AMERICAN FOREST & PAPER ASSOCIATION

RECOVERY BOILER PROGRAM

OPERATION & MAINTENANCE SUBCOMMITTEE

RECOMMENDATIONS FOR DISSOLVING TANK SAFETY

September 12, 2023

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FOREWORD

These guidelines for Dissolving Tank Safety were developed by the AF&PA Recovery Boiler Program Operation & Maintenance Subcommittee for the use of member companies in developing or upgrading policies and procedures to prevent smelt-water reactions in Kraft Recovery Boiler Dissolving Tanks.

These guidelines were developed as a result of an initiative driven by the AF&PA Recovery Boiler Program Operation and Maintenance Subcommittee led by Frank Navojosky of International Paper Company and Don Flach of Georgia-Pacific. This effort was initiated having recognized that the incidents of dissolving tank violence did not have the same downward trend as did Recovery Boiler explosions, as reported to BLRBAC. While this lack of improvement in the reduction of incidents could be the result of reporting error, recent discussions in several forums indicated significant close calls were continuing to occur.

As a result, the Operation and Maintenance Subcommittee decided to drive an effort to better understand the conditions and situations leading to these events. The O&M Subcommittee generated and distributed a survey to gather historical data and practices from North American pulp producers. The Survey responses and BLRBAC data were reviewed and tabulated by Dr. Tom Grace; for which the committee is indebted. Several presentations at AF&PA and BLRBAC were made as a result of this data. As a result of these presentations and discussions, there arose a desire to provide a more prescriptive document related to practices and procedures for the prevention and handling of such events.

- Dissolving Tank Explosions - A Review of Incidents Reported to BLRBAC – Report – November 26, 2013
- AF&PA Survey for Best Practices for The Safe Operation of Dissolving Tanks - Analysis of Responses to Survey – December 19, 2013
- Analysis of Dissolving Tank Violence – Presentation – February 12, 2014

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Purpose and Scope

The purpose of this publication is to share experience and suggestions for member companies to consider when developing or upgrading policies, procedures or specifications for the prevention of smelt-water reactions in Kraft Recovery Boiler Dissolving Tanks. The scope of this document is not intended to replace the detailed due diligence required when establishing or upgrading policies and/or procedures, modifying or constructing chemical recovery equipment, or training employees. It is provided in the spirit of capturing years of operating, maintenance and engineering experience and making it available to member companies to aid in the prevention of dissolving tank incidents.

Pre Event – Prevention from getting into an emergency situation

A. Design of Equipment

When considering a new recovery boiler, a replacement lower furnace or replacing any of the components in the furnace:

- Talk to qualified and experienced manufacturers before making design changes.
- Locating the spouts under the nose arch can provide some level of protection from large slag falls landing directly in front of the smelt spout openings.
- Previous studies have shown that sloped floor designs have a higher potential for build-up and heavy run-off. Consider decanting hearth designs prior to direct replacement in kind.
- If replacing smelt spout openings, consider the height off the floor for the opening - especially for sloped floors. As little as 3 to 6 inches elevation increase at the opening can increase the smelt pool enough to aid in settling down spout flow issues and reduce plugging tendencies.
- Pay close attention to the location, number of and turn down capability of start-up burners to assure the capability is adequate to build or re-liquefy (and burn out) a smelt pool in controllable fashion.
- Remember that smelt spout angle is key.
    - Steeper angled spouts give a more consistent trajectory.

- Flatter angled spouts will likely result in changing smelt trajectories due to exit flow/velocity. This may result in the shatter jet missing the smelt stream.
- Smelt streams have been known to skip over the shatter jets on too steeply angled spouts when faced with a large smelt pool behind them.
- The layout of the existing smelt deck and floor will affect the design options that an owner can consider.

- Do a rigorous risk assessment when considering a retrofit of spouts. Items like:
  - Opening size.
  - Wall box design and
  - Refractory types
  - Spout angle needs to be reviewed.
- To minimize the chance of smelt leaks, bent tube openings should be replaced when changing spout design types.

