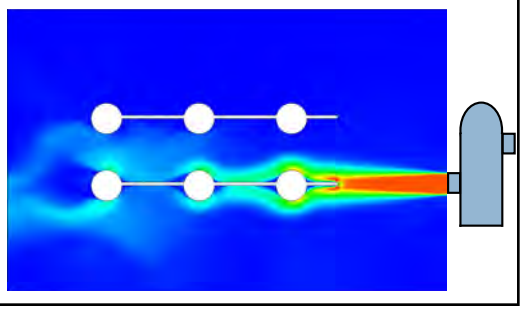
- Refine around Curvature / Areas of Interest



Incrementing the Inlet Mach Number

20

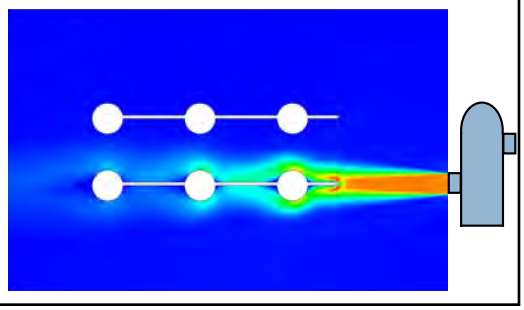
- Inlet Mach Number = 0.3



Incrementing the Inlet Mach Number

21

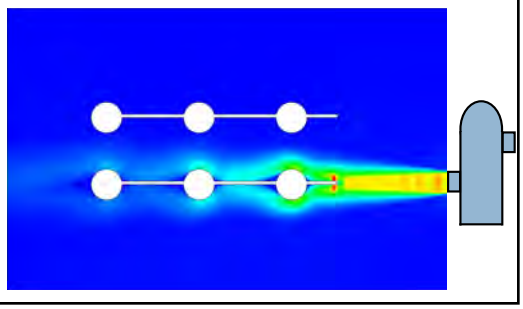
- Inlet Mach Number = 0.7



Incrementing the Inlet Mach Number

22

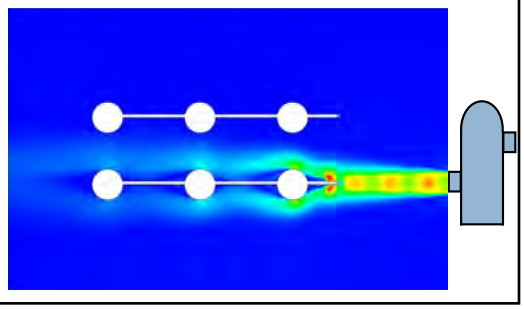
- Inlet Mach Number = 1.0



Incrementing the Inlet Mach Number

23

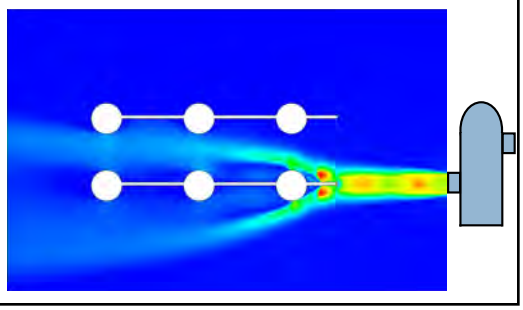
- Inlet Mach Number = 1.5



Incrementing the Inlet Mach Number

24

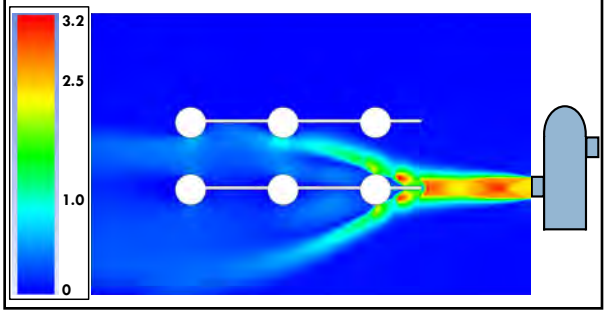
- Inlet Mach Number = 2.0



Incrementing the Inlet Mach Number

25

- Inlet Mach Number = 2.5



Comparison of Preliminary Results

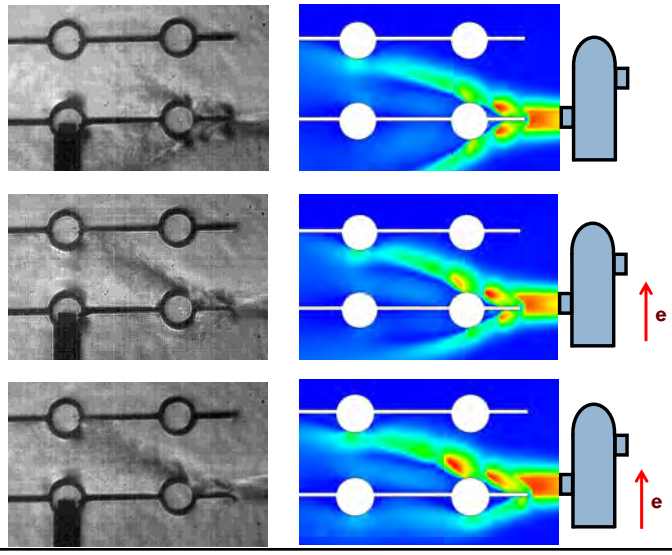
CFD plots vs Schlieren visualization

26

e/R = 0
(Head On to Fins)

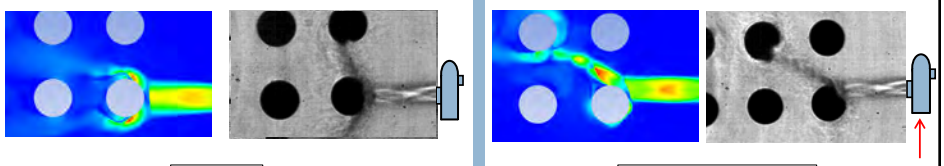
e/R = 0.36
(Slight Offset)

e/R = 0.71
(Upper Surface of the Fin)



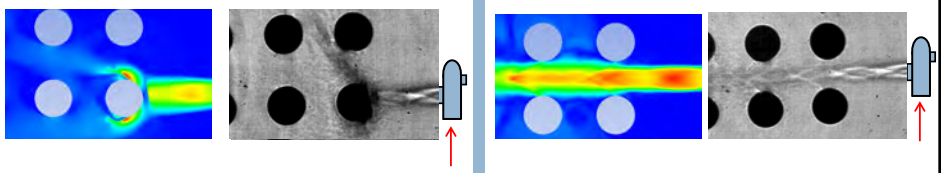
Nozzle Offsetting - Visualization

Generating Bank Results



Head On

Top Half of First Tube

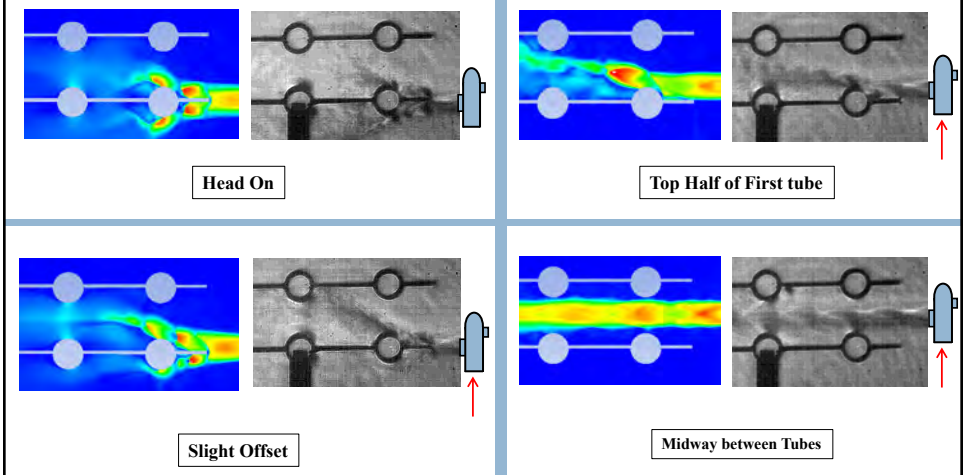


Slight Offset

Midway between Tubes

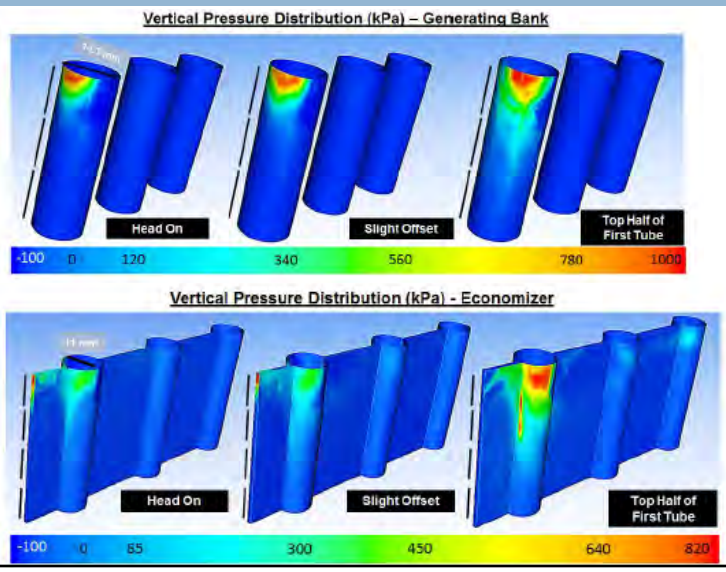
Nozzle Offsetting - Visualization

Economizer Results



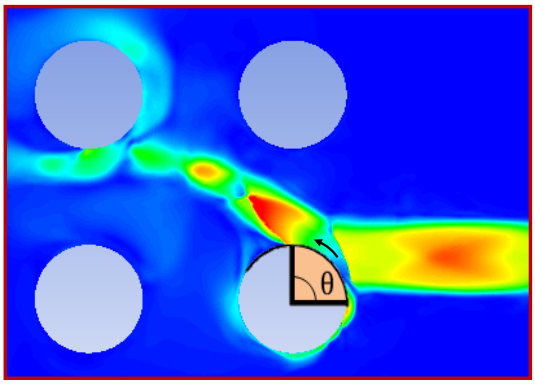
Gen. Bank + Economizer

PIP Distribution on tubes



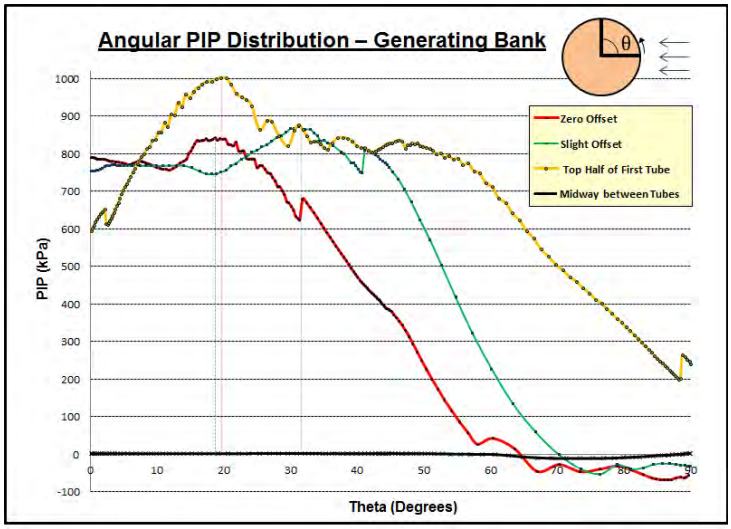
Gen. Bank + Economizer

PIP Distribution on Leading tubes



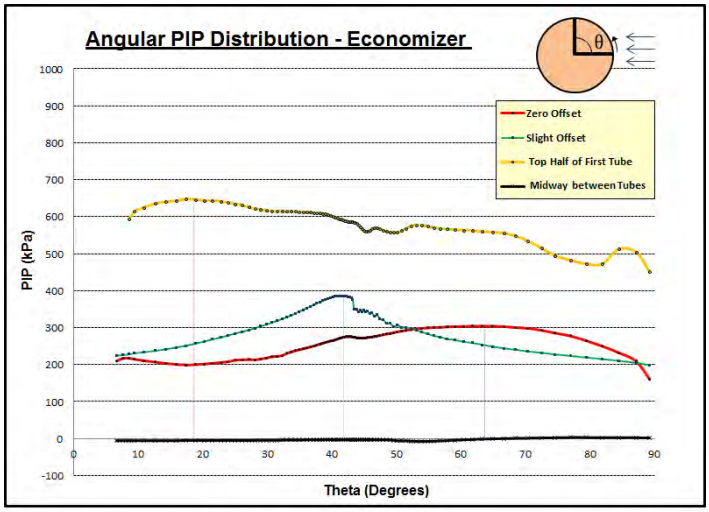
Gen Bank

PIP Distribution : Leading Tube



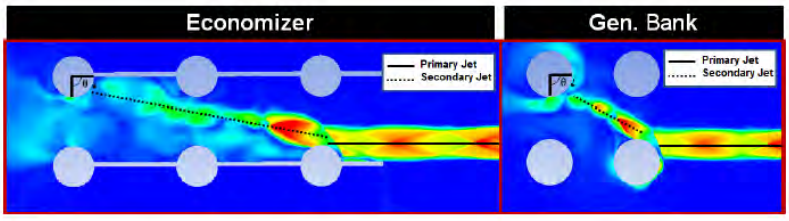
Economizer

PIP Distribution : Leading Tube



Secondary Jet Characterization

- Significantly lower PIPs exerted
- 70% (Eco.) and 80% (Gen. bank) reduction in Max PIP



In Conclusion

34

- CFD a very useful tool for modeling sootblowing
  - complement to experiments
  - good predictions of Peak Impact Pressure (PIP)
- primary jets exert significant pressure
  - secondary jets? – not so much
- future work?
  - focusing on deposits, not tubes
  - predicting deposit stresses, and cracking

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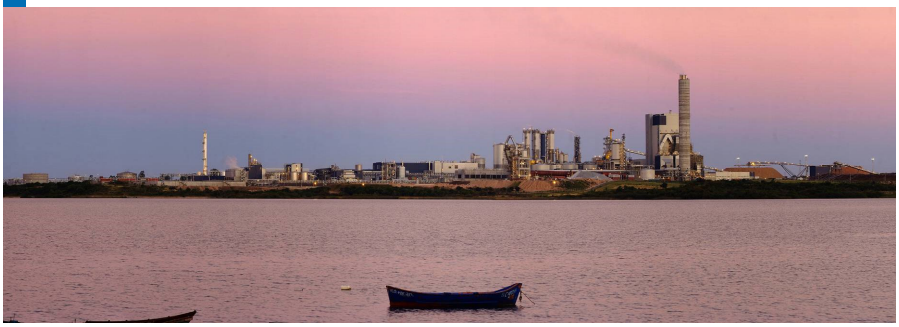
Boiler Services

Safe-Lok Burner System



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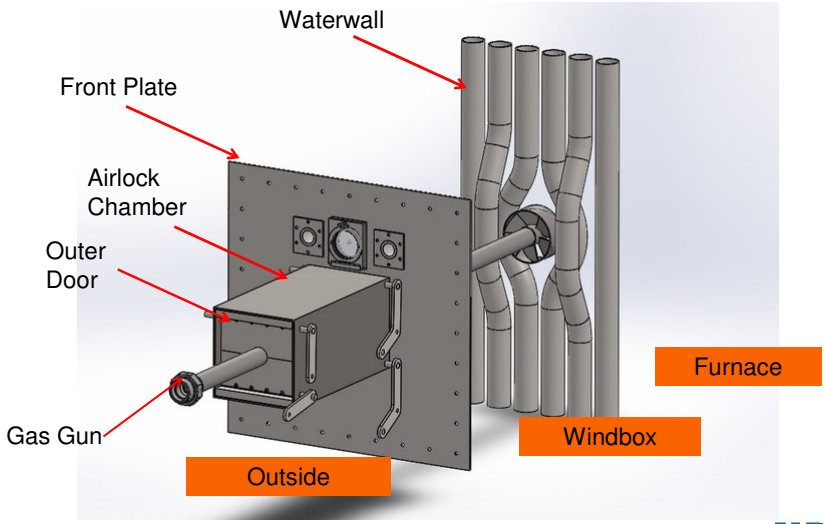
We accept the challenge!

Safe-Lok Burner System

Recovery Boiler start-up burners are:

- Unreliable
- Difficult to clean and maintain
- Cannot access innards while boiler is on line
- Difficult to operate
- Otherwise, no problem!

