**AMERICAN FOREST &
PAPER ASSOCIATION**

Recovery Boiler Program

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AF&PA Recovery Boiler Committee Meetings and Conference

Tuesday, February 7, 2012

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

Wednesday, February 8, 2012

8:00 am	Continental Breakfast
8:30 am	General Assembly – Chairman's Report Karl T. Morency - Georgia-Pacific Corporation
8:40 am	Research & Development Subcommittee Report Christopher L. Verrill – International Paper Company
8:50 am	Operations & Maintenance Subcommittee Report Donald G. Flach – Georgia-Pacific Corporation
9:00 am	Report on BLRBAC Activities Leonard T. Erickson – Boise, Inc.
9:10 am	Report on Recovery Boiler Explosions and Incidents Jules G. Gommi – Gommi Tech
9:20 am	Report on TAPPI Recovery Boiler Subcommittee Activities Alarick J. Tavares – Georgia-Pacific Corporation
9:35 am	Chloride & Potassium Accumulation, Impact & Control – A Review of 30+years of Research - Honghi Tran – University of Toronto
10:15 am	Coffee Break

(Over)

Wednesday, February 8, 2012 (continued)

10:35 am	Update on Pulp and Paper MACT Michael Curtis – Georgia-Pacific Corporation
11:00 am	Prediction of Recovery Boiler NOx Emissions in the Light of New Field Data and Theoretical Deliberations - John Phillips – Andritz
11:30 am	An Improved Method for Modeling NOx Emissions from Recovery Boilers Allan Walsh – Jansen Combustion and Boiler Technologies, Inc.
12:00 pm	Lunch
1:00 pm	Update on the First Lignoboost Plat in North Americe Gene M. Christiansen – Metso Power
1:30 pm	Using a Finishing Economizer for Recovery Boilers to Reduce DA Steam Demand – Michelle Bodnovich – Babcock & Wilcox Company
2:15 pm	Coffee Break
2:30 pm	Update on Soot Blower Technology and Plugging Technology Prevention Danny S. Tandra – Clyde Bergemann Inc.
3:00 pm	Introduction to Infrafone Monica Finnegan – Infrafone AB
3:30 pm	Considerations for Natural Gas Firing in Chemical Recovery Units Mark O. Wagner – Alstom Power Inc.
4:00 pm	Update of Property Insurance Market for Recovery Boilers Jimmy Onstead – FM Global
4:20 pm	Report from Swedish Recovery Boiler Committee Urban Andersson – AF Industry
4:40 pm	Report from Finnish Recovery Boiler Committee Markus Nieminen - Poyry Finland Oy
5:00 pm	Closing Remarks Adjournment

BLRBAC 2011 Activities

Len Erickson

February 9th, 2012

AF&PA RECOVERY BOILER COMMITTEE

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
  - **Spring meeting April 2nd, 3rd, & 4th**
  - **Fall meeting October 1st. 2nd, & 3rd**
- Members from recovery boiler: operating, manufacturing and insuring companies.
  - plus associate members with direct interest

BLRBAC's 50^{th}

BLRBAC's first 50 years will be celebrated October 2^{nd}, 2012 @ the Crown Plaza Airport.

BLRBAC Internet Site

- www.BLRBAC.org
- Guidelines and questionnaires
  - Draft revisions for review
- Articles of Association, Operating Procedures
- Meeting registration forms and information
- Meeting minutes

Meeting Attendance

- Spring 2011 Meeting April 4th-6th
  - 209 Registered
  - 23 paper cos., 4 boiler mfg., 5 insurance, 29 associate and 7 guests.
- Fall 2011 Meeting October 10th, 11th, 12th
  - 223 Registered
  - 33 paper cos., 4 boiler mfg., 6 insurance, 35 associate members and 6 guests.

BLRBAC Executive Committee 10/10 – 10/12

- **Chairman – Scott Moyer, Georgia Pacific**
- **Vice Chairman – Jim Hinman, Weyerhaeuser**
- **Operator Rep. – Dave Fuhrmann, IP**
- **Insurance Rep. – Jim Onstead, FM Global**
- **Boiler Rep. – John Weikman, Metso**
- **Treasurer – Len Olavessen, LENRO Inc.**
- **Secretary – Michael Polagye, FM Global**

BLRBAC Subcommittees (9)

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

ESP Working On

- Continuing to work on the definition of "Dedicated Stand Alone" A joint meeting with the instrumentation subcommittee is planned for April 2011.
- The Subcommittee discussed the possible use of ball valves as rapid drain valves on the boiler. The guidelines do not have specific requirements for the type of valve to be used. Any valve used should comply with the applicable ASME boiler code. If a mill is planning to use ball valves, they should consider limiting the speed at which the valve is opened to minimize potential for stressing or "hammer" in the downstream piping.

ESP continued

- **Maintaining List of Boilers in Service**
  - **Posted on www.BLRBAC.org**
  - **Any corrections to Julius Gommi**

Safe Firing of Black Liquor

- Are working on revising the prerequisites for firing liquor;
  - boiler on line
  - superheater loops cleared of condensate
  - stable firing established
- Reviewing DCE permissive requrements
- Proposing language recommending remote shut off capability of dissolving tank dilution sources.

Auxiliary Fuel

- SFAF Meets once per year at the Fall meeting
- Met in a joint meeting with the Instrumentation subcommittee

Personnel Safety Working On

- More information was presented and discussed on PP&E equipment for use in the smelt spout area.
- Continue to review safety issues and near misses in the recovery area and make the information available to the BLRBAC membership.

Instrumentation

- Updating the instrumentation checklist.
- Continuing to update Chapters 2 & 3
- Continuing work on the “Stand Alone” definition with ESP @ the spring meeting.

Waste Streams Working On

- Reviewing the temperature that waste gasses need to be reheated to. Reducing from 150 F to 120 F
- Incineration of dissolving tank vent gases

Fire Prevention in DCE

- No DCE fire incidents reported
- The committee did not meet.

Materials & Welding

- A general document revision is posted on the BLRBAC web site for review.
- Work continues on updating technical bulletins.
- Working on updating definitions and abbreviations.

Water Treatment

- Five sections in the production queue with two sections complete and in final draft form.
- Two sections will receive a second edit in the spring meeting.
- Spring of 2012, the committee will be in a position to homogenize the content and performing a final edit for all five of these sections.

Questions?

2011 BLRBAC Incidents Summary

AF&PA Conference, Atlanta

February, 2012

Jules Gommi

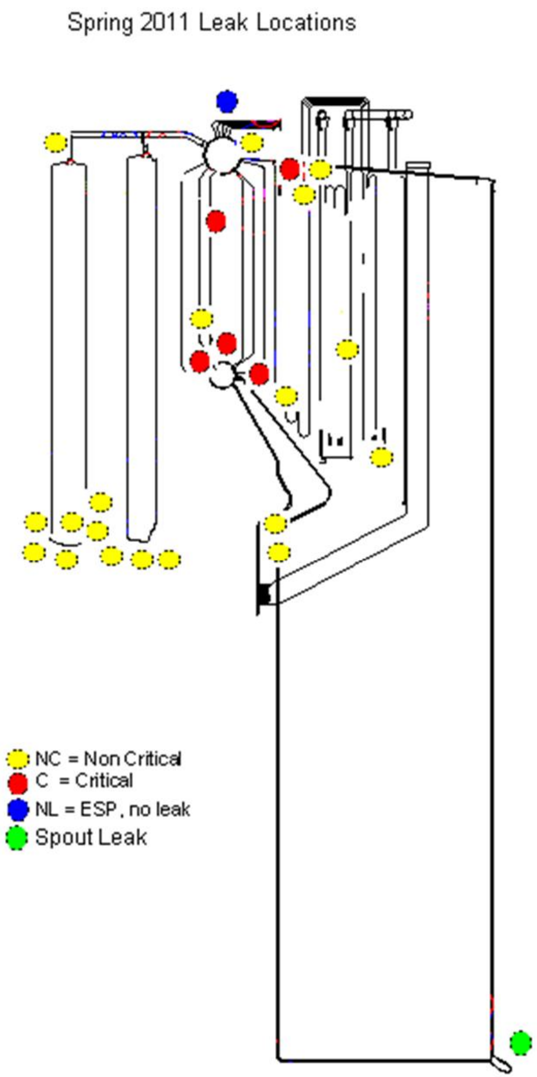
- This report summarizes the previous year's BLRBAC incidents, derived from both the Spring and Fall 2011 ESP meetings.
- The BLRBAC Meeting Reports on line contain added information. www.blrbac.org.
- Please forward new Incident Questionnaires to j.gommi@comcast.net.
- Please report all changes in company names and recovery unit operating status to j.gommi@comcast.net.

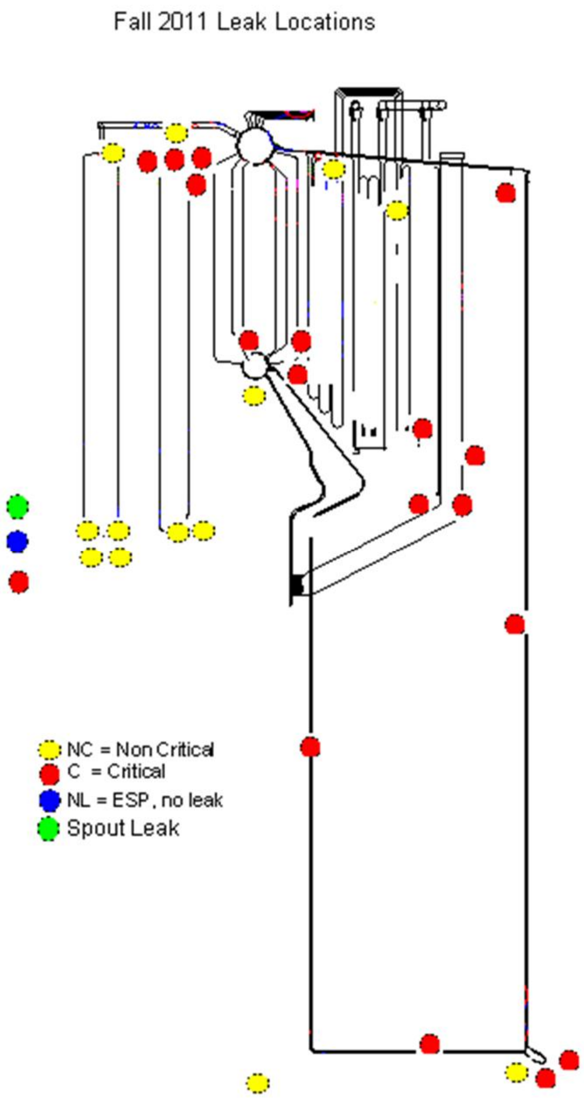
Location of leaks 2011

	Location	Spring	Fall	Total
	Econ+Handhole	11	10	**21**
	SH	5	2	**7**
	Boiler	5	2	**7**
	Screen	0	1	**1**
	Upper Furnace	3	5	**8**
	Lower Furnace	1	3	**4**
	Floor & below	0	0	**0**
	Smelt Spout	1	2	**3**
	Feedwater Air Heater	0	1	**1**
	Dissolving Tank	0	0	**0**
	ESP No Leak	1	0	**1**
	Totals	**27**	**26**	**53**

Includes 2 International reports: of which 1 was fatality in Japan (not in leak count).

Spring & Fall 2011 Incidents Spotted (N. America)





Classification of Incidents 2011

57 North American incidents

22 Critical Incidents
31 Non-critical Incidents
3 Spout Failure (2 Critical)
1 ESP No Leak
16 ESP'd of which
12 were Critical (only 54% of Criticals!)
Note: Of the non-ESP'd criticals, 1 was in smelt spout shooting water back into furnace, 1 was in 1-drum boiler thought to be below nose arch, 3 were in upper furnace, and 5 were upper economizer with a straight shot to furnace cavity!

2 International Incidents

1 Smelt-Water Reaction – Corrosion thinning at gun level, no damage
1 Fatality - Fall while dislodging ash lumps in upper furnace

Root Causes 2011

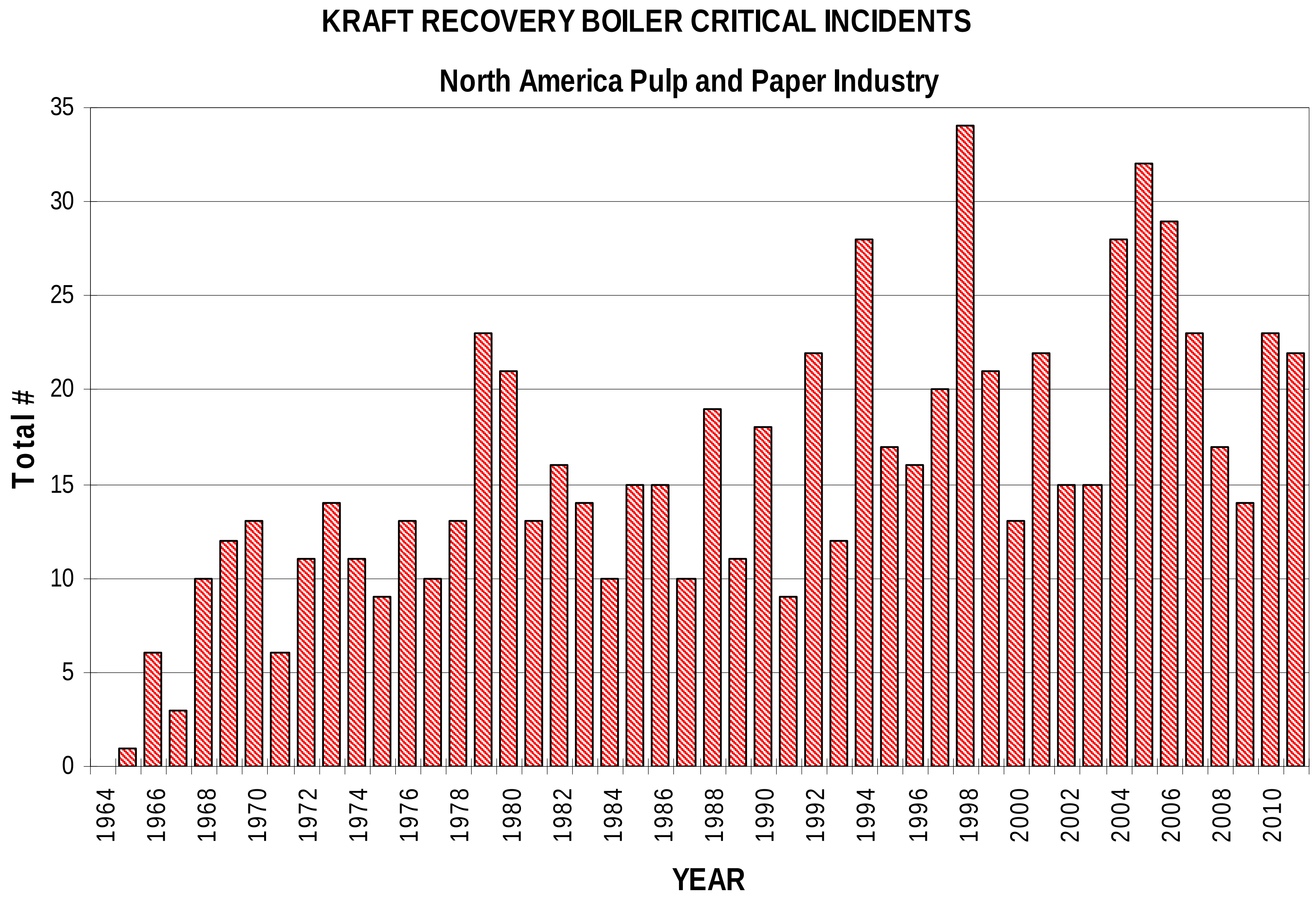
Weld Failure	21
Fatigue, Mechanical & Thermal	15
SAC/SCC/FAC	3
Thinning	12
OverHeat	2
Mechanical Damage	2
Unknown	1

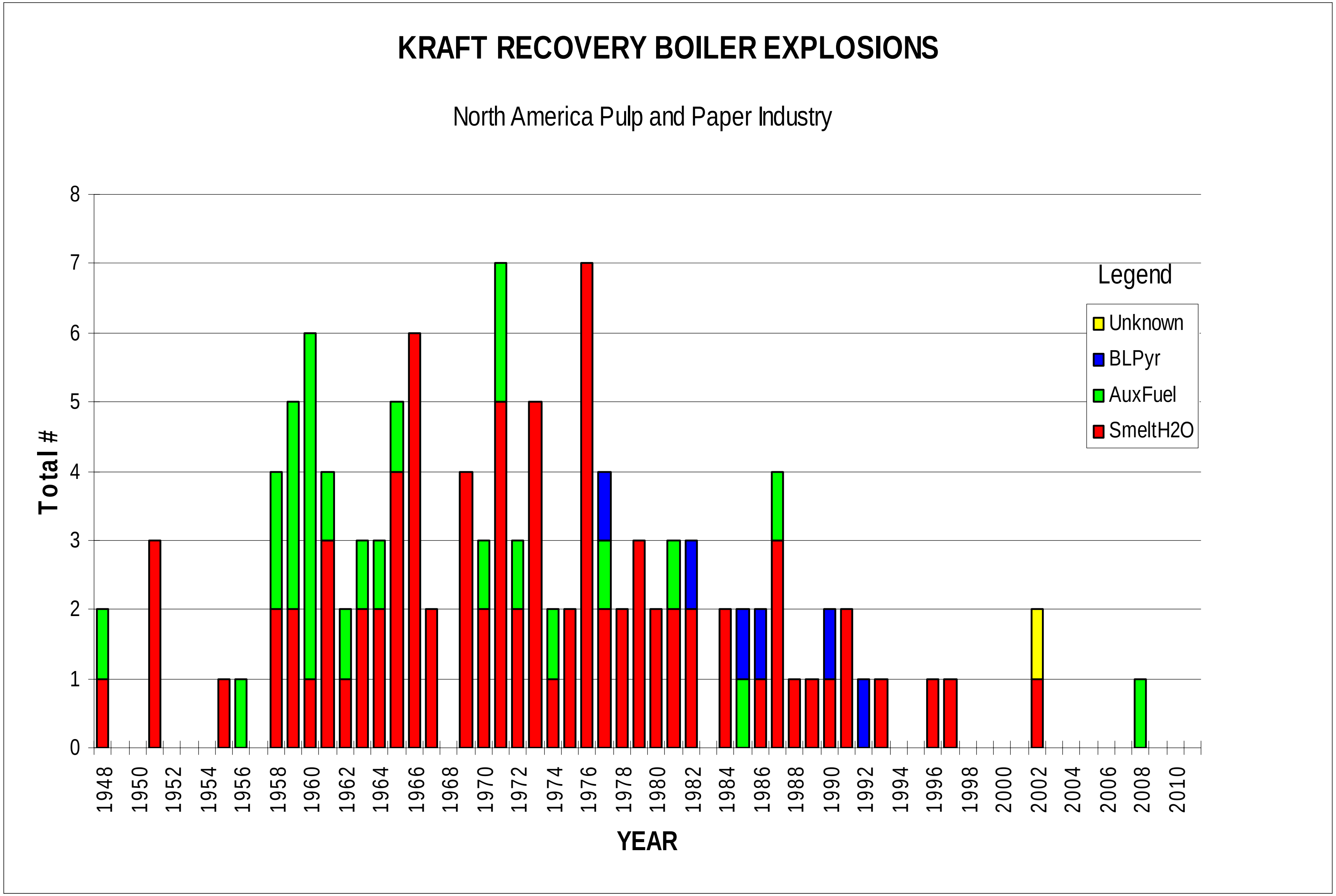
Totals may exceed # of incidents, since multiple causes were reported

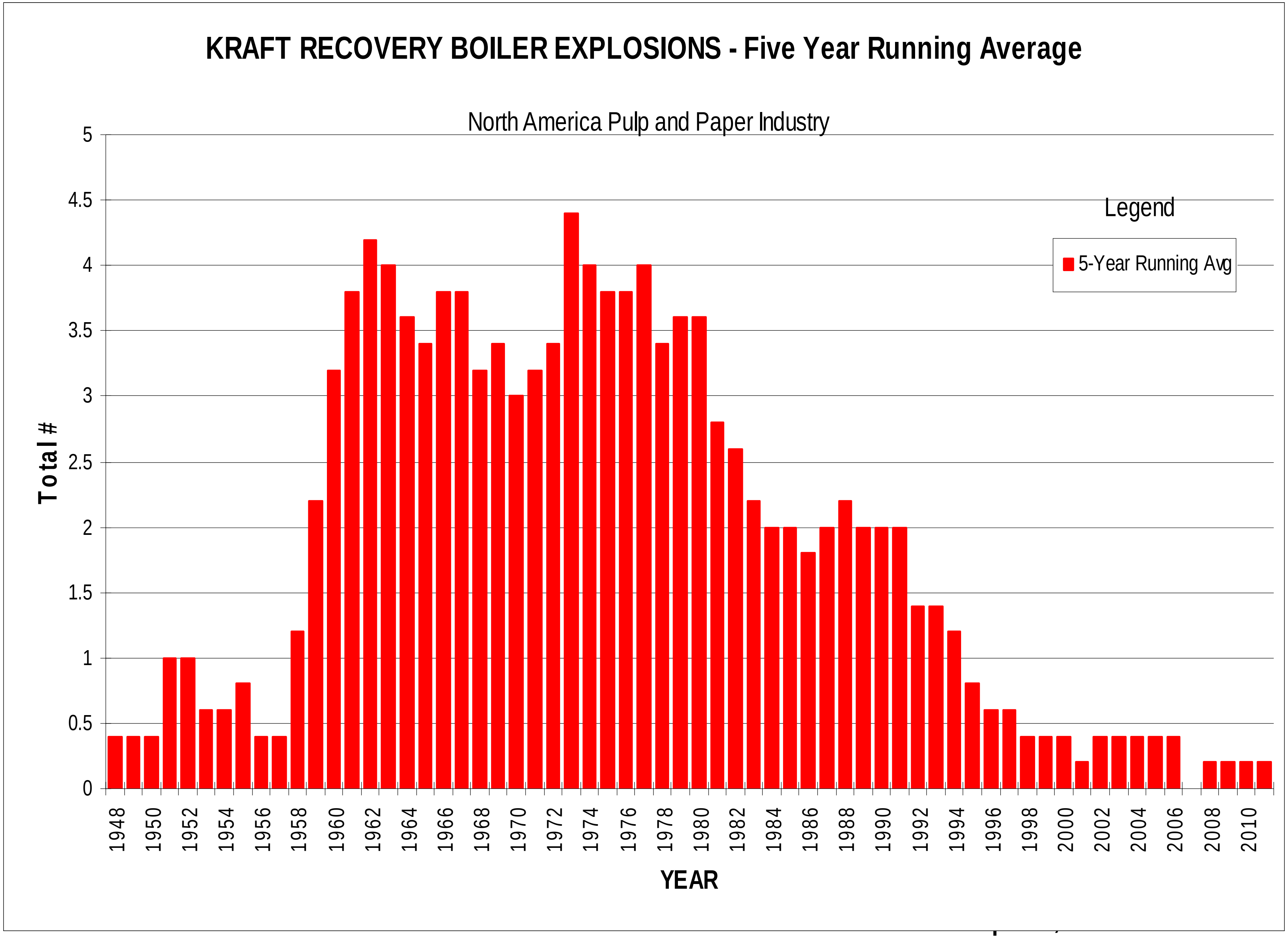
How Discovered 2011

Walk Down	30
Control Room Indications	17
Leak Detection	8
Bed Camera	-
Furnace Puff	8
SWR	1
Hydro	3
During Hydro	3
Fatality	1
Equipment Failure	1

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


KRAFT RECOVERY BOILER CRITICAL INCIDENTS
North America Pulp and Paper Industry
Total #
YEAR
0
5
10
15
20
25
30
35
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010


KRAFT RECOVERY BOILER EXPLOSIONS
North America Pulp and Paper Industry
Total #
YEAR
Legend
Unknown
BLPyr
AuxFuel
SmeltH2O


KRAFT RECOVERY BOILER EXPLOSIONS - Five Year Running Average
North America Pulp and Paper Industry
Legend
5-Year Running Avg
Total #
YEAR
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
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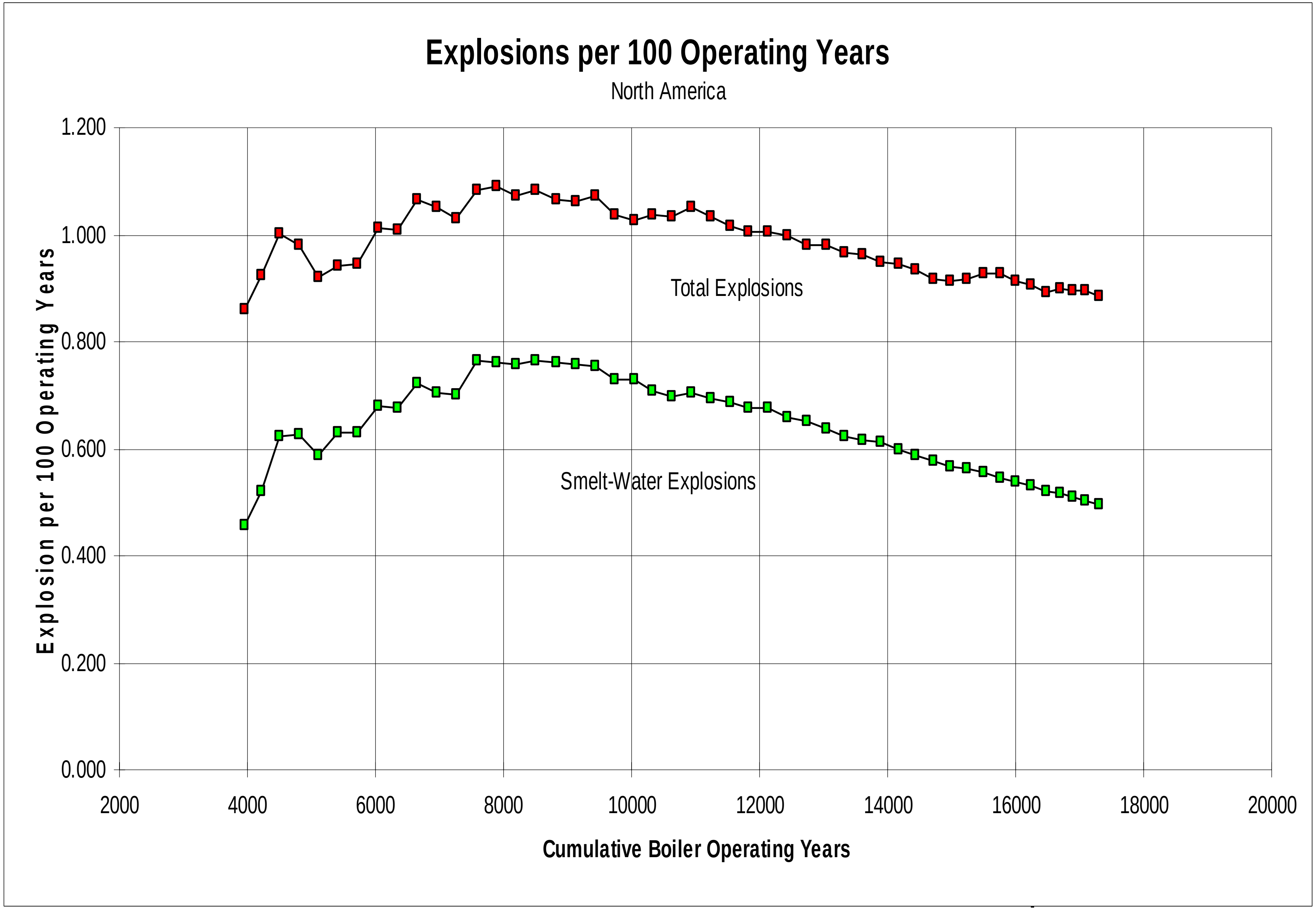
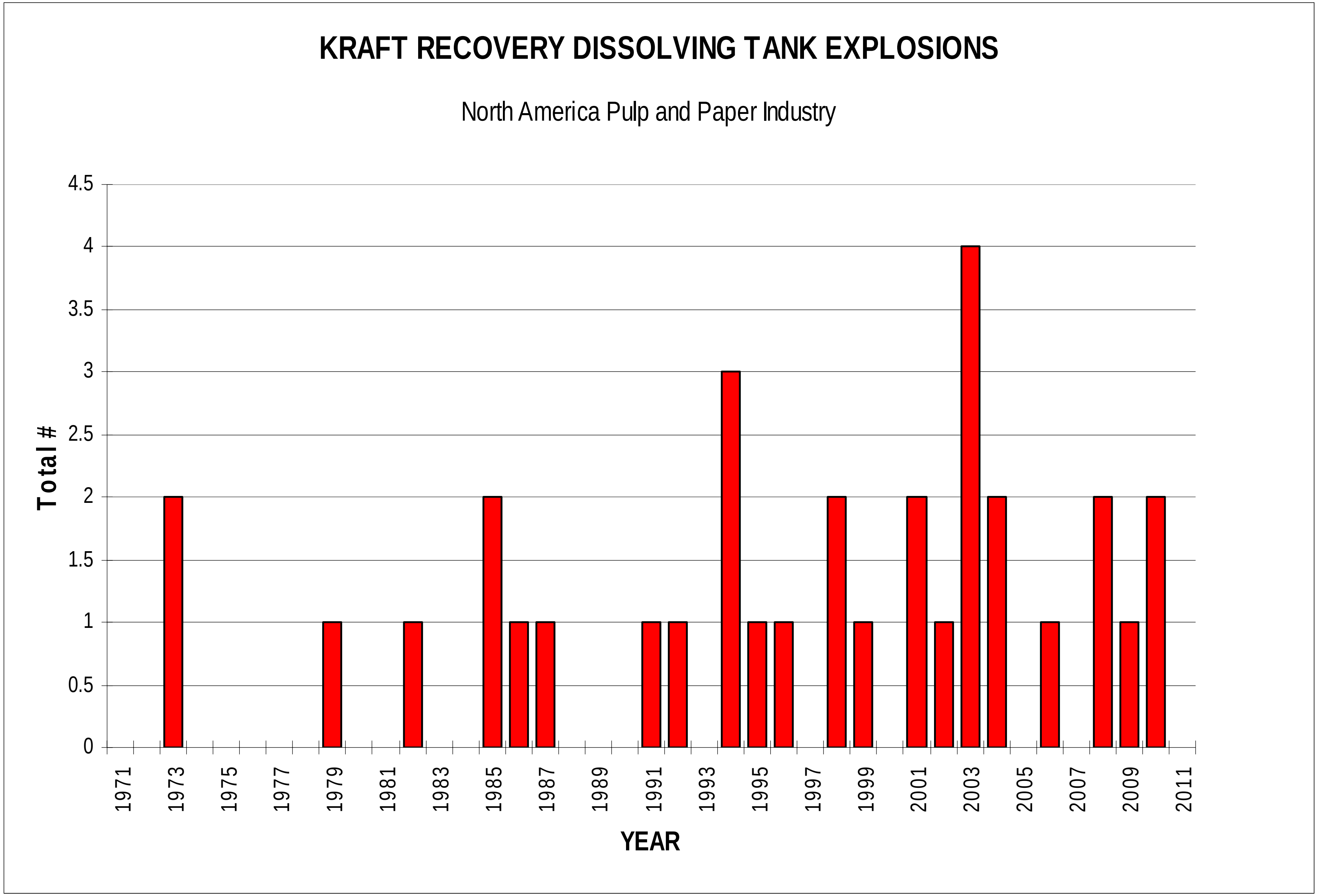
2004
2006
2008
2010



Explosions per 100 Operating Years
North America
Explosion per 100 Operating Years
1.200
1.000
0.800
0.600
0.400
0.200
0.000
Total Explosions
Smelt-Water Explosions
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
Cumulative Boiler Operating Years


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

Learnings

- Don’t assume economizer leaks are low behind boiler baffle
- Have clear indication of 1-drum baffles elevation
- Smelt spout leaks can shoot back into furnace
- One SH leak was due to short term overheat start-up conditions after only short shut-down
- Mount SH TC’s at least 12” below headers
- Check for thinning above composite tube line
- Assure operators have immediate authority to ESP

Learnings, cont’d

- Unit component, materials and control system changes need to be checked against safety consequences
- Small leaks can erode neighbor tubes to rupture – DON’T operate for extended period
- DCE dilution control and drive high amp alarm are important during upset conditions
- Leaking sootblower poppet valves can create tube leaks
- After trip, low drum level doesn’t confirm a leak

Learnings, cont'd

- Changes in unit conditions (liquor chemistry, etc.) can cause changes in corrosion progress
- Enter unit only after ash and slag are cleared
- Don't be in denial when looking for tube leaks

2011 ESP Subcommittee Summary of Activities

AF&PA Conference, Atlanta

February, 2012

Jules Gommi

- This report summarizes the 2011 activities of the Emergency Shutdown Procedures (ESP) Committee of BLRBAC, derived from both the Spring and Fall ESP meetings.
- The BLRBAC Meeting Reports on line contain added information. www.blrbac.org.
- Please forward new Incident Questionnaires to j.gommi@comcast.net.
- Please report all changes in company names and recovery unit operating status to j.gommi@comcast.net.

Normal Activities of the ESP Committee

- A major function of the Committee is to receive, review, classify, and share learnings from the Incident Questionnaires received from the North American community of recovery unit operators. In addition, international incidents are reviewed and shared as available.
- Another major function is to develop and keep up to date the Emergency Shutdown Procedure for quickly and safely shutting down a recovery unit as soon as a known hazard is recognized.

Normal Activities of the ESP Committee

- An extension of the Procedure deals with Testing Procedures.
- The subcommittee also interacts with other subcommittees and their recommendations to assure compatibility of efforts.

Normal Activities of the ESP Committee

Incident Definitions

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

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

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

Specific 2011 Activities of the ESP Committee

- The ESP Questionnaire gets minor changes regularly, so be sure to get your blank from the BLRBAC website www.blrbac.org
- The US & Canada Units In Service update lists on the website are only as good as the input you pass on to J Gommi. Please help with all the name changes and shutdowns.

Specific 2011 Activities of the ESP Committee

- ESP Procedures. Agreements and intent were reached after joint session with Instruments Subcommittee.
- They will use the term “RBSS” (Recovery Boiler Safety System) to do ESP, BMS, FSS and BLD. The ESP system must be specified “Energize to Activate” May be hard wired, but OK if programmable PLC’s. The Safety systems override the Regulatory systems.

Specific 2011 Activities of the ESP Committee, cont'd

- The final ESP Architecture to include:
- **System must be "Energize to Actuate"**
  - **Must remember Last State during power failures**
  - **Minimal logic**
  - **Seldom requires changes**
  - **Alternate means to perform all required actions**
  - **Management of Change issues**
    - **Inadvertent change of ESP logic must not be possible**
- Chapter 1 second sentence : "Upon initiation of the Emergency Shutdown Procedure, ~~a dedicated, stand-alone~~ **the** system shall perform the following automated actions"
- Page 4 after bulleted items: "The Emergency Shutdown Procedure functions must be "energized to activate" and executed either by means of relay technology and hard-wiring or other Recovery Boiler Safety System as described in Chapter 4 of the *Instrumentation Checklist and Classification Guide*. It must not be possible to alter the system unintentionally or to alter the system during operation of the boiler. Any time maintenance is done or modifications are made to the system, the system shall be functionally tested prior to putting the unit back on line. Whatever technology is utilized, the BMS or DCS systems can be used to monitor operation of the functions. Any time modifications are made to the system, the system shall be functionally tested prior to putting the unit back on line."

Specific 2011 Activities of the ESP Committee, cont'd

- Delete "Dedicated Stand Alone" definition from Section 3.24
- Note: Even maintenance activity can affect the system without realizing the consequence, and management of change is so important
- A cascade fire incident occurred where dilution water was shut off as part of the ESP. If the ESP shuts the black liquor pump and cascade dilution water is shut due to "no water to furnace" requirement, and the cascade starts to concentrate, cascade liquor can concentrate to excess with fire resulting from pyrolysis gasses or overheated dried liquor. A joint meeting will be scheduled with the Fire Protection in DCE committee and DCE operating company reps to resolve the issues. It will also cover proper operation of fans and dampers if fire detected post ESP, and revision of Post ESP Guidelines.

TAPPI Power and Recovery Boiler Sub-Committee Update

Objectives:

To develop & disseminate information, and provide best practice guidelines related to:

- Design & operation of recovery boilers, evaporators, NCG systems & related equipment
- Steam generation from solid fuels, such as coal, bark, wood refuse and MSW
- Thermal and electric power cycle design, operating performance and energy policy considerations
- Design requirements for boiler feedwater systems, monitoring requirements for boiler feedwater and condensate systems and response to feedwater contamination.
- Design, application and operation of gasification technologies for biomass and black liquor.

Activities:

- Develop TIP's (Tech. Info. Papers/Proc.)
- Support TAPPI Conferences with technical program items, coordination

Recovery Boiler – Released TIP's

- Specification for Procurement of Recovery Boiler Economizer (2009)
  - Developed from AF&PA Economizer Study
- Recommended Test Procedures for Black Liquor Evaporators (2008)
  - Documents test procedures for evaporators
- Recovery Boiler Sootblowers (2009)
  - Two TIP's – "The Basics" and "Practical Guidelines"
- Recovery Boiler Performance Calculation Forms
  - Long Form/in publication form - Short Form/includes spreadsheet

Recovery Boiler – Released TIP's

- Stripping of Kraft Pulping Process Condensates–Regulations, Design & Operations (2008)
- Collection and Burning of Concentrated NCG's – Regulations, Design, Operation (2008)
- Recovery Boiler Energy Efficiency Improvements (2008)
- Estimating the First Melting Temperature of Fireside Deposits in Recovery Boilers (2004)

Recovery Boiler – Released TIP's:

- Chloride and Potassium Measurement and Control in the Pulping and Chemical Recovery Cycle (2005)
- Guidelines for Replacement of Generating Bank Tubes with Expanded Joints in Two-drum Boilers (2009)
- Guidelines for Operating and Maintenance Impacting Recovery Boiler Economizers (2009)
  - Appendix 2 from recent AF&PA economizer study

Water Treatment Activities

- Keys to Successful Cleaning of Boilers
  - Mandatory 5-year review in 2009
- Water Quality and Monitoring Requirements for Paper Mill Boilers Operating on High Purity Feedwater
  - Mandatory 5-year review
  - Editing, review underway
- Water Quality Guidelines and Monitoring Requirements for Paper Mill Boilers Operating with Softened Make-up Water
  - Mandatory 5-year review
  - Editing, review underway
- The A-B-C's of Ion Exchange
- Steam Purity

Meetings:

- Meetings are held twice per year
  - Next Meeting
  - Spring, Following BLRBAC Meeting
  - Wednesday April 6, 2011; 1:00 pm – 4:00 pm

  - PEERS Conference October 15, 2012

Chloride (Cl) and Potassium (K) Accumulation and Control

PULP&
PAPER
UNIVERSITY OF TORONTO

Honghi Tran
Pulp & Paper Centre
University of Toronto, Toronto, CANADA

AF&PA Recovery Boiler Program Annual Meetings and Conference
Atlanta, GA, February 8, 2012

Presentation Outline

- Problems with Cl and K
- Inputs
- Accumulation
- Deposit formation and Cl and K contents
- Control

Problems with Cl and K

- Occurs mostly in recovery boilers
- Fouling of tube surfaces
  - Increase the liquid content of carryover and deposits at a given temperature
  - Decrease sticky temperatures of carryover and deposits

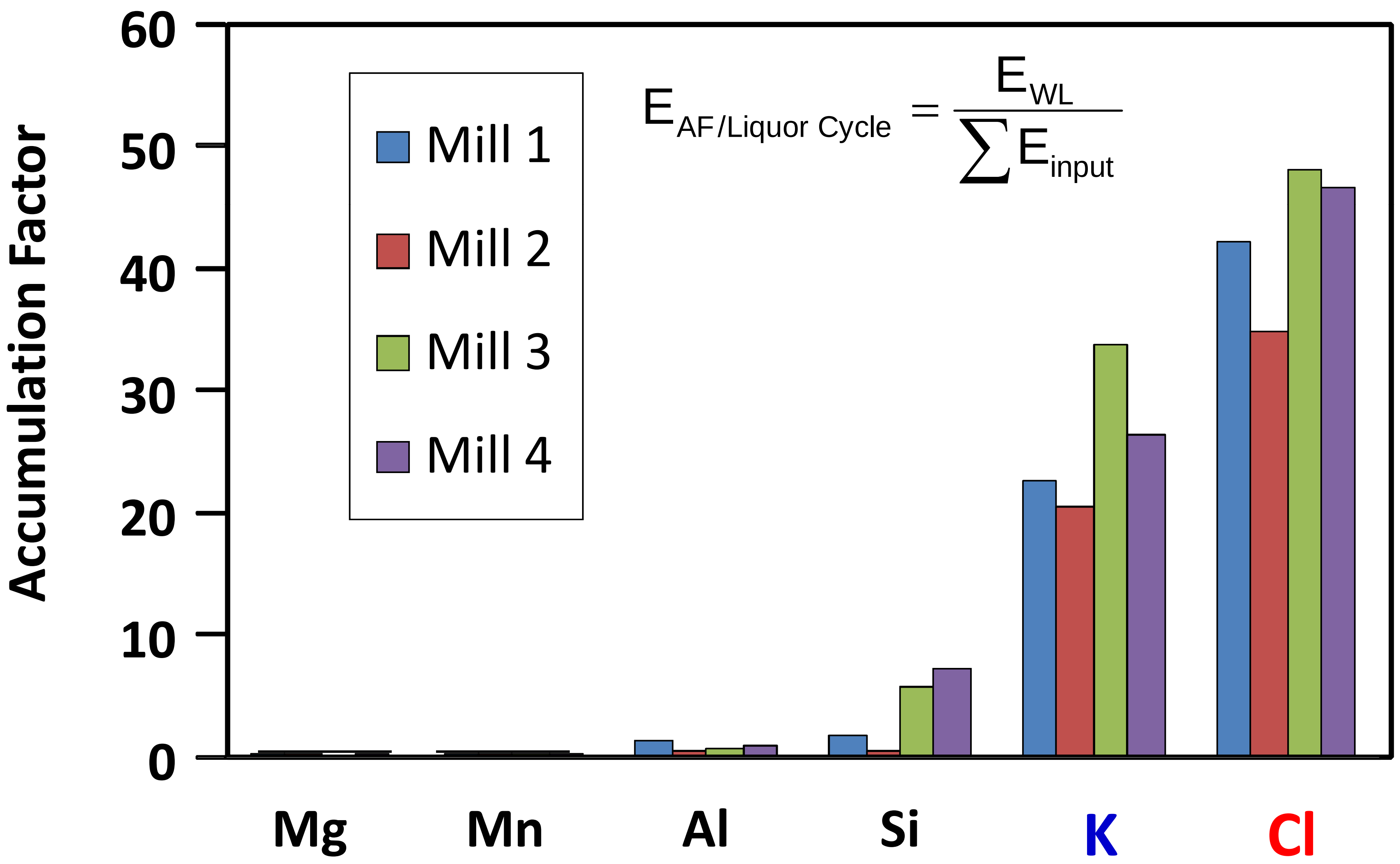
Problems with Cl and K

- Lower furnace corrosion
  - Thin wall deposits → increase tube surface temperature
- Superheater corrosion
  - Lower deposit First Melting Temperature
  - Increase deposit liquid content at FMT
  - Dissolve corrosion products
- Back end corrosion
  - HCl formation
  - Dew point corrosion

Chloride (Cl) and Potassium (K)

- Two main non-process elements (NPEs) in the liquor
- Enter the liquor cycle mainly with wood, but also with
  - Makeup sodium (Cl)
  - Makeup lime (K)
  - Water (Cl)
  - Biosludge (Cl)
- Accumulate in the liquor cycle
  - Due to the high solubility of alkali salts in water

Accumulation Factors in Liquor Cycle

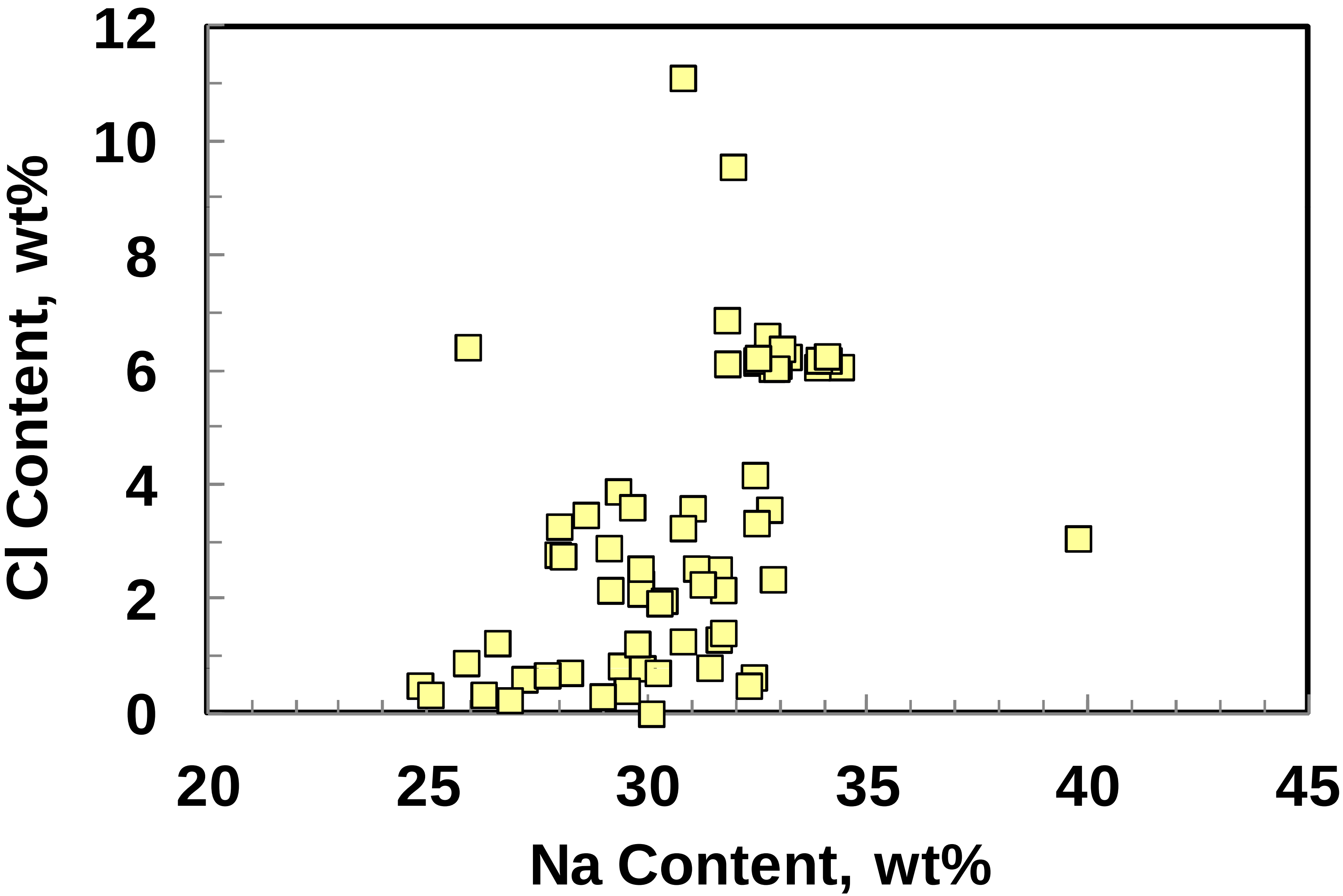


PAPRICAN

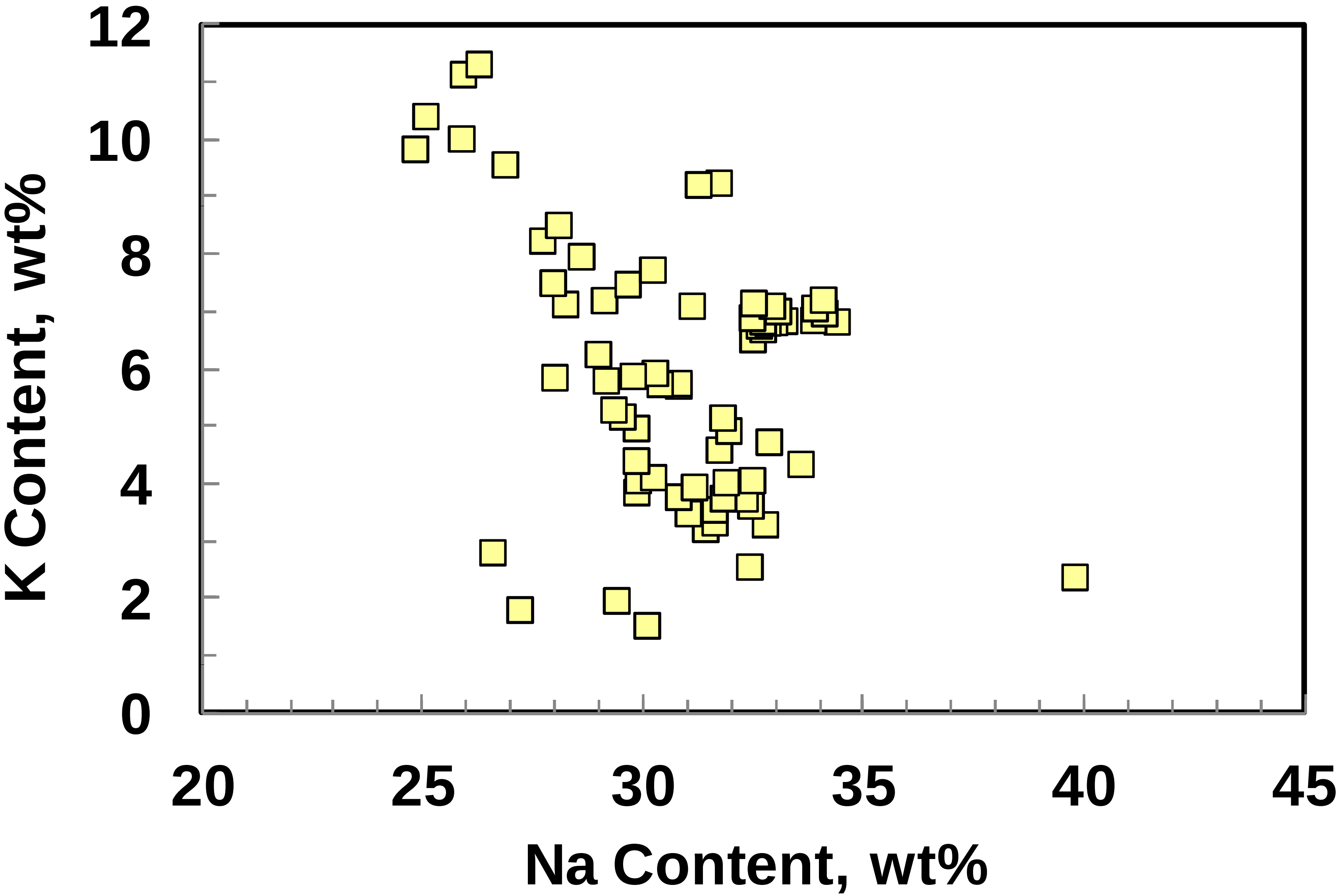
Cl and K Compounds

- **Chlorine**
  - **Mainly NaCl with a small amount of KCl, organic Cl and Cl-containing minerals**
  - **Eventually present as Cl^-**
- **Potassium**
  - **Mainly as K-containing minerals and KCl**
  - **Eventually present as OH^-, CO_3^{2-}, S^{2-}, SO_4^{2-} and Cl^-**

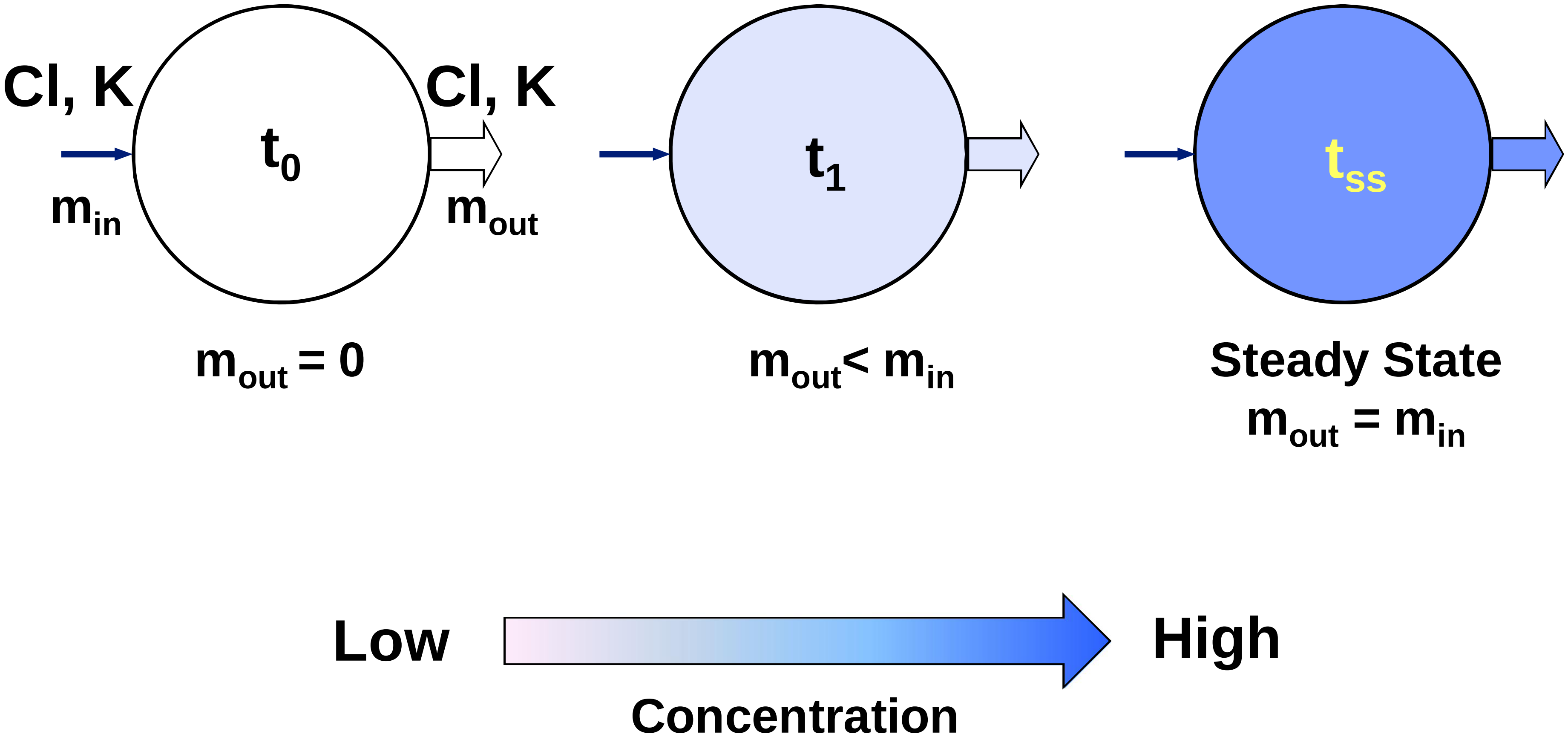
Chlorine vs. Sodium in Ash



Potassium vs. Sodium in ESP-Ash

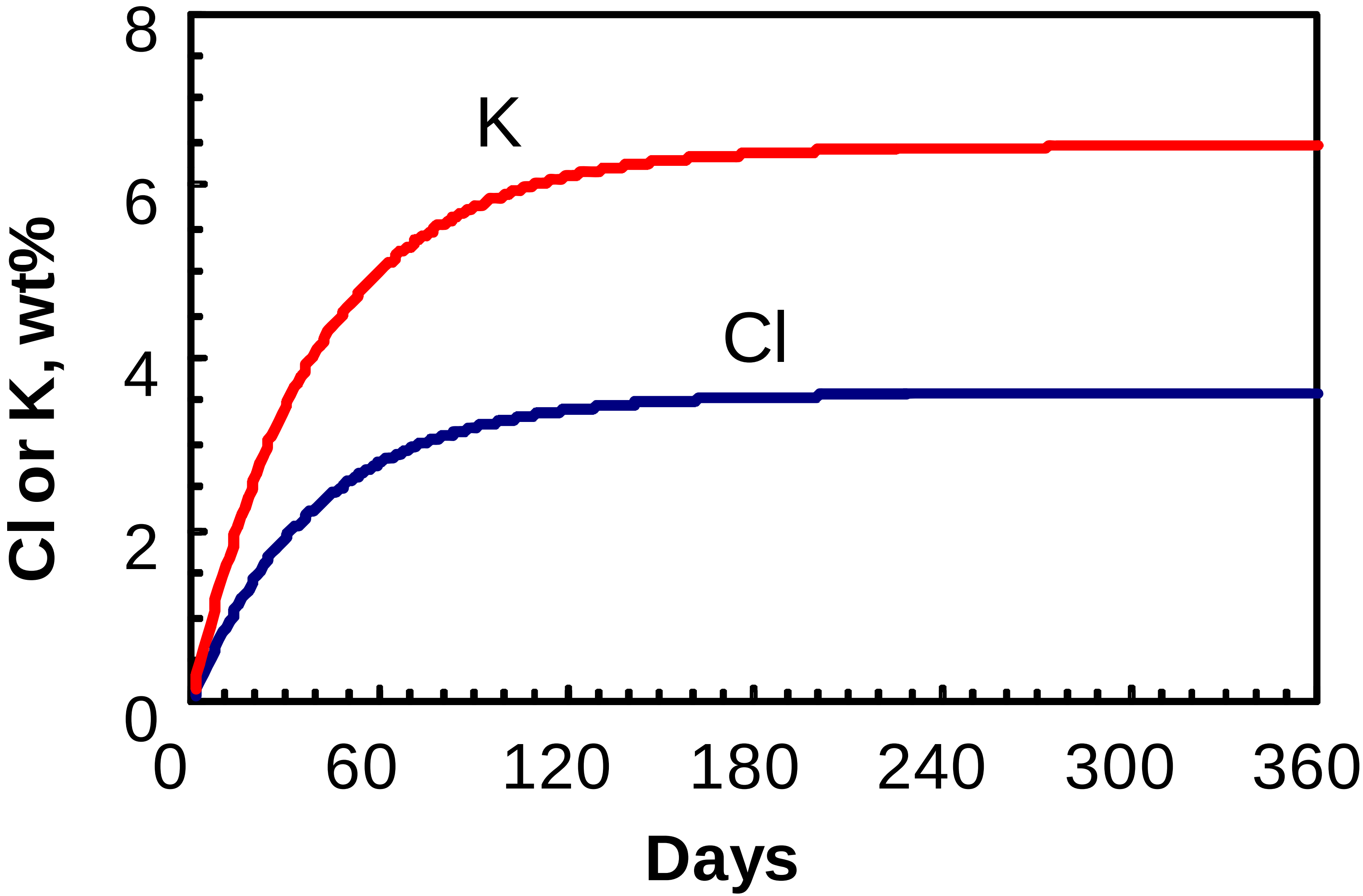


Accumulation



Cl and K Contents in Ash

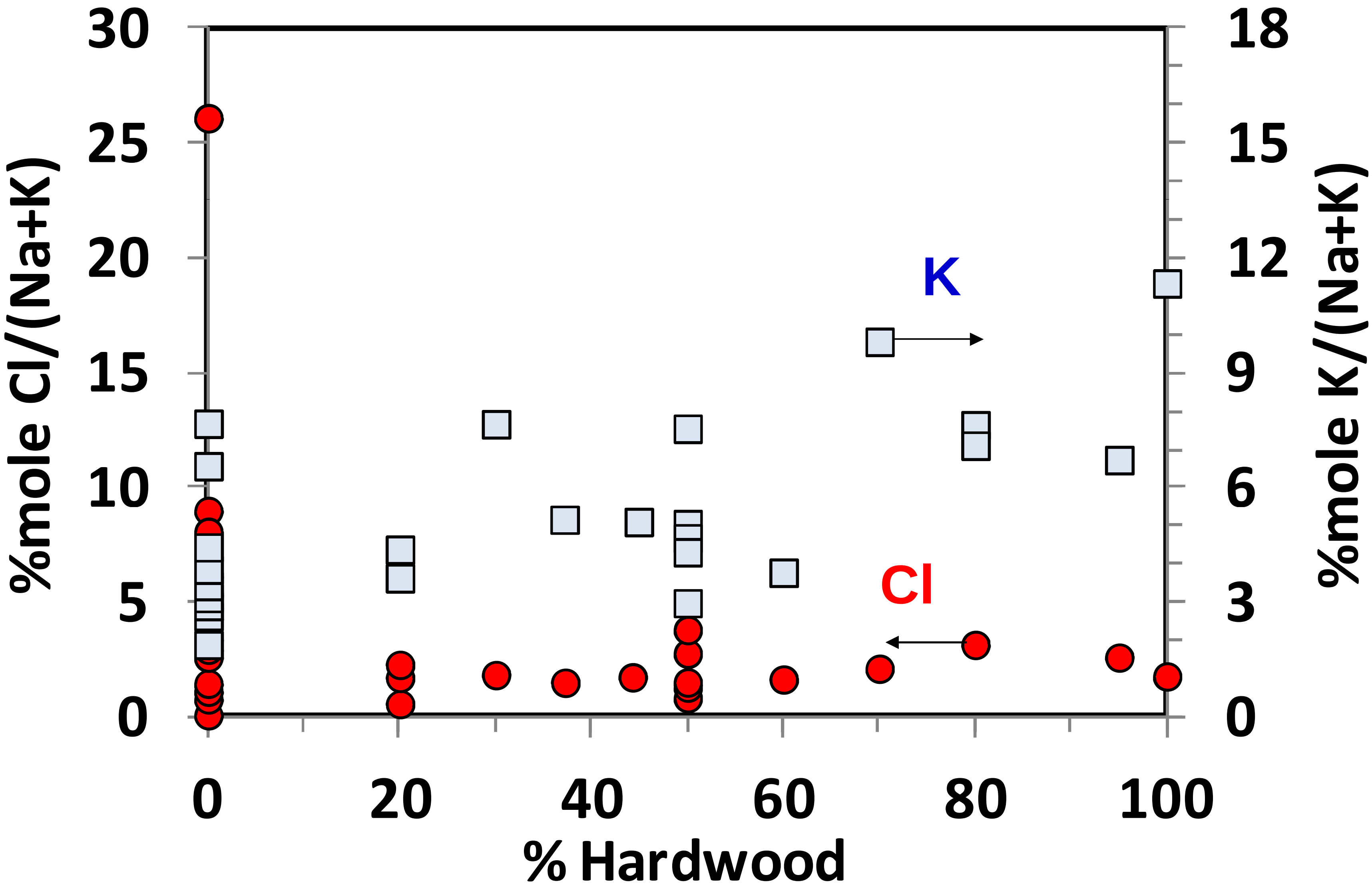
An Example



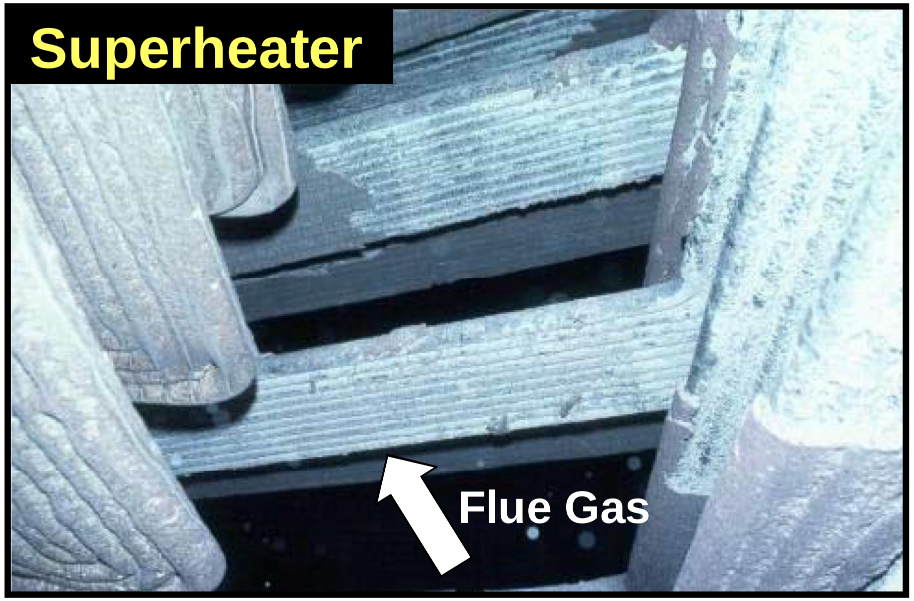
Cl and K Conc. in Liquor Increase with

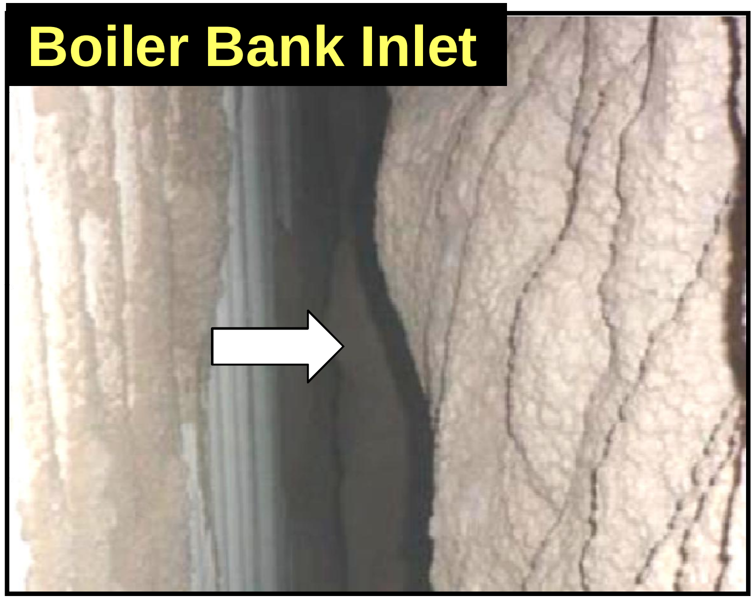
- Cl and K inputs
  - Coastal mills > Inland mills (Cl only)
  - Hardwood mills > Softwood mills (K only)
- Degree of mill closure (low chemical losses)
- Decrease in liquor sulphidity (Cl only)
- Increase in reocvery boiler bed temperature (Cl only)

