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Integrating Process Safety Management into Canadian Wood Pellet Facilities that Generate Combustible Wood Dust

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EXECUTIVE SUMMARY

This report describes the work completed under the project titled "Integrating Process Safety Management into Canadian Wood Pellet Facilities that Generate Combustible Wood Dust" funded by WorkSafeBC through an Innovation at Work grant. This project was completed in collaboration with Dalhousie University (Dr. Paul Amyotte, P.Eng., Principal Investigator), Wood Pellet Association of Canada (WPAC), BC Forest Safety Council (BCFSC), DustEx Research Ltd., and Obex Risk Ltd.

The scope of this project was to develop a foundational integration tool for wood products manufacturing that serves as the basis for a long-term strategy and implementation plan led by industry. The PSM integration tool consists of a PSM survey for gap analysis, self-assessment worksheets that include numerous industry best practices, factsheets designed for operations, and an industry implementation strategy.

The project involved the development of a PSM survey to identify key areas for improvement with respect to explicit incorporation of PSM concepts, including process safety culture and key performance indicators. Following a review of PSM frameworks as the basis for the survey and to support the integration of PSM concepts, the CSA Z767 *Process Safety Management* standard was selected. The CSA Z767 is a Canadian standard applicable to a Canada-based project and provides the opportunity to consider industry best practices based on the standard's development by experts in a wide range of high-hazard industries.

The PSM survey was distributed to producers of wood pellets and medium density fibreboard (MDF). Survey responses indicated that each element described in CSA Z767 was present in operations in varying degrees of formalization and completeness. Subject matter experts (SMEs) from other industries handling combustible dust also completed the survey and were interviewed to collect recommendations with respect to PSM implementation and available best practices. Using the survey responses, as well as input from other SMEs, the highest priority concepts to focus on for integration were identified. Staged integration was also identified as a practical approach for implementing these PSM concepts into the wood products manufacturing industry, as well as other small-and-medium enterprises more broadly. It was also determined that operations may wish to adapt this staged approach to best suit their own circumstances and judgement. Phase one PSM elements are accountability, process safety culture, process risk assessment and risk reduction, management of change (MOC), investigation, and key performance indicators (KPIs). Phase two elements are conduct of operations, process knowledge and documentation, human factors, training and competency, and process and equipment integrity. Phase three elements are emergency management planning, project review and design procedures, audit process, regulations, standards and codes, and enhancement of process safety knowledge.

A PSM implementation strategy was developed using industry best practices and resources identified in the literature. Activities in this approach include establishing a PSM Steering Committee and developing an industry-specific implementation guide. This approach, an implementation plan, and timeline will be further evaluated and developed with input of operations as part of future work.

Industry best practices for each of the PSM elements that could be adapted for the wood products manufacturing industry were identified. Resources for each of the PSM elements have been identified and collected from archival literature, and organizations including the Center for Chemical Process Safety (CCPS), Health and Safety Executive (HSE), Contra Costa County Health Services (CCHS), OSHA (Occupational Safety and Health Administration). Publicly available resources from companies operating in other high-hazard industries such as DuPont, Honeywell, and Nova Chemical have also been identified and gathered. Self-assessment worksheets have been developed that can be used by operations to identify gaps in PSM elements, develop action plans to address these gaps by considering the identified best practices, and review corrective actions to further continuous improvement.

PSM element factsheets have been designed for operations to enhance the understanding of PSM, the PSM elements and establish these concepts within the industry. These factsheets have been designed considering best practices for communicating with stakeholders at operations and take from the leading example set by the CCPS Process Safety Beacon.

Lastly, an objective of the research project was to develop KPIs to track the effectiveness of PSM implementation. A number of potential KPIs were identified for three different categories: Site-Specific Process Safety KPIs, Industry Benchmarking Process Safety KPIs, and PSM Implementation KPIs. Possible Site-Specific or Industry Benchmarking Process Safety KPIs include fires or explosions with respect to specific equipment (e.g., dryer, hammer mill, conveyor, silo) as lagging indicators, and malfunction of equipment or electrical systems as leading indicators (e.g., dryer infeed conveyor failure, error between programmable logic controller (PLC) and human-machine interface (HMI)), or automatic deluge malfunction). As part of future work, it is recommended that site-specific and industry benchmarking KPIs be evaluated, tested and revised appropriately prior to broad rollout. PSM Implementation KPIs, such as percentage completion of self-assessment worksheets, can be further expanded upon following the development of a PSM implementation plan.

Currently, in Canada, PSM is mostly voluntary; however, the CSA Z767 standard has been adopted by some authorities in Canada, including the Technical Standards and Safety Authority (TSSA) and the BC Energy Regulator (BCER). Other jurisdictions, including the Occupational Safety and Health Administration (OSHA) in the United States, have PSM regulations. Beyond regulatory compliance in a given jurisdiction, PSM provides numerous business benefits, in addition to contributing to loss prevention, including enhancing reputation, reducing costs, and contributing to sustainable growth. While occupational health and safety legislation in the province of British Columbia does not currently refer to a PSM standard, there is the potential for this in the future. Undertaking proactive implementation measures will prepare the industry if regulations are adopted in the future.

This research builds on previous industry initiatives and research projects focused on process safety, all of which have collectively contributed to a broad culture shift in industry. The current project has enhanced the awareness and understanding of PSM across the Canadian wood products manufacturing industry.

LIST OF ABBREVIATIONS USED

ASA	Advanced Safety Audit
BCER	British Columbia Energy Regulator
BCFSC	British Columbia Forest Safety Council
BCP	Business Continuity Planning
CAP	Corrective Action Plan
CCHS	Contra Costa Health Services
CCM	Critical Control Management
CCPS	Center for Chemical Process Safety
CSA	Canadian Standards Association
CSChE	Canadian Society for Chemical Engineering
EMP	Emergency Management Program
EPA	Environmental Protection Agency
ERP	Emergency Response Plan
HSE	Health and Safety Executive
IChemE	Institution of Chemical Engineers
ISD	Inherently Safer Design
JOHS	Joint Occupational Health and Safety
KPI	Key Performance Indicator
MCC	Motor Control Centre
MOC	Management of Change
MDF	Medium Density Fibreboard
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
PDC	Power Distribution Centre
PFD	Process Flow Diagram
PHA	Process Hazard Analysis
PLC	Programmable Logic Controller
PPE	Personal Protective Equipment

PSI	Process Safety Information
PSLG	Process Safety Leadership Group
P&IDs	Piping and Instrumentation Diagrams
RCS	Risk Control System
RSMP	Risk and Safety Management Plan
SME	Subject Matter Expert
SOP	Standard Operating Procedure
SWP	Safe Work Procedure
TSSA	Technical Standards & Safety Authority
WPAC	Wood Pellet Association of Canada
WSBC	WorkSafeBC (Workers' Compensation Board of British Columbia)

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1 INTRODUCTION

This report details the research and development of an integration tool for process safety management (PSM) in wood pellet production, as well as medium density fibreboard (MDF) manufacturing, as part of the wood products manufacturing industry[1]. The introduction of the report provides an overview of PSM and its relevance to high-hazard, non-chemical process industries, including wood products manufacturing, followed by a summary of the motivation, scope and objectives of the research project. The second section of the report discusses a survey approach that was used to research areas for improvement and establish priorities for PSM implementation, along with available industry best practices. The third section of the report outlines a high-level PSM implementation approach, along with best practices and integration tools that have been identified and developed, which can be scaled to wood products manufacturing, and more broadly to small-and-medium enterprises. The fourth section outlines recommendations for next steps based on research outcomes and the outlook of PSM adoption. The report closes with concluding remarks.

1.1 Process Safety Management and Wood Products Manufacturing

PSM is the use of management principles and systems to identify, understand, avoid, and control process hazards in order to prevent, mitigate, prepare for, respond to, and recover from process-related incidents. The implementation of PSM is most associated with CPI facilities, such as oil and gas refineries. There is an opportunity to incorporate best practices for PSM into other high-hazard, non-CPI applications, to manage process hazards. Currently, there is interest in integrating PSM within wood products manufacturing, including wood pellets and MDF, as these processes generate and handle combustible wood dust. Due to the presence of combustible dust, this industry stands to benefit from the explicit implementation of PSM concepts. A key focus for implementing PSM in wood products manufacturing is identifying modes of integrating PSM elements that are practical and feasible for these operations that are not managing exceedingly complex hazards, such as reactive chemistry, and do not typically have process safety specialists on-staff.

The implementation of PSM in wood products manufacturing presents several measurable benefits, including increases in productivity, and reductions in production,

[1] Wood pellet production and MDF are in the *Pressed Board Manufacture* WorkSafeBC Classification Unit serviced by the BC Forest Safety Council, who support the Wood Pellet Association of Canada's (WPAC) Safety Committee. This research focussed primarily on these types of operations.

maintenance, capital budget and insurance costs (CCPS, 2016). Business benefits the industry can gain from PSM implementation include (CCPS, 2018):

1. Corporate Social Responsibility – enhances image, reputation, and brand, which makes company more attractive
2. Business Flexibility – preserves resources that could be used to focus on growth because companies are welcomed by communities
3. Loss Prevention – prevents injuries and avoids major losses and environmental damage
4. Sustainable Growth – boosts productivity, delivers high-quality products on-time at lower cost, and contributes to shareholder value
5. Leadership Excellence – ensures consistency and reliability, which carries over to other business areas through involved leadership and management

1.2 Research Motivation, Scope and Objectives

PSM frameworks are comprised of a series of separate, yet intertwined, elements for the identification, understanding and control of process hazards to prevent process-related injuries and incidents. Robust, comprehensive PSM systems are reasonably expected to exist in chemical plants and oil refineries, but to date have found limited integration into non-CPI applications, including the Canadian wood pellet industry. To address this, research was undertaken to integrate PSM concepts with appropriate performance indicators and safety culture considerations.

The development of a PSM integration tool that supports PSM implementation and that is scalable for wood products manufacturing, and other small-to-medium enterprises more generally, is the primary outcome of this research project. The objective of the research was to develop a PSM integration tool for wood products manufacturing facilities that generate, handle, or produce combustible wood dust during operations. This integration tool can aid in the design of an industry PSM implementation plan and the development of guidance and tools to support implementation in the future. The scope of the current research is the development of an integration tool, which will establish an initial foundation and strategy for industry implementation.

2 PSM SURVEY

This section describes the development, distribution and analysis of the PSM survey that was conducted. The objective of the PSM survey was to understand the current level of integration of different PSM elements and help understand the prioritization of PSM elements for implementation.

2.1 Review of PSM Frameworks for PSM Survey Development

To inform the PSM survey design, existing PSM frameworks were reviewed and considered for the basis of the survey. PSM systems have been developed and disseminated by (among others) the (i) Canadian Standards Association (CSA, 2017), building on the work of the Canadian Society for Chemical Engineering (CSChE, 2012a,b), (ii) Center for Chemical Process Safety, American Institute of Chemical Engineers (CCPS, 2007), and (iii) Energy Institute, United Kingdom (Energy Institute, 2010), respectively. To develop the PSM survey, it was determined that it would be most efficient to base the survey off one PSM standard, which would allow a gap analysis to be completed against that standard. The CSA Z767 standard presented several benefits to the survey development, and the broader project as a whole, including:

- A Canadian standard would be used for a Canada-based project
- The CSA standard was developed based on expertise and previous work of the CSChE (Canadian Society for Chemical Engineering)
- The development of the CSA standard involved expertise from a range of industries, presenting the opportunity to leverage best practices from other high-hazard industries, like oil and gas, to the wood pellet industry.

CSA Z767 was therefore selected as the PSM framework for this project to guide the integration of PSM concepts, beginning with the development of the PSM survey. The CSA Z767 standard has four pillars:

- Process safety leadership,
- Understanding hazards and risks,

- Risk management, and
- Review and improvement.

Each pillar contains four elements; the framework is shown in Table 1.

Table 1. CSA Process Safety Management (PSM) System (CSA, 2017)

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

2.2 PSM Survey Development

Survey questions were developed by examining each of the clauses of the CSA Z767 standard and re-wording the clauses to pose them as questions to understand the extent of application in a given company. This includes evaluating how informal (undocumented) and formalized (documented) the elements are, which is an approach outlined by CCPS (2016). The survey questions are found in Appendix A. Resources developed by the CSChE, including a PSM audit protocol and workbook, and site self-assessment tool (CSChE, 2019a,b,c) were also used to help guide the structure and approach to survey questions. The survey was built using Survey Monkey, a leading survey software, which allowed for the survey to be easily shared and for respondents to participate anonymously.

2.2.1 Survey analysis and application of survey results

The survey results were analyzed qualitatively via a single-analyst approach. The survey (as shown in Appendix A) was comprised of qualitative questions that were answered by personnel with a range of different backgrounds, experiences, and current roles, and from operations of different sizes. These factors will necessarily influence the responses provided. The survey results were used to:

- Identify which PSM elements should be prioritized first for implementation, and
- Understand the most common PSM elements, or parts of elements (CSA clauses), that have gaps in implementation. This helped inform the development of element-specific guidance to align with CSA Z767.

2.2.2 NFPA 652 consideration in survey development

Given the significance of the hazard of combustible dust in the wood pellet industry, it was determined the PSM survey should also include questions focussing explicitly on combustible dust. NFPA 652 (2019) Standard on the Fundamentals of Combustible Dust was also examined and considered within the survey.

NFPA 652 was mapped to CSA Z767 and was used to develop several dust hazard specific questions. The purpose of this research activity was to identify the overlap between the management systems outlined in NFPA 652 (2019) and the PSM system described by CSA Z767.

The management system components described in each sub-section of NFPA 652 (2019) Chapter 8 were reviewed and treated as elements. Each NFPA 652 element was reviewed and then compared to the CSA PSM elements. If there was a similarity in the scope and the intention of the elements, the elements were mapped together. If aspects of the NFPA 652 element were captured in more than one CSA element, the additional CSA elements were listed. Table 2 outlines the mapping that was completed. The element numbering included is the sub-section number that refers to each element in the respective standards. Each element of the NFPA 652 management system was able to be mapped to at least one CSA element. This means that in the development of the PSM survey based on CSA Z767, specific questions regarding NFPA 652 were able to be targeted and captured.

