HIGHLIGHT REPORT

COMBUSTIBLE GAS RISK REDUCTION IN WOOD PELLET PRODUCTION DRUM DRYERS

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DATE:
August 18, 2023

BC Forest Safety
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OBEXRISK

Premium Pellet Ltd.

WOOD PELLET ASSOCIATION OF CANADA

INTRODUCTION

In wood pellet production, there is a risk of the generation and ignition of combustible gas, particularly in drying systems, including the burners. This highlight report summarizes the conditions that can lead to the generation and ignition of combustible gas, as well as preventive barriers (or controls) to stop this from occurring.

Barriers can be degraded and become less effective or reliable due to a range of issues and influences, such as environmental conditions, mechanical or electrical failure, and human factors. These can be referred to as “degradation factors”. Measures that are used to help ensure the reliability of barriers are also summarized in this report (referred to as “degradation factor controls”).

This report is based on a bow tie analysis workshop that was undertaken to evaluate the hazard of combustible gas, as part of a Wood Pellet Association of Canada (WPAC) and BC Forest Safety Council (BCFSC) initiative in collaboration with Premium Pellet Ltd. (Vanderhoof, BC).

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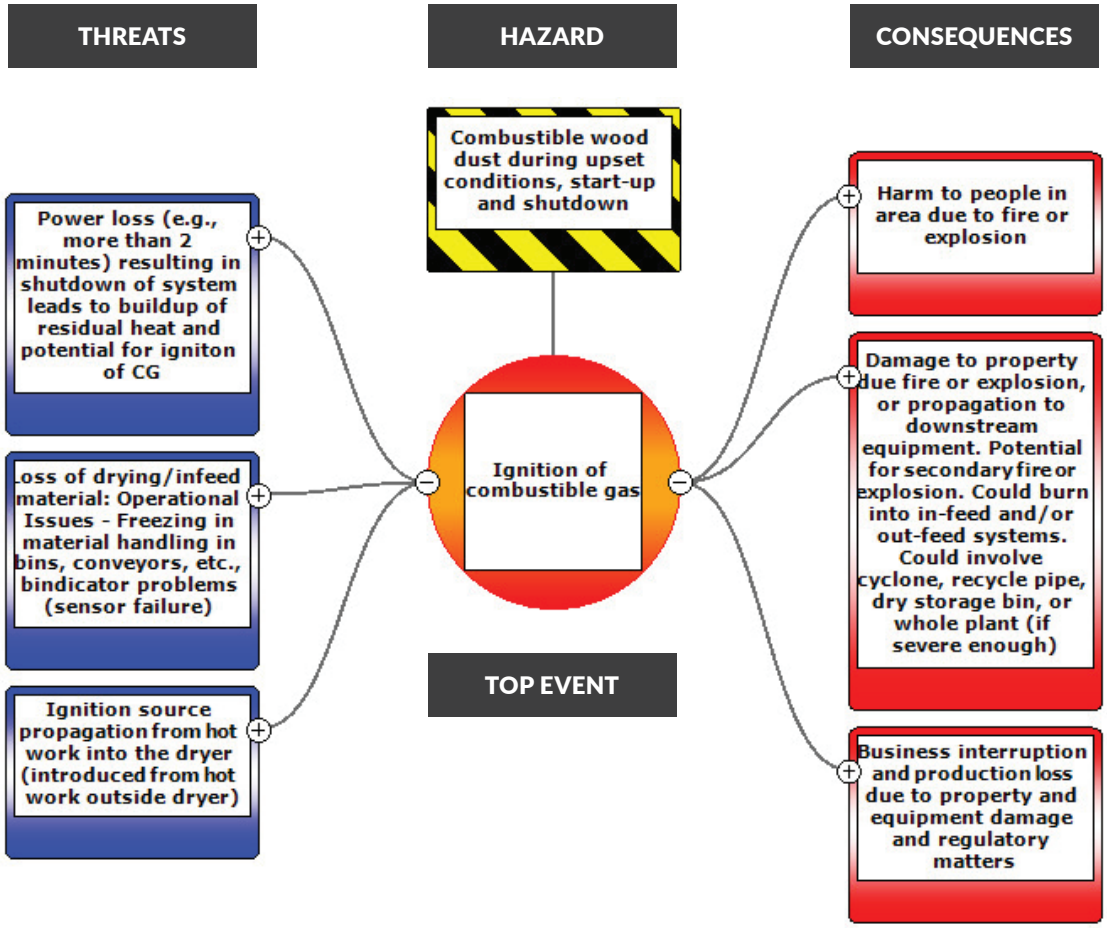
BOW TIE ANALYSIS: VISUAL HAZARD ANALYSIS TOOL

Bow tie analysis (also known as a bow tie diagram) systematically evaluates and communicates how hazardous events can occur and cause negative consequences.