US patent has been allowed for a new solution – removable burners



3

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Safe-Lok Burner System

Features:

- Airlock to isolate windbox air from operators
- Easily manipulable gas gun
- Quick connects for electrodes and gas supply
- Rugged enough for operating environment
- Can remove / replace while boiler is on line

4

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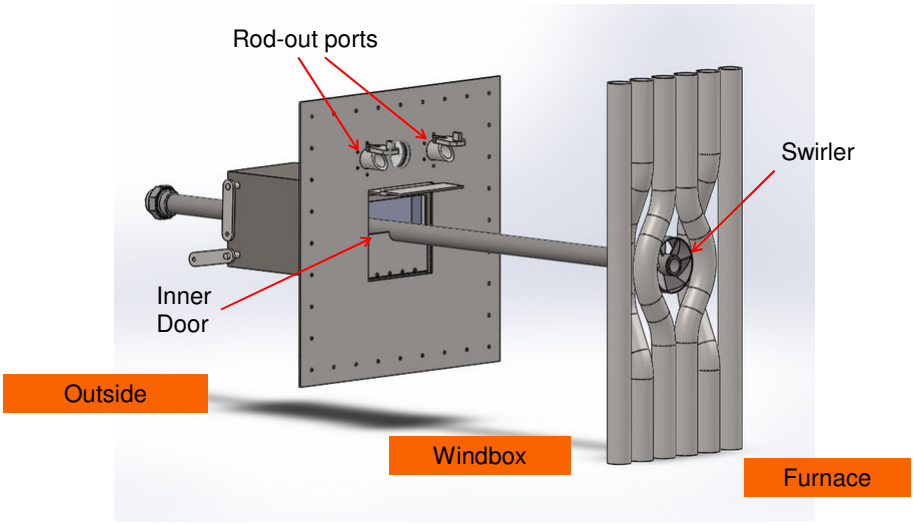

5

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Safe-Lok Burner System

Benefits:

- Higher light-off reliability
- Improved safety
- Easier to clean burner throats
- Clean, repair, or replace fouled equipment between outages

6

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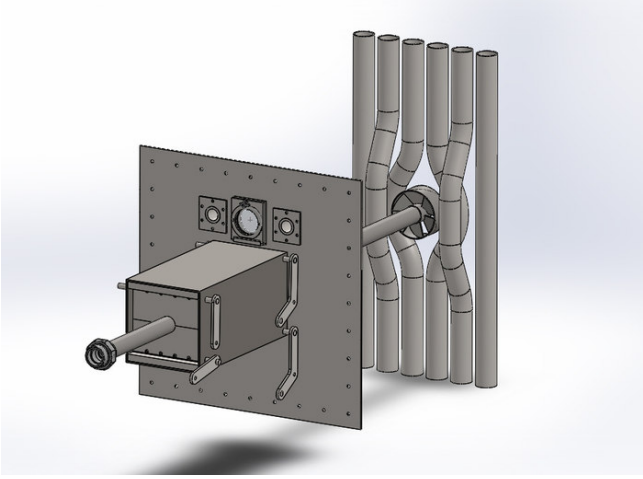
Safe-Lok Burner System



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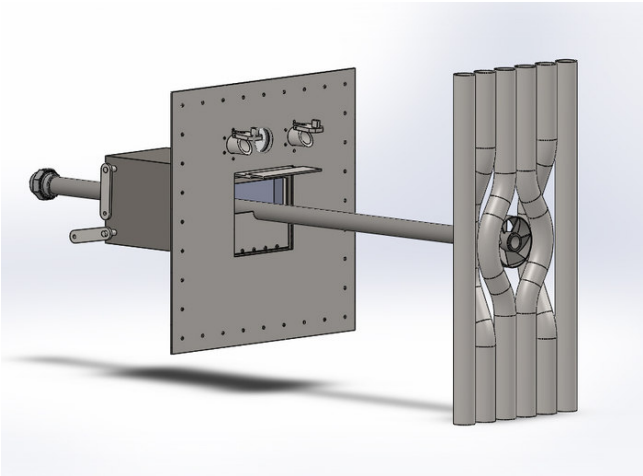
Safe-Lok Burner System



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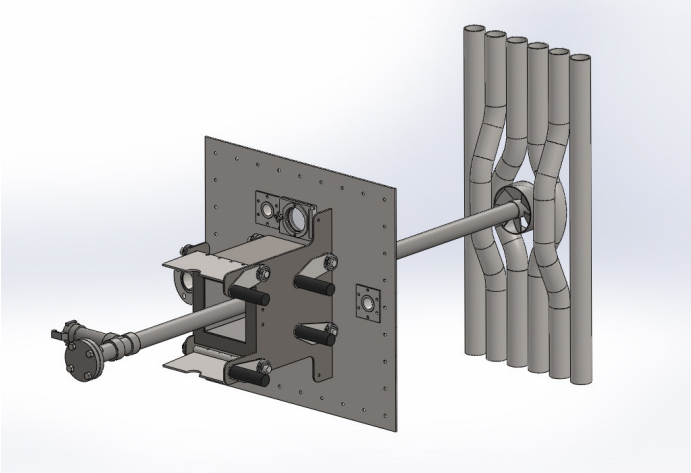
Safe-Lok Burner System



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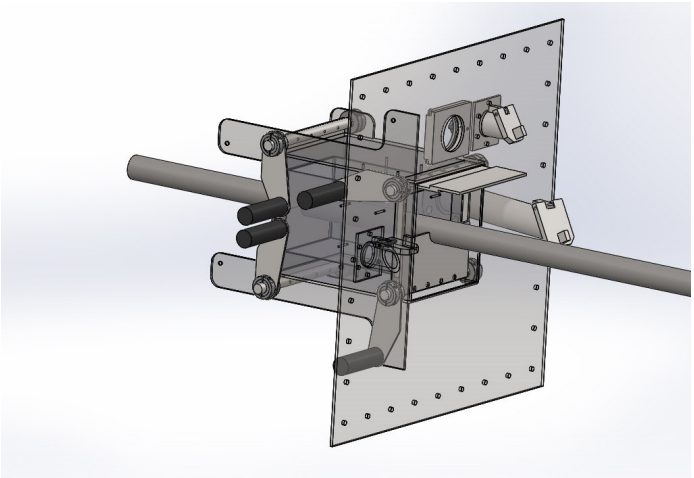
Safe-Lok Burner System



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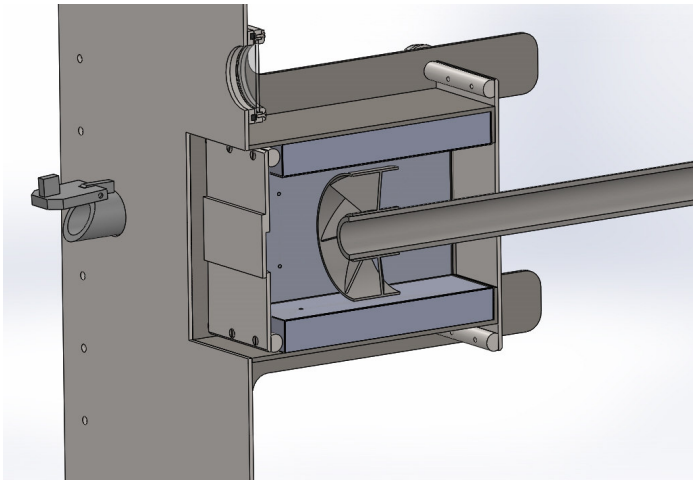
Safe-Lok Burner System



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Any questions?

For further information please contact:

ANDRITZ Inc.
770-640-2500

greg.imig@andritz.com

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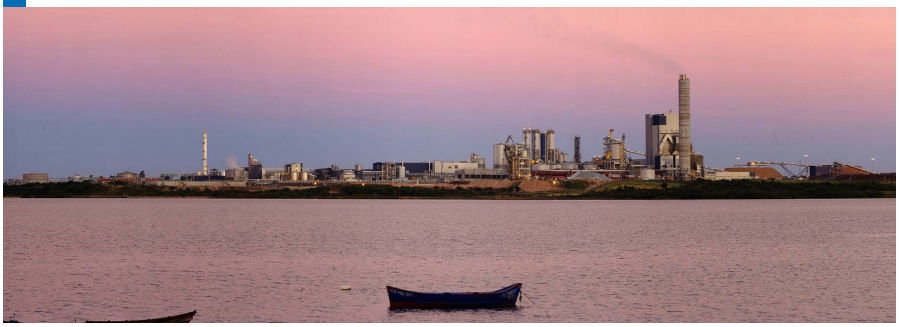
Boiler Services

Sootblower Castings



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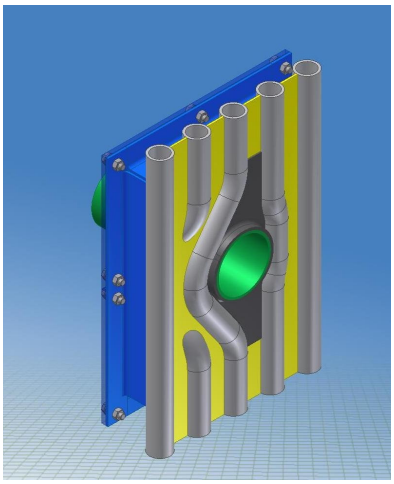
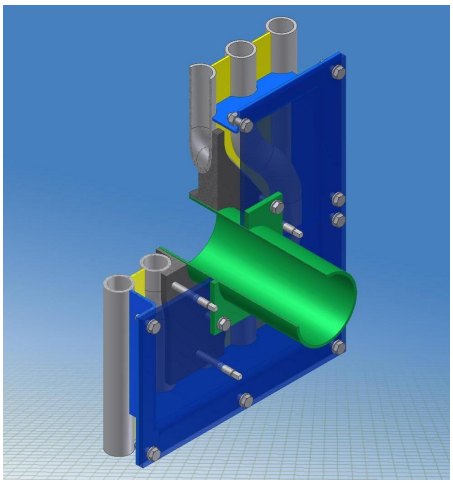
We accept the challenge!

Sootblower Port Castings

- Solution to cracks in membrane / crotch plates common around sootblowers.
- Prevents cracks from propagating into tubes.
- Mitigates a significant risk in a recovery boiler.
- Installations at three sites in Europe have demonstrated effectiveness:
  - Joutseno (Finland)
  - Stendal (Germany)
  - Obbola (Sweden)

Sootblower Cast Inserts – Cutaway Views





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Cast soot blower opening sleeve condition after 4 years of operation

Due the cracking of the wider fin areas Andritz has developed castings to fit the sootblower opening. The casting designed to be installed from outside of the boiler.

First application (pictured) was installed in mid-2012.

After four years operation, the sootblower cast nozzles were inspected from inside the boiler.

The first casting, and all subsequent castings installed were in very good condition.

No damage was evident in visual inspection.

Sealing safebond was also in good condition.

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Same opening was inspected from inside and outside after 1.5 years of operation

Box opened. Sealing refractory intact, no leaks, casting intact.

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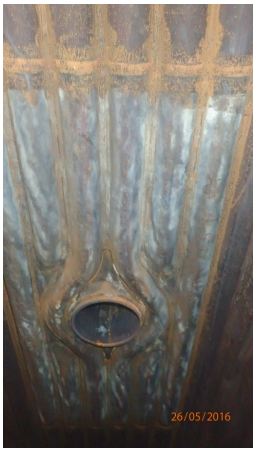
Panels with and without access door.



Typical sootblower panel (6 tubes)

Panel with sootblower opening + access door (10 tubes)

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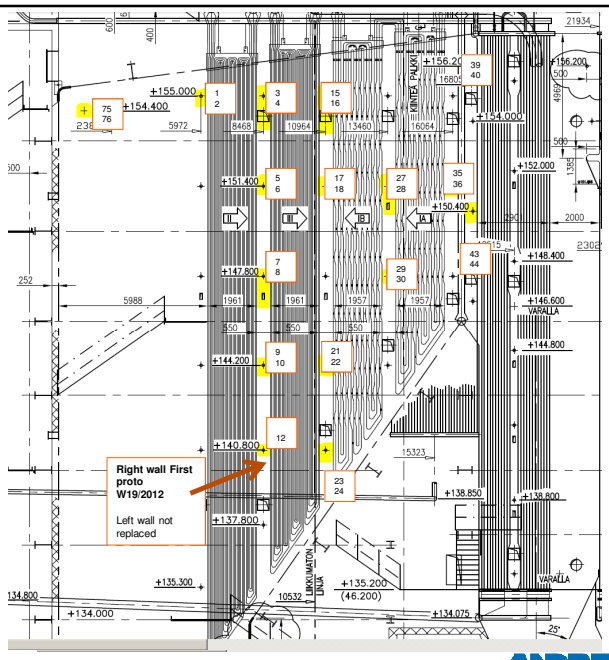
2016 Status

Sootblowers marked yellow where panels with cast nozzles were installed (2012-2015)

Total 31 pcs

SB 3, 4, 7, 8, 15, 16, 27, and 28 are long panels

Due the small distance between access door and sootblower, access doors were also replaced for easier erection



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GL Dissolving Tank Control: Reduce Risk of Smelt Dissolving Tank Explosions

Thanh Trung
FITNIR Analyzers Inc.
Vancouver, Canada

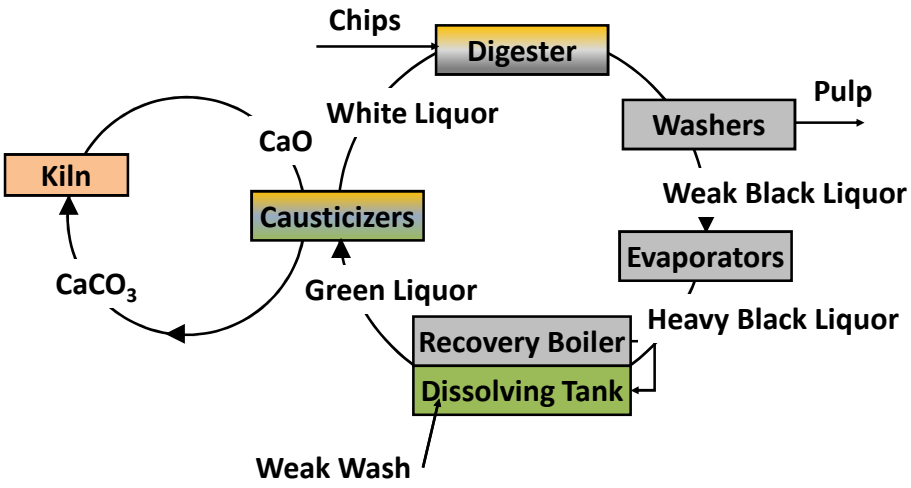
2017 AF&PA Recovery Boiler Program - Annual Conference & Committee Meetings
Atlanta, Georgia, February 7 – 8, 2017

Presentation Outline

- Motivation for dissolving tank measurements and control
- Challenges for process control
- Available technologies
- Current control practices
- Advanced control practices
- Potential Benefits
- Summary

Slide 2

Kraft Recovery Process



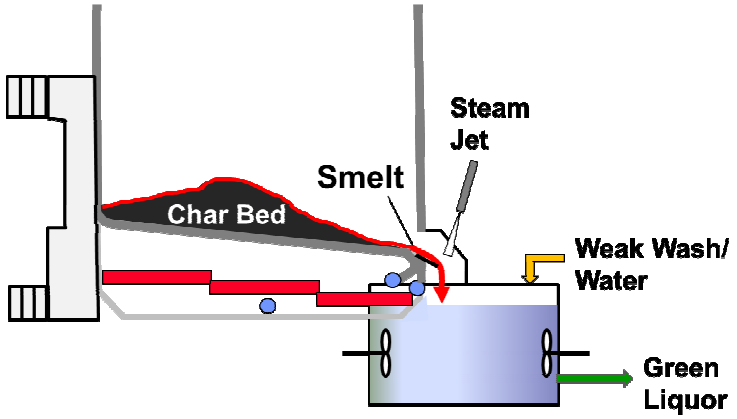
Slide 3

Process Requirements

- Safe operations and reduce risks associated with dissolving tank operation
  - Monitor for high TTA excursions
  - Limit TTA max. to minimize pirssonite deposits
- Efficient smelt dissolving tank control
  - Reduce variability of RGL TTA
  - Achieve target dissolver TTA
  - Provide good quality GL to recausticizing plant

4

Dissolving Tank Green Liquor Compositions



Na_2CO_3 + Na_2S + NaOH + Na_2SO_4

Tran, H.N., University of Toronto

Slide 5

Challenges in Dissolving Tank Control

- Uncontrolled smelt flow
  - Smelt run-off
- Incomplete shattering of smelt
- Level and temperature variations
- Weakwash variations
- All contribute to variations in TTA
- Density measurements
  - Errors due to scaling /fouling
- Lack of redundancy in measurements

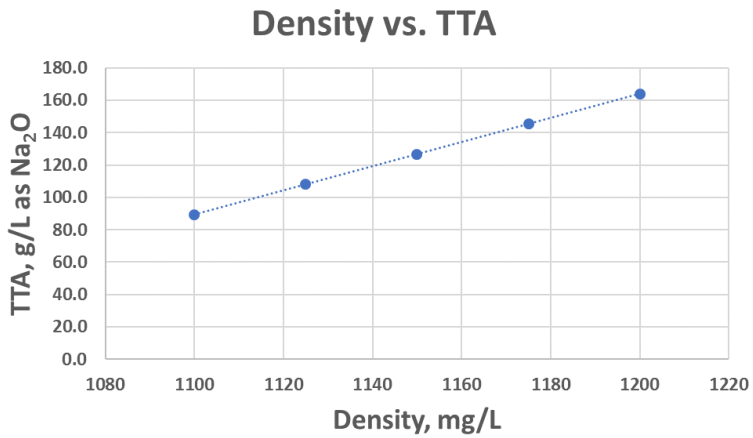
Slide 6

Density Measurements

- ABC – NaOH, Na_2CO_3, Na_2S
  - Slow
- Baume or stick test – manual test
- Online continuous measurements
  - Bubble tube
  - Nuclear gauge
  - Refractometer

Slide 7

Relationship Between Density vs TTA



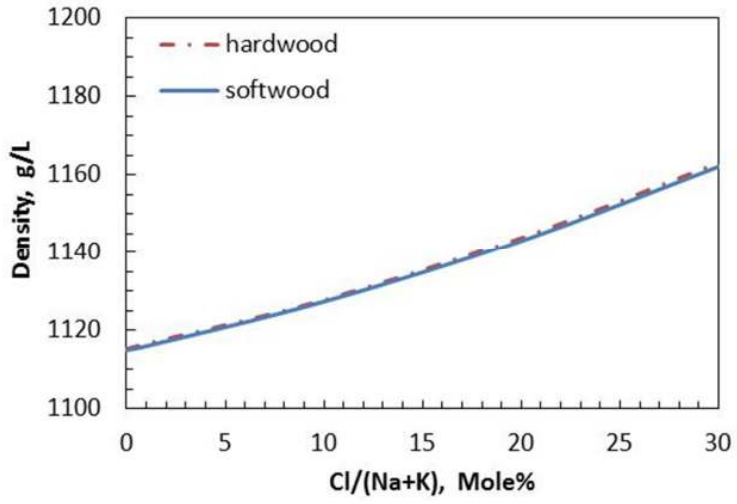
8

Green Liquor Compositions

Titratable	Non-titratable
Na_2CO_3	NaCl, KCl
NaOH	Na_2SO_4
Na_2S	Other metal soluble
Polysulfide	Dregs

