WPAC Drum Dryer Symposium

DEVELOPING BEST PRACTICES FOR SAFER OPERATIONS

WOOD PELLET ASSOCIATION OF CANADA

Online, Thursday, April 4, 2024
9-11 AM PST (1-3 PM AST)

Best Practices in Managing Combustible Gas

pellet.org/resources/best-practices-for-managing-combustible-gas/

WPAC Drum Dryer Symposium

ROTARY DRUM DRYER SAFETY

Mike Tasker, Occupational Safety Officer
WorkSafeBC


WPAC Drum Dryer Symposium
LEARNING FROM THE PAST
FOR A SAFER FUTURE
WOOD PELLET
ASSOCIATION OF CANADA
Gordon Murray, Executive Director, WPAC

OUTLINE

- Background
- Initiatives and Resources
- Looking Ahead: Upcoming Focusses
- Closing Remarks

Photo Credit: WPAC, Premium Pellet Ltd.

INDUSTRY EXPERIENCE WITH DRYER INCIDENTS

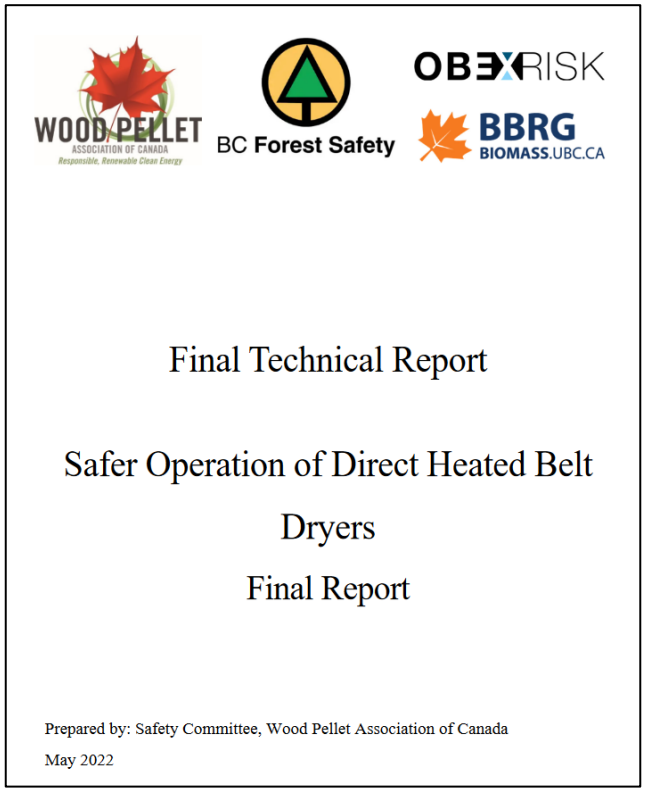
- Dryer processes pose risks of fires and explosions in wood pellet production
- Industry incidents between 2011 and 2020
- Key learnings:
  - Startup and shutdown procedures
  - Control room operator supervision
  - Coordination of activities
  - Inspection, testing and maintenance of equipment
  - Explosion isolation and venting
- More information about root causes can be found in reports by Technical Safety BC and WorkSafeBC

CRITICAL CONTROL MANAGEMENT

- Systematically assessed hazards associated with drum dryers
- Identified critical controls to prevent ignition of combustible dust
- Helped identify areas for improvement and define roles and responsibilities

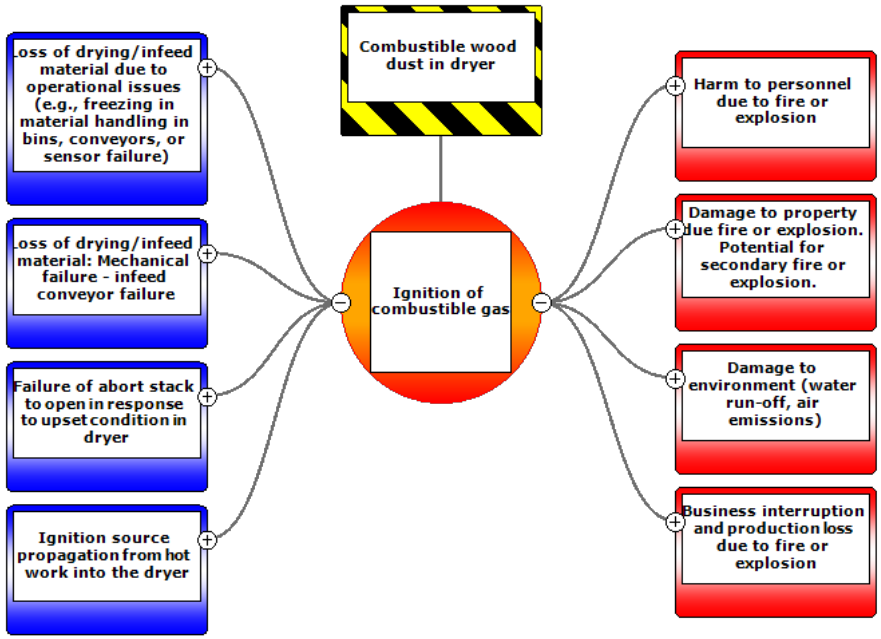
BELT DRYER SYMPOSIUM

- Extensive industry collaboration
- Presentations from Canfor, Drax, Skeena Bioenergy, suppliers
- Belt Dryer Working Group formed
- Sub-working groups specialized on key issues
- Online workshops
- Testing and research at UBC Biomass and Bioenergy Research Group to characterize fibre and improve dryer operation
- Technical report and factsheet



COMBUSTIBLE GAS BOW TIE ANALYSIS

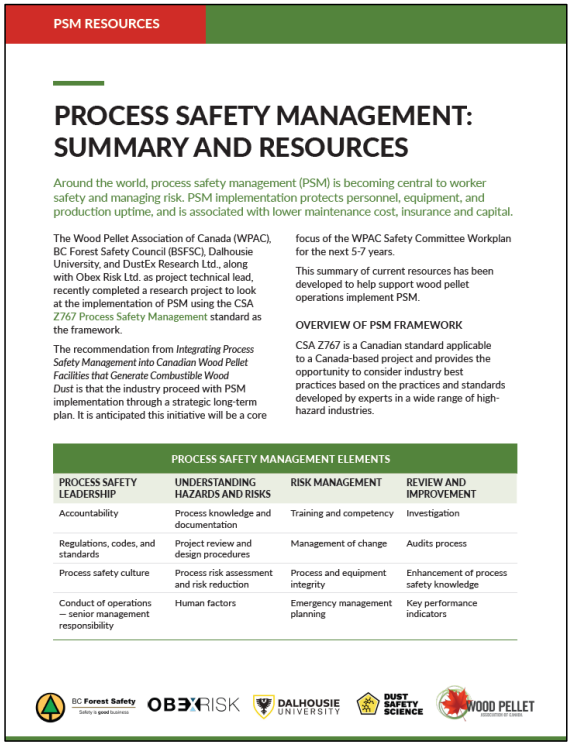
- Completed in collaboration with Premium Pellet Ltd.
- Involved online workshop with frontline team members
- Summary report produced
- Discussed in more detail later in symposium



Credit: Obex Risk, WPAC

UPCOMING INITIATIVES AND OBJECTIVES

- Proposed Drum Dryer Working Group
  - Build on successful approach taken with belt dryers
- Process Safety Management (PSM)*
  - Protects our facilities and people, access to affordable insurance, and our industry's reputation
  - Full PSM Research Project Report
  - PSM Project Summary



PSM RESOURCES

PROCESS SAFETY MANAGEMENT: SUMMARY AND RESOURCES

Around the world, process safety management (PSM) is becoming central to worker safety and managing risk. PSM implementation protects personnel, equipment, and production uptime, and is associated with lower maintenance cost, insurance and capital.