Table 2. Mapping of NFPA 652 (2019) management system to CSA Z767 (2017) PSM system

NFPA 652 (2019) Chapter 8: Management Systems	Primary CSA Z767-17 Element	Other/secondary relevant elements
8.3 – Operating Procedures and Practices	7.3 Process and equipment integrity	6.3 Process risk assessment and risk reduction
8.4 – Housekeeping	6.3 Process risk assessment and risk reduction	5.2 Regulations, standards, and codes 7.1 Training and competency 7.3 Process and equipment integrity
8.5 – Hot Work	7.3 Process and equipment integrity	5.2 Regulations, standards, and codes
8.6 – PPE	7.3 Process and equipment integrity	6.4 Human factors
8.7 – Inspection, Testing and Maintenance	7.3 Process and equipment integrity	N/A
8.8 – Training and Hazard Awareness	7.1 Training and competency	N/A
8.9 – Contractors	7.1 Training and competency	7.3 Process and equipment integrity 7.4 Emergency management planning
8.10 – Emergency Planning and Response	7.4 Emergency management planning	N/A

Table 2. Mapping of NFPA 652 (2019) management system to CSA Z767 (2017) PSM system continued

NFPA 652 (2019) Chapter 8: Management Systems	Primary CSA Z767-17 Element	Other/secondary relevant elements
8.11 – Incident Investigation	8.1 Investigation	N/A
8.12 – Management of Change	7.2 Management of change	N/A
8.13 – Documentation Retention	6.1 Process knowledge and documentation	7.1 Training and competency 7.2 Management of change 7.3 Process and equipment integrity 7.4 Emergency management planning
8.14 – Management Systems Review	8.2 Audit process	5.2 Regulations, standards, and codes
8.15 – Employee Participation	5.3 Process safety culture	6.3 Process risk assessment and risk reduction 6.4 Human factors

2.3 Survey Pilot

A survey pilot was completed to engage stakeholders with the development of the survey and gather their feedback to improve the survey quality. Comments about the terminology used, the length of the survey, and the structure were requested. Feedback from the pilot was used to improve and modify the survey prior to distribution to the broader wood pellet operations audience. Two responses were collected during the survey pilot. The questions to collect feedback during the pilot are given in Appendix B.

2.3.1 Survey improvements based on pilot survey

Improvements to the survey were made based on the pilot. Feedback regarding the technical language used in the survey was provided. Efforts needed to be made to ensure the survey is accessible to the target audience. Given that different personnel at various operations have a wide range of backgrounds and experiences, the language needed to be adapted accordingly. Efforts were made to make the survey easier to understand; some survey sections, such as the process risk assessment and risk reduction section, were difficult to simplify further based on the language used in the standard (CSA Z767). Definitions for some concepts that are referred to in the standard, such as conduct of operations, were included in relevant survey questions to improve understanding. Another feature to consider is the answer options, such as including "unsure" as an answer option. Ensuring the answers provided allow flexibility for the responders based on their role and experience with management systems was deemed important.

No significant changes to the pilot survey were required, meaning the responses from the pilot survey were able to be included with the analysis of the formal survey responses, which is discussed in Section 2.5.

2.4 WPAC PSM Survey

The survey was distributed to WPAC members across Canada and was accompanied by an informative introduction and glossary to explain the objective of the survey, as well background information on PSM (Appendix C). The survey was promoted during monthly WPAC Safety Committee meetings, and direct contact with WPAC members was also made to request participation.

2.5 WPAC PSM Survey Results and Discussion

Two responses were collected during the survey pilot and six responses were collected during survey distribution to all WPAC members, for a total of eight responses collected from wood products manufacturing. Many of these responses were provided by personnel at companies that have more than one facility in Canada, which broadens the number of plants that are captured and represented by the survey responses. As outlined in Section 2.2.1, the survey responses were evaluated qualitatively via a single-analyst approach to identify key PSM elements to target for prioritization of improvement and implementation. The survey was designed to facilitate qualitative analysis, as well as for ease of completion by respondents. The survey was designed to be easy to use, rather than exceptionally complicated that may have allowed for more quantitative analysis but may have been too complex for end-users. While the PSM survey results could potentially yield additional information, sufficient data was obtained for this research.

Figure 1 highlights survey respondents' perspectives on which PSM elements are preferred for prioritization for implementation and improvement. Figure 1 shows that process safety culture, process risk assessment and risk reduction, and key performance indicators (KPIs) are of primary interest of the surveyed operations. Figure 1 also shows that there is interest in implementing or improving almost all of the other PSM elements.

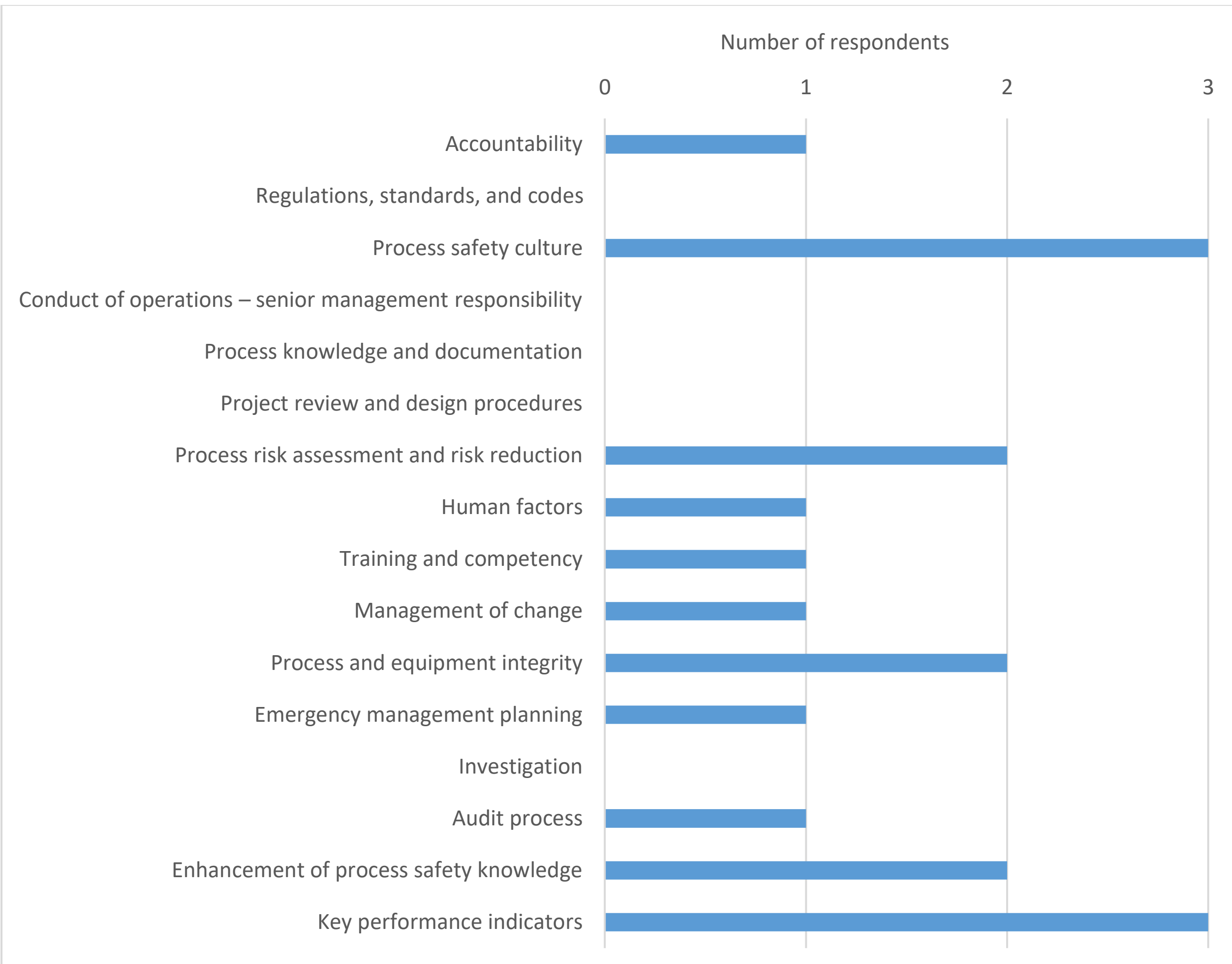

Figure 1. Results of survey question investigating the preference of PSM elements to prioritize for implementation and improvement.

Figure 2 outlines the degree of formalization (documentation) of the PSM elements and concepts at operations. The responses indicated that informal systems are being used for many of the PSM elements, which indicates there is an opportunity to build on existing management system frameworks and improve these elements through explicit documentation, plans and programs. Figure 2 shows the element investigation is formalized, in contrast to management of change which has both informal and formal implementation. Accountability is also identified as an element that would benefit from formalization and is a high-priority as process safety leadership is key for PSM implementation. Overall, these results highlight that there is an interest amongst the respondents to explicitly incorporate the PSM elements that are described by the CSA Z767 standard.

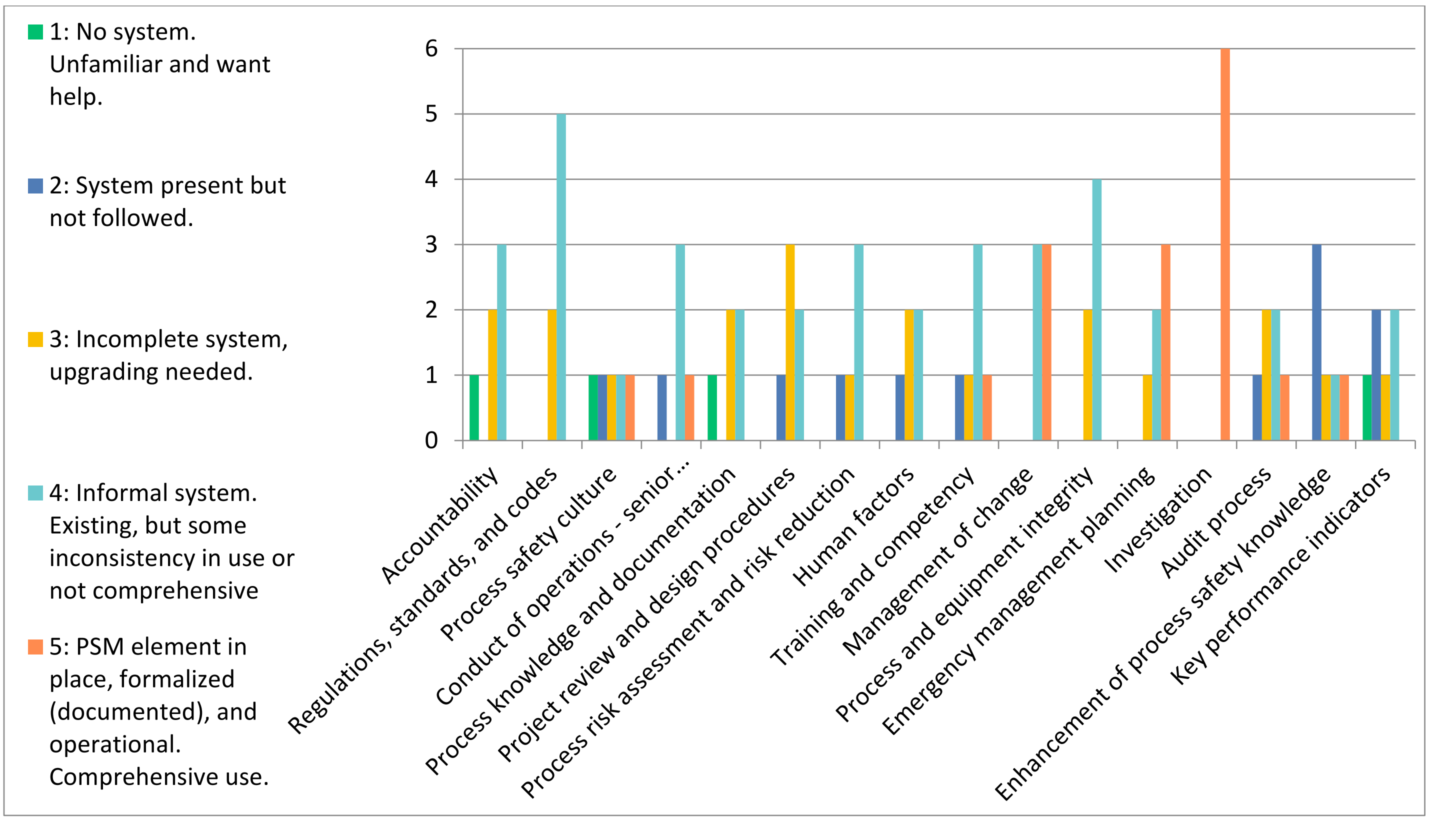

Figure 2. Results of survey question investigating the formalization of PSM elements

As part of identifying a framework for integrating the PSM concepts into wood products manufacturing, a potential avenue for research and development that was considered was identifying an appropriate subset of PSM elements for integration. However, this qualitative review of the survey results indicated the presence of each of the elements at some stage of maturity, so no subset of PSM elements was deemed necessary. The survey also identified that there were gaps in all the PSM elements, and therefore other data and resources had to be collected beyond the wood products manufacturing operations to inform integration tool development. This data gathering activity, along with the identified resources, are described in Section 3.

2.6 Validation Survey Results and Expert Opinion Research

The survey was also distributed to personnel in other industries handling combustible dust, including outside of Canada, as part of a survey validation approach. The purpose of this research activity was to support data gathering and complete a benchmark of the survey results from the wood pellet industry with other industries handling combustible dust. Validation involved examining other industries to understand the prioritization of other PSM elements to explore further.

The validation activity also included virtual meetings with the subject matter experts (SMEs) who completed the survey to gather expert opinion on practices and implementation tools used to integrate the PSM elements. The follow-up interviews involved discussing approaches with the respondents regarding how organizations can integrate, progress, and maintain PSM. The interviews aimed to gather recommendations on key elements to focus on and areas to prioritize.

The PSM survey was distributed to other industries handling combustible dust, including food, chemicals, engineered flooring, as well as wood processing operations outside of WPAC members. Seven responses were collected for survey validation and five follow-up interviews were completed. Any resources and tools able to be shared were also collected. The survey validation meetings ranged from 30-60 minutes in length. Questions including the following were used to gather data from the SMEs contacted:

- Do PSM regulations apply to the facility(s) you support?
- What do you think are the most important PSM elements to begin implementation with?
- Are there are resources or guidance you can recommend that would help with implementation?
- What challenges have you encountered with respect to PSM and how have they been addressed and overcome?

2.6.1 Engineered flooring

The facilities operated by this company (based in the United States) are not covered under the Occupational Safety and Health (OSHA) PSM standard in the United States. This company has implemented PSM voluntarily because it was identified as a best practice for protecting personnel, manufacturing high-quality products and ensuring efficient production. The company also recognizes the value of PSM for emergency management and business continuity planning (BCP). The SME indicated that establishing leadership commitment was the first initiative that was undertaken when beginning the implementation of PSM in new facilities. Approaches shared by this SME for process safety leadership accountability are given in Appendix D, including informal leadership training and resources and an Advanced Safety Audit (ASA) approach.