9

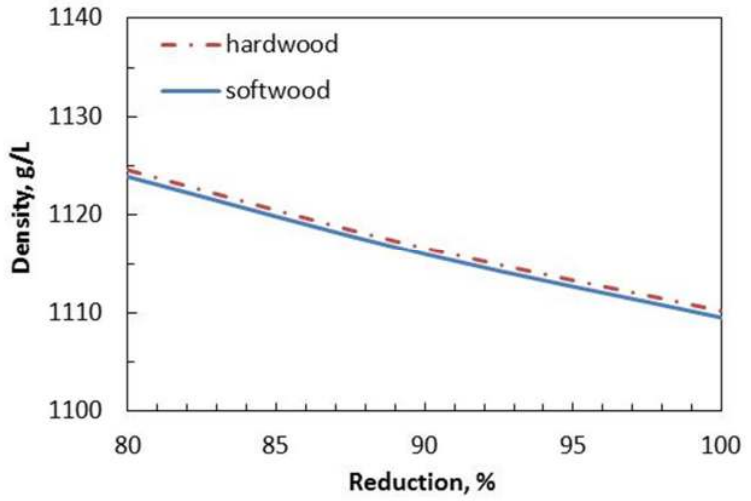
Impact of Chloride on Density



Mao, X., University of Toronto

10

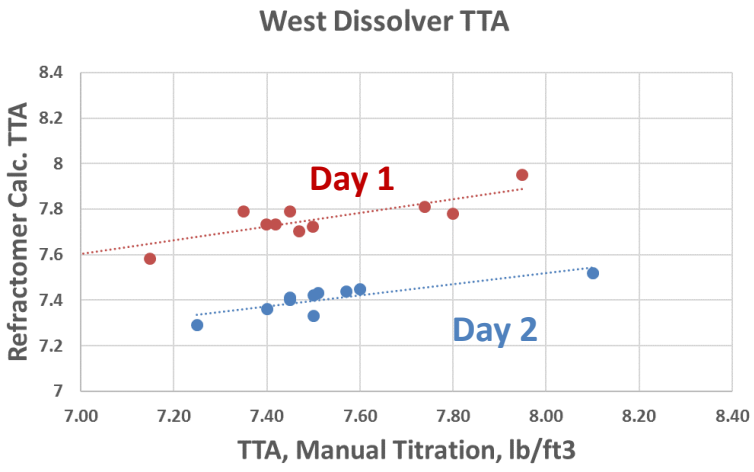
Impact of Reduction Efficiency



Mao, X., University of Toronto

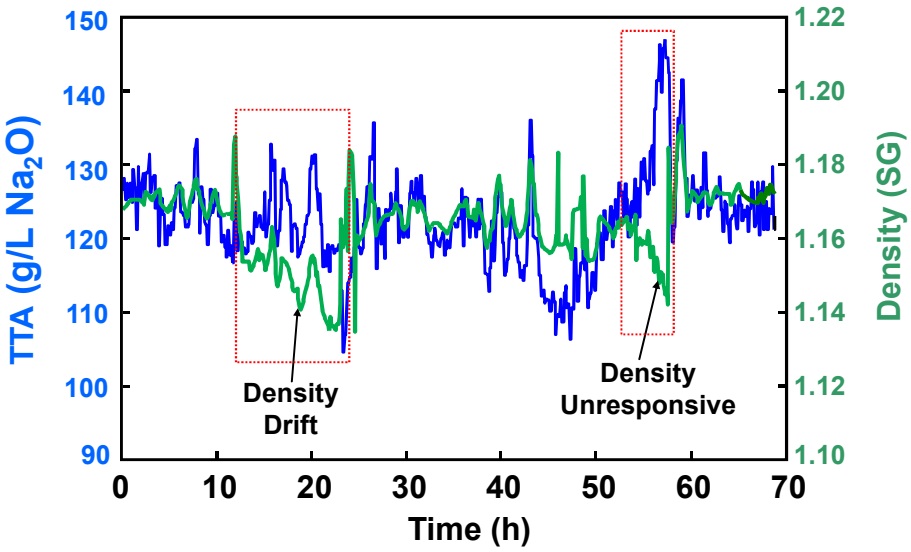
11

Changes in Refractometer TTA



12

Density Swings



Slide 13

Liquor Control Objectives

- **Main Objectives:**
  - **Stabilize TTA of green liquor (GL)**
  - Control lime addition
  - Stabilize white liquor EA to digester
- **Process Control Points:**
  - **Raw green liquor TTA control**
  - **Stabilization or Clarified GL TTA Trim control**
  - Slaker and CE soft-sensor
  - Lime quality estimator (LQE)
  - Slaker temperature control

Slide 14

Conventional Density Control

- Regulate green liquor feed to the slaker by means of density control: 2-steps:
  - Stabilize dissolver green liquor (course control) by adjusting weak wash/water
    - Target slightly higher than target at slaker
  - Stabilization tank or clarified green liquor to slaker is regulated to desired level with weak wash (trim control)

Slide 15

Challenges of Dissolver Density Control

- Under normal mill operating condition, density should have a good linear correlation with the TTA
  - Density increases linearly with an increase with TTA, Cl, and K content
  - Density decreases with an higher liquor reduction efficiency, causticity, sulfidity, and temperature;
- Drift occurs with fouling
  - Must be cleaned regularly for effective use.
- Could induce variations in TTA

Slide 16

Risk of Running with Density Alone

- Lack of redundancy of measurements in dissolver
- Measurement errors and possible prolong lack of density value due to scaling
- Error in measurements could induce conditions of higher TTA leading to higher risk
- Level and temperature control is also needed

17

Advanced Recovery and Causticizing Liquor Compositional Control

Online Auto-titration Analyzer

- **Measures green liquor TTA, sulfidity and reduction efficiency.**
- **TTA, EA, AA, CE% and Sulfidity for white liquor samples**

Courtesy of Valmet Automation

Slide 19

FT-NIR Online Measurements

Remote analysis via fiber-optic connection

Process Field Sampling Station

Spectrometer

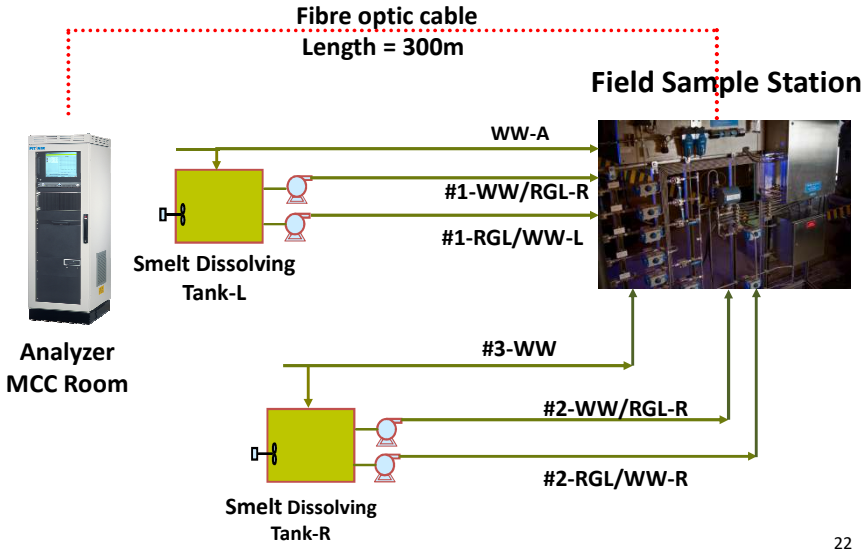
Slide 20

FT-NIR Green and White Liquor Measurements

- **Raw GL and Clarified GL:**
  - EA, AA, TTA, Carbonate, Sulfide, Sulfidity, Sulfate
  - Reduction efficiency
  - Chloride
- **WL: #1 Causticizer, #4 Causticizer, Final WL**
  - EA, AA, TTA, Carbonate, Sulfide, Sulfidity
  - Causticizing efficiency
  - Chloride

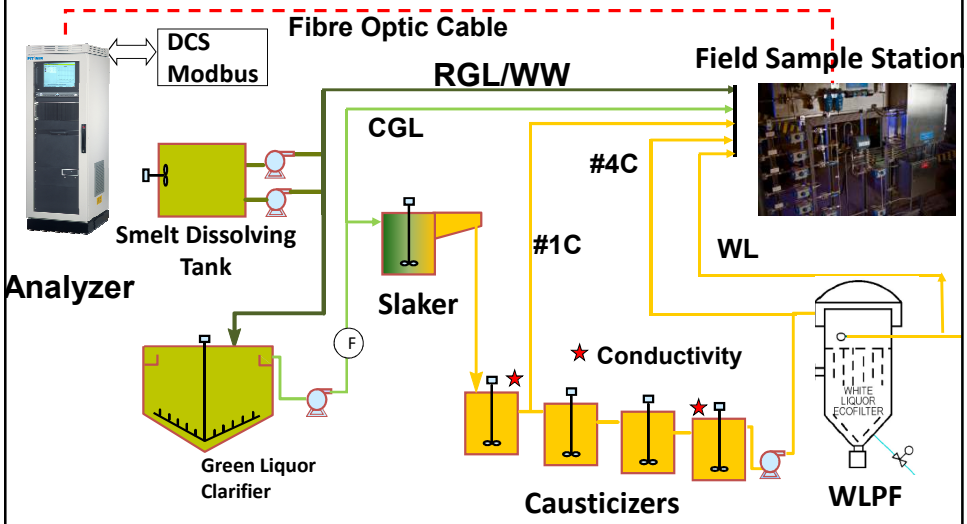
Slide 21

Smelt Dissolving Tank Measurements



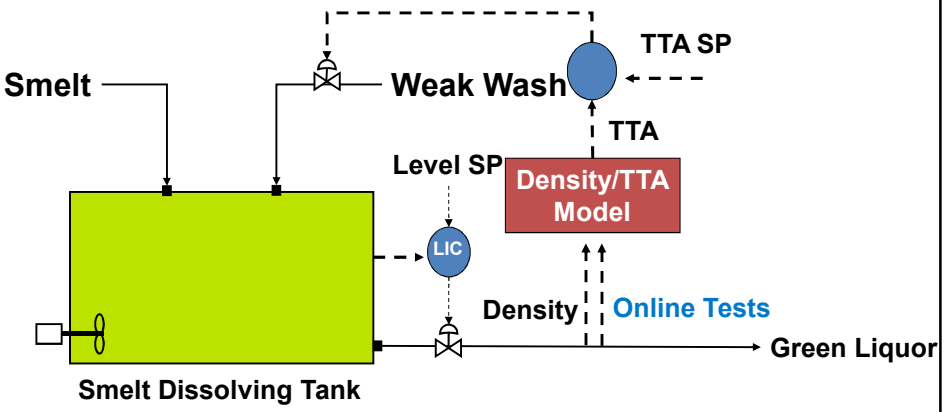
22

Recovery & Recaust Measurements



23

Advanced Dissolving Tank TTA Control



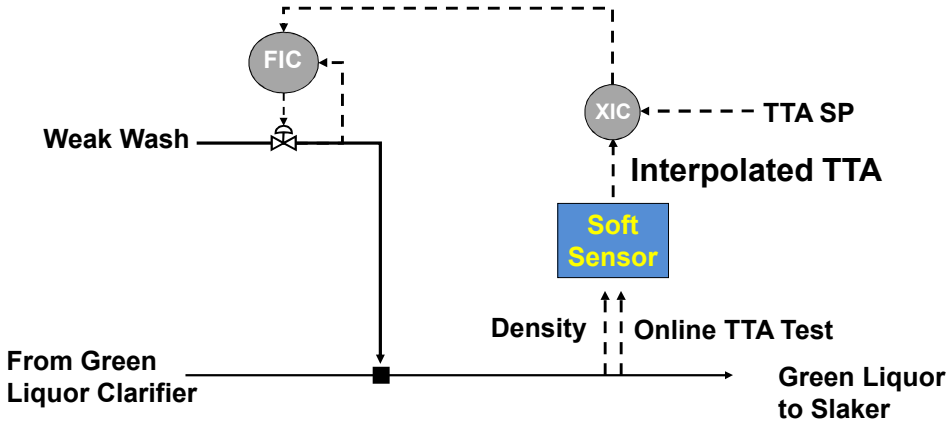
Slide 24

Advanced Dissolving Tank TTA Control

- **Continuous Density Signal**
  - **Safety, short-term, closed-loop**
- **True Liquor Compositions**
  - **Automatically corrects density drift**
  - **Calculates TTA-saturation point from liquor compositions**
  - **Temperature control > 80 deg. C**
  - **Minimize pirssonite formation**

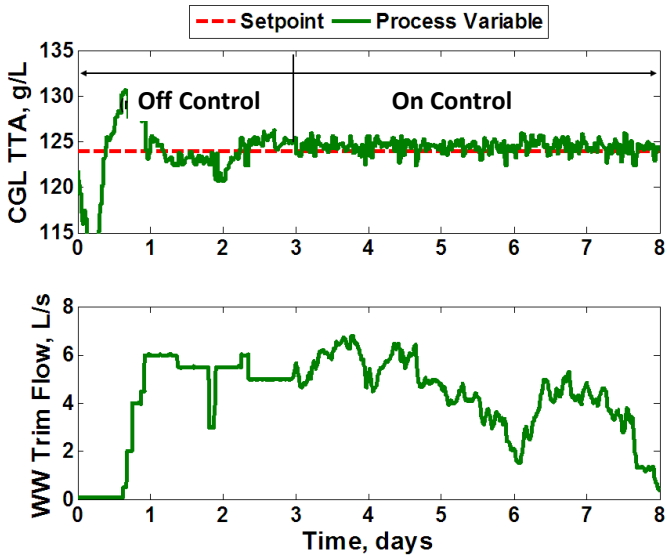
Slide 25

Advanced Clarified GL TTA Trim Control



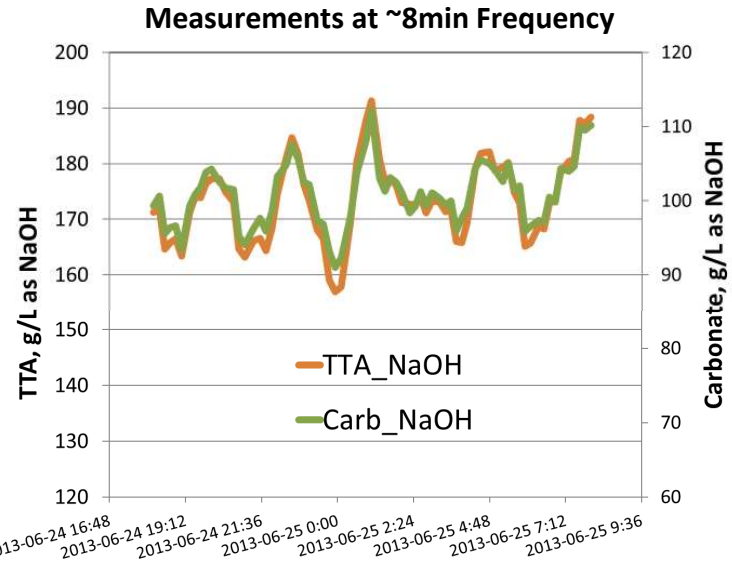
Slide 26

Trim Control Sets STAB or CGL TTA



Slide 27

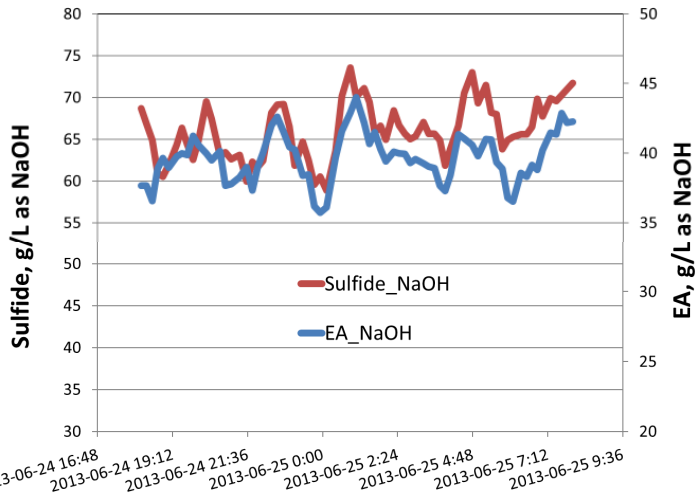
Case Study: Scandinavian Mill



28

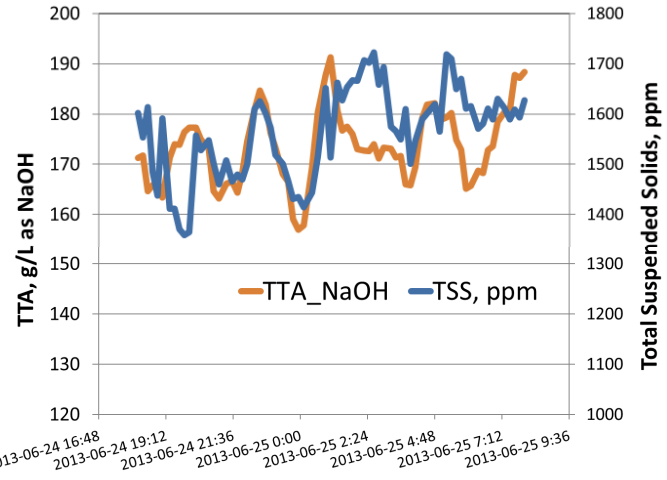
Variations in GL Sulfide and EA

Measurements at ~8min Frequency



29

TSS and TTA



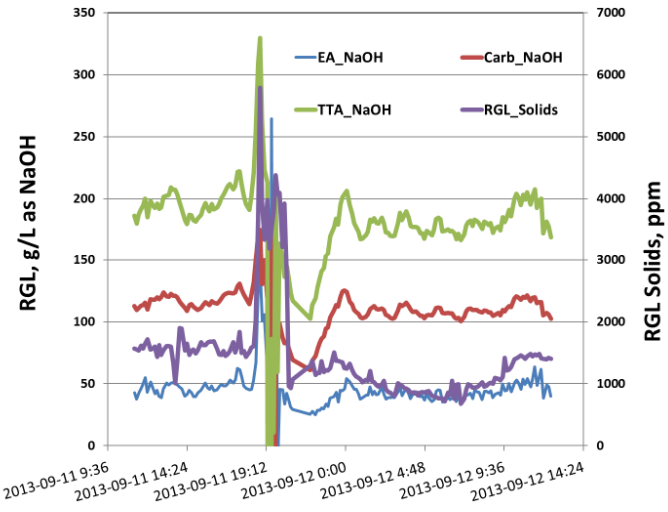
30

Conditions Leading to Excursion

- Mill was performing air distribution adjustments to lower solids in liquor
- Resulted in uncontrolled smelt flow (runoff)
- Attempted to reduce load by taking out gun(s)
- Tripped boiler
- Analyzer measured at 8min frequency captured the event: could be used as redundant information for large excursions

31

Analyzer Profile of Smelt Run-off



32

Summary

- Conventional density measurements provide continuous measurements
  - Density linear with TTA
  - Density foul overtime and must be compensated
- Control based on density alone could lead to instability and large excursions in TTA