The Wood Pellet Association of Canada (WPAC), BC Forest Safety Council (BSFSC), Dalhousie University, and DustEx Research Ltd., along with Obex Risk Ltd. as project technical lead, recently completed a research project to look at the implementation of PSM using the CSA Z767 Process Safety Management standard as the framework.

The recommendation from *Integrating Process Safety Management into Canadian Wood Pellet Facilities that Generate Combustible Wood Dust* is that the industry proceed with PSM implementation through a strategic long-term plan. It is anticipated this initiative will be a core focus of the WPAC Safety Committee Workplan for the next 5-7 years.

This summary of current resources has been developed to help support wood pellet operations implement PSM.

OVERVIEW OF PSM FRAMEWORK

CSA Z767 is a Canadian standard applicable to a Canada-based project and provides the opportunity to consider industry best practices based on the practices and standards developed by experts in a wide range of high-hazard industries.

PROCESS SAFETY MANAGEMENT ELEMENTS			
PROCESS SAFETY LEADERSHIP	UNDERSTANDING HAZARDS AND RISKS	RISK MANAGEMENT	REVIEW AND IMPROVEMENT
Accountability	Process knowledge and documentation	Training and competency	Investigation
Regulations, codes, and standards	Project review and design procedures	Management of change	Audits process
Process safety culture	Process risk assessment and risk reduction	Process and equipment integrity	Enhancement of process safety knowledge
Conduct of operations — senior management responsibility	Human factors	Emergency management planning	Key performance indicators

*This project was funded by WorkSafeBC under an Innovation at Work grant. The views, findings, opinions, and conclusions expressed herein do not represent the views of WorkSafeBC.

CLOSING REMARKS

- With the success of the belt dryer initiative, our industry has decided to focus efforts on improving drum dryer safety
- We will continue to work together to improve our understanding and resources to enhance safety
- Drum dryer working group is open to all—connect with others, share knowledge and collectively work together to improve safety


WOOD PELLET
ASSOCIATION OF CANADA

Understanding the Root Causes

Kayleigh Rayner Brown, MASc, P.Eng.,
Director and Process Safety Specialist,
Obex Risk Ltd.

WPAC Drum Dryer Symposium

April 4, 2024

Disclaimer and Notice

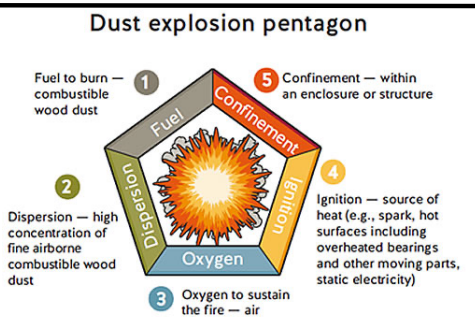
This report makes no endorsements of the products, services or companies mentioned. Identification of a company's technology is for illustrative purposes and is not endorsement.

Outline

- Hazards and threats to drum dryer safety
- Incidents, severity and frequency
- Lessons learned
- Closing remarks

Drum Dryer Hazards

- Drum dryers used in manufacturing pharmaceutical, wood, food products
- Combustible wood dust presents risk of fires and explosions, as well as the formation of combustible gas (syn gas)
- Fires and explosion can occur due to ignition from:
  - Mechanical failure, electrical failure, hot work, propagation from interconnected equipment, incorrect start-up and shutdown procedures
- Consequences:
  - Propagation to interconnected equipment, harm to people, damage to equipment and business disruption



Dust explosion pentagon (WorkSafeBC, 2024)
Progression of explosion from burner/dryer to dust collection system (Technical Safety BC, 2020)

Dryer Incidents

- Corn facility (2009, 2 seriously injured)
- Coal (2010, explosion, fire, building damage)
- Corn (ethanol plant) (2014, explosion, three walls blown out, panels blown off building)

Credit

- US Chemical Safety Board (www.csb.gov)
  - Didion Milling dry corn milling facility (2017) (fluid bed dryer)

Credit

NFPA (2016). Oven, Furnace and Dryer Explosion Incidents

Dryer Incidents

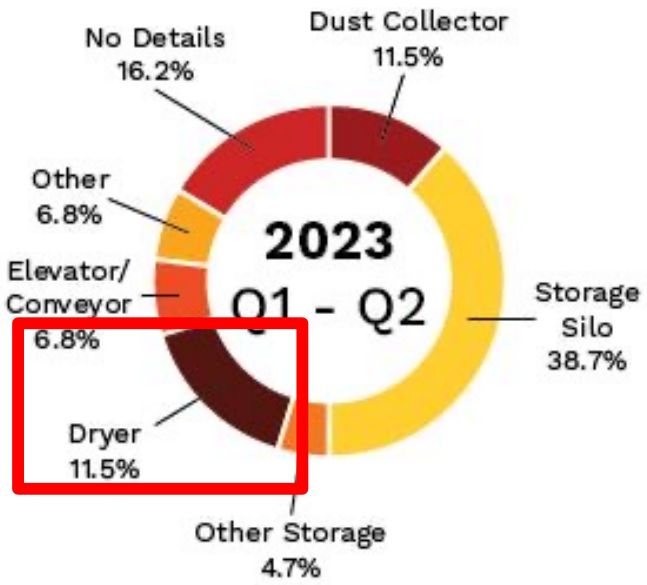
Industry	Cause or Issues	Consequence
Pharmaceuticals	Adequate relief vents were not installed	Destroyed equipment and damaged room
Wood pellets	Recycled wood fines entered dryer and ignited (ignition may have happened outside dryer)	Destroyed dryer and damaged part of building
Food processing	Operating beyond design specifications, too hot and incorrect infeed, overloaded conveyor	Destroyed dryer, one fatality and one injury, damaged part of building
Soy protein isolate	Tramp metal trapped between agitator and vessel body (ignition source)	Explosion panel replacement and building damage