2.6.2 Food products

An interview was conducted with an SME working in food production that also has previous experience in oil and gas. In their experience, ensuring good flow of information across management of change, incident investigation and PHAs is an important process to have established. The significance of developing effective corrective action plans (CAP) that achieve a reduction in risk compared to the pre-incident risk level was also emphasized. It was recommended to complete a CAP assessment that determines how the changes impact the organization. Improved flow of information enhances learning across the organization.

An approach highlighted by the SME is a management system methodology offered by a consulting organization[2]. A resource developed by Shell that is available online and titled "Learning from Incidents – Chronic Unease" can be used as part of process safety culture.[3] This resource includes numerous videos, a resource on weak signals, discussion questions and exercises.

The SME also emphasized the importance of worker engagement and operator participation. Considerations include how the leadership model considers feedback from frontline personnel, as well as the degree to which safety is driven by their input.

[2] http://vpsigroup.com/Default.html
[3] https://www.rapidview.co.uk/lfi/shell_lfi_chronic_unease/english/Launch_Presentation.html

2.6.3 Combustible dust consulting (agriculture, grain, chemicals)

The SME shared that hazard awareness, plant operation (including operational discipline and daily processes), and process safety culture are key areas of focus for beginning PSM implementation.

The SME highlighted the incidence of pellet cooler fires in other industries in their experience, which were typically caused by maintenance issues, mechanical failures, and ignition sources from the pellet mill. The SME recommended operations ensure appropriate measures are in place to prevent pellet cooler fires. The SME also highlighted that FM Global datasheets[4] are a valuable resource for managing combustible dust hazards (and which can be downloaded for free).

2.6.4 Chemicals

Two interviews were conducted with SMEs in chemical manufacturing. With respect to PSM regulations, each of the SMEs support facilities that are covered under OSHA PSM regulations. However, each remarked that they believe PSM is good business practice and they therefore conduct activities beyond compliance. The value of PSM for business continuation planning was also highlighted.

One SME highlighted the need for multi-level process safety concepts training across organizations, including risk assessments, and other best practices. Human factors and HMI (human machine interface) training were also emphasized as important areas of focus, along with management of change, PHAs, PSSR (pre-start-up safety review), and training and education for operator competency.

It was highlighted that documentation can be challenging, including that for P&IDs, equipment drawings, and evergreen documents. The SME emphasized the need to keep current process safety information (PSI) current in order to complete PHAs.

An implementation tool suggested by the SME was for operations to establish a Process Safety Committee (structured similarly to a JOHS committee). This is discussed further in Section 3.

The other SME in the chemicals industry that was interviewed highlighted that awareness and understanding of risk is a high priority. A useful consideration to include in incident investigations is asking, “How could this incident have been worse?” This helps to improve the understanding of the risk, as well as improve risk reduction measures. A self-

[4] https://www.fmglobal.com/research-and-resources/fm-global-data-sheets

assessment approach for equipment was highlighted as a tool to help improve hazard awareness and risk reduction.

Emergency response was another priority emphasized by the SME. A resource published by OSHA was suggested by them[5]. As part of emergency response planning, the value of pre-planning and having plans available at facility gates was highlighted. This also includes developing and having open lines of communication with external emergency responders, and providing guidance to operators that allows them to make judgements to determine the severity of scenarios and distinguish process upsets and elevated incidents. This emphasizes the importance of training and competency, including process technology, specifically the risks of materials and equipment, as well as what actions to take, how to conduct tasks and why they are needed. As part of the awareness and training, it is important to tailor materials for the target audiences across leadership and the plant floor.

2.6.5 Wood products manufacturing

An interview was conducted with a wood products manufacturing company outside of Canada. The company's operations are not covered under any PSM regulations. This respondent indicated that risk assessment and risk reduction is a key PSM element to focus on for beginning implementation. An initiative is currently being undertaken to align the large number of facilities with internal risk reduction standards. This initiative began with the need to understand what controls need to be implemented to prevent incidents. These risk reduction standards were developed by existing company risk reduction documentation, guidance from insurers (including industry best practices), company experience and incident history, and sharing learnings across the different sites.

The high-level process for this risk reduction initiative is to complete a gap analysis against the standard, followed by defining and developing an action plan to implement the protections required. The progress that is being made (on a quantitative basis) for achieving compliance with the internal risk reduction standards is being tracked, which helps focus efforts, clearly demonstrate progress, and prioritize action plans. This approach for tracking progress will be incorporated into the PSM implementation scheme which is highlighted in Section 3.1.

Challenges with managing key performance indicators (KPIs) were highlighted, including identifying a better digital platform to use for this purpose. The value of KPIs is recognized in order to make data-driven decisions.

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[5] https://www.osha.gov/sites/default/files/publications/OSHA_3644.pdf

Other areas of importance highlighted by the SME include training, education, and awareness. Additionally, with the onsite launch of new initiatives, operations support is needed in order to ensure that the requirements are understood and the interpretation is aligned with the intent.

2.6.6 Other research and input from SMEs

A presentation made at the 2022 Process Safety Management Division (PSMD) of the Canadian Society for Chemical Engineering (CSChE) by the BC Energy Regulator (BCER) outlined the adoption of CSA Z767 in gas processing, as the standard was recently adopted in the Oil and Gas Processing Facility Regulation (BCER, 2021a) and outlined by the Regulation Overview Document (BCER, 2022). This work incorporated a qualitative self-assessment to conduct a gap analysis between the standard and operations. This work confirms and supports the use of the PSM survey as a tool to support the implementation of PSM within wood pellet operations. Other recommendations from the BCER work include the importance of the PSSR element, as well as the use of guidelines from ABSA (Alberta Boilers Safety Association)[6] as applicable.

An SME in the pulp and paper industry indicated an OSHA PSM audit tool is used by their operation to support review of their PSM system[7]. This resource was compared with the PSM survey design, and it was identified that a similar approach to survey questions was used, which provided additional survey validation.

2.6.7 Expert opinion from project team

Expert input was contributed by the project's Principal Investigator (Dr. Paul Amyotte) that process safety culture, risk assessment and incident investigation, are high-priority PSM concepts to focus on for implementation, which validated the survey findings. Explicit focus on enhancing risk assessments is taking proactive steps to improve risk reduction and prevent incidents from occurring. A focus on improving investigation is reactively learning from incidents to address gaps in risk reduction, which also contributes to incident prevention. Lastly, a focus on improving process safety culture facilitates the behaviours and approaches to implement systemic changes to prevent incidents.

[6] https://www.absa.ca/
[7] https://www.osha.gov/sites/default/files/2019-03/08_PSM_Auditing_Checklist.pdf

Expert input that was contributed by project partner (Bill Laturnus, BCFSC) highlighted the importance of focussing on the management of change (MOC) element, as this is a gap that is commonly identified in their experience. It was also identified that a staged or phased approach to implementation, where selected PSM elements would be focussed on at a given time, would make the implementation process more feasible and manageable for operations. As part of data analysis, the development of a high-level implementation approach was initiated. The implementation of PSM elements identified as high priority would be undertaken first, as further discussed in Section 3.

2.7 Summary of Key Focus Areas for PSM Implementation

Through the analysis of the survey data, expert opinions gathered from validation interviews and expert input from the project team, the research suggests that the elements that should be prioritized for stage 1 implementation are:

- Accountability
- Process safety culture
- Process risk assessment and risk reduction
- Management of change (MOC)
- Investigation
- KPIs

While the PSM elements identified for stage 1 implementation may serve as a starting point for a given facility, an important consideration for implementation will be site-specific judgements on a case-by-case basis for element prioritization. Different sites may require different prioritization based on current status, gaps and degree of formalization, which will require a flexible approach. For example, while survey responses indicated the element of investigation was formalized and had a correspondingly low preference for prioritization, it is a key element and an emphasis on investigation will help any operations that do have gaps in their program.

OSHA (2017) provides information on PSM elements that may be most relevant to small businesses; the elements that are prioritized are Process Safety Information (PSI), Process Hazards Analysis (PHA) (risk assessment), Training, Mechanical Integrity (MI), and

Compliance Audits. These elements have also been considered within the prioritization scheme recommended here.

Based on the outcomes of the PSM survey activities, a prioritization of elements has been identified and a staged approach to PSM element implementation has been developed. Prioritization can also be adapted based on the operation's judgement through considering the outcomes of self-assessment, anticipated effort, and perceived risk.

The staged approach is outlined in Table 3. The selection of the elements for stages 2 and 3 are also based on single-analyst qualitative analysis of the survey data, including the responses in Figure 1 and Figure 2, as well as input from BCFSC.

Table 3. Staged approach to PSM element implementation (according to CSA Z767)

Stage	Element
1	Accountability
	Process safety culture
	Risk assessment and risk reduction
	Investigation
	MOC
	KPIs
2	Training and competency
	Process and equipment integrity
	Human factors
	Conduct of operations – senior management responsibility
	Process knowledge and documentation
3	Emergency management planning
	Project review and design procedures
	Audits process
	Regulations, codes and standards
	Enhancement of process safety knowledge

This staged approach must be accompanied by an industry implementation guide, as discussed in Section 3.1.2, and the development of such is recommended as a next step for future work.

3 PSM BEST PRACTICES AND INTEGRATION TOOLS

This chapter describes best practices and tools for the integration of PSM elements, which includes a self-assessment worksheet that has been developed for operations. A high-level approach is given for the implementation of PSM, which includes a staged approach to target high-priority elements, while providing flexibility through resources and tools collected and developed through the current research.

3.1 PSM Implementation Resources

The scope of this research project focussed on integration tool development, which would be used to support an implementation plan and subsequent industry implementation through a long-term strategy. This sub-section highlights key resources that can be incorporated within a given implementation approach.

3.1.1 PSM implementation example-based guidance

Resources that provide guidance on PSM implementation with a particular focus on small businesses and non-chemical process industries (non-CPI) were identified through a comprehensive literature review. Examples of PSM plans and implementation guides serve as example-based guidance for the wood pellet industry, as they outline approaches to PSM implementation. The Technical Standards and Safety Authority (TSSA), a regional authority in Ontario, provides safety services including the sector of Boilers and Pressure Vessels and Operating Engineers. The TSSA has adopted the CSA Z767 PSM standard within the Operating Engineers Safety Program.[8] As part of this adoption, the TSSA has published a Path 2 (performance-based approach) Risk and Safety Management Plan (RSMP) Implementation Guide (TSSA, 2020). This implementation guide can serve as example-based guidance for the wood pellet industry, as it directs end-users through PSM implementation and the adoption of CSA Z767, and outlines PSM element requirements with respect to policies, procedures, data analysis, and information gathering. As part of the future wood pellet PSM implementation plan to be developed, it is recommended that a similar resource be created, with appropriate simplifications and adaptations made for the wood pellet industry.

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[8] The TSSA Risk and Safety Management Plans focusses on the adoption and use of CSA Z767, or a successor standard (i.e., a standard that meets the CSA Z767 requirements)

Examples of written PSM programs and plans were also investigated to support the development of program documentation. These PSM programs, standards and codes are outlined in Table 4, which can be referenced to help develop relevant documentation. Readers are also encouraged to review the PSM Egypt (2022) PSM Implementation Guidelines for additional information.

Table 4. PSM program documentation examples and guidance

Author and Resource	Comment
HNI Risk Advisors (n.d.).	Example of PSM plan based on OSHA Standard 29 CFR 1910.119 Process Safety Management of Highly Hazardous Substances (PSM)
Newington Energy LLC (2007)	Example of PSM plan
Penn State (2023)	Pennsylvania State University has implemented PSM to manage and operate hazardous operations. Examples of written procedures for each of the PSM elements are provided.
NDEP (2023)	The Nevada Division of Environmental Protection Chemical Accident Prevention Program (CAPP) regulates facilities handling highly hazardous substances. Guidance and checklists for process safety elements are provided.
Rio Tinto (2021)	Rio Tinto Process Safety Standard
Gulf Petrochemicals & Chemicals Association (GPCA) (2011)	Process Safety Code
PSM Egypt (2022)	PSM Implementation Guidelines

3.1.2 PSM Steering Committee

Establishing an industry PSM Steering Committee was identified as an activity for the implementation of PSM. For example, in Egypt, to support the adoption of PSM in the oil and gas industry, the Egyptian Process Safety Management Steering Committee was launched. The steering committee outlines a PSM roadmap, along with numerous PSM resources, including an implementation guideline. Key items of the PSM roadmap that should be considered as part of PSM implementation in the wood pellet industry include:

- Developing a PSM Steering Committee that serves as a technical group for implementing PSM

- Creating short-term and longer-term milestones for PSM implementation
- Identifying operational PSM maturity
- Recommending a PSM organizational structure, including roles, responsibilities and competency framework
- Developing hazard management programs and policies
- Developing process safety KPIs
- Providing opportunities for industry communications, including workshops, conferences, and publications.

Readers are encouraged to review the Egypt PSM Steering Committee website[9] that serves as a valuable example of industry-wide adoption of PSM with publicly shared resources. Penn State (2016a) provides another example of a PSM Steering Committee Charter, describing the mission, responsibilities, roles, and meetings.

For PSM implementation in the Canadian wood pellet industry, it is anticipated that the PSM Steering Committee model can be leveraged and align with the already well-established WPAC Safety Committee structure. The recommended makeup of the PSM Steering Committee includes representatives from operations, WPAC, BCFSC, and supporting SMEs. The industry stakeholders should provide a cross-section of the diverse producers across the Canadian industry with respect to geography and scale.

3.1.3 PSM self-assessment worksheets

As outlined in TSSA (2020) and CCPS (2016), one of the initial steps in PSM implementation is to complete a qualitative gap analysis against the PSM standard (in this case, the CSA Z767 standard). To perform this gap analysis, PSM self-assessment worksheets have been developed as part of the current work. The self-assessment sheet format was based on the WorkSafeBC self-evaluation tool for managing risks in manufacturing workplaces (WorkSafeBC, 2023a).

Within the current work, a template for the self-assessment sheet was created and is found in Appendix F. Self-assessment sheets were developed for Accountability, the first

[9] https://psmegypt.com/

element in the CSAZ767 framework (Appendix F), and the high-priority elements of Process Safety Culture (Appendix G), Management of Change (Appendix H) and Key Performance Indicators (Appendix I). The self-assessment worksheets can be completed in the staged approach outlined in Sections 3.2, 3.3 and 3.4.

PSM best practices and tools have been identified and collected to support the integration of PSM elements and development of PSM element policies and procedures. These resources are referenced in the self-assessment worksheets to help operations address identified gaps and areas for improvement.