Slide 33

Summary

- Advanced controls based on true liquor compositions
- Soft Sensor combines continuous density with true liquor compositions
  - Relate density to TTA
  - Corrects for drifts
  - Stabilize process
- Allow secondary measurements to reduce risk of dissolver excursions

Slide 34

Benefits Dissolver Control

- Stabilize GL TTA leading to better recaust operations
- Debottleneck Recovery and Recausticizing
  - Provide sufficient liquor to digester
- Provide redundancy in dissolver GL measurements of TTA
- Reduce risk of dissolver TTA excursions

Slide 35

Disposing of secondary sludge (biosludge) in the recovery boiler

AF&PA Recovery Boiler Conference
Atlanta, GA, February 2017

Raymond Burelle
Kai Lüder
Kristin Lindholm
Mats Nordgren
Anders Wernqvist

Valmet

Type of different sludges

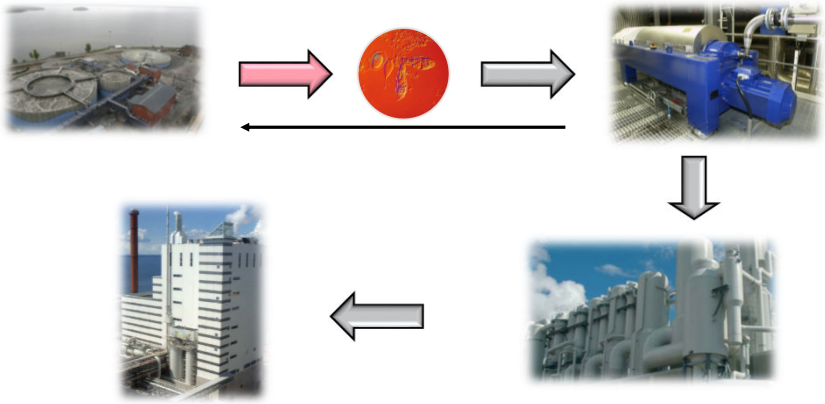
- **Bark sludge**
  debarked wood, bark, sludge in sand trap and suspended material
- **Fiber sludge** (**primary sludge**)
  suspended material separated in the pre-sedimentation basin
- **Biological sludge** (**secondary sludge**)
  sludge formed in biological purification of exhaust
- **Chemical sludge**
  sludge generated and separated in connection to chemical purification degree
- **Other**
  de-inked sludge
  sludge from treatment of coating kitchen exhaust
- Note! Biological/secondary sludge is the only sludge that can be treated and handled in evaporation plant

Potential secondary sludge disposal methods

- Landfill
  - Can have a significant cost with both transportation and disposal due to high water content (leaching) and potential for odors.
  - Europe no longer allows landfill of biomass material.
- Composting and land spreading
  - Treatment required for odors and potential biological contaminants.
  - Problems with public acceptance.
- Incineration in power boiler
  - Loss of boiler thermal efficiency due to high water content; net energy penalty.
  - Problems with combustion stability, emissions.
  - Potential for increased corrosion.
- Incineration in recovery boiler
  - Water removed in evaporators with multiple effect economy.
  - Limited handling of the wet sludge.

Combustion of biological sludge in recovery boiler

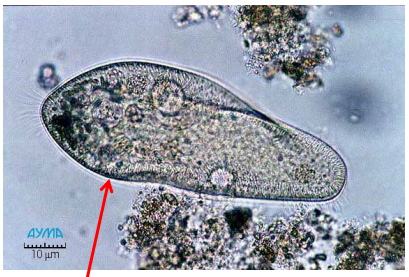
- **Biological sludge needs to be pre-treated.**



Why hydrolyze?

- The purpose of hydrolyzing the biological sludge is to:
  - Collapse the micro organism, type ciliates in order to release the bounded water and prevent scaling in the evaporation plant.

- Typical ciliat

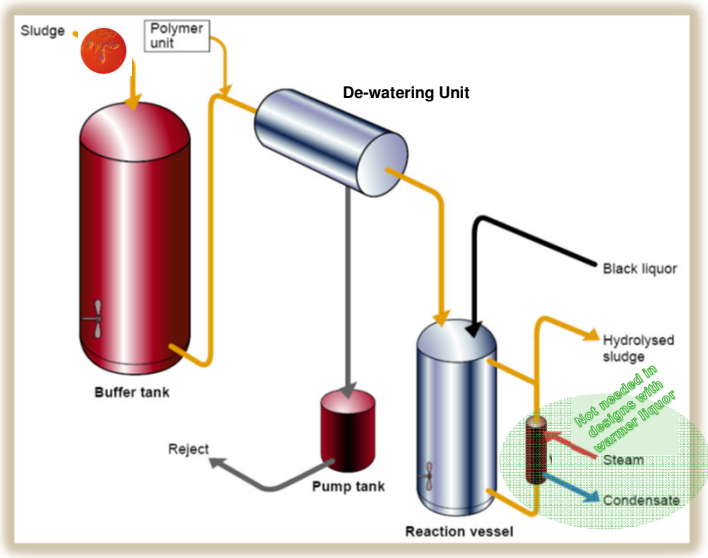


The hydrolysis in alkaline hot enviroment (> 80 ºC) will collapse the cell wall of the microrganism

Secondary Sludge Hydrolysis

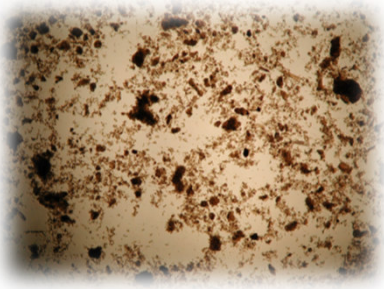
- Process consists of two parts; dewatering and hydrolysis reaction
- Dewatering
  - Polymer is added to the sludge which is typically at between 0.5% and 3% solids
  - Decanter centrifuge is used to remove water and bring the solids up to between 8% to 12%.
- Hydrolysis
  - Sludge is discharged from the centrifuge into the reaction tank where it is mixed with intermediate strong black liquor (between 40% to 50% DS).
  - Mixture is kept above 80 ℃ (175 ℉) for a minimum of one hour.
  - High pH of the mixture completes the break down of the cell walls.
- Liquor with sludge is returned to the inlet of the concentrators

Pre-treatment of biological sludge

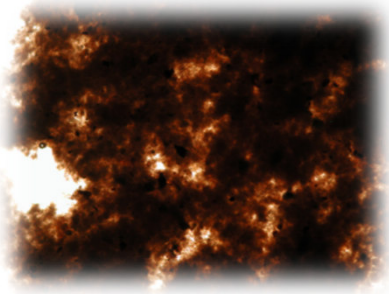


Biological sludge

- Sludge before adding polymer



- Sludge after adding polymer



References

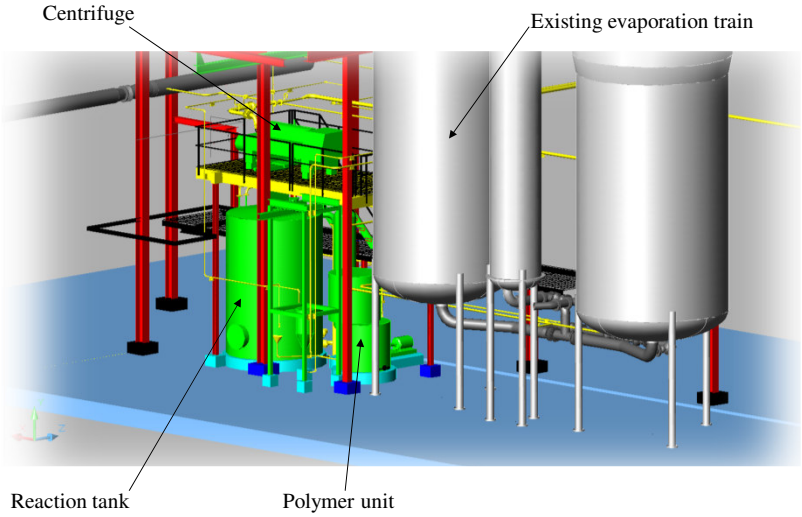
- **Botnia Kemi Mills, Finland**
  1994 Centrifuge
- **Stora Enso, Skutskär, Sweden**
  2001 Centrifuge
- **Södra Cell, Värö Mill, Sweden**
  2002 Centrifuge
- **M-real, Husum Mill, Sweden**
  2004 Centrifuge
- **BillerudKorsnäs Gruvön, Sweden**
  2006 Belt thickener
- **Södra Mönsterås, Sweden**
  2012 Belt thickener

- **Ence Pontavedra, Spain**
  2012 Centrifuge
- **Södra Värö, Sweden**
  2016 Centrifuge
- **SCA Östrand, Sweden**
  2017 Centrifuge

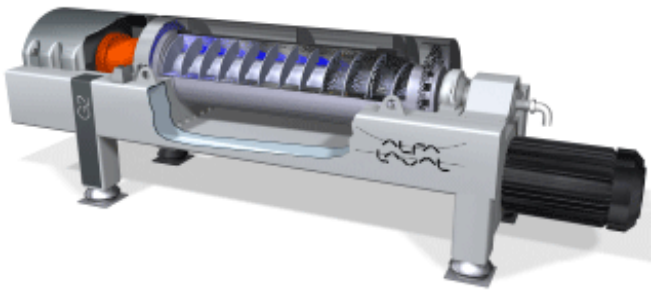
Stora Enso Skutskär mill, Sweden

Södra Cell Värö Mill 2002

Södra Cell Värö Mill 2016



Typical centrifuge



Impact on Recovery Boiler and Evaporators

- No negative impact experienced in recovery boiler
  - No change in reduction efficiency.
  - No changes in emissions.
- Impact on evaporators
  - Steam consumption increased based on added water content, but with benefit of multiple effect economy.
  - No scaling issues with treated sludge added just prior to final concentration.
  - Additional steam consumption less than loss of steam production if secondary sludge was fired in power boiler.
- Positive ROI at mills where system was implemented compared to the more traditional methods of disposal for secondary sludge.

Impact on NPE in the Liquor Cycle

- Non-Process Elements (NPE) in the liquor cycle will be affected by the incineration of secondary sludge in the recovery boiler.
- Main NPE that can be affected are Al, Ca, Fe, K, Cl, Mg and P.
- K an Cl typically controlled by purging or treating the recovery boiler precipitator ash.
- Si and Al can cause sodium – aluminum - silicate scale in the evaporators. This can be controlled with Mg to precipitate Al in the recaust plant and remove it with the dregs. $MgSO_4$ used in the bleach plant at Skutskär mill caused enough Al precipitation to manage its level.
- P accumulation can be controlled by using additional make-up lime (Skutskär used addition of 2 to 5 kg/ADT).

Impact on NPE in the Liquor Cycle

- Nitrogen content in the secondary sludge may increase the NO_x emissions. Air system adjustments / upgrade are the means to control them.
- NPE mill balances can be used to evaluate the impact of adding secondary sludge to the recovery boiler.
- Several paper have been published that discuss the impact of incineration of secondary sludge in the recovery boiler. References are provided in the paper given at the 2016 Tappi Peers Conference.

Conclusion

- Secondary sludge is difficult to disposed off. Landfill, land spreading and incineration in the power boiler all have significant drawbacks. Landfill of secondary sludge no longer allowed in Europe.
- Incineration of secondary sludge in the recovery boiler has been done successfully at several locations in Europe.
- Dewatering, hydrolysis and injection of the secondary sludge in the black liquor prior to concentration allows for water removal without causing scaling in the evaporator.
- Impact of NPE in the liquor cycle has been evaluated and means of control are available.

Committed to sustained performance improvement

Valmet Performance Solutions

Recovery Optimizers & Interactions

Valmet

Performance Improvement – How we work

Understanding the need

Process improvement study
- Evaluation of the potential and reasonable targets
- Is the Mill a candidate for optimization?

Project phase
- Operator interviews
- Control design
- Reporting and monitoring tools installation
- Programming and FAT
- Commissioning, training, final tuning

Perfomance improvement agreement
- Remote support, performance follow up and reporting
- Development meetings
- On site work

Ensuring enhanced and sustained performance

Sustainability

- APC support and enhancement solutions
  - Process analysis and consulting
  - Continuous monitoring of performance
  - Operator training
  - System maintenance and application tuning
  - Evaluation and implementation of new solution components
  - Debottlenecking of controller constraints
  - Maximizing controller utilization
  - Proactive troubleshooting
  - 24/7 phone and email support

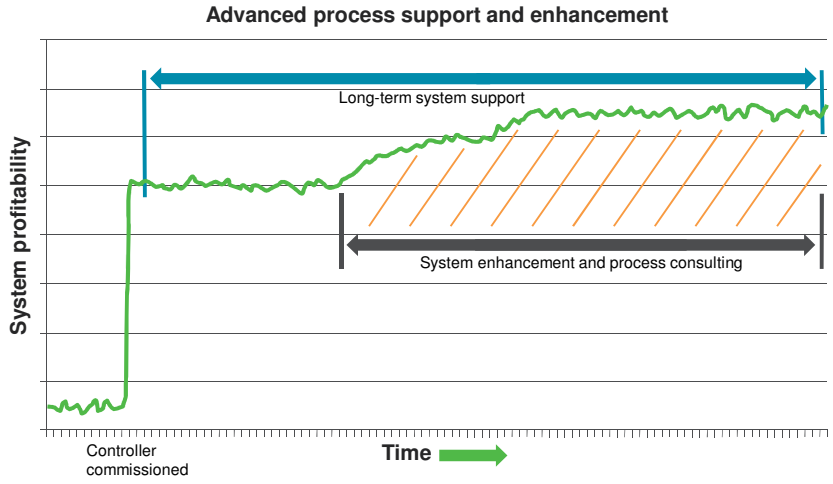
Our dedicated team – the key to success

The largest team of APC professionals for pulp and paper globally

- 50+ team members globally
- Broad process experience
- Regionalized experts
- Average experience 10+ years
- Dedicated project management
- Proven project results
- Continued system sustainability
- Centralized core competence

Maximizing performance and improving potential

Long-term Valmet Performance Solutions



Advanced Controls for the Entire Process

Debarking Optimizer
Less wood losses, 0,5 – 2 %-units

Continuous Cooking Optimizer
Kappa variation decrease 20 – 50 %
Production increase of same wood 0,5 - 3 %

Batch Cooking Optimizer
Kappa variation decrease 10 – 50%
Production increase of same wood 0,5 - 5 %

Washing Line Optimizer
Washing loss decrease 3 - 10 %
Dry solids content increase 0,3 - 1 % to evaporation

Oxygen Stage Optimizer
Kappa variation decrease 10 – 50 %
Bleaching chemicals savings 3 – 5 %

Bleaching Optimizer
Final Brightness at desired level
Final Brightness variation decrease 10 – 50 %
Bleaching chemicals savings 5 – 15 %

Causticizing Optimizer
Increased production rate 1 – 3 %

Lime Kiln Optimizer
Decreased energy consumption 3 – 7%

Evaporation Optimizer
Increased burning liquor
Dry solids 1 - 3%

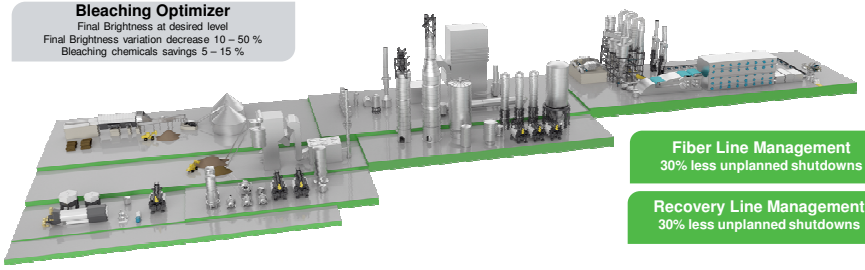
Recovery Boiler Optimizer
Increased production rate 1 – 3 %
Increased electric production 1 – 4%

RCF Optimizer
Reduced bleaching chemicals 10-40%
Improved plant yield 1-3%

TMP/BCTMP Optimizer
Reduced specific energy 3-10%
Increased production 3-7%

Brightness Optimizer
Chemical Reduction 10-30%

Pulp to Paper and Blending Optimizer
Paper strength variability reduction up to 35%



Fiber Line Management
30% less unplanned shutdowns

Recovery Line Management
30% less unplanned shutdowns

Trusted by the world's leading pulp mills

Over 270 optimizer applications worldwide

20	Batch cooking	43	Causticizing
22	Continuous cooking	25	Lime kilns
11	Washing	22	TMP and BCTMP
9	O2 delignification	9	Recycled fiber
40	Bleaching	12	Brightness
14	Evaporation	2	Stock preparation and Stock blending
42	Recovery boilers		

Recovery Line Optimization Systems Benefits & Interactions

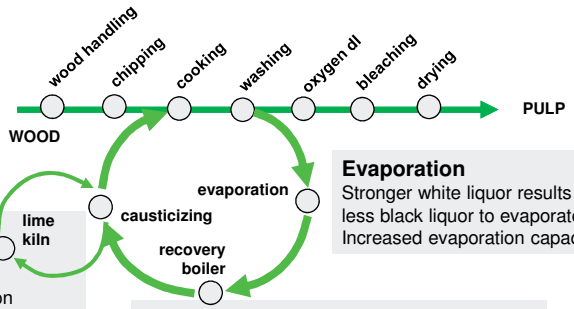
Recovery Boiler and Sootblowing Optimizer

Valmet

Optimizing Controls

Benefits & Interactions for entire pulp mill and liquor circle

Cooking
Stronger and stable quality white liquor enables Production of better & even Quality of pulp



Evaporation
Stronger white liquor results in less black liquor to evaporate
Increased evaporation capacity

Lime Kiln
Lower energy need
If lime kiln is the bottleneck
-> increased pulp production

Causticizing
Stronger white liquor ->
If causticizing is the bottleneck
-> increased pulp production

Recovery Boiler
Reduction efficiency increase with lower std
Energy efficiency increase due to:
Excess oxygen decrease with lower std
Lower flue gas outlet temperature
Lower emissions
Decreased recovery boiler fouling
Dry solids throughput increase
Steam production increase

Recovery Boiler Optimizer

Scope + add-ons

Valmet DNA

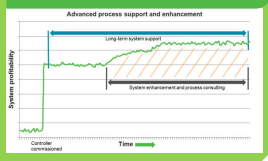
Valmet DNA based APC-platform can also connect to any other DCS