Credit

NFPA (2016). Oven, Furnace and Dryer Explosion Incidents

Incident Frequency and Trends

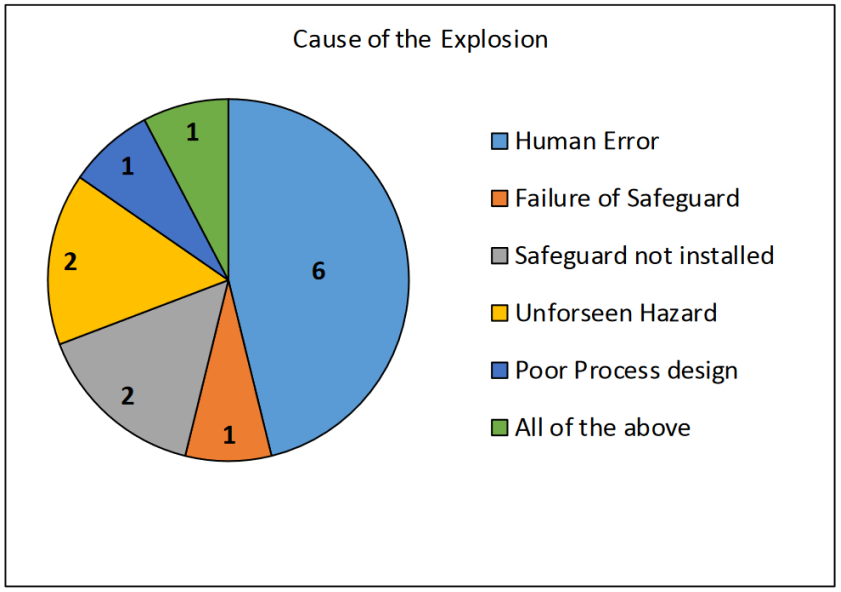
- Actual number is believed to be higher
- Loss can be significant
- FM Global (2013):
  - 25 years – 14 explosions involving dryers (5 in spray, 7 in drum, 2 flash)
  - Spray dryer manufacturer: 40 years – 285 fires, 56 explosions
- Dust Safety Science (2023) Mid-Year Incident Report: 27 fires, 2 explosions



Dehlbom, J. (Firefly). Personal correspondence.
Dust Safety Science 2023 Incident Report
Febo, H. (FM Global) (2013). Processes for Drying Powders – Hazards and Solutions.

Incident Frequency and Trends

NFPA (2016): Survey response to "*What was determined to be the cause of explosion?"*



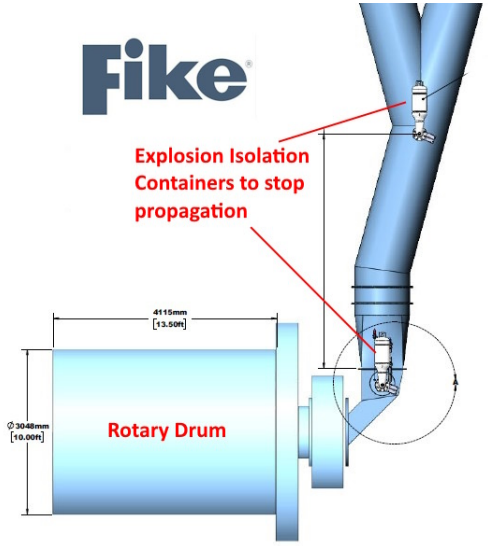
Febo (2015): Dryer incidents by cause

Cause	Number of Incidents
Overheating	20
Unknown	11
Open flame	9
Spark (other than static)	5
Chemical reaction	5
Component failure	4
Friction	2
Hot surface	2
Hot work	1
Static	1
Implosion	1

NFPA (2016). Oven, Furnace and Dryer Explosion Incidents
Febo (2015). Drying of combustible powders - Risk & mitigation

Lessons Learned and Recommendations

- Mechanical integrity
- Operating parameters (e.g., temperatures, capacity)
- Management of change
- Explosion isolation is recommended
  - Challenge: not possible to have explosion protection on the body of the rotary dryer
  - Need to mitigate effects of explosions and prevent them from propagating through process (causing secondary explosions)
- Spark detection and extinguishing in heated air and product lines
- FM Global *Property Loss Prevention Data Sheet* (e.g., high temperature switches interlocked with deluge)



Deflagration isolation (courtesy of J. Mycroft, Fike Canada)

FM Global Property Loss Prevention Data Sheet Wood Processing and Woodworking Facilities 7-10 (2010)
Febo (2015). Drying of combustible powders - Risk & mitigation

Closing Remarks

- Dryers pose the risk of fires and explosions
- Incidents occur more frequently than observed in media or described in literature
- Root causes range from mechanical failure to improper startup and shutdown procedure
- Recommendations for risk reduction include preventative maintenance, explosion protection and extinguishing, and formalized operating procedures
- Opportunity for working group to:
  - Investigate and systematically examine near-misses,
  - Assess risks and explore suitable risk reduction approaches, and
  - Standardize knowledge across industry.

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Industrial Safety and Risk Management

- Hazard Analysis
- Inherently Safer Design
- Critical Control Management
- Combustible Dust Hazard Consulting
- Process Safety Research