HOW IT WORKS

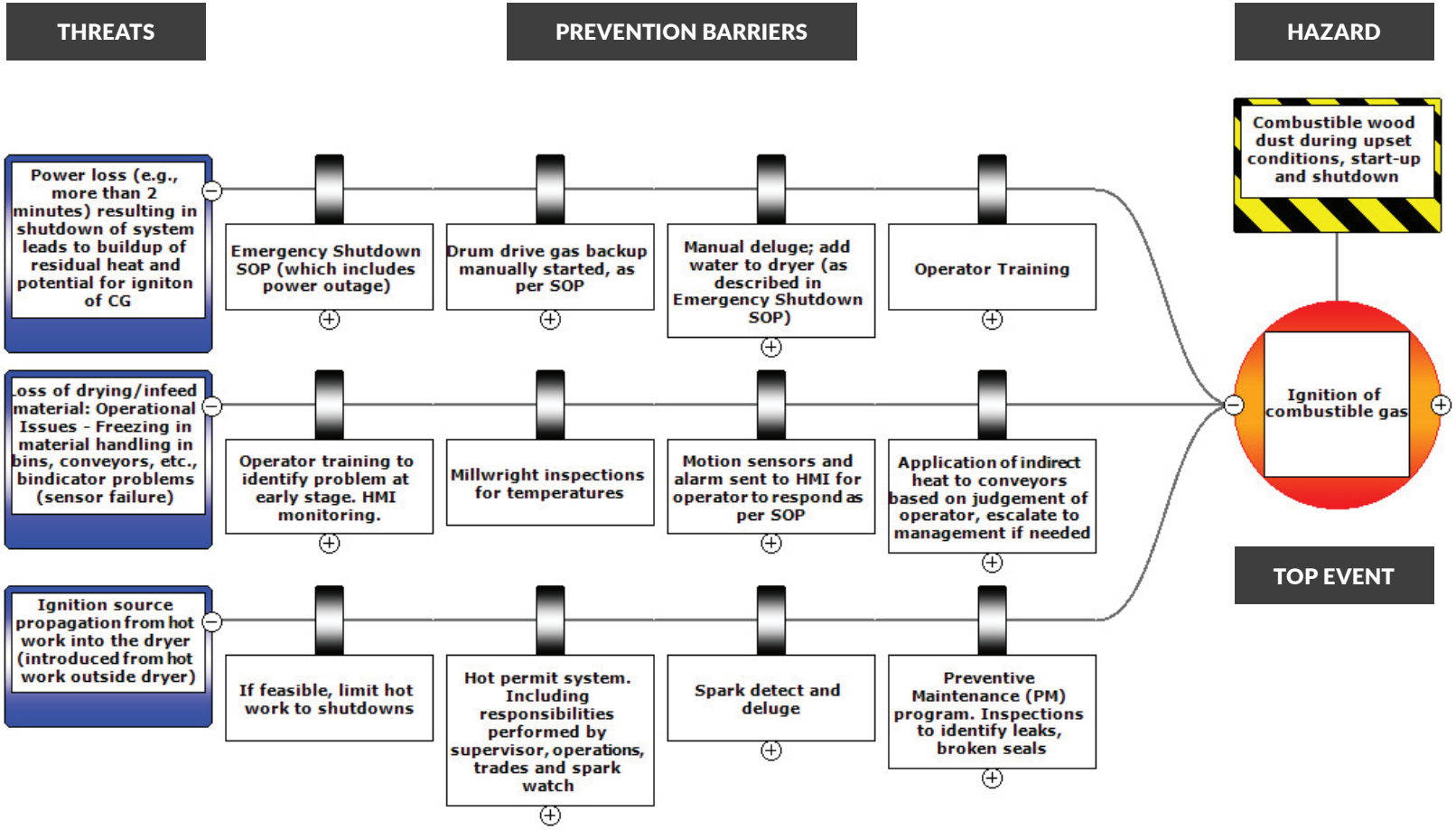
A bow tie analysis begins with four elements: **hazard**, **top event**, **threats**, and **consequences**. These are arranged in a diagram to show how a hazardous or undesired event could happen due to threats and what the potential consequences are.*



* The bow tie analysis excerpts used in this section are for illustrative purposes only.