Combustion optimization
- Air distribution
- Boiler load
- Liquor droplet size
- Bed management
- Reduction Efficiency (add-on)
- Superheated steam temperature (add-on)
- Leak detector (add-on)

Emissions management

Sootblowing optimization
- Fouling indicators
- Sootblowing efficiency indexing
- Adaptive intervals

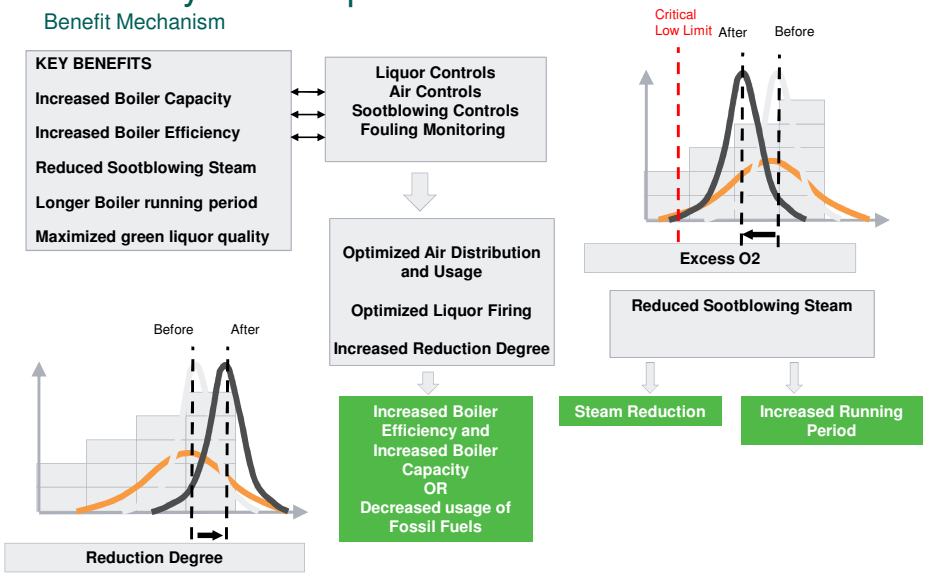
Performance Service



Dissolving tank optimization
- Valmet Alkali-R analyzer with Reduction Efficiency
- Na2CO3 solubility calculation
- TTA-control
- Dissolving tank mass balance stabilization (add-on)

Recovery Boiler Optimizer

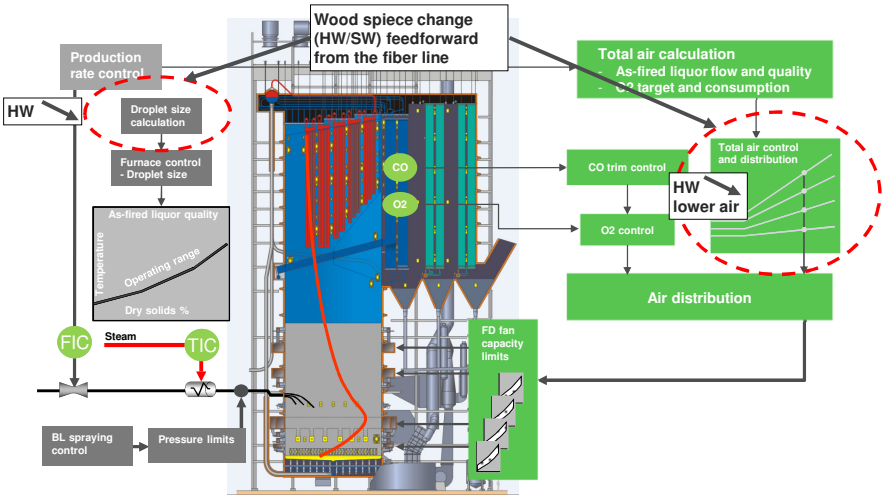
Benefit Mechanism



Recovery Boiler: power plant and chemical reactor

- Target is to maximize energy efficiency and operational run time between shut downs:
  - Energy efficiency, low fuegas exit temperature
  - Efficient sootblowing, boiler running period and steam consumption
  - Combustion management minimize carry over and emmissions
  - High and steady superheated steam temperature
- Chemical recovery:
  - Steady smelt flow to dissolver, charbed temperature and size/position is properly managed.
  - High and steady char bed reduction efficiency = high Na2S/Na2SO4 ratio
  - Low emmissions and long life time of the equipment. High dry solids is key.
  - High Na and S concentration from the dissolving tank

Combustion Optimization, Feedforward Feature



Alkali R measurement utilization

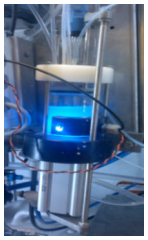
- On line, multipoint, modular analyzer
- Green liquor, lime milk, white liquor alkali analyses based on standard laboratory titration method ABC-titration/SCAN 30:85.
- Mill proven in over 600 sampling locations.
- Recovery boiler reduction degree analysis based on standard laboratory titrations
- Flexibility and expandability in analyses capacity when needs grow, with more speed and through put
- Cost effective and easy interfaces and installation , new diagnostics and supporting tools for life cycle services
- Safe, automatic sampling – no need for manual testing and presence at process site environment

Alkali R
Measurement options

Standard Titration

Proven, mill standard analysis method in hundreds of installations

Reduction Degree Titration



Provides actual liquor chemistry titration results (ABC-titration/SCAN 30:85)
Analyzer measures HCl consumption at each equivalence point and calculates: Na_2CO_3, NaOH, Na_2S and EA, AA, TTA, CE% and S% values for the sample

Recovery boiler reduction degree (includes ABC-titration)
Na_2S analysis by ABC-titration method and Na_2SO_4 titration with optical inflection point detection

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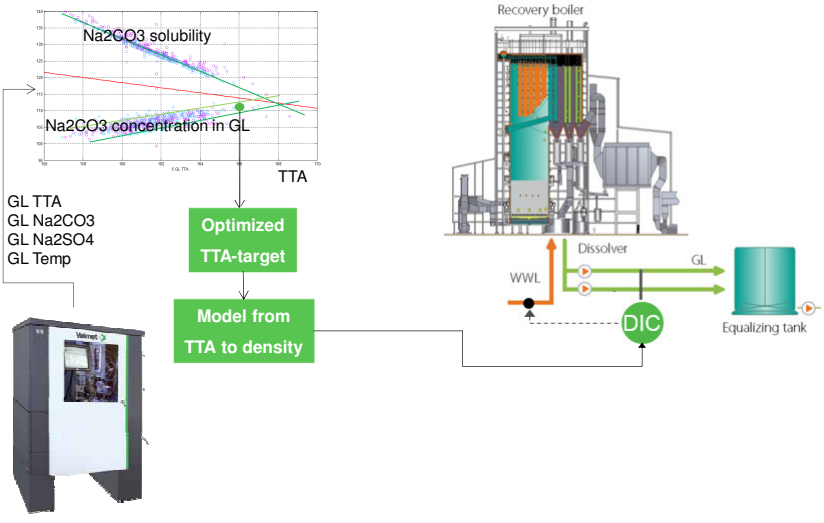
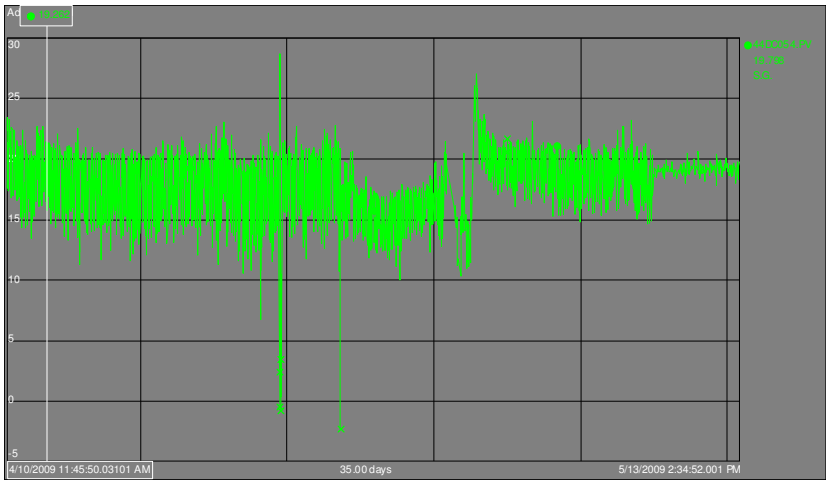
Dissolving tank TTA control
With Alkali-R

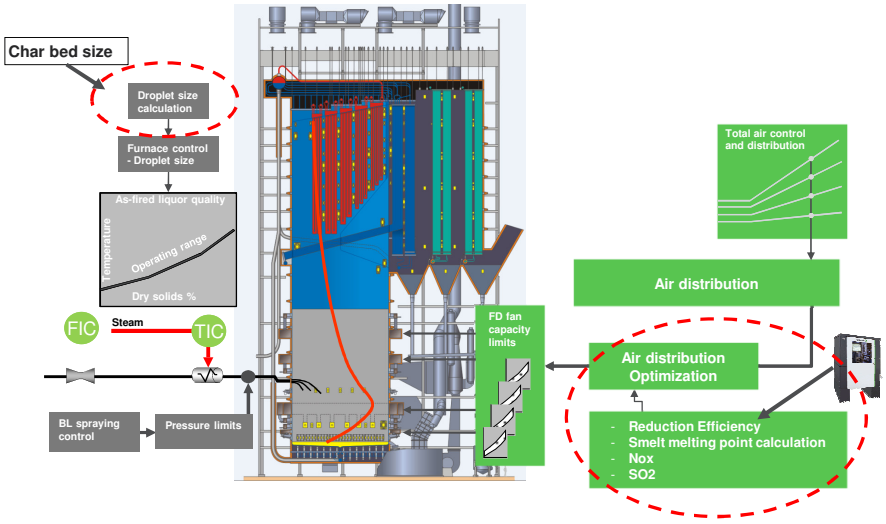


16 Date Author Title INTERNAL

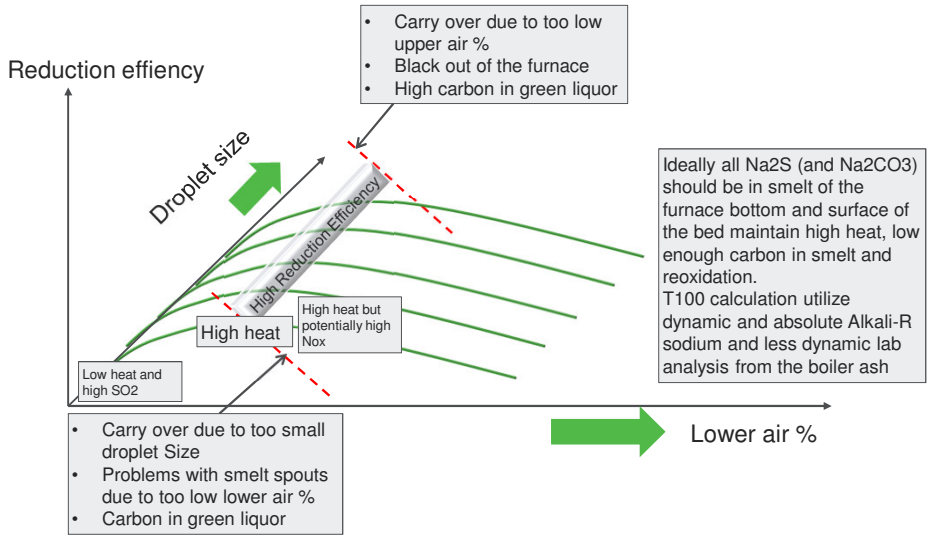
Good dissolving tank TTA control is CRITICAL to safely increasing TTA



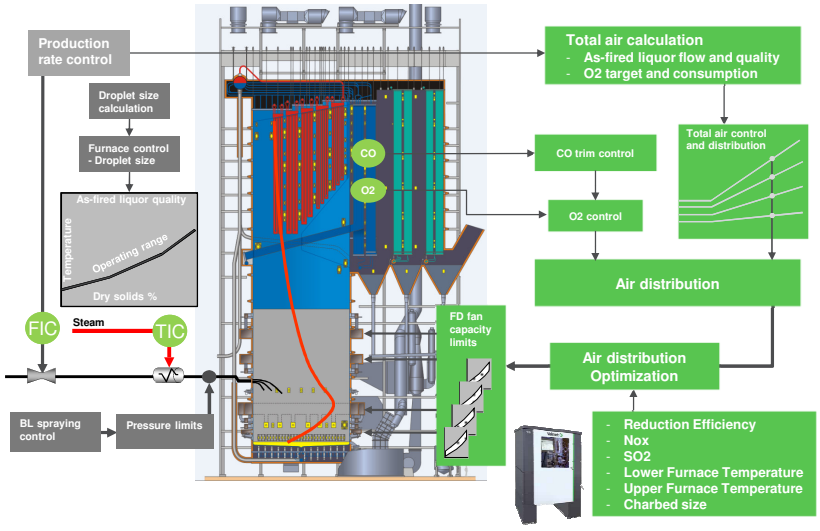
Combustion Optimization, Feedback



Reduction efficiency control challenge

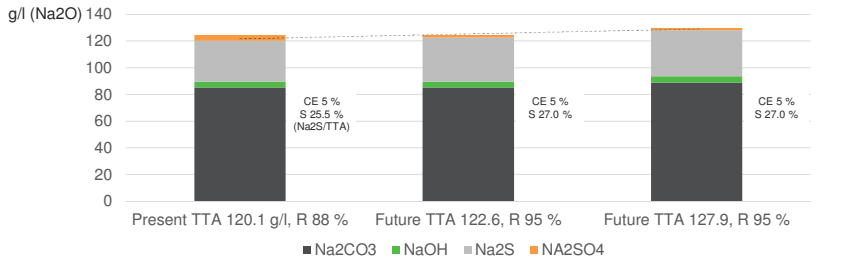


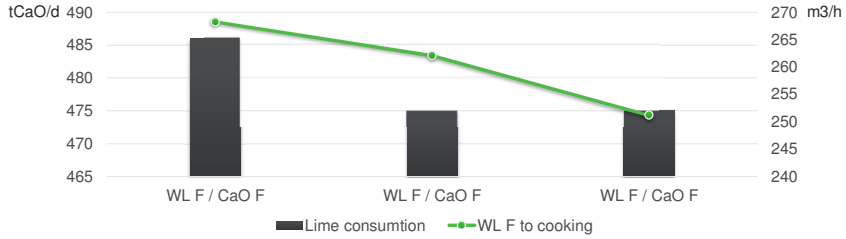
Recovery Boiler Optimizer



TTA Balance Change

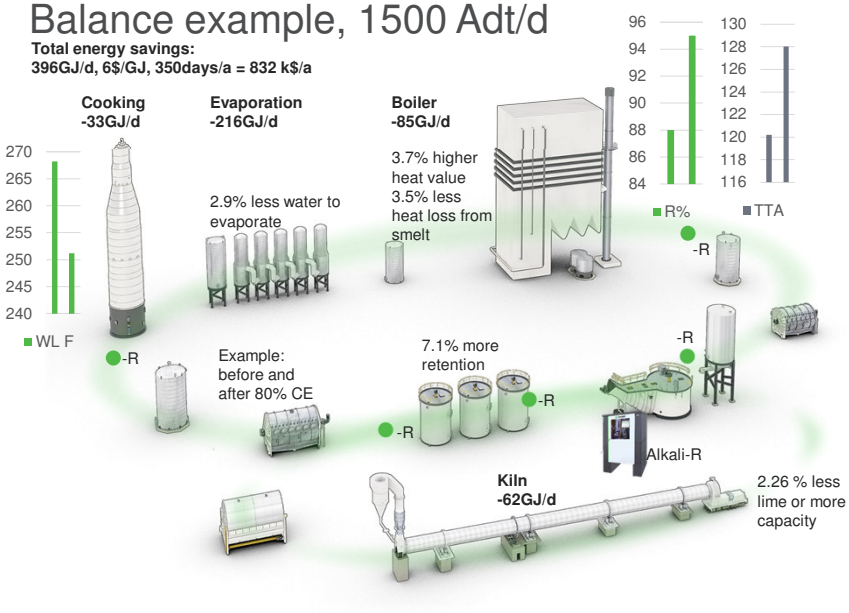
Green liquor concentration optimization



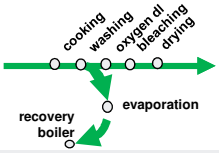


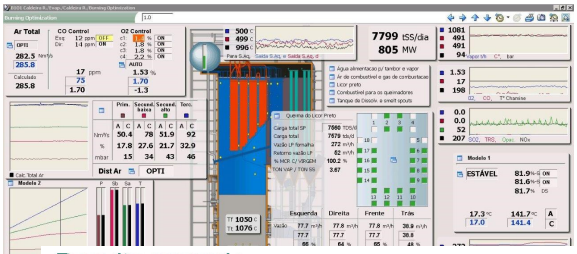
Balance example, 1500 Adt/d

Total energy savings:
396GJ/d, 6$/GJ, 350days/a = 832 k$/a



Valmet Recovery Boiler Optimizer





Controls:

- Single Button management of production
- Liquor flow and distribution
- Liquor Droplet size
- Total air
- Air distribution
- O2/CO
- Burning symmetry
- Furnace temperature profile
- Superheated steam temperature

Results example

Results Summary:

- **Liquor burning capacity increase 2.7 %**
- **Steam production increase 2.2 %**
- **Superheted steam temperature inreased from 478 C to 485 C**
- **Total electric generation increased 4.7%**
- **Running period increased from 8 months to 12 months**

Valmet FORWARD

AF&PA Recovery Boiler Conference
ESP Power and Its Relation to ESP Rebuilds

John A. Knapik – ESP Technical Consultant
B&W Controls and Electrical Group
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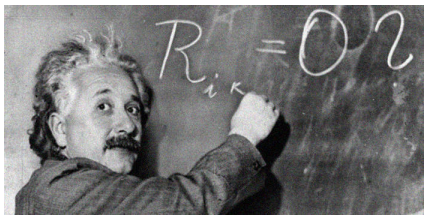
440-666-3876