Spout smelt flow capacity

- Know the smelt flow (liquor solids rate) per spout for the boiler – OEM design.
- Be aware of changes in production over time that could affect the generation rate of smelt and the pluggage rate of the spouts - both increases and decreases.
  - Risks are having too many spouts for smelt flow or not enough. - Concerns are with pluggage, spout tip reliability, and shatter jet capability.
- Review spout smelt flow and shatter jet capacity before making design changes – Use an MOC process for changes (Management of Change)

Shatter Steam

- Redundant or emergency shatter jets are recommended.
- Owners should consider the following when designing the redundant shatter jets.
  - Wide jet pattern to capture different smelt flow trajectories.
  - Different angle than for “regular” smelt trajectories.
  - Consider a different nozzle design from the primary. A different jet pattern may cover a different smelt stream pattern better than the primary nozzle. Do not use a steam saving design, maximize the shattering.

        - Should have a procedure or automation for periodic use to prevent pluggage from lack of regular use.
        - Consider a safe remote location, such as the control room, to activate the redundant shatter jets.
        - Consider the angle of the smelt spouts (and the resulting smelt flows) when designing the location and type of shatter jets.

- Back-up shatter steam should be sourced from a separate header or steam / compressed air source.
- Any source of shattering medium should have a step to ensure that water has been removed prior to initiating use.

Superheater/Furnace Screen

- Any superheater or furnace screen surface area hanging out over the bullnose can pose a risk for buildup or clinkers to shed and fall to the smelt bed causing a disturbance leading to a sudden and excessive smelt runoff.
    - Provide adequate soot blowing coverage to assure continuous deposit removal.

Dissolving Tank

- When considering a retrofit dissolving tank project, review the performance of the original tank design and production rates to identify shortcomings and improvements desired in the new design.
- Criteria for agitator design, effectiveness, and reliability – Top vs side, quantity.
    - Able to remove top mounted agitators for repair while running (spare available, other personnel exposure considerations), however they can have imbalance issues.
    - Back-up agitation (steam spargers) installed near agitators to help clean the area as well as provide emergency agitation.
    - Consider counter agitator rotation to prevent undesirable random tank wave generation.

- Dissolving tank explosion venting
  - Scandinavian RB designers' recommendation is to provide 1.5% of the floor surface area for relief capacity with a minimum area of 10.8 sq. ft.
  - Careful consideration should be given to how close reliefs / hatches are to the dissolving tank. Reliefs located closer to the tank are more effective at limiting damage, however, too close may expel liquid during a puff.
    - Scrubber bypass dampers may not be as effective in relieving pressure waves due to the distance from the dissolving tank.
  - Discharge of the relief vent should be directed to a safe location preferably outside the building.
    - Older reliefs at tank were directed into operating areas creating potential safety exposure for employees.

Dissolving tank overflow

- OEM should be consulted to determine the proper level at overflow in the dissolving tank to provide for minimum acceptable clearance for proper smelt shattering and for sufficient vapor space above the green liquor level for energy absorption during a puff and to provide adequate room for expansion of the pressure wave.
- The dissolving tank overflow should be sized such that at maximum dilution rate the tank level will not rise above the overflow pipe.
- When designing the dissolving tank overflow, consider a wider overflow opening that necks to an overflow pipe. (less likely to plug)
- Consider the use of a packing gland to seal around a hydroblasting wand with double block and bleed to enable cleaning the overflow with a hydroblast wand or rod-out on the run.
- Permanent water sprays located at the overflow connection to the tank to look for water flow in the overflow outlet drain as an indication that the overflow is clear and not blocked.
- TE used to detect overflow should be in a thermowell in the bottom of the overflow piping.

Green liquor pump suction

- Upper suctions should maintain an adequate green liquor level for dilution and agitation.
- Low suctions to allow for pumping out the tank should be secured closed and included in a managed valve system.
- Don't use an internal standpipe. They can fail unnoticed resulting in too low a level.

Level Measurement

- More than one form of level measurement or more than one instrument is recommended for level measurement.
- If using multiple instruments for level indication, it is recommended to establish alarms on deviation between the instruments as well as alarm on high and low level.
- Level readings should be compensated to the current density in the tank.