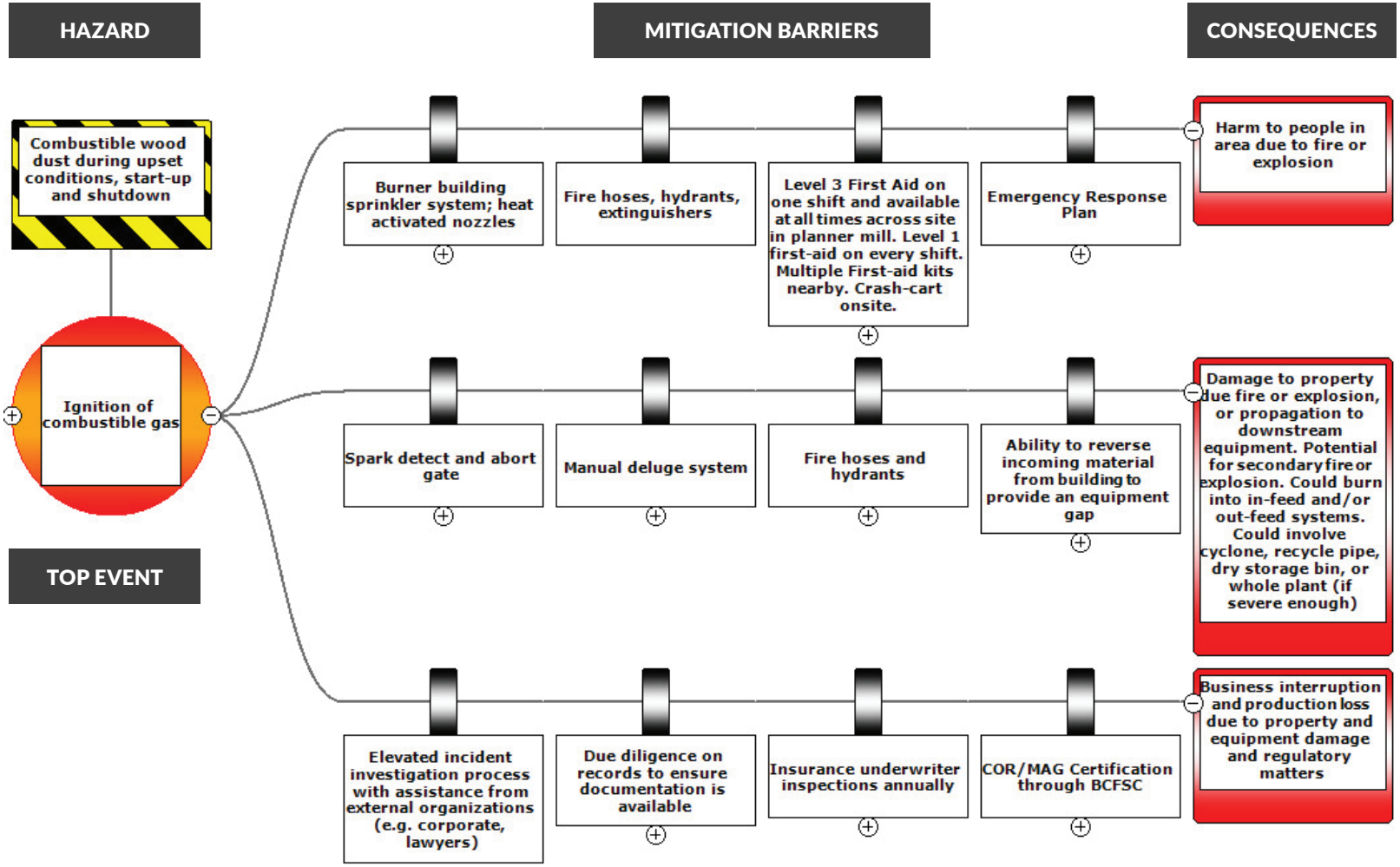
HOW IT WORKS

Next, the prevention barriers that can stop the hazardous or undesired event from happening are added to the diagram.