3.1.4 PSM factsheets

A factsheet that provides an overview of PSM in wood products manufacturing has also been developed (Appendix J). Factsheets for Accountability (Appendix K) and the high priority elements of Process Safety Culture (Appendix L), Management of Change (Appendix M) and Key Performance Indicators (Appendix N), have also been created and developed as part of this research. These factsheets have been designed to support the understanding of the PSM elements and to explicitly integrate these PSM concepts within wood products manufacturing. The use of factsheets to communicate key messages to operations is based on the leading best practice set by the Center for Chemical Process Safety (CCPS) Process Safety Beacon (CCPS, 2023b). The Process Safety Beacon is designed to primarily target process safety messages to plant operators, maintenance personnel and production staff. These factsheets, along with the self-assessment worksheets, will be further refined using input and feedback from the PSM steering committee, as discussed in Chapter 4.

Best practices for the integration of PSM elements are now described in Sections 3.2, 3.3 and 3.4.

3.2 Stage 1

As outlined previously, the PSM elements that were identified as highest priority, and thus would be focussed on in stage 1, are:

- Accountability
- Process safety culture
- Risk assessment and risk reduction

- Investigation
- MOC
- KPIs

Best practices identified for the integration of these PSM elements are outlined in the following sub-sections. All links are believed to be active as of May 31 2023.

3.2.1 Accountability

A relevant best practice that was identified is the Process Safety Leadership Group (PSLG) principles of process safety leadership (HSE, 2023). This best practice is of interest because it builds on the current WPAC Safety Committee structure. Through the collaboration of industry stakeholders, eight principles were developed through for senior individuals to follow. These include considerations such as requiring senior leadership team involvement and competence in safety management, placing process safety leadership central to the business to ensure risks are effectively managed, and engaging employees in safety management. The principles support leadership in steering continuous improvement.

The principles support leadership and staff meetings, and can be used to evaluate performance, including when determining root causes of incidents. (Offshore Energies UK, 2023). Additional accountability best practices and resources are outlined in Table 5, which includes tools designed for personnel in leadership such as leadership self-assessments and process safety leadership guides.

Table 5. Best practices and resources for Accountability

Best Practice/Resource and Link
HSE (2023). Process Safety Leadership Guiding Principles
OECD (2012). Corporate Governance for Process Safety: Self-Assessment Questionnaire for Senior Leaders
Levovnik et al. (2019). The Role of Leadership in Process Safety Management System "No Process Safety Management System is an Island"
Travers, I. (2019). Practical Leadership for Process Safety Management
Control of Major Hazards (COMAH) (2018). Managing Risk - The Hazards That Can Destroy Your Business. A Guide to Leadership in Process Safety.

Table 5. Best practices and resources for Accountability continued

Best Practice/Resource and Link
Control of Major Hazards (COMAH) (n.d.). Major Hazard Leadership Intervention Tool
CalOSHA (California Occupational Safety and Health) (2011). Identifying Measurable Safety Goals
Process Safety Forum (2023). Resources (Leadership Principles, Safety Leadership Charter, Lessons Learned)
CCPS (2019). Process Safety Leadership from the Boardroom to the Frontline

An area for future work is investigating how process safety goals should be set in a manner that includes the engagement of frontline workers and operators. CalOSHA (2011) highlights the development of process safety goals focussing on:

- Audit items: number open and time to close
- Percentage of PPE compliance – spot check audit done each month
- Employee participation rate
- Housekeeping and safety audits
- Process safety program measures
- PM and maintenance program measures

Based on the above consideration, a potential tool is a monthly process safety performance report that would involve gathering safety records and performance measures into a simple, single-page report. The report would summarize proactive measures that are related to actions, results as related to injury and incident rates, and a comparison with historical results and target goals. The process safety performance report from each operation could serve as the basis for an industry benchmarking report; benchmarking and key performance indicators (KPIs) are discussed further in Section 3.2.6.

3.2.2 Process safety culture

Safety culture surveys have been identified as a key tool for implementing and maintaining PSM. Similar to safety culture surveys, safety climate assessments (as discussed by WorkSafe Queensland (2022)) include the consideration of:

- Management visibility and commitment
- Communication
- Safety vs. productivity
- Learning organization
- Safety resources
- Participation
- Shared perceptions about safety
- Trust
- Job satisfaction and industrial relations
- Training

As outlined by CCPS (2022a), safety culture surveys allow for the effectiveness of the culture at a given operation to be evaluated and KPIs to be developed, which are subsequently monitored to identify changes and improvements to safety culture.

Available safety culture surveys identified in the literature include the Baker Panel Report (BP Refineries Independent Report) found in CCHS (2011a) and DuPont (2010). These surveys were examined with the goal of creating a process safety culture survey that may be more appropriate for smaller operations, including wood products manufacturing.

The safety culture survey included in the Baker Panel report can be used as an in-depth assessment of safety culture. However, this survey, consisting of 49 questions, may be deemed by smaller organisations to be excessively time-consuming and not feasible. The DuPont safety perception survey (DuPont, 2010) consists of 24 questions, but is structured in a manner that uses a wide range of responses, which makes data analysis more complex. The surveys were reviewed, and process safety culture survey questions were selected and/or adapted. The proposed safety culture survey is based on the Baker Panel survey due to its simple structure, as questions can be responded to using a sliding scale (agree to disagree), and the survey was able to be made more concise by selecting questions that are most appropriate and targeted for wood products manufacturing. Additionally, the questions are structured so responses can be easily anonymized, which is important for the small staff numbers at some facilities. The safety culture survey questions are given in Table 6.

Guidance for administering process safety culture surveys is described in both CCHS (2011b) and WorkSafe Queensland (2023); future work will include survey validation by working closely with operations to develop the rollout and implementation plan to ensure it is practical and anonymity is maintained.

Table 6. Process safety culture survey questions adapted from Baker Panel Report (CCHS, 2011a)

Category	**Safety Culture Survey Question**	**1: Agree 2: Somewhat Agree 3: Neutral 4: Somewhat Disagree 5: Disagree**
Process Safety Reporting	The plant provides sufficient training on hazard identification, control, and reporting.	
	I can report hazardous conditions without fear of negative consequences.	
	A culture exists in this plant that encourages raising process safety concerns.	
	Corrective action is quickly taken when management is notified of unsafe process safety conditions.	
	I am confident that process safety issues are thoroughly investigated and appropriately resolved.	
Safety Values / Commitment to Process Safety	Supervisors put a high priority on process safety through actions, not just empty slogans.	
	Plant management puts a high priority on process safety through actions, not just empty slogans.	
	Production pressures do not lead to cutting corners with respect to process safety.	
	Process safety programs have adequate resources.	
	After a process-safety incident or near miss, management is more concerned with addressing the hazard than assigning blame or issuing discipline.	

Table 6. Process safety culture survey questions adapted from Baker Panel Report (CCHS, 2011a) continued

Category	Safety Culture Survey Question	1: Agree 2: Somewhat Agree 3: Neutral 4: Somewhat Disagree 5: Disagree
Supervisory Involvement and Support	Process safety concerns are primary to production goals.	
	My supervisor encourages me to identify and report unsafe conditions.	
	Individuals with appropriate supervisory authority and expertise participate in hazardous process-related activities (e.g., start-up).	
	My supervisor takes action when workers engage in poor process safety practices.	
	My supervisor takes appropriate action in response to suggestions for process safety improvements.	
Procedures and Equipment	Interlocks, alarms and other process-safety related devices are routinely tested and maintained.	
	Written operating procedures are regularly followed and kept up to date.	
	There are written procedures that instruct operators to take immediate action if safety critical equipment (e.g., interlocks, alarms or other process safety equipment) fails during operation.	
	Maintenance checklists and procedures are easy to understand and use.	
	Inspection and maintenance are made high priority.	

Table 6. Process safety culture survey questions adapted from Baker Panel Report (CCHS, 2011a) continued

Category	Safety Culture Survey Question	1: Agree 2: Somewhat Agree 3: Neutral 4: Somewhat Disagree 5: Disagree
Worker Professionalism and Empowerment	I can influence process safety policies implemented at the plant.	
	Workers at all levels of the plant actively participate in hazard reviews and assessments, and incident investigations.	
	Workers sometimes work around process safety concerns instead of reporting them.	
	I have a responsibility for identifying process safety issues at my plant.	
	Operators are empowered to take immediate action if safety critical equipment (e.g., interlocks, alarms or other process safety equipment) fails during operation.	
Process Safety Training	The training I have received provides me with a good understanding of the process safety risks at my plant.	
	I know how to access process safety resources.	
	All worker groups (new workers, experienced workers, supervisors, contractors) receive the necessary process safety training to safely do their job.	
	My process safety training enables me to identify when the process should be shutdown if safety critical equipment (e.g., interlocks, alarms or other process safety equipment) fails during operation.	
	The process safety training received by workers is adequate for helping to prevent process safety incidents.	

Readers who wish to expand on the survey are encouraged to review the Baker Panel survey in CCHS (2011a) and the culture survey questions that have been adapted from the DuPont Safety Perception survey in Appendix O (DuPont, 2010). Additionally, CCHS (2011b) also provides further examples of open-ended survey questions that can be re-worded to either accommodate sliding scale (agree-disagree) or true-false.

WorkSafe Queensland (2022) provides a collection of webinars on safety culture. It is recommended that a webinar be developed that focuses on safety culture in wood products manufacturing, which could be added to the existing WPAC Safety Foundation Webinar Series (WPAC, 2023a). This webinar will include key concepts presented by Hopkins (2005) – safety culture, collective mindfulness and risk-awareness. Safety culture is comprised of just, reporting, learning and flexible (decision-making) sub-cultures. Collective mindfulness involves several features such as preoccupation with failure and sensitivity to operations; these correlate well with avoiding complacency and maintaining a sense of vulnerability. Risk-awareness incorporates the avoidance of normalizing evidence, sometimes called normalization of deviance or deviation.

Additional process safety culture best practices and resources are given in Table 7, including an example of a safety culture survey policy, a video focussed on the safety sub-culture of chronic unease (maintaining a sense of vulnerability), and toolkits for building a strong safety culture.

Table 7. Best practices and resources for Process Safety Culture

Best Practice/Resource and Link
WorkSafe Queensland (2023): Safety Climate and Safety Culture Videos, Assessment Guidance, Factsheet (Safety culture, climate and leadership), Factsheet (Getting the most out of your safety climate survey)
Transport Canada (2021). Example Safety Culture Policy Statement
Manufacturing Safety Alliance of British Columbia (MSABC) (n.d.). Safety Culture: A Guide to Effective Measurement and Improvement
Energy Institute (2023). Hearts and Minds Safety Culture Toolkit
Energy Institute (2023). Hearts and Minds Safety Culture: Chronic Unease Video
Contra Costa County Health Services (CCHS) (2011). Safety Culture Assessments Overview
Contra Costa County Health Services (CCHS) (2011). Safety Culture Assessments Guidance and Example
DuPont (2010). Safety Culture Survey Example: DuPont Safety Perception Survey
Contra Costa County Health Services (CCHS) (2011a). Safety Culture Survey Example: Baker Panel Report
Center for Chemical Process Safety (CCPS) (2021). Building Process Safety Culture Tool Kit: Tools to Enhance Process Safety Performance
WorkSafeBC (2023b). Enhancing Health & Safety Culture & Performance
HSE (2023). Organisational Culture: Guidance
HSE (n.d. -a). Extract from Inspectors’ Human Factors Toolkit: Safety Culture Questions

Table 7. Best practices and resources for Process Safety Culture

Best Practice/Resource and Link
Arendt, S. and Manton, M. (2015). How to Ensure Sustainable Process Safety Performance – Strategies for Managing, Maintaining, and Improving PSM Systems.

3.2.3 Process risk assessment and risk reduction

Risk assessments may be demanding and large undertakings, which can be a challenge for smaller operations. Best practices and resources for process risk assessment and risk reduction are given in Table 8. TSSA (2020) outlines the risk assessment process. Previous work completed during the WPAC-BCFSC Critical Control Management (CCM) project helps to support this PSM element. Guidance on the use of bow tie analysis to complete hazard analyses is provided by WPAC (2023b) and WorkSafeBC (2019). GCPA (2011) outlines a process safety code (a guide to PSM elements) and provides suggestions for additional activities that can be undertaken as part of implementing this PSM element.

Table 8. Best practices and resources for Process Risk Assessment and Risk Reduction

Best Practice/Resource and Link
Gulf Petrochemicals and Chemicals Association (GPCA) (2011). Process Safety Code: Process Risk Management
WPAC (2023b). Critical Control Management Resources
WorkSafeBC (2019). Barrier-Focused Approaches to Risk Analysis -Introduction to Bow Tie Analysis.
TSSA (2020). Path 2 RSMP Guidelines for Operating Engineers Safety Program - Appendix B: Detailed Guidance & References on Process Safety Risk Assessment

3.2.4 Management of change

The focus of MOC is to manage risks related to changes and modifications of design, equipment, procedures, and organization (CSA, 2017). NFPA 664 (2020) outlines that projects that involve the following should be included in the MOC process:

- Occupancy and process changes, including storage arrangements and heights, process equipment, process materials, production rates,

- Modifications to any fire protection and alarm systems (including water supplies, automatic sprinkler protection, alarm equipment),
- Exposure changes (such as yard storage and changes to neighboring facilities)
- Changes in personnel, and
- New construction or modifications to existing infrastructure.

AIChE (2021) highlights the need to include changes to engineered dust control equipment within the MOC process. For example, the addition of a dust collection pick-up point could lead to the need for increased fan capacity. It is important to understand how changes (e.g., process conditions) may impact the performance of protection systems.

Additional MOC best practices and resources are outlined in Table 9, which includes examples of MOC plans and forms, and informative guides. The NFPA 664 and 652 standards (which can be accessed for free online) are also valuable resources.

Table 9. Best practices and resources for Management of Change

Best Practice/Resource and Link
Example of Management of Change Plan[10]
SAFER (n.d.). Combustible Dust Management Assessment Handout
Occupational Health and Safety Administration (OSHA) (2019a). MOC Guidelines
CCPS (2021). Golden Rules for Combustible Dust
PSM Egypt (2022). Management of Change Guideline
CSChE (2004). Managing the Health and Safety Impacts of Organizational Change
NFPA 652 (2019). Standard on the Fundamentals of Combustible Dust
NFPA 664 (2020). Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities
Penn State (2016b). Process Safety Management: Management of Change Form

There are several resources describing factors and principles for successful implementation of an MOC program that operations may refer to. A white paper published by Dustcon Solutions Inc. (n.d.) outlines aspects that must be considered for

[10] Found in Appendix P

the implementation of an MOC process to be successful, including management support, technical expertise and communication. Readers are encouraged to review the white paper to learn more about the challenges that a given facility may face when beginning an MOC program, as well as steps for beginning to implement an MOC program. SAFER (n.d.) provides guidance on combustible dust management of change, including the elements of an effective MOC program and best practices in MOC, as well as an example of a process flow chart specifically for addressing combustible dust hazards. CCPS (2008) *Guidelines for the Management of Change for Process Safety* outlines considerations for implementing an MOC program, including:

- Keep it simple yet fit for duty
- Attain broad acceptance and commitment
- Field test the system before formal implementation
- Provide training
- Monitor MOC system effectiveness
- Conduct audits and management reviews
- Demonstrate management commitment

For support in developing MOC documentation, including forms and plans, an example of an MOC Plan is included in Appendix P. This example has been adapted from confidential resources from wood products manufacturing. This serves as an example of an MOC plan that may be appropriate for wood pellet operations. Another example of an MOC form is provided by Penn State (2016b).