Dilution

- Have a back-up source of water if using weak wash.
- A safe means must be provided to isolate all dilution sources to the dissolving tank in case of suspected crystallization or if live smelt is seen in the dissolving tank. The intent is to allow operators to isolate dilution sources from the dissolving tank with either an automatic valve or manual valve without being exposed to the dissolving tank that is in a dangerous condition, live smelt present, dangerous run-off condition, crystallization imminent, etc. This should include all liquid and steam sources (except steam shatter jets are to be left in service)
- Typical sources include:
    - Hood showers
    - Overflow from scrubber seal water
    - Dissolving tank agitator seal water
    - Any emergency water make-up to the dissolving tank
    - Weak wash supply to the dissolving tank
    - Emergency dissolving tank agitation such as steam spargers

- Have reliable density measurement and control to prevent live smelt in DT.
    - Refractometers can be reliable for density trim control. Need to keep the lens clear, the cleaning medium must be at the right pressure and temperature.
    - Consider location of refractometer. Mounting in tank vs. in pipe can affect ability to maintain while in service.
    - Dp/bubbler tube - separate taps as far as possible. Need to keep taps open, use demin water / condensate for purge.
    - Dp/bubbler tube taps should be located below the bottom of the upper pump suction to prevent the possibility of exposing the top elevation tap and generating false low density reading.
    - Use a standpipe with larger gap between taps to increase accuracy, and insulate well, use hot water flush.
    - Use of baffles may improve measurement by knocking down turbulence.
    - Utilize two types of density measurement to crosscheck accuracy between devices.

- Having a density meter on the weak wash line is a best practice allowing the measurement of weak wash density and the ability to swap density measurement devices when weak wash lines are swapped, thereby cleaning up the meter that was just measuring green liquor density. This can provide advanced forward leading information in the situation where weak wash density may increase or decrease.

- Reminders for units with 2 dissolving tanks
    - Running the tanks in series is discouraged, this is a higher risk way of operating and requires controls that are more robust.
        - It is recommended that controls/alarms monitor both tanks all the time not just the tank being controlled.
        - Measure flow in and out of both tanks.
    - Carefully consider how emergency water will be supplied to both tanks, do not assume it will flow from one tank to the other.

Spout pluggage early detection alarms

- Mills should consider use of a Smelt spout cooling water outlet low temperature alarm that is tightly set to indicate (through cooling water temperature drop) when smelt flow is diminishing as an early sign of pluggage or operator attention needed.

B. Operational Practices & Procedures

Heavy run-off was cited in 29 of the incidents that were reviewed. It is recommended that a site-specific Emergency Operating Procedure (EOP) be developed and reviewed annually with operators responsible for the safe operation of the recovery boiler. When establishing unit specific preventive operational practices and procedures, the following should be considered/stated in the procedure and are discussed in more detail later in this section:

- Do a rigorous risk assessment when establishing operational guidance to prevent heavy run-off events.
- Remind crews that the first and most important is PREVENTION to avoid the incidence of all spouts being plugged!
- Include procedures to re-liquefy and burn out the smelt bed based on the type of auxiliary fuel – natural gas vs fuel oil.
- Based on experience, provide guidance as to what auxiliary fuel rates are likely to produce smelt bed liquefication and time to initial smelt flow. Greater fuel or time without smelt flow indicate the building of a smelt pool.
- Provide guidance on sootblower use and the effect of knocking material onto the bed.
- Remember that shed material until it is fully melted will increase smelt viscosity by cooling the surrounding smelt closer to the freezing temperature and also the partially melted shed material will form jelly roll smelt until it is fully melted out, will have the propensity to plug openings, and will alter the resultant smelt stream trajectory.
- Interlock sootblowers to automatically retract and stop sequence on a MFT, at least in the furnace area.
- Consider shutting off sootblowers after removal of liquor. Consider whether the boiler has enough heat input to melt out any slag falls that could result in plugged spouts.