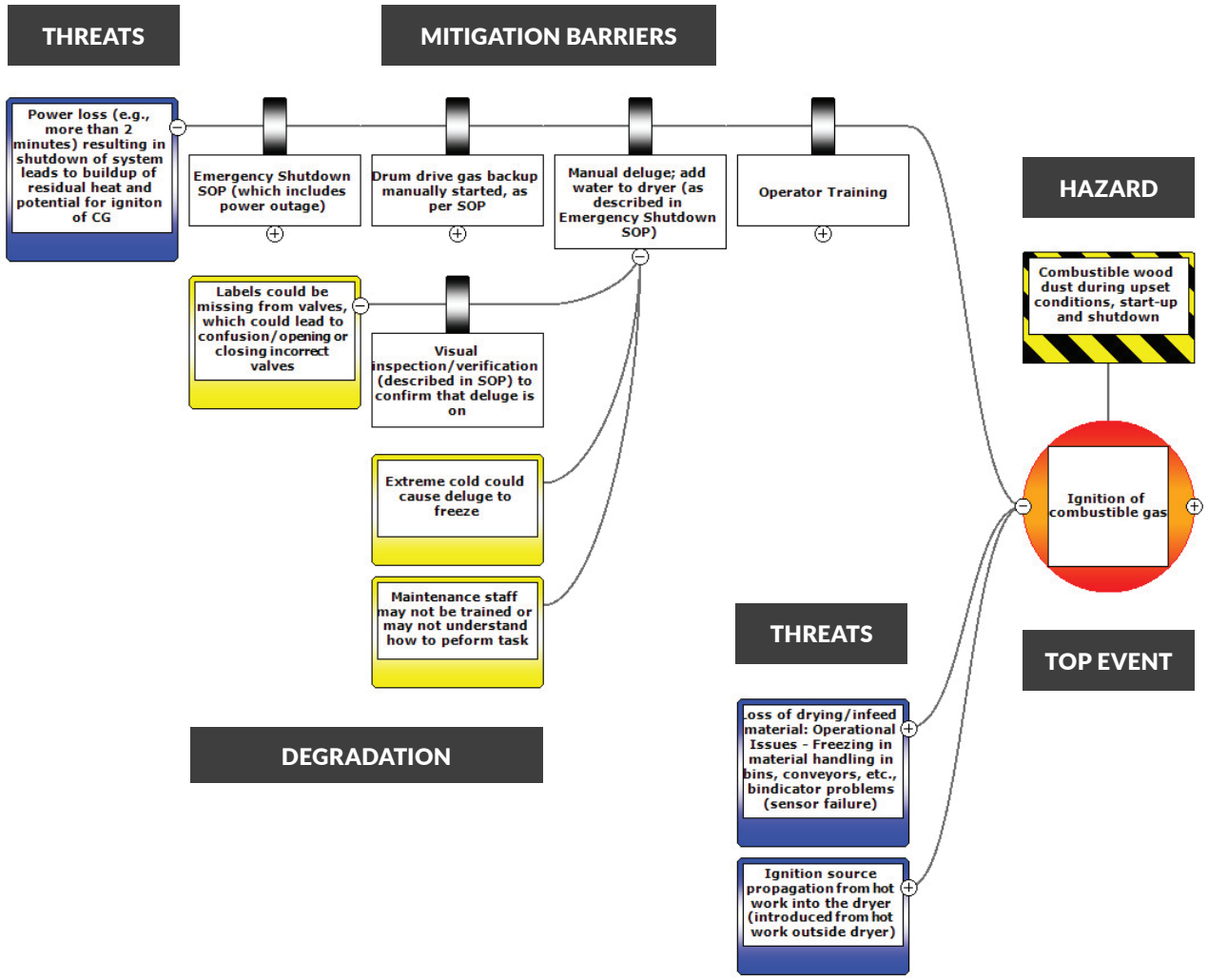
HOW IT WORKS

Additionally, the mitigation barriers that can reduce the severity or likelihood of consequences are added to the diagram.



HOW IT WORKS

Lastly, barriers can fail — this is captured in a bow tie analysis through degradation factors. Barriers can be made more effective through identifying degradation factor controls. This gives the complete story in one diagram.



BENEFITS OF BOW TIE ANALYSIS

- ✓ **Effectively identifies** areas for improvement.
- ✓ **Advances the understanding of what can go wrong** in the process and how to prevent it.
- ✓ **Improves awareness** of existing controls, their degradation factors, and what can be done to protect these systems.
- ✓ **Enhances employee participation** and safety culture.
- ✓ **Improves sharing of information** across the organization.
- ✓ **Builds on existing safety management framework** to develop a more robust system to deal with hazards at the plant.

HIGHEST RISK OPERATING CONDITIONS AND CRITICAL PREVENTATIVE BARRIERS

There are three primary operating conditions that present the risk of combustible gas ignition. There are a series of barriers to prevent the generation and ignition of combustible gas throughout different operating conditions; some measures play a significant role in this and perform as critical preventative barriers.

These barriers can be weakened in several ways, which must be addressed through additional controls. Identifying the degradation factors and degradation controls plays an important role in ensuring the reliability of barriers. The following pages go through the bow tie analyses and critical preventative barriers for each of the identified primary operating conditions.

OPERATING CONDITIONS	PREVENTATIVE BARRIERS
Upset conditions, start-up, or shutdown	Emergency shutdown standard operating procedure (SOP)
Normal operation	Operator response and training
Confined space entry activities	Confined space entry program

UPSET CONDITIONS, START UP, OR SHUTDOWN

Start-up and shutdown poses the highest risk for combustible gas accumulation and ignition, particularly if defined procedures to conduct this operation are not followed.

When start-up and shutdown procedures are not followed, not present, unsupervised, or weak, there is an increased potential for the buildup of combustible gas. Historically, there have been incidents involving drying systems that have been caused by start-up and shutdowns that have deviated from the formalized standard operating procedure (SOP). For example, the SOP has been designed to use the ID fan (induced draft fan) to remove combustible gas from the system, and as such, the ID fan should be operated according to the procedure.

CONDITIONS THAT PRESENT RISK OF COMBUSTIBLE GAS IGNITION

Power loss that results in a shutdown of system, which leads to buildup of residual heat and the potential for ignition of combustible gas.
Power bump or surge where power to the system is lost and/or system shuts down, but system can immediately be rebooted.
Controlled shutdown completion, including lack of operator knowledge or knowledge of procedure or activities.
System-generated auto shutdown, which could be triggered by conditions including probe failure, over-temperature, dryer plugging, or multi-spark detection.
Loss of drying/infeed material caused by operational issues, such as freezing in material handling in bins or conveyors, and bindicator problems (sensor failure).
Loss of drying/infeed material caused by mechanical failure, such as infeed conveyor failure.
Failure of abort stack to open in response to upset condition in dryer (e.g., multi-spark event), which creates pressure inside the burner chamber.
Ignition source propagation from hot work into the dryer (spark introduced from hot work outside dryer).