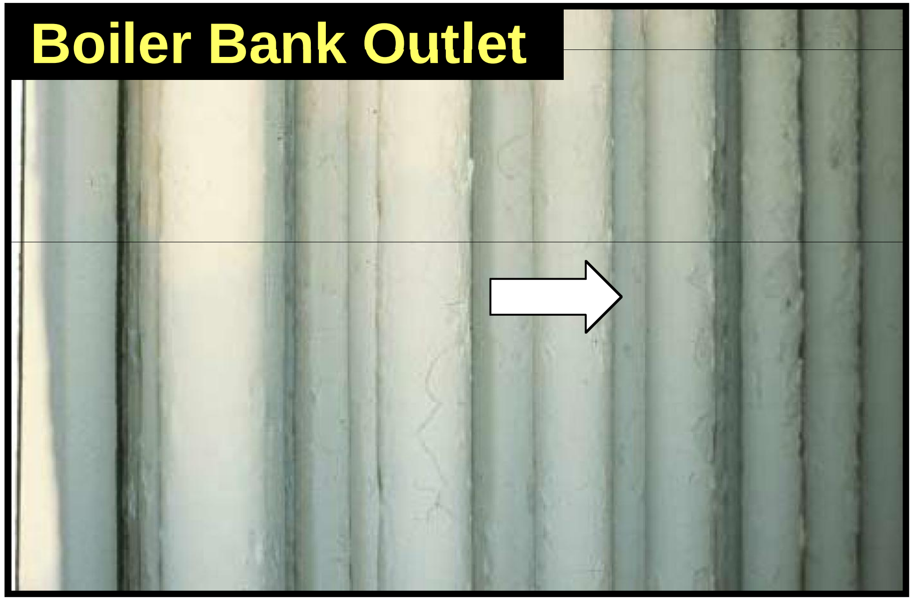
Hardwood Pulping vs. Cl and K in Dust

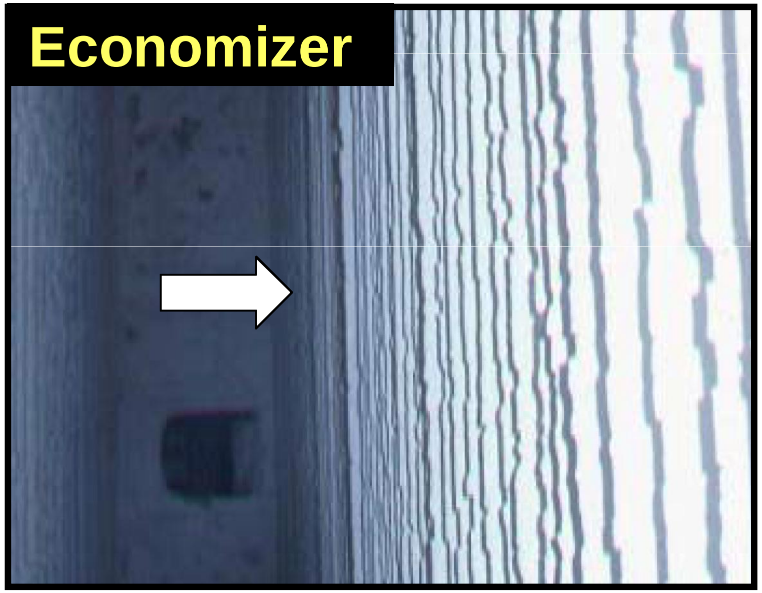


Deposit Formation

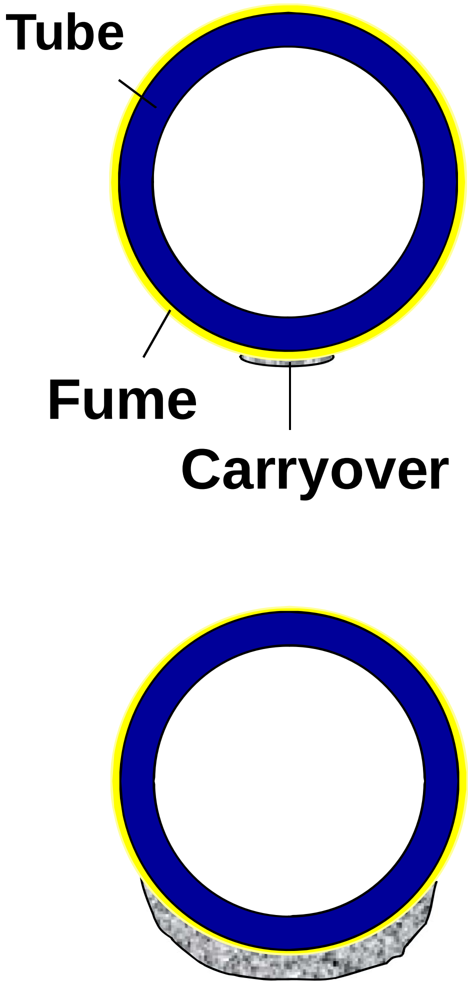


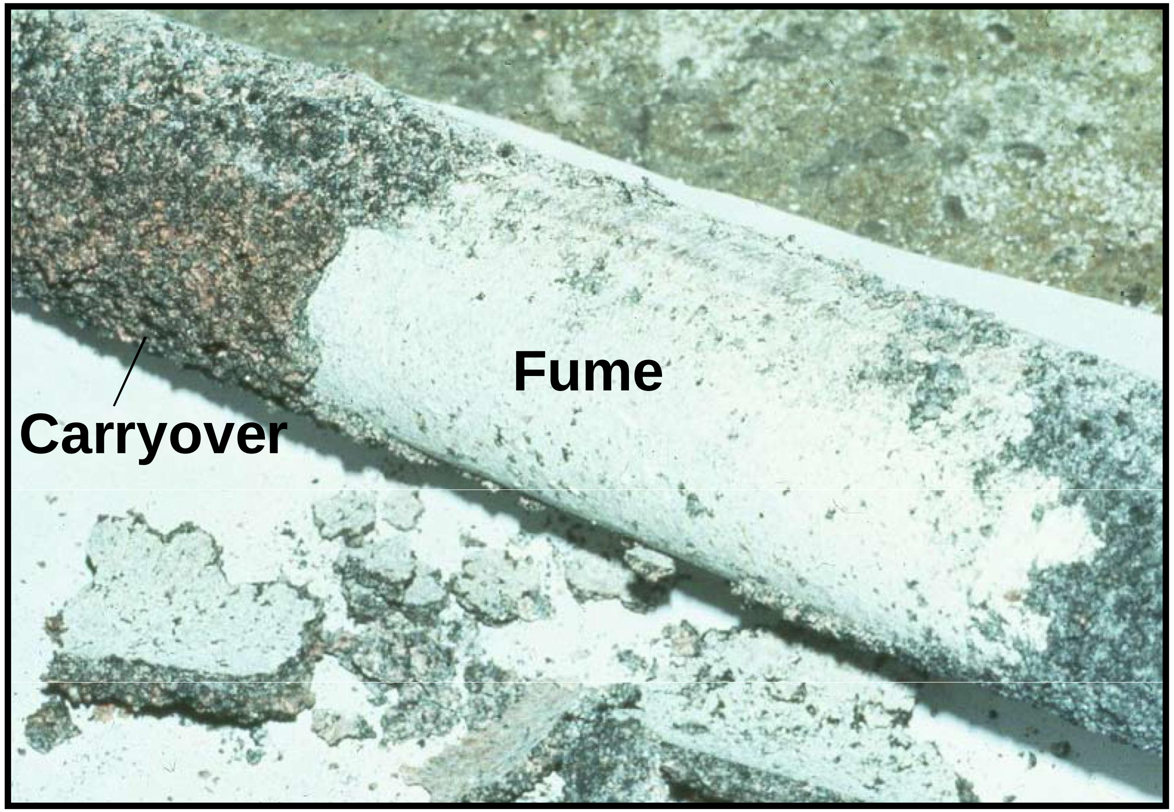






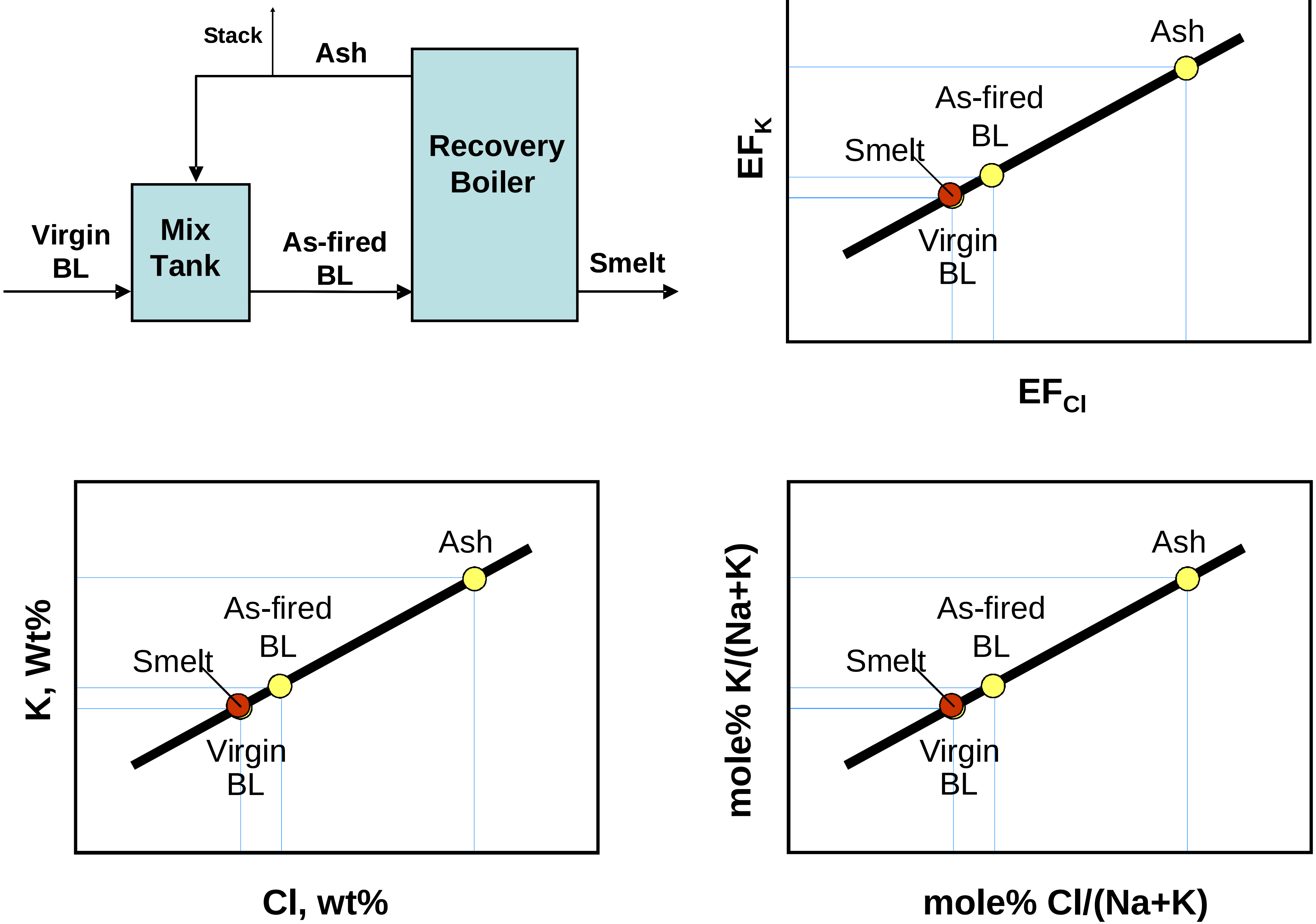
Carryover and Fume Deposits





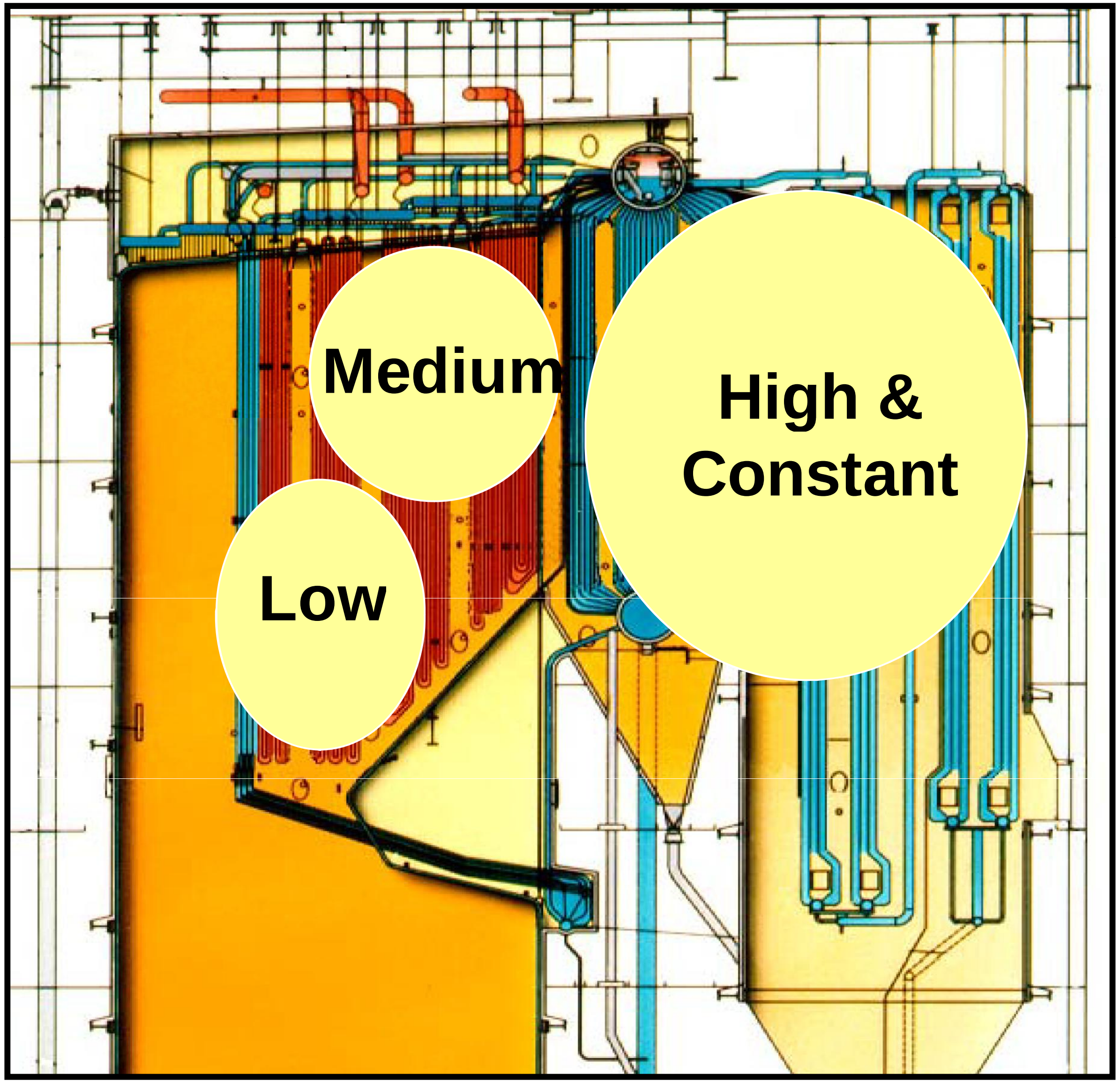
Deposits are a Mixture of Carryover and Fume

- **Carryover Deposits**
  - **Inertial impaction**
  - **Formed mostly in the superheater region**
  - **Depleted in Cl and K (EF_{Cl} = 0.3, EF_{K} = 0.8)**
- **Fume Deposits**
  - **Direct condensation and thermophoresis**
  - **Formed mostly in the upper superheater, generating bank and economizer regions**
  - **Enriched in Cl and K (EF_{Cl} = 2.5, EF_{K} = 1.5)**

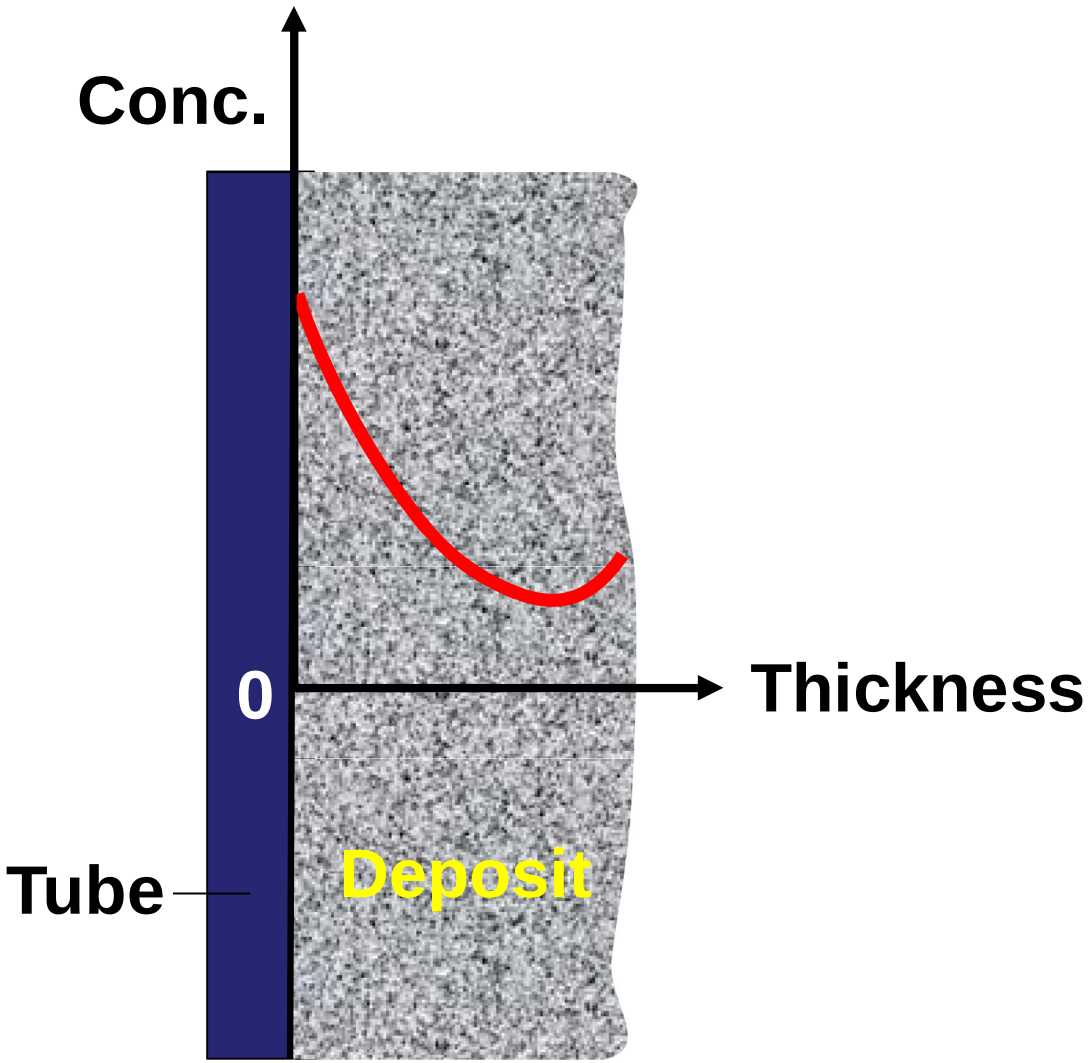


Stack
Ash
Recovery Boiler
Mix Tank
Virgin BL
As-fired BL
Smelt
Ash
As-fired BL
Smelt
Virgin BL
EF_K
EF_Cl
Ash
As-fired BL
Smelt
Virgin BL
K, Wt%
Cl, wt%
Ash
As-fired BL
Smelt
Virgin BL
mole% K/(Na+K)
mole% Cl/(Na+K)

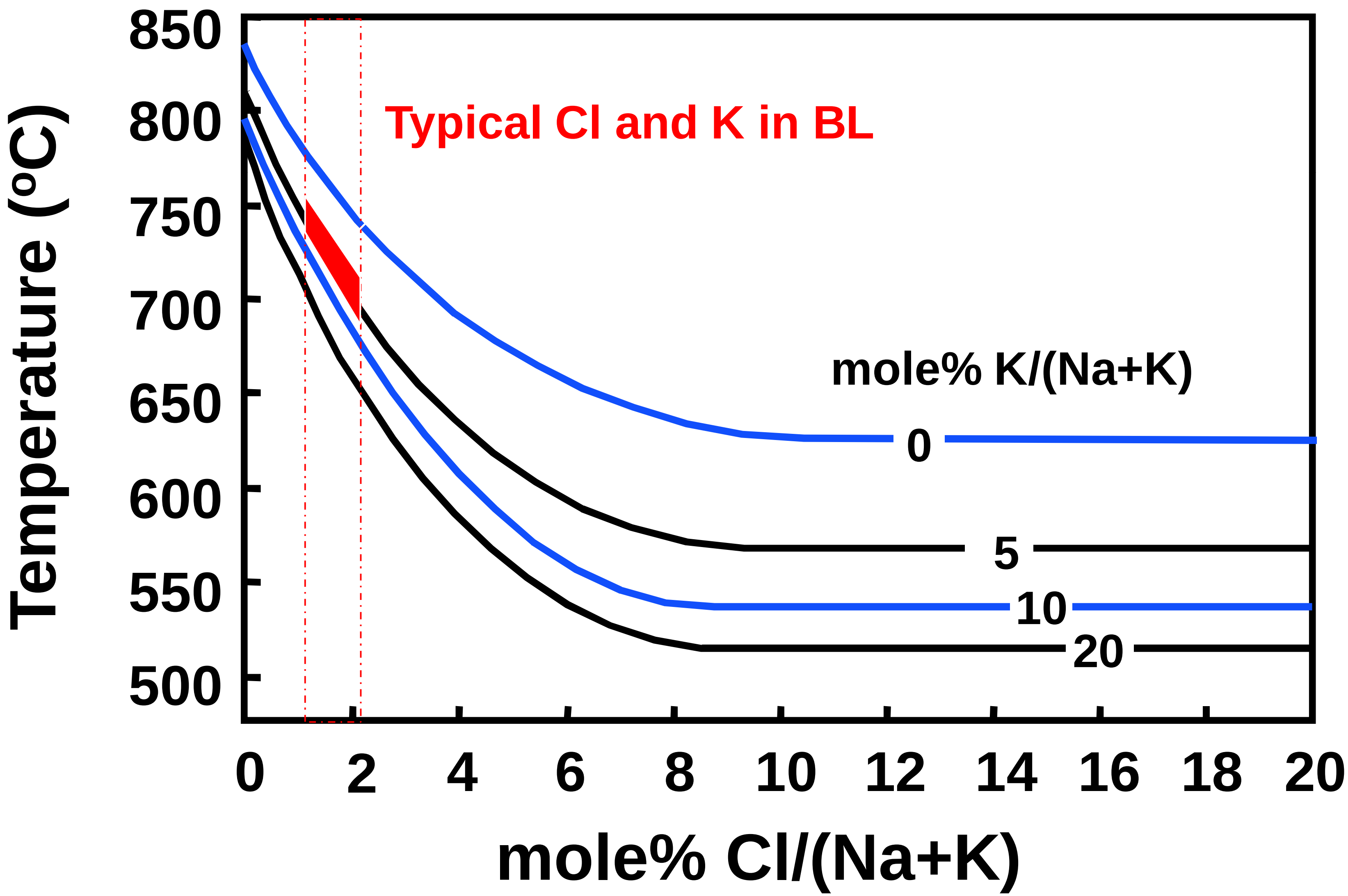
Cl and K Contents in Deposits



Cl and K Conc. Profile Across the Superheater Deposit Layer



Deposit Sticky Temperature



Concentration Units

- Units
  - wt% (as Cl, NaCl)
  - mole% (as Cl/Na%, Cl/(Na+K)%)
  - g/L, lb/ft^3, lb/gal
  - ppm
- Media
  - Black liquor (weak, virgin, as-fired)
  - White liquor
  - Smelt
  - Precipitator ash
  - Deposits

Concentration Units

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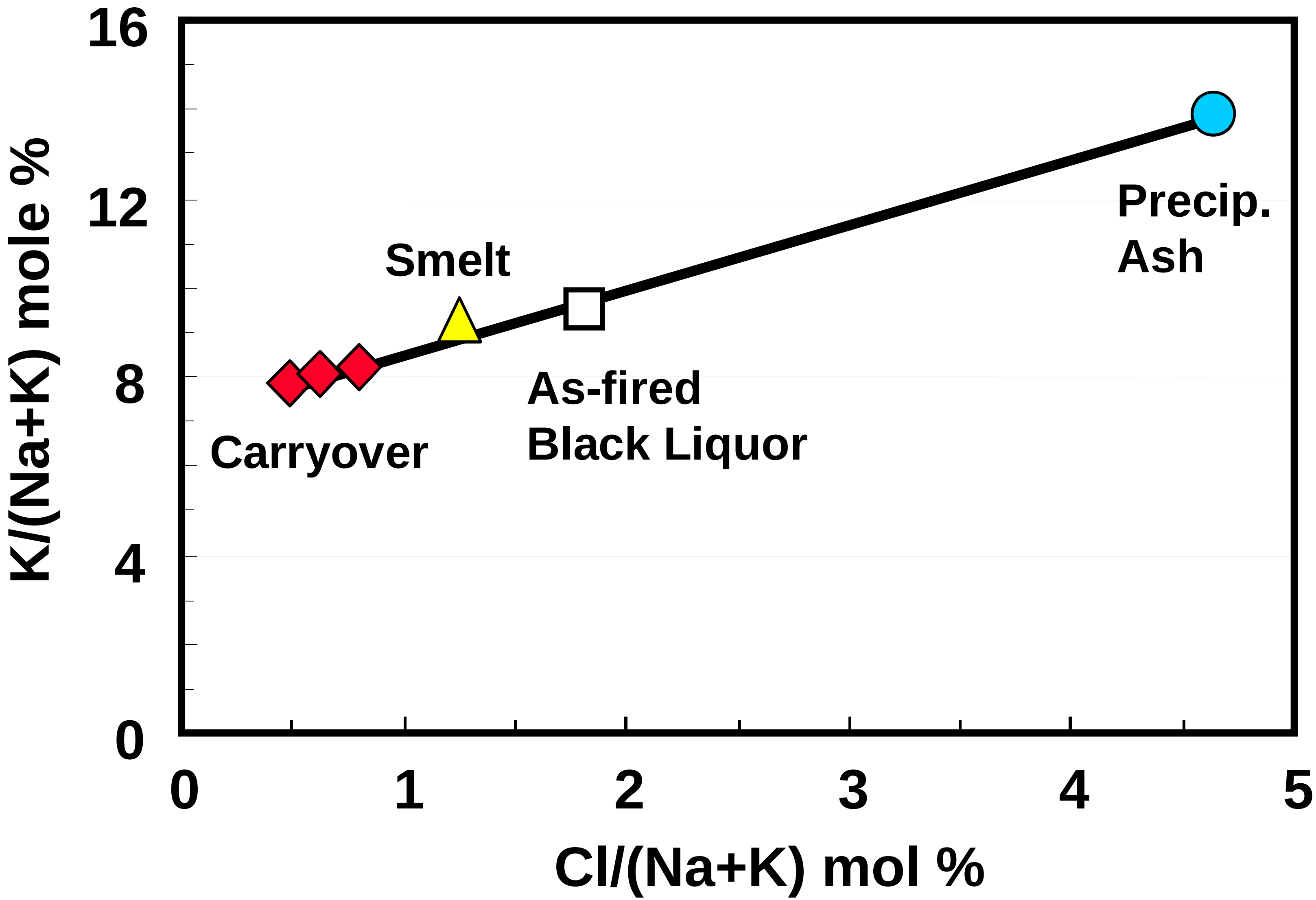
  - ppm
- Media
  - Black liquor (weak, virgin, as-fired)
  - White liquor
  - Smelt
  - Precipitator ash
  - Deposits

Same value in mole%

Cl content vs. K Content in a RB



Rules of Thumb for Unit Conversions

- **Black Liquor**
  - **1 wt% Cl = 3.3 mole% Cl/(Na+K)**
  - **1 wt% K = 3.0 mole% K/(Na+K)**

  → To convert wt% into mole%, multiply by 3

- **Precipitator Ash**
  - **1 wt% Cl = 2.0 mole% Cl/(Na+K)**
  - **1 wt% K = 1.8 mole% K/(Na+K)**

  → To convert wt% into mole%, multiply by 2

Rules of Thumb for Unit Conversions

- **Precipitator Ash vs. As-fired Black Liquor**
  - **1 wt% Cl in ash $\Rightarrow$ 0.24 wt% Cl in as-fired BL**
  - **1 wt% K in ash $\Rightarrow$ 0.40 wt% K in as-fired BL**

Guidelines for Controlling Cl and K in As-fired Black Liquor

	Chloride (wt% Cl)	Potassium (wt% K)
Very low	< 1	< 0.7
Low	0.1 – 0.3	0.7 – 1
Typical	0.3 – 0.7	1 – 2
High	0.7 – 2	2 – 4
Very high	> 2	> 4

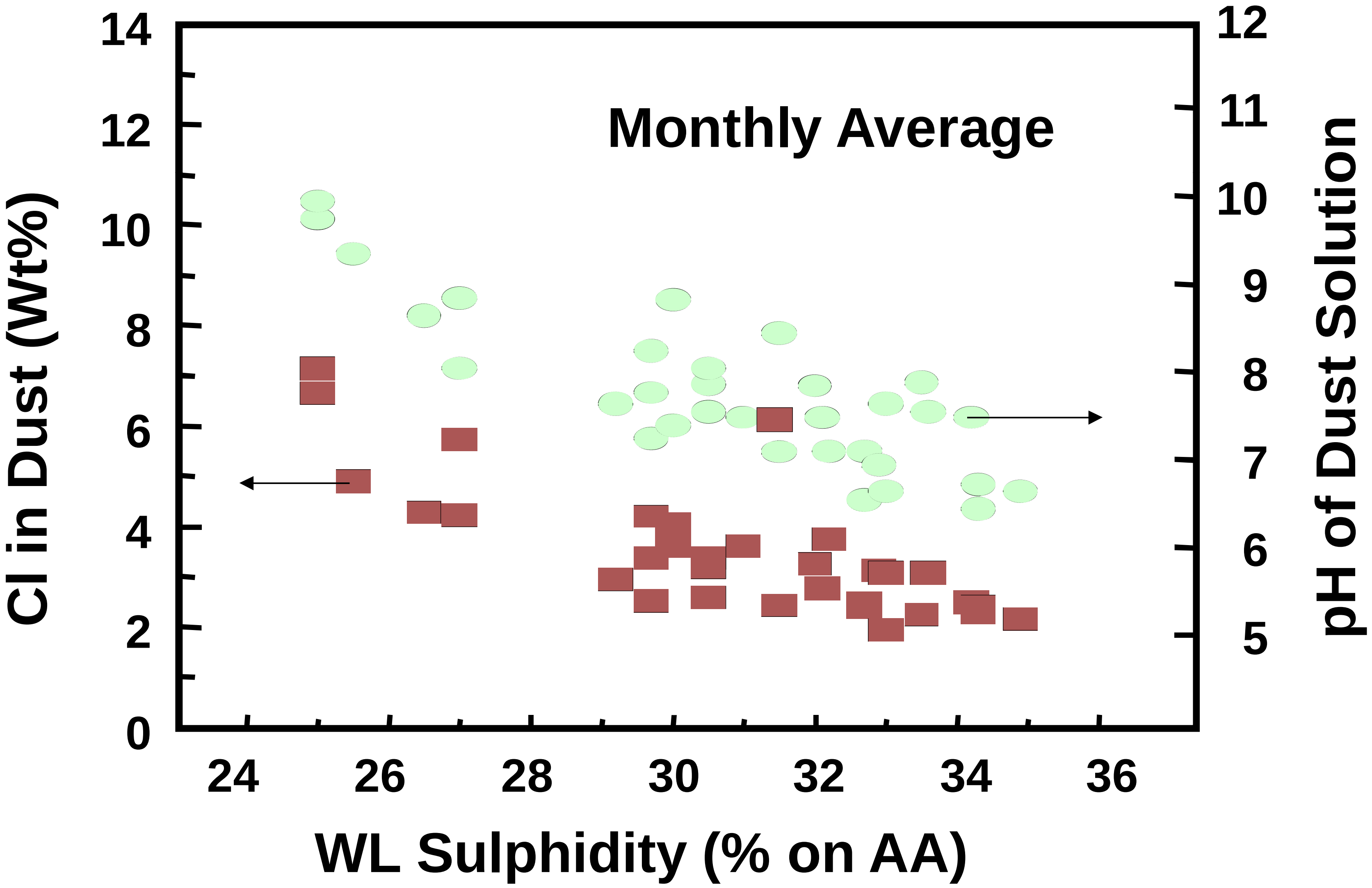
Guidelines for Controlling Cl and K in Precipitator Ash

	Chloride (wt% Cl)	Potassium (wt% K)
Very low	< 0.4	< 1.8
Low	0.4 – 1.2	1.8 – 2.5
Typical	1.2 – 2.9	2.5 – 5
High	2.9 – 8.5	5 – 9
Very high	> 8.5	> 9

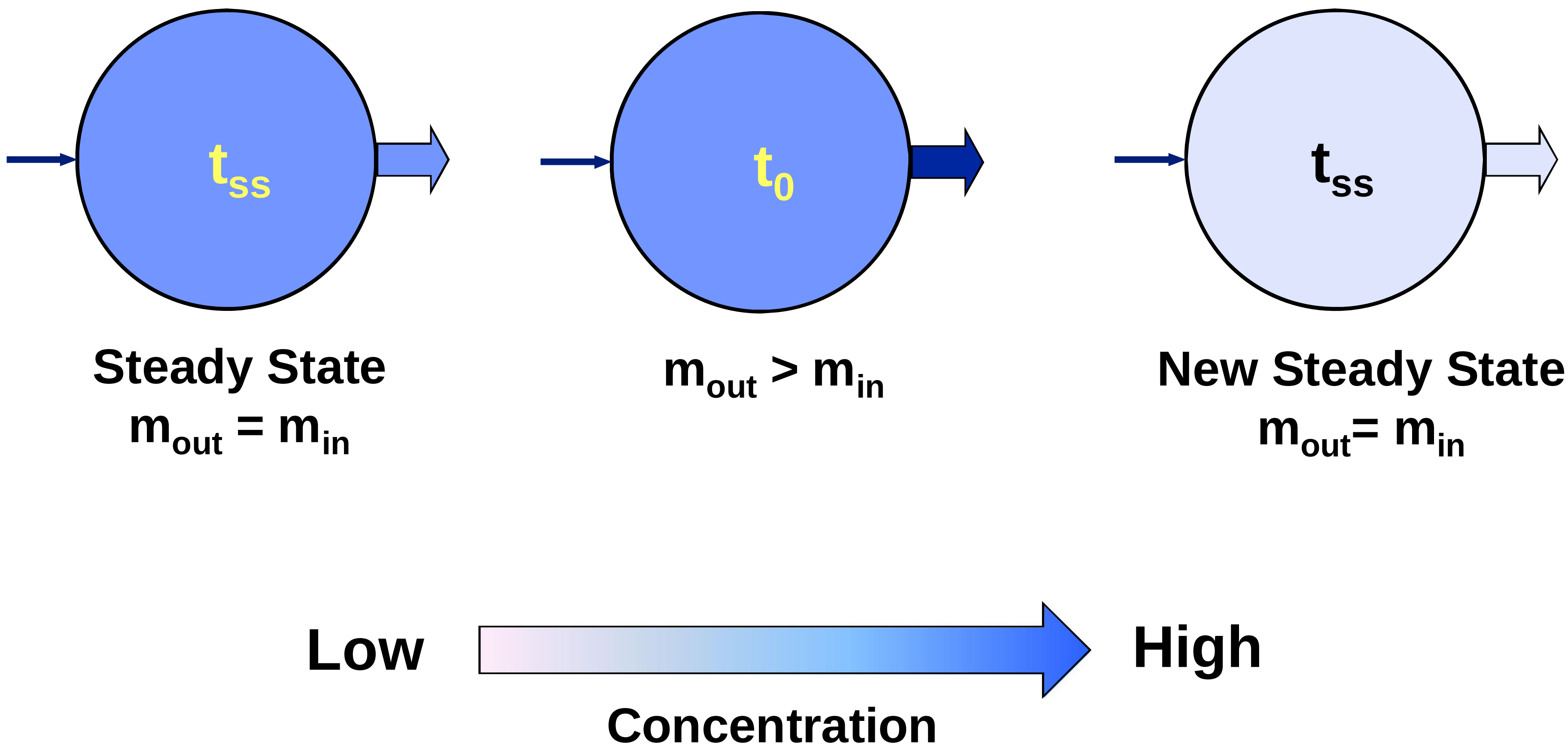
Factors Affecting Accumulation

- Input
- Loss
- Ash purged
- Sulphidity, SO_2, HCl release
- Na inventory
- Makeup chemicals

Effect of Sulphidity

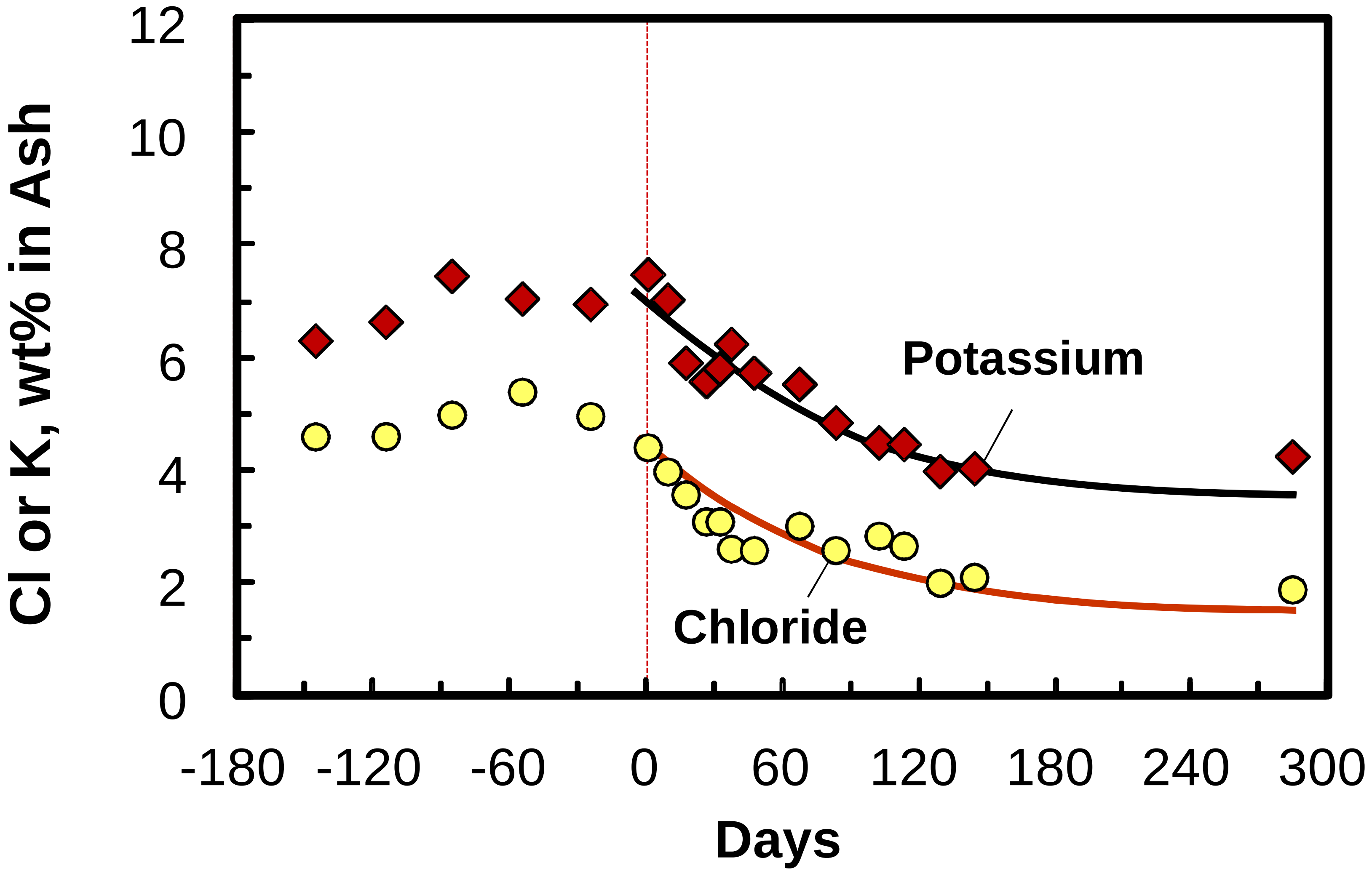


Ash Purging/Treatment



Experience of Ash Treatment System

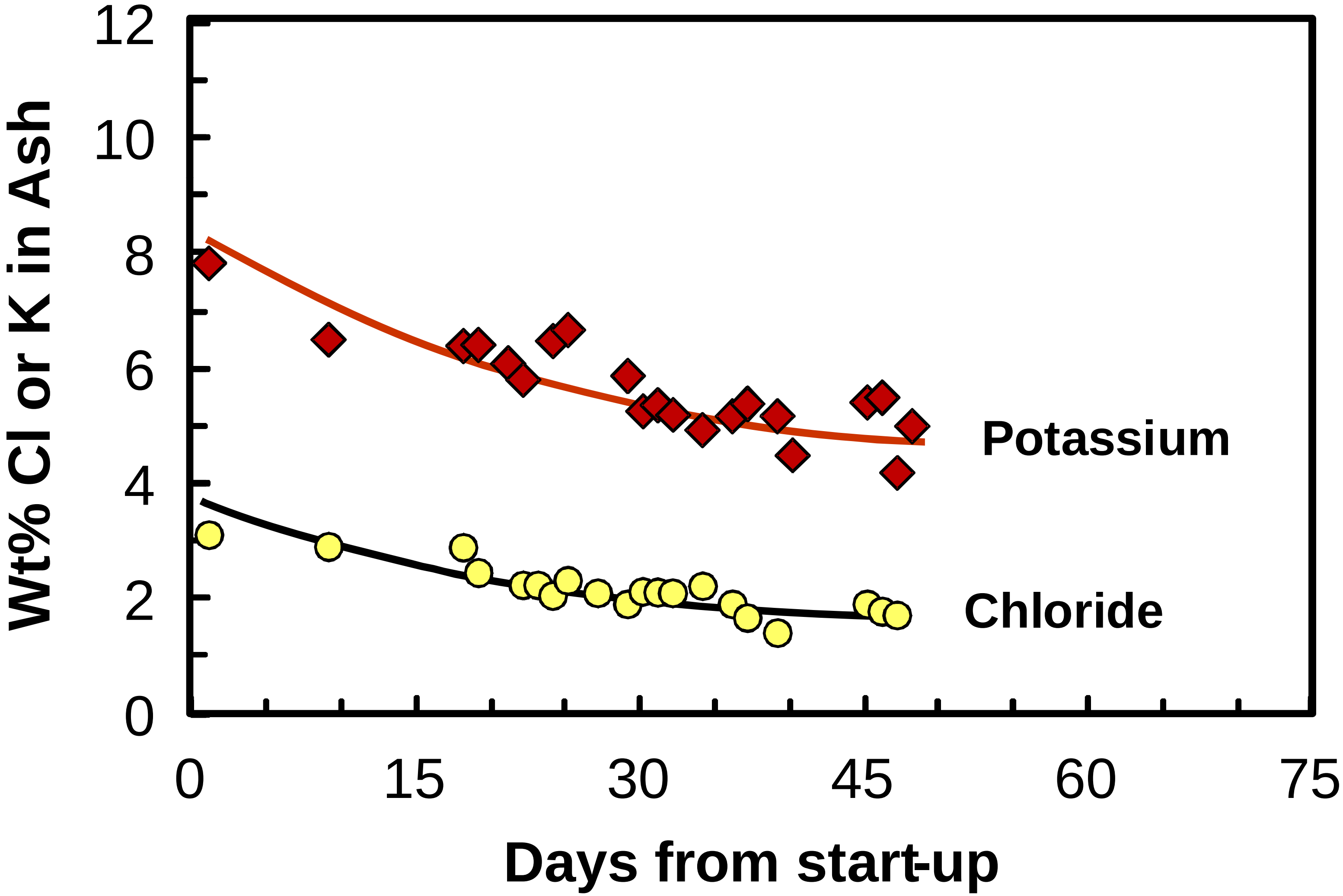
(Oji Paper Yonago Mill, Japan)



MHI (2001)

Experience of Ash Leaching System

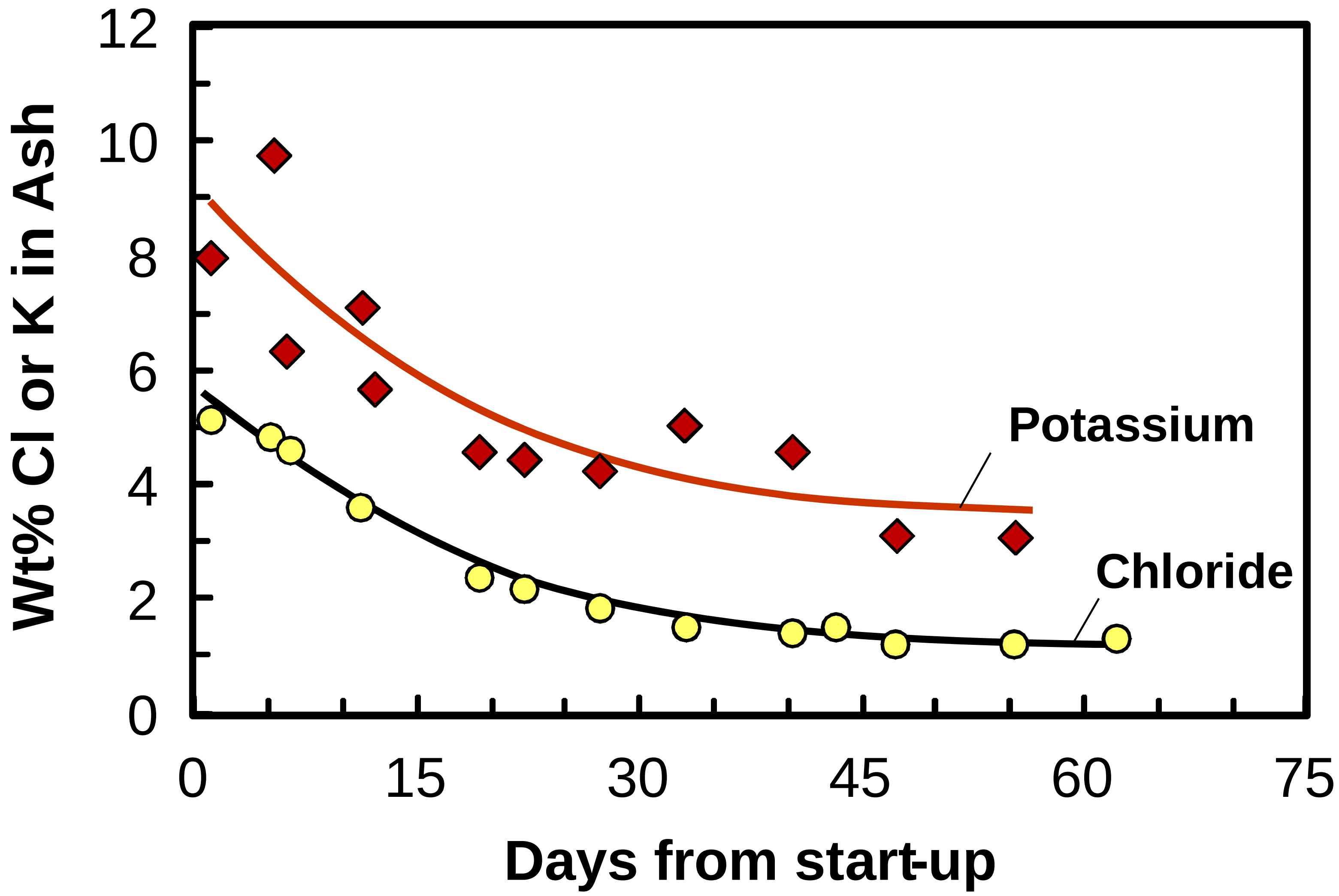
(MeadWestvaco, Evadale mill, USA)



Hart, P. et al, TAPPI Journal (2010)

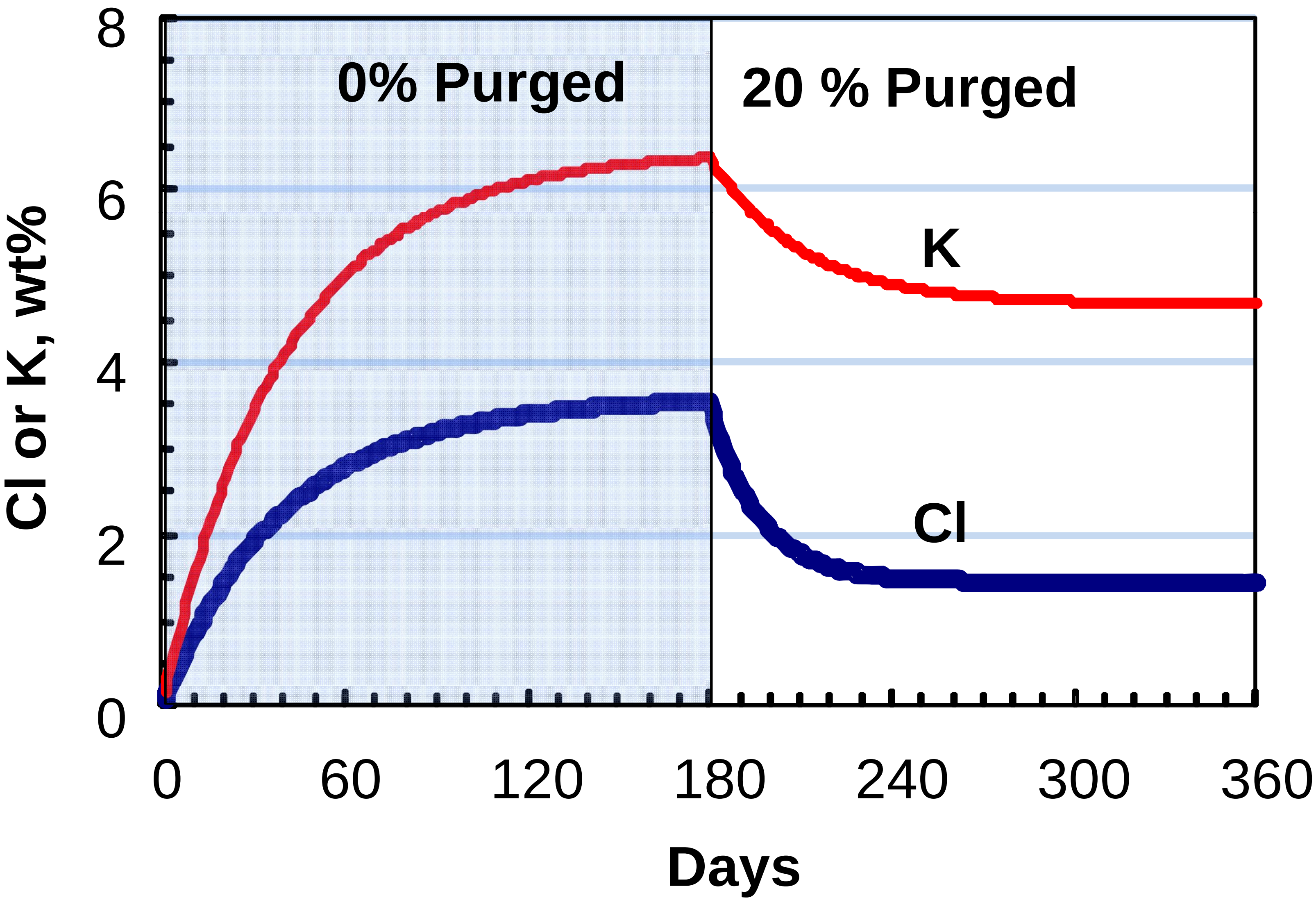
Experience of Ash Leaching System

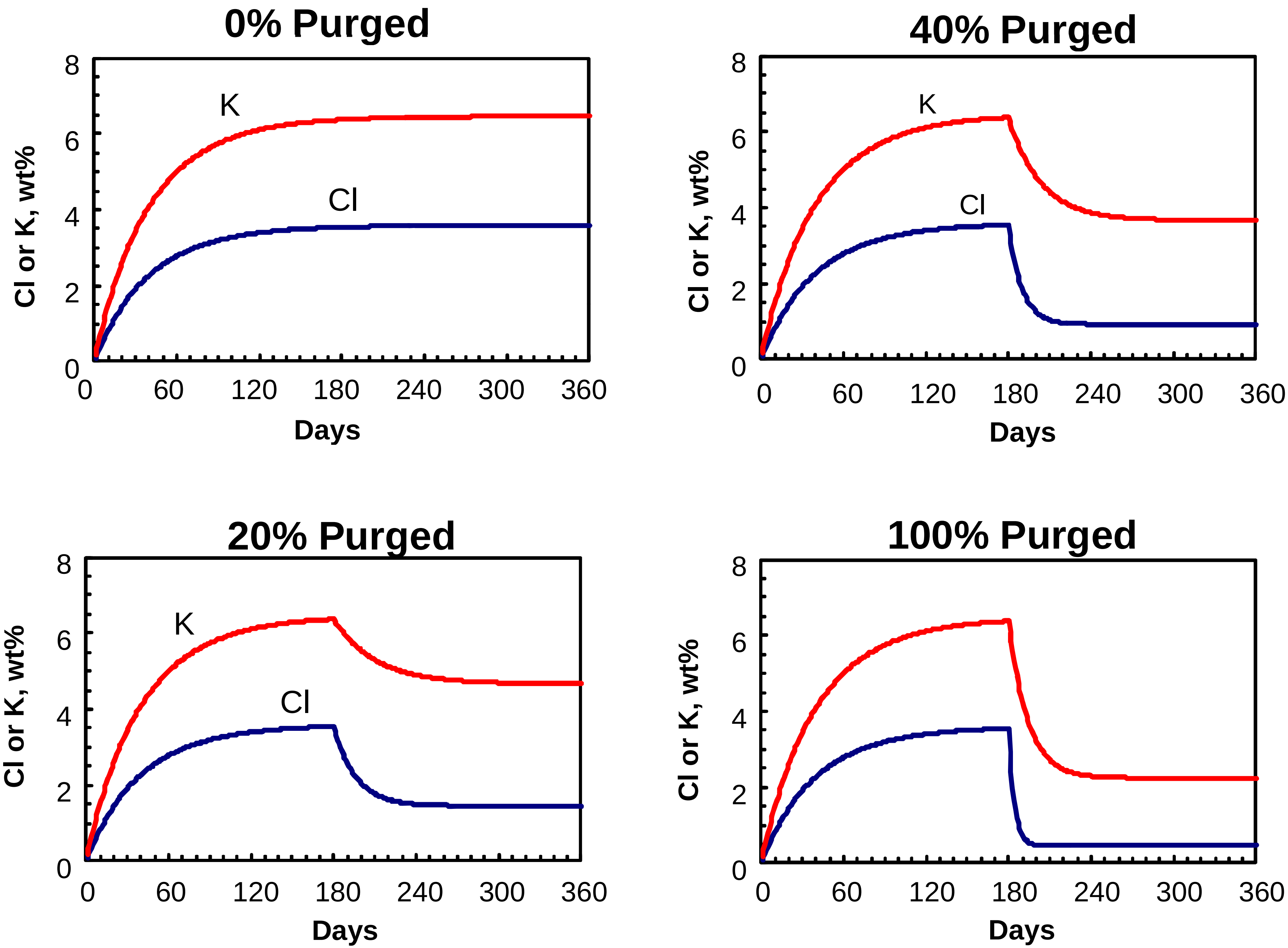
(UPM Fray Bentos mill, Uruguay)



Doldán, J., et al (2010)

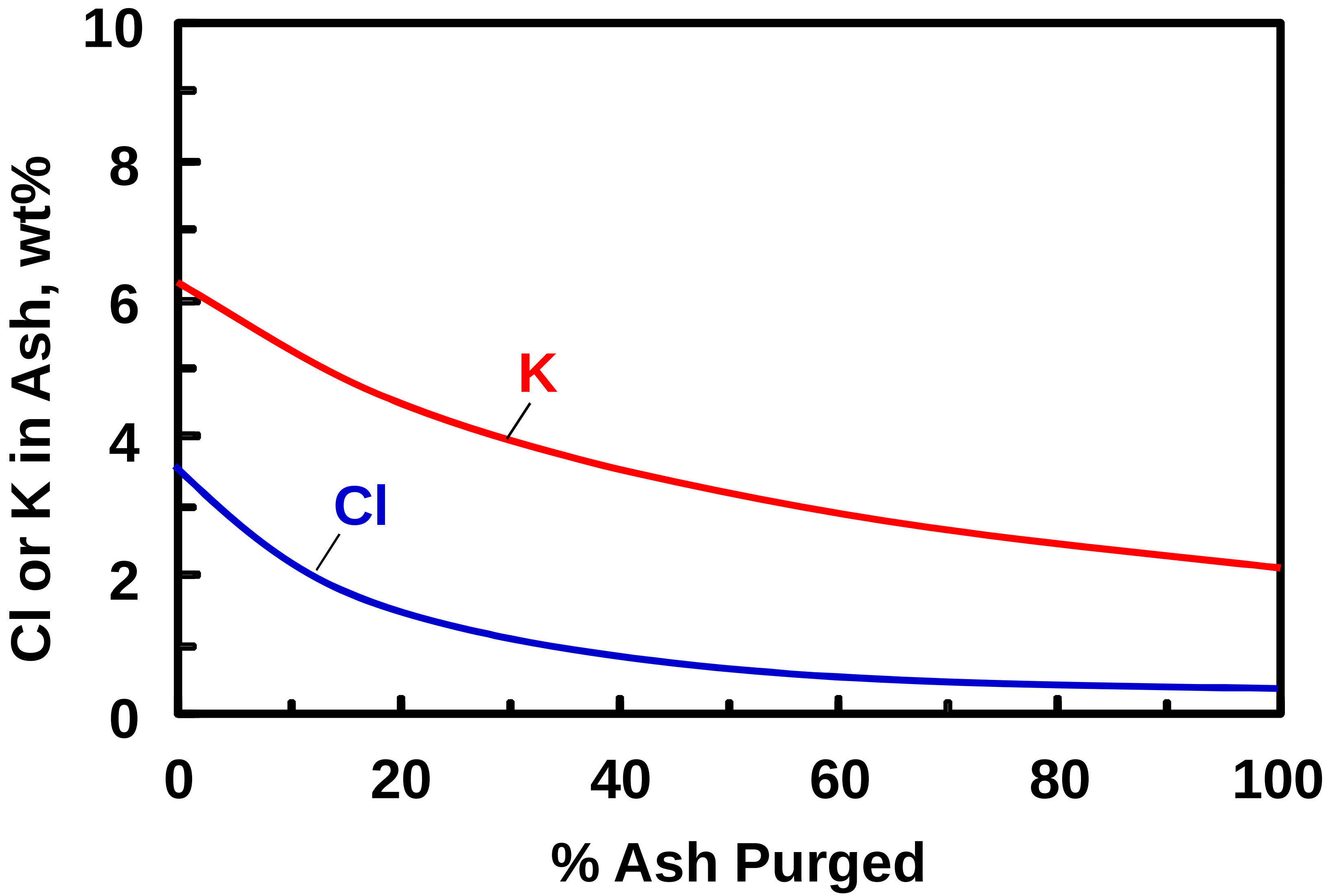
Effect of Purging on Cl and K in Ash





0% Purged
K
Cl
Cl or K, wt%
Days
40% Purged
K
Cl
Cl or K, wt%
Days
20% Purged
K
Cl
Cl or K, wt%
Days
100% Purged
K
Cl
Cl or K, wt%
Days

Effect of ESP Ash Purging on Cl and K Contents



Summary

- Cl and K originate mostly from wood
- Accumulate due to high solubility
- Steady state concentrations determined by net inputs
- Take about 1 month to reach steady state
- No need to purge more than 40% of total ESP ash

Acknowledgements

- Andritz
- AV Nackawic Group
- Babcock & Wilcox
- Boise
- Carter Holt Harvey
- Celulose Nipo-Brasileira
- Clyde-Bergemann
- DMI-Peace River Pulp
- Eldorado
- ERCO Worldwide
- Fibria
- FP Innovations
- International Paper
- Irving Pulp & Paper
- Kiln Flame Systems
- Klabin
- Metso Power
- MeadWestvaco
- StoraEnso
- Tembec
- Tolko Industries

NSERC

SUBPART MM RTR UPDATE

Mark Aguilar

February 8, 2012

What is Subpart MM RTR?