3.2.5 Investigation

Links to investigation best practices and resources are given in Table 10, which includes examples of investigation plans and forms. These resources include considerations for completing incident investigations for all incidents that happen, including those that do not lead to injuries (such as a process safety failure of a critical control). As part of implementation in wood pellet operations, this will be an aspect of interest. Similar to the webinar focused in process safety culture highlighted in Section 3.2.2, a webinar on the topic of investigation on how to investigate a process safety incident would be a valuable resource to operations.

Table 10. Best practices and resources for Investigation

Best Practice/Resource and Link
CCPS (2023a). Introduction to Incident Investigation
HSE (2014). Investigating Accidents and Incidents: A Workbook for Employers, Unions, Safety Representatives and Safety Professionals
Penn State (2014). Compliance Guidelines for Incident Investigation
Penn State (2016c). Process Safety Incident Report Form
Vale (2016) Incident Investigation Standard Procedure Instruction
Vale (2017) High Potential Incident Reporting (HiPo or HPI) Standard Procedure Instruction

CCPS (2023a) provides a description of the PSM element of investigation, including a flow chart for the investigation process. HSE (2023) also provides information for key actions in effective incident investigation with respect to leaders, managers, worker consultation and involvement, and competence.

3.2.6 Key performance indicators for process safety

Process safety key performance indicators (KPIs) best practices and resources are outlined in Table 11, which includes guides for developing and selecting process safety KPIs.

Table 11. Best practices and resources for Key Performance Indicators

Best Practice/Resource and Link
HSE (2006). Developing Process Safety Indicators A Step-By-Step Guide for Chemical and Major Hazard Industries
Fanelli, P. (2014). Process Safety Performance Indicators for a Fuel Storage Site: A Worked Example
Chemical Business Association (2018). Safety Performance Leading Indicators
Center for Chemical Process Safety (CCPS) (2022): Process Safety Metrics Guide for Leading and Lagging Indicators (Version 4.1)

As a key objective of the current research is ensuring effective integration of PSM, the development of KPIs is critical. Effective integration refers to the measurement of PSM performance via safety metrics and the assurance of a robust safety culture. Effective integration requires the identification of appropriate leading/lagging indicators and safety culture components. There are three categories of KPIs of interest for this research.

The first is KPIs for PSM implementation that can monitor and track the progress of integrating PSM elements. The second is site-specific process safety KPIs, focussing on leading indicators such as inspections and training, and lagging indicators, including fires and deflagrations. The third is process safety KPIs for industry benchmarking to monitor industry-wide PSM performance. Each of these types of KPIs are discussed in the following sections.

PSM Implementation KPIs

Following the proposed implementation plan, and referring to the implementation indicators outlined in TSSA (2020), potential PSM implementation KPIs include percent completion of:

- PSM element self-assessment worksheets
- Corrective action plans identified in self-assessment worksheets
- PSM element policies development (as outlined in TSSA (2020))
- PSM element procedures development (as outlined in TSSA (2020))

Additionally, desired outcomes and target indicators of implementation (as outlined in TSSA (2020)) include:

- Senior leadership knowledge of and commitment to PSM framework
- Operating staff knowledge of and commitment to PSM framework, its procedures and policies
- Staff training records
- Incident reporting and investigation records
- Accessible information system
- Testing, inspection and maintenance records
- KPI tracking system
- Audit reports

- Corrective action plans for implementing recommendations from risk assessments
- Documented MOC program, including updating the PSM program based on plant changes, and completing risk assessments and approval logs on new projects and process changes

Site-Specific Process Safety KPIs

HSE (2006) provides a step-by-step approach that can be adapted for the wood pellet industry. Fanelli (2014) describes a worked example of developing proposed KPIs for a fuel storage site following the method described in HSE (2006).

Using previously collected data from the bow tie analyses developed through the WPAC-BCFSC Critical Controls Management (CCM) project and referring to the process outlined in HSE (2006), potential process safety indicators are outlined in this section. In this example, wood pellet production is the scope of the analysis. For future work, it is recommended that an evaluation of the bow tie analyses developed for MDF (medium density fibreboard) be completed to identify KPIs. Additionally, the focus of this section is inspection and maintenance. Future work should include evaluating the other risk control systems (RCS), which are types of barriers for managing hazardous scenarios (e.g., training, operating procedures) for KPIs, as per the HSE (2006) methodology.

There are numerous leading metrics that could be chosen and monitored. Metrics should be selected that are practical to collect and report and allow opportunities for improvement to be identified. For future work, it is recommended that validation of the proposed leading and lagging indicators be completed with operations through a pilot and revised accordingly as needed, prior to broad implementation.

Leading indicators include Tier 4 (operating discipline and management system performance indicators) and Tier 3 (challenges to the safety system). In the context of bow tie analysis, Tier 3 are barriers that failed, and Tier 4 are behaviours that caused a failure (focussing on degradation factors); this is described by Pipeline Safety Trust (2017) that discusses safety metrics for pipelines with respect to the CSA Z260 Pipeline Safety Metrics standard. Tier 1 and Tier 2 indicators are consequences in bow ties of large significance and lesser significance, respectively.

The scope of the hazard is combustible dust ignition in raw fibre storage, hammer mill, dryer, baghouse, pelletizer and finished pellet silo storage. The ignition of the combustible wood dust can lead to:

- A major fire onsite,
- An explosion, and/or
- Propagation of an ignition source to other equipment.

Immediate causes of the hazardous scenarios include:

- Hot work
- Mechanical failure of ID (induced draft) fan, conveyors, bucket elevators, belts, motors, hammers, bearings due to
  - Wear
  - Corrosion
  - Damage
- Static charge
- Infeed fibre quality (foreign material and rock contamination, variable moisture content)
- Electrical failure (instrumentation, power)
- Spontaneous combustion/self-heating
- Ignition source from powered equipment (e.g., mobile equipment, chipper, grinder)

As outlined in HSE (2006), at a high level, the RCS include:

- Planned inspection and maintenance
- Staff competence
- Operating procedures

- Instrumentation/alarms
- Plant change
- Plant design
- Communication
- Permit to work
- Emergency response programs

Desired safety outcomes:

- No fires or explosions due to:
    - Hot work
    - Mechanical failure of ID fan, conveyors, bucket elevators, belts, motors, hammers, or bearings due to wear, corrosion, or damage
    - Static charge
    - Infeed fibre quality (foreign material and rock contamination, variable moisture content)
    - Electrical failure (instrumentation, power)
    - Spontaneous combustion/self-heating
    - Ignition source from powered equipment (e.g., mobile equipment, chipper, grinder)
- Fire detection and fire-fighting equipment is available and properly functioning

Potential leading indicators include:

- Percentage of safety critical plant and equipment inspections completed to schedule
- Percentage of maintenance actions identified that are completed to the specified timescale
- Percentage of safety critical plant/equipment that performs within specification when inspected

Potential lagging indicators include:

- Number of fires or explosions that result from
    - Hot work
        - Mechanical failure of ID fan, conveyors, bucket elevators, belts, motors, hammers, bearings due to wear, corrosion, or damage
    - Static charge
    - Infeed fibre quality (foreign material and rock contamination, variable moisture content)
    - Electrical failure (instrumentation, power)
    - Spontaneous combustion/self-heating
    - Ignition source from powered equipment (e.g., mobile equipment, chipper, grinder)
- Number of fires or explosions that result from propagation of ignition sources
- Number of fires or explosions where fire detection and fire-fighting equipment is not available and not functioning properly

As previously stated, the results of process safety culture surveys can be monitored and tracked in order to measure the effectiveness of the safety culture. Recommended future work includes further research into the development of safety culture leading and lagging indicators, along with a proposed selection of safety culture KPIs for wood products manufacturing operations.

Industry Benchmarking Process Safety KPIs

As part of mid-year and yearly incident reporting, DustEx Research Ltd. tracks fires, explosions, injuries and fatalities as combustible dust incident (CDI) metrics (DustEx Research Ltd., 2021). Data is also summarized regarding regional statistics, materials involved, industries involved, equipment and causes, and cost of damages.

Considering the incident metrics tracked by DustEx Research Ltd., as well as key upset conditions identified by the WPAC Safety Committee, proposed metrics are outlined in Table 12. These are suggested for industry benchmarking, which would also be recorded as part of site-specific KPIs.

Table 12. Incident and near-miss metrics as part of leading and lagging indicators for sites and industry benchmarking

Incident Detail	Category
Materials involved	Green wood fibre, dry wood fibre, wood pellets
Equipment involved	Wood pellet: raw material/wood fibre storage, green hammermill, dry hammermill, dry fibre silo, dryers (direct-heated belt dryer, indirect heated belt dryer, drum dryer), dust collector (cyclone, baghouse), elevator/conveyor, pelletizer/extruder, cooler, pellet silo. MDF: raw material handling, dryer, forming, production baghouse, finishing, press.
Incident type – lagging indicators	Fire - ID (induced draft) fan fire - Silo fire - Pelletizer/extruder fire - Cooler fire - Pipe fire - Dryer fibre silo fire - Conveyance fire

Table 12. Incident and near-miss metrics as part of leading and lagging indicators for sites and industry benchmarking continued

Incident Detail	Category
Incident type – lagging indicators	Deflagration/Explosion - Hammer mill deflagration - Belt-dryer deflagration - Deflagration propagation (multiple equipment impacted)
Ignition sources (if an ignition occurred and if source was identified)	Hot work and welding, mechanical sparks, electrical equipment, smolder spots, self-ignition, hot surfaces, static electricity, friction, propagation from upstream or downstream equipment
Upset conditions – leading indicators (as they are not a top event or consequence, such as a fire or explosion)	Electrical: - Loss of power, and key process components affected by an electrical loss, including HMI/PLC (human-machine interface/programmable logic controller) communication, ID fans (loss of air flow), deluge system, electric fire pump, fire or explosion detection systems - Communication error between PLC and HMI or between electrical and computer communication - Auto deluge malfunctions - Motor failure Mechanical - Cyclone plug-ups/clogs - Conveyor plug-ups and breakdowns - Dryer infeed conveyor failure - Dryer outfeed conveyor failure - Drag chain breakage - Hammer mill shutdowns - Belt breakage (dryer or conveyor) - Dryer high temperature shutdowns (due to losing power or due to losing feed)

Table 12. Incident and near-miss metrics as part of leading and lagging indicators for sites and industry benchmarking continued

Incident Detail	Category
Upset conditions – leading indicators (as they are not a top event or consequence, such as a fire or explosion)	Weather - Deluge system failure due to freezing - Dryers have trouble with fluctuating fibre moistures (Inconsistent speeds) - Sparks caused by combustion air fluctuating with ambient air - Freeze up in abort gates - Freeze up in utilities/compressed air system - Operational issues with pneumatic sensing/differential pressure lines/flow sensor due to cold temperatures - Freezing of incline conveyors - Blower intake screens plug due to hoar frost - Building dry valve systems break the drain systems due to frost - Excursions of high-speed bearing temperatures, including hammermills and fans during hot ambient temperatures - Excursions of high pellet temperatures out of the coolers and into the rail cars during hot ambient temperatures - Issues with electrical drives, PDCs (power distribution centres), MCCs (motor control centres) during hot ambient temperatures Operations - Magnets filled with metal contaminants (not cleaned) - Rock traps full (not cleaned or emptied) - Worn hammers - Holes in hammermill screens - Pelleter roll and dies worn or out of adjustment - Bridging of material in surge bins - Failing bin level indicators or bindicators - Fibre too wet or too dry coming into pelleters - Decks bridging off or running empty - Mixing bin bridging - Cooler bins plugging up - Manual deluge malfunction - Burner will not relight

It is also recommended that the metrics be tracked with respect to dates so annual/seasonal trending can be completed to analyze how seasonal fluctuations impact process safety.

3.3 Stage 2

The PSM elements identified as priority for stage 2 were:

- Conduct of operations – senior management responsibility
- Process knowledge and documentation
- Human factors
- Training and competency
- Process and equipment integrity

3.3.1 Conduct of operations - senior management responsibility

Conduct of operations (which may also be referred to as operational discipline) best practices and resources are outlined in Table 13, which includes examples of investigation plans and forms.

Table 13. Best practices and resources for Conduct of Operations

Best Practice/Resource and Link
CCPS (2022b). Introduction to Conduct of Operations
CCPS (2022c). Key Principles of Process Safety for Operational Readiness
Klein and Thompson (2022). Audit Process Safety for Compliance and Performance, CEP (Chemical Engineering Progress) (subscription required)

Klein and Thompson (2022) describe the use of use of an operational discipline (OD) checklist as part of a formalized operational discipline program. Examples of these questions include:

- Has the site established systems to achieve and maintain high levels of OD in process safety program activities?

- Has training on the importance of and programs related to OD been provided to site personnel?
- Has site management set, clearly communicated, and reinforced expectations that employees are accountable for following procedures?
- Do procedures and training provide guidance on troubleshooting and responding to situations that deviate from normal operating conditions?

Suggested future work includes adapting the questions developed as part of the PSM survey, as well as designing an operational discipline workshop customized for wood products manufacturing. An operational discipline workshop is another tool recommended by Klein and Thompson (2022) and Klein and Vaughen (2017) for implementing the conduct of operations PSM element.

3.3.2 Process knowledge and documentation

Process knowledge and documentation best practices and resources are outlined in Table 14, which includes publicly available examples of standards, programs and procedures used in industry for managing this PSM element. For example, Suncor (2015) is a process safety information standard that outlines process safety information collection, the management of process safety information and roles and responsibilities.

Table 14. Best practices and resources for Process Knowledge and Documentation

Best Practice/Resource and Link
Suncor (2015) Process Safety Information (PSI) Standard
Nevada Division of Environmental Protection Chemical Accident Prevention Program (2011). Process Safety Information Program
Inland Star Distribution (2016). Process Safety Information Procedure
EPA (2013). Presentation: Prevention Program Safety Requirements for Program Level 3 Processes

3.3.3 Human factors

Best practices and resources for human factors in process safety are given in Table 15. These resources include CCHS (2011c) and State of Western Australia (2021) that provide tools and checklists that can help consider human factors and identify potential areas for improvement. As part of future work, a potential area of interest is a review of the bow tie analyses developed as part of critical control management (CCM) with respect to human factors to examine any feasible opportunities to make improvements.