February 8, 2017

To Become an ESP Expert, You Simply have to Know Two Things

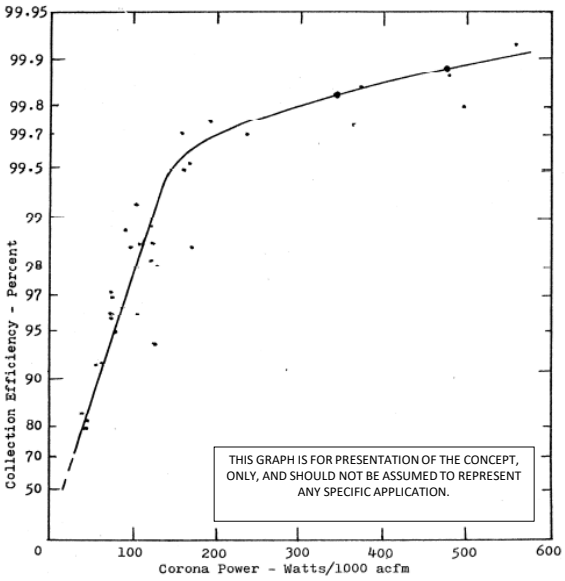
1. Precipitator Efficiency is directly proportional to:
   a) How quickly the dust in the ESP migrates toward the collecting plates (Best monitored thru ESP Total Power (KW))
   b) The relative size of the ESP (SCA)

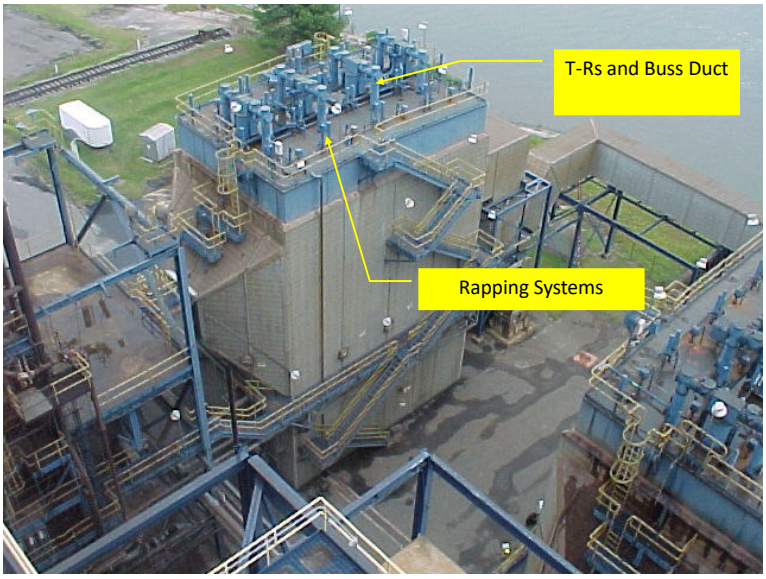
2. Therefore, whatever we can do to maximize the above two parameters, will increase the ESP collection efficiency



Rebuilding A Recovery Boiler ESP has an Impact on ESP Power and Outlet Emissions

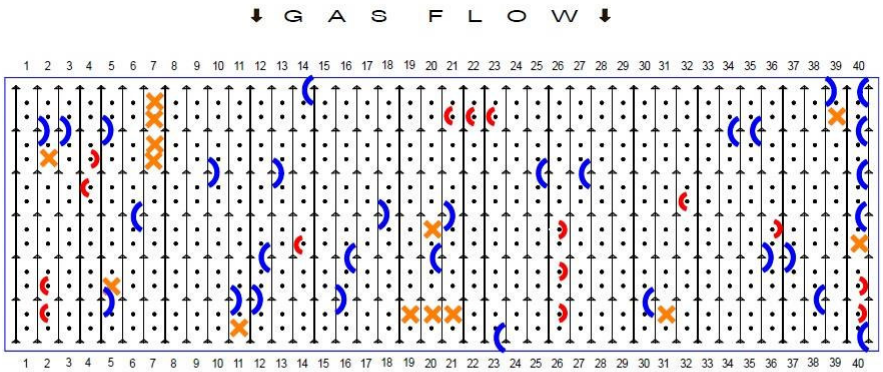
ESP Power is a Barometer for ESP Performance. The more ESP Power, the Higher the ESP Collection Efficiency





Precipitator (ESP) Power is the summation of the secondary power (KW=KV*mA) of all the power supplies on the ESP

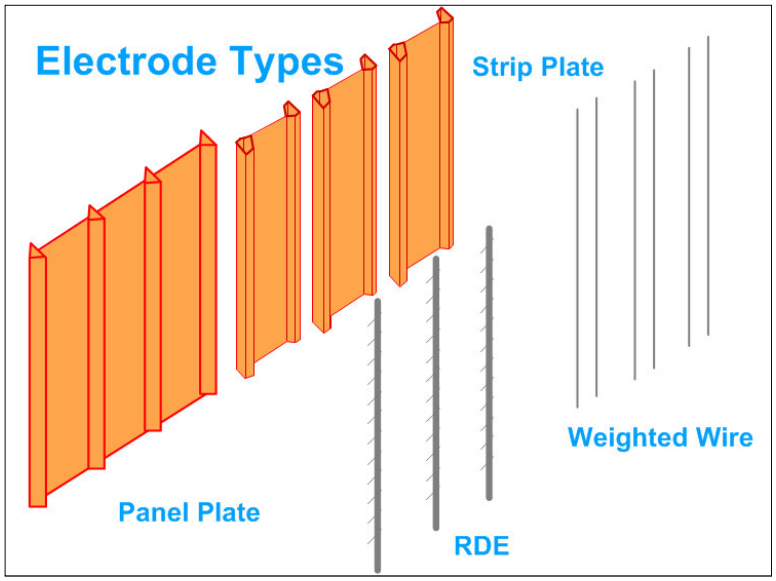
If your most recent ESP inspection showed cell charts similar to this (very poor), the power to those cells is compromised and their efficiency at collecting particulate matter (PM) has diminished .



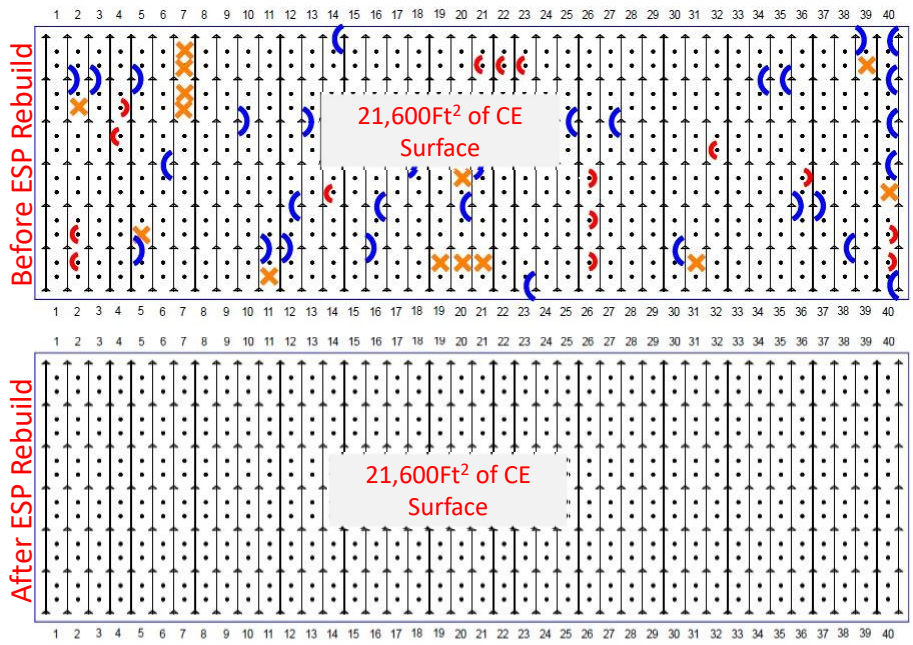
NOTES:

30-foot Field Width
9-foot Long, ESP-1 Style CE Plates
40 Gas Passes
9-inch Centerline Spacing
12 DE Wires per Gas Pass

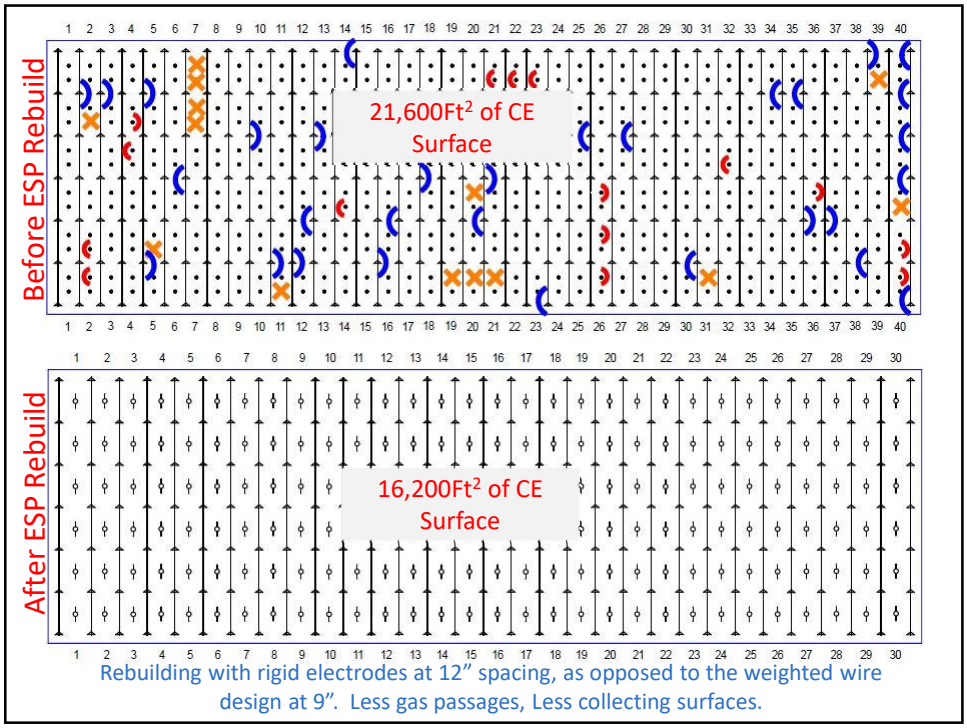
- Collecting plate vertical rib bowed
- Discharge electrode missing
- Discharge electrode bowed



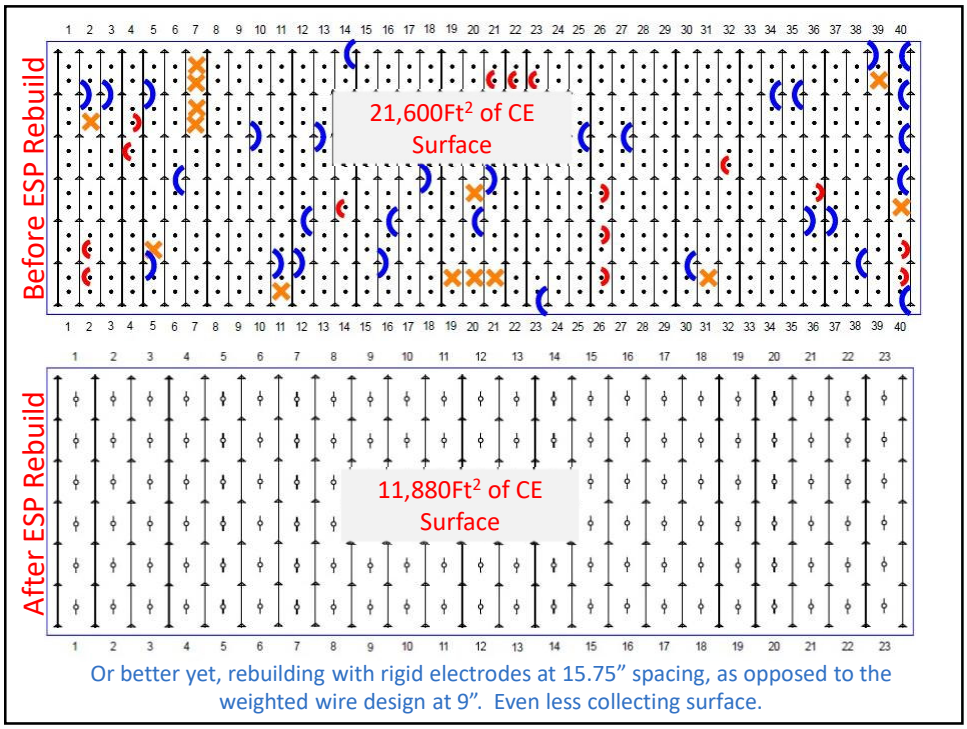
An ESP Rebuild can Utilize Either Wires with Weights or Rigid Discharge Electrodes (RDE)



Rebuilding "in-kind" with weighted wires, would improve power (efficiency) but is no longer done. Rigid electrodes are the superior technology.



Rebuilding with rigid electrodes at 12” spacing, as opposed to the weighted wire design at 9”. Less gas passages, Less collecting surfaces.



Or better yet, rebuilding with rigid electrodes at 15.75” spacing, as opposed to the weighted wire design at 9”. Even less collecting surface.

But how can Rebuilding an ESP with Rigid Electrodes and Progressively less Collecting Plate Area have the same Collection Efficiency as a New Weighted Wire Rebuild?

The Answer Rests in the Amount of Power Delivered to Each Ft^2 of Collecting Plate in the Rebuild

ORIGINAL IS AN OUTLET FIELD ON A 2 CHAMBER RECOVERY BOILER ESP WITH 40GP ON 9" SPACING WITH WEIGHTED WIRE.
GAS VOLUME IS 486,000 ACFM.

ESP CONFIGURATION					ESP POWER SUPPLY						DENSITY
CONDITION	uA/FT²	AREA	NO. OF GAS PASS	GAS PASS	VOLT	AMP	MA	KV	KVA	KW	W/FT²
WW,9",CONV.	69.4	21600.0	40	9	400	240.0	1500	45	96.0	67.5	3.1
RDE,12",CONV.	67.9	16200.0	30	12	400	236.0	1100	60	94.4	66	4.1
RDE,16",CONV.	71.5	11880.0	23	15.75	400	243.1	850	80	97.2	68	5.7

Conventional Transformer Rectifier Set

The Above Table Shows the Theoretical Size of the Conventional Power Supply Required for Each Rebuild Scenario. Note that the Input Power Remains Relatively the Same (Approximately 96KVA) but the Amount of Power in the ESP on Each Ft^2 of Collecting Plate Increases Proportionately.

One Exception to Wide Plate Spacing

1. Unlike a coal fired utility boiler ESP, a Recovery Boiler ESP sees a much higher dust loading at the inlet , of a much finer size distribution
2. This condition is called “space charge” and renders 15.75” gas passages **in the inlet field prohibitive.** If 15.75” is used in the rest of the ESP (it is a very sound approach), then the first mechanical field will need to utilize 12” gas passages.
3. Last, because of the space charge, a very aggressive high voltage electrode must be used in the first mechanical field (see v-pin electrode at right).

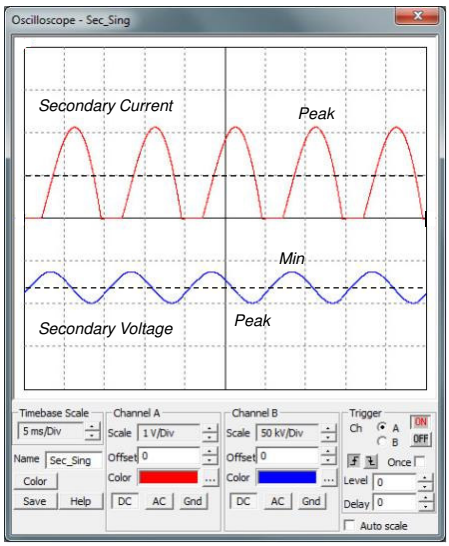
How to get Even Lower PM Emissions

1. Remember, collection efficiency is related to the size of the ESP and the total internal power (KW).
2. The new era of ESP power supplies utilizes a low ripple, almost DC waveform that increases ESP power by 25 to 35%.
3. More power in means less dust out. Often times 25 to 50% less outlet emissions

High Frequency Power Supply (HFPS)

Three Phase Power Supply (TPPS)

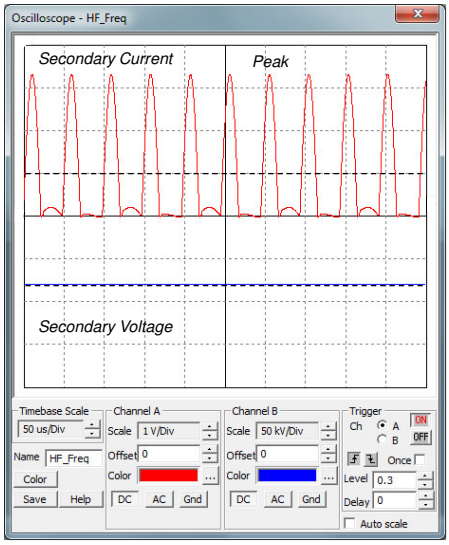
Single Phase = Conventional TR Set



True DC: ----------

1. It produced an ESP DC waveform for current and voltage that looked like this.
2. Because the wave does not cross zero (change polarity), it is DC and not AC.
3. It is said to have a lot of "ripple" (35-45%)

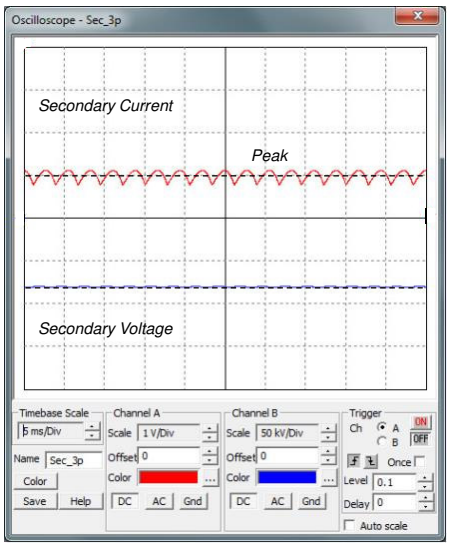
High Frequency Power Supply (HFPS)



True DC: ----------

1. Over the last decade, a lot of conventional ESP TR sets have been replaced with power supplies that provide a more true DC (very little ripple (<1%) in the waveform).
2. Their advantage is more output power.
3. More ESP power equates to higher collection efficiencies.