"Subpart MM" – the Maximum Available Control Technology (MACT) Standard the was Promulgated in 2001 that established emission limits Pulp and Paper Mill Recovery Furnaces, Smelt Dissolving Tanks and Lime Kilns.

First "R" – Residual risk analysis required by Section 112(f)(2) of the Clean Air Act (CAA)

"TR" – Technology Review Section required by 112(d)(6) of the CAA

- <u>Residual Risk</u> – ONE time analysis

§ 112(f)(2) of CAA directs EPA to conduct risk assessments on each MACT source category within 8 years of MACT rule promulgation to determine if additional standards are needed to reduce residual risks.

- <u>Technology Review</u> – Every 8 years

§ 112(d)(6) of CAA requires EPA to review/revise the MACT standards, as necessary, taking into account developments in practices, processes and control technologies.

When???

When will EPA finalize the Subpart MM RTR?

- Pulp and Paper Mills submitted data to EPA for Subpart S and Subpart MM RTRs in 2011. EPA will not solicit additional industry-wide data.

- EPA issued a proposed RTR rule on December 27, 2012 for Subpart S sources and expects to issue a final rule by July 31, 2012.

- Subpart MM RTR not defined, BUT:

  Center of Biological Diversity, Green Peace, and Port Townsend Airwatchers sued EPA on December 6, 2011 to force EPA to complete the Pulp and Paper NSPS review §111(b)(1)(B). NSPS Subpart BB regulates PM and TRS from RFs, SDT and LKs.

- Ongoing negotiations will determine the schedule for this NSPS review to be completed.

- EPA indicates they expect to complete the Subpart MM RTR at the same time as the NSPS Subpart BB review.

Are there concerns with Subpart MM?

What issues may be of concern with Subpart MM? (Part 1)

Residual Risk – EPA summary from Subpart S proposal:

Of the 171 mills included in this analysis:

- 7 have facility-wide maximum predicted individual cancer risks of 10 in 1 million or greater. Only 30% of the risk at these mills, is from pulp and papermaking operations
- 99 have facility-wide maximum predicted individual cancer risks of 1 in 1 million or greater. 43% of the risk at these mills are from pulp and papermaking operations
- For these sets of Mills, all other (non-S) risk is *primarily driven by emissions of arsenic compounds, chromium compounds and nickel compounds from boiler and lime kiln operations.*

What issues may be of concern with Subpart MM? (Part 1)

Residual Risk –

- EPA has provided mills all their risk analysis details for individual sites and requested corrections for their Subpart S rule.

- As the S rule includes facility-wide risk modeling, sites should confirm/correct any data for Subpart MM sources.

- Deadline is February 27, 2012

What issues may be of concern with Subpart MM? (Part 2)

- Technology Review – this analysis has not been completed by EPA and we do not have indications if there will be issues.
  - In the technology review, EPA will be evaluating the BACT clearinghouse to determine advancements in technology are documented, The following are a few BACT determination issues:
    - SDT vents routed into recovery furnaces.
    - ESP installed on Lime Kilns.
  - Though technology is stable, BACT for PM has become much more stringent than 2004 MACT Subpart MM.
    - Example gr/dscf RF: MACT=0.044; BACT = 0.02
    - Example gr/dscf LK: MACT= 0.064; BACT= 0.01

Subpart MM RTR

- EPA has wrapped the RTR into two other rule makings – Subpart S RTR and NSPS Subpart BB.

- Subpart MM technology concerns are unknown at this time. However, the BACT standards are an issue for PM emissions. PM used as a surrogate for metal HAPs. Metal HAPs contribute to EPA's predicted facility-wide risk.

- Subpart S Schedule is certain: Final rule by July 2012. Subpart MM timing is contingent on the NSPS BB review negotiations.

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Pulp & Paper

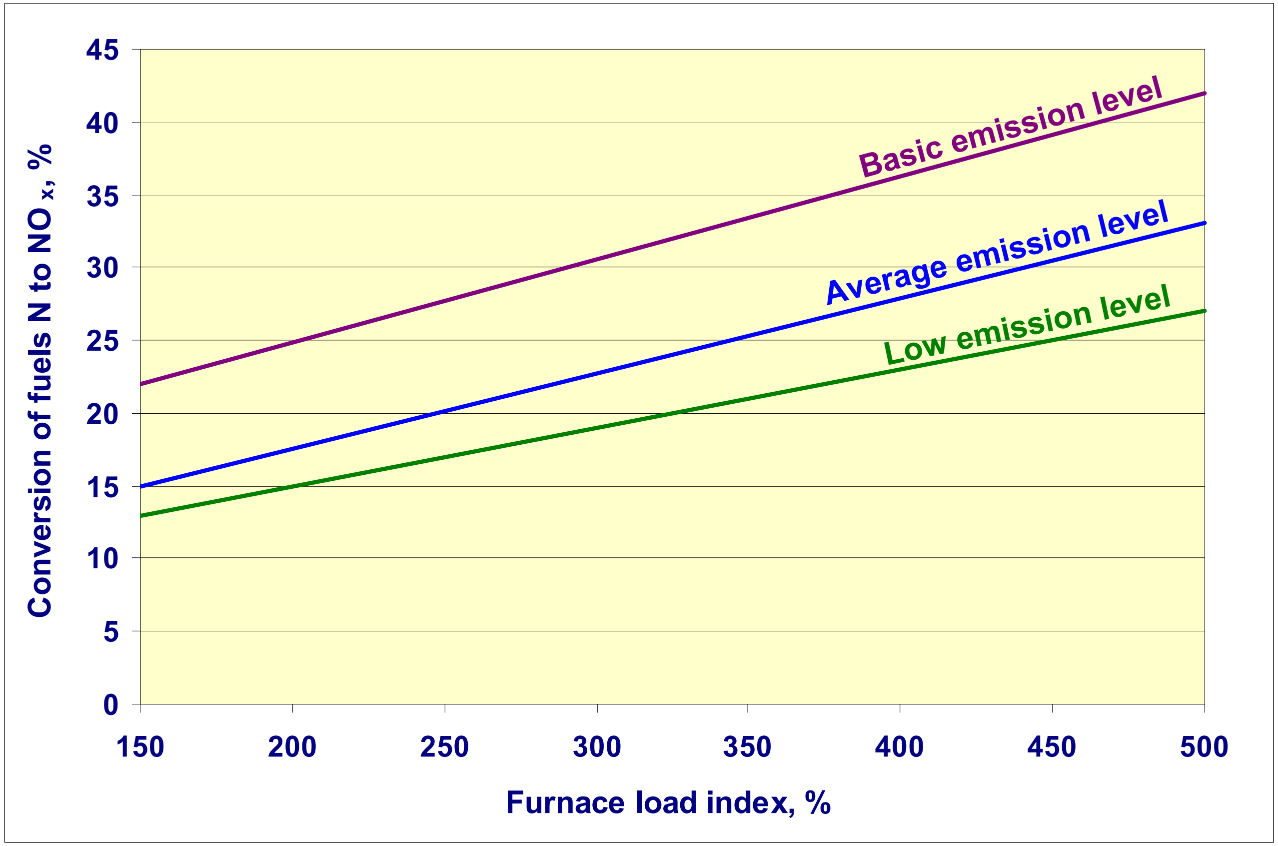
Prediction of recovery-boiler NO_x emissions in the light of new field data and theoretical deliberations

Paterson McKeough and Jukka Savolainen

Starting point: Andritz's correlations prior to this study

Published by Saviharju, et al, 2007

Correlations based on extensive field data gathered from numerous boilers



Refer: Saviharju, et al, Distribution of black liquor nitrogen between smelt, NO_x and flue gases in recovery boilers, 2007 International Chemical Recovery Conference, Quebec City, May 29 - June 1, 2007, pp. 589-597.

Starting point: Andritz's correlations prior to this study

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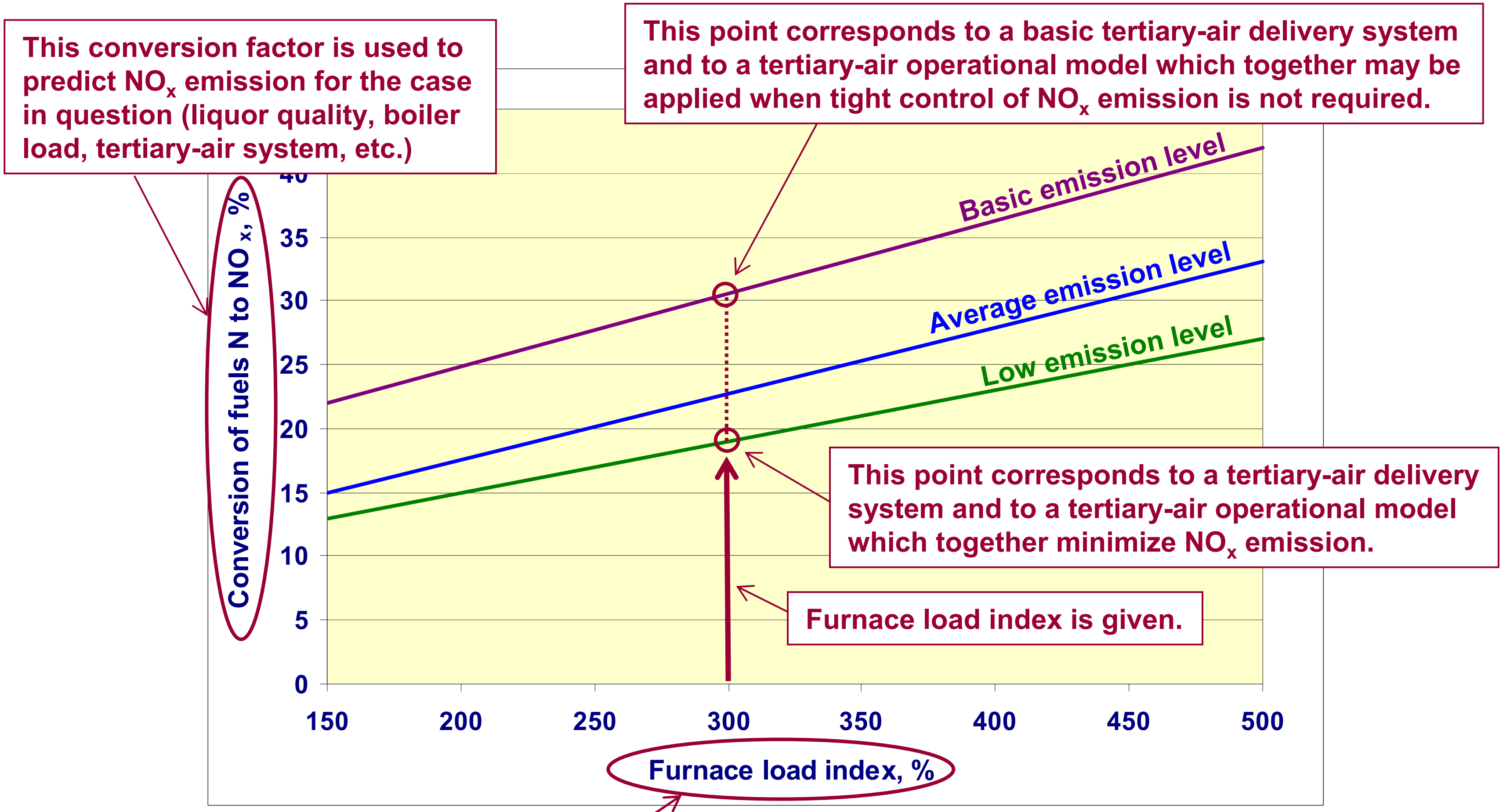
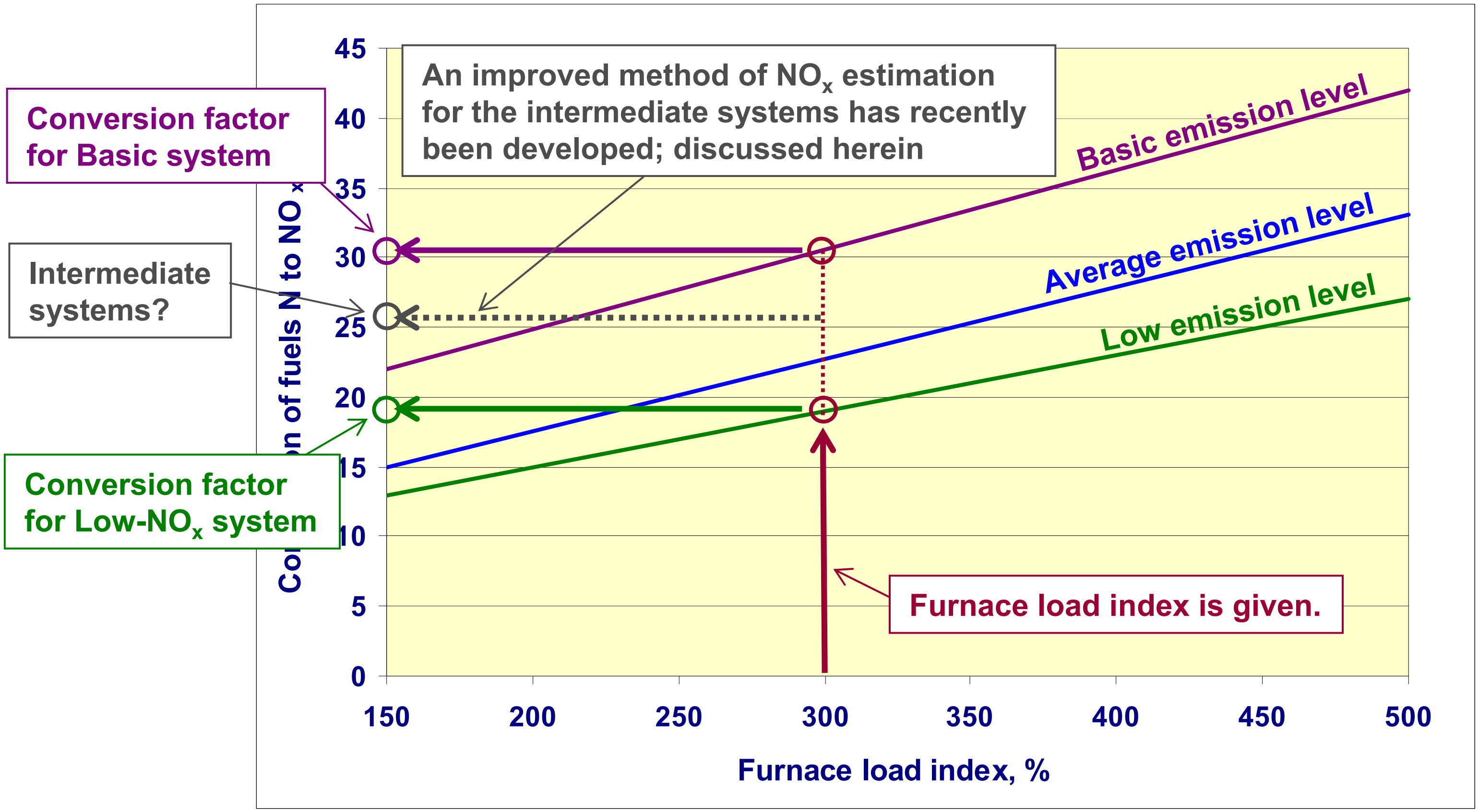


Refer: Saviharju, et al, Distribution of black liquor nitrogen between smelt, NO_x and flue gases in recovery boilers, 2007 International Chemical Recovery Conference, Quebec City, May 29 - June 1, 2007, pp. 589-597.

This index takes into account the final combustion temperature including staging.

Starting point: Andritz's correlations prior to this study

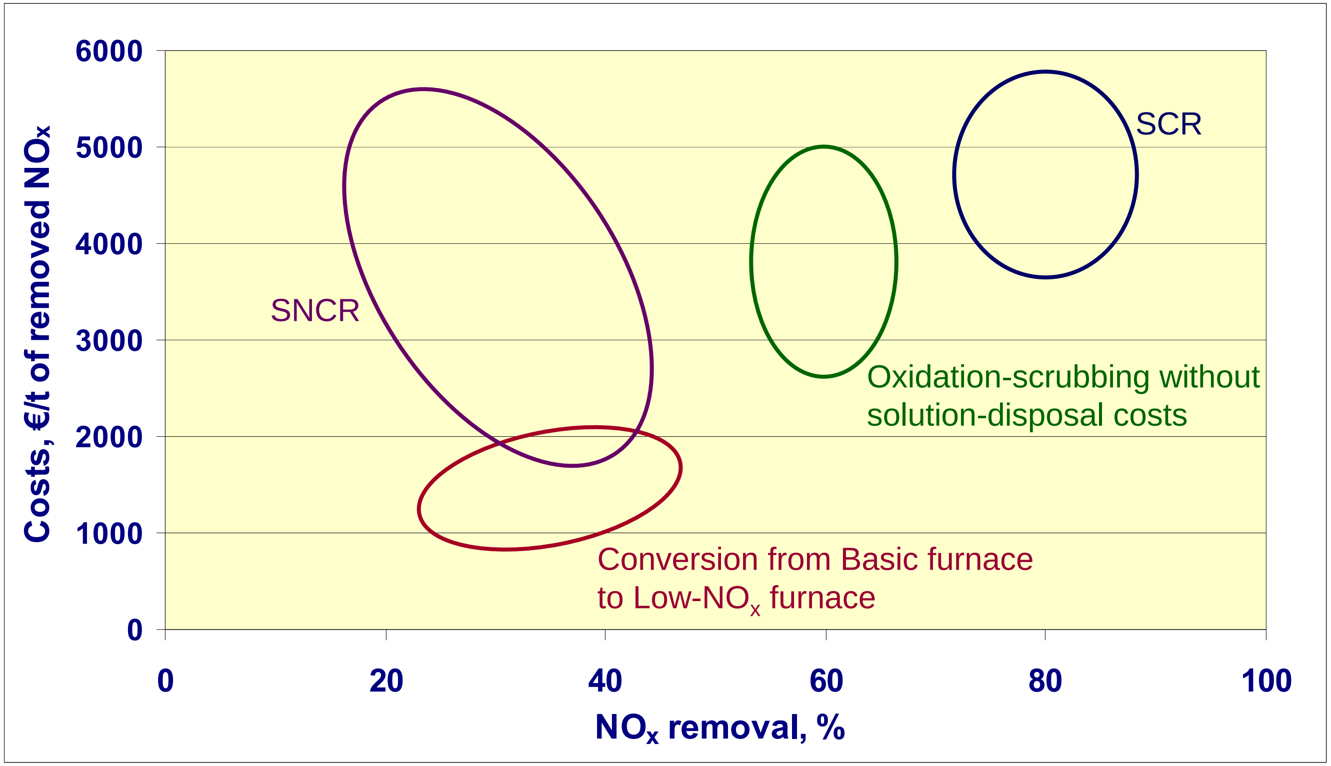
Published by Saviharju, et al, 2007



Refer: Saviharju, et al, Distribution of black liquor nitrogen between smelt, NO_x and flue gases in recovery boilers, 2007 International Chemical Recovery Conference, Quebec City, May 29 - June 1, 2007, pp. 589-597.

Reminder: Additional NO_x removal always has a cost

Ball-park estimates of NO_x-removal extents and costs for various alternatives



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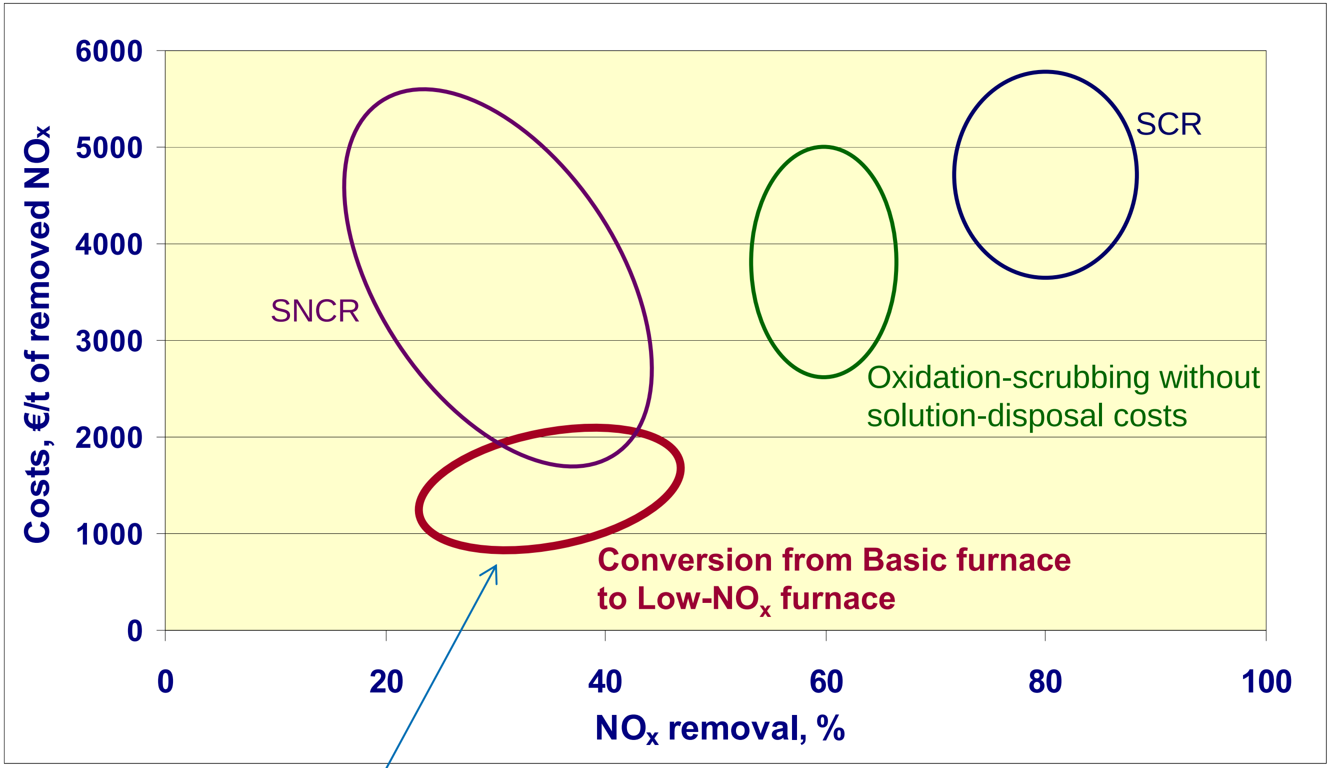
Reminder: Additional NO_x removal always has a cost

Ball-park estimates of NO_x-removal extents and costs for various alternatives

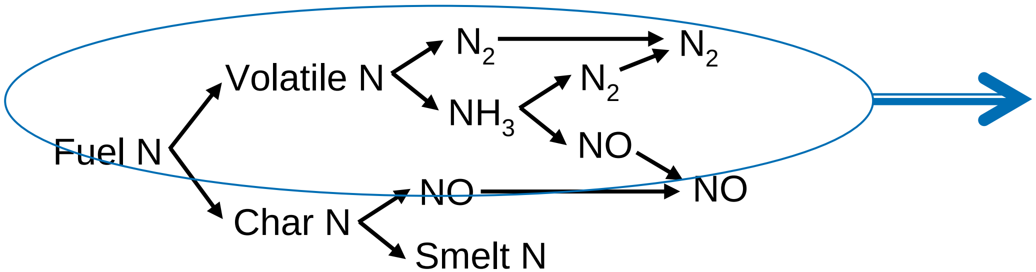


This presentation is dealing with in-furnace NO_x reduction, only.

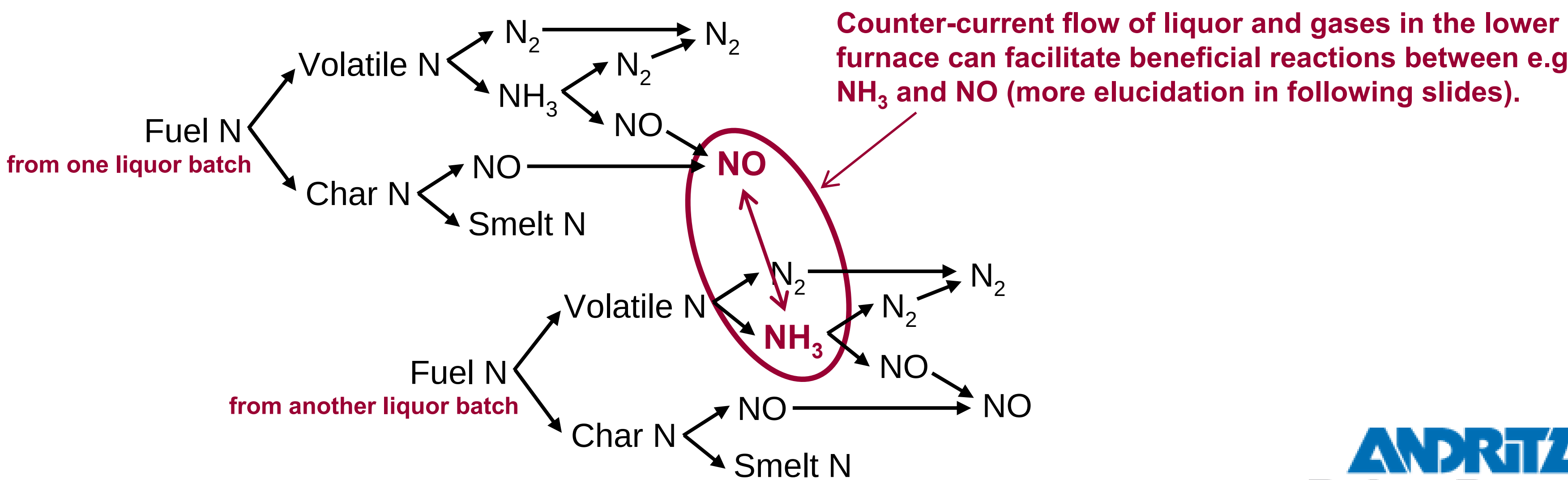
NO_x formation and reduction in the recovery furnace

A shift of emphasis

Traditionally, the reactions have been envisaged as occurring with both **fuel** (excluding char/smelt) **and gases** moving in basically the same direction; viz., **co-currently**:



However, **in the recovery-boiler lower furnace, the gas flow** is, in the main, **counter-current to the flow of liquor droplets** / particles. As explained in more detail in the following slides, this results in increased opportunity for NH_3, NO and fuel-derived combustible components to come into contact and react beneficially with each other:



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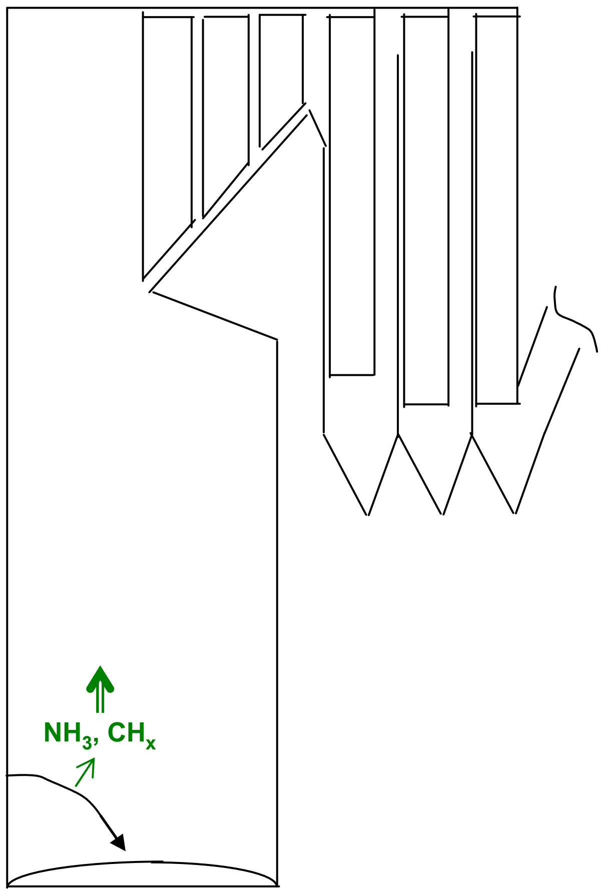
NO_x formation and reduction in the recovery furnace

Counter-current flows of liquor and gases in lower furnace taken into account

Step 1. The release of NH_3, and also combustible fuel-derived compounds, such as hydrocarbons CH_x, begins at a relatively short distance from the black-liquor nozzles. The compounds released here tend to be conveyed upwards and the oxidation of these compounds is initially limited.



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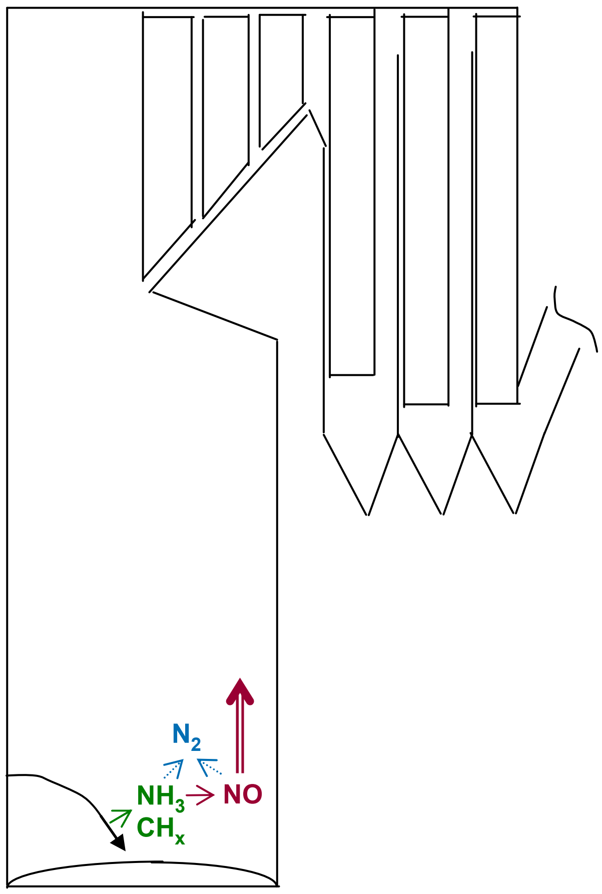
NO_x formation and reduction in the recovery furnace

Counter-current flows of liquor and gases in lower furnace taken into account

Step 2. NH_3 released from black liquor lower down tends to be converted to NO to a significant degree (higher temperatures; more oxygen available) and the NO so produced is then conveyed upwards. (Some of this NO may react locally in beneficial N_2-forming reactions with NH_3 and/or fuel-derived combustibles.)



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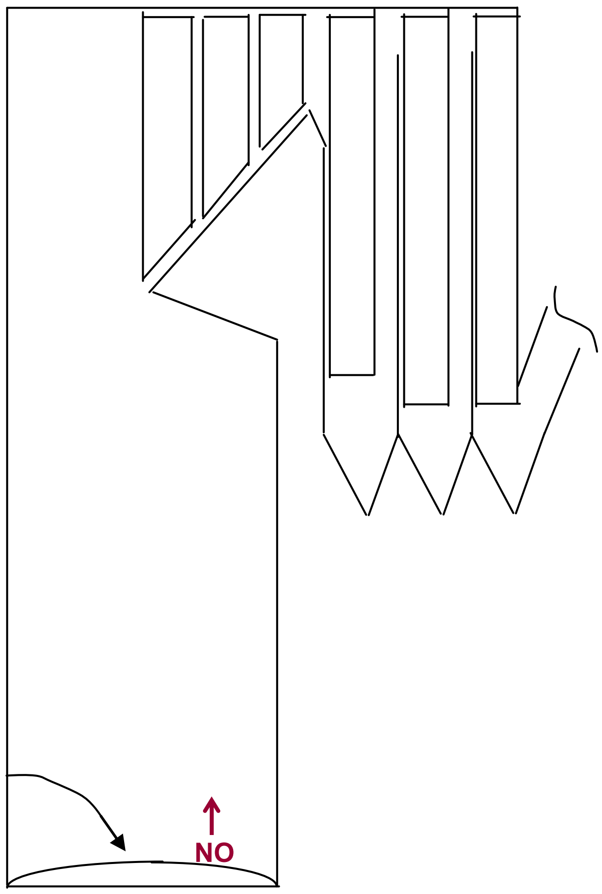
NO_x formation and reduction in the recovery furnace

Counter-current flows of liquor and gases in lower furnace taken into account

Step 3. Some NO is also released from the char burning on the bed

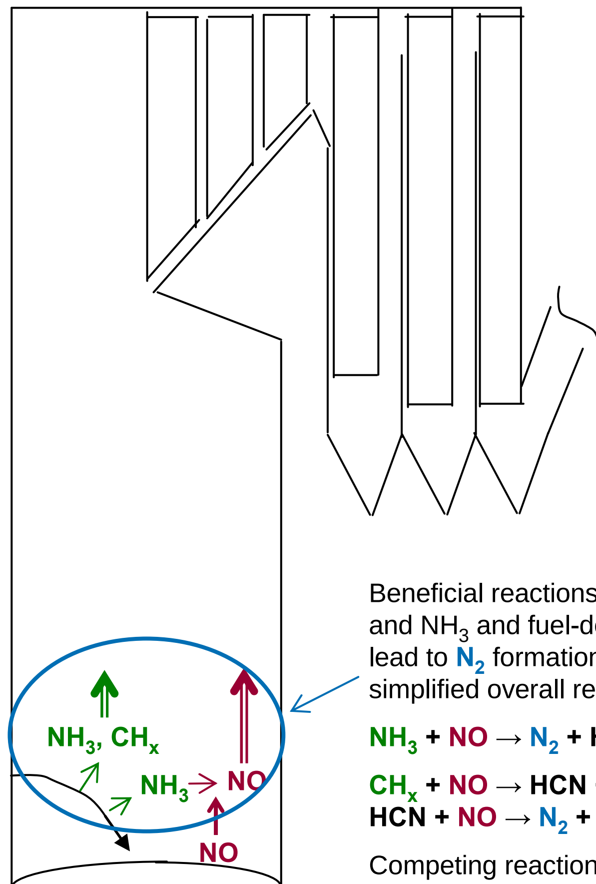


NO_x formation and reduction in the recovery furnace

Counter-current flows of liquor and gases in lower furnace taken into account

Step 4. NH_3 and fuel-derived combustibles from Step 1 and NO from Steps 2 and 3 come into contact under conditions which are reasonably favourable for beneficial (N_2-forming) reactions between them. Apparently, at the relatively high temperatures encountered in the lower and middle furnace, N_2-forming reactions benefit from reducing conditions in the gas stream.

An essential feature of this theoretical mechanism is that the main reactants, NO, on the one hand, and NH_3 and fuel-derived combustibles, on the other, have not, in general, originated from, essentially, the same portion of black liquor. The NO has mainly come from black liquor that was fed to the furnace earlier than the liquor from which the co-reactants, NH_3 and/or fuel-derived combustibles, have been released.



Beneficial reactions between NO, on the one hand, and NH_3 and fuel-derived combustibles, on the other, lead to N_2 formation; e.g. according to the following simplified overall reactions:

$NH_3 + NO \rightarrow N_2 + H_2O + 1/2H_2$

$CH_x + NO \rightarrow HCN + H_2O + [(x-3)/2]H_2$
$HCN + NO \rightarrow N_2 + CO + 1/2H_2$

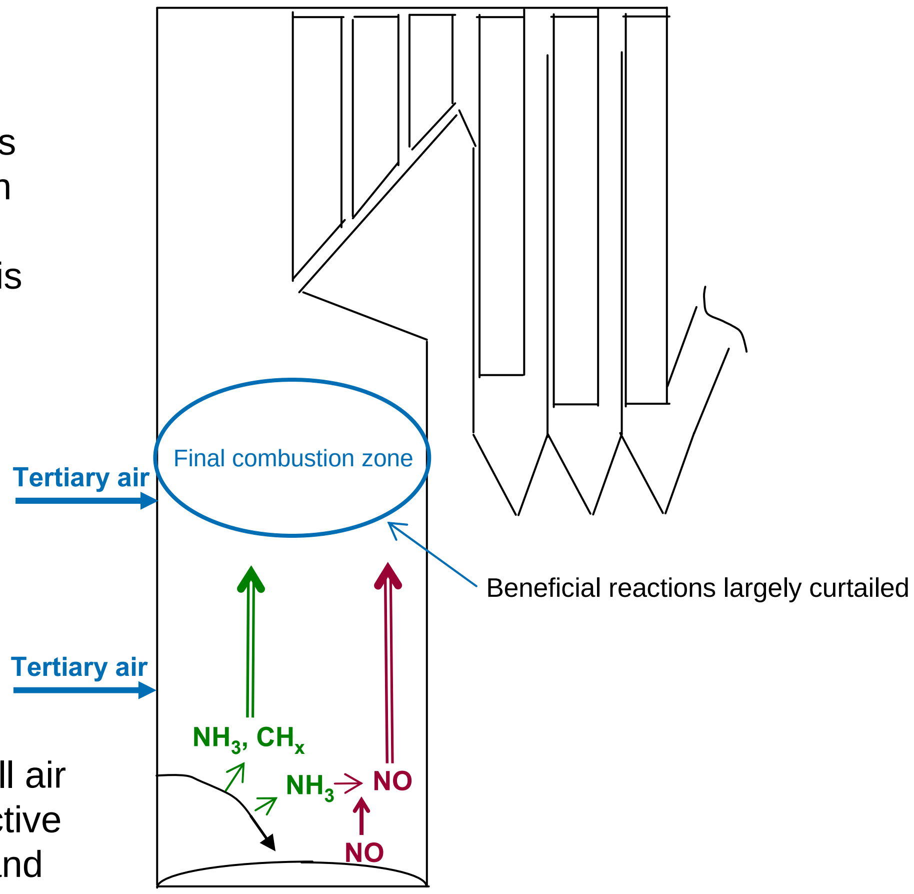
Competing reactions include oxidation of NH_3, HCN and CH_x.

NO_x formation and reduction in the recovery furnace

Counter-current flows of liquor and gases in lower furnace taken into account

Step 5. The beneficial reactions are largely curtailed at or near the final combustion zone.

Assuming that this theoretical picture is correct, the higher the final combustion zone, the more opportunity there is for the beneficial reactions to occur. This is consistent with the well-known trend that higher overall tertiary-air input lowers NO_x emission.



Note that, in Andritz's nomenclature, all air delivered above the gun level, irrespective of the number of such delivery levels and their elevations, is termed tertiary air.

Recent field data generated in the ChemCom 2.0 project

Measurements of gas composition in various zones of a recovery furnace

Boiler: recovery boiler of the UPM Wisaforest mill, Finland

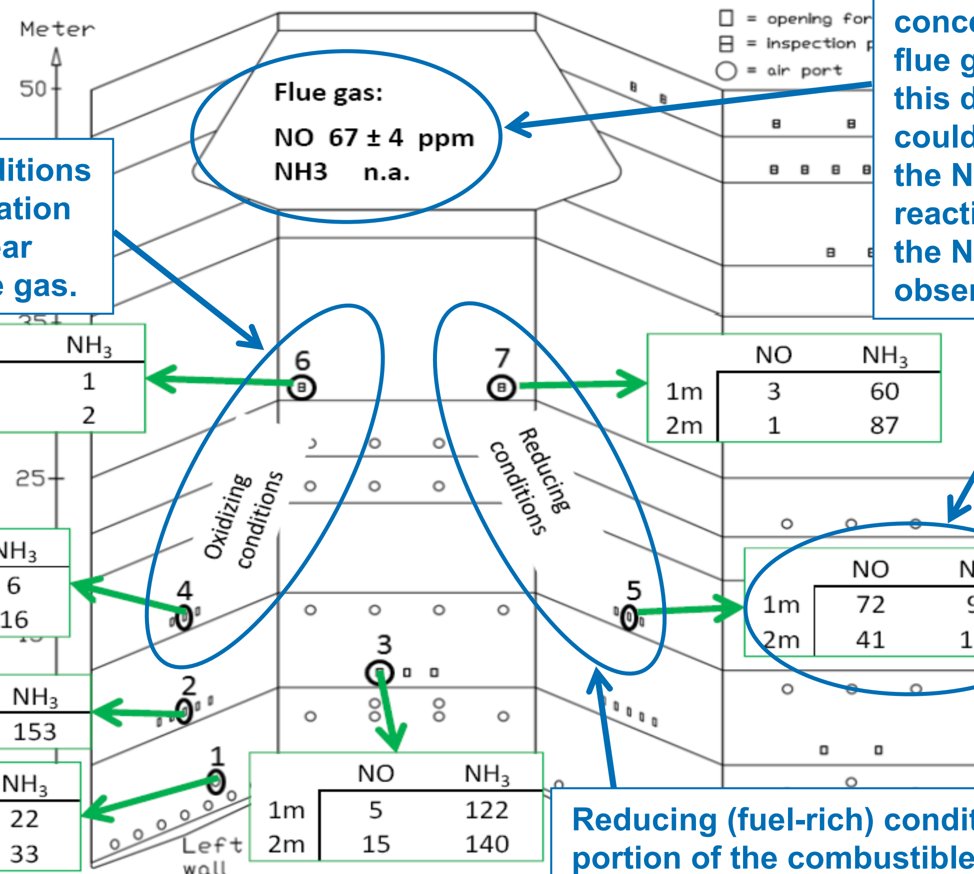
- ChemCom 2.0 R&D project 2008 - 2010: main funding from Tekes and industrial companies; leading research group: Process Chemistry Centre, Åbo Akademi U.
- Results of the gas-composition measurements have been reported in the following publication:
  - E. Vainio, A. Brink, N. DeMartini, M. Hupa, H. Vesala, K. Tormonen, and T. Kajolinna, In-furnace measurement of sulfur and nitrogen species in a recovery boiler, 2010 International Chemical Recovery Conference, Williamsburg, USA, 29 March – 1 April, 2010, Vol 1, pp 106-118.
- As indicated in the next slide, the results concerning nitrogen species seem to support the ideas, presented herein, regarding the role of beneficial N_2-forming reactions occurring between the liquor guns and the highest tertiary level.

Recent field data generated in the ChemCom 2.0 project

Measurements of gaseous nitrogen species

Oxidizing (fuel-lean) conditions on left side; the concentration of [$NO+NH_3$] is already near that of NO in the final flue gas.

The concentration of [$NO+NH_3$] at location 5 is much higher than the concentration of NO in the final flue gas. It seems improbable that this drop in concentration level could come about without part of the NO observed at location 5 reacting en route with the part of the NH_3 (and/or combustibles) observed at location 5.



Location 6:

	NO	NH_3
1m	54	1
2m	59	2

Location 7:

	NO	NH_3
1m	3	60
2m	1	87

Location 4:

	NO	NH_3
1m	38	6
2m	39	16

Location 5:

	NO	NH_3
1m	72	94
2m	41	177

Location 2:

	NO	NH_3
0.5m	200	153

Location 1:

	NO	NH_3
1m	24	22
2m	17	33

Location 3:

	NO	NH_3
1m	5	122
2m	15	140

Courtesy of the ChemCom2 project

Reducing (fuel-rich) conditions on right side: a greater portion of the combustibles and NH_3 released from black liquor have been conveyed to this side.

PS: Obviously one has to be cautious in interpreting these measurement data collected from a limited number of locations at different times.

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Recent in-house field data

Comprehensive measurement campaign at one mill

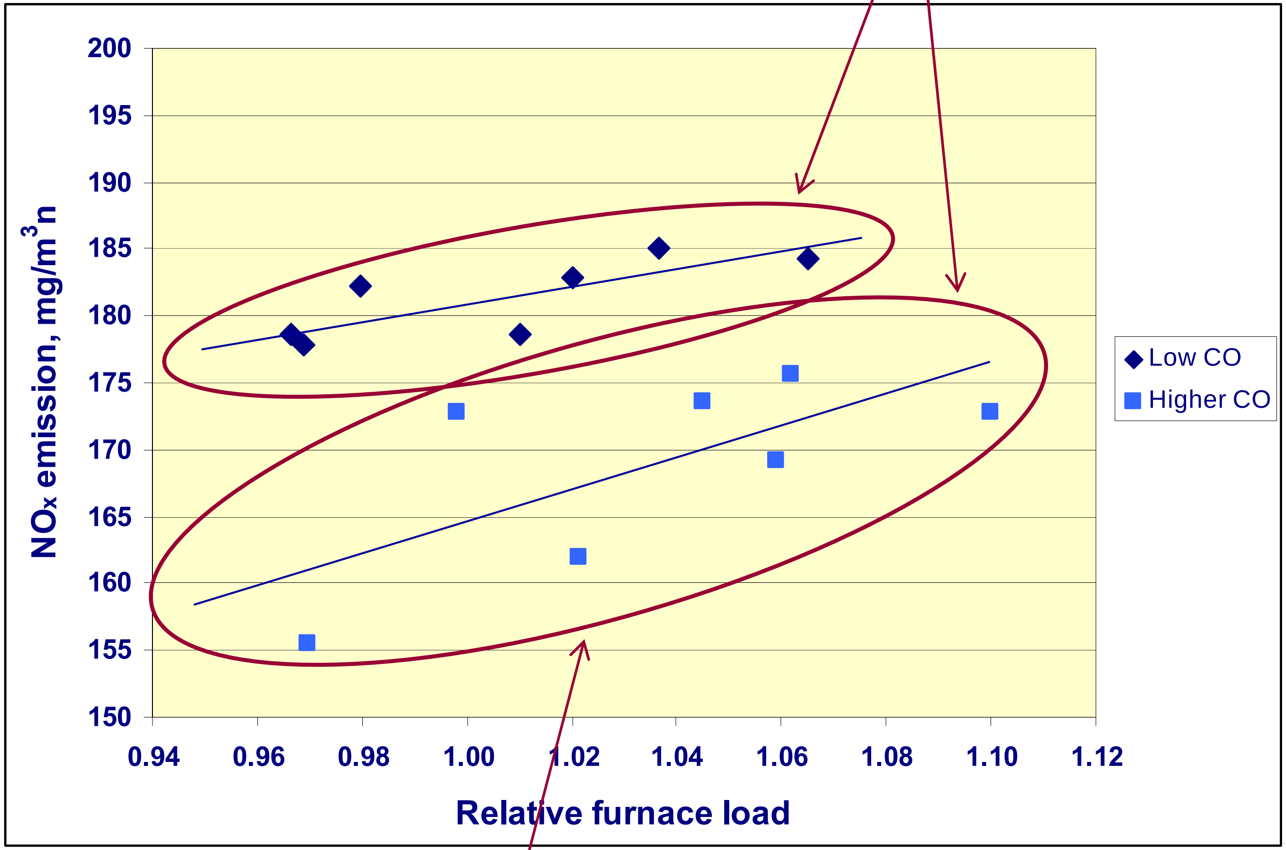
- Boiler: large recovery boiler with a multi-level tertiary-air system (Note, however, that the boiler is not one designed for lowest possible NO_x emission.)
- Campaign manager: J. Savolainen
- The boiler tests were meticulously planned and carried out with the aim of "one key variable at a time".
- Main variables investigated:
  - boiler load
  - excess oxygen (CO emission level)
  - secondary-air operational model, including share of secondary air
  - tertiary-air operational model, including share of tertiary air.

- The in-house data presented in the following slides were all generated during this one campaign.

Recent in-house field data

NO_x vs. furnace load

Two regions corresponding to different CO emission levels



Larger scatter in this region explained by the fact that it covers the tests with the significant variations in tertiary-air operational model.

Recent in-house field data

Testing the emphasized theoretical viewpoint against the field data

- In order to test the idea that beneficial reactions occurring between the liquor guns and the highest tertiary-air level can explain the dependence of NO_x emission on the tertiary-air operational model, the following procedure was adopted:
  - an index was developed to describe the relative extent of reaction of the N_2-forming beneficial reactions above the liquor guns
  - the NO_x emission figures were corrected for boiler load and CO emission level, the aim being that the corrected figures would depend on one major variable only: the tertiary-air operational model.
- As seen in the next slide, a reasonable correlation between the corrected NO_x emission figures and the reaction-extent index was obtained.

Recent in-house field data

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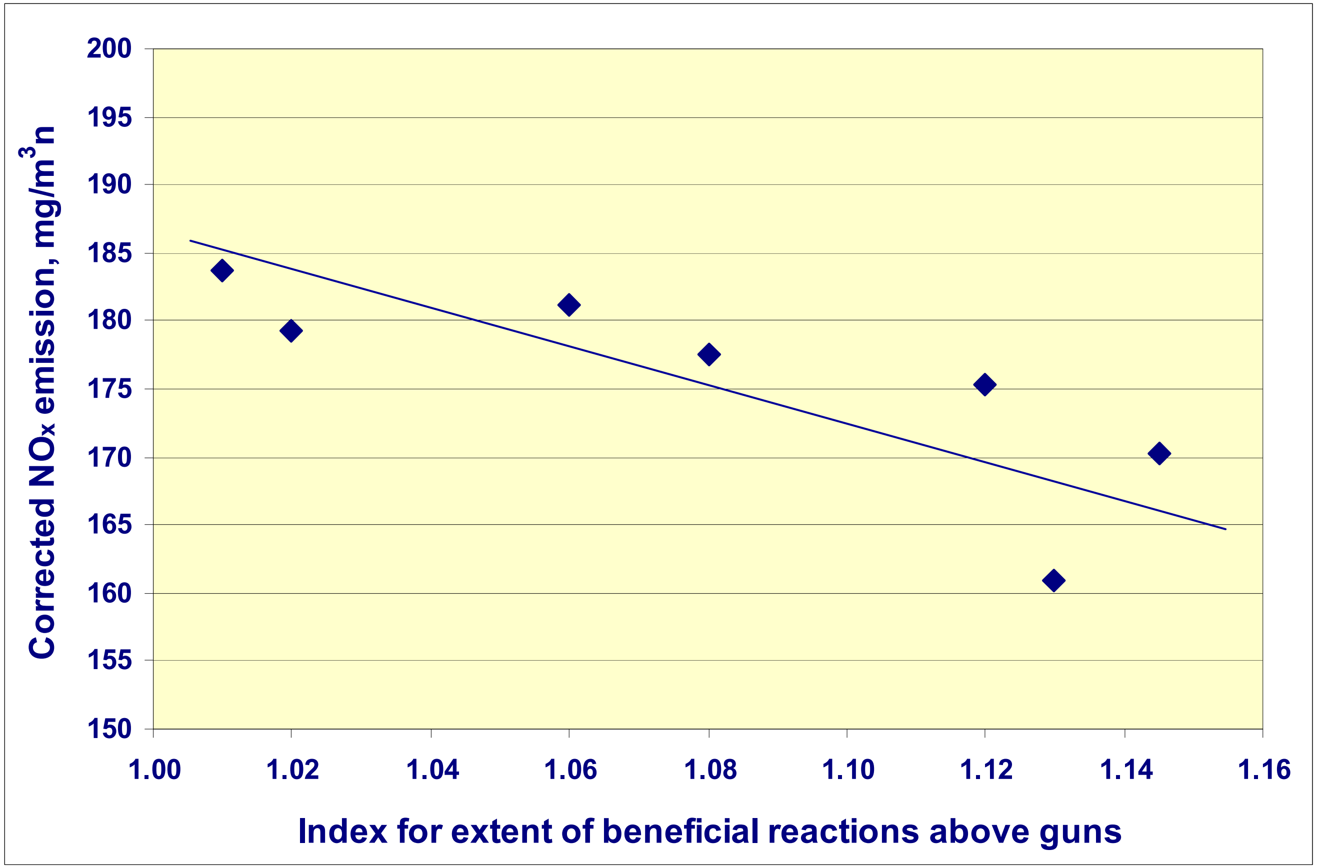
Recent in-house field data

Testing the emphasized theoretical viewpoint against the field data

These tests cover significant variation in the tertiary-air operational model, including changes in the overall share of tertiary air and changes in the distribution of tertiary air between the different levels.



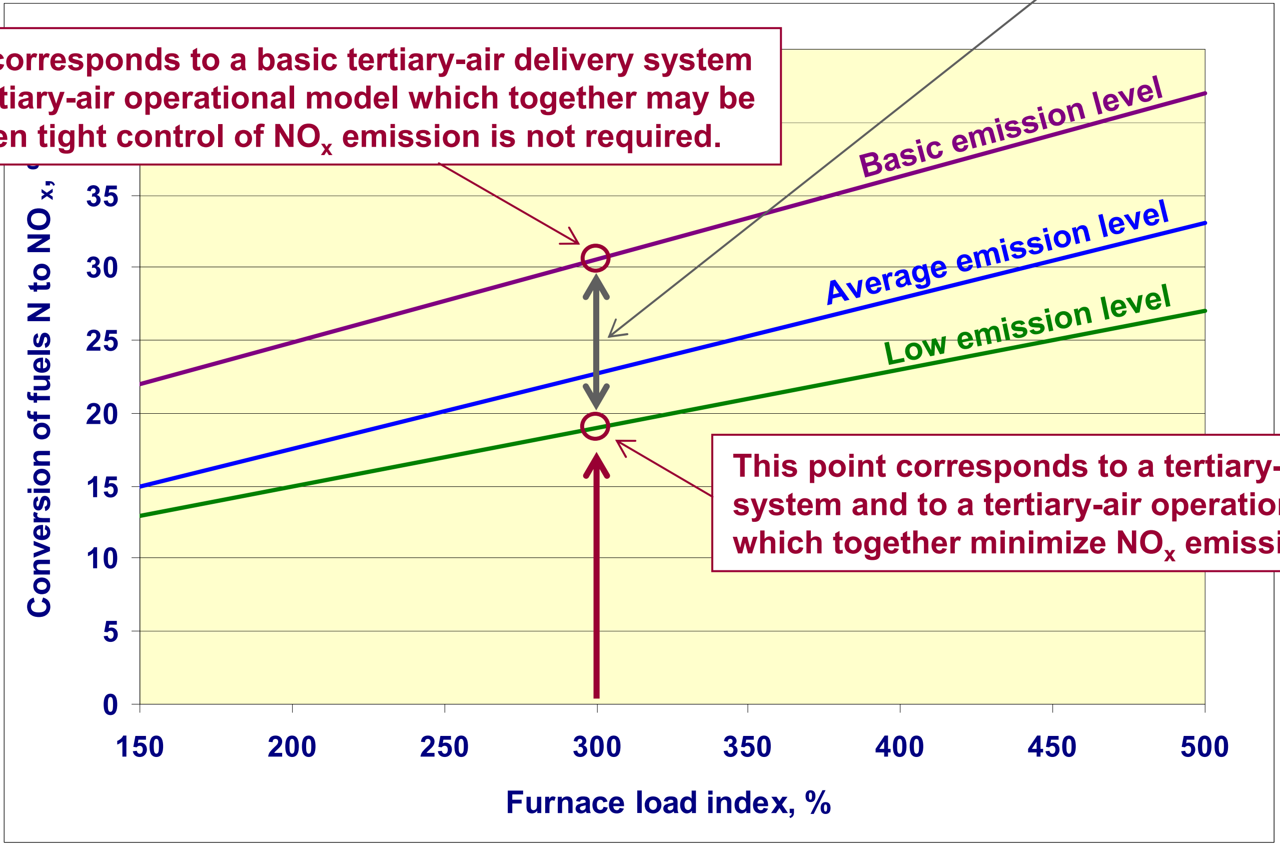
The data points in this figure correspond to those of the seven tests in which, specifically, the tertiary-air delivery was varied.