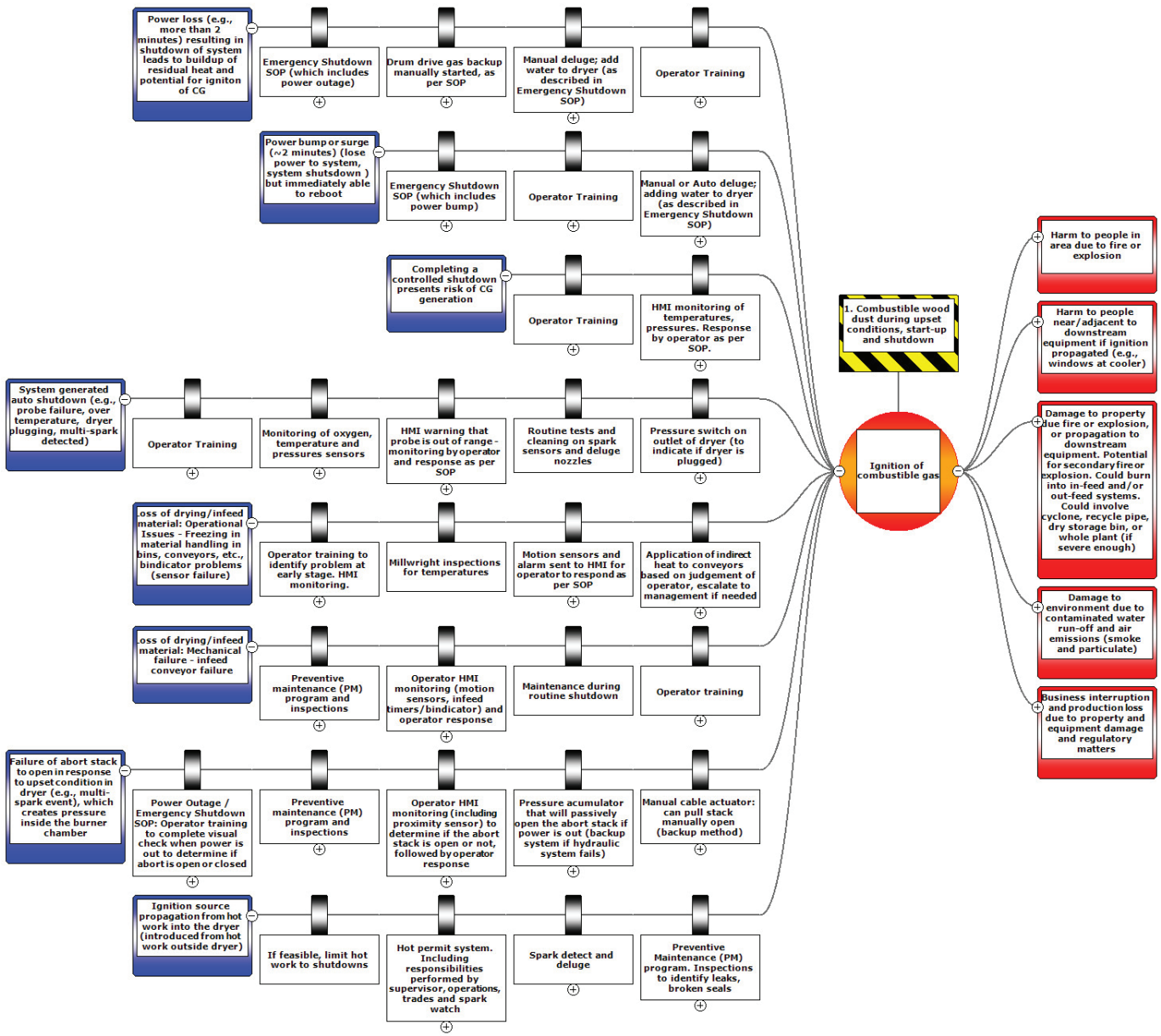
UPSET CONDITIONS, START UP, OR SHUTDOWN

CONTROL: EMERGENCY SHUTDOWN SOP (WHICH INCLUDES POWER OUTAGE)

DEGRADATION FACTOR	**DEGRADATION FACTOR CONTROL** (including inspection, testing, maintenance and calibration)
Operator does not understand SOP	- Provide coaching, mentorship, and additional training. - Hold a post-incident debrief to review what happened and identify lessons learned. - Review the SOP and make any appropriate revisions to improve clarity. - Increase operator competency audits and drills for emergency shutdowns.
Operator does not use or refer to SOP	- Provide coaching, mentorship, and additional training. - Discipline staff if needed. - Increase operator competency audits and drills for emergency shutdowns.
Operator is inattentive, distracted, fatigued, or overwhelmed while managing multiple demands in high-stress situations.	- Provide coaching, mentorship, and additional training. - Ensure operators are fulfilling responsibility to be fit for duty. - Encourage and train operators to reach out for help and communicate with others to get guidance as needed. - Ensure persons are qualified. - To reduce potential distractions, maintain that only essential personnel are allowed in the control room during work hours (except tailgate meeting). - Consider possible rotation of trained operators at defined frequencies.
Operator lacks training and understanding of maintenance, other staff, and activities.	- Formalize a Management of Change (MOC) program to stay informed and up to date with procedure changes. - Provide coaching, mentorship, and additional training. - Complete annual expectation reviews with staff. - Ensure operators are fulfilling responsibility to be fit for duty. - Encourage and train operators to reach out for help and communicate with others to get guidance as needed. - Ensure persons are qualified. - Establish a strong process for cross shift communication.
Operator does not have practice or experience to handle incidents because events may rarely happen, which makes it difficult for operators to be prepared.	- Provide coaching, mentorship, and additional training. - Complete annual training system review sign off of job safety analysis (JSA) and SOP. - Consider conducting additional drills to practice for emergency shutdowns.
HMI and PLC malfunction and do not communicate.	- Call electrical staff to repair the system. - Install a UPS (battery backup) to maintain short term power. - Alternate transformer switch.
Abort stack does not open.	- Complete visual verification when abort stack is triggered to ensure it is open. - Install a backup system (e.g., accumulator). - Maintain a backup cable if a manual open needs to be completed. - Complete routine inspections and preventive maintenance (PM) (e.g., daily). - Complete maintenance on semi-annual shutdown.