www.obexrisk.com

Drum Dryer Symposium

Optimizing Dryer Operation and Reducing Risk

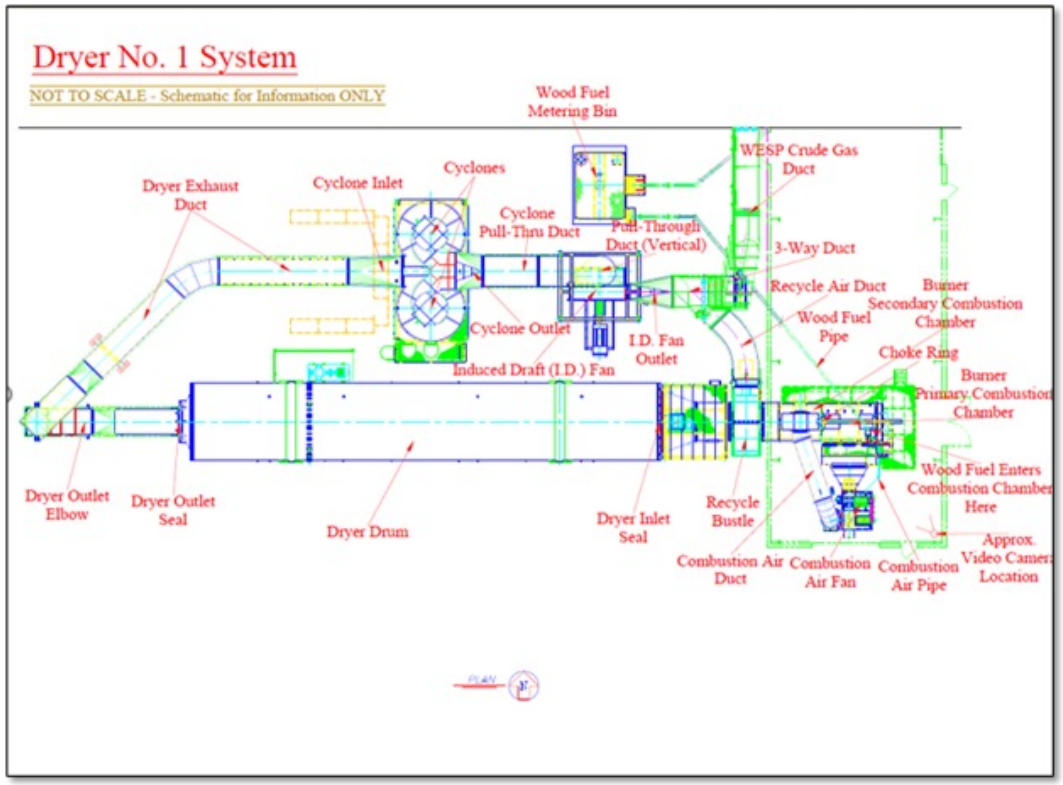
Jeff Johnston

Drax North America

Understanding the Basics

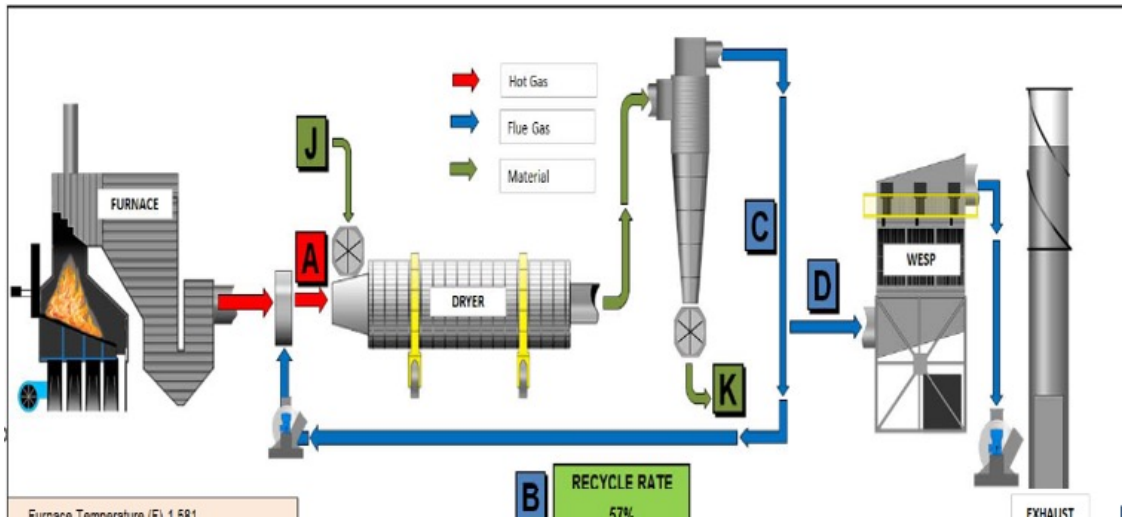
What is the purpose of a Dryer?

- Dryers are machines that take dry solid wood materials like wood chips, sawdust, animal feed, hog, etc. and process the material to reduce the moisture content



Rotary Dryers

Depending on the specific facility's dryer system, there are slight differences in the process, but the outcome is still the same. we will look at the Rotary dryers and how time, turbulence and temperature impact the drying process.



Rotary Dryers (time)

- In looking at the drum dryers, time impacts the process of drying the same way your home dryer does with clothing.
- The Drum dryers used at Drax allow for breaks in the airflow. There are louvres within the dryer and as they rotate, the material hits them, they deflect material in different directions thus allowing the material to dry as it is working through the drum.
- The ID fan, located within the ducting for the drying system, determines how fast material moves through the drum. Speeding up the fan will pull product through faster, which will result in a higher moisture content of the product inside, while slowing it down will let the product have more drying time

Rotary Dryers

Turbulence

•This is the force at which the material will cycle through the drum, mixing the hot gas and wet material to thus resulting in dried material.

Temperature

•**<u>The more heat, the drier the material.</u>**

•The higher the outlet temperature, the dryer the material. The reason for this is that the moisture content in the sawdust we are drying acts as a sponge for heat (or energy). Water acts as a better heat transfer medium than the air or sawdust does, and therefore absorbs the heat effectively. As moisture content drops, the ability of the product to absorb the energy also drops, therefore resulting in a higher outlet temperature.

•Outlet temperature: there is a sensor right at the end of the drum – it is a temperature probe that takes a temperature reading, an inline thermocouple that constantly provides feedback to the PLC/HMI. There is also a sensor at the beginning of the drum, called the inlet temperature.

•The difference in the inlet temperature to the outlet temperature tells you how effectively the dryer is performing.

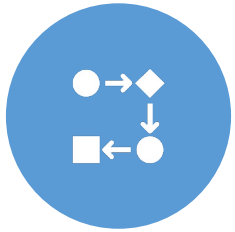
•Drum dryers require constant human interaction to assess moisture content and adjust as needed. This is done by the Operator!

Start up Procedures

STARTING THE DRYERS ARE A CRITICAL SAFETY STEP

DEVELOP 1 STANDARD FOR STARTING THE DRYER DRUMS.

ALWAYS PERFORM FIELD INSPECTION PRIOR TO STARTING THE SYSTEM



CREATE A STEP BY STEP PROCESS FOR STARTING.

How to Optimize your system Operationally

- Control Narratives & HMI Refinement
  - Updated for dryer/furnace
  - Updated for balance of plant
  - HMI Alarms rationalized per alarm philosophy
- Furnace Combustion Optimization
  - Fuel handling system software enhancements to increase reliability (pushers have redundant controls, prox and time base)
  - Update P&ID controls for main combustion parameters based on ambient temperature compensation.
  - Primary/secondary combustion air flow control improvements
  - Grate-speed, fuel push cycles, & under-fire damper flow control re-balanced to maximize pre-heat and combustion zone surface area.
  - Signals from flue gas combustion analyzers to be used for fuel/air real-time adjustments (pending re-calibration)
- Dryer Throughput Measurement & Improvements
  - Dryer infeed wet fibre moisture content (Install moisture meters)
  - Dried fibre outfeed weigh scale
  - Modified PM schedule of dryer instrumentation to improve reading accuracy
  - Yard loader operator's dryer infeed display
- Dryer Control Optimization
  - Dryer ID Fan control & cyclone pressure differential sensor improvements
  - Dryer outlet temperature, and backpressure / recycle flow re-balancing
  - Emergency shutdown automated sequences & improved isolation gate hydraulic controls
  - Deluge system improvements (pumps, nozzles, valve supervision & flow confirmation)
  - Safety functions respond to critical thresholds to independently achieve safe-state

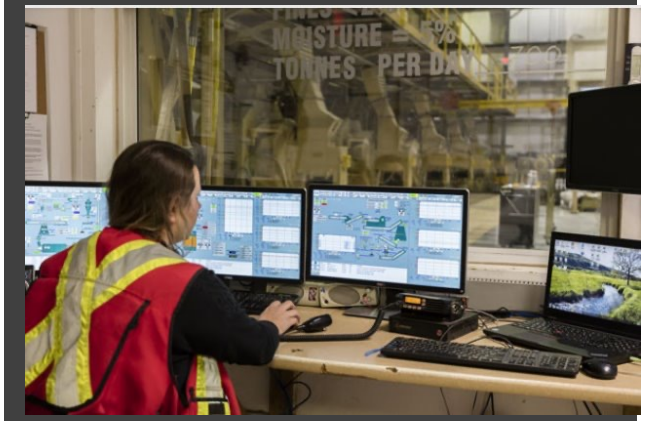
How to Optimize your system Safety Perspective

Fault Group PLC Tag	Fault Group	Fault Group Description	Individualized Event Description
DRYER_SAFETY_SIS.SIF.1.1	1	High-Temperature	Dryer Inlet over-temperature
DRYER_SAFETY_SIS.SIF.1.2			Dryer Outlet over-temperature
DRYER_SAFETY_SIS.SIF.1.4			Dryer ID Fan over-temperature
DRYER_SAFETY_SIS.SIF.1.5			Dryer recycle over-temperature
DRYER_SAFETY_SIS.SIF.2.1	2	High-Pressure	Dryer Inlet over-pressure
DRYER_SAFETY_SIS.SIF.2.2			Dryer ID Fan over-pressure (backpressure)
DRYER_SAFETY_SIS.SIF.8.1	8	Gas Composition Monitoring	WESP Stack Gas Analyzer High COe
DRYER_SAFETY_SIS.SIF.8.2			WESP Stack Gas Analyzer High O_2
DRYER_SAFETY_SIS.SIF.8.3			WESP Stack Gas Analyzer Faulted
DRYER_SAFETY_SIS.ESD.9	9	Emergency Stop	Dryer E-Stop Pushbutton Activation