3-Phase Power Supply (TPPS)

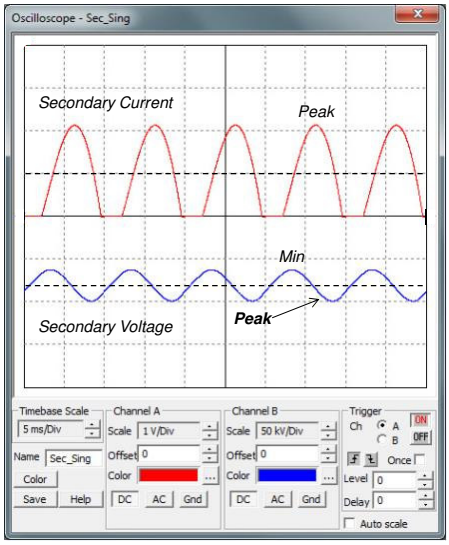


True DC: ----------

1. Since the 1960's, the Europeans have been using 3 Phase power supplies on ESP's to reduce waveform ripple (0.5-1.5%) and increase total power
2. Their advantage is higher output power, almost as high as the HFPS, but with a higher reliability than a HFPS

 .17

Single Phase = Conventional TR Set



True DC: ----------

Higher Power – How?

1. Sparking in the ESP is relative to the peak value of the secondary voltage waveform
2. The 3 phase and the switch mode allow you to run at that peak voltage value
3. That is why they produce more ESP current for the same peak voltage than a single phase transformer can

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Although the Low Ripple Devices are more Efficient, They still will Require More Station Power

ORIGINAL IS AN OUTLET FIELD ON A 2 CHAMBER RECOVERY BOILER ESP WITH 40GP ON 9" SPACING WITH WEIGHTED WIRE. GAS VOLUME IS 486,000 ACFM.

ESP CONFIGURATION					ESP POWER SUPPLY						DENSITY
CONDITION	uA/FT²	AREA	NO. OF GAS PASS	GAS PASS	VOLT	AMP	MA	KV	KVA	KW	W/FT²
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RDE,16",CONV.	71.5	11880.0	23	15.75	400	243.1	850	80	97.2	68	5.7
WW,9", LOW RIPPLE	69.4	21600.0	40	9	480	148.2	1500	70	123.2	105.0	4.9
RDE,12", LOW RIPPLE	67.9	16200.0	30	12	480	139.8	1100	90	116.2	99.0	6.1
RDE,16", LOW RIPPLE	71.5	11880.0	23	15.75	480	120.0	850	100	99.8	85.0	7.2

NOTE: 100KV IS THE LARGEST "STANDARD DESIGN" VOLTAGE RATING FOR A LOW RIPPLE POWER SUPPLY

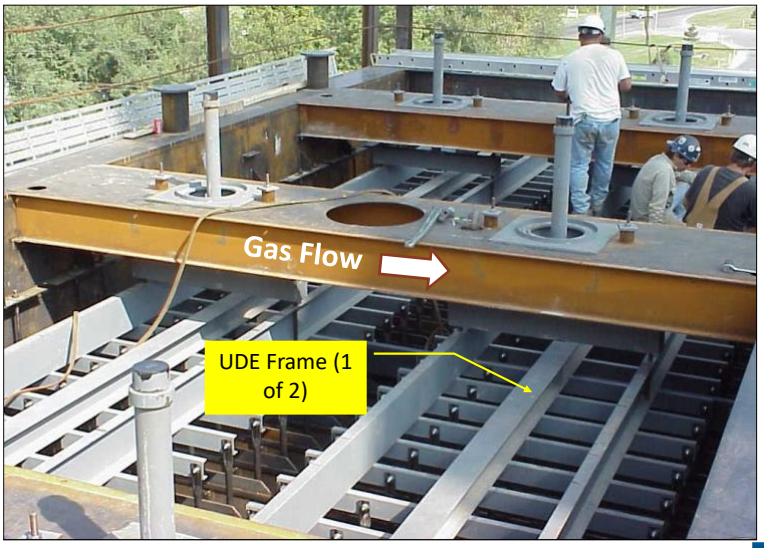
The Above Table Shows the Theoretical Size of the Conventional and Low Ripple Power Supply Required for Each Rebuild Scenario. For roughly 25% more input power to the low ripple three phase TR set, it will produce 50% more power out.

Advantages and Disadvantages of Low Ripple Power Supplies

- TPPS has lowest harmonic distortion, HFPS the highest
- HFPS is smaller and lighter than the TPPS
- HFPS's controls are at the device on the roof of the ESP and require their own cooling system. TPPS's controls are separate back in the MCC room.
- TPPS is much more reliable
- HFPS is slightly more electrically efficient

Last Method to Increase ESP Collection Efficiency, Convert 1 Mechanical Field into 2 Electrical Fields

Rebuild Utilizing 2 Electrical Fields where Originally there was only 1



AF&PA Recovery Boiler Conference
ESP Power and Its Relation to ESP Rebuilds

QUESTIONS?

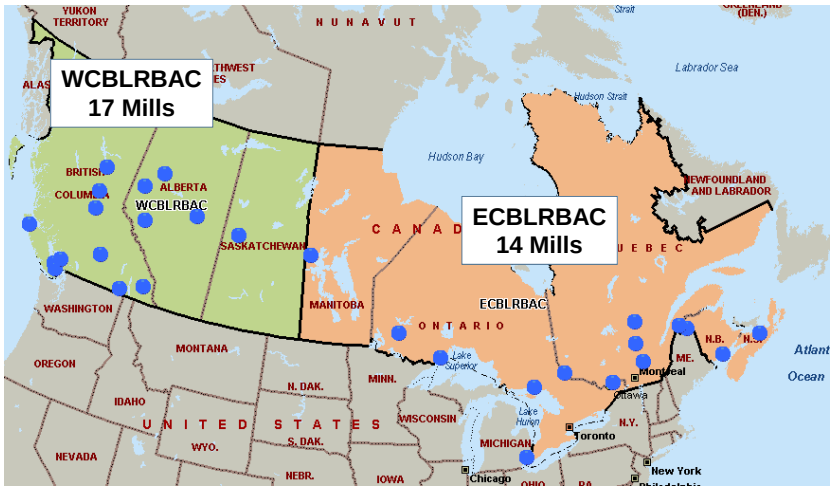
SOLENIS
Strong bonds. Trusted solutions.

CANADIAN BLRBAC

AF&PA FEB 2017

SOLENIS

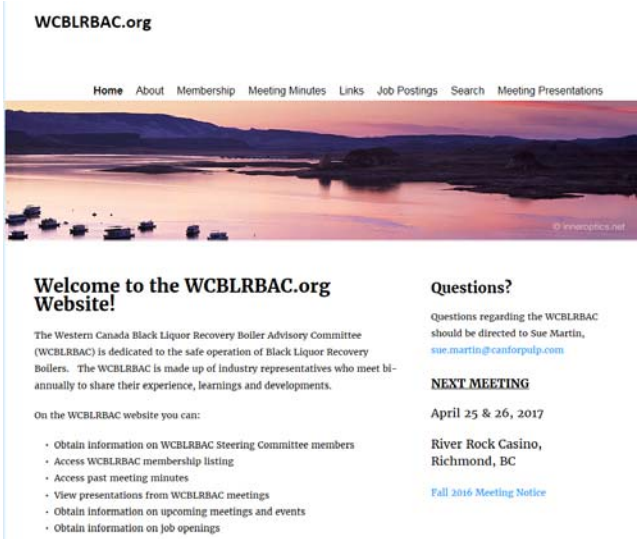
EASTERN AND WESTERN CANADA BLRBAC



WCBLRBAC

- **Founded in 1965, in 52 year!**
- **Spring and Fall Meetings, typically following Atlanta BLRBAC**
- **Strongly supported by Western Canada mills**
- **Two-day meeting format**
  - Day 1 is a full-day closed session for mill representatives, boiler manufacturers and a select group of industry supporters
  - Day 2 is a full-day open session consisting of technical presentations
- **Website is www.wcblrbac.org**

WWW.WCBLRBAC.ORG



ECBLRBAC

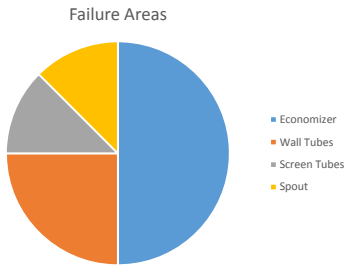
- ECBLRBAC combines the PAPTAC Steam and Steam Power Committee and the former ECBLRBAC into a single group hosted by PAPTAC since 2013
- Annual meetings, 2-day open meeting format with a third day for a local mill tour
- Combination of incident reviews, operating, safety, environmental discussions and technical presentations
- Website is www.paptac.ca/ecblrbac/

RECOVERY BOILERS COMPARISON

	USA	CANADA
TOTAL NUMBER	149	41
AVERAGE AGE, YEARS	38.8	38.7
OLDEST, YEARS	64	69*

FALL 2016 INCIDENTS REPORTED TO BLRBAC

Corporation	City	Incident	ESP	Location	Comment
Catalyst Paper	Crofton	Non-critical	No	Economizer	
ALPAC	Boyle	Non-critical	No	Economizer	
Paper Excellence	Skookcumchuck	Non-critical	No	Economizer	
Paper Excellence	Skookcumchuck	Non-critical	No	Economizer	
WestRock	LaTuque	Critical	No	Screen tube	Hydro
Northwood	Prince George	Critical	Yes	Wall tubes	
Tolko	The Pas	Critical	No	Wall tubes	Start-up
Fortress	Thurso	Spout	No	Spout	



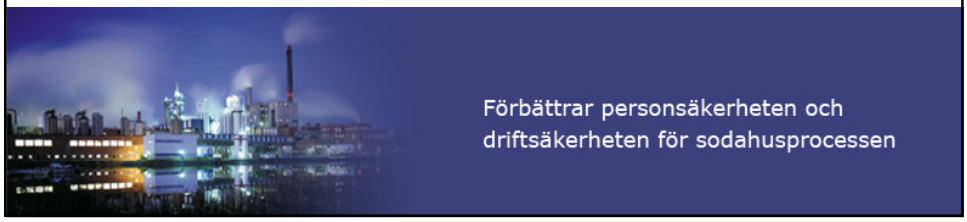
WE WELCOME YOUR PARTICIPATION

On behalf of both the Eastern and Western Canada BLRBAC, we extend an invitation to you to participate in our meetings and committees.

Sodahuskommittén

Report from the Swedish-Norwegian Recovery Boiler Committee

AF&PA Recovery Boiler Conference 2017
Kajsa Fougner, ÅF
Secretary of the Swedish-Norwegian Recovery Boiler Committee (SNRBC)



Sodahuskommittén

Topics

- Organization
- Recovery Boilers in Sweden and Norway
- Reported incidents
- Recommendations
- Certification of operators
- Experience sharing day
- Recovery Boiler meeting
- Prioritized projects

Sodahuskommittén

Organization

The Board of the SNRBC
Chairman: Hans Holm, Stora Enso Skoghall mill
Secretary: Kajsa Fougner, ÅF
19 members (13 voting)

- Recommendations Subcommittee
  Secretary: Lars Andersson, ÅF
  Additional 4 members
- Incidents Subcommittee
  Secretary: David Good, Dekra
  Additional 9 members
- Education Subcommittee
  Secretary: Björn Lundgren, Inspecta
  Additional 7 members
- EIA Subcommittee
  (Electricity, Instrumentation, Automation)
  Secretary: Kajsa Fougner, ÅF
  Additional 7 members

Sodahuskommittén

Recovery Boilers in Sweden and Norway

Autumn 2016
- Increased capacity recovery boiler Södra Cell Värö

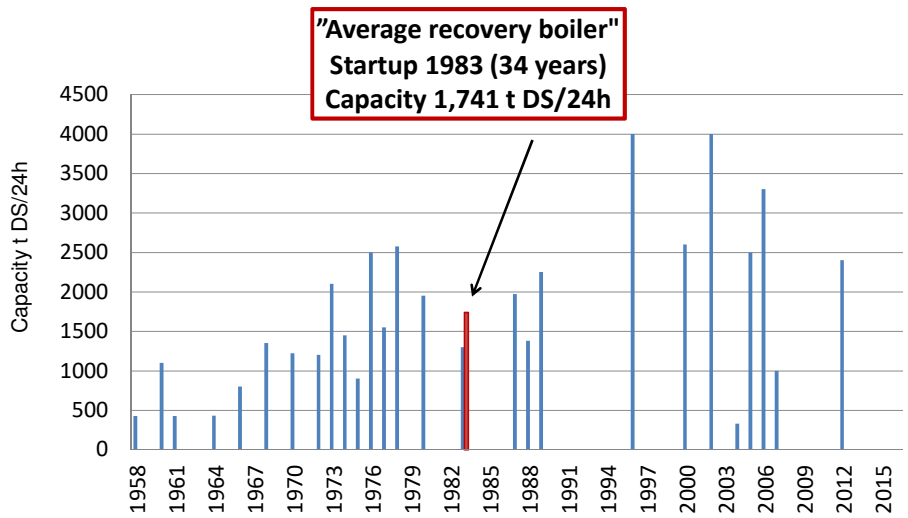
Autumn 2013
- The boiler in SCA Munksund was converted to single drum
- New evaporator line in BillerudKorsnäs Skärblacka

Summer 2013
- Closure of Södra Cell Tofte, Norway

Summer 2012
- Start up of a new boiler in Holmen Iggesund (the two old boilers were shut)

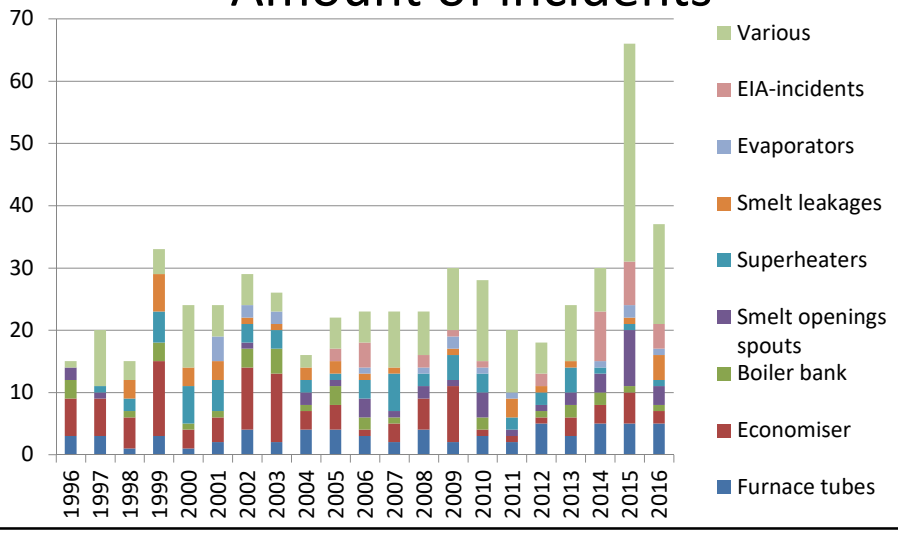
Sodahuskommittén

Recovery Boilers in Sweden and Norway



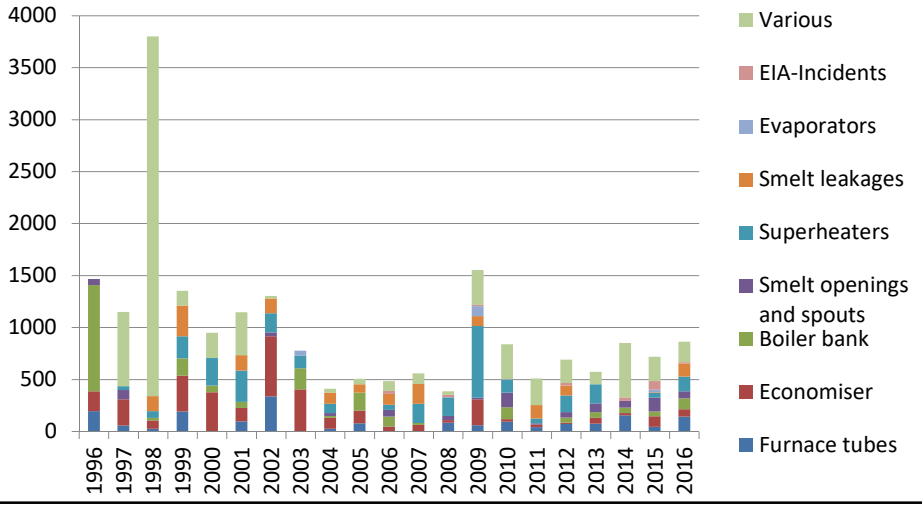
Sodahuskommittén

Reported incidents
- Amount of incidents



Sodahuskommittén

Reported incidents - Down time [h]



Sodahuskommittén

Recommendations

The SNRBC has 40 recommendations, divided in areas like:

B: Construction and equipment
C: Operation and operational disturbances

B: Konstruktion och utrustning

Nr.	Titel	Utgåva	År
B1	Sodapannors konstruktion och utrustning	3	2013
B2	Säkerhet i sodahusbyggnader	1	2001

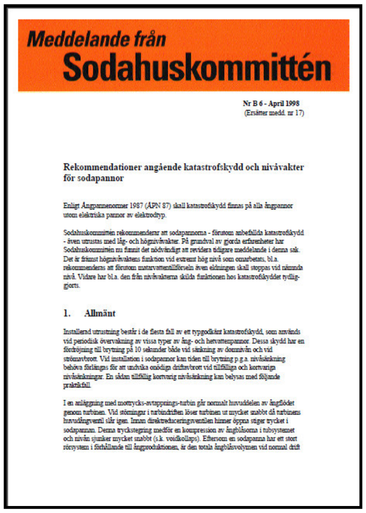
C: Drift och driftstörningar

Nr.	Titel	Utgåva	År
C1	Information om kritiska tillstånd och händelser i sodahuset.	2	2003
C2	Information om sodapannedrift samt förebyggande och åtgärdande av driftstörningar.	2	2001

Updating of the recommendations every third year

Sodahuskommittén

Recommendations



Meddelande från
Sodahuskommittén

Nr B 6 - April 1998
(Ersätter medd. nr 17)

Rekommendationer angående katastrofskydd och nivåvakter för sodapannor

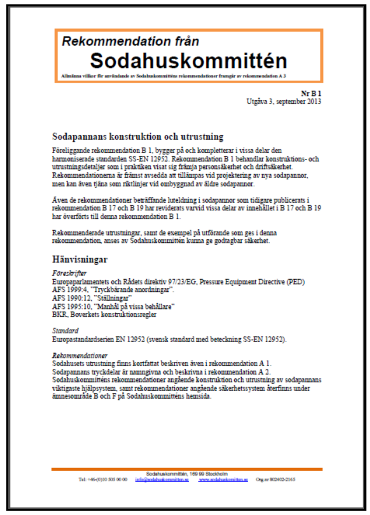
Enligt Ångpannenormer 1987 (ÅPN 87) skall katastrofskydd finnas på alla ångpannor utom elektriska pannor av elektrodtyp.