Improving Andritz's NO_x-prediction method

The basic correlations

For the intermediate cases, a more accurate prediction method has now been developed (refer later slides).

This point corresponds to a basic tertiary-air delivery system and to a tertiary-air operational model which together may be applied when tight control of NO_x emission is not required.



This point corresponds to a tertiary-air delivery system and to a tertiary-air operational model which together minimize NO_x emission.

Refer: Saviharju, et al, Distribution of black liquor nitrogen between smelt, NO_x and flue gases in recovery boilers, 2007 International Chemical Recovery Conference, Quebec City, May 29 - June 1, 2007, pp. 589-597.

Improving Andritz's NO_x-prediction method

Shift of focus

- The idea that the effects of variations in tertiary-air delivery on NO_x emission are a result of changes in the extents of beneficial reactions occurring between the liquor guns and the highest tertiary-air level opens up the way for more precise prediction of recovery-boiler NO_x emission.
- Exploitation of this idea constitutes a shift of focus. Earlier it was believed that key beneficial reactions occur during the final combustion stage(s) and that the temperature of the final combustion stage is a key variable.
- From the pragmatic viewpoint of simply correlating field data, both the earlier picture and the present picture are useful and are not in contradiction with one another. However, because the present viewpoint appears to have a better grounding in both theory and practice, it has the potential to provide a better basis for recovery-boiler NO_x prediction and to ultimately facilitate more accurate predictions.

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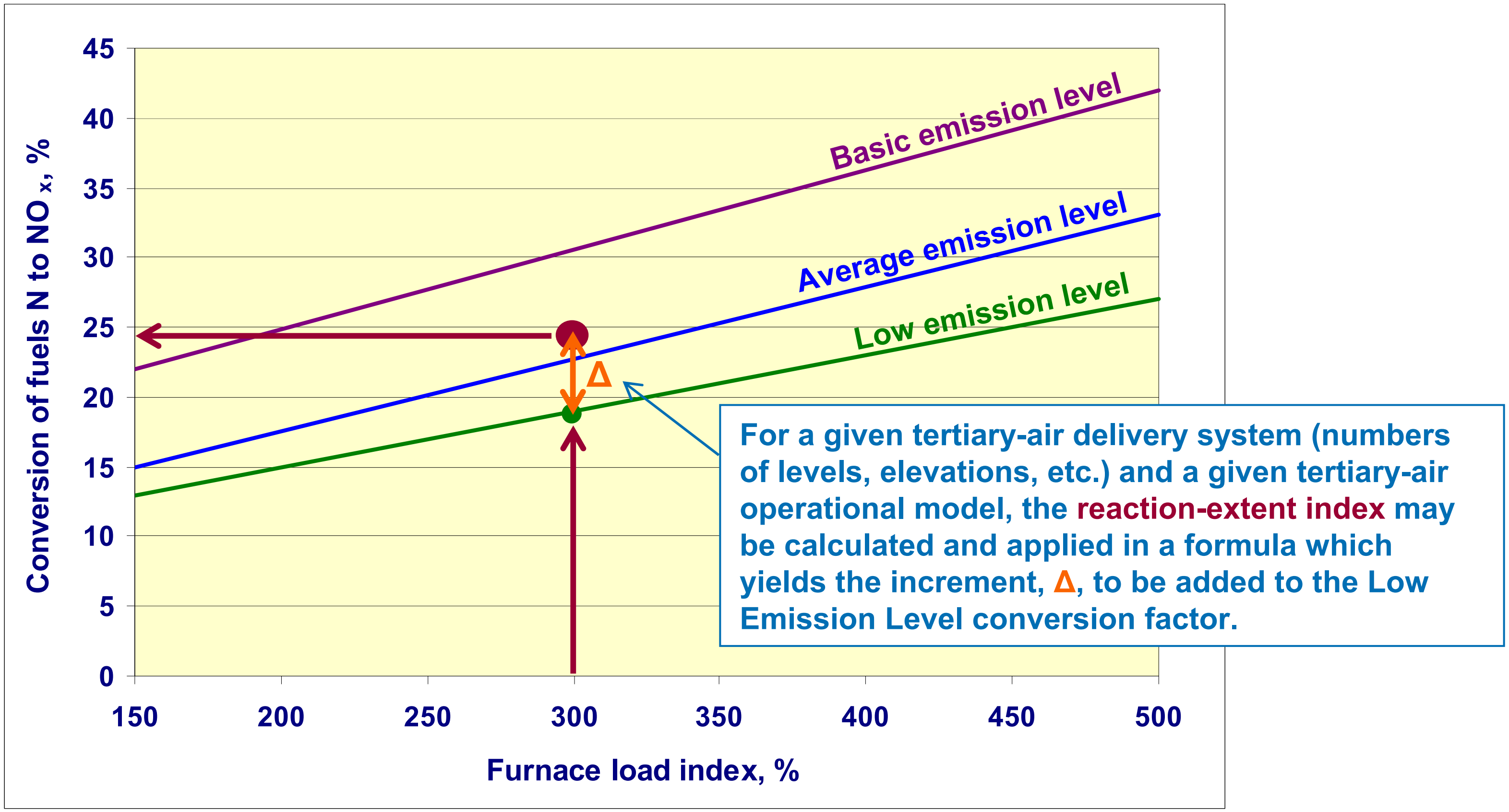
Improving Andritz's NO_x-prediction method

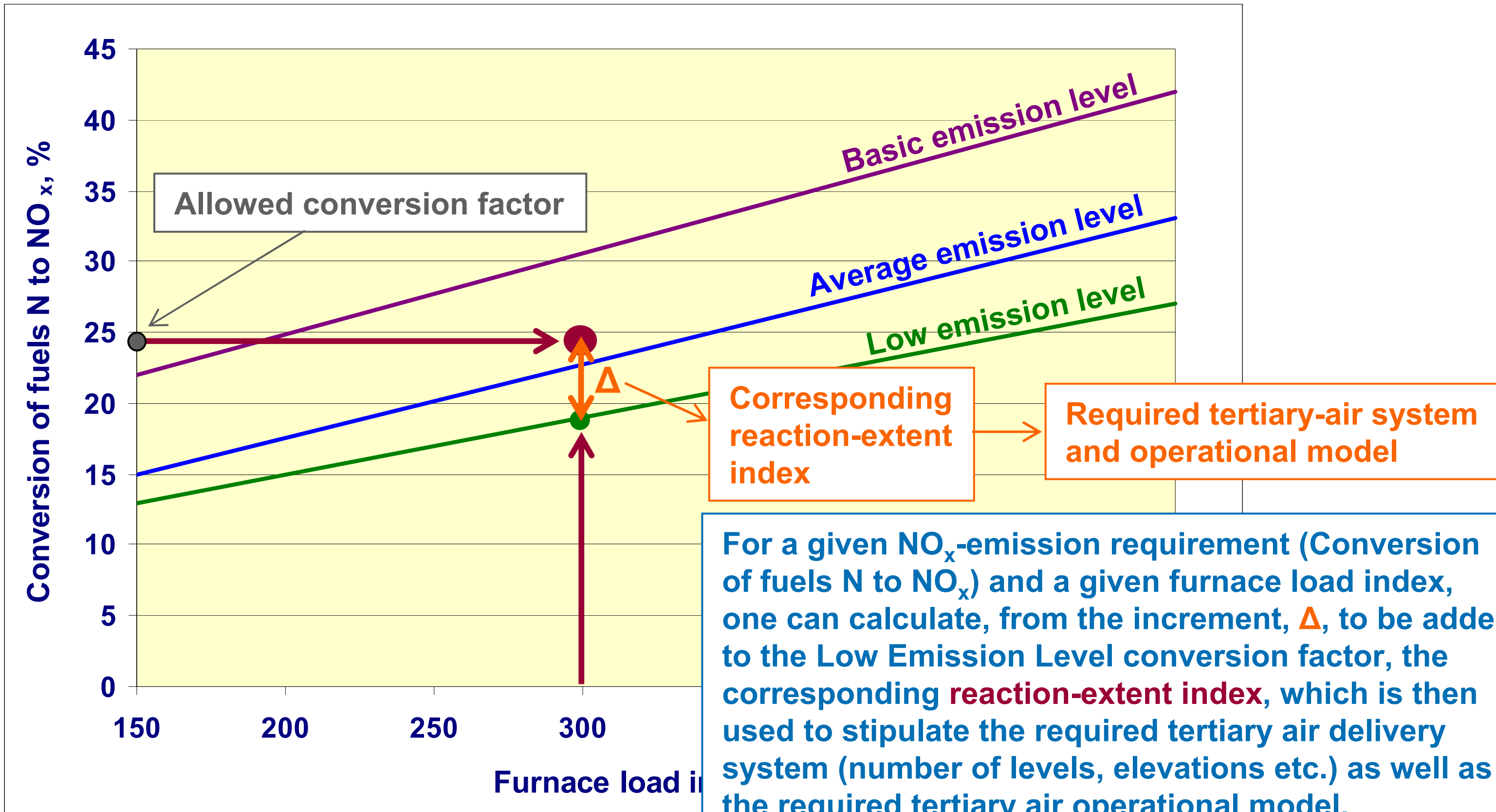
Exploitation of the dependence of NO_x emission on the extent of beneficial reactions occurring above the liquor guns. I Tertiary-air system given



Refer: Saviharju, et al, Distribution of black liquor nitrogen between smelt, NO_x and flue gases in recovery boilers, 2007 International Chemical Recovery Conference, Quebec City, May 29 - June 1, 2007, pp. 589-597.

Improving Andritz's NO_x-prediction method

Exploitation of the dependence of NO_x emission on the extent of beneficial reactions occurring above the liquor guns. II NO_x-emission requirement given



For a given NO_x-emission requirement (Conversion of fuels N to NO_x) and a given furnace load index, one can calculate, from the increment, Δ, to be added to the Low Emission Level conversion factor, the corresponding reaction-extent index, which is then used to stipulate the required tertiary air delivery system (number of levels, elevations etc.) as well as the required tertiary air operational model.

Refer: Saviharju, et al, Distribution of black liquor nitrogen between smelt, NO_x and flue gases in recovery boilers, 2007 International Chemical Recovery Conference, Quebec City, May 29 - June 1, 2007, pp. 589-597.

Concluding remarks

- Theoretical deliberations have led to the following hypotheses:

  1. Largely as a consequence of the counter-current flow of fuel and gases in the lower furnace, the gas stream immediately above the gun level contains significant quantities of NO, on the one hand, and NH_3 and combustible fuel-derived components, on the other.

  2. Beneficial, N_2-forming reactions between these components take place between the gun level and the highest tertiary-air level.

  3. The effects of variations in tertiary-air delivery on NO_x emission result from changes in the extents of these beneficial reactions.

- These hypotheses are consistent with the results of recent field measurements.

- Based on these hypotheses, an improved method for estimating recovery-boiler NO_x emission as a function of, among other things, the tertiary-air delivery configuration and the tertiary-air operational model has been developed and implemented.

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Recovery and Power Division

Any questions?

For further information please contact:

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AF&PA Recovery Boiler Conference

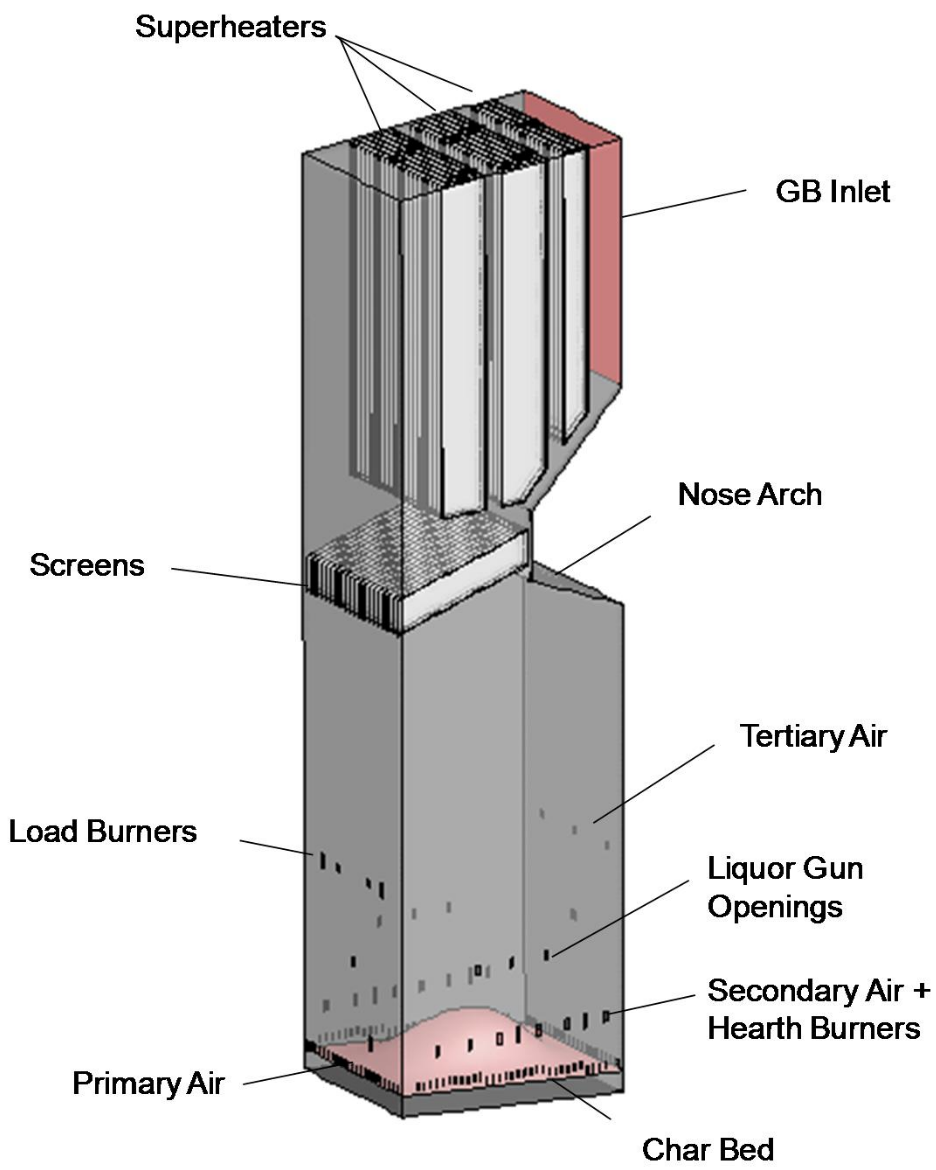
February 2012

Atlanta, GA

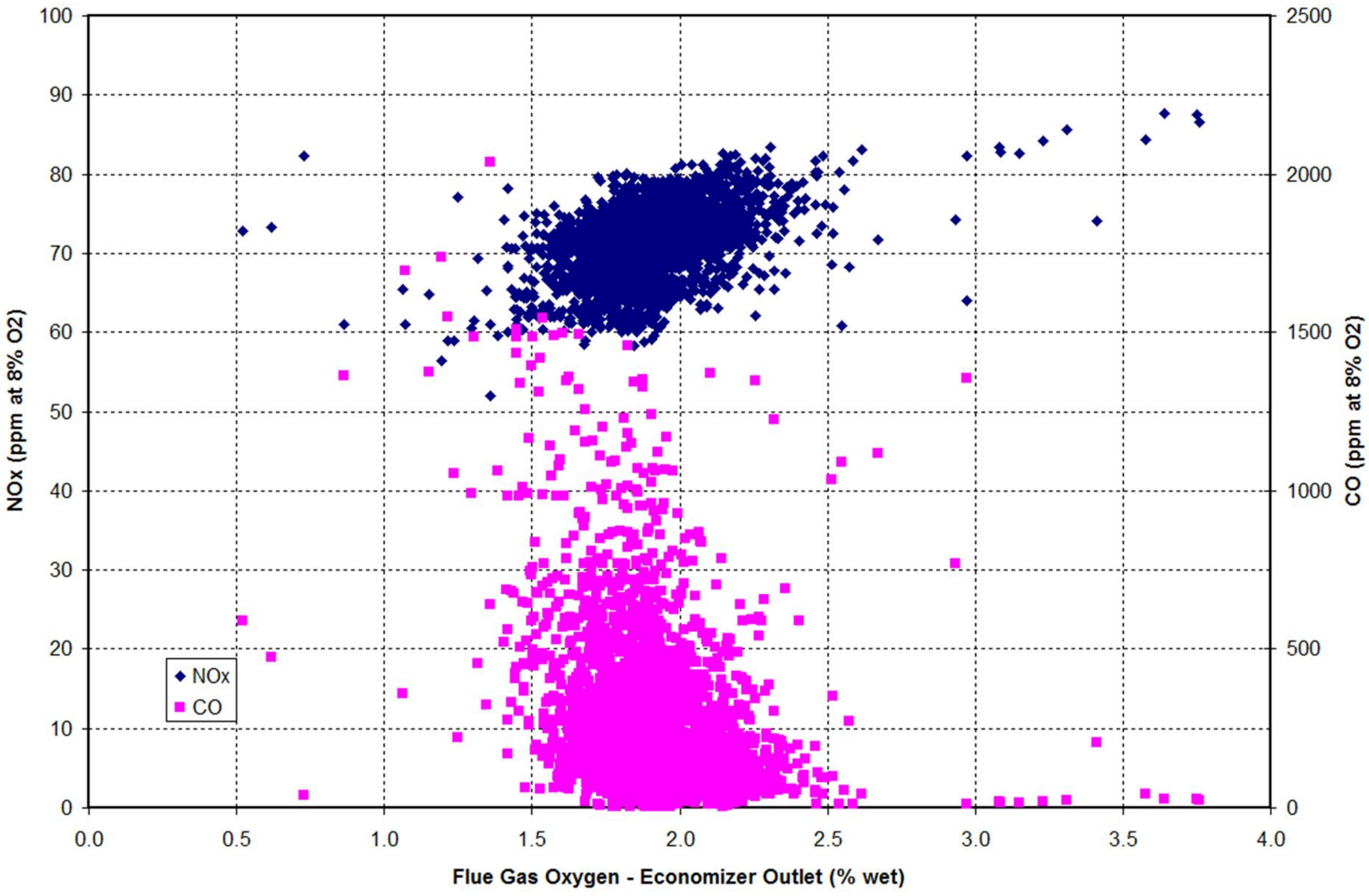
An Improved Method for Modeling NO_x Emissions from Recovery Boilers

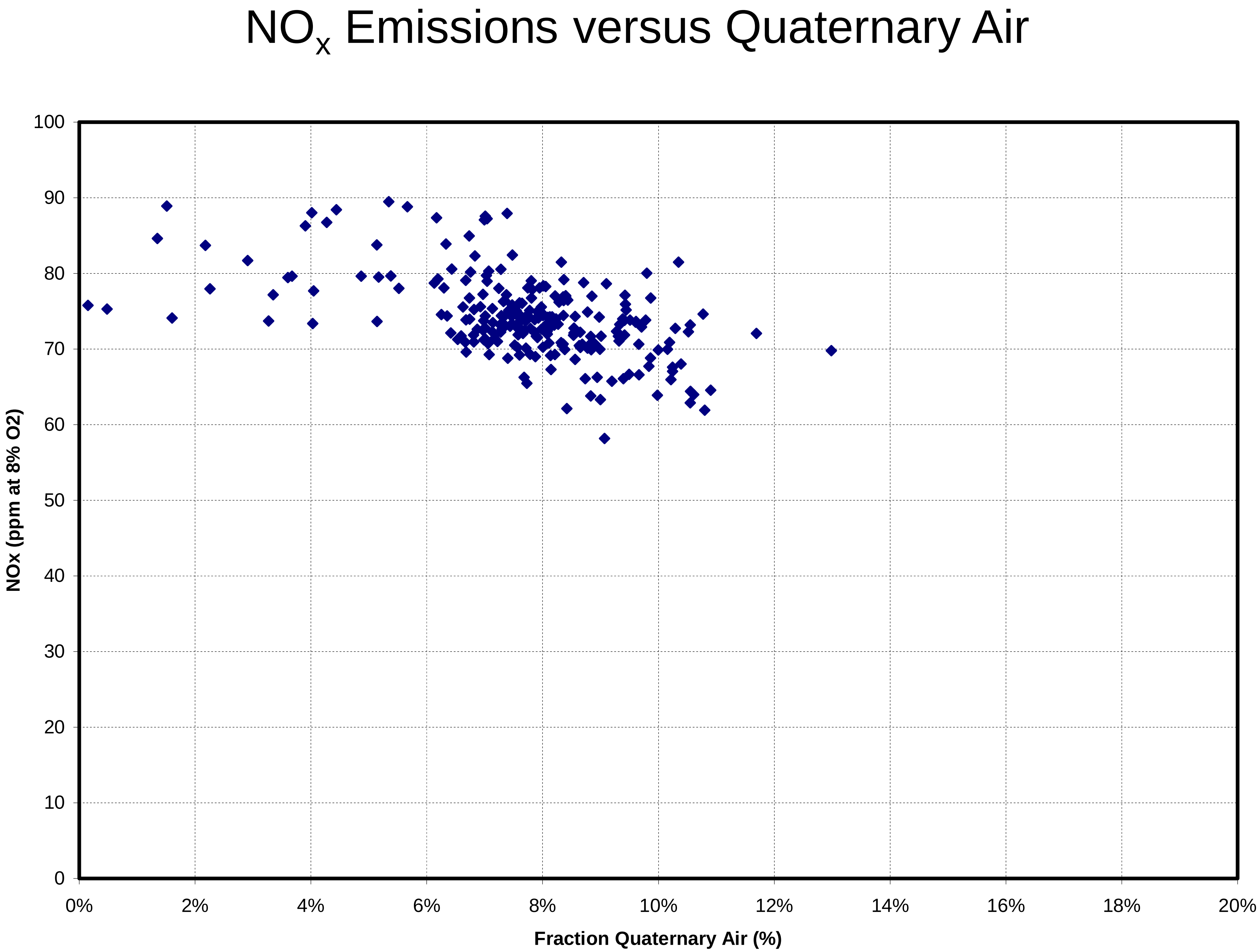
Allan R. Walsh

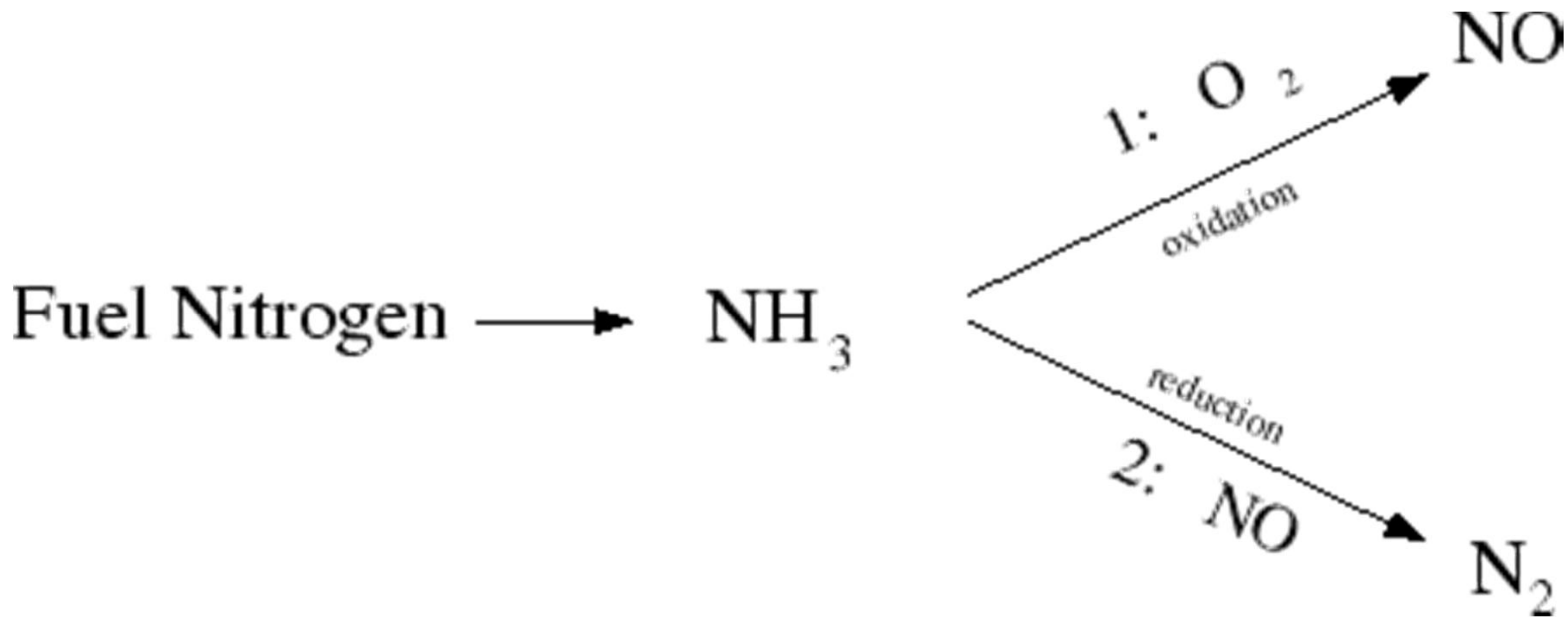
JANSEN Combustion and Boiler Technologies, Inc.


Superheaters
GB Inlet
Nose Arch
Screens
Tertiary Air
Load Burners
Liquor Gun
Openings
Secondary Air +
Hearth Burners
Primary Air
Char Bed

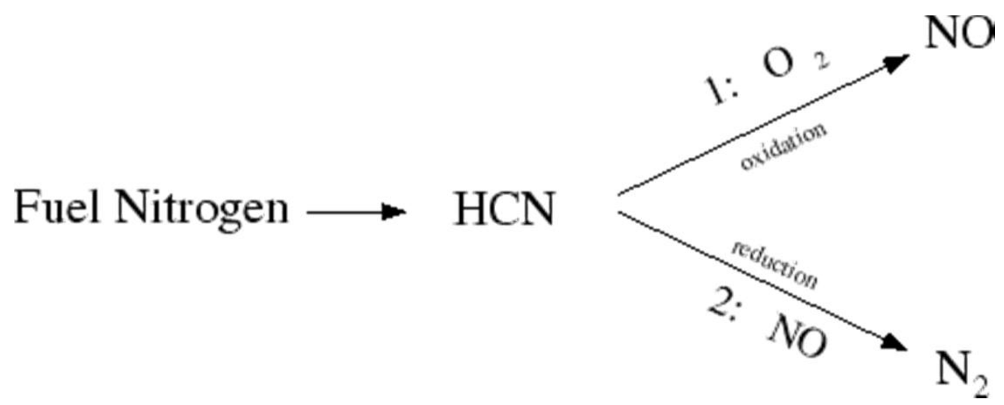
NO_x and CO Emissions versus Excess Air



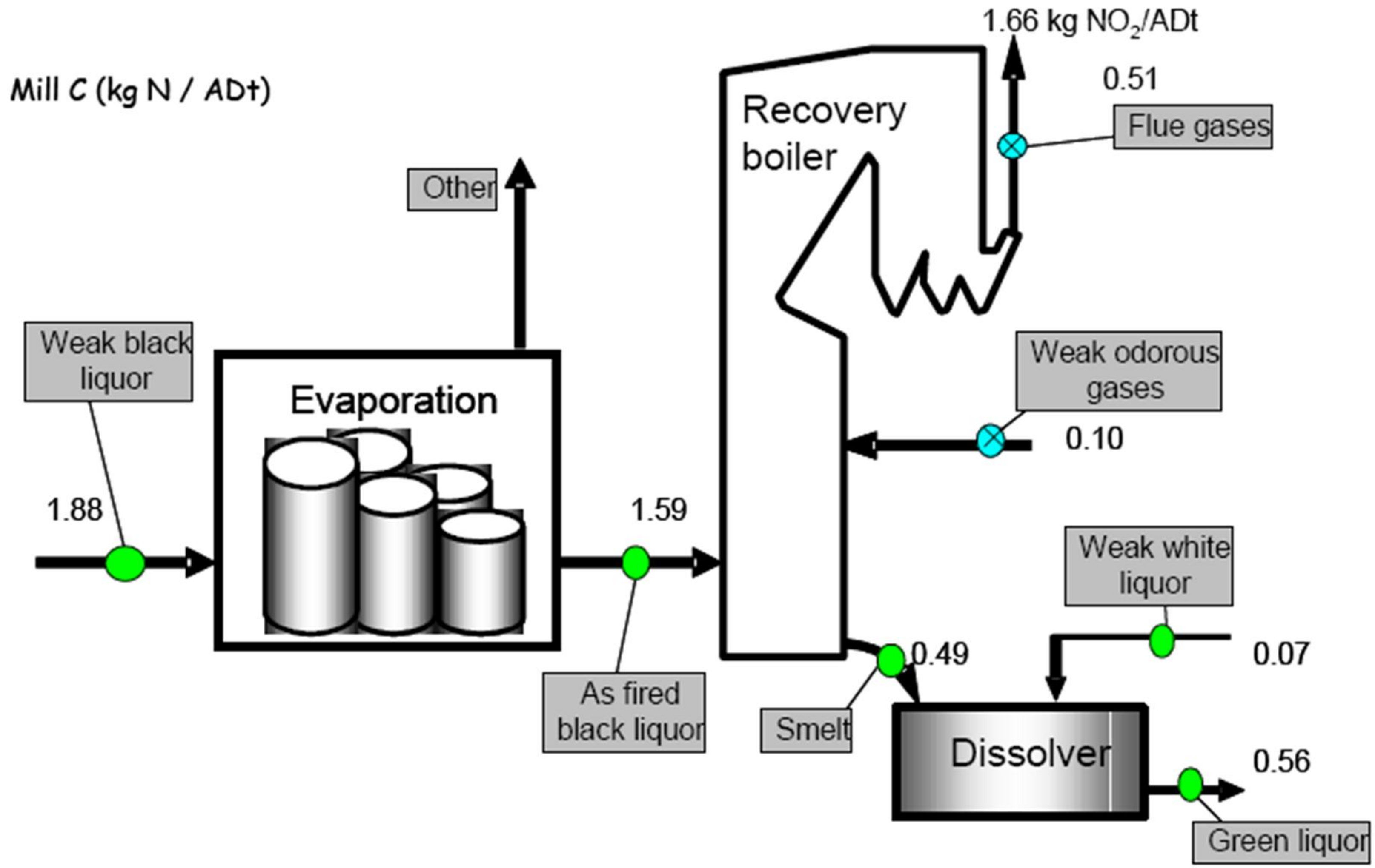

NOx Emissions versus Quaternary Air
NOx (ppm at 8% O2)
0
10
20
30
40
50
60
70
80
90
100
0%
2%
4%
6%
8%
10%
12%
14%
16%
18%
20%
Fraction Quaternary Air (%)



Fuel Nitrogen
NH3
1: O 2
oxidation
NO
reduction
2: NO
N2



Fuel Nitrogen
HCN
1: O 2
oxidation
NO
reduction
2: NO
N2


Mill C (kg N / ADt)
1.66 kg NO2/ADt
0.51
Flue gases
Recovery boiler
Other
Weak black liquor
Evaporation
1.88
1.59
Weak odorous gases
0.10
Weak white liquor
0.07
0.49
As fired black liquor
Smelt
Dissolver
0.56
Green liquor

Rates

$$d[NH_3]/dt = - r_{ox} - r_{red} \quad (1)$$

$$d[NO]/dt = r_{ox} - r_{red} \quad (2)$$

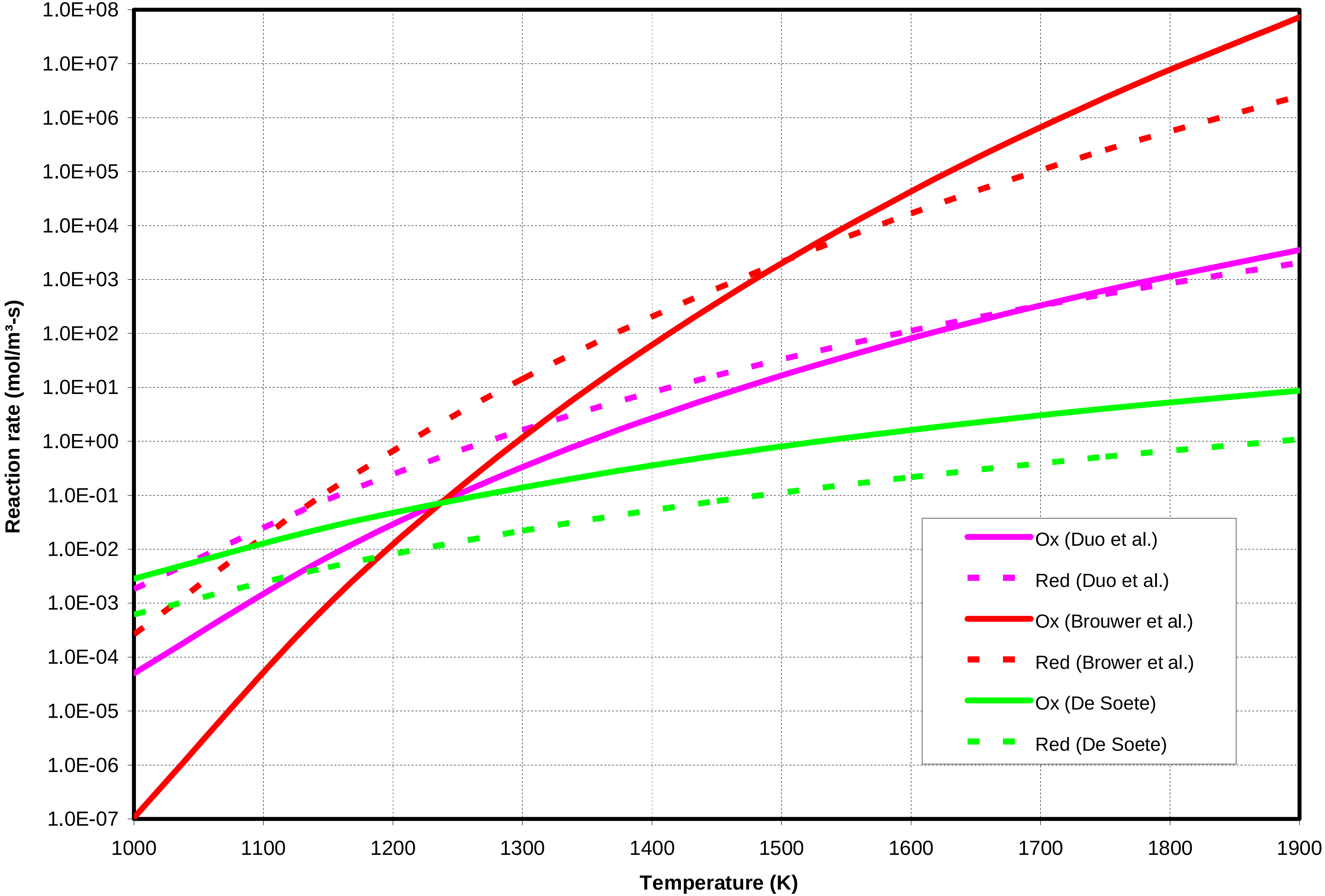
$$r_{ox} = k_{ox}[NH_3]^a [O_2]^b \quad (3)$$

$$r_{red} = k_{red}[NH_3]^c [NO]^d \quad (4)$$

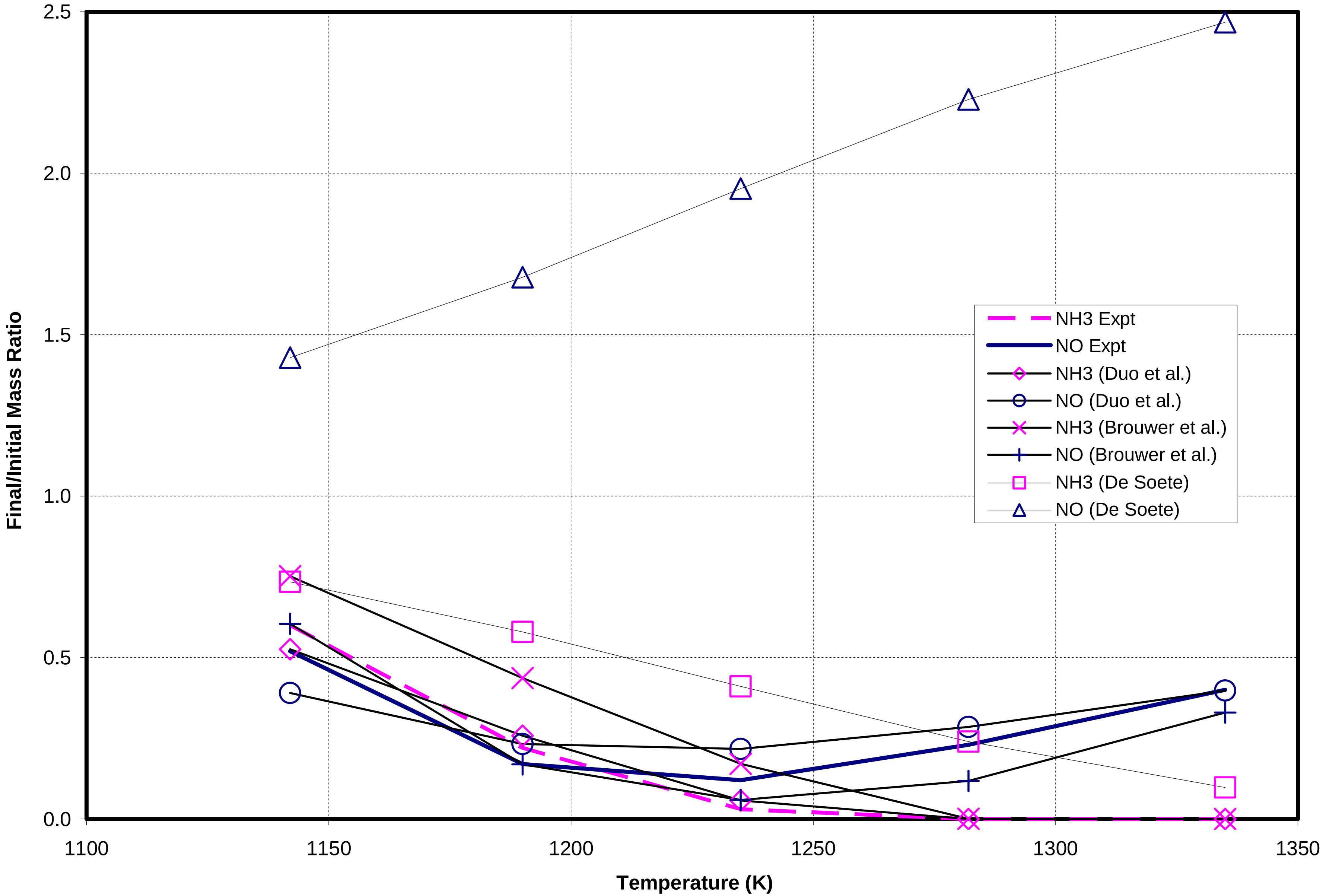
Notes

- in the De Soete mechanism, a, c, d = 1; b = $f[O_2]$
- in the Duo *et al.* mechanism, a, c, d = 1; b = 0
- in the Brouwer *et al.* mechanism, a, b, c, d = 1
- in the Brouwer *et al.* mechanism, k_{ox} and k_{red} are a $f[CO]$

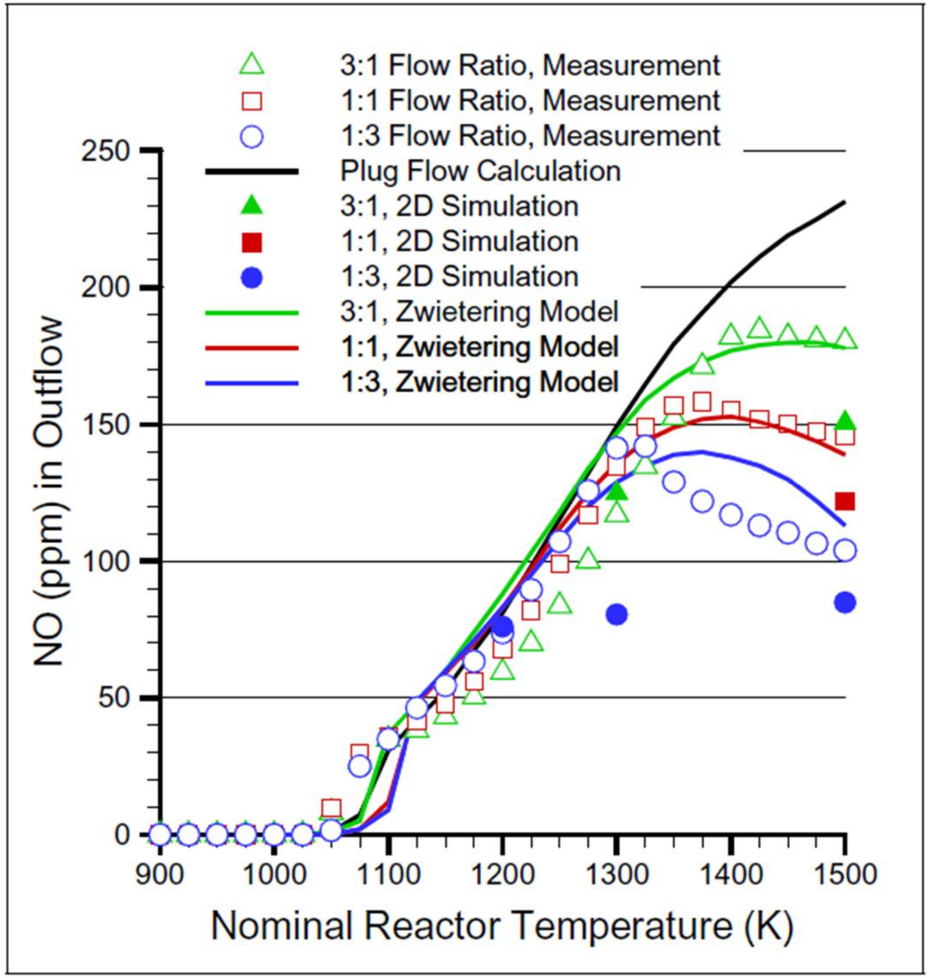
Comparison of Calculated Reaction Rates



Post-flame: Experiment versus Calculated

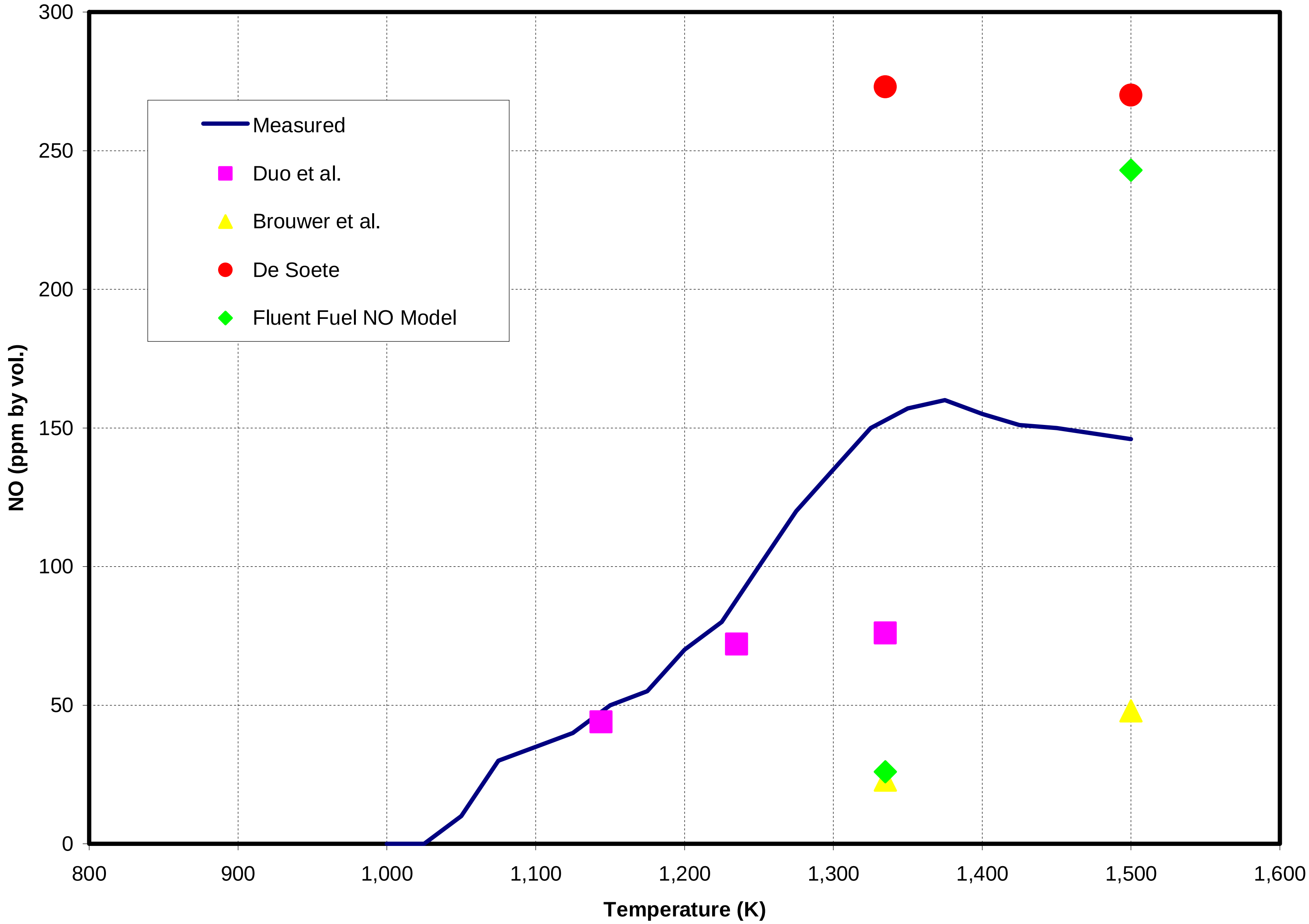


Experimental Results for Intermediate Temperature NH_3-seeded Diffusion Flame

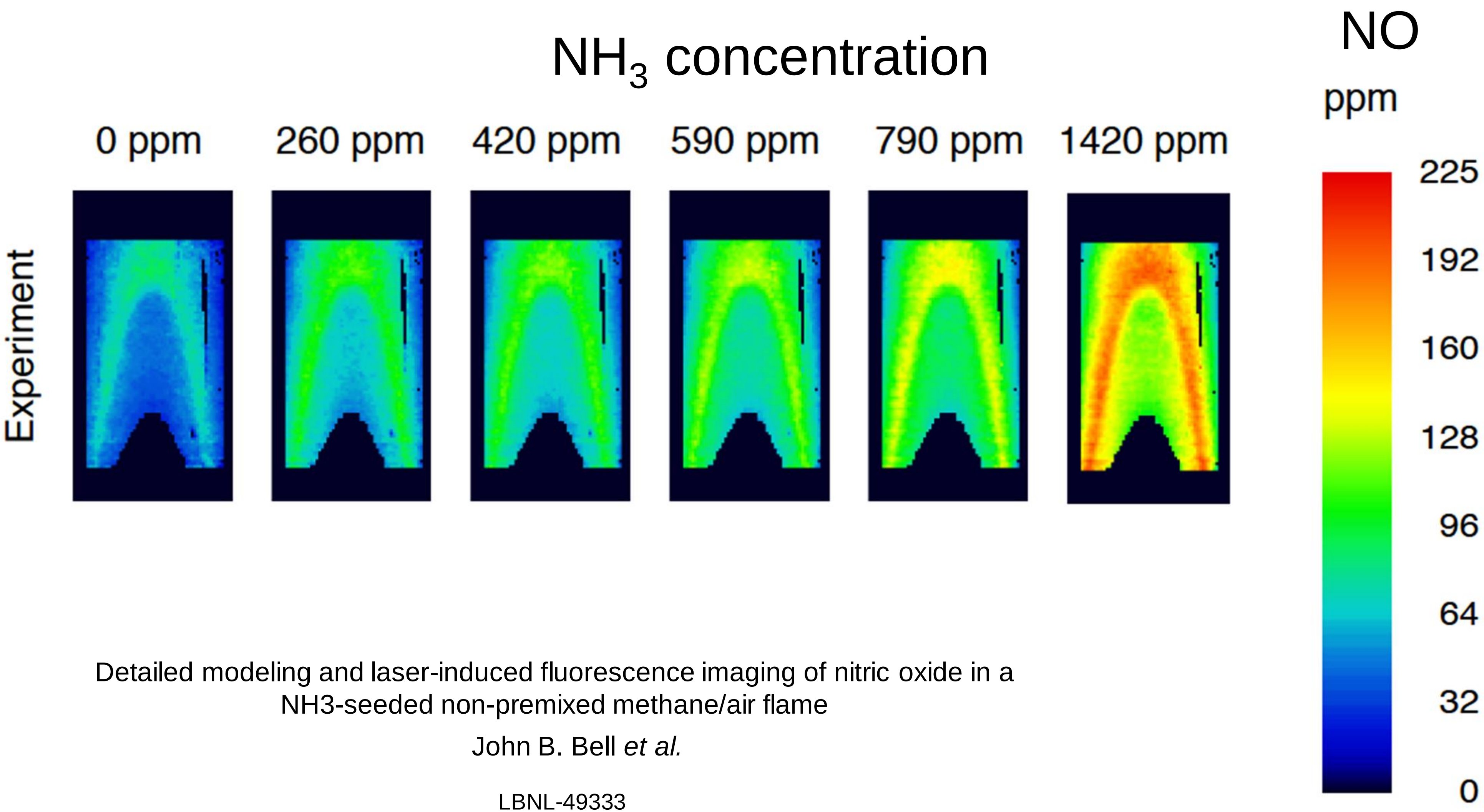


Grcar, J. F., *et al.*

Intermediate temperature NH_3-seeded Diffusion flame



Experimental Images of NO concentration

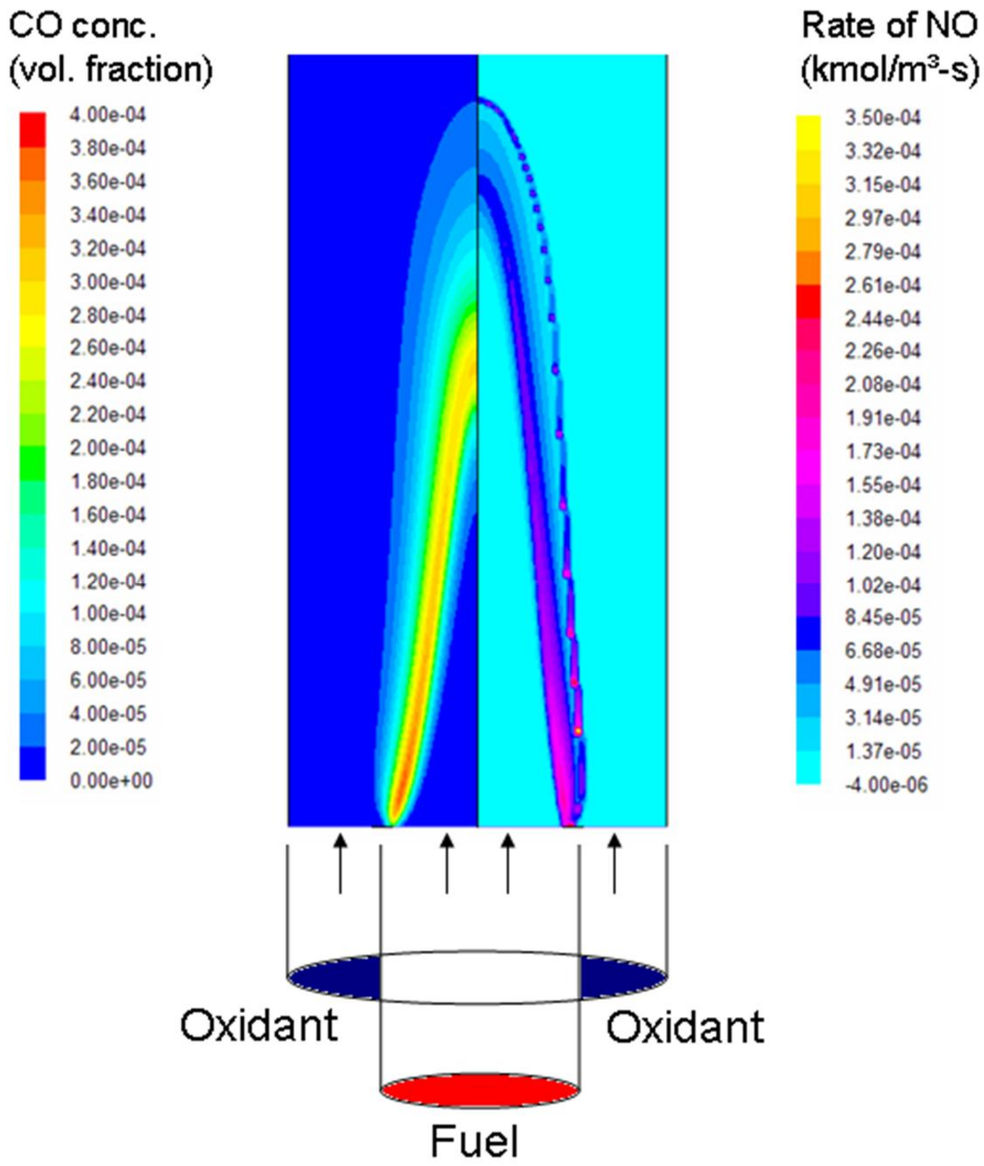


Detailed modeling and laser-induced fluorescence imaging of nitric oxide in a NH3-seeded non-premixed methane/air flame

John B. Bell *et al.*

LBNL-49333

“Flame” region NO formation



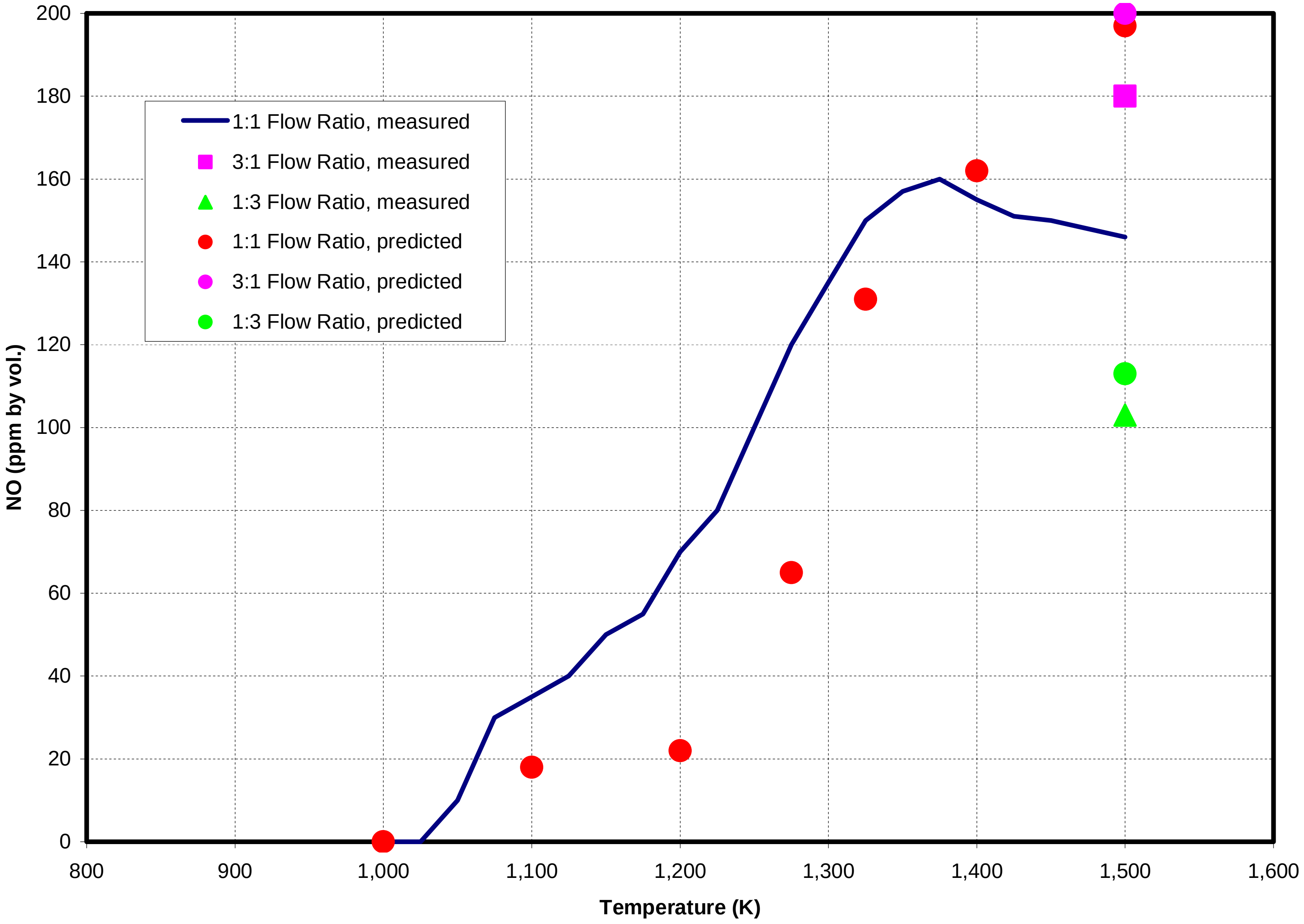
Algorithm for Flame-based NO_x model:

- IF $CO > CO_{Thresh}$ AND $T > T_{Thresh}$, Use the De Soete mechanism,

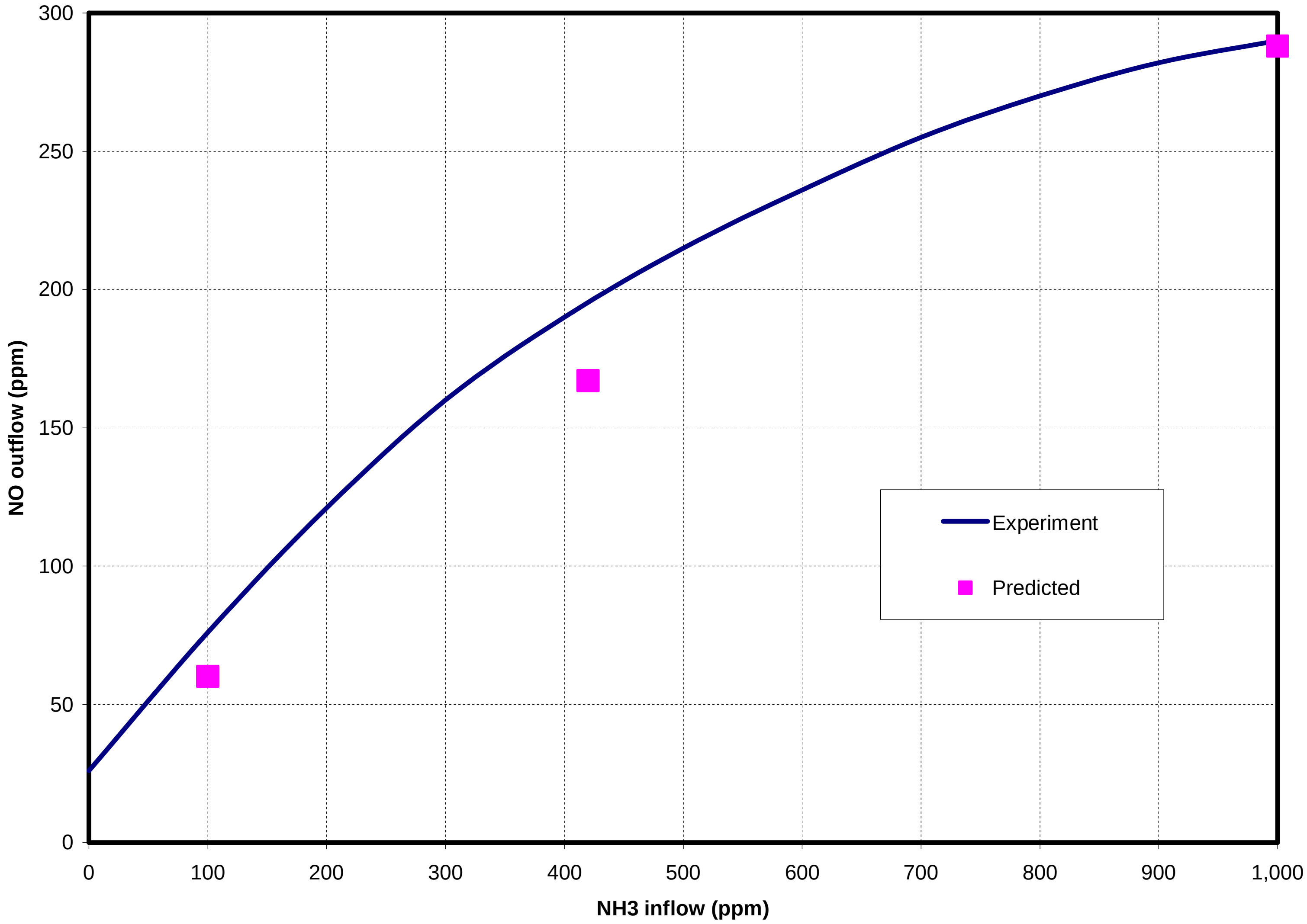
- Else IF $O_2 < 4\%$ Use the Brouwer *et al.* mechanism,