- Deluge and process water delivery (Pump House)
  - Install flow and pressure meters on process water piping to stage pumps and measure throughput
  - Improve dryer island deluge system based on flow and pressure
  - Develop new HMI screen to control all deluge valves and nozzles
  - Develop alarms based on pressure and flow
- Safety Instrumented Systems Installation
  - Critical process measurement via redundant SIL2 sensors
  - Using SIS to bring everything to a fail safe

Dryer	Cause	Consequence	Safeguard	Action Item

Shutdown Procedures

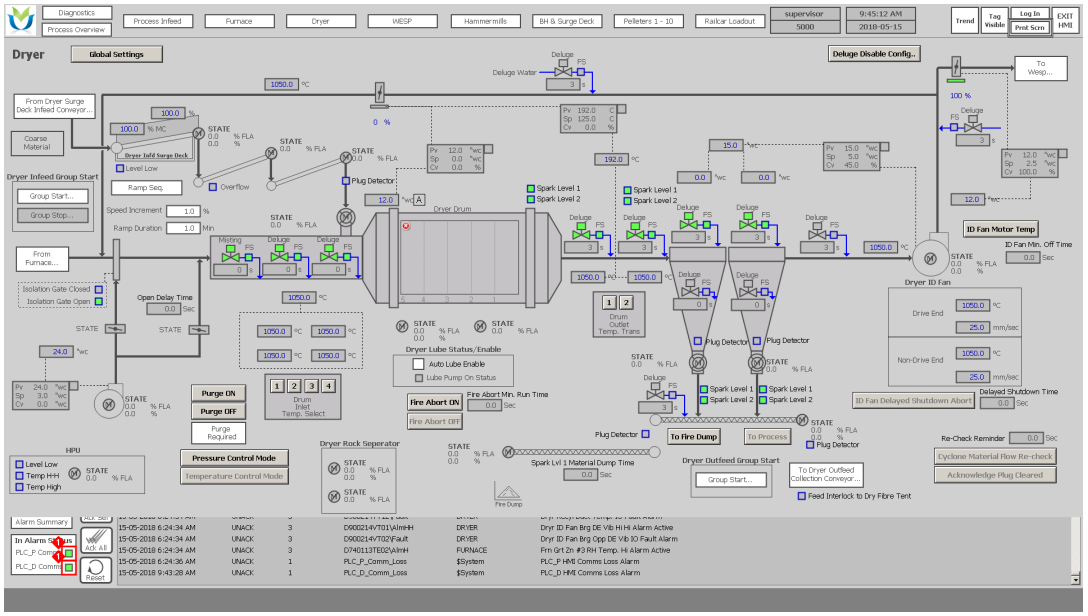


- The Shutdown Procedure must be filled out every time the dryer is shut down!
- ANY abnormal HMI or Spark Events must be recorded
- Must be signed by team lead/Supervisor
- Must have a Cool down assessment time
- Must record time when each stage of process has been completed
- Constantly record temperature noting any swings or changes
- Must be reviewed by Management team to ensure it is filled out correctly everytime

- **Dryer System Shutdown for Entry** –
- **Plant Operator Procedure**
-
- *When any process stop occurs, manual (by Operator "Burner Stop" or "Cool down") or automatic (as a result of high temperature(s), fire shutdown, dryer motor faults, etc.), the dryer enters the Cool Down cycle. The Cool Down process is the most vulnerable operating mode of the dryer as it involves the using oxygenated air and water to cool down the dryer.*

- The *Cool Down Period* is **a minimum of THREE hours** (regardless of the temperatures in the system). This Period must be completed successfully prior to initiating 45 minute *Cooling Assessment Test* listed below.
- During the *Cool Down Period*, the system automatically triggers the system deluges to activate intermittently (at pre-specified settings (aka in the medium setting the system deluges for 10 seconds every 3 minutes)) to ensure any hot spots in the dryer system are addressed during this *Cool Down Period*.

- **How do we manage risk in the dryer systems?**
- Always follow written shutdown procedures every time a dryer is turned to cool down.
- Be aware of the dryer, recycle, inlet, outlet, stack temperatures at all times.
- Write down any anomalies from the procedure and report.
- Communicate to your supervisor when something out of the ordinary happens ie. Excessive sparking, temperature fluctuations, and take the appropriate steps.
- Ensure all deluges are working at all times.
- Airflow is always happening during the drying process, IF airflow stops Syngas can build up
- Use temperature gun to record outside temperature of ducts.
- Drum Dryers have spark detects spread throughout the system.
- All Dryers have many temperature sensors spread throughout them.
- Maintenance and cleanings are done as often as needed.
- Watch dryer pressures to ensure dryer systems stay negative.
- Ensure all other sensors are working (Prox, switches, Moisture Sensors, Level Sensors, etc)



SHAW RENEWABLES

Drum Dryers

Continuous Improvement, Status & Outlook

April 4, 2024

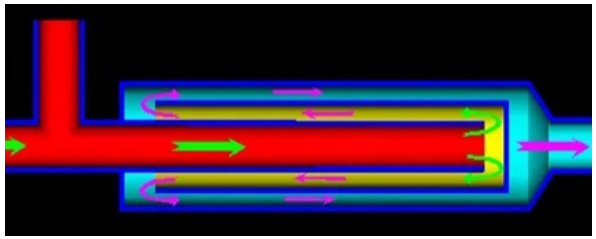
Jody Head
Site Supervisor, Shaw Renewables

Current Status

Shaw Renewables operates 2 plants. Process heat is supplied by dry sawdust suspension burners.

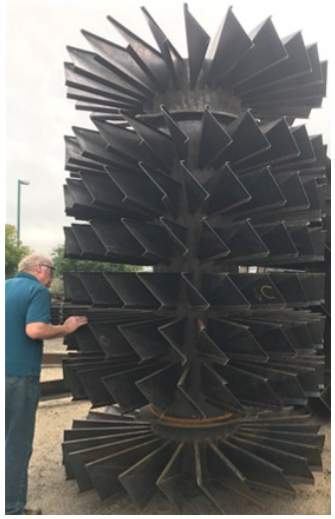
NS Plant

- 12 X 28 Triple Pass Rotary Dryer



NB Plant

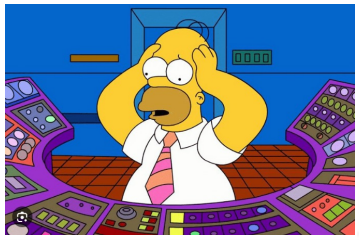
- 14 X 64 Single Pass Rotary Dryer
- Integrated starting sequence in the PLC

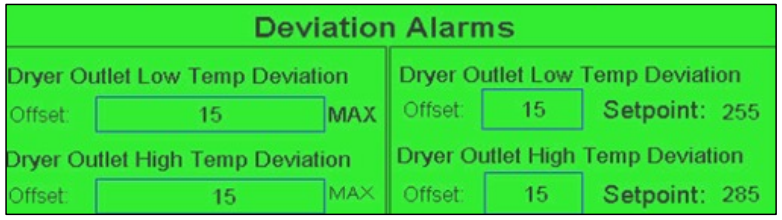


Current Status

What are our current risks with our dryer systems?