UPSET CONDITIONS, START UP, OR SHUTDOWN

BOW TIE ANALYSIS: IGNITION OF COMBUSTIBLE GAS



NORMAL OPERATION

CONDITIONS THAT PRESENT RISK OF COMBUSTIBLE GAS IGNITION

Oxygen level is too low in the burner. This would lead to incomplete combustion, which can produce gas that can carry through to the dryer. This can lead to introduction of burning fibre into the dryer from burner chamber.
The burner is run incorrectly, such as introducing too much fibre into burner.
Process equipment failure, such as cyclone, ID Fan, drum drive, bearing failure, airlocks, and outfeed conveyor.
Operator error (e.g., mis-enter temperatures) related to human factors. There is the potential for operators to be inattentive, distracted, fatigued, overwhelmed, and strained when managing multiple demands in high-stress situations.
Operational factors cause fresh oxygen to be introduced into the dryer; could be due to temperature fluctuations, extreme cold and heavy rainfall. This causes the oxygen levels to be too high.
Mechanical factors cause fresh oxygen to be introduced into the dryer; could be due to compromised seals. This causes the oxygen levels to be too high.
Drying temperatures are too high, which could potentially lead to smolder spots and combustible gas formation in the dryer.
Dust and creosote that are present in ductwork presents the potential for combustible gas generation.
Introduction of excessively dry fibre or rapid changes of moisture content of incoming fibre.
Control damper failure, such as jamming or being worn out.