- Remind crews of the potential adverse effects of Chill n Blows (avoid Chill n Blows completely if possible), have procedures and standby additional manpower to respond if upsets occur.
- Preventing accumulation in Super Heaters through operating practices. Monitor conditions in upper furnace, quantity of build-up. (Establish a routine boiler inspection protocol on aux. fuel events to confirm level of accumulation in gas passes)
- Require change management (MOC) for sootblower changes (location, frequency, pressures, nozzle type)
- Consider educating and refreshing mill management on the importance of EOP's that protect against catastrophic events. Solicit endorsement from them for operators to take early and immediate actions to prevent these potential events, similar to ESP endorsement.
- Provide guidance for troubleshooting the loss of agitation indicators – low amps, high amps.
- Establish procedures to ensure back-up agitation nozzles are clear.
- Consider a procedure for running back-up agitation prior to any dissolving tank outage. This can help clean out the tank prior to entry.
- Remind operator to bump weighted dissolving tank vent dampers during rounds to ensure they are free to operate. Consider environmental permit requirements.
- Establish a procedure with guidance for liquor firing rate vs. number of open spouts
    - Start-up check list for aux fuel and liquor.
- Other reminders to consider:
    - Verify dissolving tank overflow is clear.
    - Ensure hood wash is adequate rather than adjusting shatter jets to keep build-up down. Do not compromise primary protection.
    - Consider low density or low weak wash flow alarms while firing liquor.
    - Indication that dilution media may not be going where intended.
    - Aux fuel and liquor purge permissive requirements – shatter jet steam flow, spout cooling water flow, dissolving tank level, agitators proven running.
    - Consider permissive for hood wash flow. At a minimum, include in start-up checklist to ensure they are placed in service when needed.

  - Ensure spout cooling water temperature is not too cold, as this can exacerbate build-up and spout pluggage.
  - Determine mill specific upper safe limit for DT density.
    - Typical <27 Baume'
    - This does not necessarily mean the point at which crystallization starts to occur.
    - When is the dissolving tank density considered out of control and should be shut down to reset.

Prevention of plugged spouts

Preparation for chill and blow

- Prepare for chill and blow by reducing bed size.
- Debris falling from superheaters due to sootblowers continuing to run can cause an accumulation of slag in the lower furnace. Slag is often difficult to melt out and can create jelly rolling by being only partially melted, can plug spouts, and can form dams while the rest of the bed melts which can lead to forming pools of smelt
- Shut sootblowers off following a boiler trip to help avoid a large inventory in the char bed.
- Adjust sootblowing during chill and blow and monitor accumulation on the floor

What to do when spouts start to plug

- Procedures should be established to reduce liquor firing based upon the number of remaining open spouts
- Additional resources should be assigned to the Smelt spout pit to ensure spouts remain open.
- A dedicated resource must be assigned to the Recovery Boiler to ensure the bed is monitored for accumulations of smelt pooling behind dams or plugged spouts.
- The use of torches may be needed.

Proper use of Aux fuel

- Put a burner in over the spouts.

- Do not put a burner in behind (uphill) a dam or pile of slag. More critical on a sloped floor boiler.
- Fuel oil, if available, will provide more intense heat.

Proper air adjustments, etc.

- Open primary air dampers on side wall next to spout and also over spout.
- Air will cool and solidify smelt but also intensify runoff if char bed is not completely burned out.

Dissolving tank back up agitation

- Consider proactively starting back up agitation
- Understand the impact on each boiler and the potential damage to the dissolving tank from steam agitation. Refractory lined tanks may be damaged by long periods of steam agitator use.
- Back-up agitation is a temporary measure. Consider the temperature impact of steam agitation.
- Type of back-up agitation (air/steam) may impact the timeline before action is required.
  - Preferential steam agitation design includes a permanently mounted circumferential header around the tank with multiple nozzles entering the tank tangentially.
  - Isolation valves should be mounted as close as possible to the tank wall to reduce pluggage.

C. Maintenance Practices

- Hatches on tank tops need to be functionally verified annually.
- Clean dissolving tank hatches and dampers internally during major outages.
- Temporary shatter jets and Spout torches must be maintained and available for immediate use.