- Else, Use the Duo *et al.* mechanism

Predictions with flame-based model

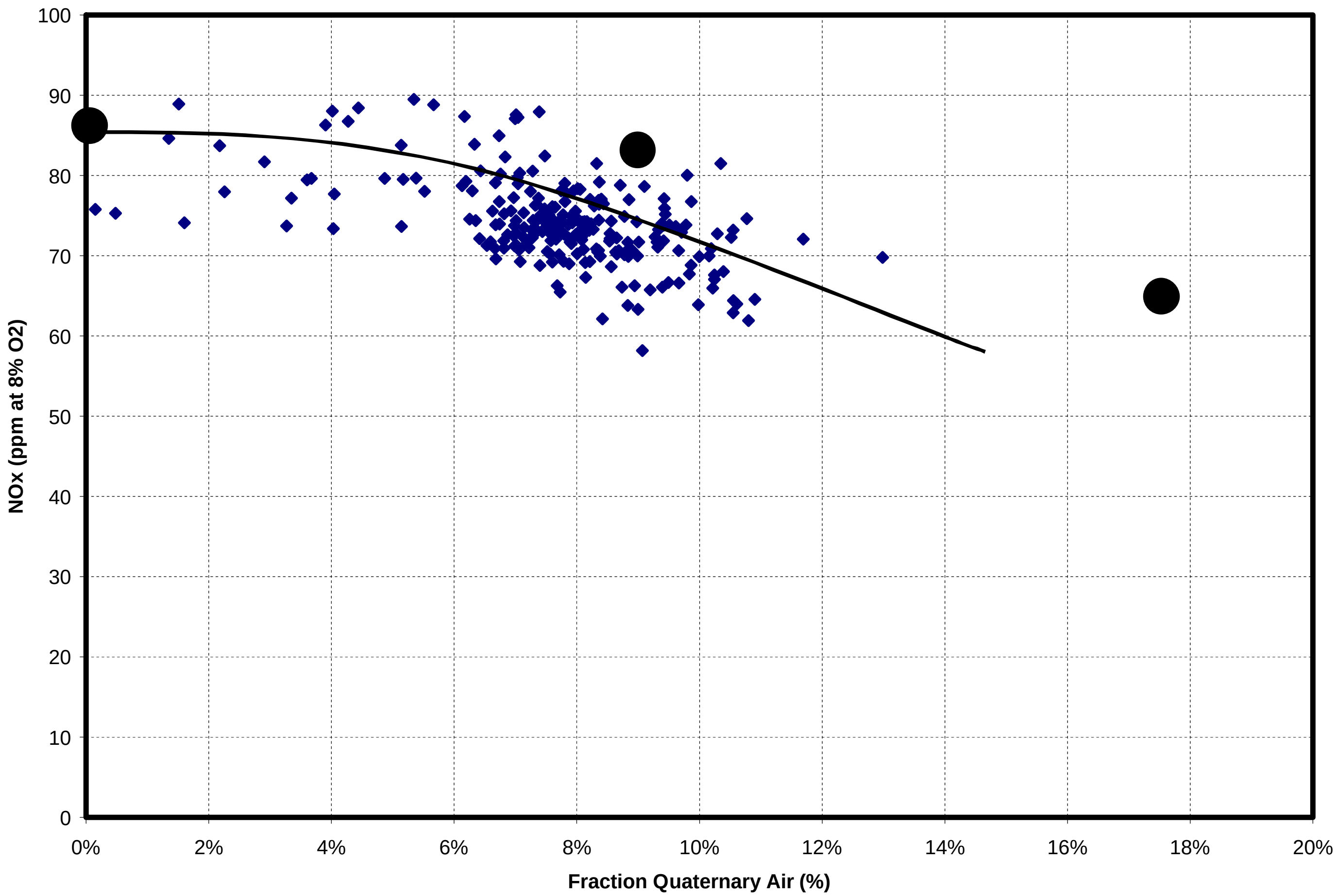


NO versus initial NH_3 concentration

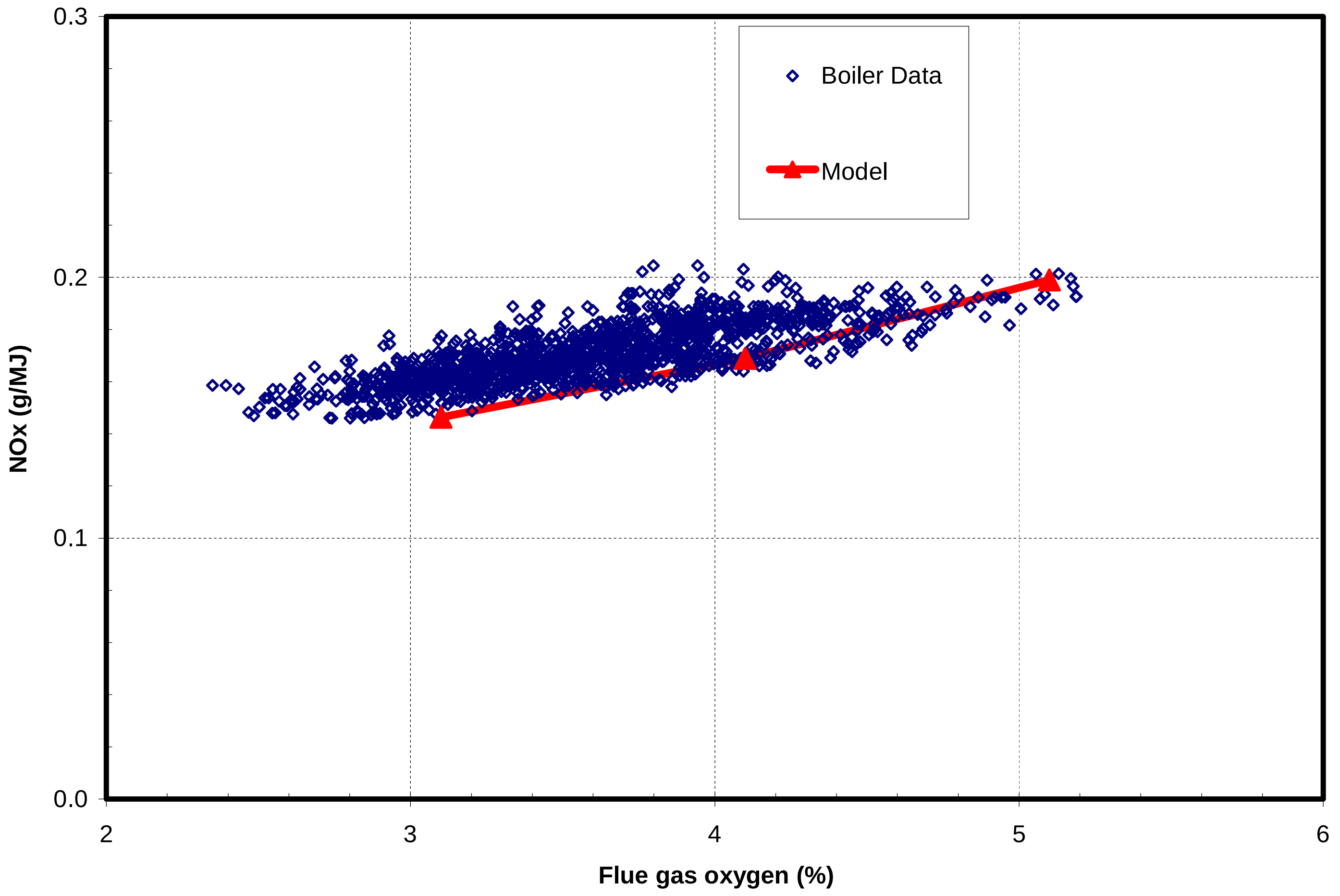


Sullivan *et al.*

Effect of Air Staging on NO_x



Effect of Excess Air on NO_x



Results

- Use mechanisms for specific conditions
- Used in combination, give reasonable agreement with laboratory results
- For industrial furnace conditions, not substantially different than kinetic based multiple-species multiple-reaction schemes

Results (cont.)

- Half-dozen RB combustion designs for NOx minimization
- 4 SNCR evaluations
- Several biomass boiler NOx studies

Discussion

- Fuel nitrogen content, conversion, and species
- Turbulent reaction limitations
  - Cell size/resolution
  - Models
  - Time dependence
- Model SNCR
- What are factors to describe flame region?

Summary

- Simple, well-established equations for NO_x modeling, depending on conditions
- Satisfactory for laboratory flame data
- Reproduce data for large industrial boilers burning biomass

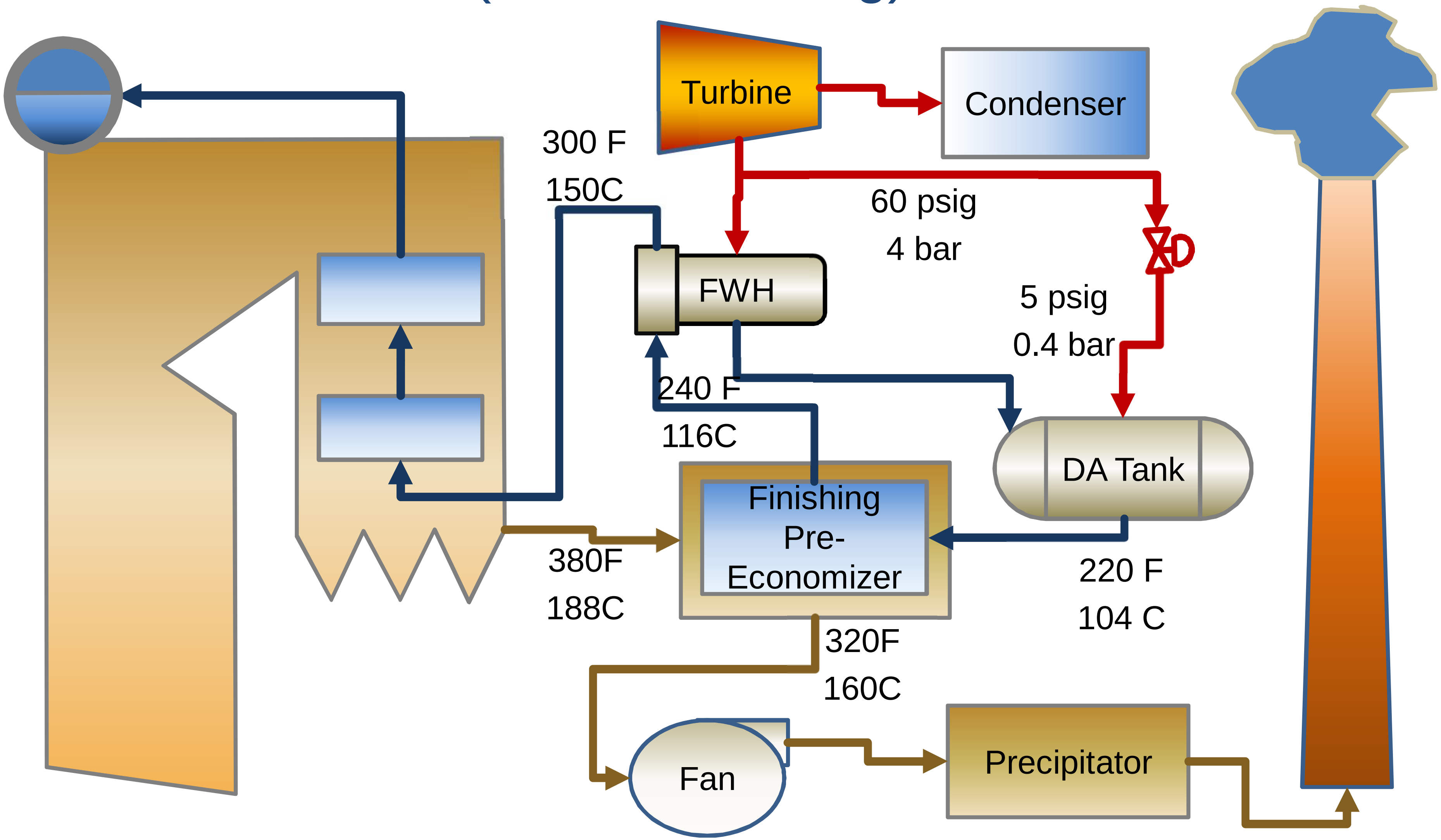
Finishing Pre-Economizer

AF&PA February 8, 2012

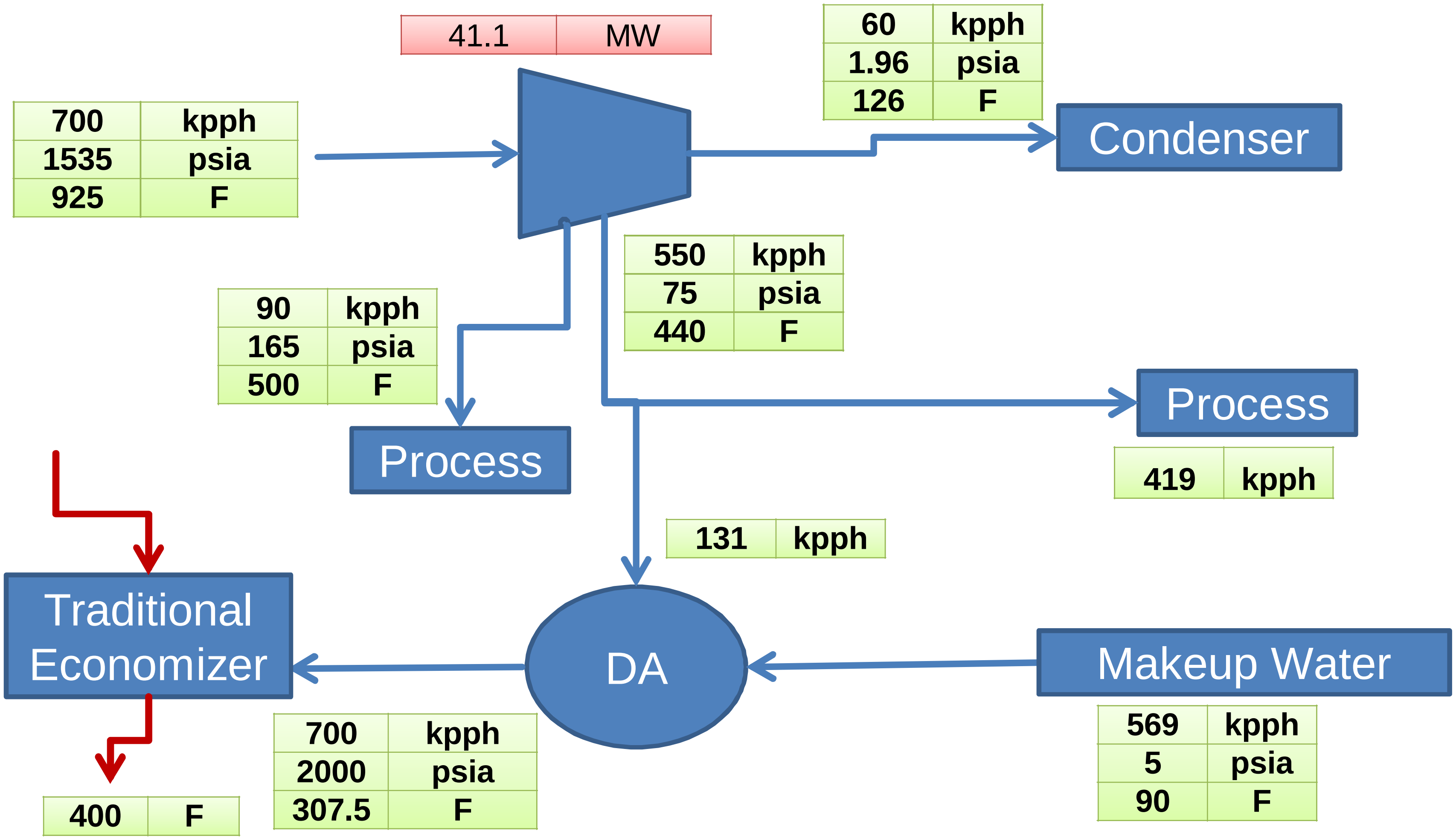
Michelle Bodnovich
Engineering Manager, Pulp & Paper

thebabcock&wilcoxcompany

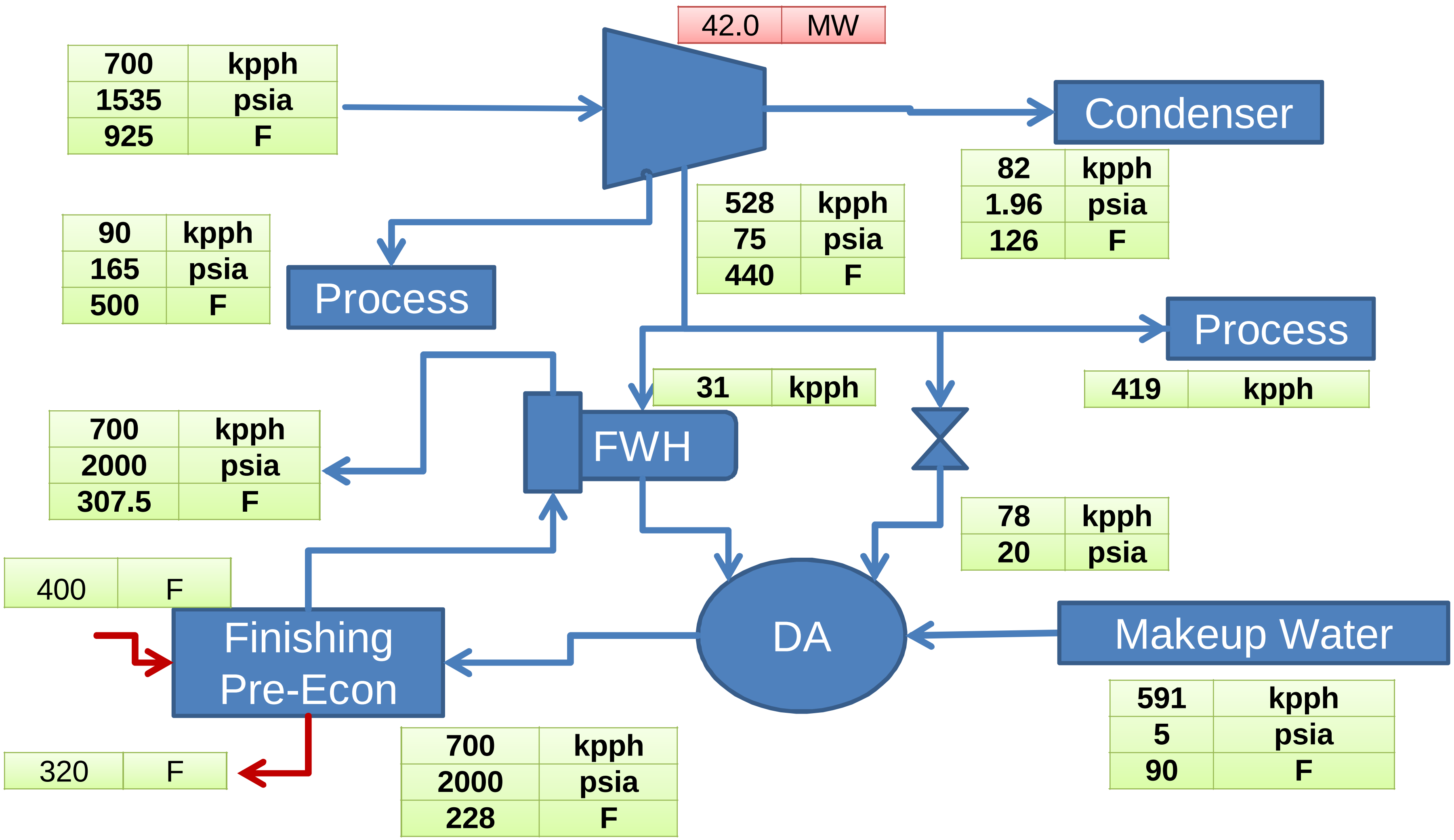
Finishing Pre-Economizer (Patent Pending)

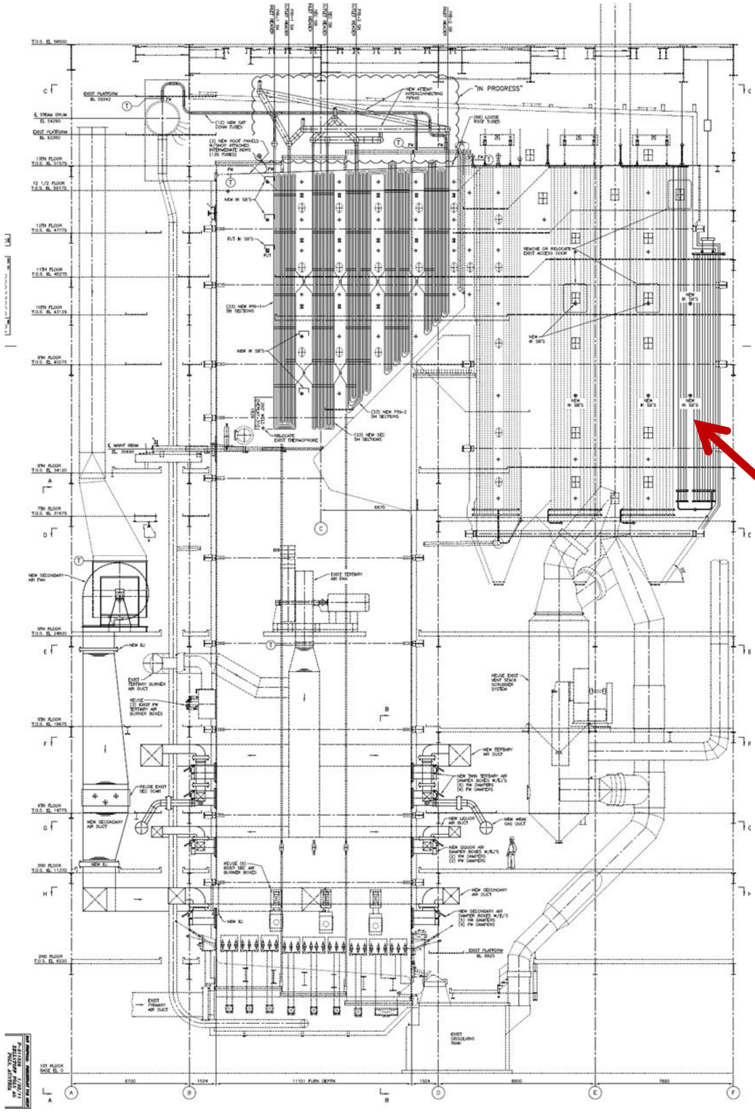


Typical Existing DA/Economizer



Finishing Pre-Economizer

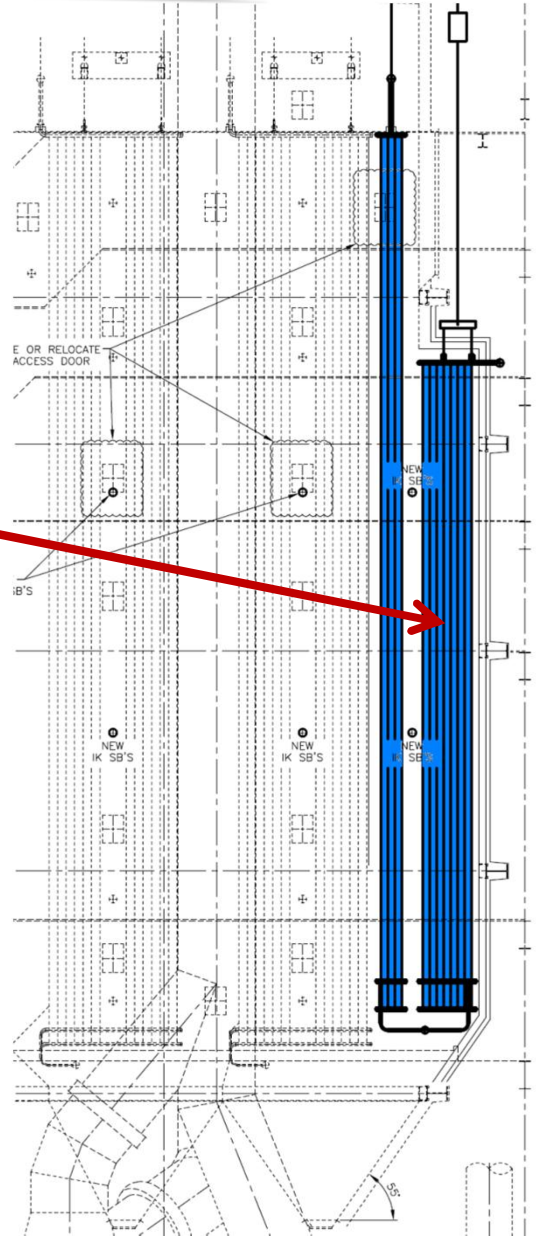




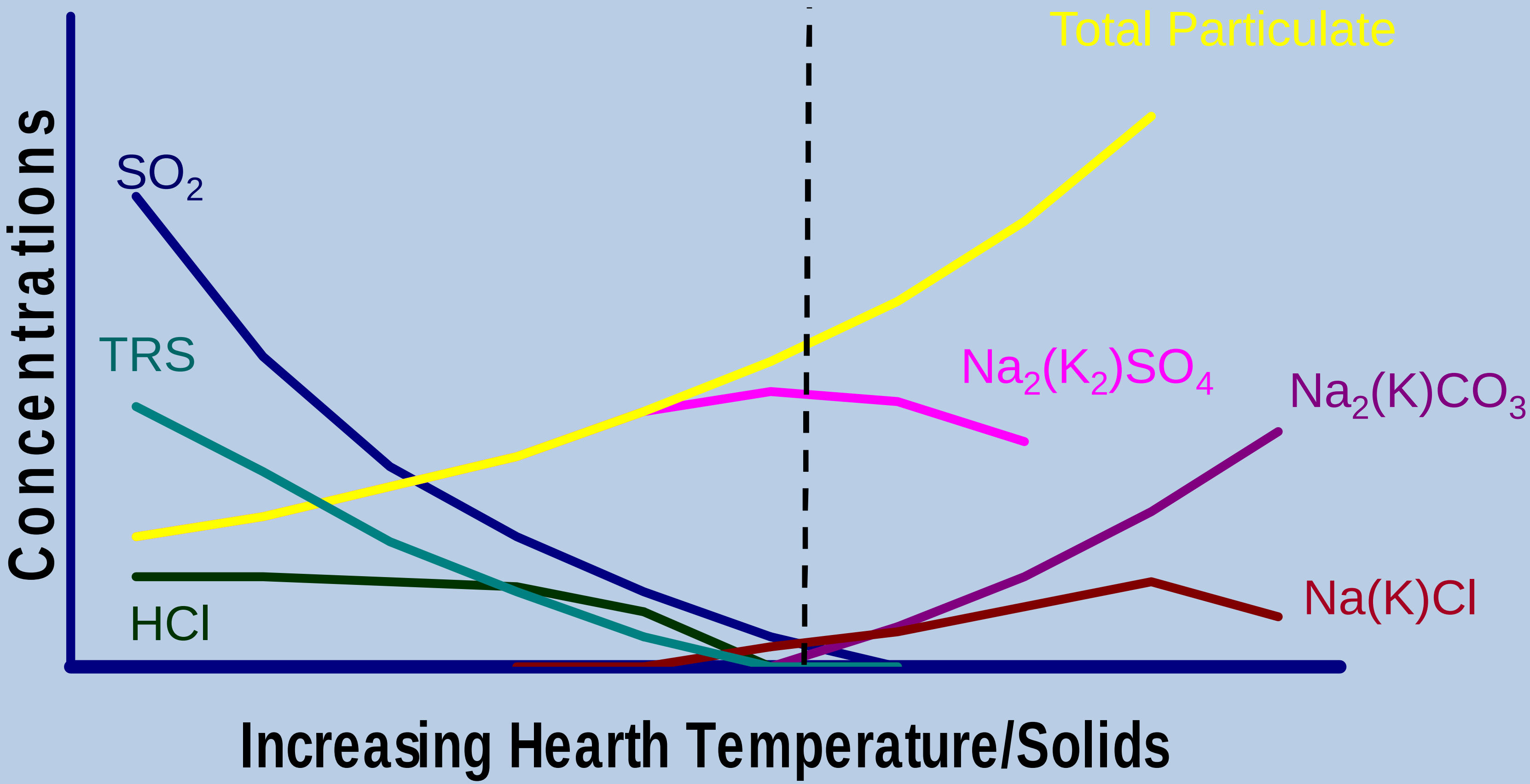
Finishing Pre-Economizer (Patent Pending)

Upgrade Project

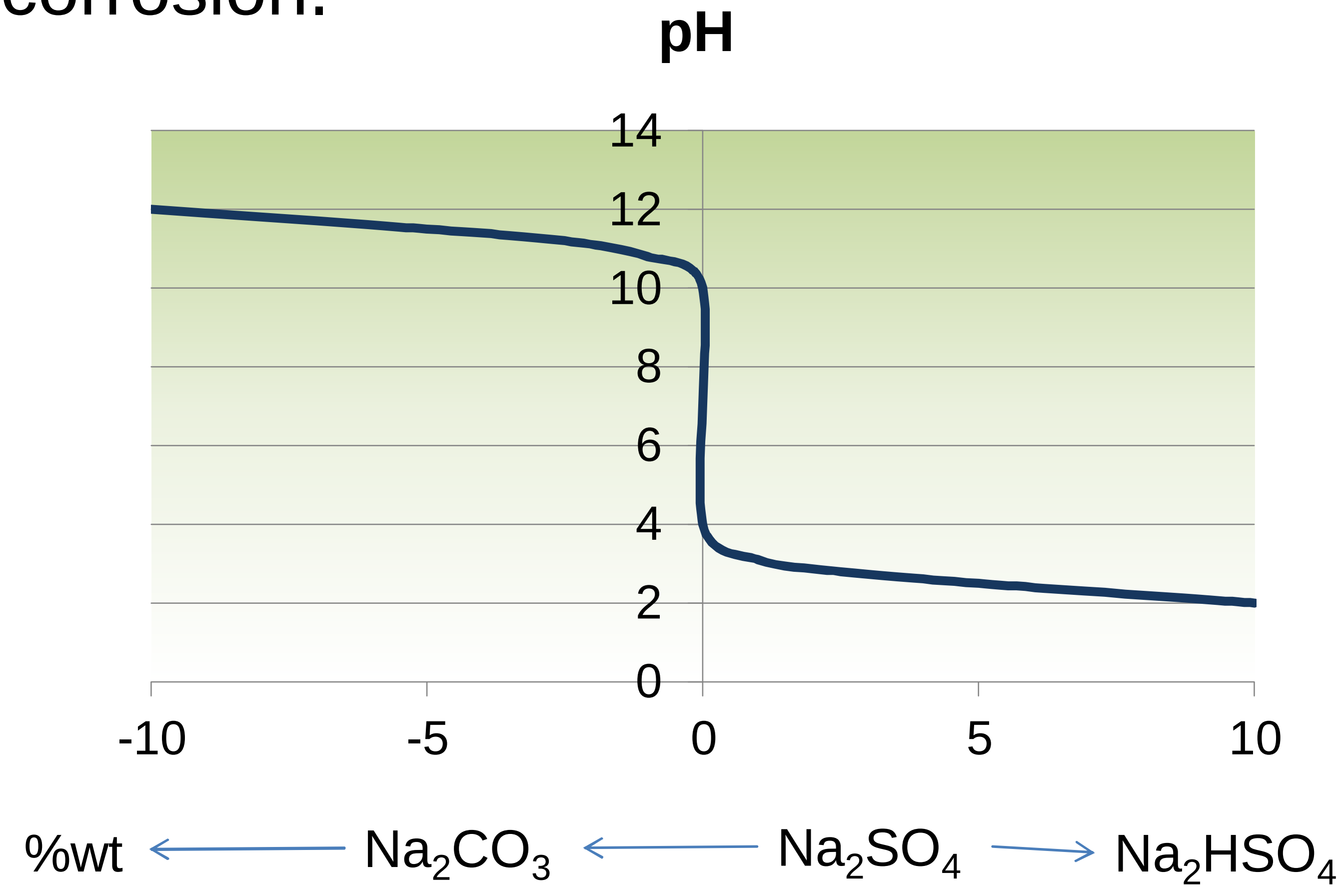
Pulp Mill Has Evaluated a 2 MW Increase



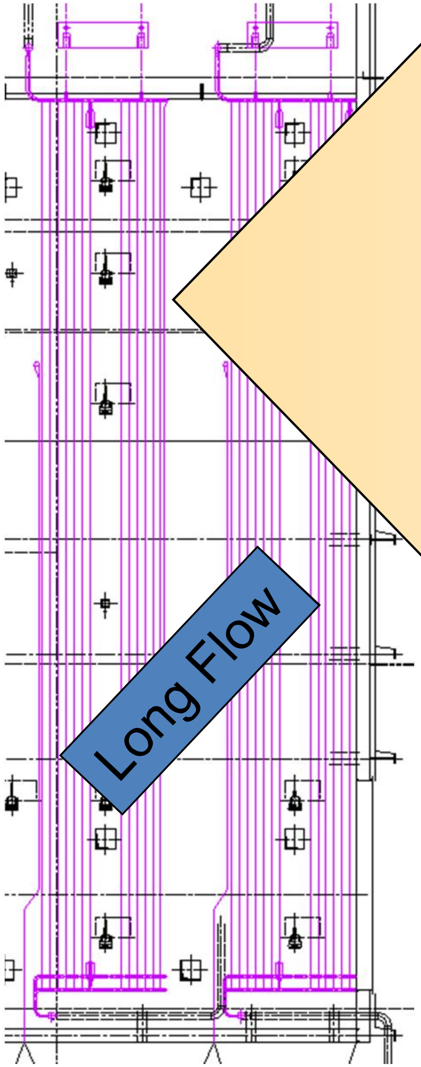
Furnace Reactions



Higher Solids produces more Na_2CO_3 and allows a lower temperature economizer without acid dew point corrosion.

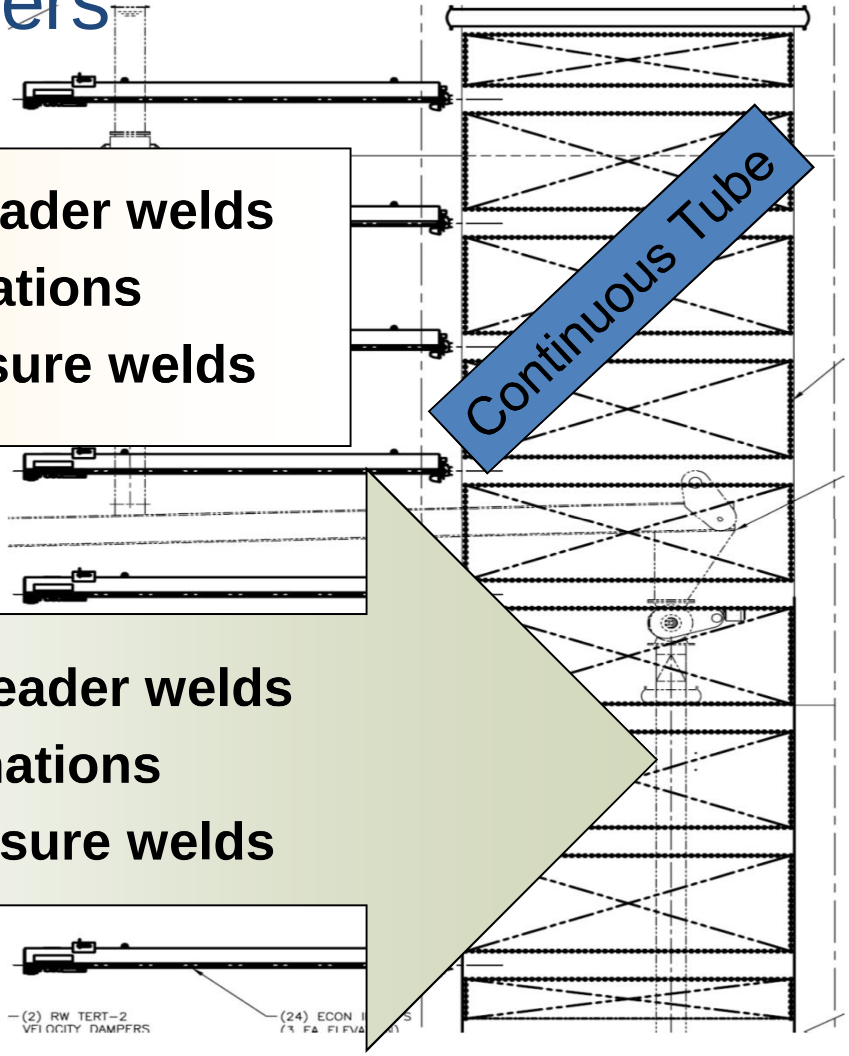


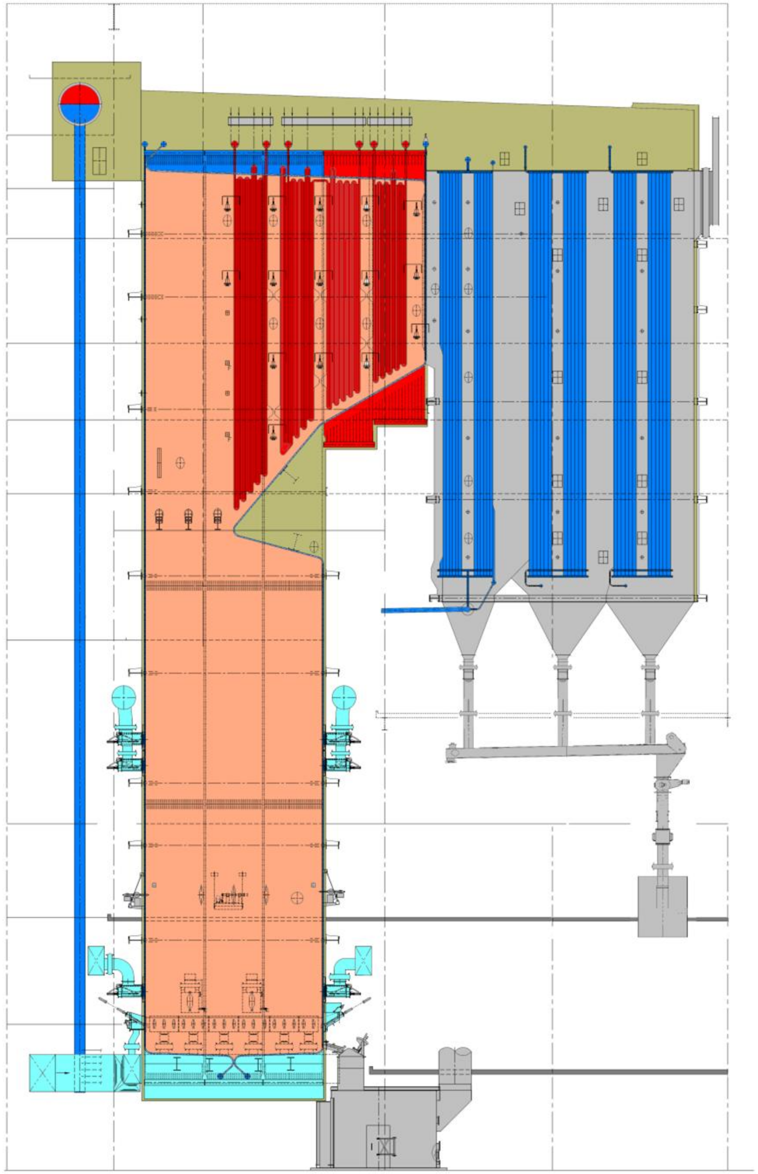
Lower leak potential with continuous tube economizers

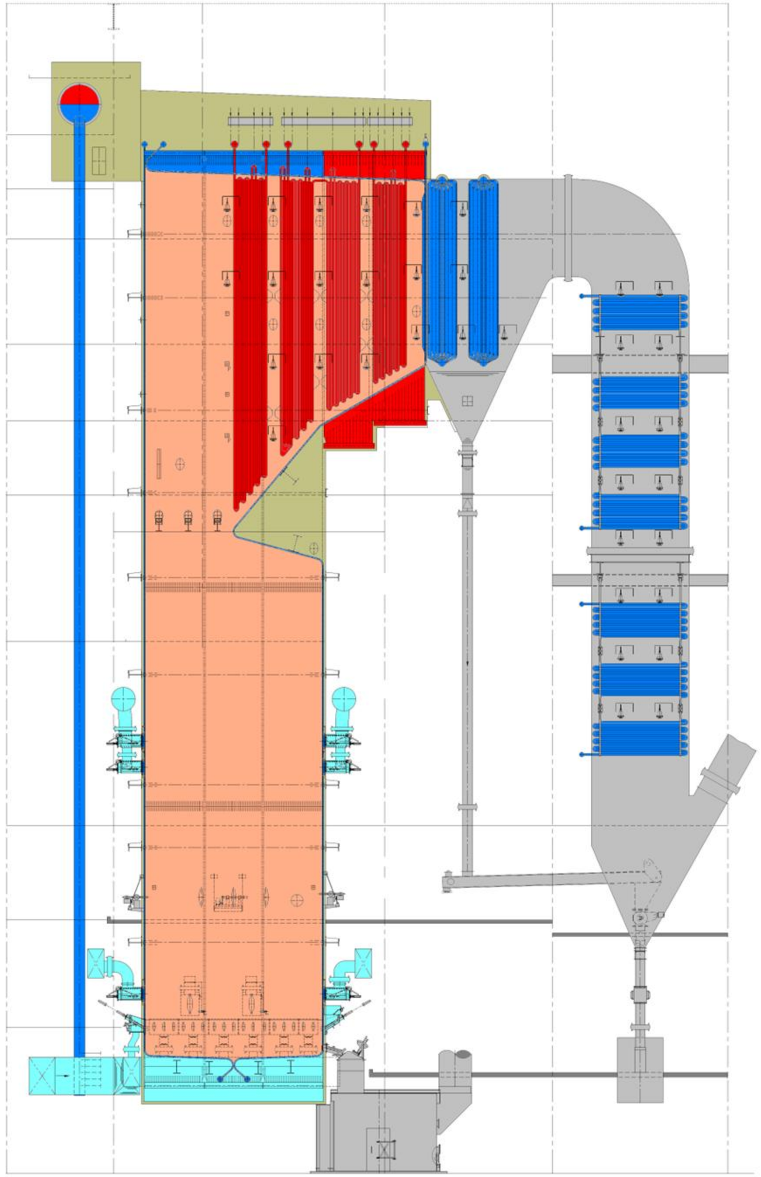


4,200	tube to header welds
8400	fin terminations
525	field pressure welds

186	tube to header welds
0	fin terminations
525	field pressure welds

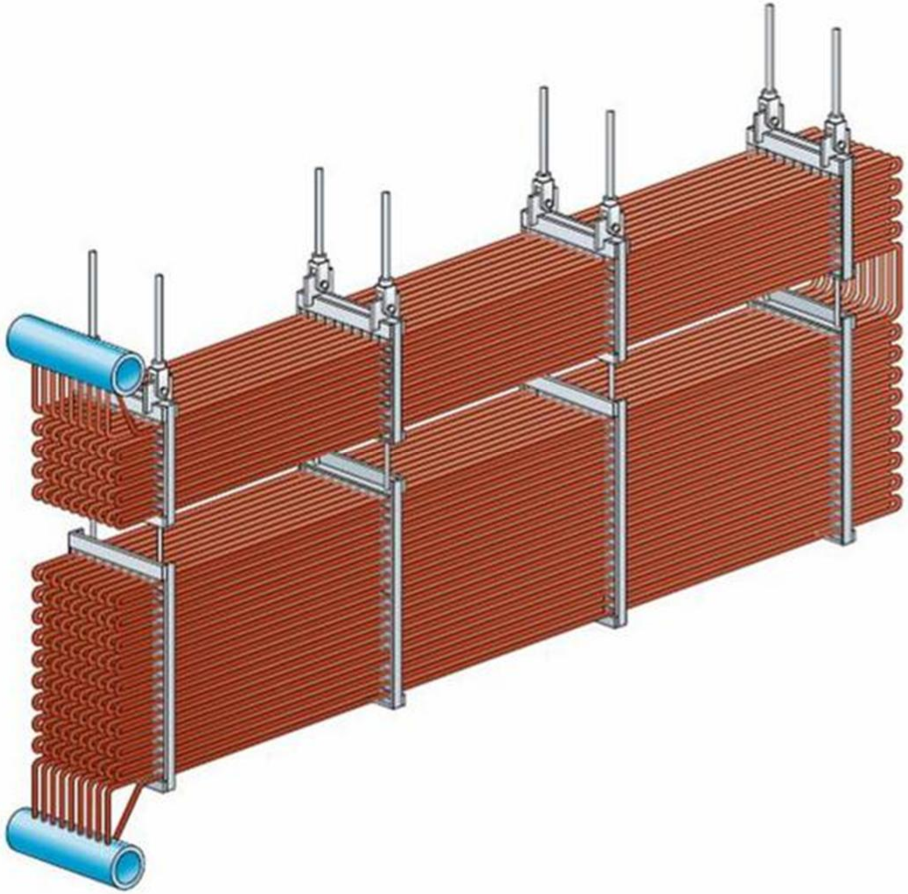


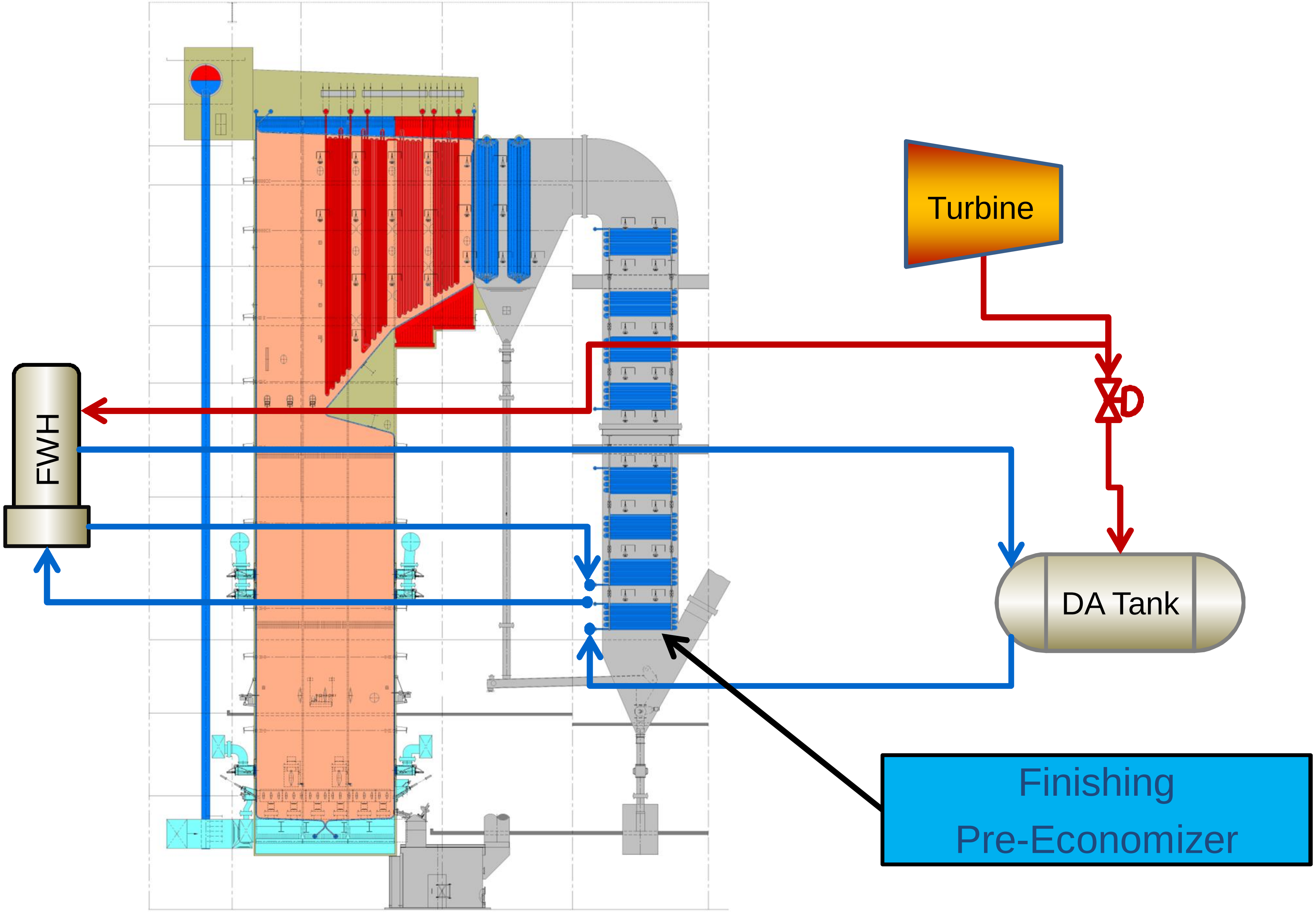




Continuous Cross Flow Economizer

2 inch OD tube on 4x4 inch spacing





Turbine
FWH
DA Tank
Finishing
Pre-Economizer

Thank You!

Update on Sootblowing Technology

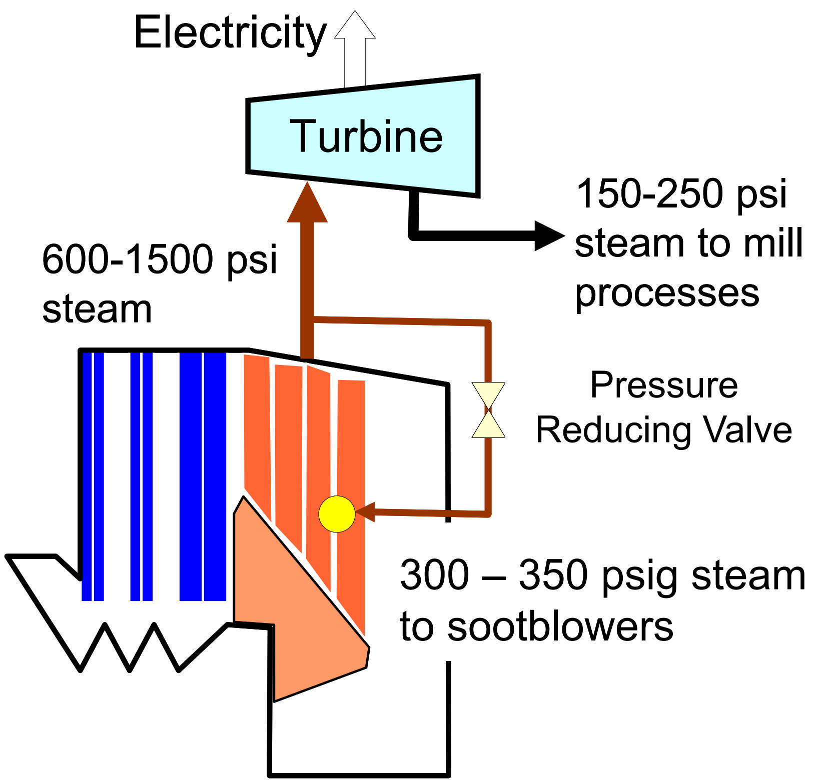
D. Tandra

2012 American Forest & Paper Association
February 8th, 2012

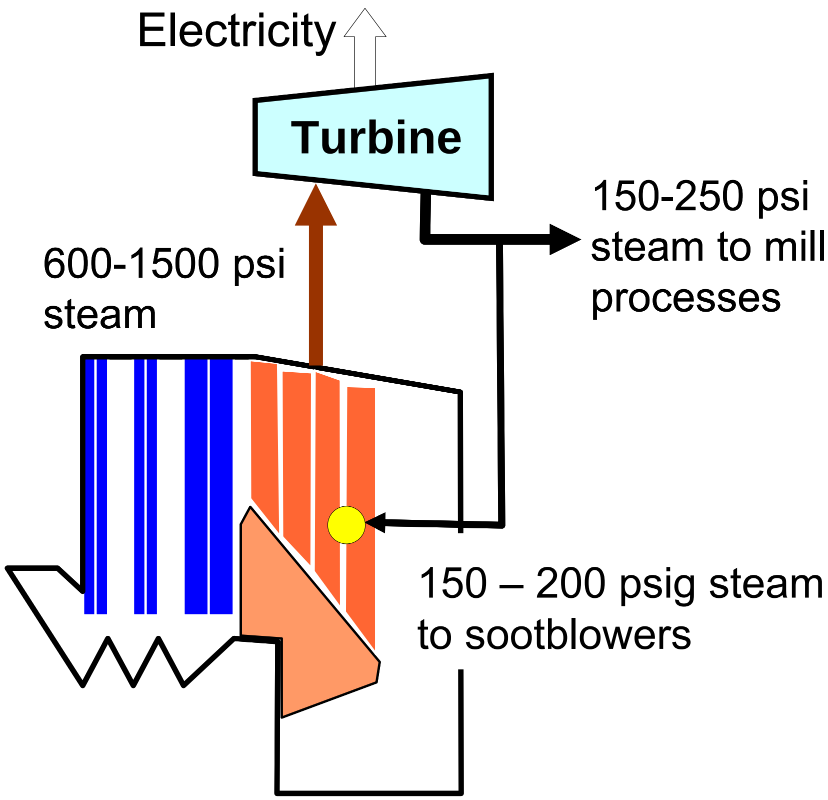
Outline

- Low Pressure Sootblowing Technology
- Sootblower Equipped with Gas Temperature Measurements
- Recovery Boiler Water Wash System
    - ➔Shower Cleaning system

Low Pressure Sootblowing Technology

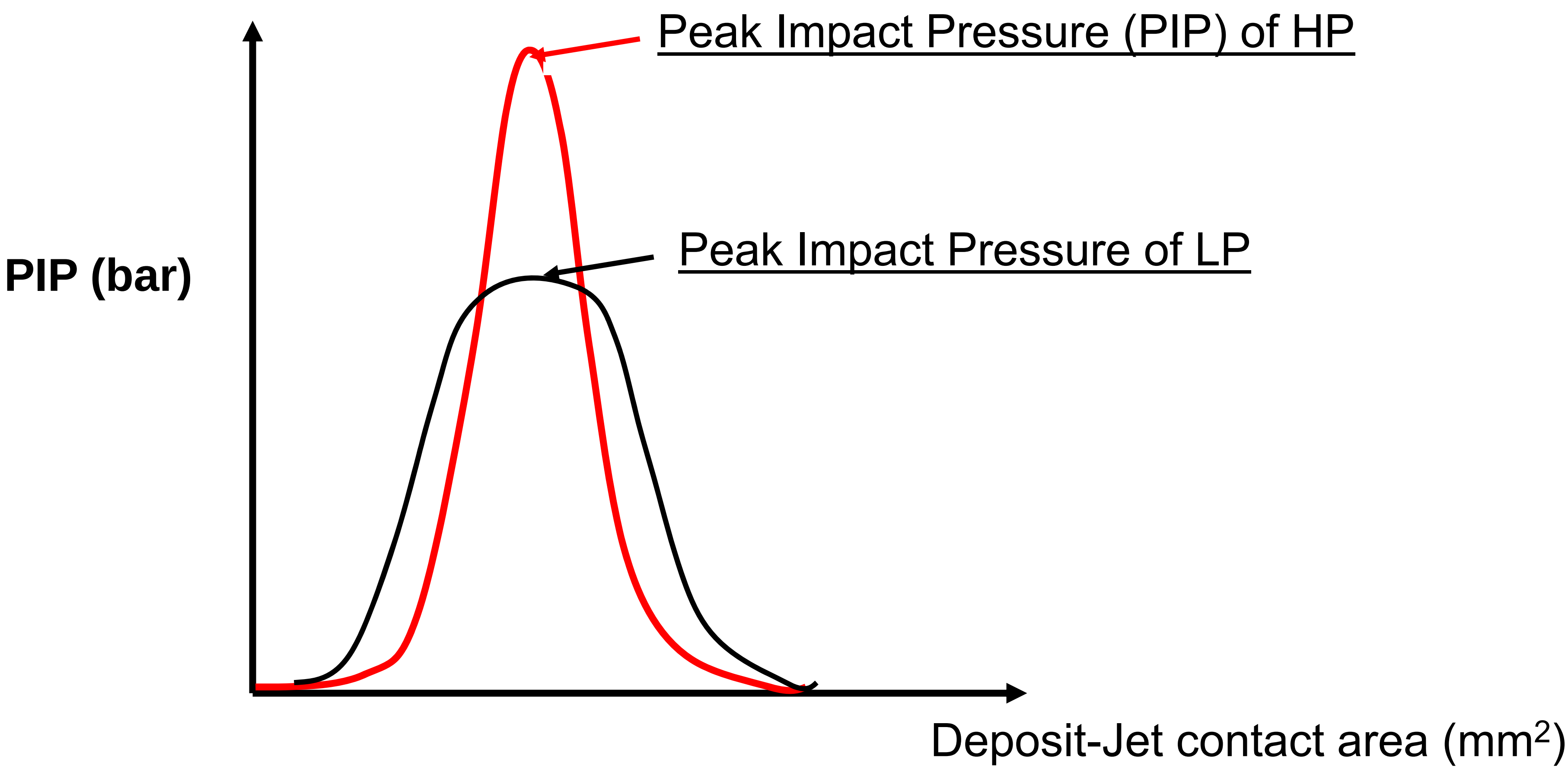


High Pressure Sootblowing



Low Pressure Sootblowing

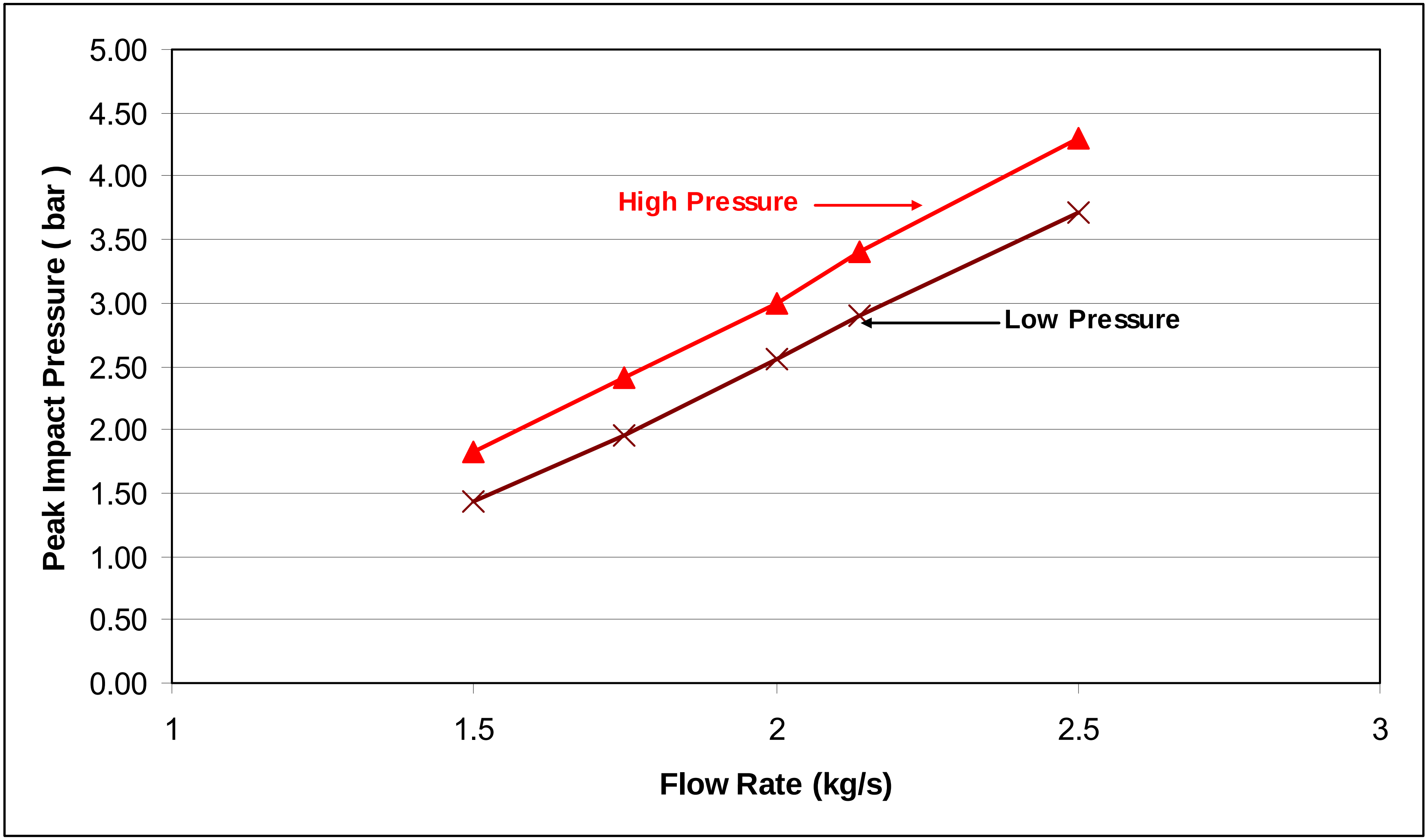
LP vs HP: A comparison



- PIP of HP is higher than the PIP of LP, but the area under the curve (<u>which is force</u>) of HP and LP are made comparable.