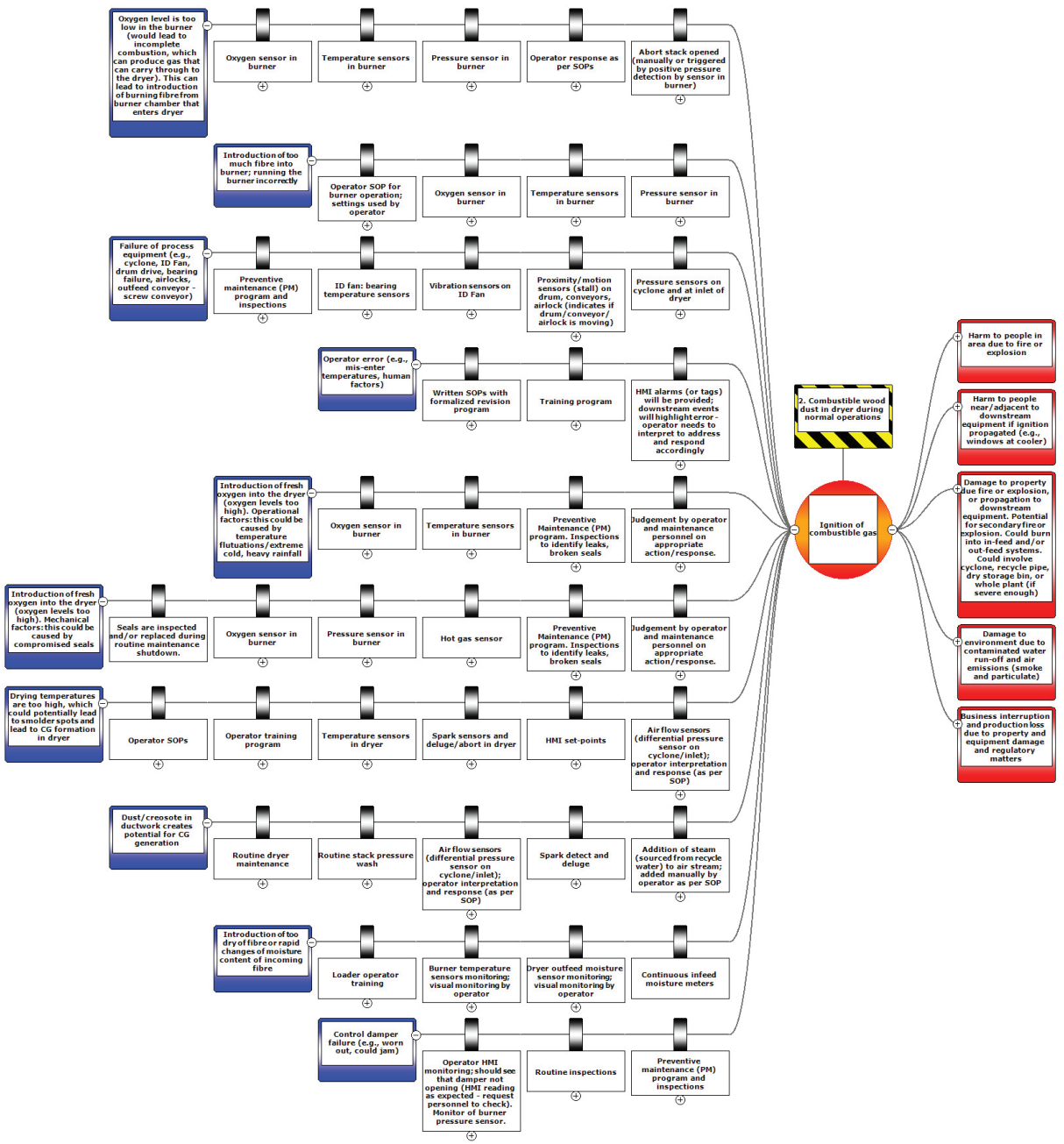
NORMAL OPERATION

CONTROL: OPERATOR RESPONSE AS PER SOPS

DEGRADATION FACTOR	DEGRADATION FACTOR CONTROL (including inspection, testing, maintenance and calibration)
SOP not used or referred to by operator. Operator may hesitate to refer to procedures if they feel over-confident in the situation.	- Provide coaching, mentorship, and additional training. - Discipline staff if needed. - Consider HMI feature that automatically presents the shutdown/startup SOP when the operator triggers a scheduled shutdown and the operator reads and acknowledges the SOP.
Operator does not have practice or experience to handle incidents because events may rarely happen, which makes it difficult for operators to be prepared.	- Provide coaching, mentorship, and additional training. - Complete annual training system review sign off of job safety analysis (JSA) and SOP. - Conduct additional drills to practice for shutdowns.
Miscommunications between operator, maintenance, other personnel	- Provide coaching, mentorship, and additional training. - Ensure operators are fulfilling responsibility to be fit for duty. - Train staff on proper radio communication technique. - Consider conducting audits to check radio communications during regular operations.
Operators may be inattentive, distracted, fatigued, or overwhelmed while managing multiple demands in high-stress situations.	- Provide coaching, mentorship, and additional training. - Ensure operators are fulfilling responsibility to be fit for duty. - Encourage and train operators to reach out for help and communicate with others to get guidance as needed. - Ensure persons are qualified. - Implement policy that only essential personnel are allowed in the control room during work hours (except tailgate meeting) to reduce potential distractions.
Lack of understanding by operator of training	- Provide coaching, mentorship, and additional training. - Hold a post-incident debrief to review what happened and identify lessons learned. - Review the SOP and make any appropriate revisions to improve clarity. - Consider possible rotation of trained operators at defined frequencies. - Consider hands-on competency assessments to provide additional training and proficiency checks.

NORMAL OPERATION

BOW TIE ANALYSIS:
IGNITION OF COMBUSTIBLE GAS



CONFINED SPACE ENTRY ACTIVITIES

CONDITIONS THAT PRESENT RISK OF COMBUSTIBLE GAS IGNITION

Presence of combustible gases in dryer during maintenance activities.
Presence of residual combustible gas or condensed VOCs (volatile organic compounds).
Hot work ignites residual combustible gas or VOCs.

