Recovery Boiler Safety and Audits

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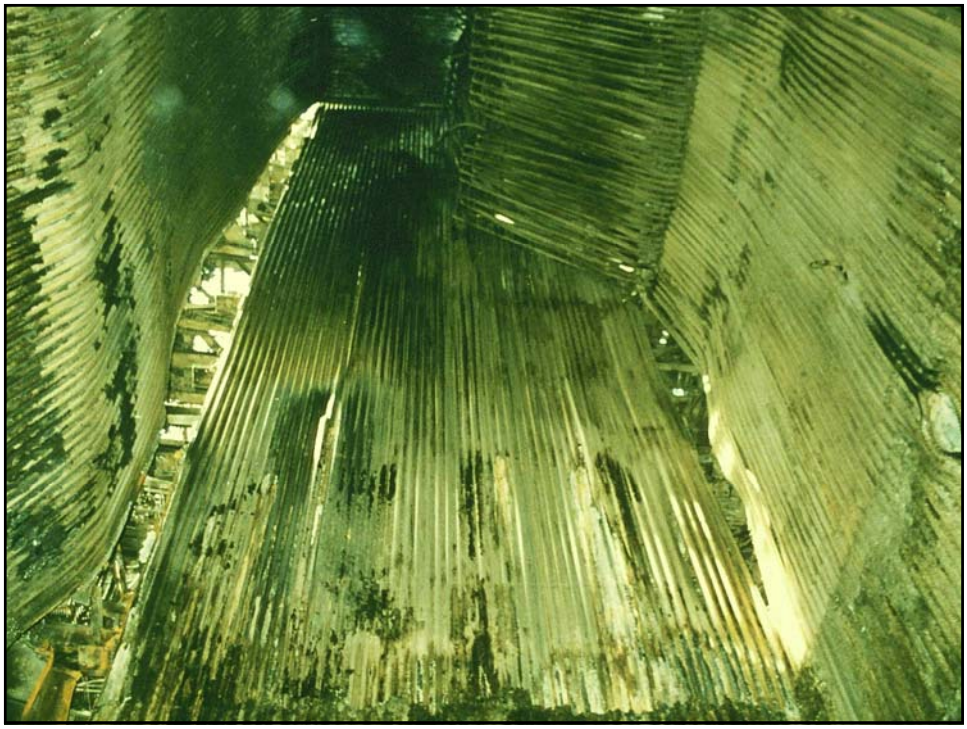
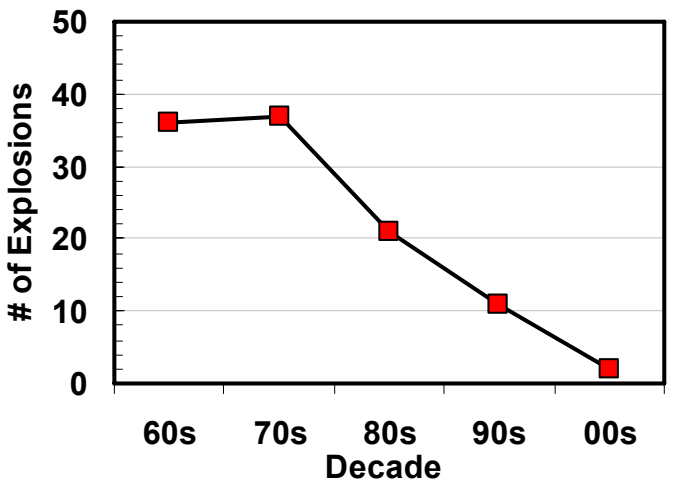
Potential Catastrophe

- A major recovery boiler explosion is a catastrophic event at a kraft pulp mill
- Risk of injury or death
  - Fatalities in ≈ 5% of explosions
  - Serious injuries in another 5%
- Cost of repair
  - Depends on explosion magnitude
- Lost production