Table 15. Best practices and resources for Human Factors

Best Practice/Resource and Link
HSE (1999). Reducing Error and Influencing Behaviour
WorkSafeBC (2023c). Human Factors Overview and Resources
Energy Safety Canada (2022). Video: Human and Organizational Performance – The 5 Principles in Action
Gambetti, F., Casalli, A., Chisari, V. (2012). The Human Factor in Process Safety Management
Contra Costa County Health Services (2011c). Process Hazard Analysis Human Factors Checklist
State of Western Australia (Department of Mines, Industry Regulation and Safety) (2021). Human Factors Self-Assessment Guide and Tool for Safety Management Systems at Petroleum and Major Hazard Facility Operations.
CCPS (1994). Guidelines for Preventing Human Error in Process Safety

3.3.4 Training and competency

Best practices and resources for human factors in process safety are outlined in Table 16. Hitachi (2022a) is an example of training matrix used to outline training required and the working knowledge for different roles. Hitachi (2022b) is an example of a procedure that describes health, safety and environment (HSE) requirements for contractors; as outlined in CSA (2017), a system must also be in place to support contractor competency.

Table 16. Best practices and resources for Training and Competency

Best Practice/Resource and Link
Hitachi (2022a). HSE Training Matrix
Hitachi (2022b). HSE Requirements for Contractors
Leach and Wright (2014). A Guide to Enhancing Process Safety and Plant Efficiency Through the Competence of Control Room Operators (CROs)

WPAC and the BC Forest Safety Council are completing an Operator Competency Training project (in 2023) that provides industry-wide training modules for operators and supervisors (WPAC, 2023c); the modules are outlined in Table 17. The training modules cover both occupational, health and safety, as well as process safety topics.

Table 17. WPAC-BC Forest Safety Council operator and supervisor training modules

General	
1008	Describe and Apply Workplace Attributes
1039	Risk and Risk Control
1155	Describe Legislation, Regulation, Standards, Tickets and Documentation
Plant Operator	
1156	Describe Health and Safety for Operators
1157	Describe and Control Upset Conditions
1158	Describe Process Safety Management
1159	Operate Plant
1160	Describe Dust and Gas Combustion
Supervision	
1099	Describe and Apply Communication Skills
1101	Describe and Apply Due Diligence
1102	Describe and Apply Leadership Skills
1103	Describe Human Factors
1104	Orientation, Training and Skills
1105	Hazard ID, Inspection, and Investigation
1106	Cornerstones of Effective Supervision

Publicly available training resources that can be used for self-learning and informal training are outlined in Table 18.

Table 18. Training resources

Topic	Title and Link	Resource Type	Comment
Combustible Dust Safety Resources	BC Forest Safety Council (2023a). Combustible Dust Resources	Factsheets, Videos	Publicly available resources provided by BCFSC (health and safety association)
Supervisor Training	BC Forest Safety Council (2023b). Supervisor Training Program – Wood Products Manufacturing Supervisor	Free Training Modules	Publicly available resources provided by BCFSC (health and safety association)
Combustible Dust Safety Resources	WorkSafeBC (2023d). Combustible Dust Resources	Factsheets, Videos	Publicly available resources provided by WorkSafeBC (regulator)
Operator and Supervisor Training	WPAC (2023c). Plant Operator Training	Free Training Modules and Assessments	Online training platform for operators and supervisors
Combustible Dust Safety Resources	WPAC (2023d). Combustible Dust Resources	Factsheets, Webinars, Videos	Publicly available resources provided by WPAC (industry association)
Combustible Dust Safety Resources	US Chemical Safety Board (2023). Combustible Dust Safety	Factsheets, Videos	The US Chemical Safety Board is an independent federal agency in the United States responsible for investigating industrial chemical accidents.
Process Safety for Operators (training, ERP, culture)	CCPS (2023b). Process Safety Beacon	Factsheets	The Process Safety Beacon delivers process safety messages to plant operators and other manufacturing personnel. The monthly factsheet covers a range of process safety topics.

Table 18. Training resources continued

Topic	Title and Link	Resource Type	Comment
Enhancing Process Safety Knowledge	IChemE (2023). Safety Lore Issue 1: Start-up incidents Issue 2: Maintenance on atmospheric storage tanks Issue 3: Flare systems Issue 4: Ageing assets Issue 5: Creeping changes Issue 6: Flanges Issue 7: Road transportation Issue 8: Shift handover Issue 9: Permit to work Issue 10: Alarm Rationalisation Issue 11: Ammonium Nitrate Fertilisers Issue 12: Coal Mine Methane Explosions Issue 13: Key lessons from incidents related to audits Issue 14: Key lessons from inadequate hazard identification Issue 15: Key lessons from Dust Explosions Issue 16: Key lessons from incidents related to procurement Issue 17: Key lessons from incidents related to intermediate bulk containers Issue 18: Key lessons from incidents related to flammable atmospheres Issue 19: Key lessons from incidents involving confined space entry	Factsheets	The IChemE Safety Lore highlights safety issues in different processes and operations with the aim to communicate key learnings. The Safety Lore Issues deal with high-hazard industries and have learnings applicable to wood products manufacturing.

3.3.5 Process and equipment integrity

Best practices and guidance for process and equipment integrity are outlined in Table 19. Resources, including Honeywell (2012), HSE (n.d. -b; 2000), ABB (2021) and Hydrocarbon Processing (2021) provide support on alarm handling and management. Pre-start up safety reviews (PSSR) are part of process and equipment integrity; Marsh (2016) outlines excerpts of PSSR checklists, which can be used as a benchmark for a PSSR checklist that could be adopted by a given wood pellet operation. An example of the PSSR checklist adopted from Marsh (2016) is found in Appendix Q.

Table 19. Best practices and resources for Process and Equipment Integrity

Best Practice/Resource and Link
Honeywell (2012). Alarm Management Primer
HSE (n.d.-b). Alarm Handling Checklist
HSE (2000). Better Alarm Handling Information Sheet
ABB (2021). Alarm Management - A Practical Guide
Hydrocarbon Processing (2021). Alarm Management: A Pillar of Process Safety Management
Marsh (2016). Risk Engineering Position Paper: Pre-Start-Up Safety Review

3.4 Stage 3

The PSM elements identified as priority for stage 3 were:

Stage 3 elements:

- Regulations, codes and standards
- Project review and design procedures
- Emergency management planning
- Audits process
- Enhancement of process safety knowledge

3.4.1 Regulations, standards, and codes

There was not an extensive collection of publicly available guidance on regulations, standards, and codes; future work could involve additional development of support for operations for this PSM element. A potential activity could include developing a self-assessment that consists of documenting the standards and regulations that are applicable to PSM in the wood pellet operations, which will allow facilities to complete the assessment themselves or seek assistance from third party. This self-assessment worksheet would be accompanied by supporting documentation which would include a glossary of terminology and guidance on how to complete the assessment. Table 20 includes CCPS (2023c), which provides an introduction to complying with standards.

Table 20. Best practices and resources for Regulations, Standards, and Codes

Best Practice/Resource and Link
CCPS (2023c). Introduction to Compliance With Standards

It is noted that in British Columbia, there are currently proposed amendments to Part 6 of the *Occupational Health and Safety Regulation* relating to combustible dusts (WorkSafeBC, 2023e), which is pertinent to wood products manufacturing.

3.4.2 Project review and design procedures

Guidance for project review and design procedures are summarised in Table 21. CCHS (2011d) and EPA Ohio (n.d.) are facility siting checklists that consider building protection, process protection, health and safety and building location in order to mitigate potential impacts of a fire or explosion. Bridges and Tew (2008) describe the basics and best practices for scheduling and performing risk assessments and hazard reviews during different project phases of capital expansions at facilities.

Table 21. Best practices and resources for Project Review and Design Procedures

Best Practice/Resource and Link
Contra Costa County Health Services (2011d). Process Hazard Analysis Facility Siting Checklist
EPA Ohio (n.d.) Facility Siting Checklist
Bridges, W. and Tew, R. (2008). Controlling Risk During Major Capital Projects

3.4.3 Emergency management planning

Best practices, including plans and programs from industry, for emergency management planning are outlined in Table 22. Publicly available emergency management programs (EMP) and emergency response plans (ERP) from the oil and gas and chemical industry are available for wood pellet operations to refer to, including Nova Chemical (2020), Arc Resources Ltd. (2021; 2022), and Fortis BC (2022). As outlined in CSA (2017), an EMP that meets the requirements of CAN/CSA-Z246.2 or CSA Z1600 will meet the requirements of CSA Z767. BCER (2021b) describes EMP guidance from a regulatory standpoint through an Emergency Management Manual. OSHA (2013) and Persson (2013) delivers guidance on handling combustible dust incidents, including silo fires, which can be referred to by operations and first responders to enhance the understanding of these scenarios and incorporate any improvements to site-specific incident response plans.

Table 22. Best practices and resources for Emergency Management Planning

Best Practice/Resource and Link
OSHA (2013). Firefighting Precautions at Facilities with Combustible Dust
BC Energy Regulator (BCER) (2021b). Emergency Management Manual.
Nova Chemical (2020). Pipeline Operations Emergency Response Plan
Arc Resources Ltd. (2021). Emergency Management Program
Arc Resources Ltd. (2022). Northeast BC Emergency Response Program
Fortis BC (2022). Corporate Emergency Response Plan
Persson, H. (2013). Silo Fires: Fire Extinguishing and Preventive and Preparatory Measures

3.4.4 Audit process

Tools for applying the audit process to PSM frameworks are outlined in Table 23. Numerous auditing checklists have been developed for the OSHA PSM standard, including OSHA (2019b), Georgia Tech OSH Program (2011), and NDEP (2016). The audit workbook, protocol and self-assessment tools described by CSChE (2013, a,b) and (MIACC) (2001), which were originally developed for the CSChE PSM Guide (CSChE, 2012) can each also be adopted for the CSA Z767 standard (which as previously stated was developed based on the previous work by the CSChE). As part of future implementation work, it is recommended that a customized PSM audit tool by BCFSC and WPAC to support operations with this element.

Table 23. Best practices and resources for Audit Process

Best Practice/Resource and Link
OSHA (2019b). PSM Auditing Checklist
Georgia Tech OSH Program (2011). PSM Program Review Checklist
CSChE (2013a). Process Safety Management Standard Audit Protocol.
CSChE (2013b). Process Safety Management Audit Protocol Workbook
CSChE/Major Industrial Accidents Council of Canada (MIACC) (2001). Site Self-Assessment Tool.
NDEP (2016). Process Safety Element Audit Checklist

3.4.5 Enhancement of process safety knowledge

Resources for enhancing process safety knowledge are outlined in Table 24. Energy Institute (2023) is a new online resource that includes incident shares from high-hazard industries, as well as a series of webinars focussing on topics such as learning from incidents and leadership. Dust Safety Science provides a combustible dust incident database and research reports that helps to improve the awareness of combustible dust hazards (DustEx Research Ltd., 2023).

As outlined in GPCA (2011), programs and resources developed by professional and trade associations, such as WPAC, can be beneficial for enhancing process safety knowledge, as tools and guidance are adapted for the particular needs of the wood products manufacturing industry. Additionally, there are a number of PSM-focussed organizations that develop and publish tools and resources, and also have networks of PSM expertise. These organizations include the CCPS (Center for Chemical Process Safety), the CSChE (Canadian Society for Chemical Engineering) PSM division, MKOPSC (Mary Kay O'Connor Process Safety Center) and IChemE (Institution of Chemical Engineers).

Table 24. Best practices and resources for Enhancement of Process Safety Knowledge

Best Practice/Resource and Link
Suncor (2011). Distribution Contractor Process Safety Awareness
International Association of Oil and Gas Producers (2020). Process Safety Fundamentals

Conoco Philips (2023). Process Safety - Process Safety Summit
Energy Institute (2023). Toolbox Webinar Series (including Learning from Incidents, The Role of Leadership in Accident Investigations, Learning from What Goes Right and others listed)
DustEx Research Ltd. (2023). Combustible Dust Incident Database and Reports

Table 24. Best practices and resources for Enhancement of Process Safety Knowledge continued

Best Practice/Resource and Link
GPCA (2011). Process Safety Code: Process Risk Management – Enhancing Process Safety Knowledge

4 PSM IMPLEMENTATION STRATEGY

This chapter outlines strategic next steps for PSM implementation in wood products manufacturing and others who wish to implement PSM.

The implementation strategy is industry driven by establishing the PSM Steering Committee to provide input and support. The cross-industry collaboration facilitates the efficient development and sharing of resources and tools.

Activities and steps that have been identified to support PSM implementation are outlined below:

1. Communication of research outcomes to stakeholders; provide recommendations and gain consensus on next actions to proceed.
2. Establishment of a PSM Steering Committee, scope, and objectives, and development of a process to provide ongoing support across the industry.
3. Development an implementation guide, workplan and milestones by the PSM Steering Committee. Proposal of timeline, milestones, and other processes to support implementation.
4. Development of self-assessment worksheets for remaining PSM elements with support of the PSM Steering Committee.
5. Development of additional resources with input from operations based on their needs, such as a webinar to provide guidance on the self-assessments and factsheets for other PSM elements.
6. Completion of qualitative gap analysis against CSA Z767 standard using the self-assessment sheets through support process provided by WPAC and BCFSC.
7. Development of action plans to address identified areas for improvement through support process provided by WPAC and BCFSC. Other tools and resources for

helping operations determine prioritization of actions as part of planning will be developed. Strategies, such as value graphing (evaluating corrective actions with respect to effort and value), will be explored to help identify priorities.

8. Creation of a library of industry developed policies and procedures to share with operations.
9. Development of KPIs for PSM implementation to regularly review and monitor progress, along with the site-specific and industry benchmarking process safety KPIs. Design of a reporting process to provide industry with the progress and pace of implementation.
10. As part of the Plan-Do-Check-Act cycle, development of additional guidance and resources to support operations for determining the effectiveness of improvement actions.

5 KNOWLEDGE TRANSFER AND EXCHANGE

Numerous knowledge transfer and exchange (KTE) initiatives have been completed during the course of the project and are planned to follow the completion of the research project. The communications deliverables are focussed on reaching wood processing facilities across Canada, in addition to the broader process safety and global combustible dust research and practice community. To reach audiences at wood processing operations, avenues including the industry trade publication, Canadian Biomass, as well as the monthly WPAC Safety Committee meetings, are used. For the dissemination of research results, a manuscript submission to an archival journal relevant for this research focussed on process safety management is planned. Additional KTE initiatives to communicate the research project are summarised in Table 25. It has been identified that the KTE activities that have been completed throughout the project have enhanced the awareness of PSM in wood products manufacturing, which has contributed to a culture shift.