1. Potential for human error on startup and shutdowns
2. Limited automated response to process deviations (Setpoint vs Actual)
3. Plugging of dryer drum and potential for fires if all safety systems are not 100% operational (Spark detection, zero speed, flow switches)

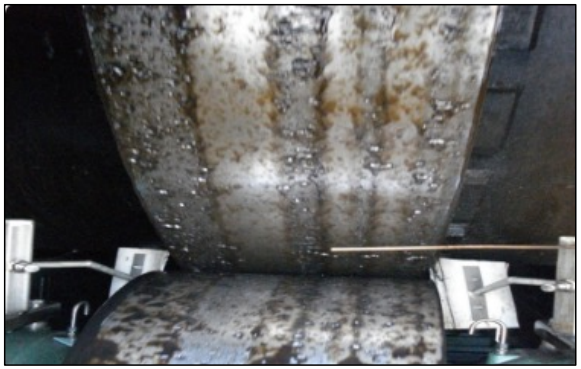




Current Status

What are our current risks with our dryer systems?

4. Overheating on startup due to unstable suspension burner operations causes carryover from burner
5. Buildup of flammable material in drying system ID fan & ductwork
6. Unexpected interruptions to raw material infeed
7. Flammable material accumulating on dryer surface from trunnion lubricant



Continuous Improvement

What have we done to reduce our risk?

- Improve focus on HSC (Heat, sparks, charring) and fire events
  - HSC/Fire Investigations and root cause analysis
  - Monthly DFMT
  - Fire Prevention Initiatives (ie. Hot work & MOC)
- Additional safety devices (ie. Zero speed and level switches)
- Automation
  - HMI startup & shutdown sequencing

Continuous Improvement

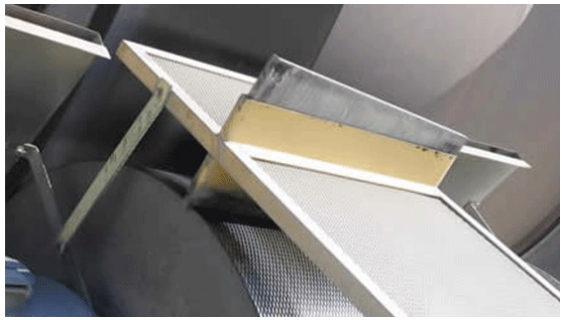
What have we done to reduce our risk?

- Installation of dual view cameras
  - Surveillance of green fiber & fuel storage
  - Thermal imaging
  - Temperature Fencing & Alarms
- Continuously upgrading SOPs/Checklists
  - Checklists for hard stops
  - SOP for cleaning spark detect eyes
  - SOPs for startup/shutdown

Outlook – Constant Improvement

What are we doing to constantly improve?

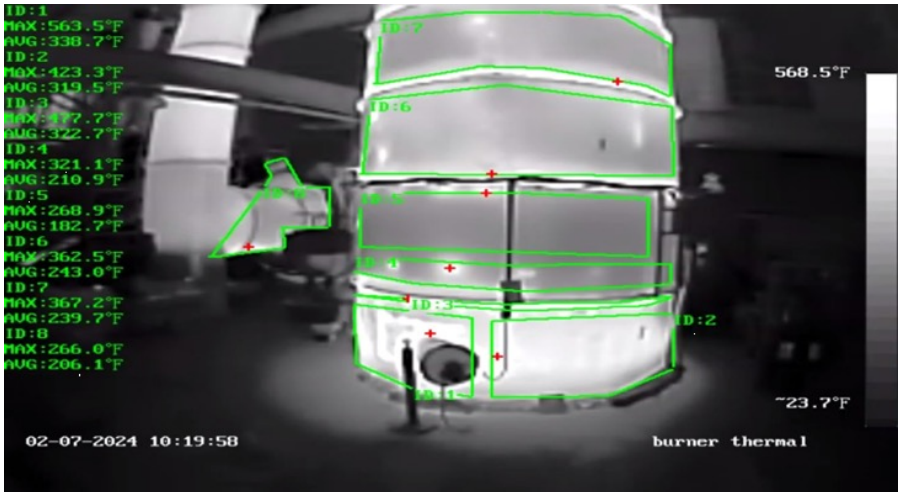
- Investigating graphite lubrication to prevent degradation (cracks and metal flakes), and to eliminate buildup of flammable material.



Outlook – Constant Improvement

What are we doing to constantly improve?

- Upgrading dual view cameras
  - Number of Cameras
  - Thermal Range Capacity
  - Temperature Alarm Fencing



Outlook – Constant Improvement

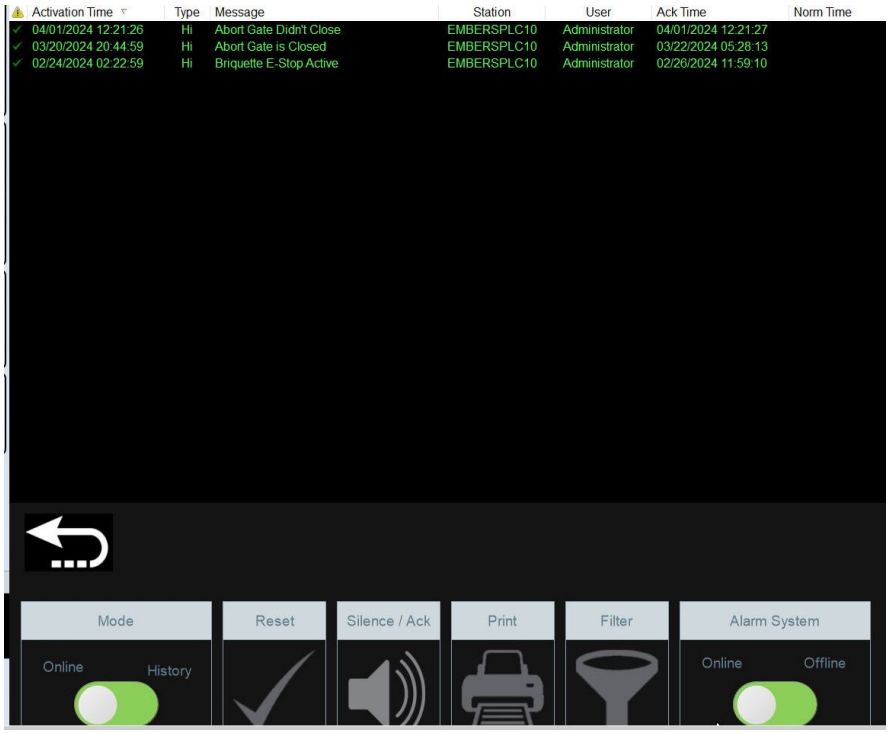
What are we doing to constantly improve?

- Startup sequencing
  - Implement sequencing for NS facility
  - Upgrade sequencing in NB
  - Improve sequencing for burner stability during dryer startup

Outlook – Constant Improvement

What are we doing to constantly improve?

- Evaluating if we are intervening correctly (aggressively) to all alarms
- Addressing alarm fatigue



Thank you for listening!

Applying Bow Tie Analysis to Drum Dryers

Michael Fantillo, Production Supervisor, Premium Pellet Ltd.