Recovery Boiler Explosions



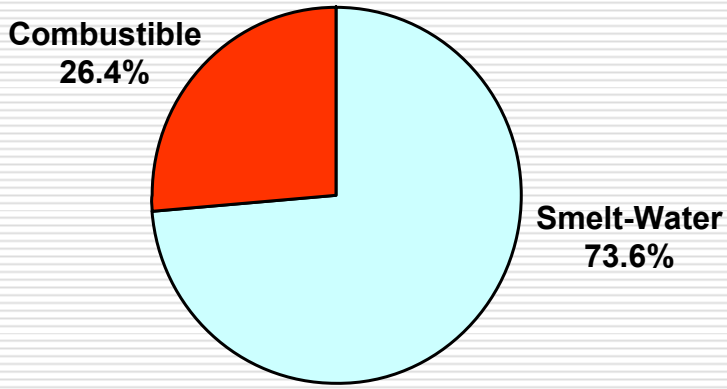
Progress on Explosion Control

- Nearly 4 explosions per year in 1960s and 70s
- Running 0.3 per year in current decade
  - Only 2 so far this decade in North America
  - Have had several near misses
- More explosions in other countries

Types of Explosions

- Smelt-Water Explosions
  - Due to extremely rapid steam generation
  - Non-combustible in nature
- Combustible Gas Explosions
  - Accumulation of air-fuel mixture within the explosive concentration range
  - Ignition source

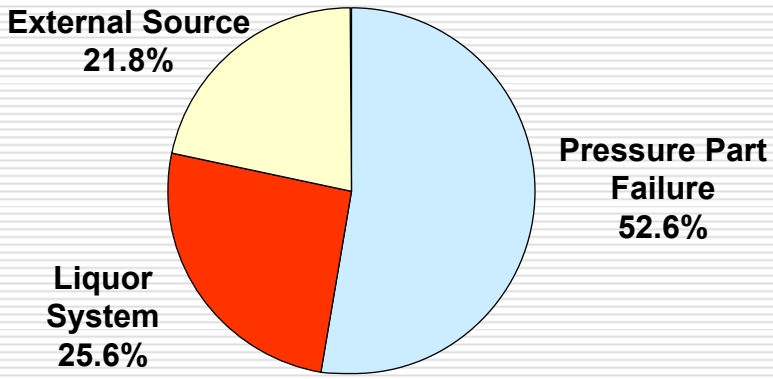
Types of Explosions



Smelt-Water Explosions

- Prevent by keeping smelt & water apart
  - Keep liquid water out of furnace
  - Make sure smelt is frozen before introducing liquid water to furnace
- Emergency shutdown procedure
  - Aimed at minimizing likelihood and consequences of an explosion

Smelt-Water Explosions



Leak Size Matters

- Large Magnitude Explosions (13)
  - 11 involved large leaks
  - 2 involved relatively small floor tube leaks
- Moderate Intensity Explosions (18)
  - 13 involved large leaks (not in floor)
  - 5 floor tube leaks (3 small, 2 larger)
- Low Intensity Explosions (10)
  - Include 4 from small lower wall leaks
  - Include 2 with cold side ruptures in non-membrane walls

Ranking of Risk

1. Large Failure in Wall, Screen, Roof
2. Floor Tube Leak of Any Size
3. Large Leak in Generating Bank
4. Small Leak in Lower Furnace
5. Other Leaks

No Explosions Have Occurred From

- Small leaks in wall tubes above lower furnace
- Small leaks in screen tubes, roof tubes and generating bank tubes
- Economizer tube leaks of any size

- The risk of a small leak in wall, screen, roof, or generating bank is thinning an adjacent tube which can then rupture

Preventing Explosions from Pressure Part Failures

- Eliminate tube leaks – focusing on the highest risk categories
  - Identify causes of failures
  - Take proactive action
- Minimize water input to furnace by initiating ESP (emergency shutdown procedure)
  - Rapid drain boiler
  - Time is critical in a high risk leak

Time to Initiation of ESP

- Affects the amount of water into furnace
- Operators often fail to recognize tube leaks, even large tube leaks
- This was a factor in 2/3 of explosions involving pressure part failure since 1980
  - Shortest time lag was 9 minutes
  - In some ESP never initiated
- This is still a problem