Table 25. Summary of knowledge transfer and exchange (KTE) initiatives

KTE Deliverable	Date	Target Audience and End-Users	Stakeholder Engagement	Information Sharing Strategies	Reference
Article "New grant supports process safety management research" for *Canadian Biomass* magazine highlighting PSM research.	July 2021	Wood pellet producers, facilities handling combustible dust	Advertising on LinkedIn and other social media channels, website, email	Industry trade publication	Canadian Biomass (2021)
PSM survey introduction and glossary	June 2022	Wood pellet producers	Communications during WPAC Safety Committee meetings, emails to WPAC members	Written document	Appendix C
Project updates in monthly WPAC Safety Committee meetings	January 2022-Present	Wood pellet producers	WPAC Safety Committee meetings	Presentation	N/A
PSM survey overview, invitation to complete, follow-up meetings and interviews	April – November 2022	Wood pellet producers, industries handling combustible dust	Emails to WPAC members and combustible dust network, advertising on LinkedIn	Sharing written documentation and summaries	N/A

Table 28. Summary of knowledge transfer and exchange (KTE) initiatives continued

KTE Deliverable	Date	Target Audience and End-Users	Stakeholder Engagement	Information Sharing Strategies	Reference
Presentation at WPAC 2022 Annual Conference – "Advancing Process Safety Management in Wood Pellet Production"	September 2022	Wood pellet producers, wood pellet industry stakeholders	Advertising on LinkedIn and other social media channels, website, email	Presentation	N/A
Summary of PSM initiatives in WPAC Annual Workplan with WorkSafeBC	January and June 2023	Wood pellet producers, regulator	Stakeholder meeting	Presentation	N/A
Participation in CSA Z767 Technical Committee (non-voting) (B. Laturnus, G. Murray, K. Rayner Brown, F. Yazdanpanah)	January 2023 - Present	Global PSM practice community	Technical Committee meetings (monthly)	Meeting, sharing insights and experience	N/A
Planned - Dust Safety Science podcast episode, article in Dust Safety Journal magazine, research deliverables in Dust Safety Academy	Planned	Global combustible dust research and practice community	Advertising on LinkedIn and other social media channels, website,	Podcast	N/A

Table 28. Summary of knowledge transfer and exchange (KTE) initiatives continued

KTE Deliverable	Date	Target Audience and End-Users	Stakeholder Engagement	Information Sharing Strategies	Reference
Planned – article for *Canadian Biomass* summarizing research outcomes and available resources	Q3-Q4 2023	Wood pellet producers	Advertising on LinkedIn and other social media channels, website, email	Industry trade publication	N/A
Planned – Pre-Conference Process Safety Workshop at WPAC 2023 Annual Conference. Topics include PSM, and others to be determined (TBD)	September 2023	Wood pellet producers, wood pellet industry stakeholders	Advertising on LinkedIn and other social media channels, website, email	Workshop	N/A
Planned – preparation and submission of manuscript to peer-reviewed journal	Q3-Q4 2023	Global combustible dust research and practice community	Publication in established journal in relevant field	Archival journal article	N/A
Planned - Presentation at WPAC 2023 Annual Conference and pre-conference workshop (Dr. P. Amyotte, P.Eng.)	September 2023	Wood pellet producers, wood pellet industry stakeholders	Advertising on LinkedIn and other social media channels, website, email	Presentation	N/A

Table 28. Summary of knowledge transfer and exchange (KTE) initiatives continued

KTE Deliverable	Date	Target Audience and End-Users	Stakeholder Engagement	Information Sharing Strategies	Reference
Planned – Webinar summarizing research outcomes and available resources	Q3-Q4 2023	Wood pellet producers	Advertising on LinkedIn and other social media channels, website, email	Industry trade publication	N/A
Planned – Factsheets summarizing research outcomes and available resources, and other topics TBD	Q3-Q4 2023	Wood pellet producers	Advertising on LinkedIn and other social media channels, website, email	Industry trade publication	N/A
Planned - Communications through BCFSC Forest Safety Newsletter (FSN)	Q3-Q4 2023	Wood pellet producers	Advertising on LinkedIn and other social media channels, website, email	Industry trade newsletter	N/A
Planned – Communications on findings of project for wood pellet producers (other formats and deliverables TBD)	Q3-Q4 2023	Wood pellet producers	Advertising on LinkedIn and other social media channels, website, email	Industry trade publication, others to be determined (TBD)	N/A

6 CONCLUSIONS

In conclusion, the outcomes of this research provide a PSM integration tool for wood products manufacturing, including a PSM survey for gap analysis, self-assessment worksheets supported by a collection of industry best practices, a series of informative factsheets, and an implementation strategy.

The CSA Z767 framework was selected to guide PSM implementation. Using survey results and expert opinion, elements were prioritized, which informed the development of a staged or phased approach to PSM element implementation. This approach involves focussing on a selection of PSM elements to integrate at operations, followed by elements in subsequent stages. This strategy of PSM element phases helps make the PSM framework more feasible for adoption by wood products manufacturing and other small-and-medium enterprises. Stage one PSM elements are accountability, process safety culture, process risk assessment and risk reduction, management of change (MOC), investigation, and key performance indicators (KPIs). Stage two elements are conduct of operations, process knowledge and documentation, human factors, training and competency, and process and equipment integrity. Stage three elements are emergency management planning, project review and design procedures, audit process, regulations, standards and codes, and enhancement of process safety knowledge.

This research project provides a foundation to improve the integration of process safety in operations and has enhanced the understanding of how the CSA Z767 can be used to meet the needs of the wood products manufacturing industry. A broad culture shift in the industry is being observed through the continued support of progressive process safety initiatives. Process safety has been embraced by WPAC leadership and this project has accelerated the awareness and understanding of PSM across the wood products manufacturing industry and others handling combustible dust.

7 RECOMMENDATIONS FOR NEXT STEPS

In the province of British Columbia, while PSM standards are not currently referenced in occupational health and safety legislation, there are working groups exploring amendments. Beginning the process of implementing PSM proactively will well-position industries, like wood products manufacturing, should regulations come into effect.

The next step is to communicate the outcomes of the research project to operations, which will include a webinar to highlight key findings and resources (including the final report and factsheets). A transition from the research project into an implementation plan will take place, which will involve engagement and input from operations. A workplan for implementation activities will be created, including the development of implementation guide. Section 3.1 described other activities and recommendations, including the formation of a PSM steering committee, the rollout of self-assessment worksheets, developing action plans, and developing KPIs to track implementation progress. In addition to the broad implementation activities, a recommendation for future work includes the creation of webinars on safety culture and investigation hosted within the WPAC learning platform. The development of site-specific, industry benchmarking, and PSM implementation KPIs is also an area for future working, including a pilot program for validation of the proposed leading and lagging indicators. It is also recommended that a PSM audit tool tailored for operations be developed by BCFSC and WPAC to support and sustain PSM performance.

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APPENDIX A: PSM SURVEY QUESTIONS

Process Safety Leadership – Accountability

1. Has your company established (formalized and documented) goals and objectives related to process safety at your facility?
2. Check all statements that apply: Senior management does the following:
   - Establishes performance requirements by setting process safety goals and objectives and makes resources available to reach these goals.
   - Sets process safety goals that encompass a range of risks (e.g., personnel, public, environment).
   - Directs decision-makers related to design to consider inherently safer design.
   - Ensures compliance with safe operating conditions through use of proper conduct of operations. (Conduct of operations is defined as carrying out tasks in a methodical way to achieve excellence in operations.)
   - Directs the completion of risk assessments to address mechanical equipment integrity and process integrity.
3. Is an approval process established for matters relating to maintenance and production?
4. Does the approval process consider risks relating to the process?

Process Safety Leadership - Regulations, Standards, and Codes

1. Have you identified which regulations, standards, and codes apply to your facility?
2. Is there a management system in place to trigger the development of a new company standard or procedure, or make an improvement or change to an existing one?

Process Safety Leadership - Process Safety Culture

1. Is process safety leadership and competency a core value of all management?
2. Is there a visible and active commitment to process safety from all levels of management?
3. As it relates to process safety culture, check all statements that apply:
   - Company policy states that process safety is a representation of successful operations.
   - Management regularly reviews key performance indicators (KPIs) to support the process safety management system.
   - Management ensures that corrective actions from risk assessments, incident investigations, and audits are addressed.
4. Is there an understanding of the consequences that could arise from a process safety incident (e.g., loss of control) and the impact it may have on personnel, property and the environment?
5. Do personnel (including operators, maintenance technicians, electricians, and instrumentation specialists) follow conduct of operation requirements? (Conduct of operations is defined as carrying out tasks in a methodical way to achieve excellence in operations.)
6. Do personnel (including operators, maintenance technicians, electricians, and instrumentation specialists) contact their supervisors if they have a concern about any gaps, issues, or incidents with the process safety system?
7. Do personnel (including operators, maintenance technicians, electricians and instrumentation specialists) have the responsibility and ability/authority to stop unsafe work or operations?
8. Is there open and effective communication regarding process safety?

9. Is there open communication between all people in the organization (operations, management) around the following process safety aspects? Check all that apply.
   - Process safety goals
   - Process safety issues and concerns
   - Process safety incidents
   - Process safety near misses
   - Process safety performance
10. Does management respond in a timely way to the following (check all that apply)?
    - Process safety issues and concerns
    - Process safety incidents
    - Process safety near misses
11. Are process safety issues and concerns communicated with operational personnel (operators, maintenance technicians, electricians, and instrumentation specialists) in a timely way?
12. Are relevant process safety-related issues and incidents at other organizations or facilities communicated with relevant stakeholders (e.g., operators, supervisors) in a timely way?
13. How strongly is the following statement communicated and demonstrated throughout the organization: "Management and workers both hold responsibility for the role they play in preventing a process safety incident."
14. Is there a system and process in place for senior management to engage with and consult personnel and workers on the implementation of the management system?
15. Does management maintain a sense of vulnerability that a process safety incident (loss of control) can occur?
16. Do workers maintain a sense of vulnerability that a process safety incident (loss of control) can occur?
17. Does the organization have initiatives to prevent/avoid complacency? Check all that apply:
    - Regular safety meetings and briefings
    - Refresher training
    - Development, sharing, or review of safety bulletins, factsheets, or newsletters
    - Sharing and discussion of process safety incidents and near misses

<u>Process Safety Leadership: Conduct of Operations – Senior Management Responsibility</u>

1. Does senior management meet regularly with facility managers and operators to oversee operations and activities?
2. Has senior management set the following expectations for process safety? Check all that apply:
   - Maintain effectiveness of safety critical systems and equipment
   - Maintain fitness of duty of personnel and equipment (Note: fitness of duty refers to the ability to competently and safely perform tasks/duties.)
   - Ensure personnel have necessary skills and conduct/behaviour
   - Establish and formalize communication across personnel (workers, shifts, groups)
   - Adhere to operating within safe operating limits
   - Ensure personnel implement operational discipline (Note: operational discipline is defined as the performance of all tasks correctly every time.)
3. How does senior management develop a strong process safety culture? Check all that apply.

- They understand and are aware of primary process safety risks in their operations
- They support programs to ensure adherence to process safety expectations
- Routinely seek input and ask questions across organization to maintain process safety awareness
- Demonstrate support for stopping work if process cannot be performed safely

<u>**Understanding Hazards and Risks - Process Knowledge and Documentation**</u>

1. Is there a document control system for process safety information, which allows easy access of information? (Note: Process safety information is the physical, chemical, and toxicological data for the process, and considers chemicals and equipment.)
2. Indicate the following documents and data that are obtained and kept current regarding hazardous materials in your facility. Check all that apply
   - Physical properties
   - Flammability
   - Special hazards (e.g., deflagration or detonation pressure and flame speeds under all operating conditions)
   - Other combustible dust characterization parameters, including particle size, KSt (dust deflagration index)
   - MEC (minimum explosible concentration), MIE (minimum ignition energy), Pmax (maximum explosion pressure)
3. Indicate the following technical documents regarding processes and equipment that are readily available (check all that apply).
   - Design basis
   - Plot plan
   - Process boundary
   - Electrical area classification
   - Process flow diagrams (PFDs)
   - Pressure relief systems
   - Piping and instrumentation diagrams (P&IDs)
   - Shutdown key
   - Material and energy balances
   - Safe operating limits (e.g., levels, temperatures, pressures, flow rates, time)
   - Maximum intended inventory
   - HVAC (heating ventilation air conditioning) design basis
   - Process risk assessments
4. Are there documented (formalized) procedures for the following operating stages? Check all that apply.
   - Commissioning
   - Regular and temporary operations
   - Regular shutdown
   - Emergency shutdown (and includes description of circumstances that necessitate an emergency shutdown)
   - Start-up (after regular or emergency shutdown)

- Maintenance

5. Are there written formal procedures for the following matters? Check all that apply.
   - Steps needed to address or prevent going outside safe operating limits
   - Operation and maintenance of safety systems and their purpose
   - Safe work practices for specific applications
6. Is there a formalized system for updating procedures in the case of changes with the following items? Check all that apply.
   - Operating practice
   - Process chemistry
   - Technology
   - Equipment
   - Facilities
   - Organization

Understanding Hazards and Risks – Project Review and Design Procedures

1. Does the project approval process include considerations for potential process hazards associated with the project, as well as the project activities needed to properly manage those hazards?

Understanding Hazards and Risks – Process Risk Assessment and Risk Reduction

1. Has a Process Hazard Analysis (PHA) or Dust Hazard Analysis (DHA) been completed at your facility?
2. How are hazards identified and documented?
3. Does the PHA or DHA include a likelihood analysis, or an estimation of risk, for the identified hazard scenarios?
4. Does the PHA or DHA list the following potential consequences? Check all that apply.
   - Effects on people
   - Effects on the environment
   - Effects on business operations
   - Effects on property
   - Combined effects of all released materials for a given scenario
   - Potential knock-on/domino effects, where nearby hazards may make consequences worse
5. If a likelihood analysis is completed, does it include the following? Check all that apply.
   - Events inside of the facility/operations
   - Events outside of the facility/operations
   - Human error
   - Equipment failure
   - Process control failure
6. Has a risk value been established where a value above is intolerable (unacceptable) and a value below is broadly tolerable (acceptable)?
7. Has a plan been put in place for implementing control measures related to the risk assessment, PHA, or DHA?