D. Training and Procedures

Training and accountability are critical. Make sure that emergency procedures are in place and followed. Scenarios shown below are examples where EOP's and training/reviews should be provided to crews.

- When having issues with spouts plugging, it is critical to make air and fuel adjustments per SOP so as not to make the problem worse. This could be building a bigger smelt pool, increasing temperature to suddenly cause a heavy run-off. Procedure to include which spouts have the greatest tendency to plug or flow well.
- Lower furnace burner reliability is critical to avoiding issues. Operate burners near spouts; know which burners have most impact. Routinely test burners, maintain operability.
- Use tight low spout cooling water temperature alarms to pick-up plugged or reduced smelt flow for early identification that does not rely on watching camera image. Rate of change more important than absolutes to take out effect of firing rate.
- Dissolving tank vent gas temperature. Increases on run-offs, decreases on reduced flow. Some mills have integrated the gas temperature into tank density control to get ahead of density indication. Rate of change of gas temperature. Consider starting back-up shatter jets on a sudden change.
- Good planning for start-ups to maintain liquor sulfidity. Include production rate limits for given sulfidity ranges.
    - 24% lower control limit (AA basis).
    - Understand impacts of synthetic liquor
- Suggested Liquor firing rate % based on sulfidity measurement

60% BLS firing rate	<16.5% sulfidity	4 startup burners
60-70% BLS firing rate	16.5% < sulfidity <18%	3 startup burners
70-80% BLS firing rate	18% < sulfidity <20%	2 startup burners
80-90% BLS firing rate	20% < sulfidity <22%	1 startup burners
Full BLS firing rate	>22% sulfidity	0 startup burners

- Train operators to monitor and trend bed shape. Consider using a dry erase marker on the bed camera screen to track bed shape and ideal bed shape.
- Remember there is little time to deal with a smelt rush when it occurs.
- Employees at all operational levels must be trained on Emergency procedures and Scenario drills must be held to ensure understanding.

Loss of Agitation Emergency - When to stop firing liquor and fuel

Determine a time limit to operate with back-up agitation in service (steam/air lance, steam ring header) with one or more mechanical agitators still in service.

- Determine the minimum number of agitators to remain in service and the maximum production rate that can be allowed if agitator failure occurs. (i.e. If one or more mechanical agitators fail, production rate reduced by 25%, 50%, etc.)
- Use motor running signal and/or low amp alarm to indicate loss of agitator.
- Understand the impact on each boiler including potential damage to tank from steam agitation as well as the impact on high temperature limits.
- Type of back-up agitation (air/steam) may impact the timeline before action is required.
    - Back-up agitation should be used while a controlled outage is planned, not as an extended substitute for mechanical agitation.
- Consider automatic liquor divert that occurs 30 minutes after the loss of the last mechanical agitator.
    - This allows for some time to stop liquor firing while preventing drawn out events and losing track of time while a pile of molten smelt grows. Temporary agitation is intended only to provide a safe means to allow shutdown.

<u>During the Event</u>

A. Things to do when the unit is in unstable/emergency condition

Once the boiler has entered a situation where a smelt rush or dissolving tank violence event has the potential to begin, appropriate action and equipment utilization must be employed to ensure the safety of the personnel and to protect the equipment.

Emergency condition Alarming

- Sound emergency lights and sirens in upset conditions to keep extra personnel away.

B. Operational Adjustments

Dissolving tank agitation

- Ensure all permanently mounted agitators are in service and amp loads are in normal range.
- Ensure the availability of and consider the proactive use of additional dissolving tank agitation using spargers, steam or air lances. Care must be taken to not have temporary lances interact with rotating agitators.
- Increase monitoring of DT conditions / tests, then begin using back-up agitation.

Dissolving tank level

- Maintain normal dissolving tank level, do not increase or lower the level in anticipation of an event.
- Maintain appropriate vapor space in the dissolving tank.
- Need adequate room to shatter the smelt stream before contacting the liquid surface.
- Need vapor space above the liquid to handle a potential shock wave.