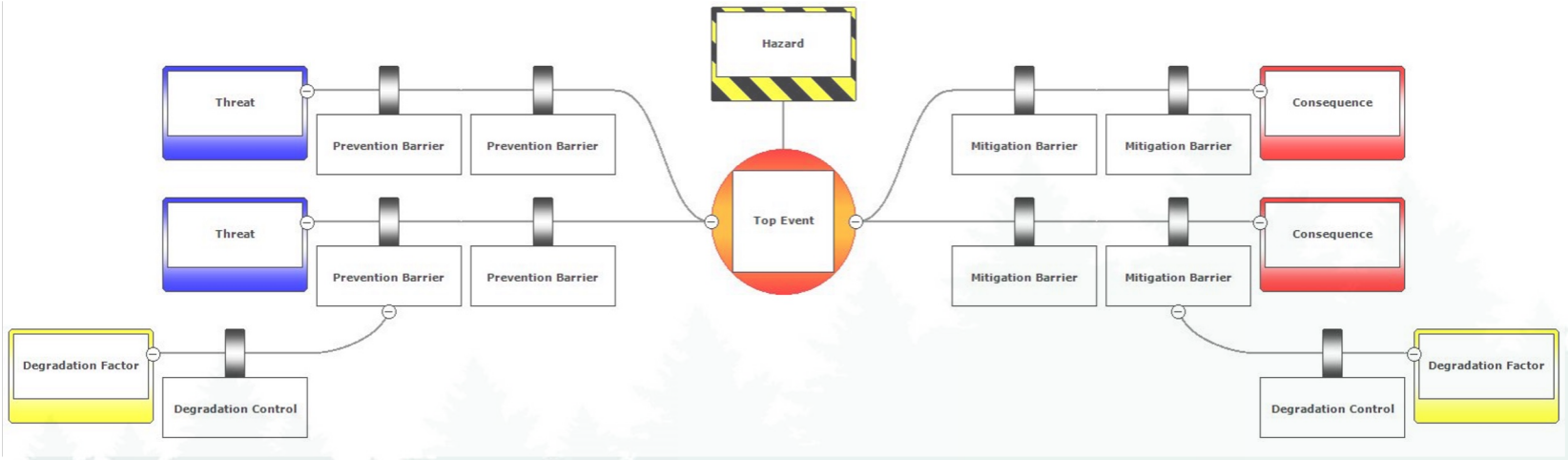
WPAC Drum Dryer Symposium, April 4, 2024

Presentation Outline

- Bow tie analysis overview
- Applying bow tie analysis to our operation
- Outcomes of bow tie analysis workshops
- Drum dryer safety

Bow Tie Analysis Overview

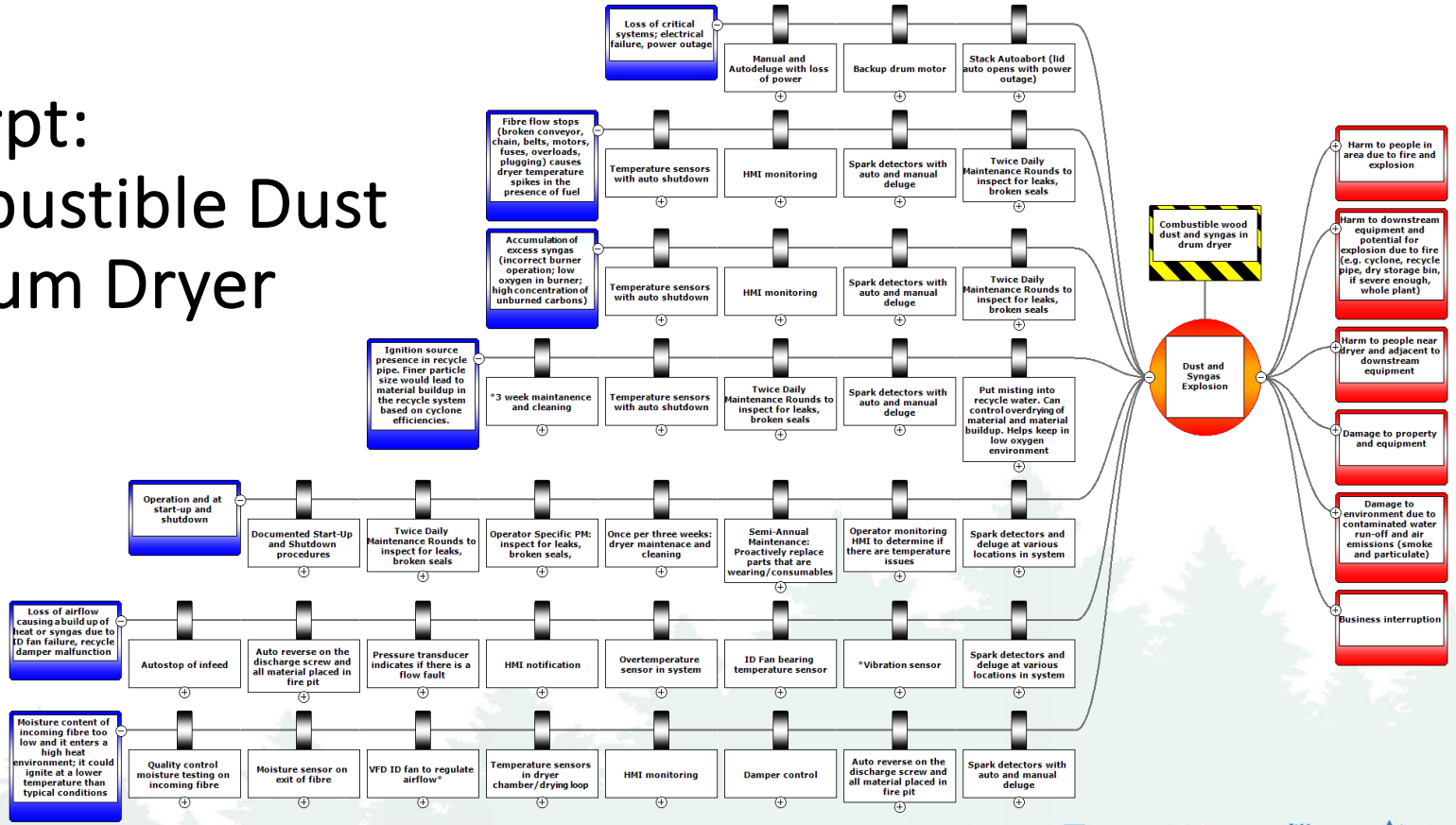
- Visual hazard analysis tool that systematically analyzes and communicates how hazardous events can occur and cause negative consequences