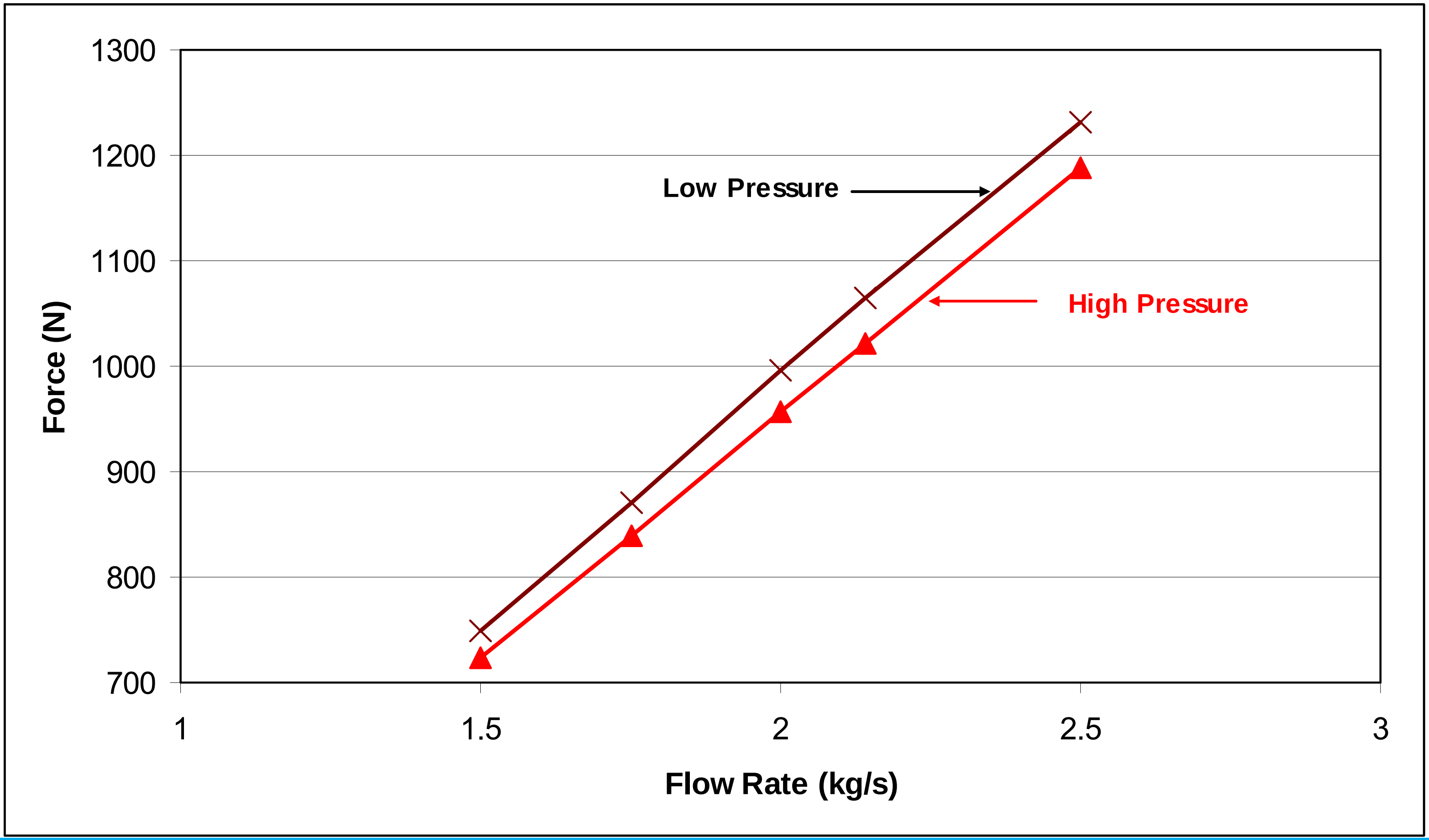
Peak Impact Pressure (PIP)

- PIP of HP sootblower is higher than its LP counterpart …… BUT



Force

- But the FORCE of LP can be made comparable to its HP counterpart
- Deposit is only “care” about how much force the jet exerted on its surface.
- Deposit can be removed if the force can overcome the deposit adhesion strength



Mill Trials

- MILL TRIALS
  - Irving Pulp & Paper (2004)
    - TAPPI Engineering Conference 2005, Philadelphia, PA, USA
      - *"Mill trial on LP sootblower performance"*
        Contributors: **Clyde Bergemann, Univ of Toronto, Irving Pulp & Paper**
  - International Paper Vicksburg, MS, USA (2005)
    - International Chemical Recovery Conference (ICRC) 2007, Quebec City, QC, CANADA
      - *"Development of LP sootblowing technology"*
        Contributors: **Clyde Bergemann, Univ of Toronto, International Paper**

❖ **FIRST FULL SCALE INSTALLATION**

- ❖ Weyerhaeuser Valliant (2007)
  - ❖ TAPPI PEERS Conference 2008 (Clyde Bergemann & Weyerhaeuser)

Installations

- Sootblower Specification
  - Steam Pressure
    - 200 psig (13.8 bar) turbine extraction
    - Poppet valve setting:
    - Superheater - 170 psig (12 bar g)
    - Generating Bank - 150 psig (10.3 bar g)
    - Economizer - 107 psig (7.38 bar g)
  - Steam consumption
    - 16,000 – 18,500 lb/hr (7.25 – 8.4 ton/hr)
    - Same as its high pressure sootblower counterpart

Installations

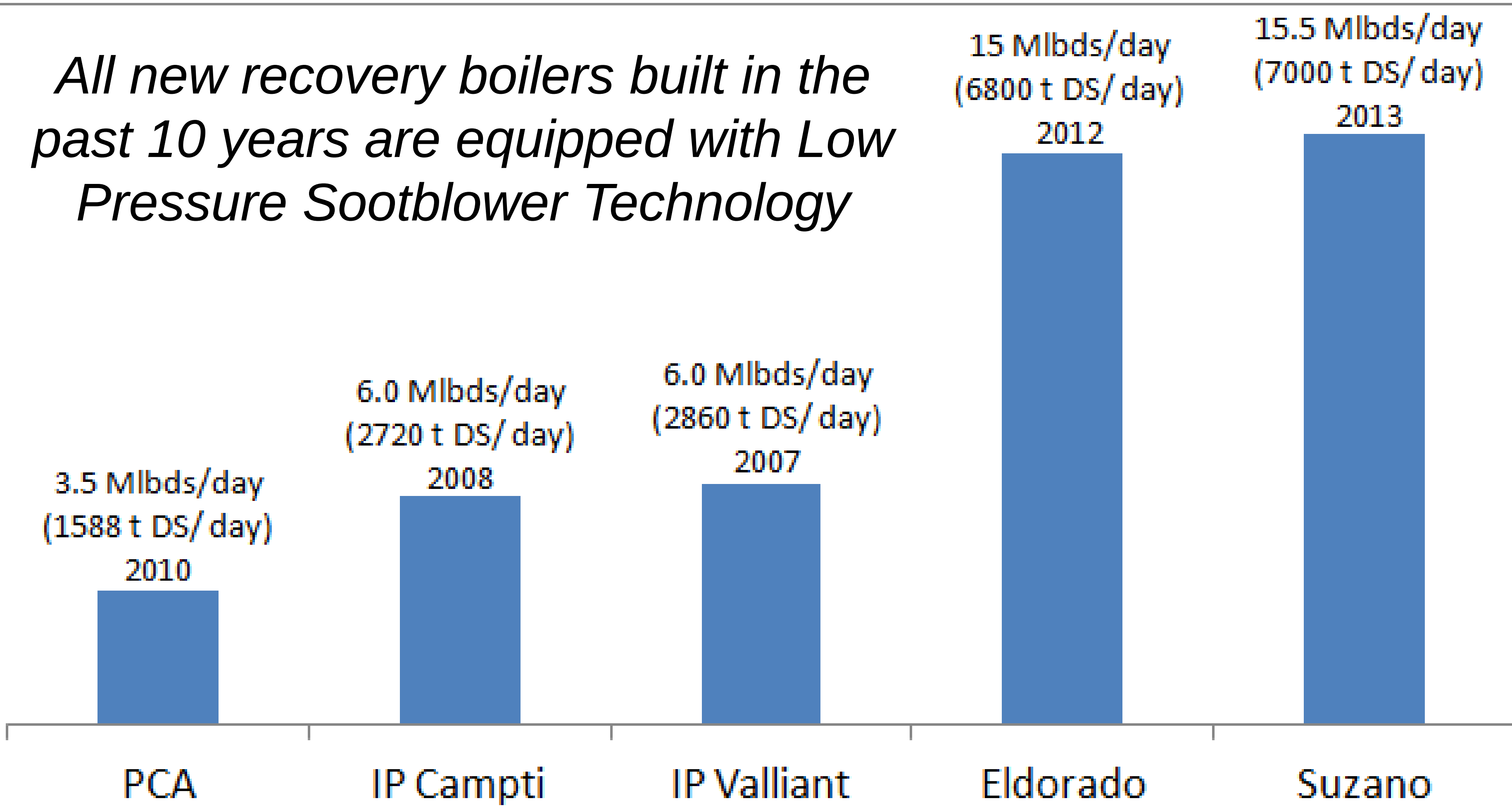
- International Paper
  - ➔ Valliant, OK (2007)
    - Capacity 6.3 million lb dry solid / day (2,860 ton DS / day)
    - 80% Solid
    - 1500 psig, 925 ^{o}F (103 bar g, 496 ^{o}C)
    - 88 low pressure sootblowers (32 SPHR, 34 GB, 24 ECON)
  - ➔ Campti, LA (2008)
    - Capacity 6.0 million lb dry solid / day (2,720 ton DS / day)
    - 80% Solid
    - 1500 psig, 950 ^{o}F (103 bar g, 510 ^{o}C)
    - 88 low pressure sootblowers (32 SPHR, 34 GB, 24 ECON)
- PCA
  - ➔ Valdosta, GA (2010)
    - Capacity 3.5 million lb dray solid / day (1,588 ton DS / day)
    - 75% solid, 1500 psig, 925^{o}F (103 bar g, 496 ^{o}C)

Installations

- Eldorado
  - ➔ Tres Lagoas – Green Field Pulp 1.5 Mt/yr (2012)
    - Capacity 15 million lb dry solid / day (6,800 ton DS / day)
    - 80% Solid
    - 1235 psig, 905 ^oF (85 bar g, 485 ^oC)
    - 116 low pressure sootblowers
- Suzano
  - ➔ Maranhao, Imperatriz – Green Field Pulp 1.5 Mt/yr (2013)
    - Capacity 15.5 million lb dry solid / day (7,000 ton DS / day)
    - 80% Solid
    - 1335 psig, 915 ^oF (92 bar g, 490 ^oC)
    - 120 low pressure sootblowers

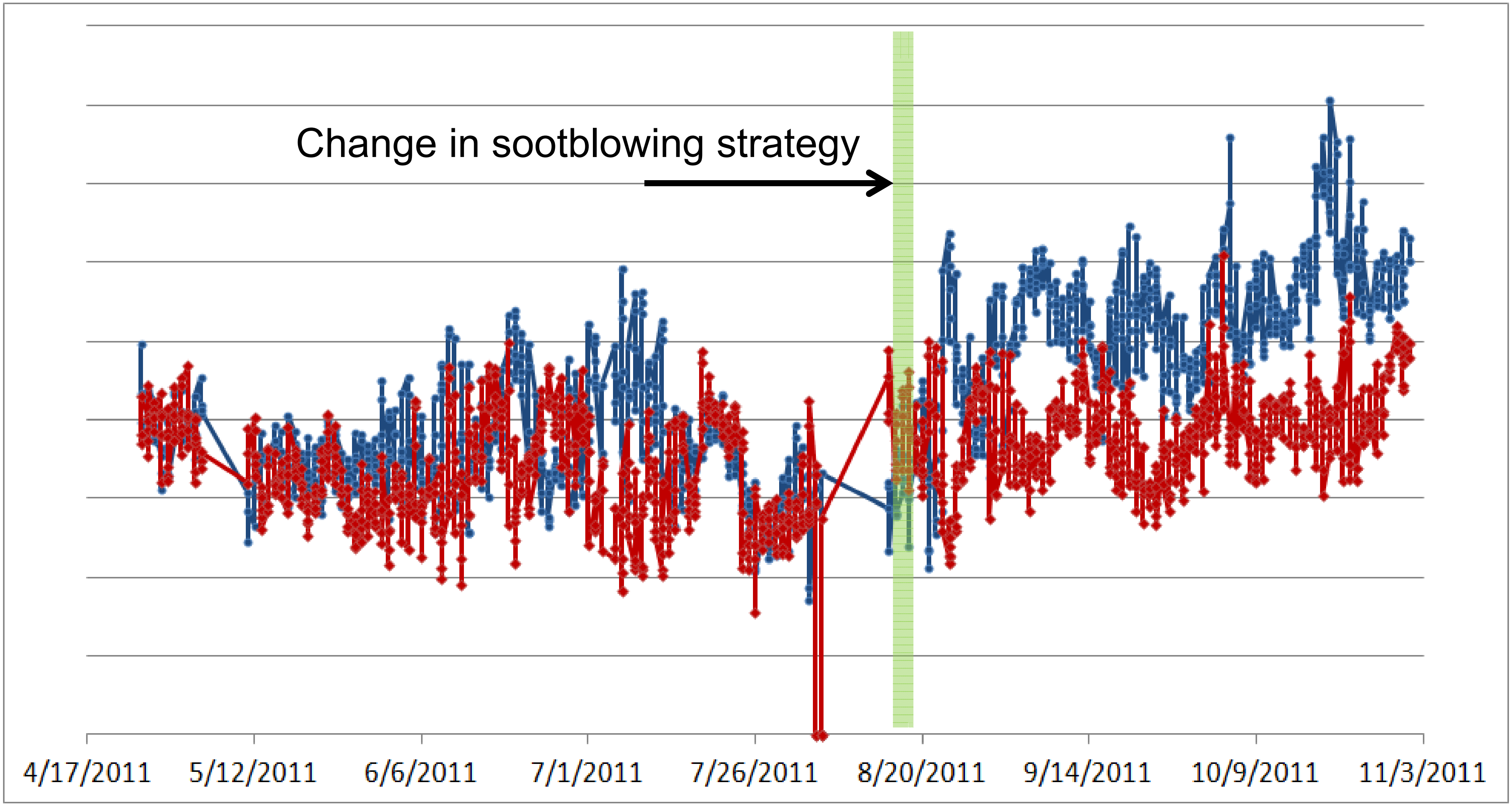
Low Pressure Sootblower Installations

All new recovery boilers built in the past 10 years are equipped with Low Pressure Sootblower Technology



International Paper

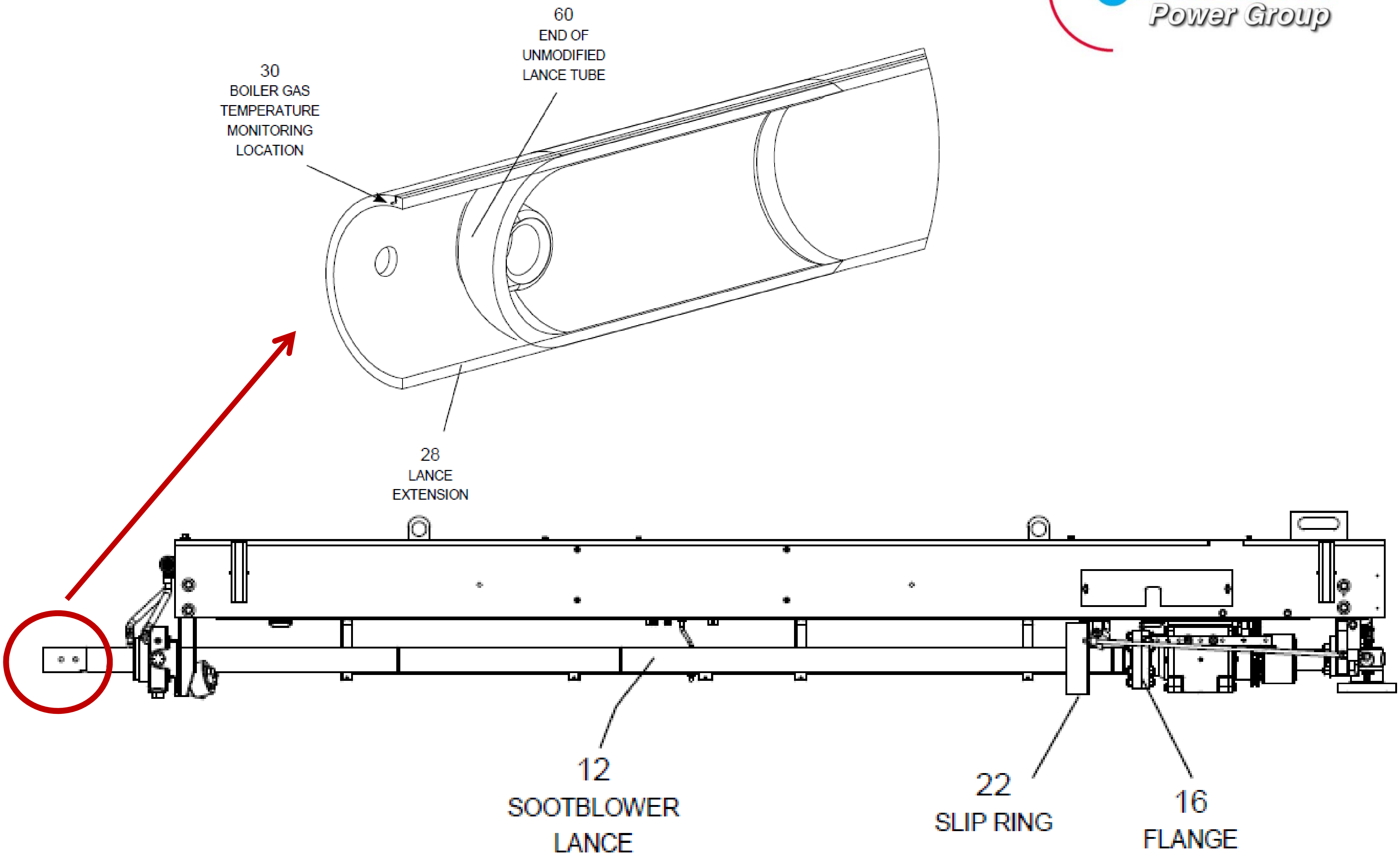
Deposit Accumulation Trend – Strain Gauge



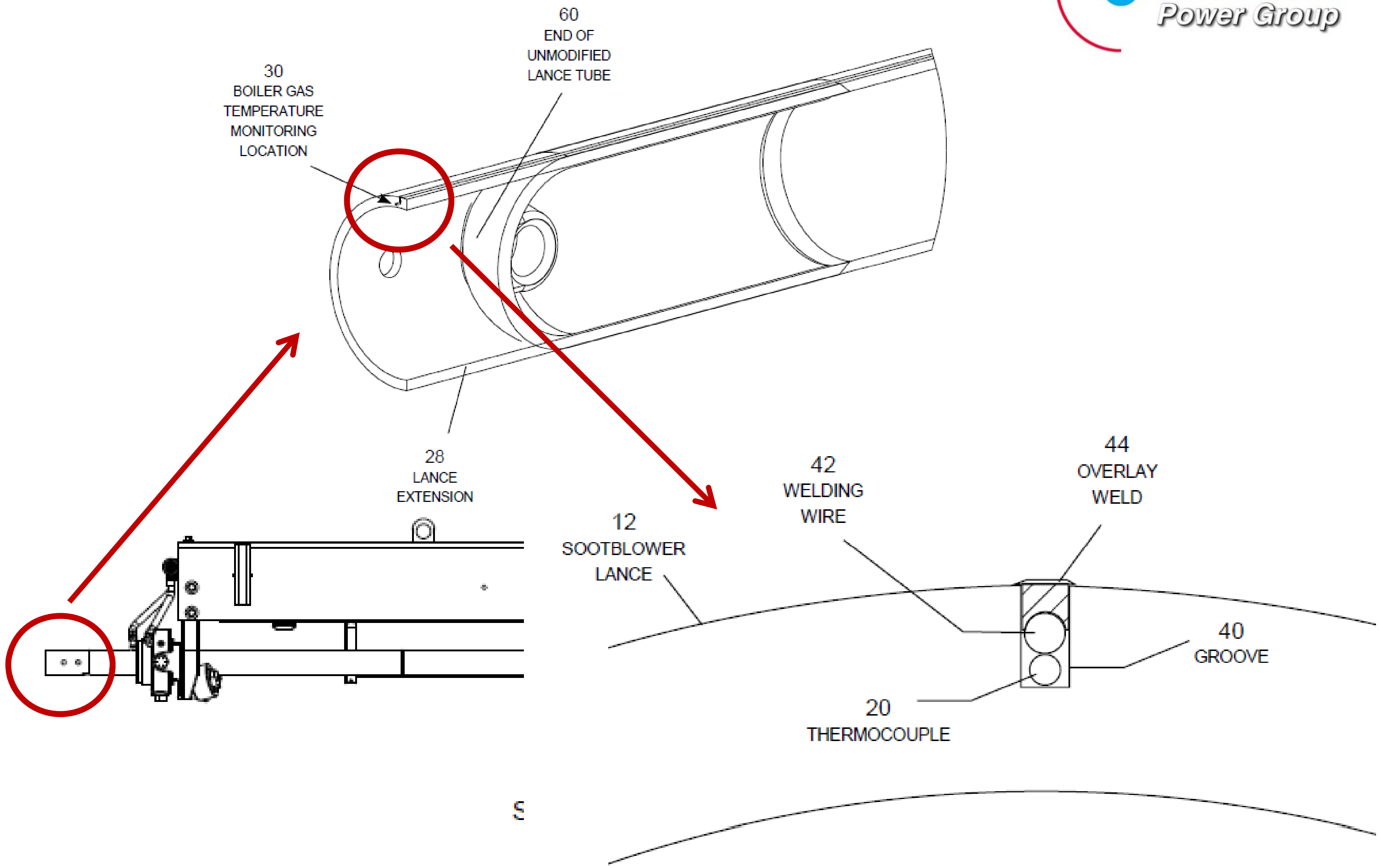
Outline

- Low Pressure Sootblower Technology
- Sootblower Equipped with Gas Temperature Measurements
- Recovery Boiler Water Wash System
    - ➔ Shower cleaning system

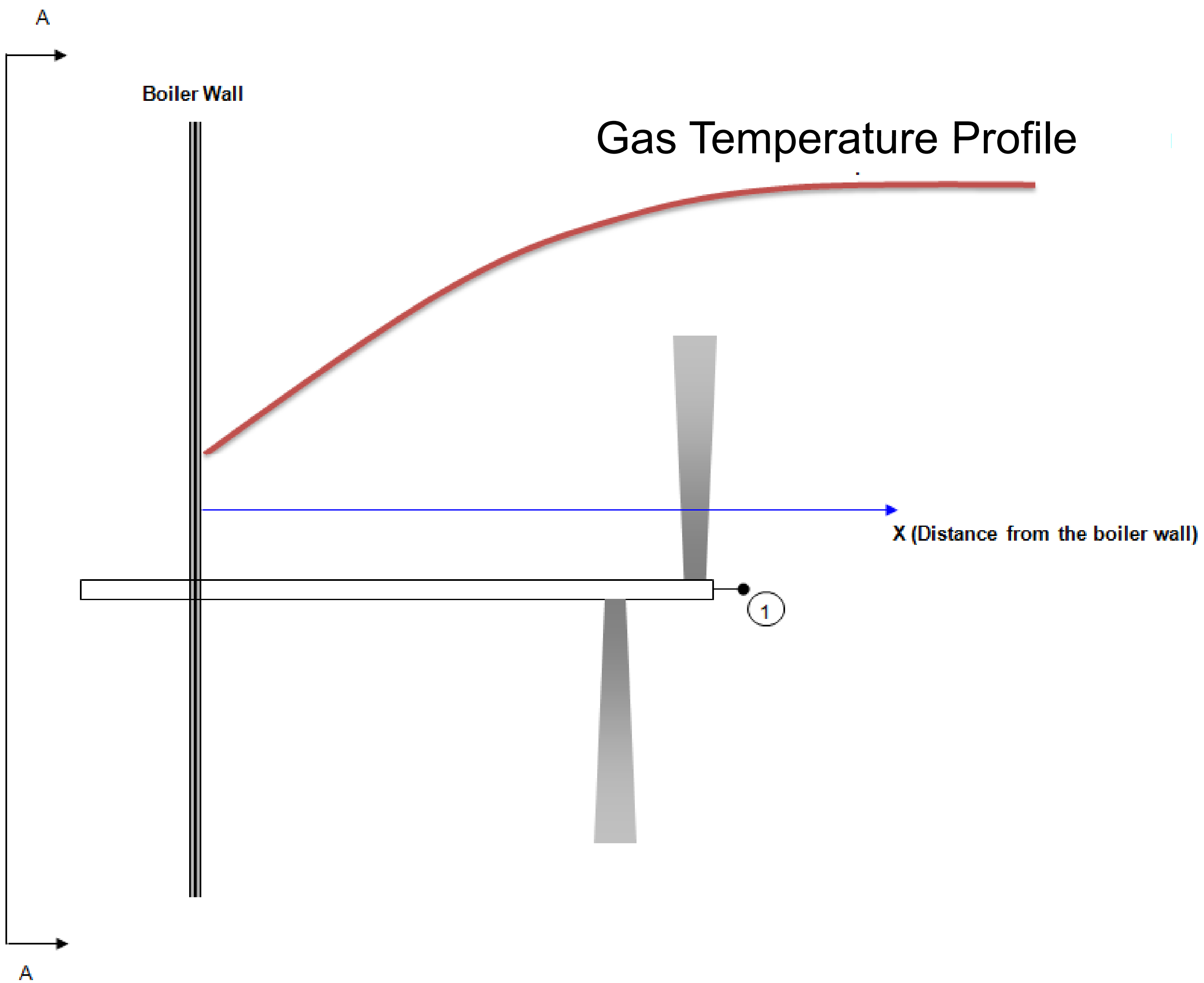
Sootblower with Gas Temp Sensors



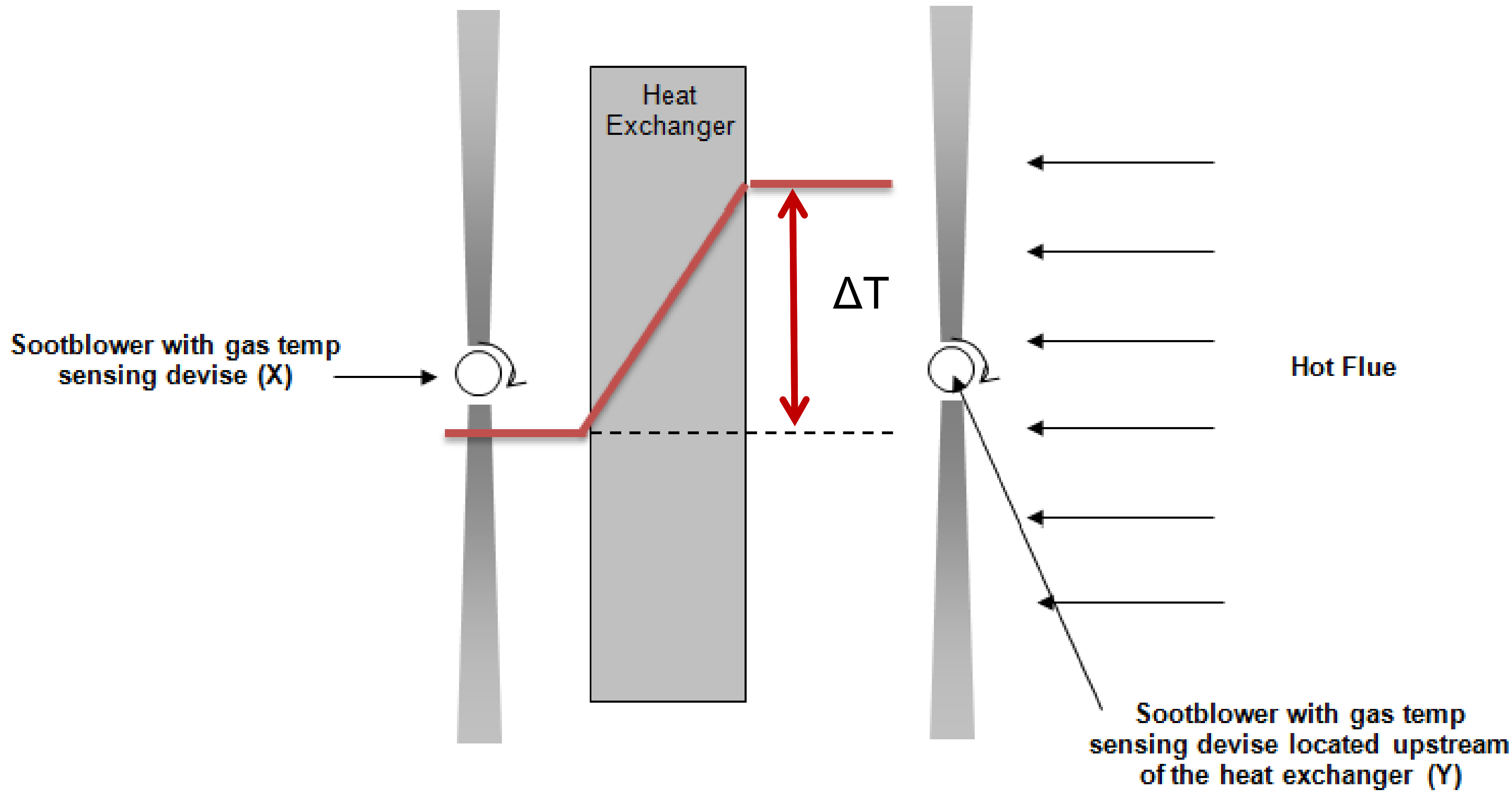
Sootblower with Gas Temp Sensors



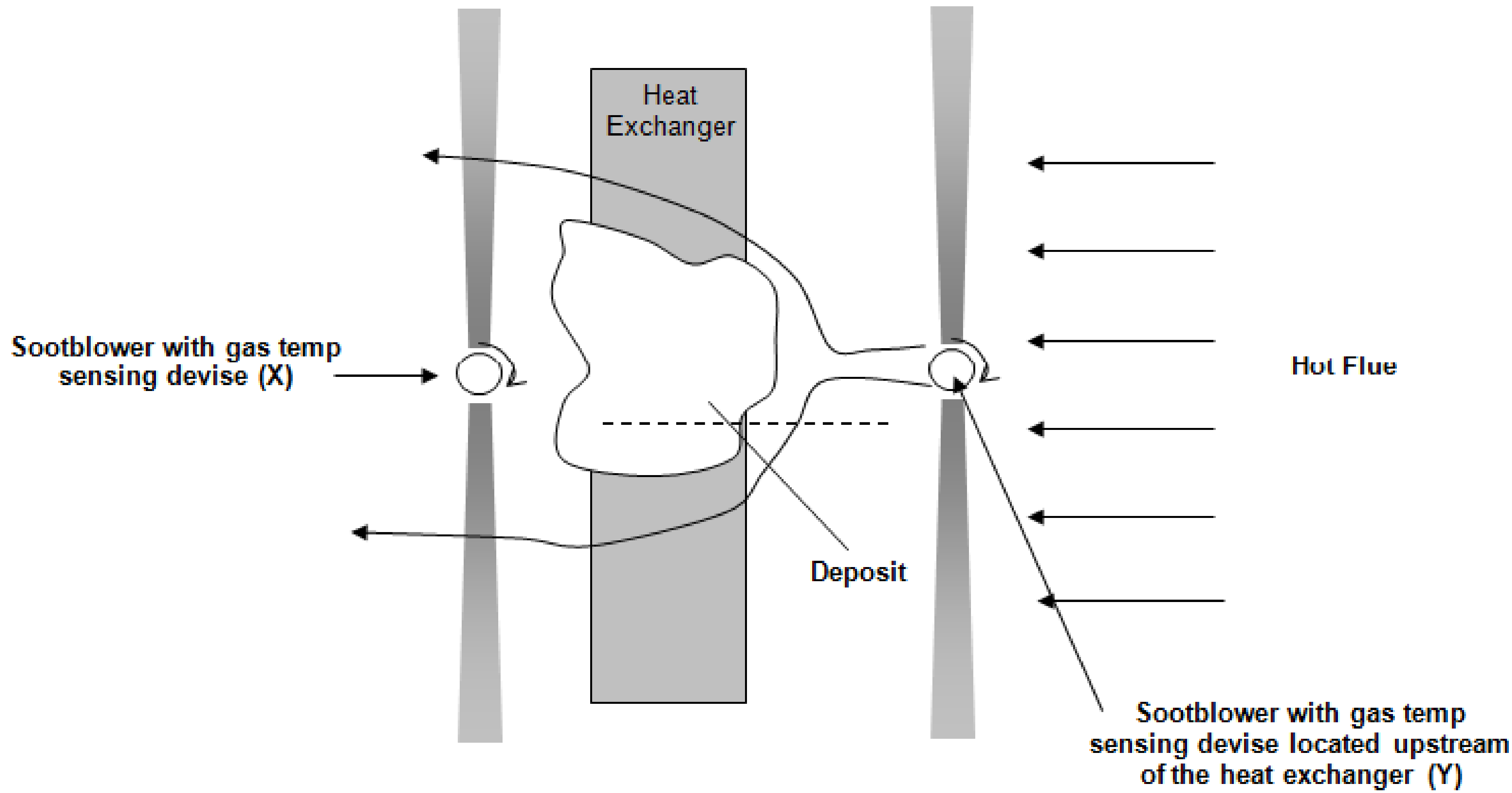
Gas Temperature Profile



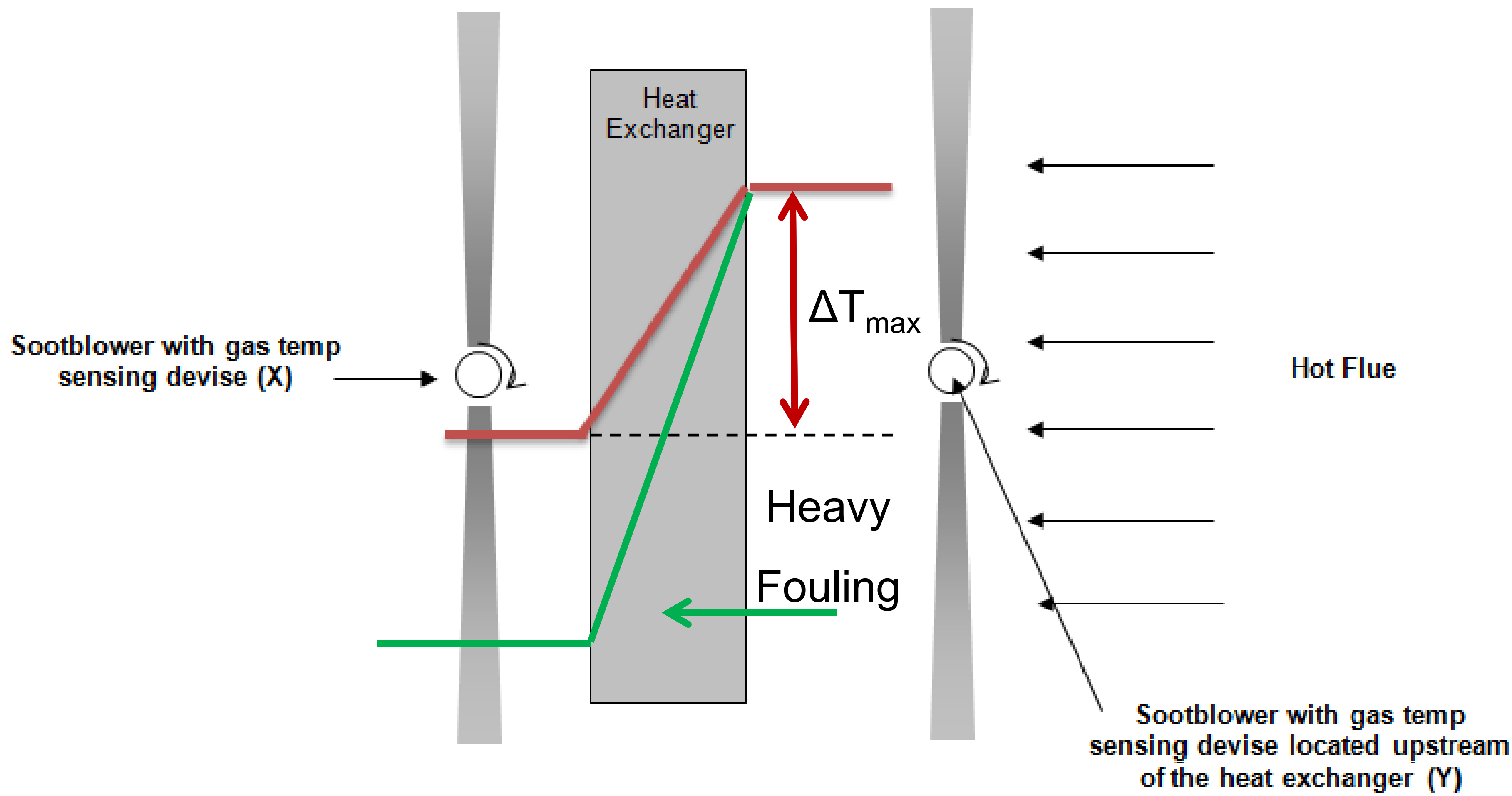
Generally, large ΔT = good heat transfer



But … Large ΔT may not = Good heat



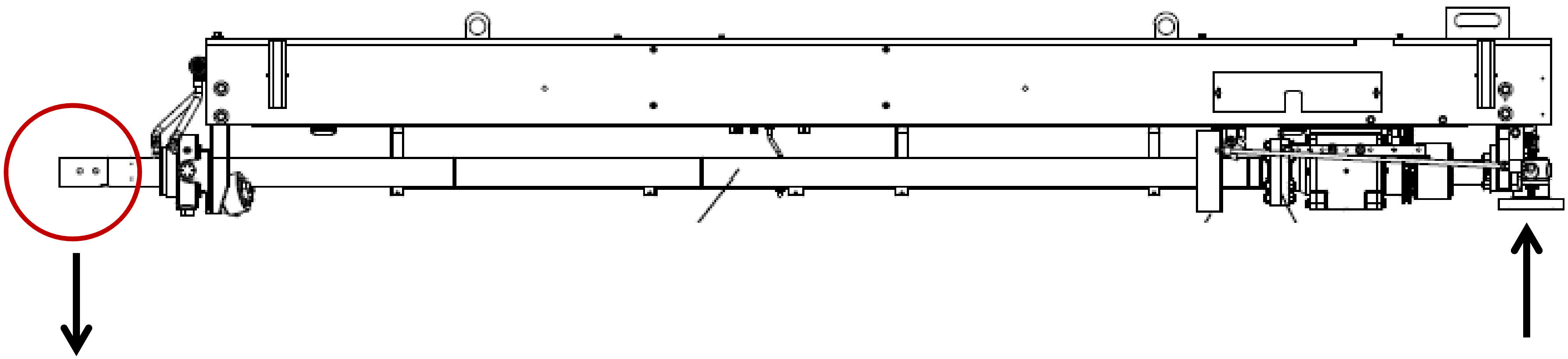
Identify ΔT_{max} , Greater than this = heavy fouling



Outline

- Low Pressure Sootblower Technology
- Sootblower Equipped with Gas Temperature Measurements
- Recovery Boiler Water Wash System
    - ➔Shower Cleaning System

Typical Water Wash



500 – 600 GPM

114 – 136 m^3/hr

200 – 300 psig (13 – 21 bar g)

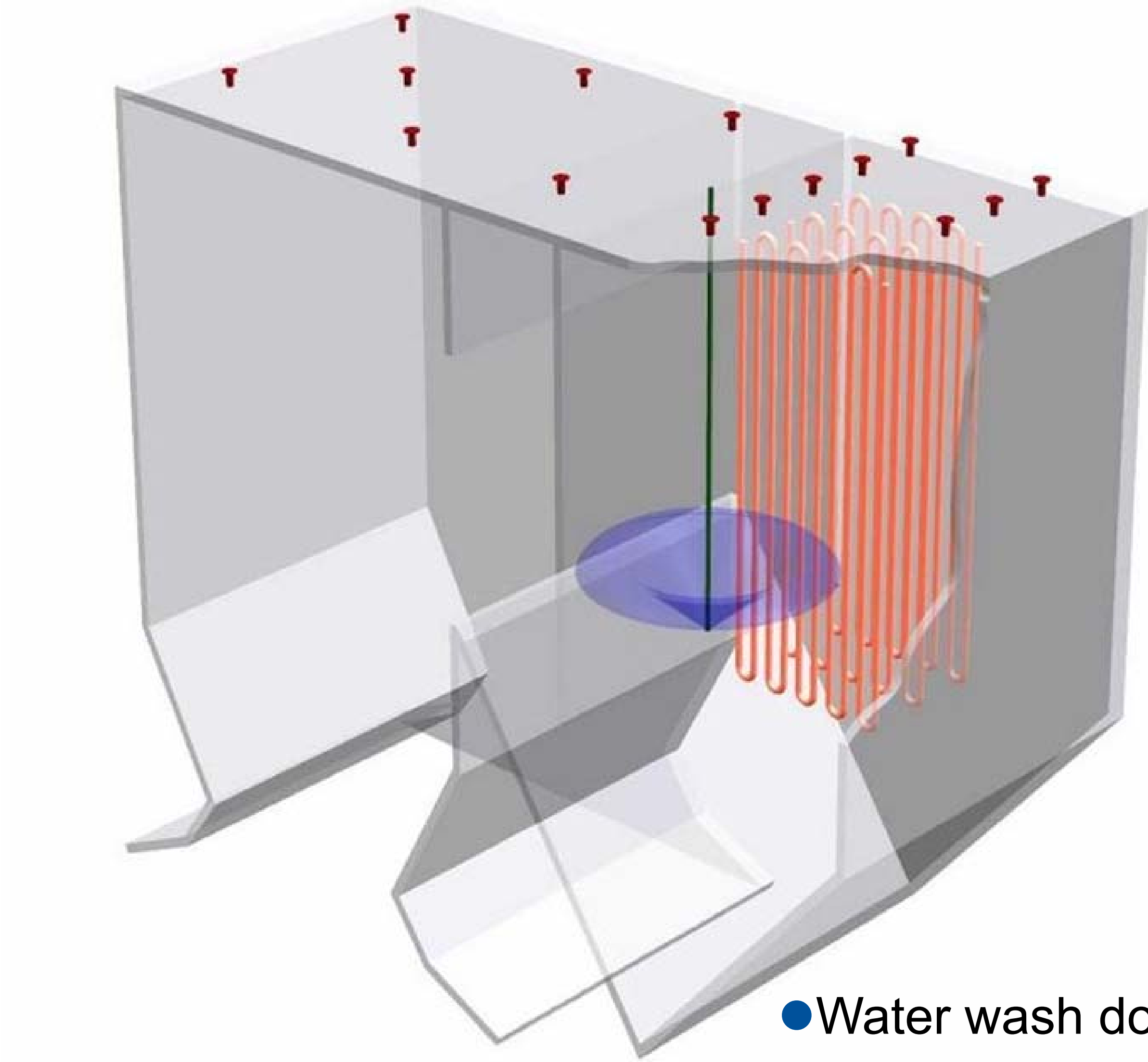
Water Pressure

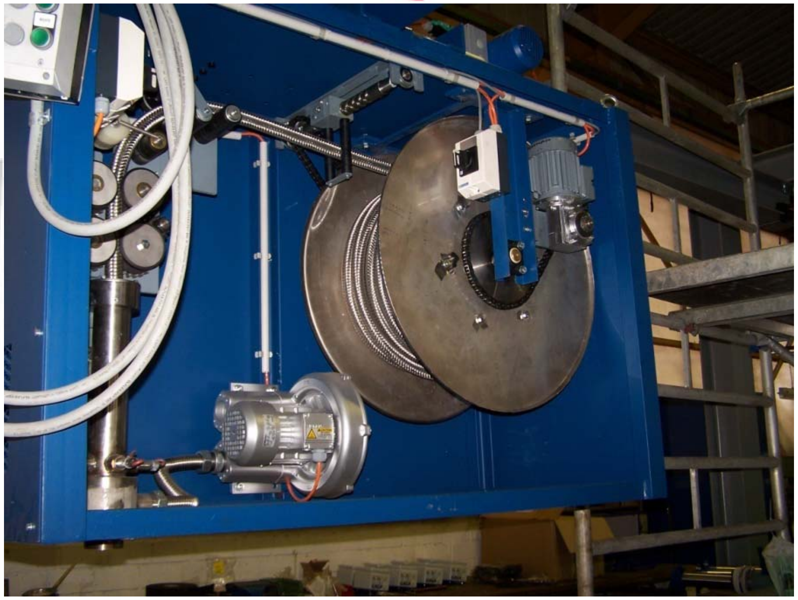
One sootblower is typically parked inside the boiler to prevent water hammer

Total water consumption = 1,000 – 1200 GPM (227 – 273 m^3/hr)

- Shorten the life of the packing
- Damage feed tube

Recovery Boiler Water Wash System

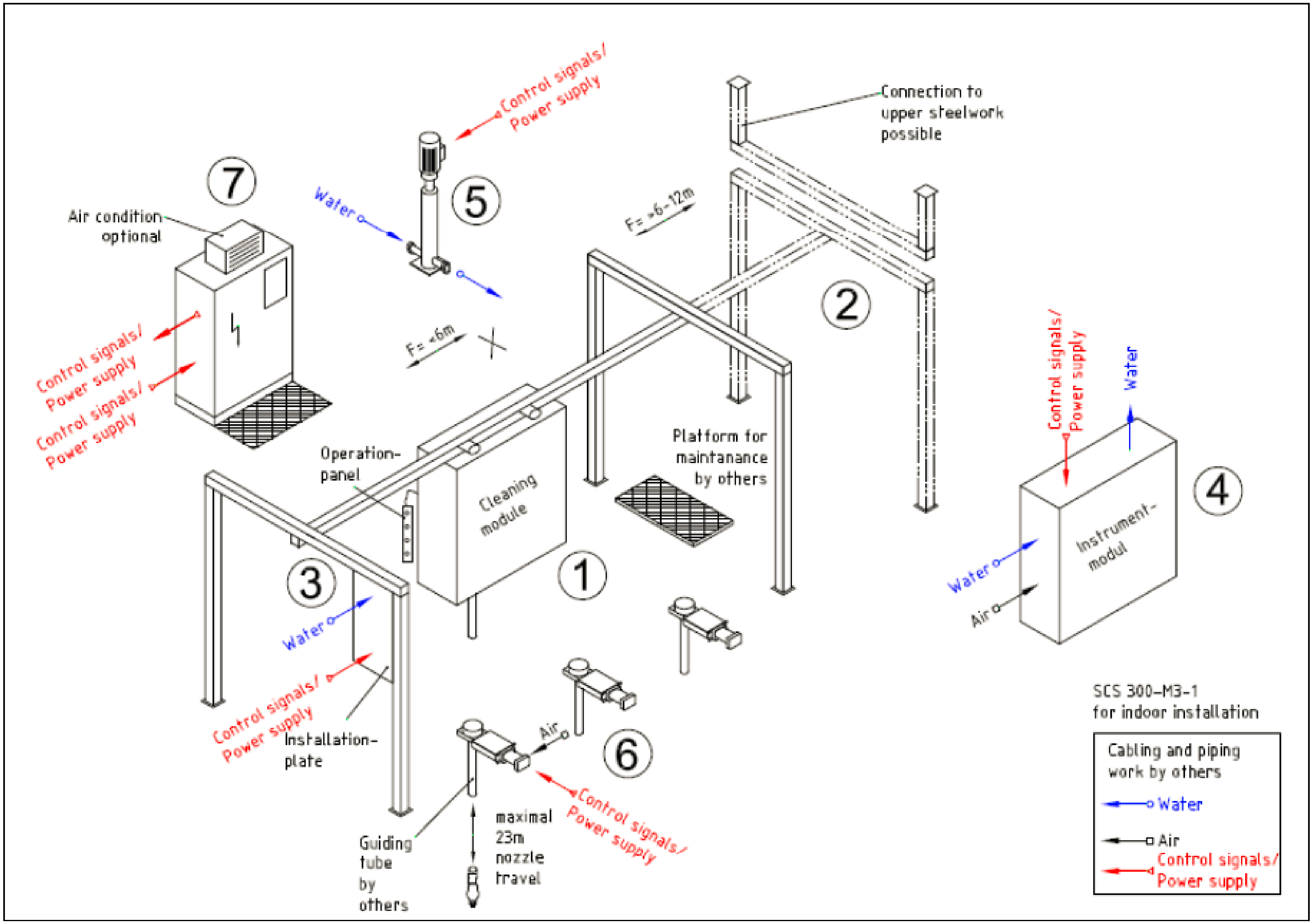




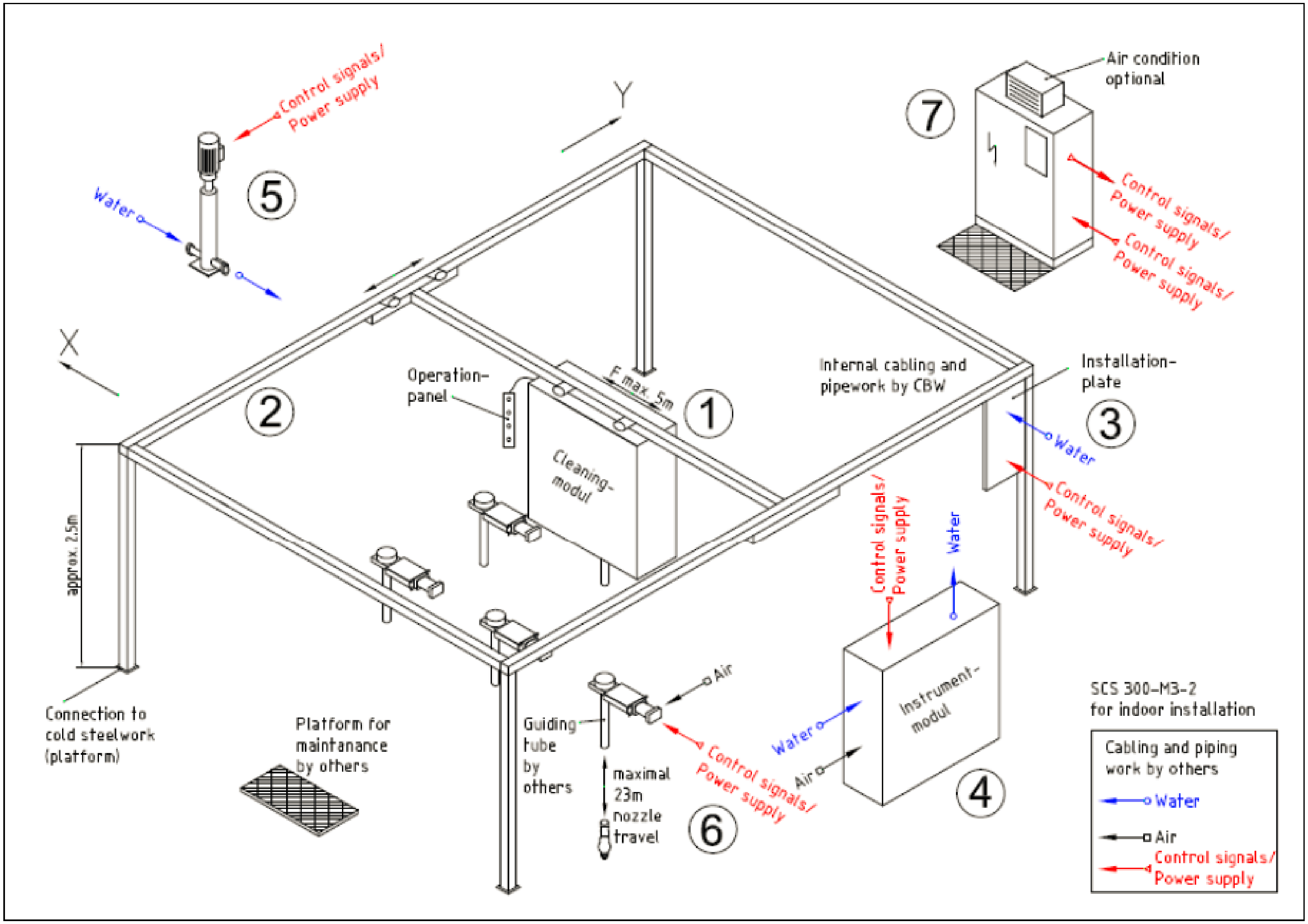
Shower Cleaning System

- Water wash does not require high cleaning force
- Water temperature is the key

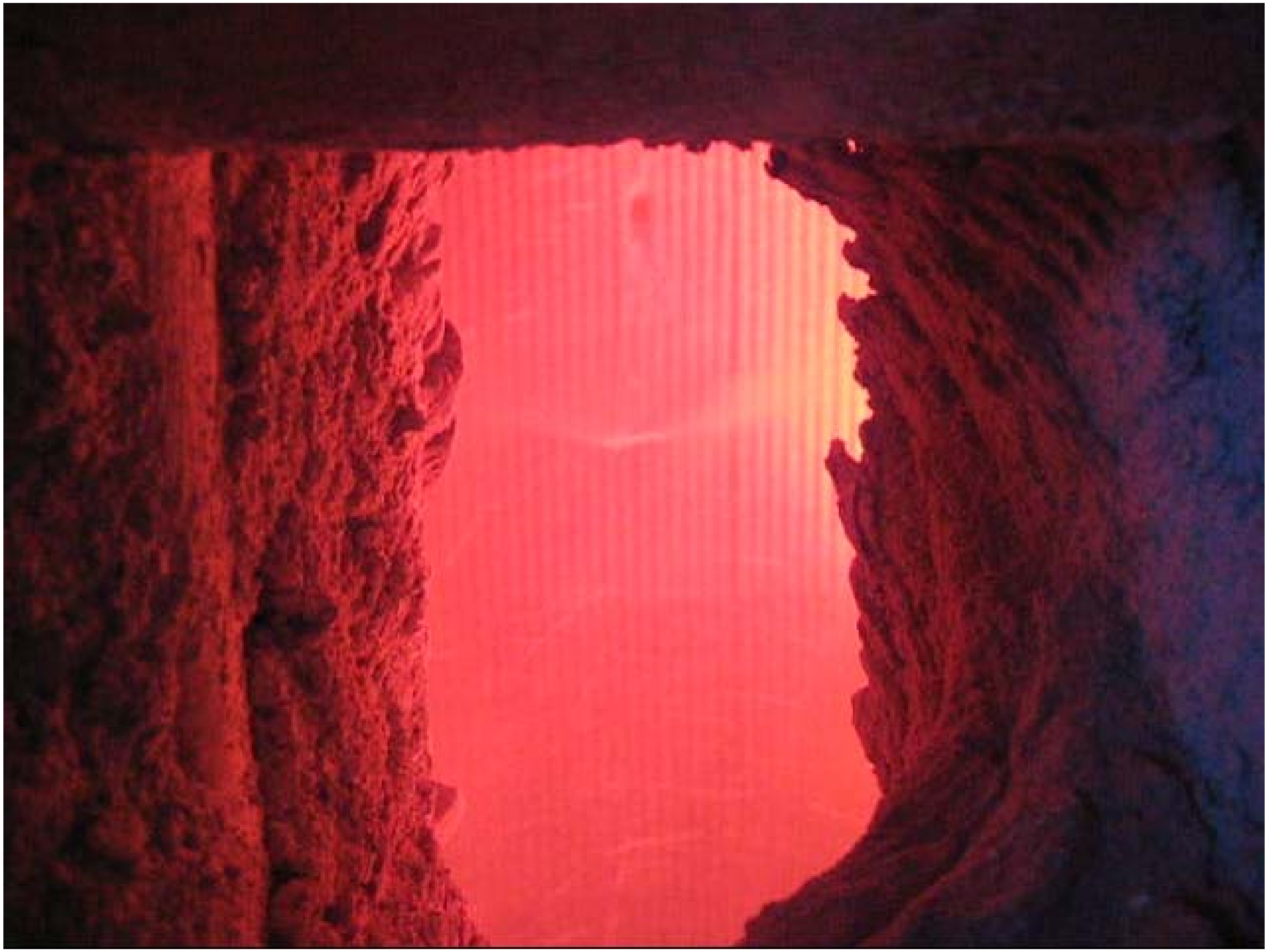
Recovery Boiler Water Wash System



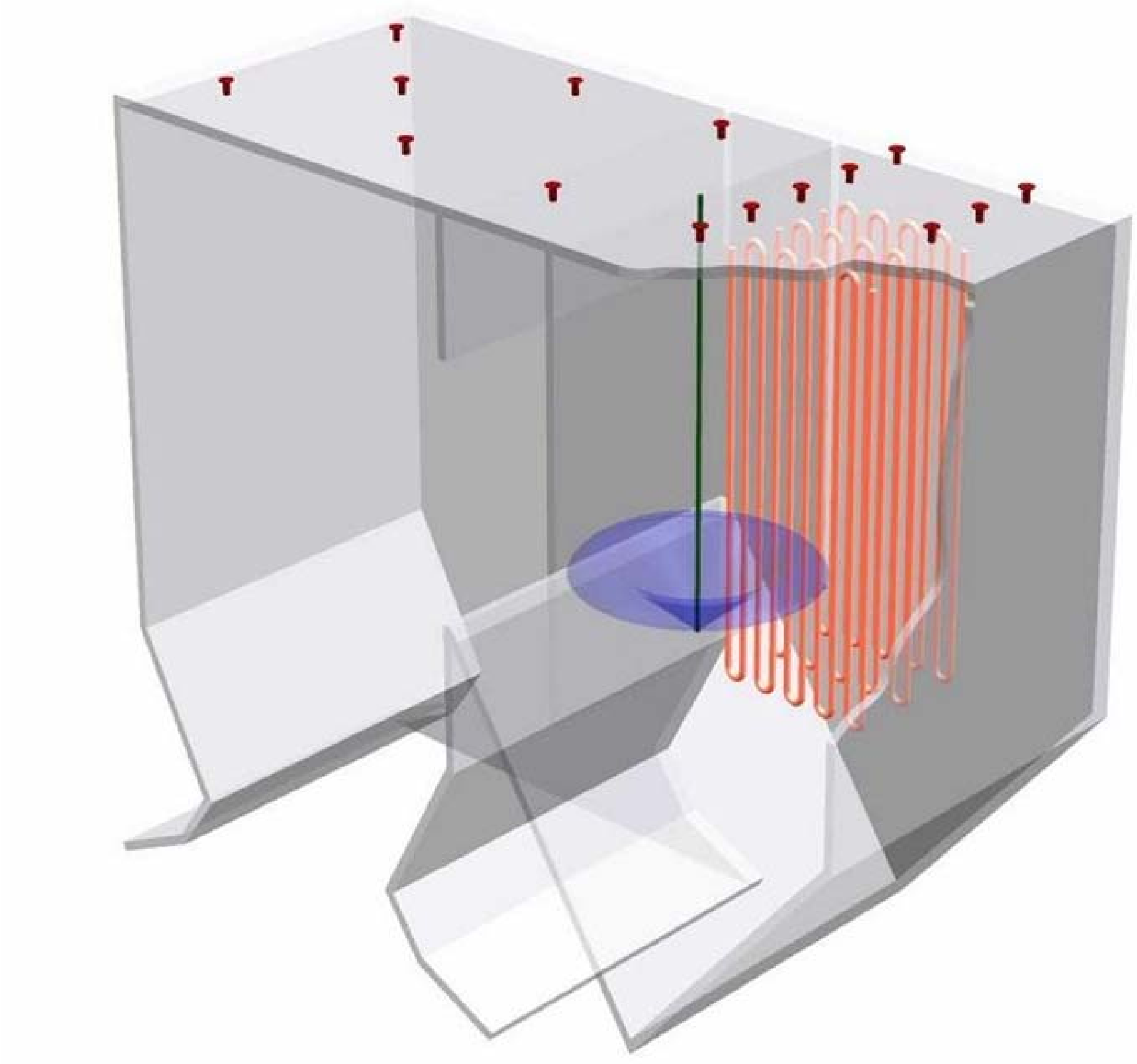
Recovery Boiler Water Wash System



Recovery Boiler Water Wash System



Recovery Boiler Water Wash System



150 psig, 13 - 27 GPM

C.f. regular sootblower

1,000 – 1200 GPM

Outline

- Low Pressure Sootblower Technology
- Sootblower Equipped with Gas Temperature Measurements
- Recovery Boiler Water Wash System