Elements of ESP Procedure

- Alarm and evacuation of danger area
- Stop all fuel firing
- Stop air to bed area – maintain a balanced draft
- Drain water out of boiler (rapid drain)
  - Drain to 8 ft level
  - 15-20 minutes typical drain time
- Done by a fully automatic system

Benefits of ESP

- It works – it reduces chance for explosion
  - Less water in – better chance to avoid explosion
- It reduces consequences of an explosion if it should occur
  - Gets rid of the superheated water and steam within the boiler that would be released if the pressure parts open up
  - When complete, eliminates major cause of injuries and death

Liquor System Explosions

- Sources
  - Weak black liquor
  - Wash water
  - Inadvertent dilution
- Procedures and systems exist that will prevent these events
  - BLRBAC - Safe Firing of Black Liquor
  - These have been very effective – last one in 1992

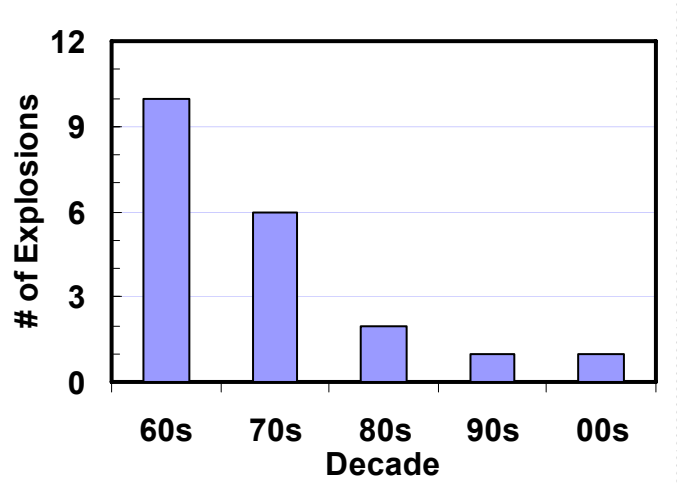
External Sources "still a concern"

- Waterwashing furnace after ESP
  - One explosion in 90s
  - Several recent near misses
  - Accelerated bed cooling not a cure-all
  - No positive way to know all molten smelt is absent
- NCG incineration systems provide another path for water entry
- Smelt spouts not a likely cause for boiler explosions unless pressurized

Combustible Gas Explosions

- Auxiliary Fuel
- Black Liquor Pyrolysis Gas
- NCG Incineration

Auxiliary Fuel Explosions



Successful Prevention of Auxiliary Fuel Explosions

- Use of Monitored Burners
  - BLRBAC – Safe Firing of Auxiliary Fuel
- 15/16 explosions in 60s & 70s did not have monitored burners in use
  - Exception was not properly maintained
- 3 of the 4 since 1980 have been on units with monitored burners
  - 2 had unrecognized tube leak in furnace
  - 1 still being installed and adjusted

Pyrolysis Gas Explosions

- Source of combustible gas is thermal decomposition of black liquor solids
  - Black liquor accumulation in hot furnace without burning is critical factor
  - Most common scenario is hot restarts without shutting off black liquor
- Prevention dealt with in BLRBAC Safe Firing of Black Liquor Procedures
  - None in last 15 years

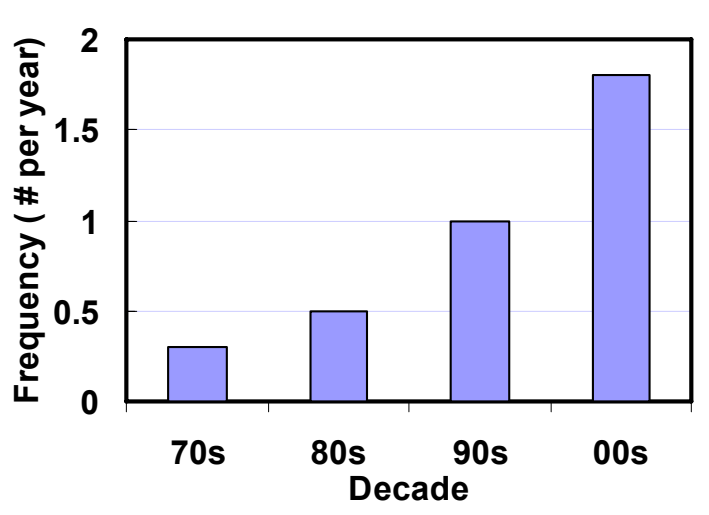
NCG Incineration

- No recovery boiler explosions involving NCG incineration have occurred (yet) in the USA or Canada
- BLRBAC has guidelines for waste gas incineration in recovery boilers
- This remains a concern because in early stages of gaining experience