Dissolving tank density action limits

- Dissolving tank density should be controlled to stay below limits that would accelerate toward a crystallization event
    - Typical upper control 19 to 21 Baume
    - Start reducing firing rate (Typically greater than 23 Baume)
    - Shutdown limits to initiate the Dissolving tank crystallization emergency procedure must be established. (Typically around 27 Baume)

Example Conversion Chart from a specific Mill at 90% RE for Reference:

(Courtesy of Jeff Butler, Valmet Automation)

GL Density @203F (g/l)	S.G.	Baume	TTA @90% RE (lb/cuft)	TTA @90% RE (g/l)
1102	1.142	18	6.2	98.6
1120	1.16	20	7.1	113.1
1128	1.169	21	7.5-8.0	120.4
1148	1.189	23	8.5	136.4
1166	1.208	25	9.5	151.7
1177	1.219	26	10.0	160.6
1186	1.229	27	10.5	168.6

Shatter jets

- Valves for adjusting the shatter jet flow should be arranged to allow method(s) to adjust shatter jets from a safer location than right in front of the spout. Linkages to adjust from a deck above or to the side have worked well.
- Consider shutting door (if spout hood design has a door) while adjusting the shatter jet. Alternately, a welding blanket can be put over the opening.
- Activate 2nd or emergency jet ahead of time if an issue is suspected that may result in a smelt rush

- Consider automating activation of emergency shatter jets based on modeling of dissolving tank gas temperature or spout cooling water outlet temperature.
- Temporary shatter jet (lance supplied by a hose) can be installed ahead of time. Ensure the steam has been properly purged of condensate.

How to handle large slag falls

- Crew must be aware of the potential of slag to fall and create a dam preventing smelt from reaching the spout opening and forming a pool of smelt.
- Designate an individual with authority who is knowledgeable and is not a person involved in the details /work. This person must be free to assess and to oversee all aspects of the situation. They must be able to step back to assess the situation and not be so focused on one aspect, such as unplugging the spouts, that they miss what may be occurring in the recovery boiler furnace with smelt pooling for example.
- Slag is often difficult to melt out and can create jelly rolling by being only partially melted, can plug spouts, and can form dams while the rest of the bed melts which can lead to forming pools of smelt.
- Preference must be given to utilizing burners that provide heat in front of the spouts to melt saltcake in front of the spouts first and allow smelt/salt to flow out of the spouts before using burners in other areas of the bed to melt the remaining bed. This is to avoid the potential for forming pools of smelt and the risk of a smelt rush.

Preventing spout pluggage during Boiler trips

- Put a rod in spout openings immediately after boiler trips.
- This can help to keep an opening when the shed occurs. This may leave a smelt path clear for the restart and will assist in opening the spout if the clear pathway is not maintained.

What to do when a smelt pool is observed

- It is hard to judge the size of a smelt pool, even with very experienced personnel
- Consider starting actions to reduce or eliminate the smelt pool when any smelt pool is observed. This can be done by air and fuel adjustments.

- If pool is small, begin to cool the pool by adding air to that location and removing burners that provide heat to that location while monitoring the actions to ensure the smelt pool is rapidly beginning to diminish or solidify.
- If the pool is large, remove all fuel from the boiler and allow the smelt pool to cool and solidify before re-starting fuel firing. Note that a spout must be open before re-firing auxiliary fuel. Consider whether to cool and waterwash rather than burning out.

C. How to safely unplug spouts

Typically, rods are used as a first attempt at unplugging spouts.

- Limit the time using rods to prevent ergonomic and stress injuries.
    - Rod support stands and strike plates can reduce the risk of mechanical rodding.
    - There is a risk of damage to spouts, spout openings and floor tubes from the rods.
        - Only blunt tipped rods should be utilized.