CLYDE BERGEMANN

Power Group

www.cbpg.com

Creating Value With Infrasound

Presentation to AF&PA Recovery Boiler Program

By Monica Finnegan of INFRAFONE in partnership with Goltens

Who we are

- Our business idea is to help our customers to increase the efficiency, availability and lifetime of industrial boilers through the optimization of soot cleaning
- By harnessing the power of infrasound we offer soot cleaning solutions that create value through unique knowledge and experience. With more than 1000 installations worldwide, we are experts in “creating value with infrasound”
- We have been working in the field of Infrasound since 1978 and our headquarters are in Stockholm, Sweden

Recent History

- Renewed focus on the Paper industry
- Renewed focus on Biomass boilers
- Renewed focus on the Waste to Energy market
- Emphasis on improved project management and keeping the customer at the center of everything we do
- Continued success in the marine and land side of the business in tandem with our partners Goltens

Our Applications

- Ducts
- Goose necks
- Electrostatic precipitators
- Economizers
- Catalysts
- Air pre-heaters

Fuels suitable for Infrafone

- Black liquor
- Bio-fuels (wood chips,peat, bark, pellets, demolition waste, shells (sunflower, cotton seeds, grain shells)
- Waste (industrial, MSW)
- Coal
- Oil, FCC-process
- Diesel

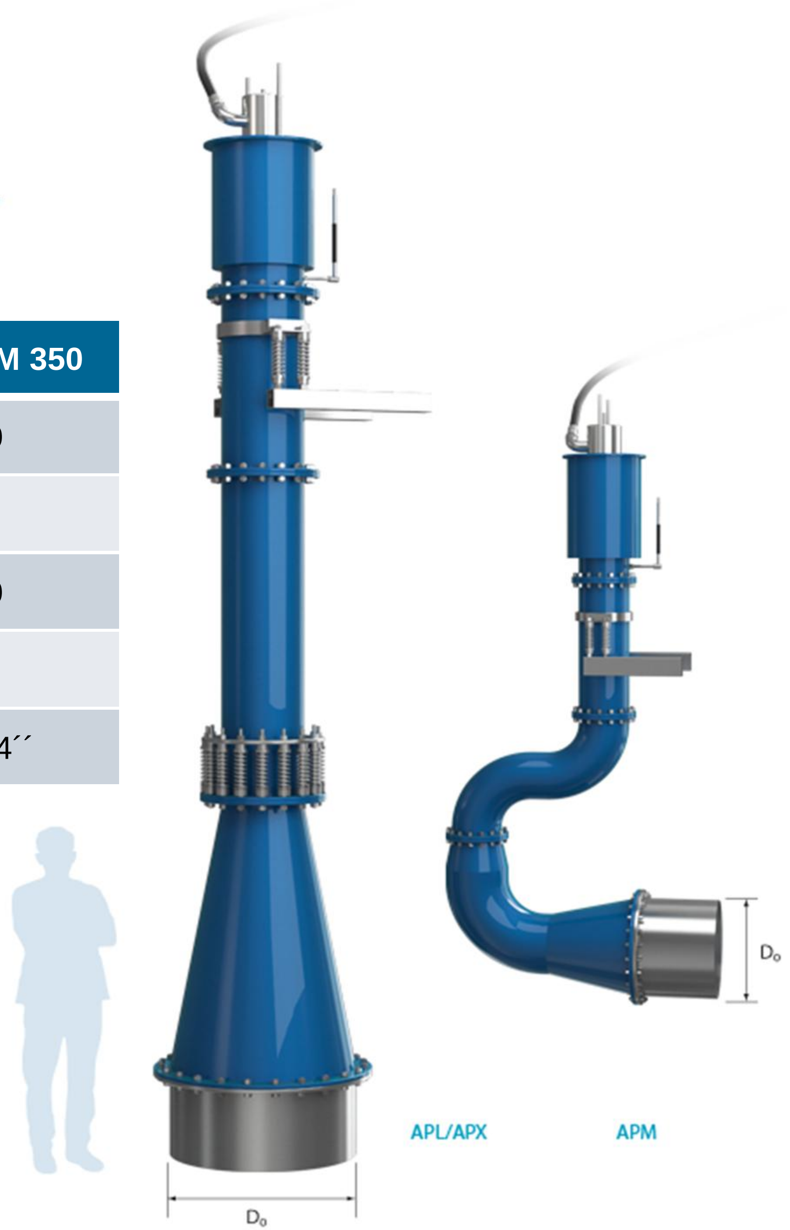
BLRB Challenges

- Build up of soot in goose neck ducts or inlet vanes which leads to the ID or FD fans working harder- using up precious energy
- Restricted air flows due to build up of soot on screens which leads to increased emissions/opacity and less than optimal operation of the ESP
- Blockages of ducts where it is not physically possible to install a steam soot blower
- Build up of soot in convection ducts
- Build up of soot leading to shut down for manual cleaning which adversely effects production

Customized Product

Size	APM 15	APM 70	APM 150	APM 350
Acoustic Power (W)	15	70	150	350
Frequency (Hz)	16-32			
Weight (lbs)	330	385	495	770
Height, H (m)	8´1´´-14´9´´			
Ø D_o	11´´	12.5´´	16´´	20.4´´

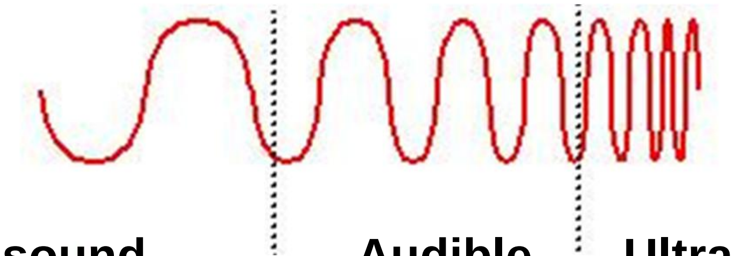
Size	APL 1000	APX 2000	APX 5000
Acoustic Power (W)	1000	2000	5000
Frequency (Hz)	16-32		
Weight (lbs)	1320	2200	2860
Height, H (m)	11´6´´-18´	13´-21´4´´	
Ø D_o	28.6´´	35.4´´	58.8´´



Goltens

INFRAFONE

Our technology, infrasound



Infrasound (low frequencies) | **Audible frequencies** | **Ultrasound (high frequencies)**

• The technology is based on the energy of the infrasound (frequencies under 30 Hz)

• The infrasound waves create a turbulence in the gasflow that prevents the soot deposits

• The key to a successsful installation is in the mathematical models that we use in order to model the behaviour of the acoustic waves inside the boiler

Infrafone Key to Success

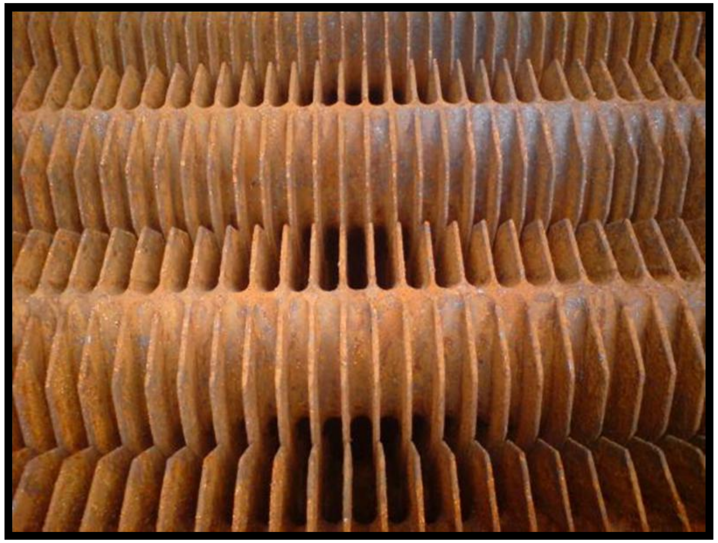
- Our expertise and knowledge, the key to success

•Dimensions, gasflow and exhaust gas temperatures of the boiler

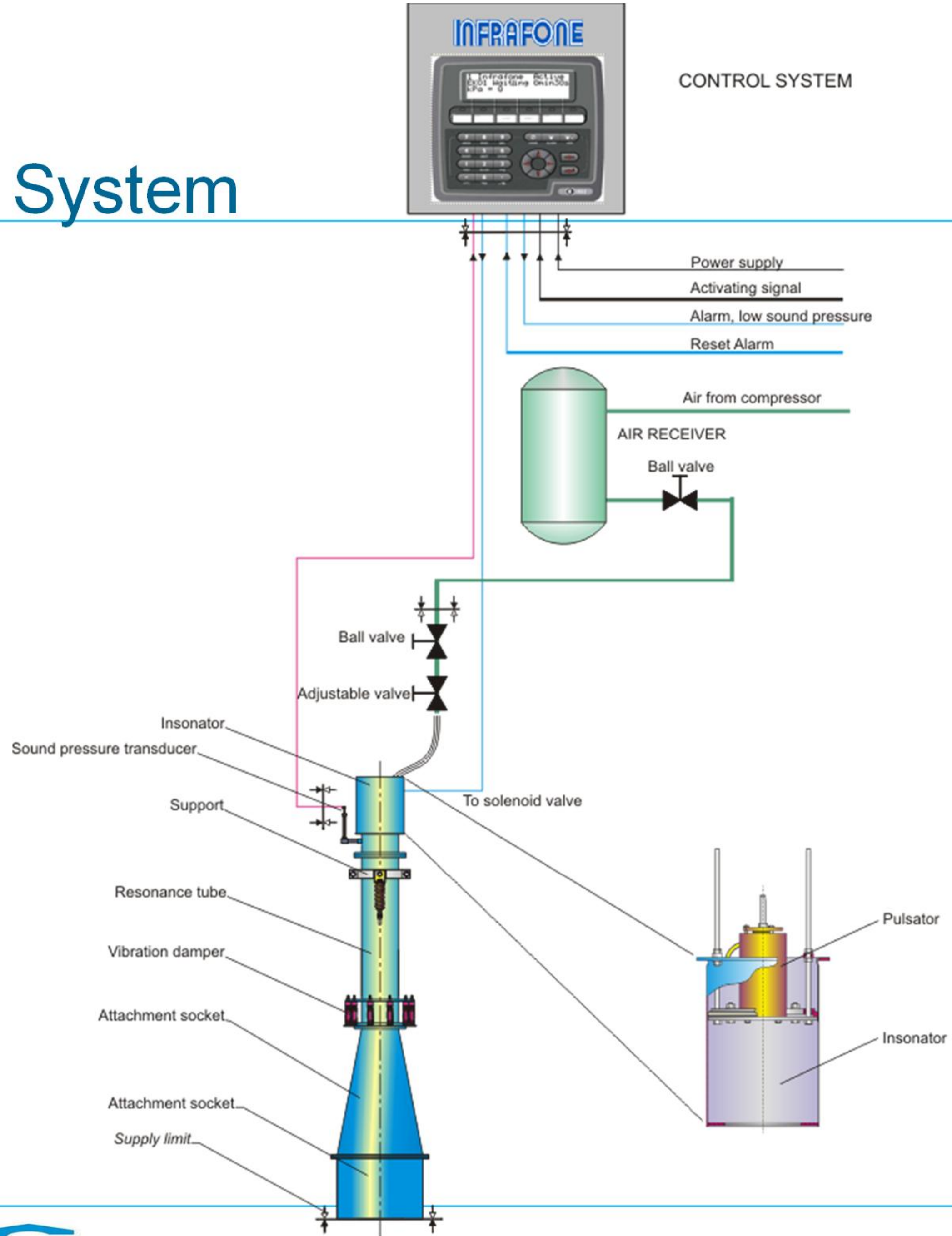
•Modeling of the boiler
•Modeling of the infrasound behaviour in the boiler ,sound pressure and particle velocity

•Size
•Frequency
•Location
of the sonic cleaner in order to maximise the cleaning effect in the desired area e.g. Inlet ducts, ESP, economizers etc.

Infrafone effect



Infrafone System



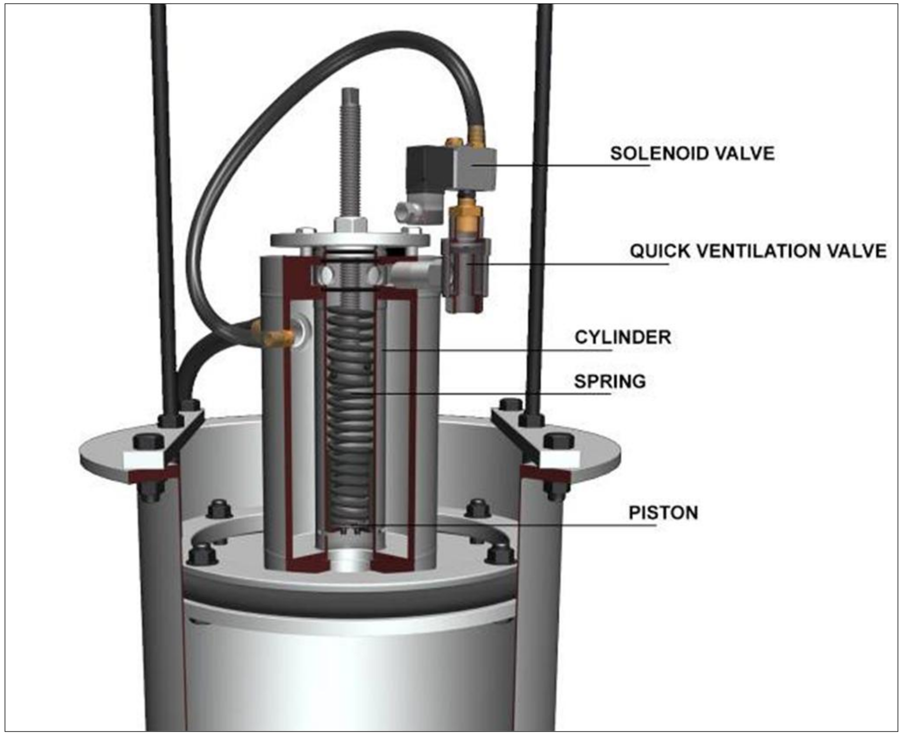
Goltens

INFRAFONE

Infrafone Reliability

- Key to mechanical reliability, high power and low compressed air consumption: The pulsator

[Infrafone sonic cleaner animation]



Case Study: RockTenn, Stevenson, Alabama, USA

Installation specification	
Type of plant	Paper pulp, corrugated paper/ Andritz boiler
Fuel	Black liquor
Capacity	649 metric tones /day
Particulate	Sodium Sulphite, pH 3,6
Areas to be kept clean	Gooseneck of the ESP
Commissioning date	APX2000 April 2006

Case Study: RockTenn, Stevenson, Alabama, USA

- Challenge description

- Severe obstruction problems due to low pH of the particulate:
  - Outage each 6th or 7th day to clean the gooseneck between the economizer and the ESP
  - Stoppage of the first field of the ESP during 24 hours each 2nd or 3rd day due to excessive spark rate. Failure of the second and third field due to the stoppage of the first one
- Boiler availability below 85%
- Boiler production capacity limited due to the low performance of the ESP (24 500 kg DS/h)

Case Study: RockTenn, Stevenson, Alabama, USA

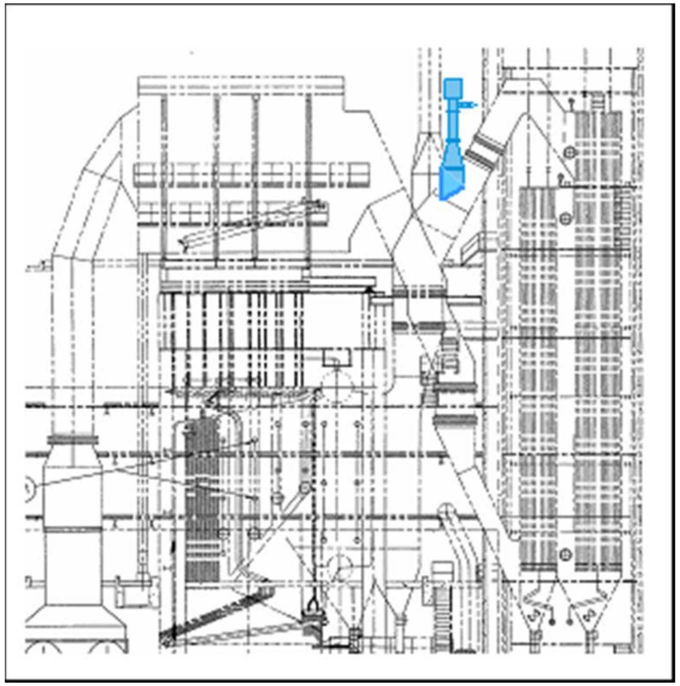
- Results after installing an Infrafone APX2000

- Large reduction of the accumulation and obstruction problems
- The five fields of the ESP are kept constantly at a constant voltage rate
- Increased boiler efficiency from 24 500 kg DS/h to 28 100 kg DS/h
- Compliance with the environmental regulation when it comes to emissions (permitted level 0,036 #/MMBTU, level after the installation of Infrafone 0,008 #/MMBTU)
- 80-90% reduction of the outages to clean the goose neck
- Currently the ESP stops range from once a month to once every 3 months

Case Study BLRB

Korsnäs, Frövi, Sweden

Installation specifications	
Type of plant	Paper pulp/ Kvaerner boiler
Fuel	Black liquor
Capacity	2,130 metric tones DS/day
Particulate	Sodium sulphate, pH 10,5-11,5
Areas to keep clean	Duct between the generating bank and the economizer.
Commissioning date	APX 2000 February 2007



Infrafone Case Study

Korsnäs, Frövi, Sweden

The challenges

- Boiler production capacity limited due to soot build-up in the duct between the generation bank and the economizer
- Corrosion of the duct due to the use of water and steam for cleaning Frequent replacement of the damaged areas (complete change of duct in 2003)
- Increase of Δp across the duct, making the ID fan work at its capacity limit

Prior to Infrafone's installation the duct was kept clean using the following methods:

- Four steam soot blowers
- On-line manual waterwashing 1-2 times/day
- Off-line waterwashing through the soot blowers noozles every 6 weeks

Infrafone Case Study

Korsnäs, Frövi, Sweden

Results after installing an Infrafone APX2000

•Elimination of the soot accumulation problem
•Elimination of the need of waterwashing, reducing the corrosion and the manpower needed for this task previously
•Reduction of the use of steam soot blowing, from 4 units to 2 units
•Low and stable Δp, leading to low and stable fan speed
•Direct impact on bottom line due to an increase in annual production

Our Solution

- We utilise the power of Infrasound to keep the ducts clean
- How do we do it-we model your boiler and then we model how the Infrasound will act inside it
- Based on this information we determine the number, size, location and the frequency of the Infrafone sonic cleaner

Expected Outcomes

- Confirmed cleaning effect as measured by boiler performance post installation-performance warranty
- Post installation confirmation of how the Infrasound is working within the boiler by taking sound measurements- these match the predictive modeling
- A satisfied customer

Creating Value through Infrasound

- What value do we offer our customers?
  - Reduced maintenance costs
    - Savings related to operation of soot blowing
    - Savings related to extending equipment lifetime
    - Savings related to reduced manual cleaning
  - Stable Δp, which means:
    - Less downtime, higher energy production
    - Less downtime, higher production of DS
    - Reduced electrical consumption of ID fan
  - Lower risk for high flue velocity in local areas
    - Reduction in level of opacity due to improved ESP function
    - Improved work environment, improved safety

Thank you for listening!

If you would like to know more, please contact us at monica.finnegan@infrafone.se or on +46736 544 687

Or

Vince Rodomista at vince.rodomista@goltens.com or on 13055764410

Chemical Recovery Boilers

Considerations for Gas Firing

February 8, 2012

Mark Wagner , Alstom Power Inc.

POWER | ALSTOM

Considerations for Gas Firing

Introduction

Natural gas currently inexpensive, preferred fuel

Economic and environmental benefits

Multiple aspects to consider when converting

Contracting and permitting to get started

Focus on boiler area hardware and engineering

Considerations for Gas Firing

Purpose and Boiler Load

Fuel Firing Equipment

Controls

Balance of Plant

Emissions

Performance Validation

Considerations for Gas Firing

ALSTOM

Purpose and Boiler Load

Fuel Firing Equipment

Controls

Balance of Plant

Emissions

Performance Validation

Considerations for Gas Firing

Purpose and Boiler Load

Bed ignition at start-up and stabilization

Bed burndown prior to boiler shutdown

Supplemental load carrying

Plant steam demand drives need for capacity

Considerations for Gas Firing

Purpose and Boiler Load

Thermal characteristics similar to black liquor

Convective rather than radiant energy transfer

Typical furnace is suitable for gas firing

Slight Btu increase required vs. oil

Furnace height, superheater and air flow review

Combustion volume and temperature control

Considerations for Gas Firing

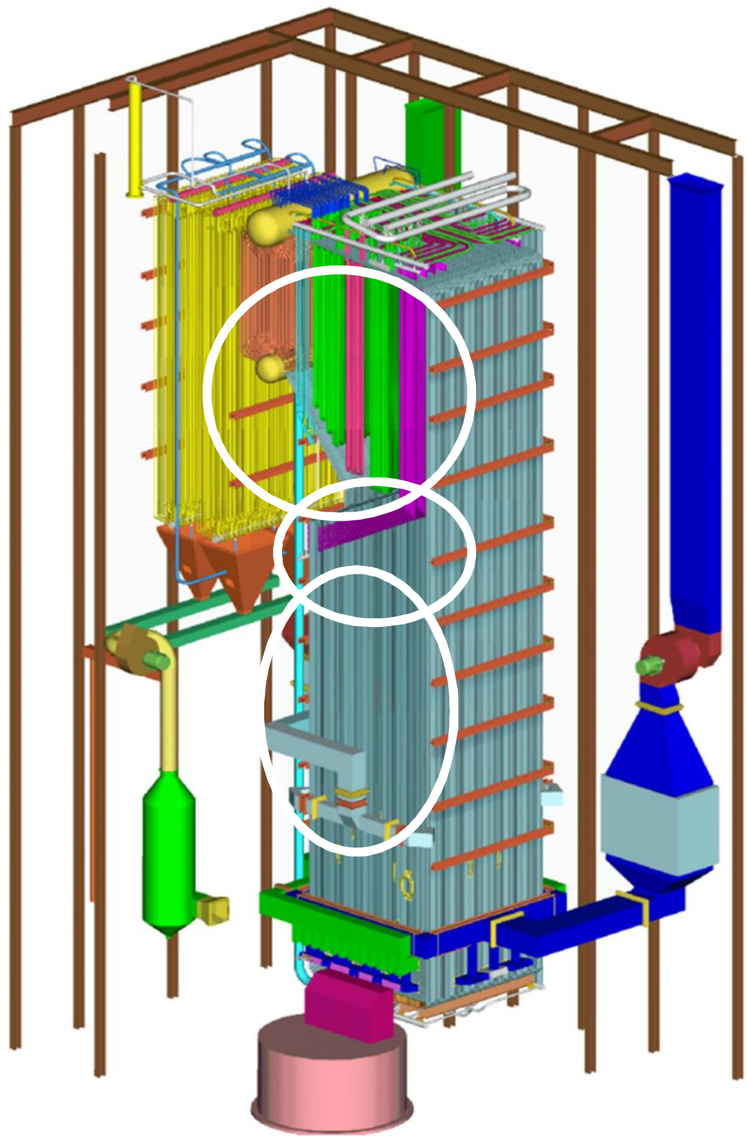
Boiler Modeling

Heat Transfer Effectiveness

Furnace Exit Gas Temperature

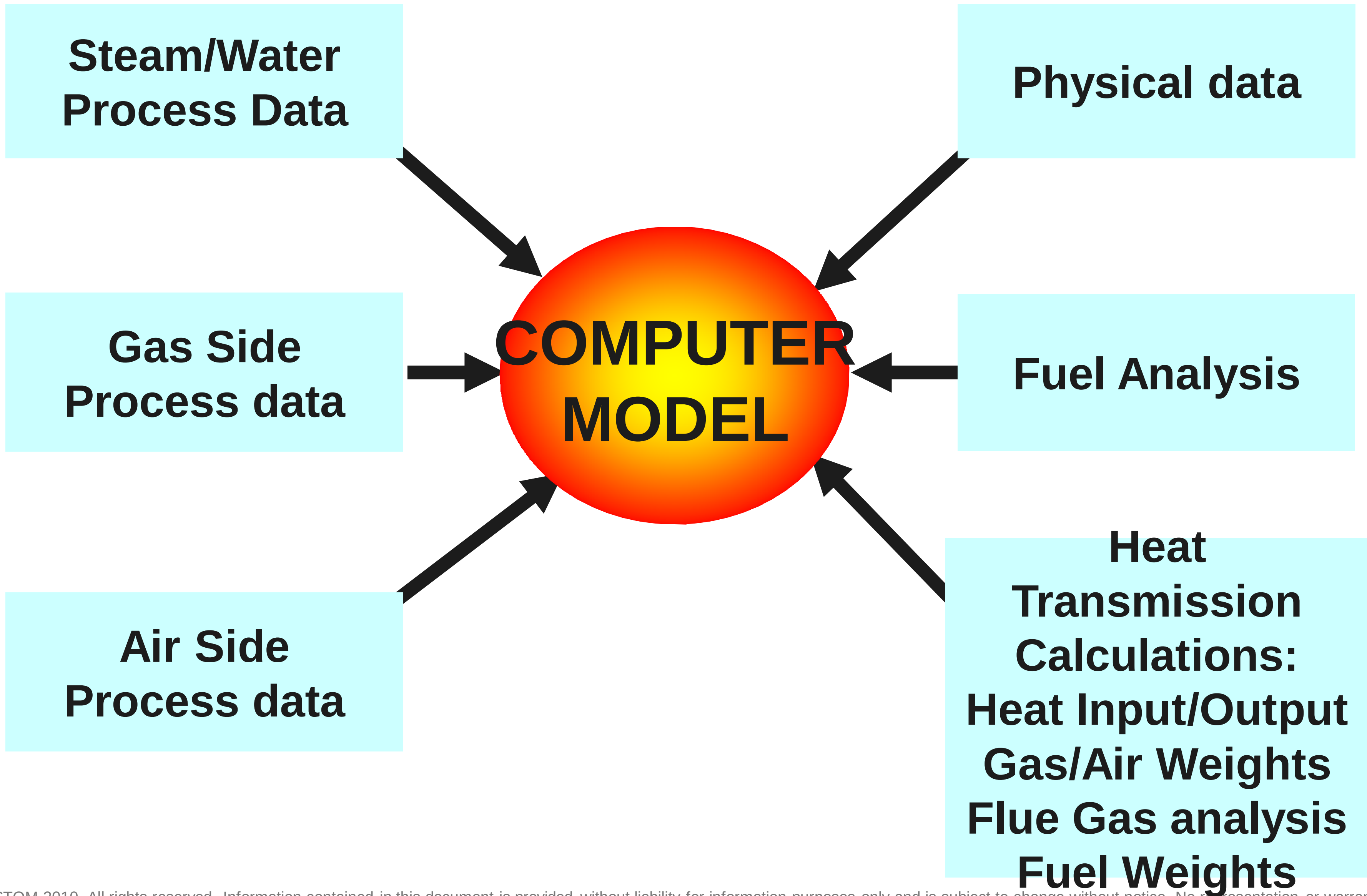
Combustion Volume

Heat Balance



Considerations for Gas Firing

Boiler Modeling



Considerations for Gas Firing

Purpose and Boiler Load

Fuel Firing Equipment

Controls

Balance of Plant

Emissions

Performance Validation

Considerations for Gas Firing

ALSTOM

Purpose and Boiler Load

Ignition system for start up and stabilization

Starting burners sized for bed management

Load burners sized for partial or full load

Dual fuel firing capability for flexibility

Considerations for Gas Firing

ALSTOM

Fuel Firing Equipment

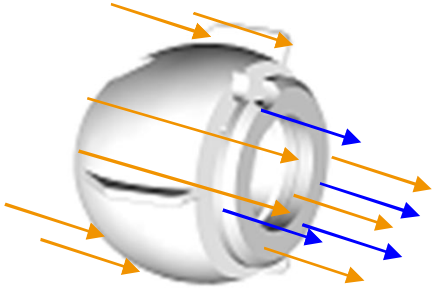
Bluff Body Gas Ignitor

Highly reliable with integral flame proving

Wide range of capacity – 1 to 18 MMBtu

Patented bluff body fuel/air mixing device

Bluff Body Flame Stabilizer

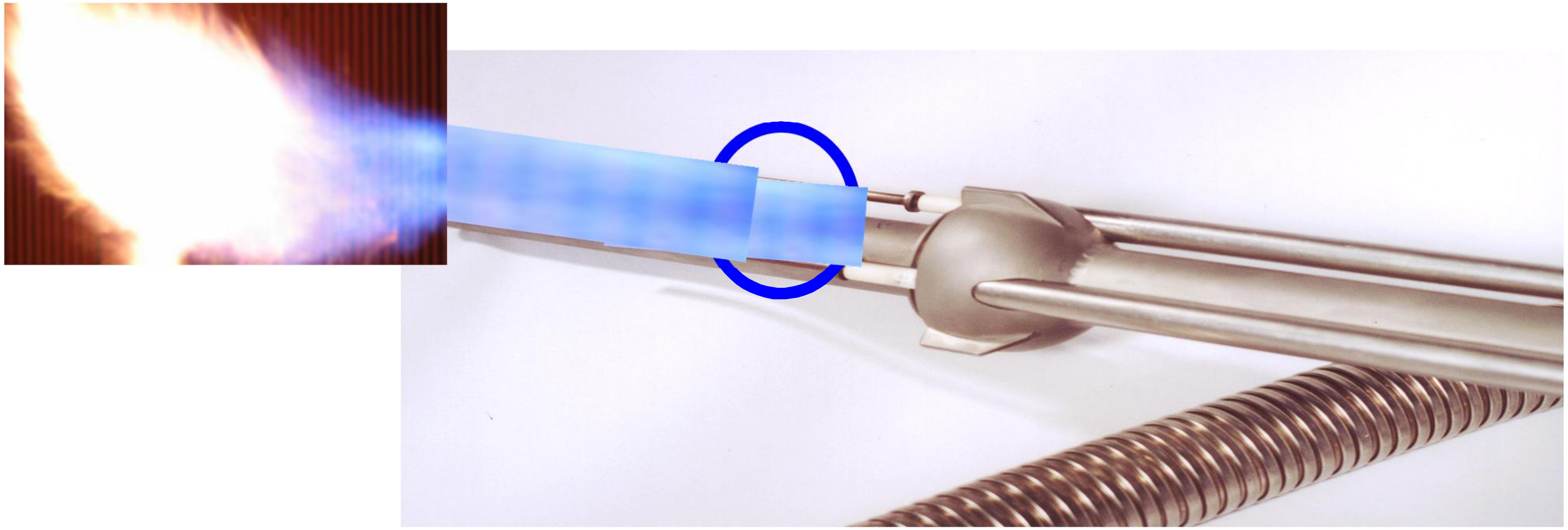


Bluff Body air movement provides turbulence

Aerodynamic flow for optimal fuel/air mixing

Optimized at the electrical spark for ignition

Superior pilot flame stability at root of flame



Considerations for Gas Firing

Ignitor in service with load burner

Considerations for Gas Firing

ALSTOM

Fuel Firing Equipment

Starting Burner

Simple technology for hearth bed management

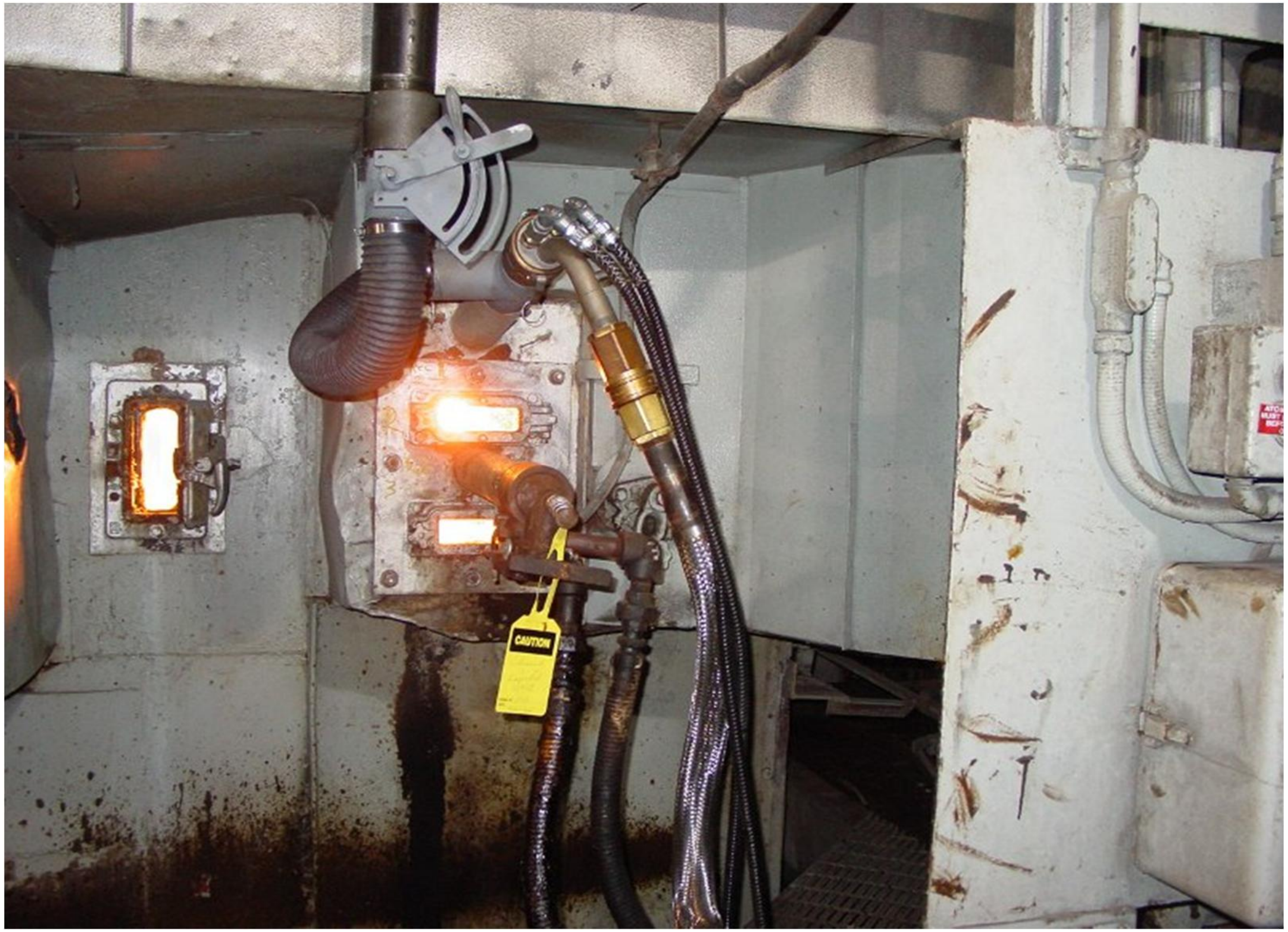
Limited capacity to avoid tube rupture

Typically 15-30 MMBtu firing rate

Available in oil/gas arrangement for flexibility

Considerations for Gas Firing

Starting Burner Assembly with Ignitor



Considerations for Gas Firing

ALSTOM

Fuel Firing Equipment

Load Burner

Sized for boiler load carrying capacity as needed

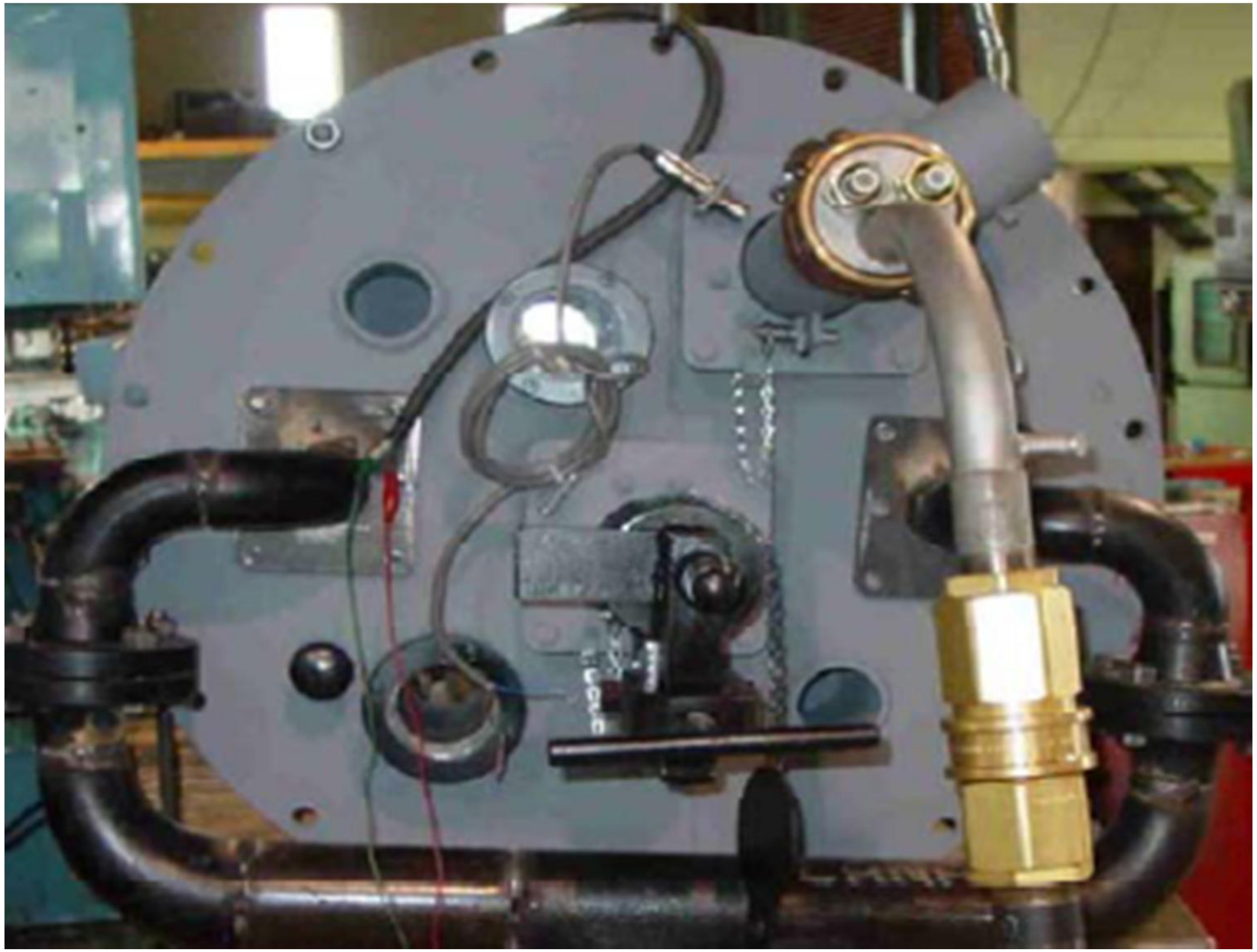
Wide range of capacity – 40 to 100 MMBtu

Extended turndown to vary heat input

Available with oil gun for fuel flexibility

Considerations for Gas Firing

Oil/Gas Load Burner with Ignitor



Considerations for Gas Firing

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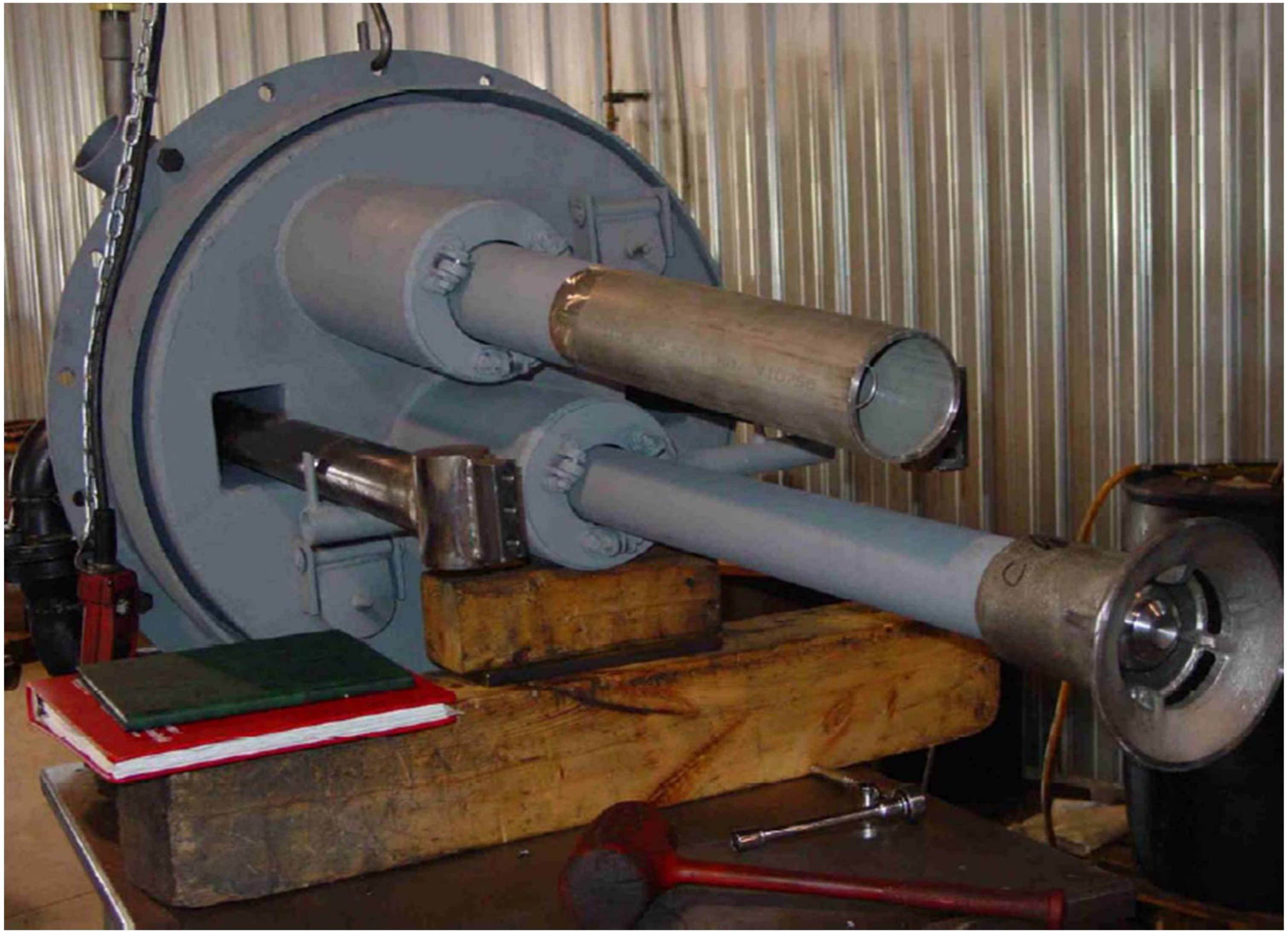
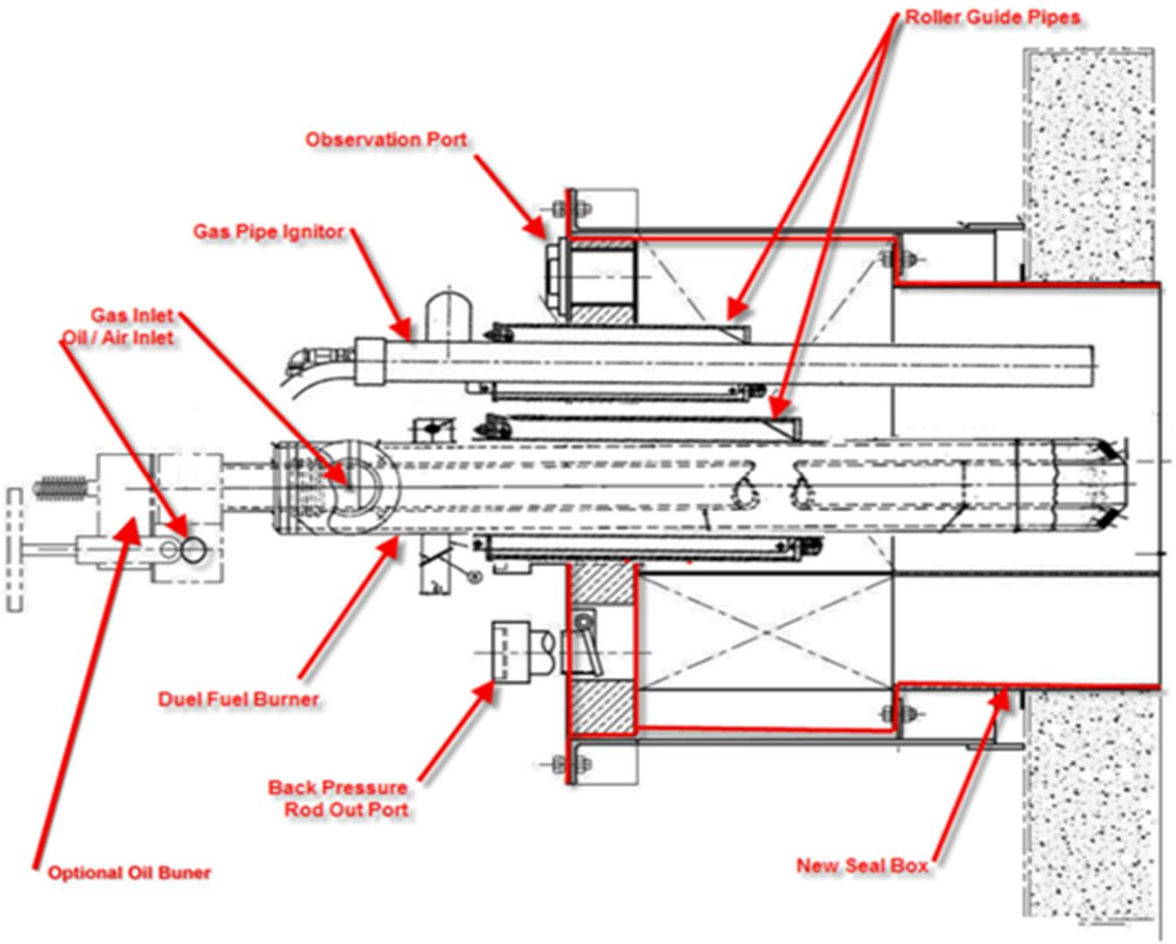
Oil/Gas Load Burner with Ignitor



Considerations for Gas Firing

Concentric Oil/Gas Load Burner with Ignitor



Considerations for Gas Firing

ALSTOM

Fuel Firing Equipment

Starting/Load Burner Operation and Maintenance

Supplied with Class 1 Ignitor (or flame scanner)

Convenient “roller” retract for removal of assembly

Protects equipment in harsh environment

Extend life and reduce maintenance

Considerations for Gas Firing

Purpose and Boiler Load

Fuel Firing Equipment

Controls

Balance of Plant

Emissions

Performance Validation

Considerations for Gas Firing

ALSTOM

Controls

Combustion Control for efficient operation

Burner Management for fuel firing safety

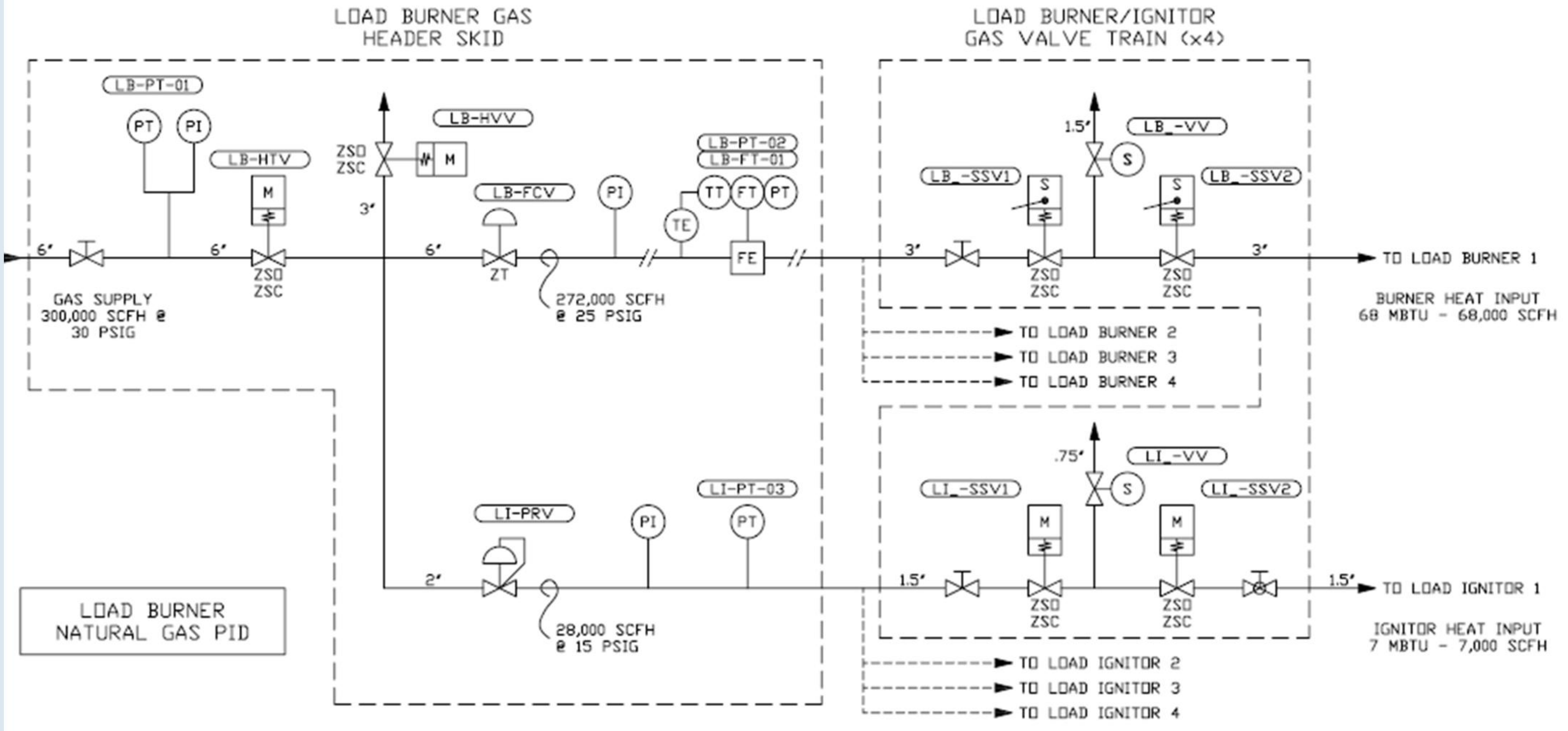
Primary sensors and end control devices

Operator interface for ease of use

Data management for analysis

Considerations for Gas Firing

Gas Burner/Ignitor P&ID



Considerations for Gas Firing

Controls

Fairly easy integration into combustion controls

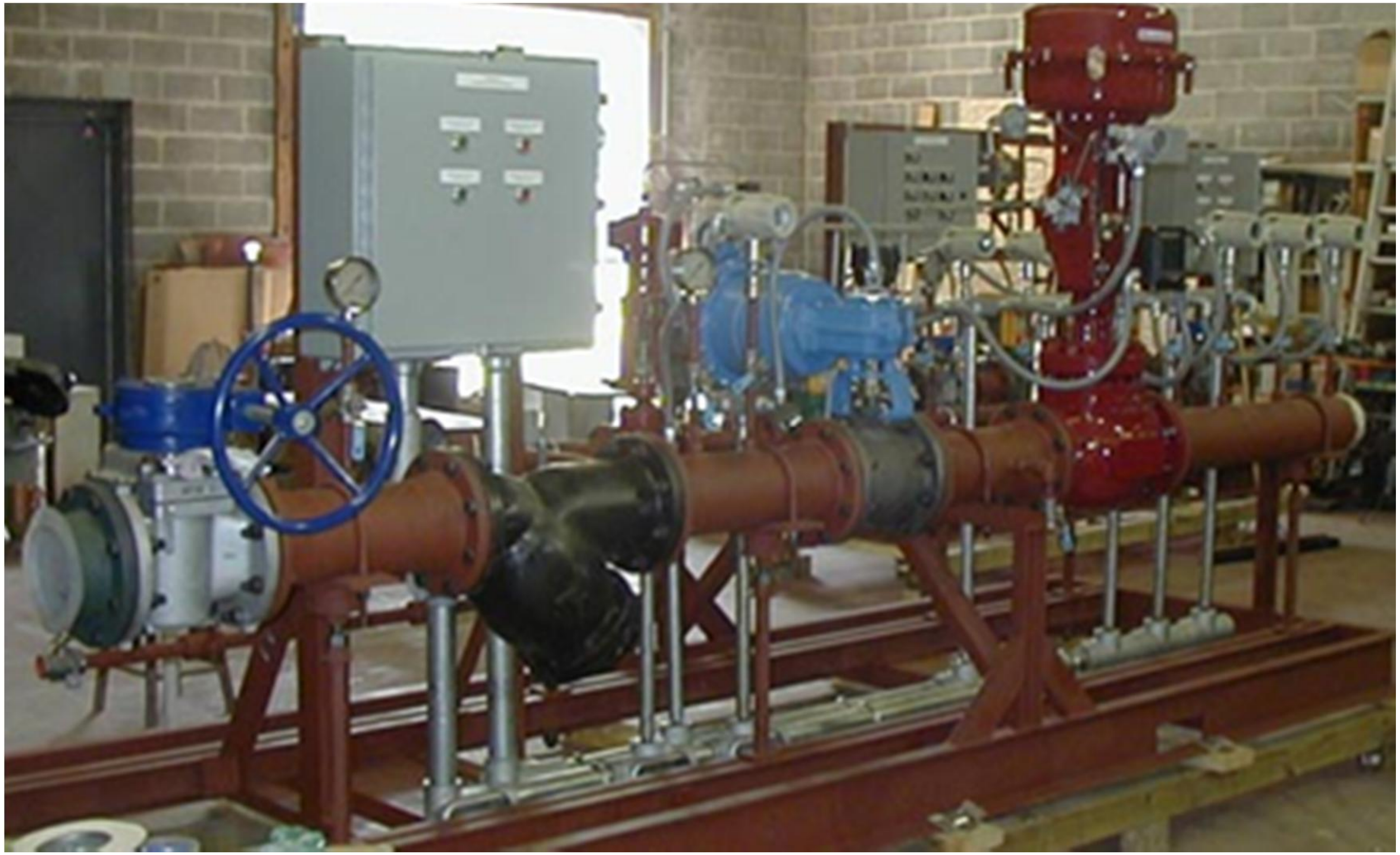
Locating equipment can be a challenge

Remote I/O can reduce wiring cost

Centralized valve skids can simplify installation

Considerations for Gas Firing

Gas Piping Valve and Instrument Skid



Considerations for Gas Firing

ALSTOM

Individual Gas Burner/Ignitor Valve Skid

Considerations for Gas Firing

ALSTOM

Controls

More complex integration into Burner Management

Segregation of duty from combustion controls

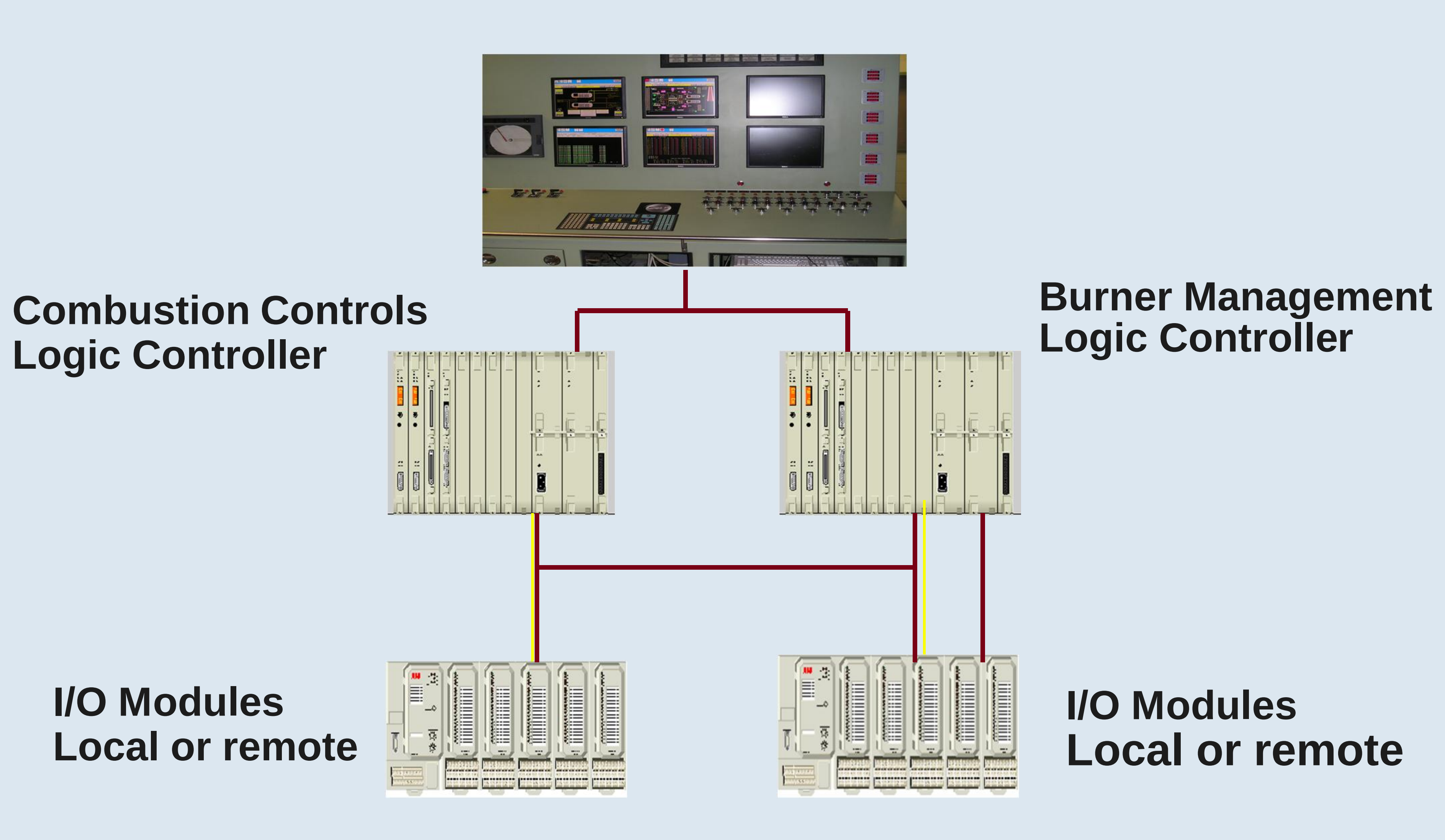
Separate controllers often used for gas firing