CONTROL: OPERATOR RESPONSE AS PER SOPS

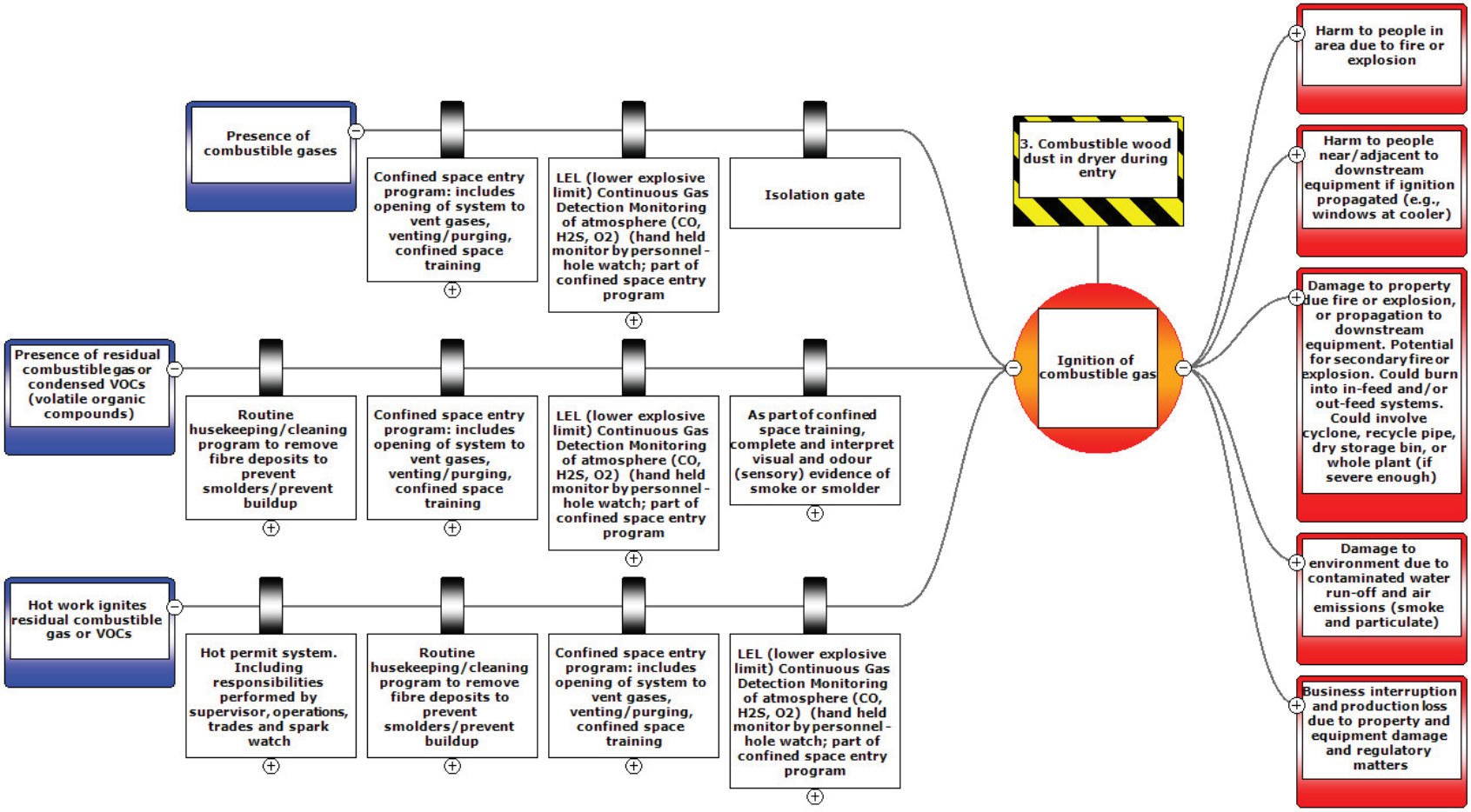
DEGRADATION FACTOR	**DEGRADATION FACTOR CONTROL** (including Inspection, Testing, Maintenance and Calibration)
Training for confined space entry, as well as rescue personnel, is insufficient.	- Require annual training through formalized program. - Complete annual drills. - Require certifications (on routine basis) for confined space rescue training. - Complete hazard assessment completed prior to entry. - Complete bump test [1] (atmospheric testing with calibrated sensor) as per formalized SOP. - Implement permit system for designated confined space entry zones.
Gas detection/monitoring equipment is unavailable or in poor condition. [2]	- Calibrate and test gas monitoring equipment before use. - Have backup/spare equipment maintained and available. - Use multiple sensors in case of failure. - Keep spare parts for sensors in stock. - Complete routine calibration according to the equipment manufacturer instructions. Some units notify users when calibration is needed — complete accordingly. - Complete routine inventory review of rescue equipment; perform critical inventory checks as part of the monthly JHSC (Joint Health and Safety Committee) facility inspection (requirement defined in Act). - Provide training on the use of all equipment (e.g., rescue equipment, gas detectors).

1 A bump test is used to check if a gas detector's sensors and alarms are working. Bump tests do not verify accuracy, however, which is why gas detector calibration is required.

2 Gas detector performance can be degraded if it is dropped (which can loosen sensors) and by environmental conditions (extreme temperatures, humidity, dust and debris can lead to plugged filters).

CONFINED SPACE ENTRY ACTIVITIES

BOW TIE ANALYSIS: IGNITION OF COMBUSTIBLE GAS



ACTIONS FOR OPERATIONS

Ignition of combustible gas could result in serious injury, death, or the complete destruction of your plant.

- ✓ Ensure that your **teams and all new employees are adequately trained** and aware of the risks of combustible gas by engaging in regular toolbox talks.
- ✓ Take **all employee concerns for combustible gas risks seriously**.
- ✓ **Share this document** with maintenance staff and operators at your facility.
- ✓ To help ensure the reliability and effectiveness of controls, **consider the frequency of inspection, testing, maintenance, and calibration of these controls**.
- ✓ Explore any **opportunities to use engineering controls to alleviate reliance on procedures**. Examples of engineering controls include spark detect and deluge, continuous sensors (combustible gas, oxygen, moisture), and programmed purge cycles.
- ✓ Encourage staff at your facility to **enroll in the new WPAC Operator Training Platform (wpaclearning.com)** and complete the training module on combustible dust and gas safety.
- ✓ **Contact WPAC (pellet.org) and BCFSC (bcforestsafe.org)** for additional combustible gas resources.