Use spout torches to open a smelt path

- A completely plugged spout should be able to be opened in less than 45 minutes and with significantly less physical effort as compared to mechanical rodding.
- Torches should be available for use ahead of the actual need.
- The torch fuel is lit first and compressed air is added to intensify the flame. Too much air can blow the torch out. Position in the spout trough can affect the stability of the torch flame.
- Implementing their use requires a lot of prep-work, training, and practice.
- Procedures for torch use must be in place, operators trained on use, and the use practiced.
    - The torch must be continually manned.
    - Consider needs for sloped floor units; a bend may be required to direct the flame up, rather than just running along the floor.
    - Gas supply to the torch must be after main SSOV, (before start-up and load SSOV) requiring a boiler purge to allow fuel admission.
        - This enables remote shut-off of the torch if needed.
        - For systems fueled by propane, a solenoid valve interlocked to the BMS purge should be used to provide this protection.

  - Ensure there is not a time limit to start a burner in the BMS logic. This is not a requirement although it is included in some designs. Purge conditions must be maintained.
  - A method of ignition of the torch must be designed prior to use. Handheld propane household torches: a road flare and other methods have been successfully utilized and provide reliable method of light-off without personnel near the working end.

D. When not to unplug spouts & what to do

In some cases, it may not be safe or the most efficient path to open up plugged spouts. If there is a loss of agitation, or other dissolving tank issue, or a large pool of molten smelt in the furnace is present, no smelt flow is desired. In these cases, pull all fire.

Many incidents regarding the dissolving tank are the result of trying to run through problems due to production pressures. To guard against this, recognize potential problems ahead of time and provide guidelines for when events occur to take some of the emotion and production pressure out of the calculation.

Consider the size of the bed.

- Is it too large to safely control the burn-out?

How long has the boiler been down?

- Proactively wash out the bed while it is cool rather than attempting to burn out and possibly have to re-cool again if not successful.

Consider present condition and availability of start-up burners.

- Load burners provide no benefit for burning out the bed.
- Inoperable burners above the spouts can create an unsafe smelt pool if burners distant from the spouts are used while the spouts are plugged, or a dam exists.
- Switching to oil can cause rapid changes in bed conditions and spout opening conditions, leading to smelt rushes.

E. Emergency Procedures - Procedures when all spouts are plugged

Emergency condition Alarming

- Sound emergency lights and sirens in upset conditions to keep extra personnel away

Auxiliary and Liquor fuel firing

- All Auxiliary and Liquor fuel should be tripped immediately once all spouts are plugged
- Procedures should be in place to establish the minimum # of open spouts before re-firing auxiliary fuel
- Do not use aux fuel to open spouts if all spouts are plugged
- Procedures should be in place to establish limits on auxiliary fuel firing rate based on number of open spouts
- For lower furnace heat rate on auxiliary fuel, most decanting units cannot get above 50% MCR with starting burners. Most sloped floor units can achieve this.

Spout pluggage

- If pooling is observed, the pool should be allowed to cool and only then should a path from the spout into the boiler be re-established through rodding or torch use (See above section for unplugging spouts).
- If the solidified smelt is deep and rodding is not sufficient to establish an opening, properly designed torches should be utilized. (The boiler must have the fans running to maintain a purge).
- For sloped floor units, torches should be bent so when they are inserted, they burn upward vs. parallel to the floor slope.

Observe the bed

- Monitor the bed for smelt flow and internal bed dams
- Designate an individual with authority who is knowledgeable and is not a person involved in the details /work. This person must be free to assess and to oversee all aspects of the situation. They must be able to step back to assess the situation and not be so focused on one aspect, such as unplugging the spouts that they miss what may be occurring in the recovery boiler furnace with smelt pooling for example.

Water wash may be needed

- Procedures must be in place that based on an assessment that the situation cannot be rectified in a safe manner by rodding or use of torches, to shut down, cool down to a safe level, and water wash the spouts open.

What is an open spout

- Procedures must be available to define what an "open spout" means. A dam just inside the spout opening with pooled smelt behind it is not a spout that is considered open and safe.
- Procedures must be available on how to identify dams that would prevent smelt from reaching the spout opening.

Spout open but not smelting

- After a normal amount of time to avoid building a large smelt pool:
    - Limit the time for heat input with auxiliary fuel (<50% MCR) with no smelt flow
    - Limit the time of firing liquor without smelt flow (even with spouts open)
    - It is difficult to determine how large/deep the smelt pool is and operations should rely on an experienced person to assess the situation and to assess any size smelt pool that could be an issue if released uncontrollably.