Local I/O cabinets reduce installation cost

Pre-fab valve skids reduce installation time and cost

Considerations for Gas Firing

Control System Architecture



Considerations for Gas Firing

Controls

Operator interface for local and remote operation

Local controls require hardened equipment

LCD displays for easy view of operating conditions

Advanced software for historical data analysis

Considerations for Gas Firing

Gas Burner Local Control Cabinet

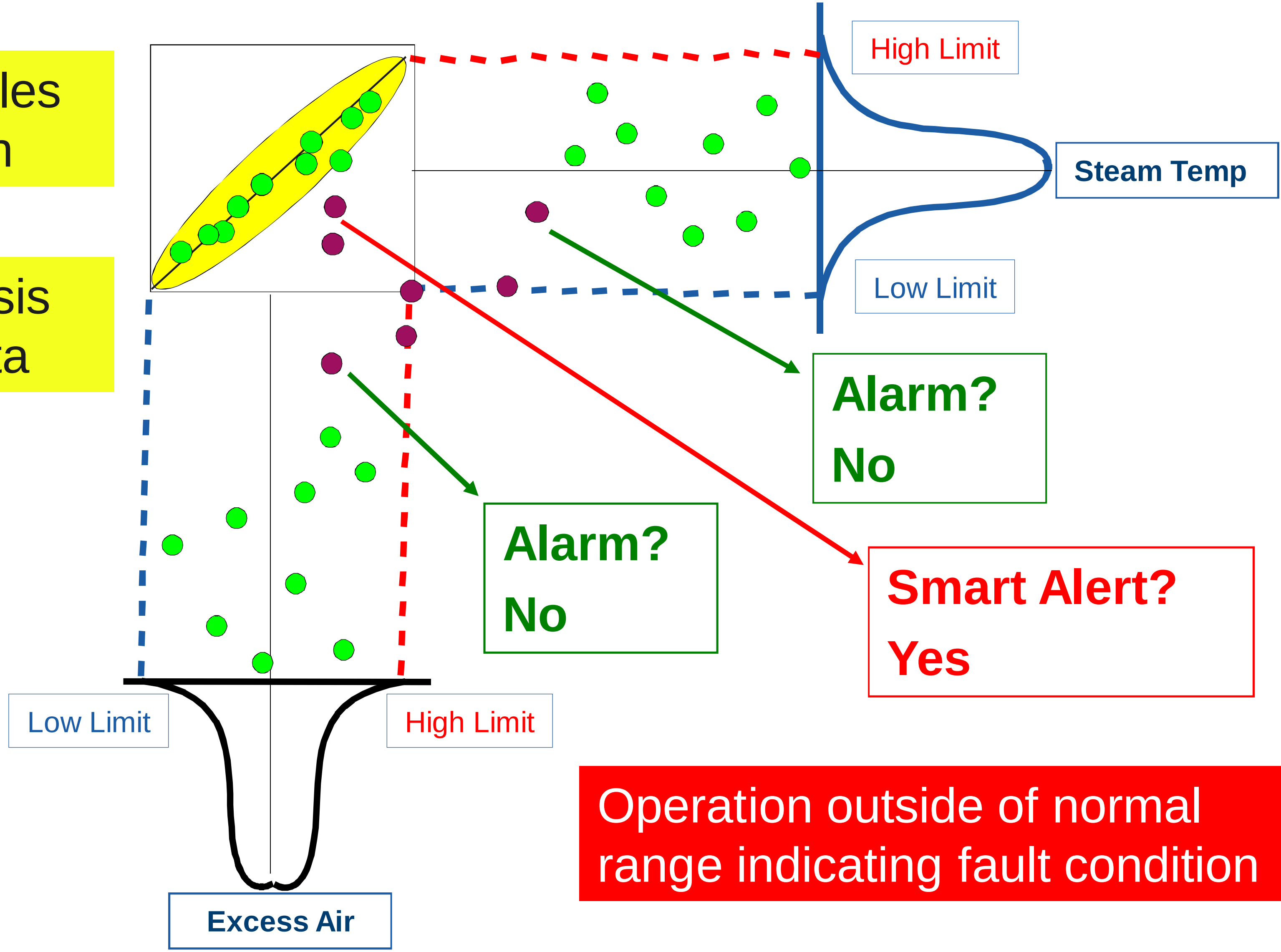
Boiler Data Advisor

ALSTOM

Pattern Recognition Software

Multiple variables with correlation

In depth analysis of complex data



Operation outside of normal range indicating fault condition

Considerations for Gas Firing

Purpose and Boiler Load

Fuel Firing Equipment

Controls

Balance of Plant

Emissions

Performance Validation

Considerations for Gas Firing

Balance of Plant

Gas piping

Structural support

Electrical wiring

Code compliance

Leak and fire protection

Considerations for Gas Firing

ALSTOM

Balance of Plant

Gas pipe routing through the plant

Flow, pressure and velocity management

Vent piping to safe location, above roof line

Structural steel, hangers, stress analysis

Considerations for Gas Firing

Balance of Plant

Instrument location

Electrical wiring

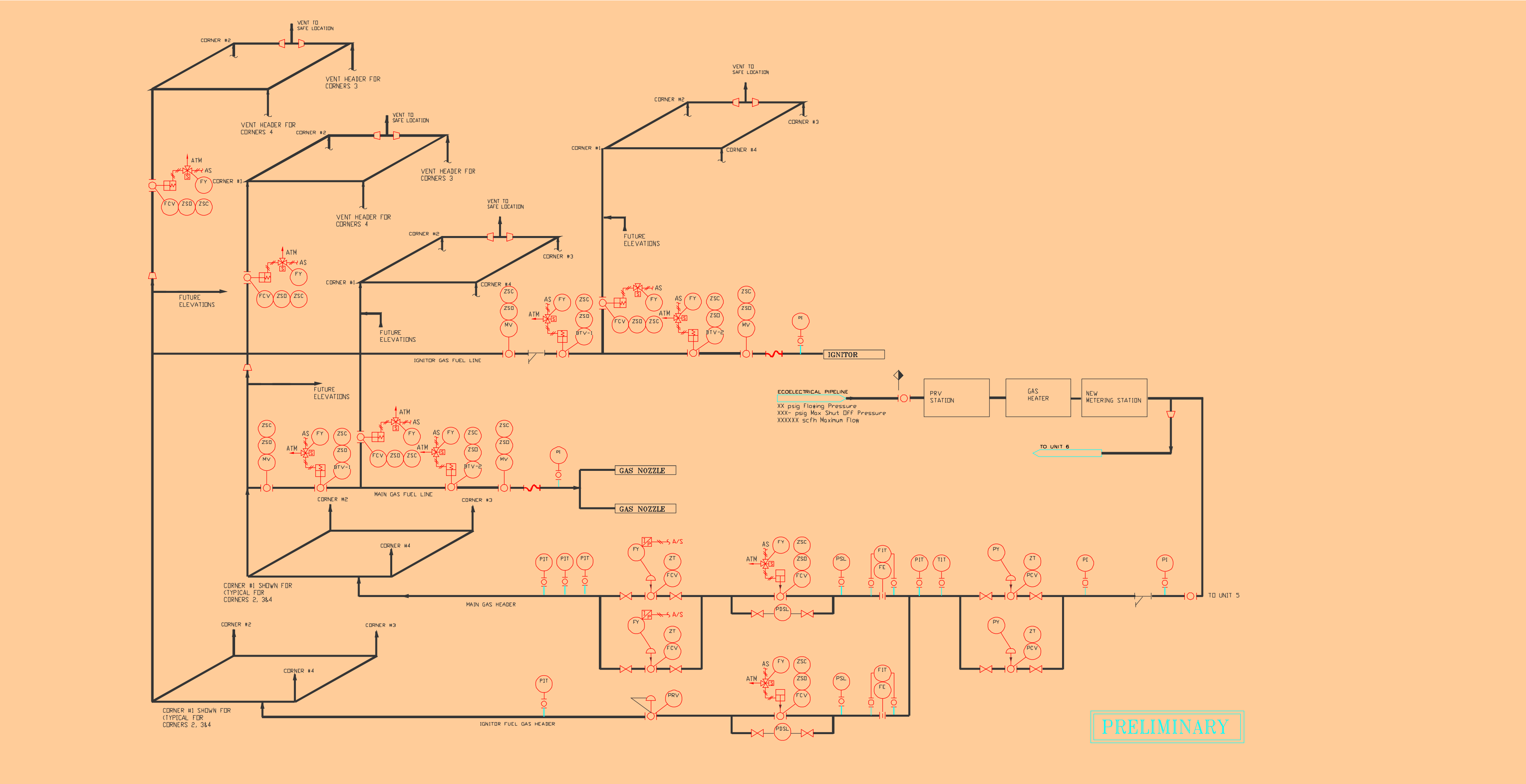
Power distribution and safety protection

Signal wire and grounding

Communication bus network

Considerations for Gas Firing

Balance of Plant



Considerations for Gas Firing

Purpose and Boiler Load

Fuel Firing Equipment

Controls

Balance of Plant

Emissions

Performance Validation

Considerations for Gas Firing

Emissions

- Typically not an issue with CRU's
- Intermittent use, 30 day rolling average
- Inherently low emissions from gas
- Boiler in leakage impact
- Reduce or eliminate solid and liquid wastes

Considerations for Gas Firing

ALSTOM

Emissions

Competing and/or simultaneous objectives

NOx vs. CO vs. Efficiency

Particulates virtually eliminated

Reduction in NOx, SO^2 and CO^2 compared to oil

Considerations for Gas Firing

Purpose and Boiler Load

Fuel Firing Equipment

Controls

Balance of Plant

Emissions

Performance Validation

Considerations for Gas Firing

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Performance Validation

Engineering study to determine likely outcomes

Baseline testing to assess current performance

Optimization tuning

Post installation performance test

Considerations for Gas Firing

Performance Validation

Temporary test instruments

Sampling grids

Thermocouples, flow meters

NOx, CO, O2, steam flow and temperature

Considerations for Gas Firing

ALSTOM

Conclusions

Gas firing is good!

Low cost fuel

Increased reliability

Less maintenance

Low impact emissions

Multiple aspects to consider

Considerations for Gas Firing

Mark Wagner , Alstom Power Inc.

?...?.....?.....?'s

POWER | ALSTOM

AF&PA Recovery Boiler Conference
Atlanta, GA

Recovery Boiler Insurance Market Update

Jimmy Onstead

FM Global

8 Feb 2012

Globalization

Paper mills are still underwritten in a specialized way.

But, what happens globally affects the price of insurance capacity available in the US, and the world market.

8.8 magnitude EQ in Chile, February, 2010

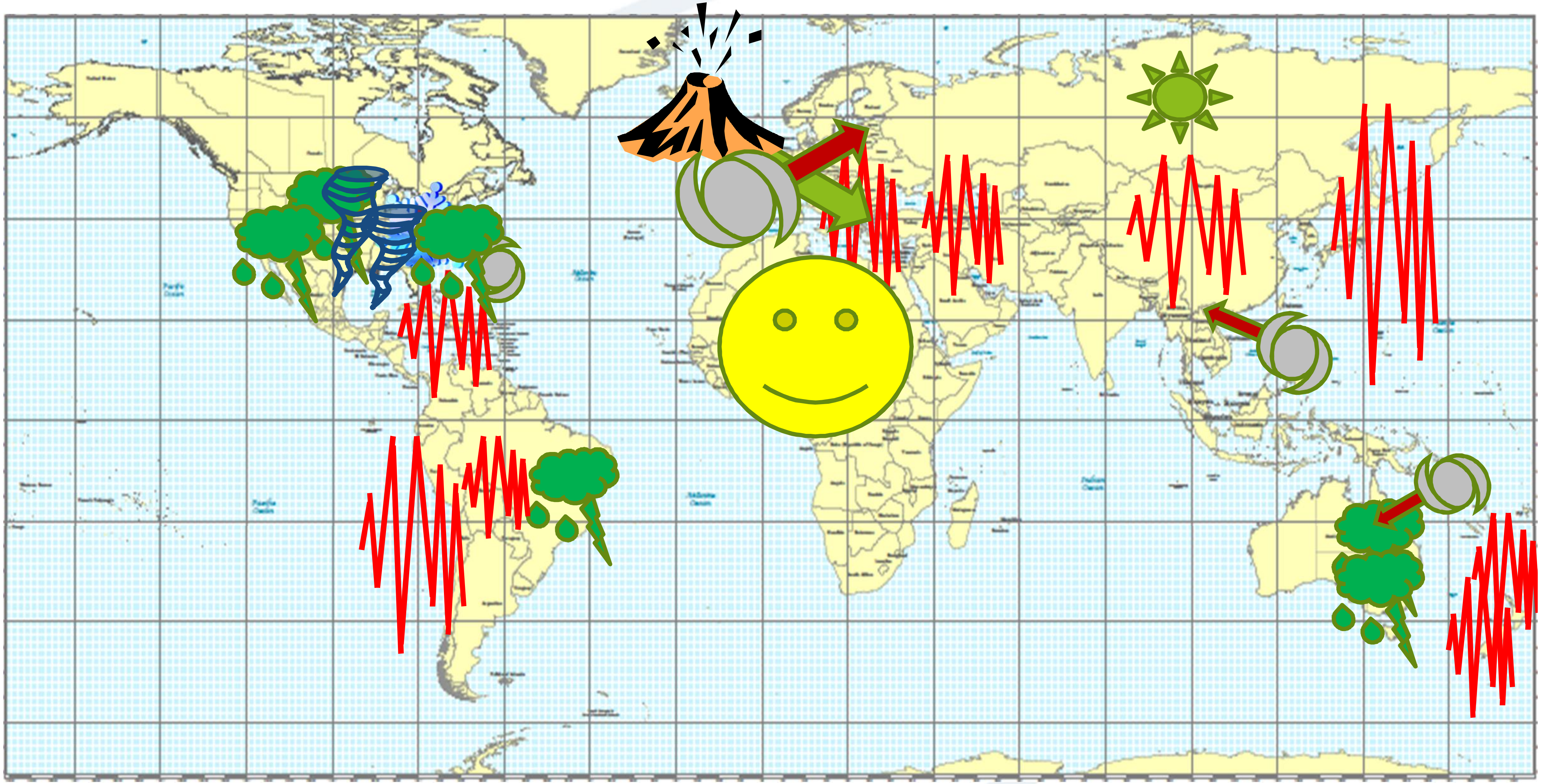
Pulp Market

- *Demand was on rise*
- *3.7M tons/year Pulp taken off-line immediately*
- *Pulp price went up about 25% over the next month.*

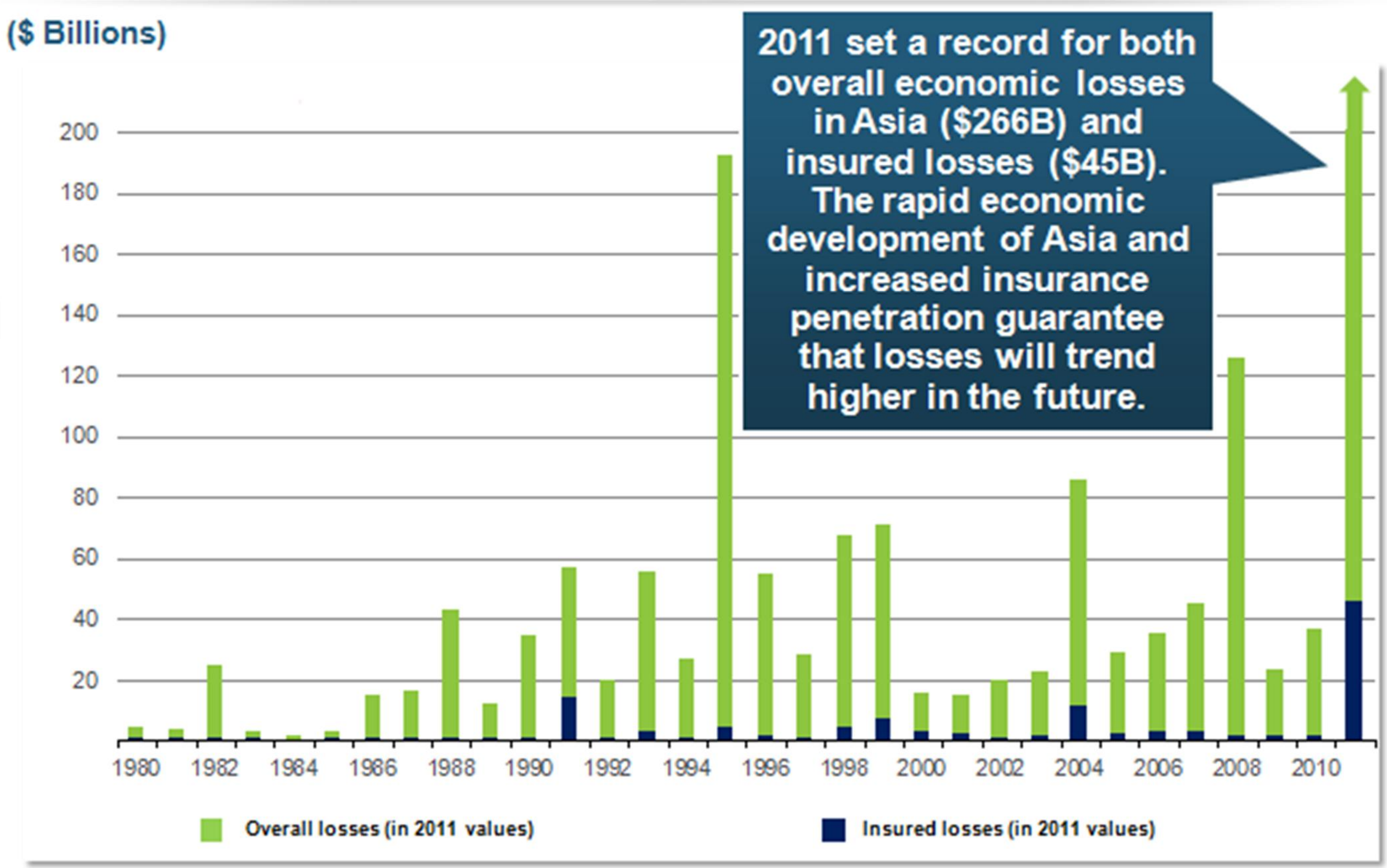
Insurance Market

- *Market will continuing to soften*
- *$12B insured loss*
- *$10B covered by European companies*
- *20% + increases in Chile*
- *Global market began to harden*

2010 & 11 Catastrophes

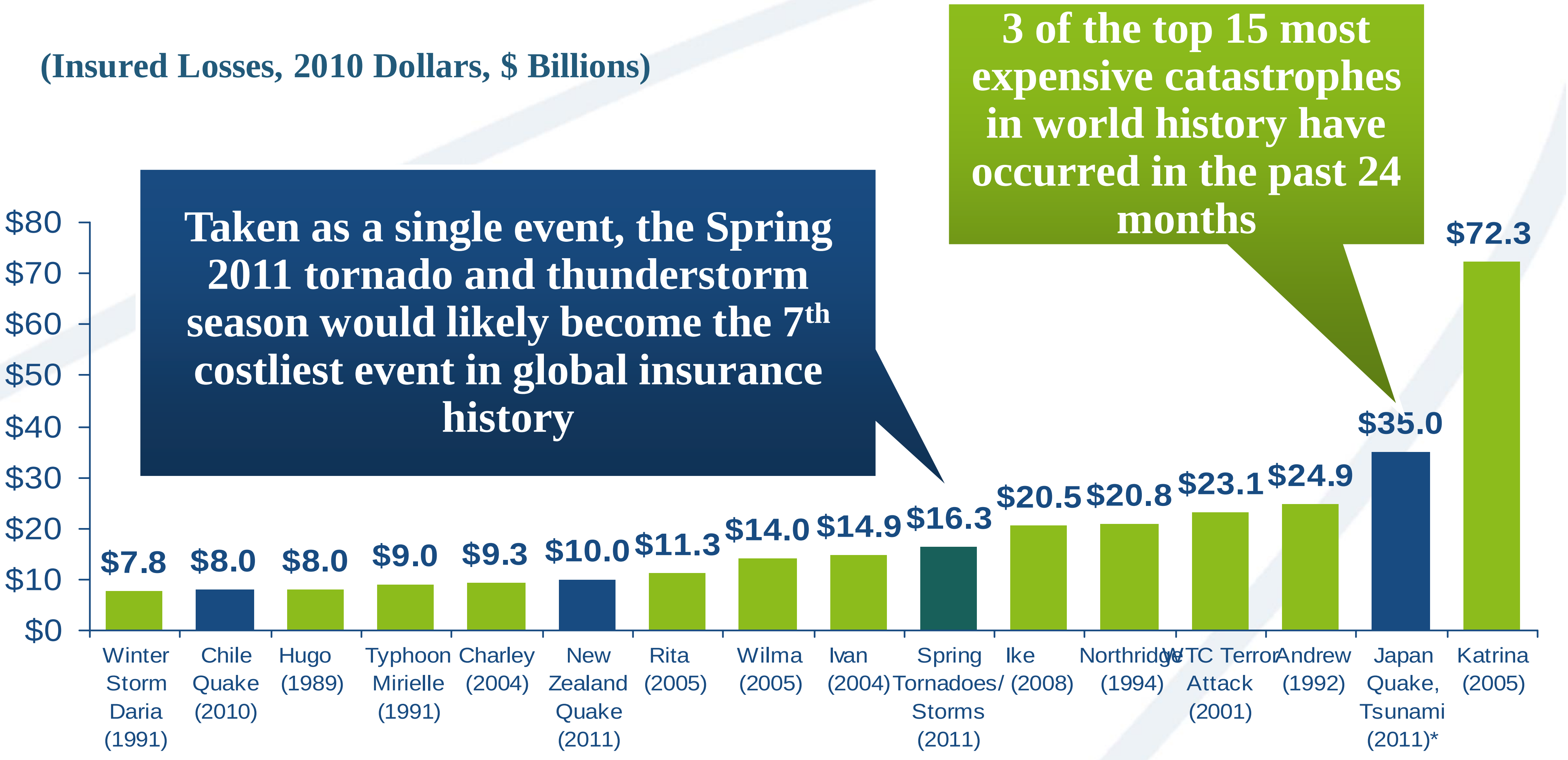


Worldwide Natural Disasters 1980–2011, Overall and Insured Losses*



Source: Ins. Information Inst.

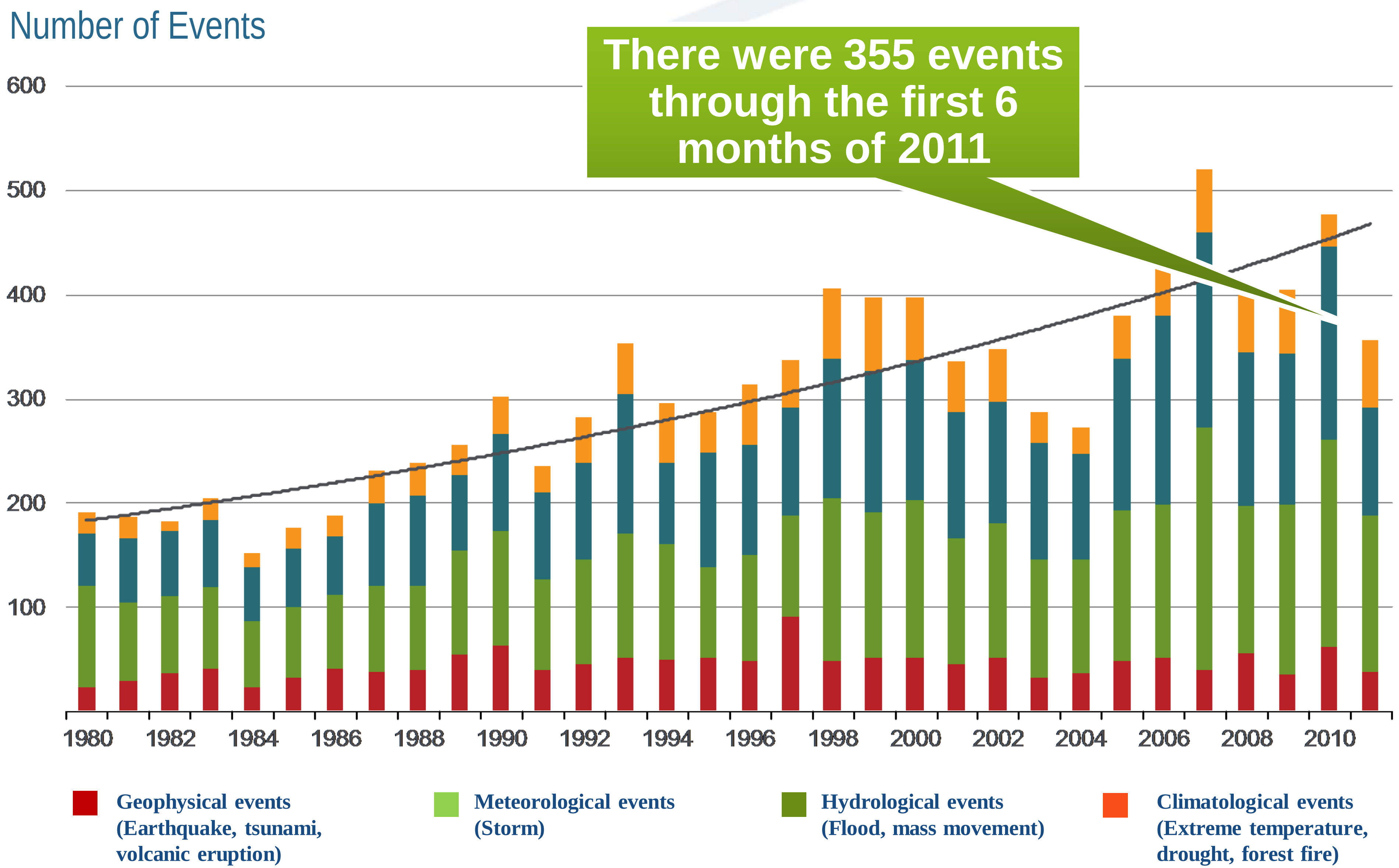
Top 16 Most Costly World Insurance Losses, 1970-2011*



*Through June 20, 2011. 2011 disaster figures are estimates; Figures include federally insured flood losses, where applicable.

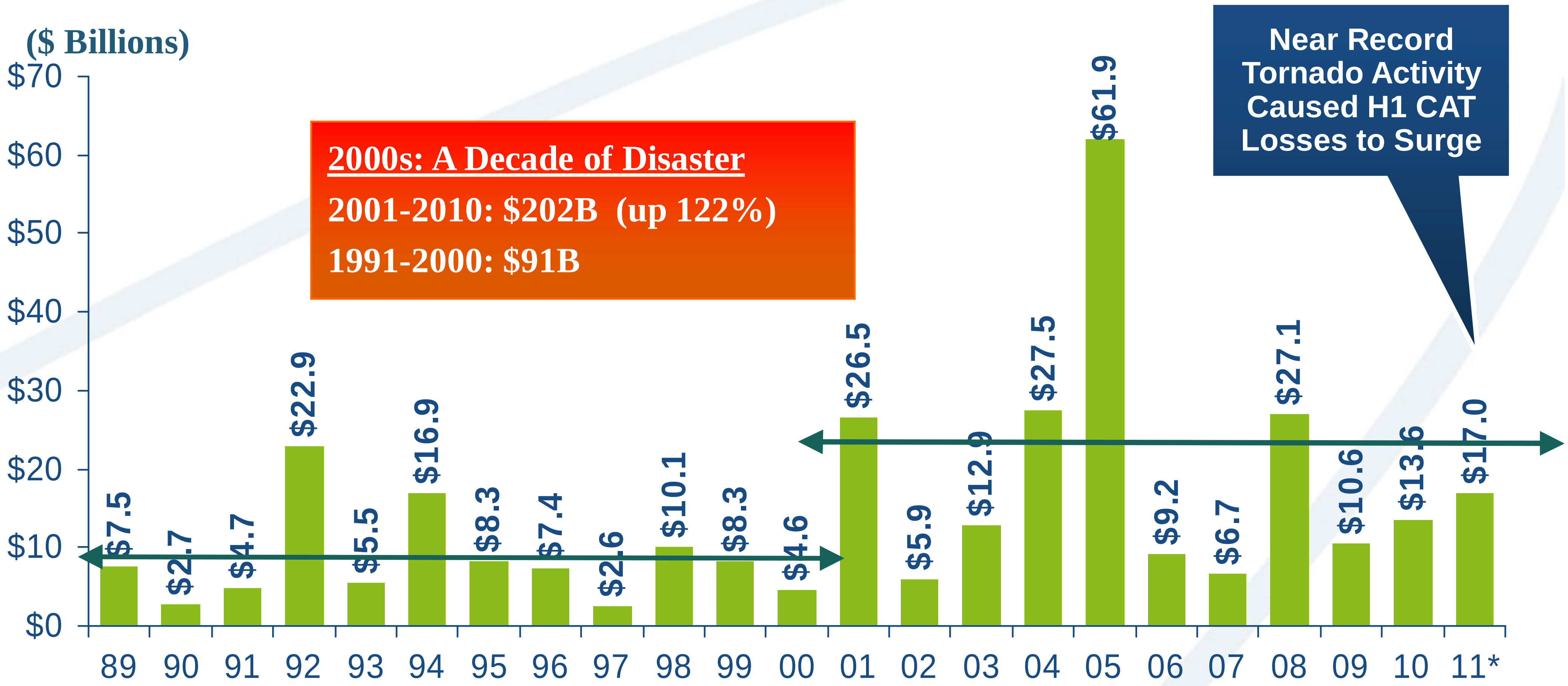
Sources: Swiss Re *sigma 1/2011*; AIR Worldwide, RMS, Eqecat; Insurance Information Institute.

Worldwide Natural Disasters,1980 – 2011*



*2011 figure is through June 30.
Source: MR NatCat*SERVICE*

US Insured Catastrophe Losses

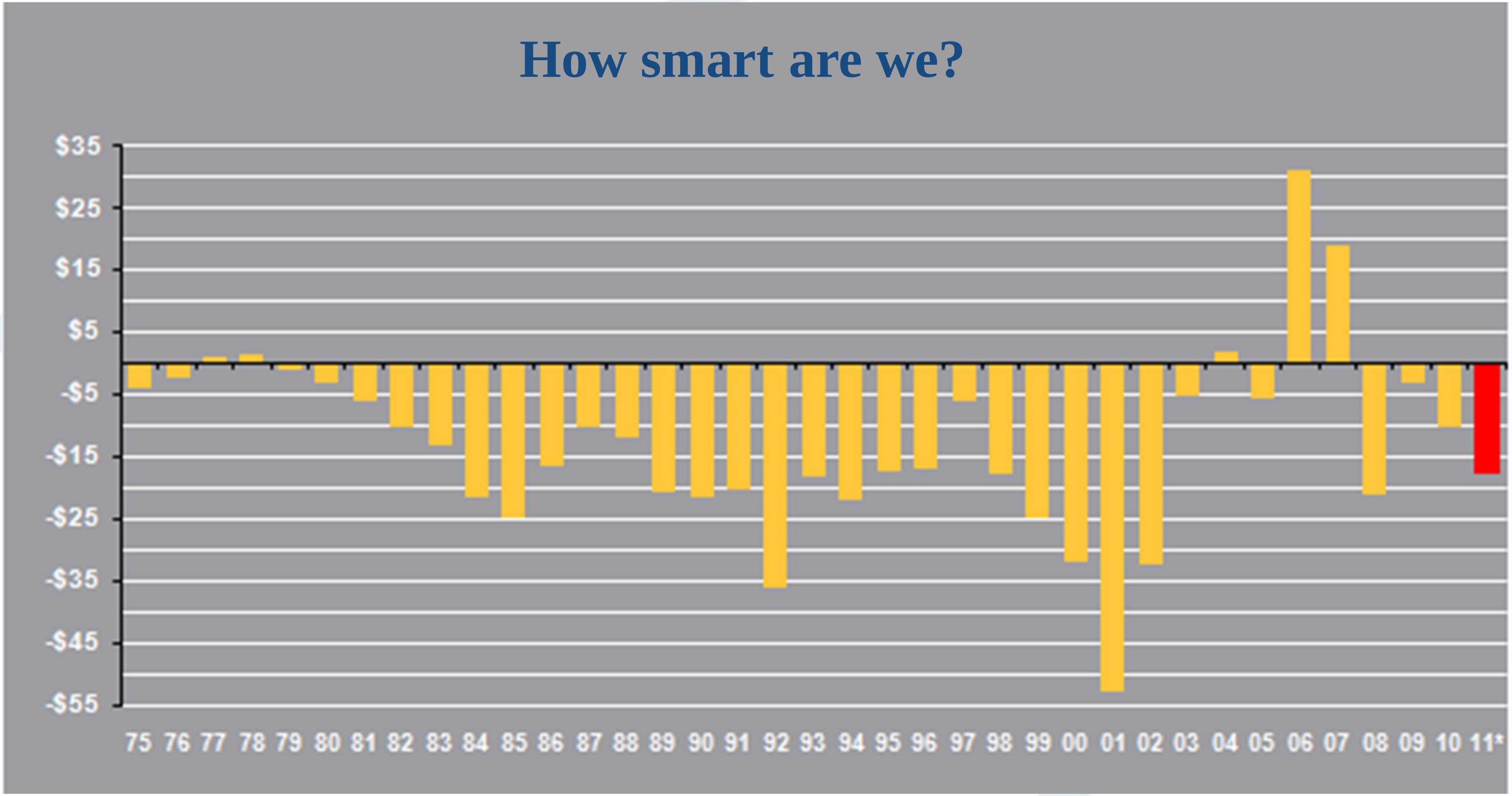


***First half 2011 (est).**

Note: 2001 figure includes $20.3B for 9/11 losses reported through 12/31/01. Includes only business and personal property claims, business interruption and auto claims. Non-prop/BI losses = $12.2B.

Sources: Property Claims Service/ISO; Munich Re; Insurance Information Institute.

Property Underwriting Profit



Sources: A.M. Best, ISO; Insurance Information Institute.

Rate trend compared to 2007

Rates are expected to increase in 2012

What can you do?

- ***Continue focus on loss prevention – specifically the Nat Cat.***
- ***Have you ever evaluated your recovery boiler and facility with regard to wind, flood, quake? Maybe you should.***
- ***Learn from others poor risk management and bad luck.***

Annual Report from the Swedish-Norwegian Recovery Boiler Committee

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

Sodahuskommittén
The Swedish Norwegian Recovery Boiler Comittee

Topics

- The organization of the SNRBC
- State of the boiler park in Sweden and Norway
- Incidents 2010 – statistics
- Details on some serious incident

General information

- Research – A DCS-group is formed for analysis of increased numbers of DCS problems

The organization of the SNRBC

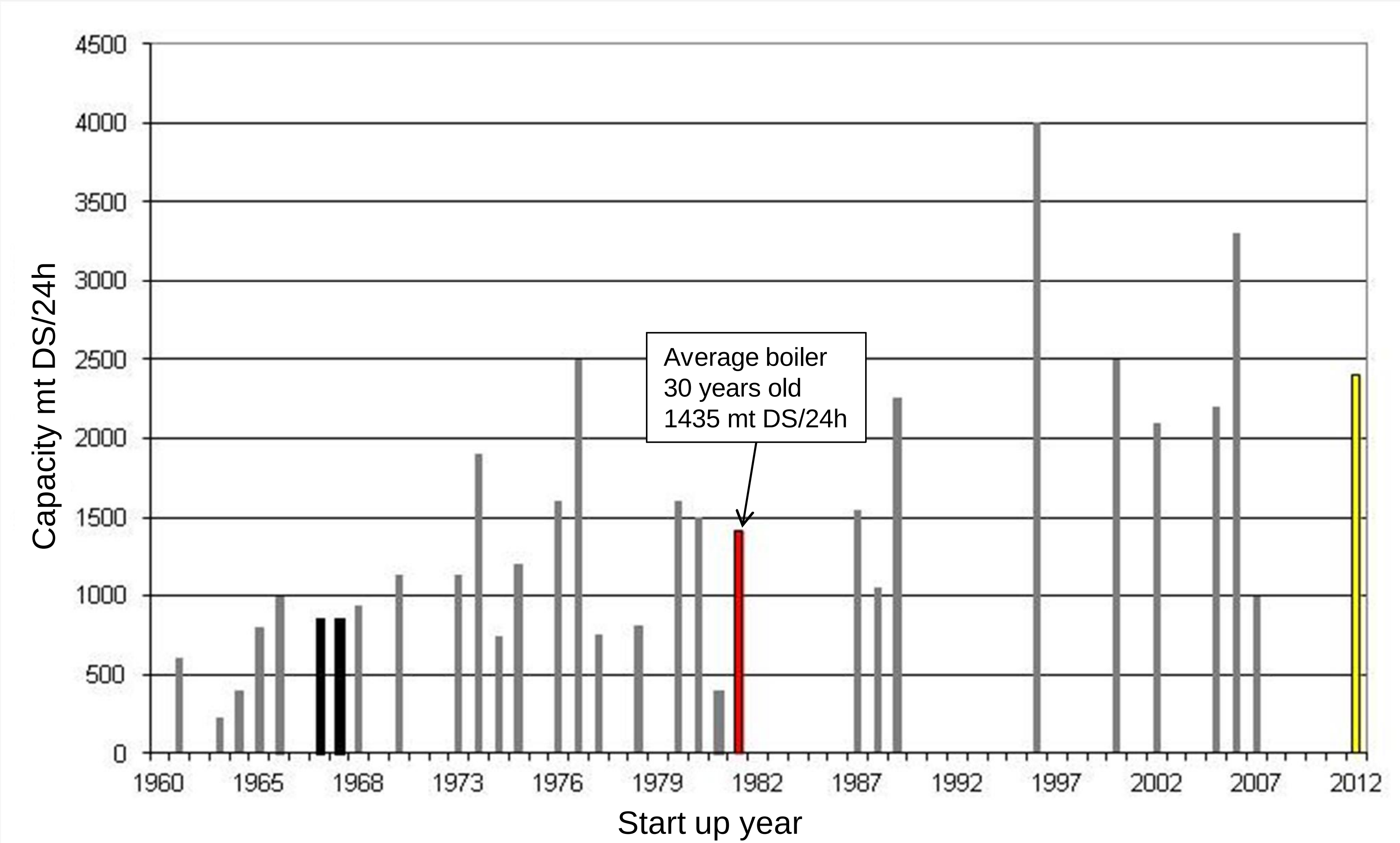
The Board of the SNRBC
Chairman: Mats Jakobsson, Mondi Group
Secretary: Urban Andersson, ÅF
16 members (11 voting)

- **Recommendations Subcommittee**
  Lars Andersson, ÅF
  3 members
- **Incidents Subcommittee**
  Bert Flodqvist, ÅF
  David Good, ÅF
  9 members
- **Training Subcommittee**
  Björn Lundgren, Billerud
  2 members

Sodahuskommittén

The Swedish Norwegian Recovery Boiler Comittee

The boiler park in Sweden and Norway



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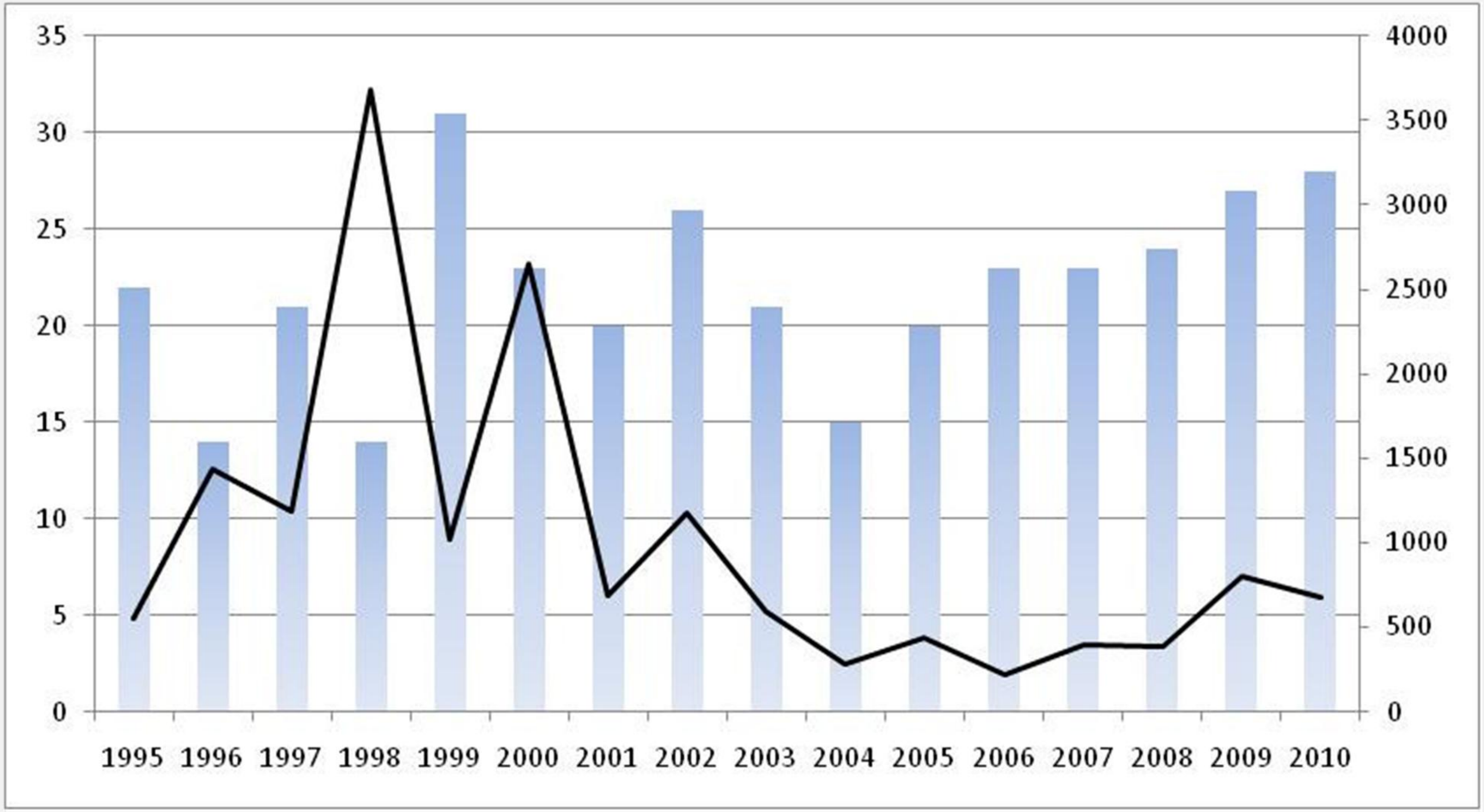
Incidents

A total number of 28 incidents were reported for 2010

No.	Incident headline	Down time	No.	Incident headline	Down time
10-1	Boiler bank tube leak	66 h	10-15	Leak, secondary air pre-heater	17 h
10-2	Tube leak, screentube (explosion?)	n/a	10-16	Leak, secondary air pre-heater	17.5 h
10-3	Tube leak, primary superheater	44 h	10-17	Leak, secondary air pre-heater	22.5 h
10-4	Tube leak, boiler wall (penthouse)		10-18	Tube leak, primary superheater	36 h
10-5	Communication errors, DCS-system	0.9 h	10-19	Tube leak, between smelt spouts	26 h
10-6	smelt spout cooling water leak	35.5 h	10-20	Wall tube leak at screen level	
10-7	Leaking economizer	23 h	10-21	Water leak from smelt spout	24 h
10-8	Gas explosion, pyrolysis	118 h	10-22	Low pH in boiler water	-
10-9	Boiler bank tube leak	48 h	10-23	Boiler bank tube leak	45 h
10-10	Broken bolts in evaporator liq. leak	-	10-24	Water leak,Smelt spout cracking	26 h
10-11	Pitot line leakage	-	10-25	Leaking smelt spout	10 h
10-12	Dissolving tank agitator failures	24 h	10-26	Failure of mixer in dissolving tank	36 h
10-13	Purge line leak	-	10-27	Sootblower lance failure	-
10-14	Leak in rolled tube end, steam drum	54 h	10-28	Sootblower lance failure	

Incidents

A total of 28 incidents reported for 2010



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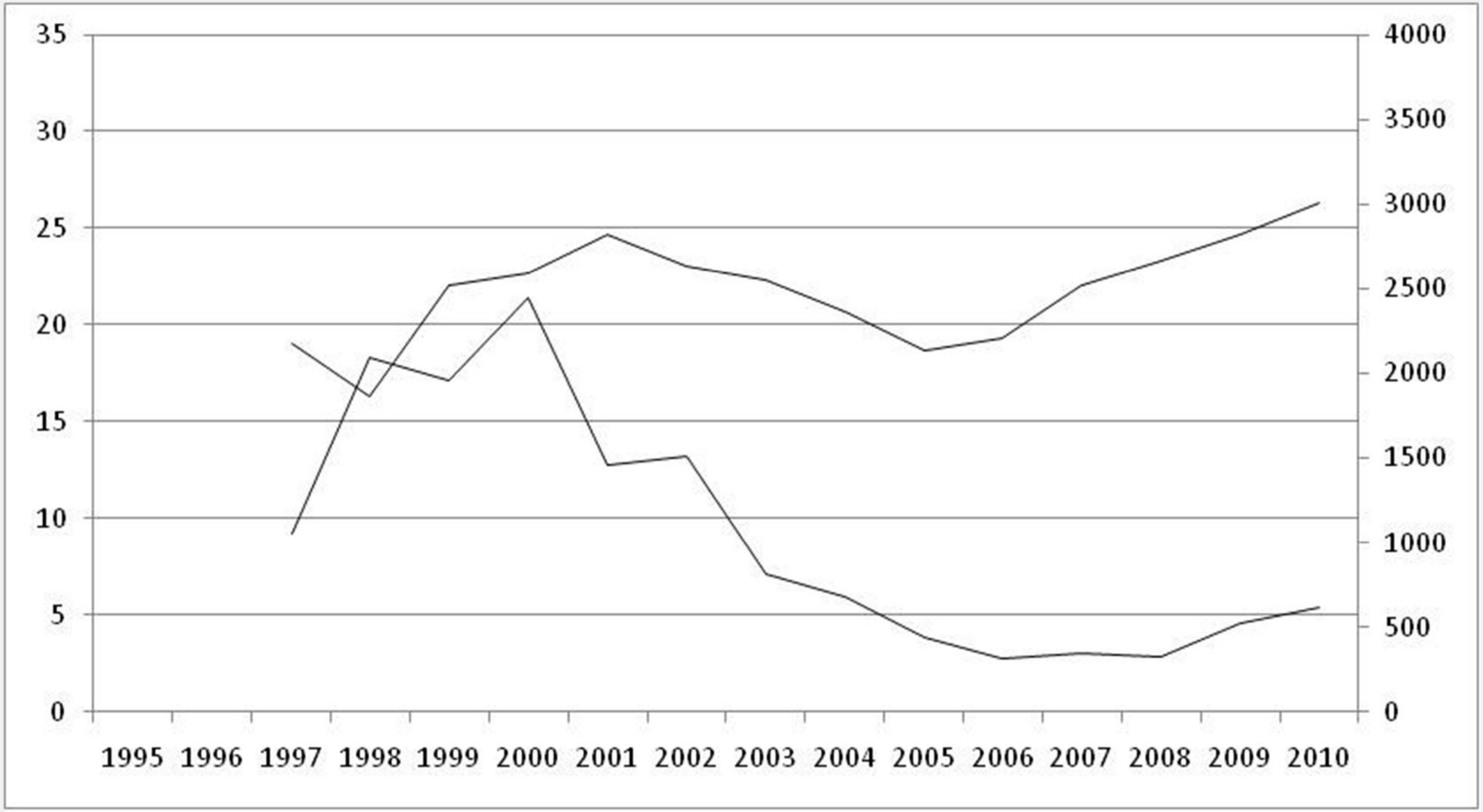
Incident trends

3-year running average



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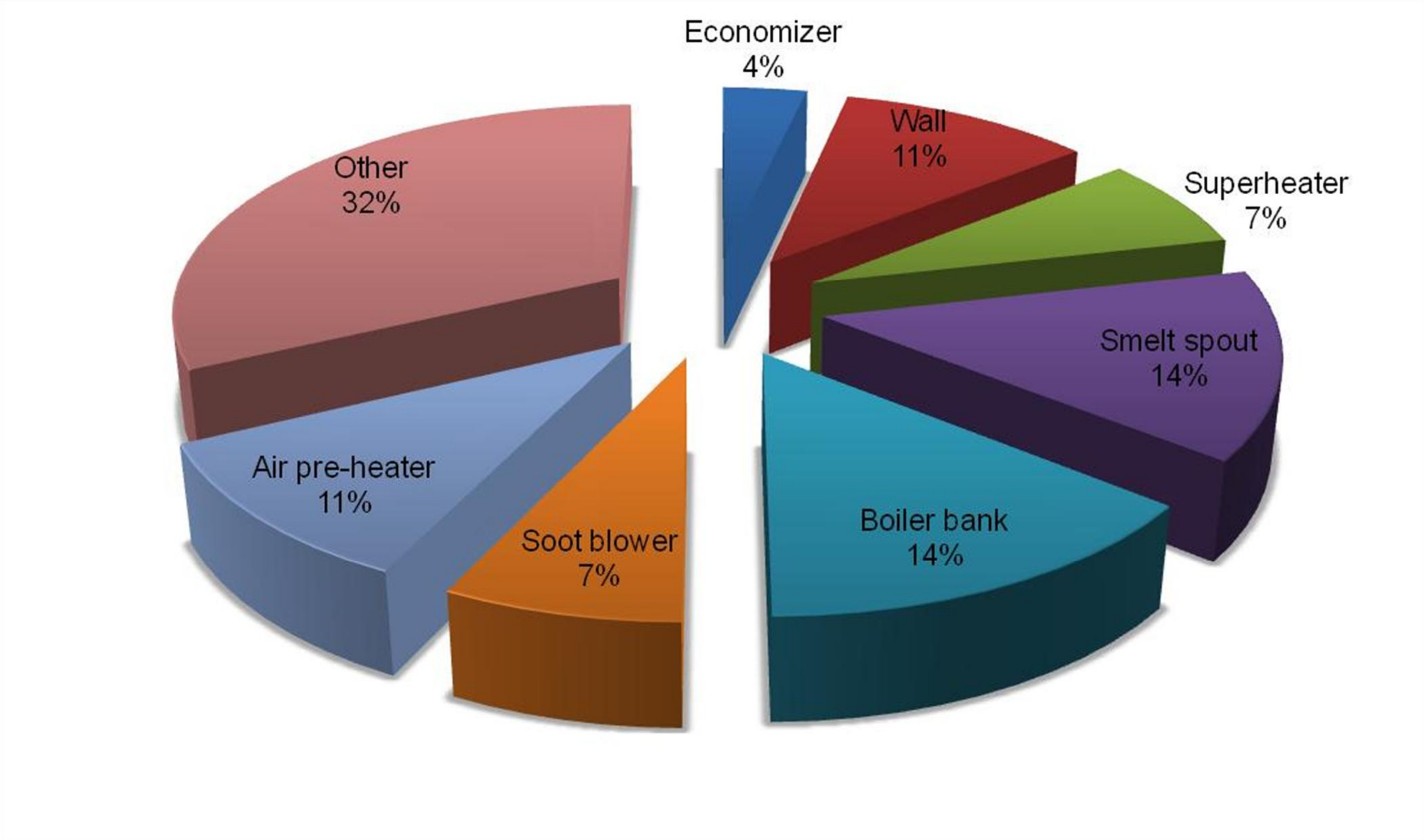
Incidents per area 2010

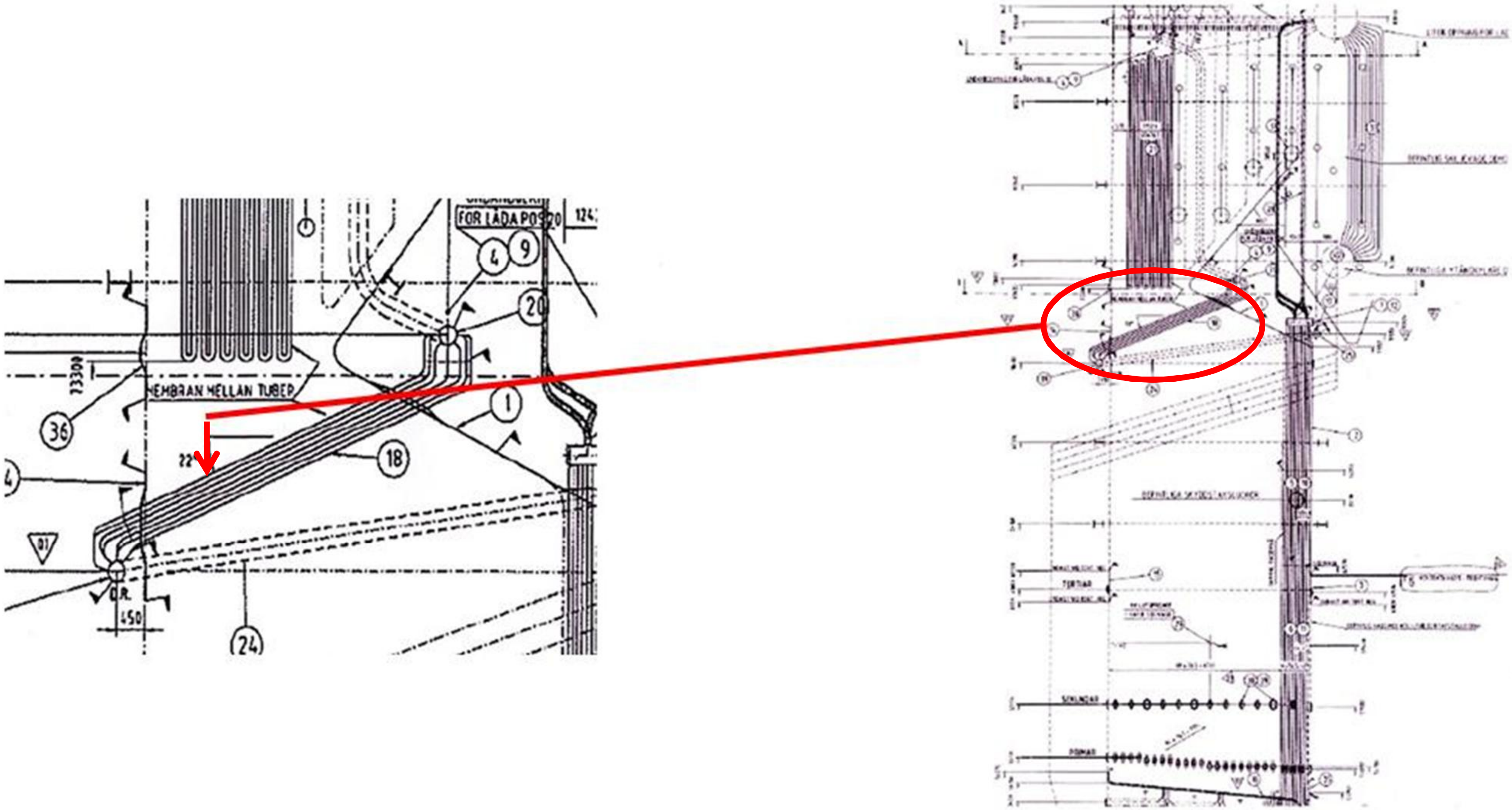


Incident: 2010-02 Screen tube leak

- The feed water flow was increasing and water were coming out from the smelt spouts
- The boiler was emergency shout down
- Water was leaking from a overheated screen tube which had opened
- Overheating was caused by water side deposits
- A smelt-water explosion probably occurred

Incident: 2010-02

Leaking screen tube on top due to overheating



Incident: 2010-02 Screen tube leak

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Incident: 2010-05 Water leak from smelt spout

- Water from smelt spout cooling system was sprayed into the boiler
- The boiler was emergency shut down
- The smelt spout was made of stainless material
- The cooling system works at present with overpressure and cannot be shut off outside the boiler house

- Smelt spout cooling should have a vacuum system

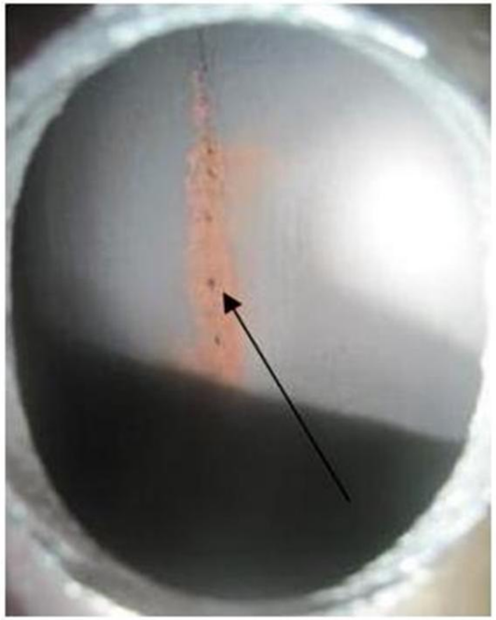
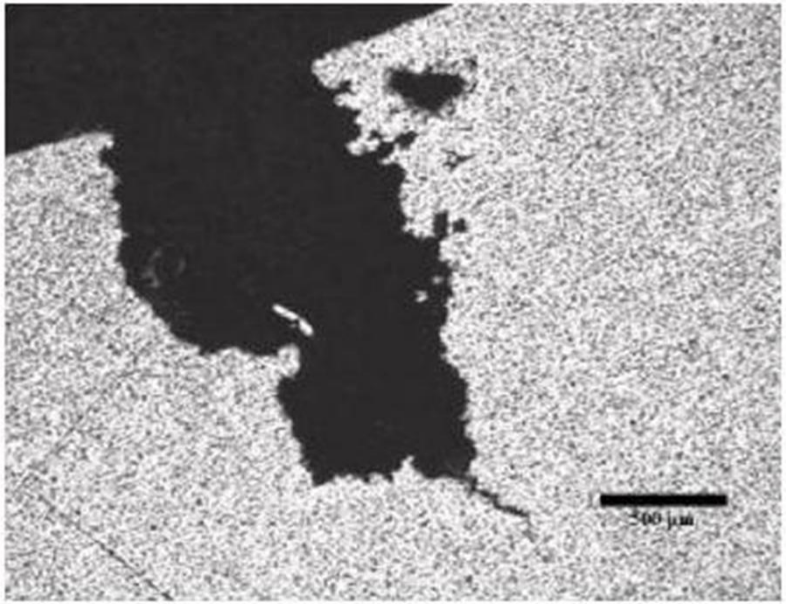
Incident: 2010-19 Water leak between smelt spouts

- Water was coming out from isolation between smelt spout openings during operation

	
Picture from the isolation side of the front wall tubes	Leaks could also be be found behind the other cover plate

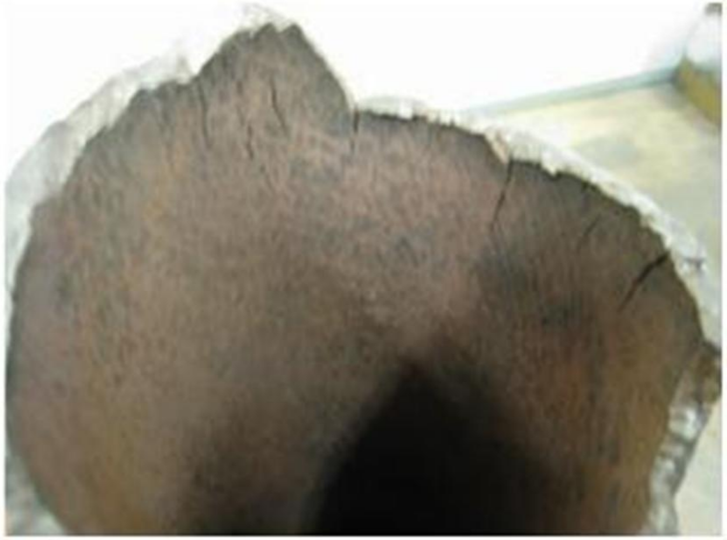
Incident: 2010-19 Water leak between smelt spouts

- The failure analysis showed stress assisted corrosion.
- Hih residual and thermal stresses in and at the weld between the cover plate and the tubes.
- The cracks have started in the water side of the tube and propagated towards the cover plate.

	
Crack in the left leaking tube	Microscope picture of crack

Incident: 2010-27/28 Breaking soot blower lances

- Both lances broke 4 dm from the rear flange
- The break occurred both times in the unaffected lance not at any welding or dimensional change

	
Broken lance 4 dm in from the rear flange	All cracks started from the inner side of the lances

Thank you for your attention!

Sodahuskommittén

The Swedish Norwegian Recovery Boiler Comittee