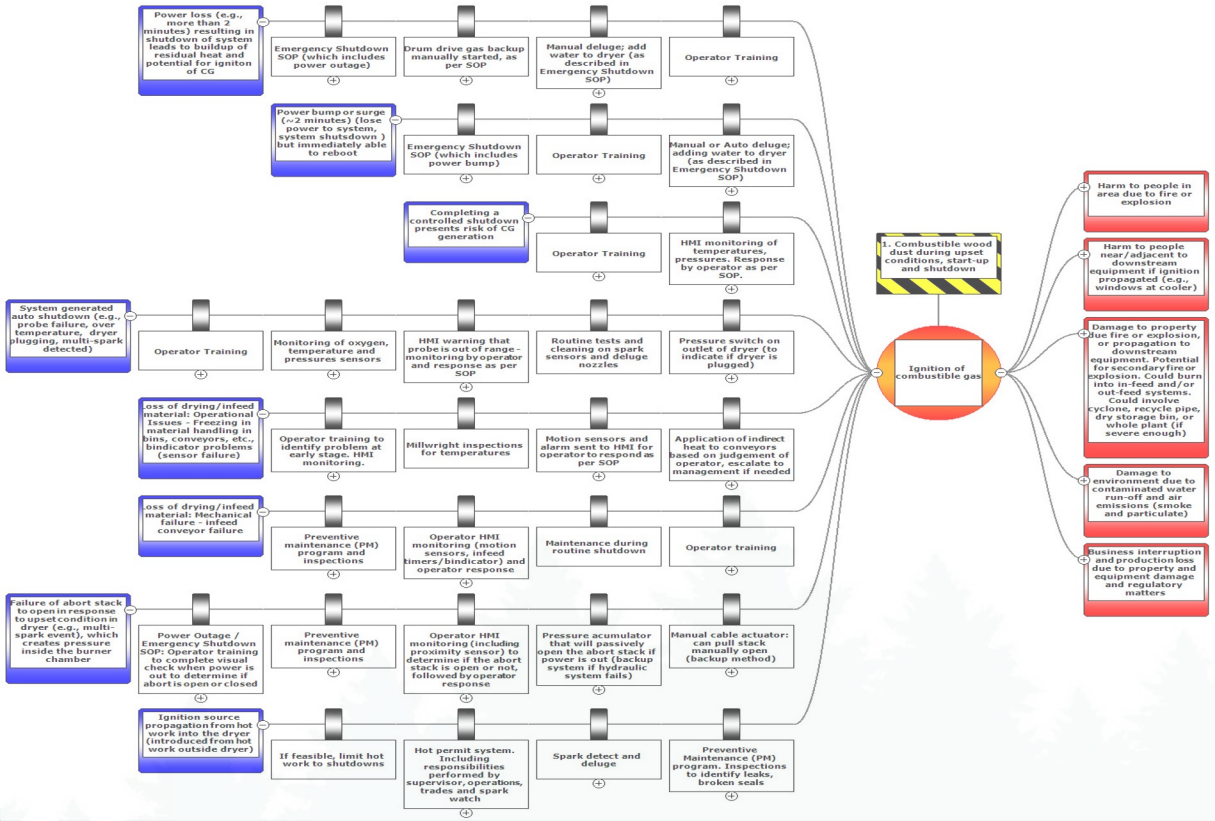
Bow Tie Analyses at Premium Pellet Ltd.

- Pilot workshop in *Critical Control Management* project:
  - Drum dryer
  - Pelletizer
  - Raw material storage, hammer mill, cooler, storage silo developed by other operations
- Dedicated workshop evaluating formation and accumulation of combustible gas
  - Normal operations
  - Start-up and shutdown
  - Confined space activities
- Our workshop team included operators, maintenance personnel, electricians, supervisors

Excerpt: Combustible Dust in Drum Dryer



Excerpt: Combustible Gas in Drum Dryer



Outcomes at Our Operations

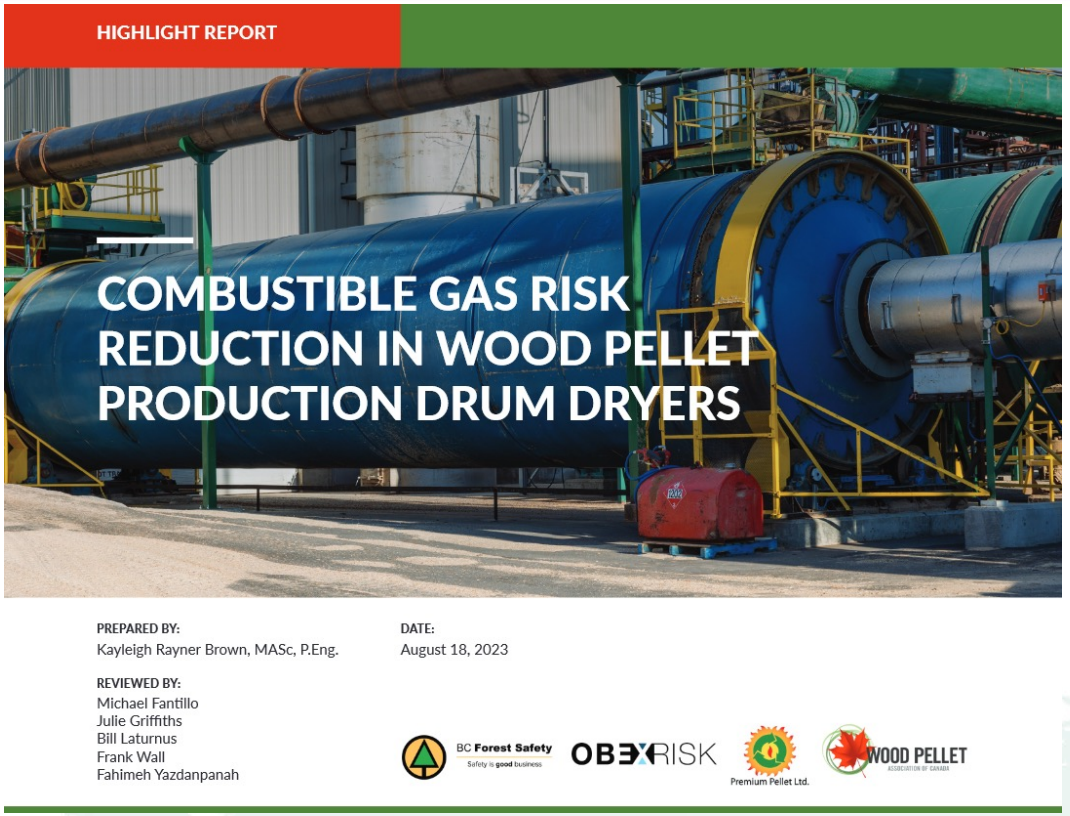
- Effectively identified areas for improvement.
- Shifted to proactive instead of reactive.
- Improved understanding of reliability of controls.
- Enhanced employee participation and safety culture.
- Improved sharing of information.
- Added to existing safety framework to improve risk management.

Drum Dryer Safety – Learnings from Bow Tie Analysis

- Identified conditions that present risk of combustible gas ignition
- Affirmed the importance of critical controls:
  - Emergency shutdown procedures
  - Operator response and training
  - Confined space program
- Measures to ensure reliability of controls, such as:
  - Management of change program
  - Training
  - Drills
  - Preventative maintenance

Resource:
Summary Report

[WPAC website]



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WPAC Drum Dryer Symposium

TOWARD A SAFER FUTURE

Group Discussion
Moderated by Julie Griffiths, Shaw Renewables and WPAC Safety Committee Chair

DRUM DRYER WORKING GROUP

Working Group Deliverables

Similar to the belt dryer working group (i.e., technical report, factsheet).

Join the Working Group!

Email Fahimeh Yazdan Panah (fahimeh@pellet.org)
to join the working group or have any further questions.

WPAC Drum Dryer Symposium

WORKSAFEBC'S OBSERVATIONS AND RECOMMENDATIONS

Geoff Thomson, Occupational Safety Officer
WorkSafeBC

WPAC Drum Dryer Symposium

NEXT STEPS AND CLOSING REMARKS

Julie Griffiths, Shaw Renewables and
WPAC Safety Committee Chair


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