Other factors

- Some boilers run with some spouts intentionally plugged to improve smelt flow
- Need to take Emergency situations into account in procedures
- Procedures must be in place to identify the risk of adding black liquor when a large pile of slag is in the furnace and a quick melting of the slag that could cause a smelt rush in either sloped or decanting floor boilers

F. Additional Equipment Use

Bed Cameras

- Multiple cameras that capture spout wall(s) and the rest of the furnace floor are preferred.
- Cameras should be kept functional
- Having the ability to review incidents (recording function) after the fact for knowledge sharing, training, and monitoring is essential. High quality bed cameras with recording capability are available

Spout cameras

- Have cameras aimed at spouts and displayed in the control room to verify spouts are open and flowing
- IR cameras can detect, and alarm based on a change in temperature, indication of a change in flow

Spout torches

- The use of properly designed torches can greatly aid in unplugging spouts and reducing physical strain injuries.
- Spring loaded gas valves at the torch should be utilized to ensure torches are continually manned when lit. No bypasses of gas valves are allowed.
- Remote gas supply shutoff must be provided in case evacuation is needed and gas must be shut off remotely.
- Procedures for use must be well written and understood and operators should be allowed to practice with torches to ensure familiarity prior to use.

Spout plugs

- Operators must be discouraged from inserting / removing a plug or restrictor manually during a smelt rush or dissolving tank violence event

G. Emergency Procedures - Dissolving tank Crystallization/Live Smelt in dissolving tank

If crystallization occurs or live smelt is known to be present in the dissolving tank perform an immediate shutdown. This may be indicated by very high density or high agitator amp readings following a loss of dilution or agitation.

- Look in the dissolving tank before adding water to determine if live smelt is present. Do not add water if live smelt is present or if it cannot be determined.
- Shut down agitators to prevent disturbing the smelt.
- Live smelt in dissolving tank
  - If live smelt is assumed, don't send someone to confirm, just take actions
  - Smelt observed glowing inside the tank and/or a hot spot on the tank are indications of live smelt
  - Shut off all water sources from a safe location if live smelt is suspected, not just dissolving tank dilution returning back through the spare green liquor line. Shut off: dissolving tank dilution, scrubber make-up, duct wash, wall wash, hood showers, emergency water, dilution water, agitator seal water, pump packing water, and any other know water source going into the tank
  - Perform an immediate shutdown and trip all fuel and cool the bed in the boiler
  - Shut off all permanent agitators and any temporary or auxiliary agitation in the dissolving tank that may be in use at the time
  - Allow the tank to cool before restoring agitation and dilution
  - The internal tank condition must be evaluated to determine the best way to remove accumulations of crystalized material. Normal tank start-up conditions must be established. This may be physical removal through hydroblasting or by re-dissolving the material through dilution and agitation.
  - Determine root cause of live smelt in the dissolving tank before resuming liquor firing

H. Safe procedures if efforts cannot prevent a smelt-water reaction

Consider if ESP is needed after a significant dissolving tank explosion.

- There may be pressure part damage in the lower furnace that could cause a larger reaction.

Post Event - Post Incident critique

Once the boiler has been stabilized, and safely restored to an operational state a post outage critique should be held.

- This should include a review of all emergency procedures utilized to ensure they were clear and understood.
- Was the emergency equipment available in sufficient quantities and in good condition? Such as temporary agitators, temporary shatter jets, spout torches.
- All personnel involved should be given an opportunity to discuss what worked and what did not work
- Improvements in emergency procedures and scenario drill documents should be updated in a timely manner
    - Was emergency egress appropriate
    - Any fume / vapor concerns
- Are there design changes that need to be made as a result of the critique
- Conduct a root cause analysis of the event.
    - If appropriate, report the incident to BLRBAC (Black Liquor Recovery Boiler Advisory Committee) using the guidance found at BLRBAC.net and the most recent incident report form found on that site