Dissolving Tank Explosions

- Smelt-water explosions during smelt dissolution
- Historically have gotten less attention
  - Less costly than recovery boiler explosions
  - Reporting has been spotty
  - BLRBAC started list in 1973 after a bad one
  - There are now 27 dissolving tank explosions on the BLRBAC list

Dissolving Tank Explosions



Causes of D.T. Explosions

- Most (>80%) due to heavy runoff after plugged spouts opened
- Miscellaneous causes for the other 20%

External Resources

- Black Liquor Recovery Boiler Advisory Committee (BLRBAC)
  - Started in early 1960s
  - Operating mills, boiler manufacturers, insurers
  - Makes recommendations
- AF&PA Recovery Boiler Committee
  - Started in mid-1970s
  - Restricted to operating companies
  - Carries out various projects
  - Cooperates with BLRBAC

BLRBAC Procedures / Guidelines

- Safe firing of auxiliary fuel
- Safe firing of black liquor
- Emergency shutdown procedures
- Personnel safety and training
- Waste streams in recovery boilers
- Instrumentation and control system guidelines

How to Use BLRBAC

- Attend meetings – April & October in Atlanta
- Go to website – www.blrbac.org
  - Download recommended practices
  - Meeting minutes (available from 2001 – now)
    - Summary of incidents reported and discussed
    - Discussions of current issues
  - Report incidents at your mill
  - Comment on proposed changes to guidelines

AFPA Recovery Boiler Comm.

- Reference Manuals
- AFPA Training Program
  - Now available in electronic format
- Safety Seminars – aimed at operators
- Studies of industry experience
  - Furnace design and explosion damage
  - Floor tube failures
  - Economizers
  - Superheaters (in progress)

AFPA RBC Contact

- Tom Grant
  - Phone (914) 776-6697
  - E-mail tom_grant@afandpa.org

Prevention of Recovery Boiler Explosions

- Management commitment from top down
- Boiler integrity management program
  - Effective inspection and maintenance program
  - Shutdown planning and follow up
  - Well-trained operators
  - Regular audits

Audits

- Audits a key element in risk management
  - Need to be done on a regular basis
  - Need to be taken seriously and have management support
  - Need formal documentation and follow up
  - Should involve resources from outside the mill
- Basically a guided peer review
- Safety audit should be directed strictly at safety and reliability
  - Efficiency audits should be separate from safety audits

AFPA RBC Audit Guidelines Focus Areas

- Personnel safety
- Pressure part integrity
- Boiler water treatment
- BLRBAC recommendations
- Safety interlock systems and fail-safe designs
- Normal and emergency operating procedures
- Training
- Maintenance
- Operating reliability

Keys to an effective audit

1. Commitment from top management
2. Consistent standards for recommendations
3. Written response plan from mill with schedule
4. Company-wide follow-up procedures

- Continued carryover of recommendations from year to year is a sign of a flawed process

Pitfalls

- Lip service from higher management
- Lack of belief in the process by operations
- Adversarial relationships – retaliation
- Lack of standards to audit against
- Superficiality
- Lack of a follow-up plan

The Audit Song
(Santa Claus is Coming to Town)

Oh you better clean up,
they'll look low and high
The department must look sharp,
I'm telling you why
The audit team is coming to town

Fix the steam leaks,
sootblowers better run dry,
Mark the escape routes,
the paint has to be dry,
The audit team is coming to town

They'll find your dirty linen,
They'll review each outage too
They'll look at water and pressure parts,
and how well you've trained your crew

So you better shape up,
got to get on the beam
One that <u>you</u> nailed last year
is on this years team
The audit team is coming to town