Sodahuskommittén rekommenderar att sodapannorna - förutom anbefallda katastrofskydd - även utrustas med låg- och högnivåvakter. På grundval av gjorda erfarenheter har Sodahuskommittén nu funnit det nödvändigt att revidera tidigare meddelande i denna sak. Det är främst högnivåvaktens funktion vid extremt hög nivå som omarbetats, bl.a. rekommenderas att förutom matarvattentillförseln även eldningen skall stoppas vid nämnda nivå. Vidare har bl.a. den från nivåvakterna skilda funktionen hos katastrofskyddet tydliggjorts.

1. Allmänt

Installerad utrustning består i de flesta fall av ett typgodkänt katastrofskydd, som används vid periodisk övervakning av vissa typer av ång- och hetvattenpannor. Dessa skydd har en fördröjning till brytning på 10 sekunder både vid sänkning av domnivån och vid strömavbrott. Vid installation i sodapannor kan tiden till brytning p.g.a. nivåsänkning behöva förlängas för att undvika onödiga driftavbrott vid tillfälliga och kortvariga nivåsänkningar. En sådan tillfällig kortvarig nivåsänkning kan belysas med följande praktikfall.

I en anläggning med mottrycks-avtappnings-turbin går normalt huvuddelen av ångflödet genom turbinen. Vid störningar i turbindriften löser turbinen ut mycket snabbt då turbinens huvudångventil slår igen. Innan direktreduceringsventilen hinner öppna stiger trycket i sodapannan. Denna tryckstegring medför en kompression av ångblåsorna i tubsystemet och nivån sjunker mycket snabbt (s.k. voidkollaps). Eftersom en sodapanna har ett stort rörsystem i förhållande till ångproduktionen, är den totala ångblåsvolymen vid normal drift



Rekommendation från
Sodahuskommittén
Allmänna villkor för användande av Sodahuskommitténs rekommendationer framgår av rekommendation A 3

Nr B 1
Utgåva 3, september 2013

Sodapannans konstruktion och utrustning

Föreliggande rekommendation B 1, bygger på och kompletterar i vissa delar den harmoniserade standarden SS-EN 12952. Rekommendation B 1 behandlar konstruktions- och utrustningsdetaljer som i praktiken visat sig främja personsäkerhet och driftsäkerhet. Rekommendationerna är främst avsedda att tillämpas vid projektering av nya sodapannor, men kan även tjäna som riktlinjer vid ombyggnad av äldre sodapannor.

Även de rekommendationer beträffande luteldning i sodapannor som tidigare publicerats i rekommendation B 17 och B 19 har reviderats varvid vissa delar av innehållet i B 17 och B 19 har överförts till denna rekommendation B 1.

Rekommenderade utrustningar, samt de exempel på utförande som ges i denna rekommendation, anses av Sodahuskommittén kunna ge godtagbar säkerhet.

Hänvisningar

Föreskrifter
Europaparlamentets och Rådets direktiv 97/23/EG, Pressure Equipment Directive (PED)
AFS 1999:4, "Tryckbärande anordningar".
AFS 1990:12, "Ställningar"
AFS 1995:10, "Manhål på vissa behållare"
BKR, Boverkets konstruktionsregler

Standard
Europastandardserien EN 12952 (svensk standard med beteckning SS-EN 12952).

Rekommendationer
Sodahusets utrustning finns kortfattat beskriven även i rekommendation A 1.
Sodapannans tryckdelar är namngivna och beskrivna i rekommendation A 2.
Sodahuskommitténs rekommendationer angående konstruktion och utrustning av sodapannans viktigaste hjälpsystem, samt rekommendationer angående säkerhetssystem återfinns under ämnesområde B och F på Sodahuskommitténs hemsida.

Sodahuskommittén, 169 99 Stockholm
Tel: +46-(0)10 505 00 00 info@sodahuskommitten.se www.sodahuskomitten.se Org.nr 802402-2165

Sodahuskommittén

Certification of recovery boiler operators

The education take place during three occasions, one week each.

The minimum accepted recovery boiler experience until examination and certification is 2 years.

All certificates need to be updated/renewed each 7th year.

The "re-examination test" is web-based and divided into three main parts:

- Recovery boiler design
- Combustion optimization
- Safety

Sodahuskommittén

Experience sharing day 2016

Operators and other persons from member companies meet and discuss important topics.

2016 the topic was

”Instructions for critical situations”

- Regulations, norms, recommendations: What do they say about ”Instructions for critical situations”
- How does it look in our home mills?
- Good examples

Sodahuskommittén

Recovery Boiler Meeting 2016

…was hosted by Valmet in Gothenburg. Participants went on tour in Valmet facilities in Gothenburg and also in Mölndal Energy´s combined heat and power plant. Recovery boiler operator certificates!

Sodahuskommittén

Three incidents

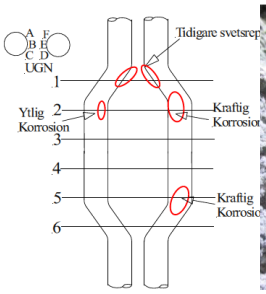
Corroded compound layer at protective roof openings

Acute intoxication at the electrostatic precipitator

High density in dissolving tank

Sodahuskommittén

Corroded compound layer at protective roof openings



- Since 2002 the recovery boiler has compound tubes all the way to protective roof
- 2009 corrosion on the compound layer was noticed
- 2010 welding on compound layer
- 2015 examination of all eight openings for protective roof
- All eight openings had corroded compound layers

Sodahuskommittén

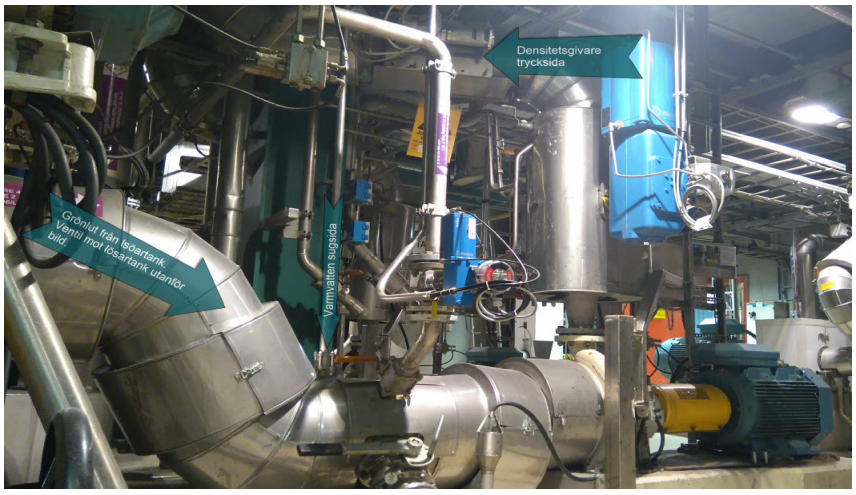
Personal injury at the electrostatic precipitator

- During revision stop work was done at electrostatic precipitator
- ”Cold” testing of electrostatic precipitator
- Troubleshooting needed: Resulted in acute intoxication
- Ozone is produced in the electrostatic precipitator, normally eliminated during cooling and ventilation
- Improved routines in the mill, clarify the danger of ozone in SNRBC recommendations

Sodahuskommittén

High density in dissolving tank

- Density of green liqour from dissolving tank is measured in different ways



Sodahuskommittén

High density in dissolving tank, cont

- The valve on a warm water pipe is open by accident, thus diluting green liqour in the pipe from dissolving tank
- Density measurement after the dilution point
- In the dissolving tank the dilution was thus reduced and density rised to dangerous levels

Sodahuskommittén

Prioritized projects 2016

Smelt Spouts
Questionnaire and conclusions

Risk Analysis Recovery Boiler (continuation)
Guidelines on risk analysis of recovery boiler

New Products, Analysis and Control Strategies for increased Safety in Recovery Boilers
Summary of research activities, development and new products on the market as well as inprovements in operation in the mills

SUOMEN SOODAKATTILAYHDISTYS
FINNISH RECOVERY BOILER COMMITTEE

Finnish Recovery Boiler Committee Report 2016

Markus Nieminen

SUOMEN SOODAKATTILAYHDISTYS
FINNISH RECOVERY BOILER COMMITTEE

Content

1) Overview to FRBC
2) Overview to Finnish recovery boilers
3) Incident statistics 1996 - 2016
4) Activities

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FINNISH RECOVERY BOILER COMMITTEE

1) Overview to Finnish recovery boiler committee

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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
  - publishes guidelines, recommends practices and arranges conferences and meetings
  - conducts and supports research projects related to safe operation and improved economy of recovery boilers

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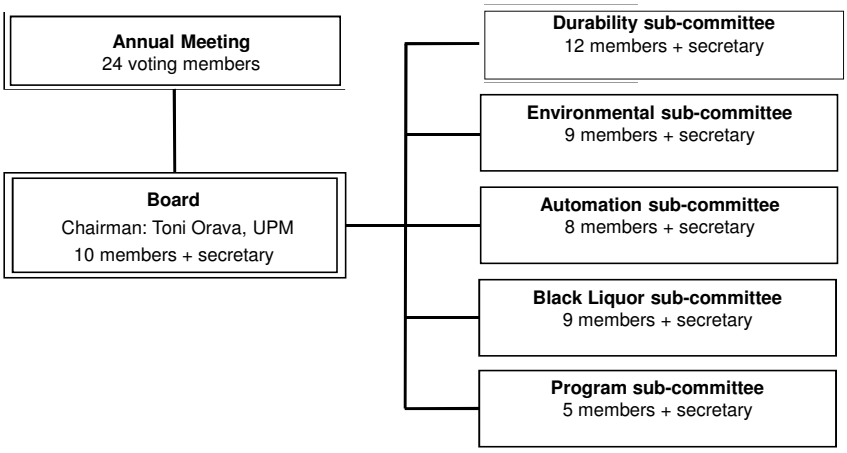
Organisation



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Members

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

- Total 28 members, including 15 pulp mills
- There is a yearly member fee

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2) Overview to Finnish recovery boilers

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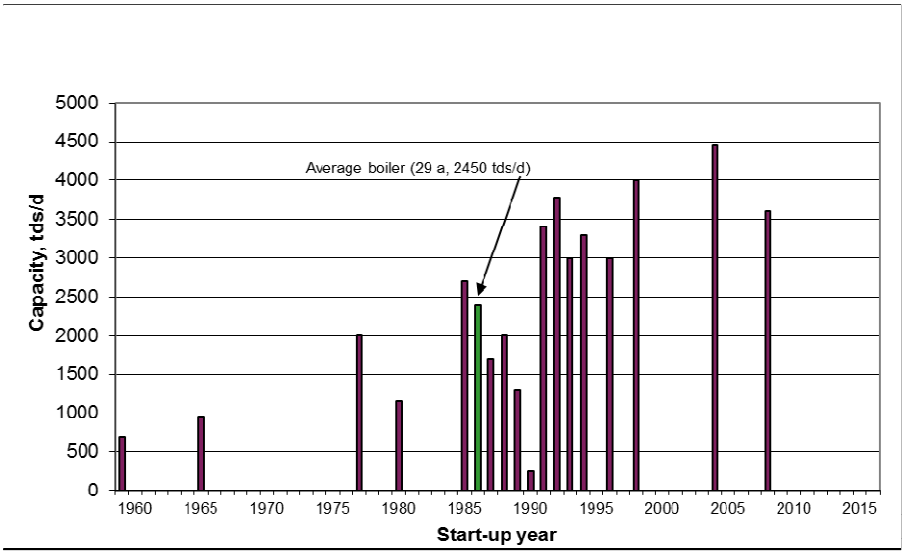
Finnish recovery boilers



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Finnish recovery boilers

- No. of recovery boilers 17
  - Oldest started up in 1959, CE boiler (700 tDS/d) in Kotka Mills
  - Newest started up in 2008, Valmet boiler (3600 tDS/d) in UPM Kymi
  - Smallest is in Stora Enso Heinola mill, Valmet (Tampella) boiler 250 tDS/d
  - Biggest is in UPM Pietarsaari mill, Andritz boiler 4450 tDS/d
- Number of mills 15
  - 2 mills operate more than one RB
- Average boiler age 29 yrs
- Average boiler capacity 2450 tDS/d
- Combined capacity 42 000 tDS/d

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Finnish recovery boilers - updates

- LignoBoost lignin separation plant (50 000 t/a) has been in operation at Stora Enso's Sunila mill since 2015
  - Lignin is dried to >95% with lime kiln flue gases
  - Lignin is used as fuel in lime kiln but also sold out in big bags
- Construction of the new Äänekoski mill has been ongoing since summer 2015 (replaces the existing mill)
  - Construction work is mainly done, equipment installations are ongoing
  - Planned start-up is on third quarter of 2017

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The new Äänekoski pulp mill

- Investment value of EUR 1.2 billion (SEK 11.8 billion)
  - Largest investment in history of Finnish pulp&paper industry
- The annual pulp production 1.3 million tonnes (existing 0.5)
  - 800,000 tonnes softwood and 500,000 tonnes hardwood pulp
- Yearly wood consumption 6.5 million cubic metres (existing 2.4)
  - ~10% increase in the consumption of pulpwood in Finland
- No fossil fuels (lime kiln uses gas from bark gasifier)
- Electricity production 1.8 TWh
  - 2.4 times more electricity than it is consumes
- Recovery boiler capacity 7 200 tDS/d (biggest in Finland)

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3) Incidents statistics 1996 - 2016

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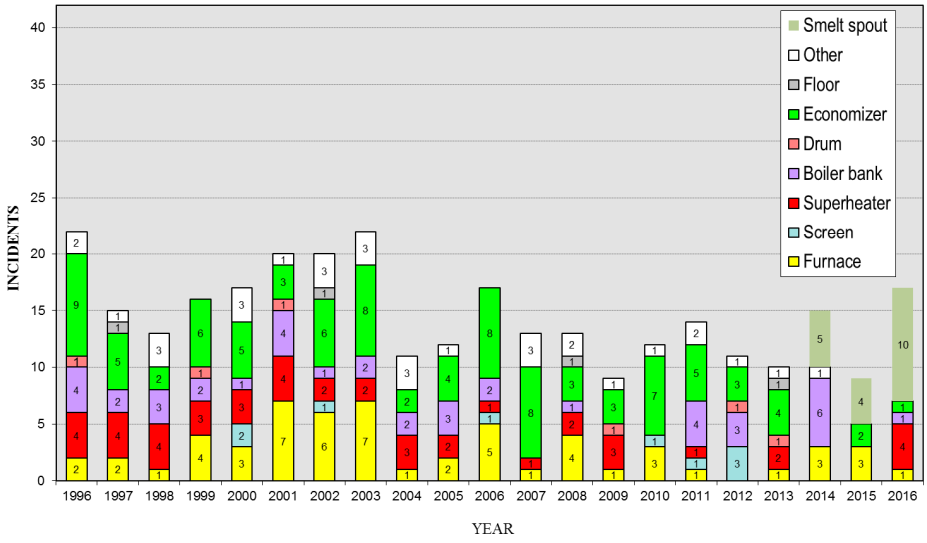
INCIDENTS 1996-2016



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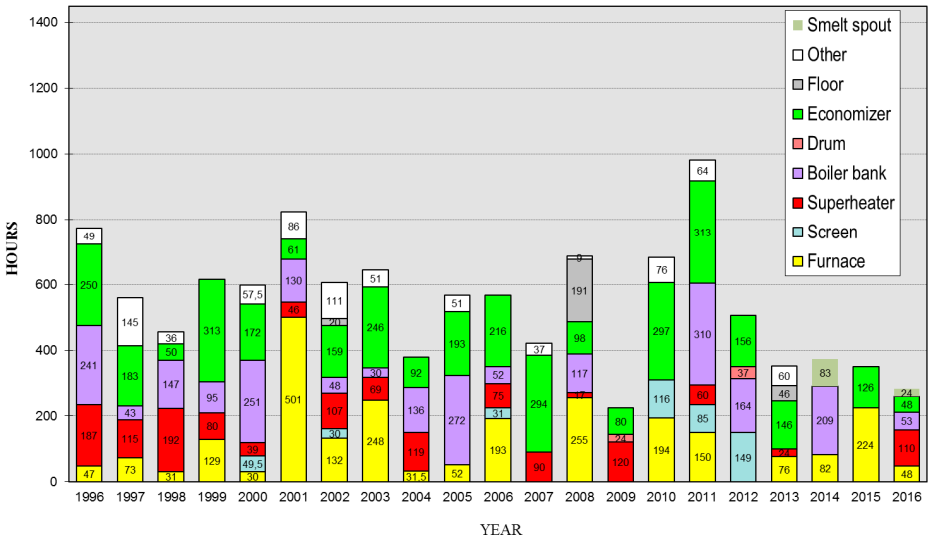
DOWNTIME IN FINLAND 1996-2016



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4) Activities

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Recent Activities

- FRBC history book project
  - Was started in 2014 to celebrate Committees 50 years jubilee
  - Based on archive material but also interviews of people who have had close involvement with Committee
- Operators day -seminar was arranged first time in spring 2016
- Projects:
  - Smelt spout study / recommendation
  - Review of recovery boiler leak detection systems
  - Study on overlay welded tubes
  - Nitrogen in wood and its fate in kraft pulping – a review

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Projects

- Review of recovery boiler leak detection systems
  - Aim is to collected experiences from different leak detection systems used in recovery boilers. New technologies (if any) are also reviewed
- Smelt spout study / recommendation
  - In recent years several incidents related to smelt spouts have been reported to FRBC database
  - One main reasons restricting longer drive times between maintenance shutdowns (target 18-24 months)
  - Process data related to smelts spouts has been collected
  - Recommendation work is ongoing

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Projects

- Study on overlay welded tubes
  - The objective is to perform thermal and mechanical analyses on tubes made by weld overlay process
  - This type of tubes are typically used in waste incineration plants. Also, recovery boilers in South / North America, but not in Finland.
- Nitrogen in wood and its fate in kraft pulping – a review
  - Present results from several studies made in past years
  - Behaviour of wood-based Nitrogen in kraft pulping
  - Fate of nitrogen in chemical recovery cycle