7. Is there a plan for implementing risk reduction measures/controls that includes prioritizing controls and creating a schedule?
8. Is there a formal process (e.g., corrective action plans) to track the implementation of risk reduction measures/controls to completion?
9. Is the implementation of risk reduction measures/controls monitored with respect to:
   - monitoring changes involving equipment, procedures, or organization,
   - determining if the risk reduction measures have been effectively implemented and if the
   - targeted risk reduction is accomplished.
10. Is the hierarchy of controls and inherently safer design (ISD) considered when identifying and selecting control measures from the risk assessment, PHA or DHA?
11. Are risk assessments revalidated (re-examined) after changes to any of the following? Check all that apply:
    - Facility
    - Operation/Process
    - Operating environment
    - After 5 years regardless of any changes
    - Not applicable
12. With respect to combustible dust risk reduction measures/controls, rate how well the combustible dust housekeeping program is working.

Understanding Hazards and Risks - Human Factors

1. Has a human factors review been completed to understand the impacts of human error?
2. Are the following factors considered as it relates to human factors and human error?
   - Completion of human factor audit
   - Use of engineered controls
   - Design of human-machine interface (HMI) (e.g., operator-equipment)
   - Use of written plans and procedures
   - Use of written communications for incident reviews, training
   - Development of fatigue management program
   - Consideration of staff levels
   - Consideration of work conditions, including noise, light, and temperature
3. Are engineered controls generally regarded as preferred over administrative/procedural controls?
4. Are the following considerations for administrative controls used? Check all that apply.
   - Creating controls that are easily understood and effective that involves relevant personnel in their design
   - Establishing thresholds on upset conditions, as well as actions to take to prevent a given situation from escalating
   - Performing routine review of administrative controls to assess their effectiveness
   - Implementing a method to ensure procedures are accurate and relevant
   - Implementing a method to incorporate changes to procedures in a timely manner
   - Implementing a method to share and effectively communicate administrative controls to necessary personnel

Risk Management - Training and Competence

1. Is there a training program to ensure employees have the necessary experience, education and training to manage process safety risks at the facility?
2. Is combustible dust awareness training provided?
3. Is there a training program in place to ensure all contractors have the necessary experience, education and training to manage process safety risks at the facility?
4. If there is a training program in place, how well would you subjectively say it works?
5. Does the training program include the following features (check all that apply):
   - Designates roles and responsibilities
   - Documents competencies and skills needed for each role
   - Outlines time intervals for refresher training
   - Uses both formal and informal training methods, including hands-on experience, conferences, technical committees and working groups.
   - Documents the technical knowledge and experience of instructors that provide training
6. Have personnel received any process safety-specific training? For example, job-specific training on fire and explosion hazards associated with combustible dust.
7. If there are explosion protection systems installed at your facility, is training provided to relevant personnel involved with these systems (e.g., maintenance, operators)?
8. Are contractors trained on the emergency response plan, including evacuation and muster points?
9. How effective would you say the combustible dust training is?

Risk Management - Management of Change

1. Is a management of change (MOC) program in place?
2. Does the MOC system manage risks associated with the following changes? Check all that apply:
   - Design changes
   - Equipment changes
   - Procedural changes
   - Organizational changes
3. If an MOC system is present, does it consider the following aspects? Check all that apply.
   - States what a change is
   - States what type a given change is (emergency or temporary)
   - States what replacement-in-kind (RIK) is (which is not included in MOC)
   - Considers changes in operating procedures or safe operating limits
   - Considers changes in the structure of the organization and staffing
   - A process for reviewing and approving changes
   - Includes a risk assessment of the change
   - Includes the communication of the change with relevant stakeholders before the change is made
   - Includes any necessary training of relevant stakeholders before the change is made
   - Includes a procedure for implementing an emergency change, as well as communicating with relevant personnel in a timely manner

- States the documentation needed for a change including: Explanation of proposed change, Change authorization, Training requirements, Up-to-date drawings, Confirmation that change was implemented as design intended

4. Does the MOC system manage temporary changes?
5. Does the MOC system use any of the following considerations to manage temporary changes? Check all that apply.
   - A time limit/timeframe is set
   - A process for review and approval if the temporary change needs a time extension
   - A process to return the equipment or system back to the original state when the temporary change has ended (e.g., removing any temporary installations)
6. If there have been instances of temporary changes being permanently implemented, are the following considerations made? Check all that apply.
   - Changes for other lifecycles (e.g., maintenance turnaround)
   - Changes to documents and procedures
   - Changes to supporting programs
7. Is the hierarchy of controls and inherently safer design (ISD) options considered during management of change?
8. How well would you say the MOC program works?

<u>Risk Management - Process and Equipment Integrity</u>

1. Are there written procedures for the inspection, testing and maintenance of the reliability of the facility's equipment?
2. Are there inspection, testing and maintenance procedures for the following equipment? Check all that apply:
   - Pressurized vessels
   - Storage vessels/tanks
   - Process control and instrumentation systems
   - Relief and venting equipment
   - Ventilation equipment and systems
   - Emergency systems
   - Fire systems protection systems
   - Gas systems
   - Release protection systems
   - Monitoring systems, sensors, alarms, interlocks, and other controls
   - Electrical infrastructure, power transformers and other utilities
   - Overhead/elevating equipment (e.g., cranes, gantry systems)
   - Rotating equipment
   - Hydraulic equipment
   - Emergency response equipment, including mobile equipment/vehicles
3. Has process safety critical equipment been identified at your facility?
4. Do you have an alarm and instrument management program that covers the following? Check all that apply:
   - Identification of critical alarms and interlocks

- A procedure to control changes to alarm set points and interlock systems
- Regular testing of alarms, interlock systems, pressure safety valves and other equipment identified as critical safeguards

5. Is there a formal (documented) Pre-Startup Safety Review (PSSR) process? PSSR is a systematic review of a process before starting-up a new or modified process or equipment. A PSSR involves:
   - verifying that equipment and construction correspond with design specifications,
   - that necessary procedures (e.g., safety, operating, maintenance, emergency) are in place,
   - that a risk assessment of the equipment and facilities has been conducted,
   - management of change requirements have been met, and
   - personnel have been trained.
6. Have safe work practices been implemented for the following? Check all that apply.
   - Personal protective equipment (PPE) requirements for hazardous tasks and areas
   - Hot work
   - Confined space entry
   - Lock-out tagout
   - Access to hazardous process areas
   - Excavation
   - Critical lifting (crane/rigging activity)
   - Traffic control
   - Opening of process lines and equipment
   - Facility access control for maintenance, contractor, visitors, and vehicles
7. How well would you say the program for the inspection, testing and maintenance of equipment works?
8. Are there written procedures for operating the process and equipment to prevent or mitigate hazardous scenarios involving combustible dust (fires, deflagrations, explosions)?
9. Are there routine walk-through of operations (by supervisors or operators) to confirm that operating procedures and safe work practices are being used?
10. Do procedures for manual operations outline the practices, techniques, and equipment to reduce or eliminate combustible dust hazards?
11. Are there safe work practices that focus on the hazards associated with explosion protection systems like inerting and suppression (e.g., nitrogen inerting, explosion blast vents)?
12. Are combustible dust housekeeping procedures documented?
13. Are hot work procedures documented?
14. Rate how well the hot work program is working.
15. Rate how well the personal protective equipment (PPE) program is working.
16. Is equipment used for prevention and mitigation of combustible dust fires and explosions (e.g., isolation valves, spark detect and deluge systems) inspected, tested, and maintained as per manufacturers' recommendations?
17. Are routine walk-throughs of operating areas performed to check if equipment is in safe operating condition?

Risk Management - Emergency Management Planning

1. Is there a formal Emergency Management Program (EMP)? The Emergency Management Program (EMP) manages the consequences of hazardous scenarios that could arise from an incident.
2. Is there a formal Emergency Response Plan (ERP)? An emergency response plan (ERP) is a document that is prepared to ensure that critical information needed when responding to an emergency is readily available.
3. Does the Emergency Management Program and/or Emergency Response Plan include engagement of local emergency responders in its development and review?
4. Is there an emergency drill plan?
5. Does the emergency drill plan include a process for documenting and implementing lessons learned from emergency exercises?
6. Do the emergency drills include the following considerations? Check all that apply.
   - They are completed at all levels of the organization (including senior management)
   - They are completed frequently enough to assess emergency response abilities
   - Involve different potential emergencies
7. Do community fire departments and/or industrial fire brigades receive specialized training on managing combustible dust fires (as the methods for extinguishing dust fires are different than those used for typical fires they commonly deal with)?
8. How often are emergency drills completed?
9. Do emergency drills involve all internal and external stakeholders?
10. After an emergency, which of the following actions are taken? Check all that apply:
    - Incident investigation
    - Site secured for safety and evidence preservation
    - Clean up and recovery procedures
    - Review of emergency response procedures and resources used
    - Identification of lessons learned and their incorporation into the EMP and ERP
11. Is the emergency response plan reviewed and validated annually?

Review and Improvement - Investigation

1. Do you have a system to identify, report, investigate and record all incidents including near misses and abnormal events?
2. Which of the following is included in incident investigation reports? Check all that apply.
   - Incident date
   - Incident description
   - Detailed description of equipment failures and/or human errors
   - Contributing factors of the incident
   - Incident analysis method and/or identification of root causes
   - Recommendations to prevent the incident from happening again
3. Is there a process, including a corrective action plan (with timelines), to follow-up on and make changes recommended in incident investigation reports?
4. Is the hierarchy of controls and inherently safer design (ISD) considered when developing corrective action plans?
5. Are incident investigation reports analyzed to identify common/frequent causes of incidents?

6. Are incident investigation reports used to improve process safety understanding/knowledge?
7. How well would you say the incident investigation program works?

Review and Improvement – Audit Process

1. Is there an audit system to assess whether the PSM program meets the requirements in a given PSM standard?
2. Is there a routine review of each management system element to assess their effectiveness?

Review and Improvement – Enhancement of Process Safety Knowledge

1. Is there a system in place to continuously improve the organization's Process Safety Knowledge. This could include building on experiences across the industry and incorporating technological advances.
2. Does the organization participate in professional, trade, labour, and technical associations as a way to improve staff process safety knowledge?

Review and Improvement - Key Performance Indicators

1. Have you identified leading and lagging key performance indicators (KPIs) for process safety at your facility?
2. Are unsafe behaviours or inadequate operational discipline measured? Operational discipline is defined as the performance of all tasks correctly every time.
3. Are process safety near misses tracked? These may include, for example, small fires, system failures or instrumentation failure that could lead to an incident.
4. Are near misses collected and used for lessons learned, enhancing awareness, and improving process safety culture?
5. When selecting key performance indicators, which of the following are considered? Check all that apply.
   - Indicators that refer to process safety critical equipment and items that influence system performance
   - Indicators that advance process safety performance improvement and learning
   - Indicators that are relatively easy to implement, measure, and understood by stakeholders
   - Indicators that can be used for benchmarking

APPENDIX B: PSM SURVEY PILOT FEEDBACK QUESTIONS

Survey Overview and Introduction Document

1. Did you find the Survey Overview and Introduction document helpful?
2. Were the definitions in the glossary of the Survey Overview and Introduction document helpful and clear?
3. Are there any other definitions you think should be included in the Survey Overview and Introduction document?
4. Do you have any questions about the PSM survey or the PSM project that should be included in the FAQ section of the Survey Overview and Introduction document?
5. If you have any additional feedback about the Survey Overview and Introduction document that you wish to provide, please enter it here.

Survey Terminology and Language

6. After reading the Survey Overview and Introduction document, did you find the language/terminology used in the survey understandable? Were there any terms that were unclear? If so, please indicate them here.

Survey Length

7. Did you find the length of the survey appropriate and reasonable?
8. How long (in minutes) did it take you to complete the survey?
9. Were you able to complete the survey within the estimated time (30-45 minutes)?
10. If you have any additional feedback about the survey length that you wish to provide, please enter it here.

Survey Questions

11. Are the questions easy to understand? If there are any that are difficult to understand, please include the question number here and provide any relevant details.
12. Are you willing to respond to all the questions? If there are any questions where the tone needs to be changed or sensitivities need to be considered, please include the question number here and provide any relevant details.
13. Are there any questions that weren't answered? If there were any questions that couldn't be answered, please describe the reason for that.
14. Do any questions seem repetitive or unnecessary? If there are any questions that seemed repetitive or unnecessary, please provide the question number here.
15. If you have any additional feedback about the survey questions that you wish to provide, please enter it here.

Survey Answers

16. Do the answer options make it as easy as possible for people to respond?
17. Please describe any challenges you had answering survey questions

18. Are there any questions that you feel there should be another answer option (e.g., other, unsure)?
19. Are you able to use all response options appropriately? Please outline any issues you had using the answer options.
20. If you have any additional feedback about the survey answers that you wish to provide, please enter it here.

Overall Survey Feedback

21. Did you have any issues completing the survey? Please enter any additional comments here.
22. Were you confident that you could correctly interpret and respond to the questions? Please enter any additional comments here.

APPENDIX C: PSM SURVEY INTRODUCTION AND GLOSSARY

Integrating Process Safety Management into Canadian Wood Pellet Facilities that Generate Combustible Wood Dust

PSM Survey Introduction and Glossary

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Contents

1. Process Safety Management (PSM) Survey Introduction

The purpose of this document is to provide an overview of the Process Safety Management (PSM) survey that is being distributed for the project "Integrating Process Safety Management into Canadian Wood Pellet Facilities that Generate Combustible Wood Dust." This project is being undertaken by Dalhousie University, Wood Pellet Association of Canada (WPAC), British Columbia Forest Safety Council (BCFSC), DustEx Research Ltd., and Obex Risk Ltd during 2022-2023.

PSM is the use of management principles and systems to identify, understand, avoid, and control process hazards in order to prevent, mitigate, prepare for, respond to, and recover from process-related incidents. The purpose of this research survey is to identify the PSM elements that are currently found in the wood pellet industry. This will help us understand areas to prioritise and help to improve for the implementation of PSM within your organisation.

This survey is based on the CSA (Canadian Standards Association) Z767 *Process Safety Management* standard. This standard has four pillars:

- Process safety leadership,
- Understanding hazards and risks,
- Risk management, and
- Review and improvement.

Each pillar contains four elements; the framework is shown in Table 1. Section 3 of this document contains a PSM Elements Glossary that provides definitions of each of these elements.

Table 1. CSA Process Safety Management (PSM) System (CSA, 2017)

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 survey also includes questions developed from the National Fire Protection Association standard NFPA 652 (2019) to capture specific aspects of combustible dust safety.

2. Frequently Asked Questions

What is the purpose of the survey?

The purpose of this research survey is to identify the PSM elements that are currently found in the wood pellet industry. This will help us understand areas to prioritise and help support the implementation of PSM within your organisation.

Who is this survey being completed for?

This survey is being completed for Dalhousie University, WPAC, BCFSC, DustEx Research Ltd., and Obex Risk Ltd. as part of a project, titled "Integrating Process Safety Management into Canadian Wood Pellet Facilities that Generate Combustible Wood Dust." The project is funded by a WorkSafeBC Innovation at Work (IAW) grant.

How was this survey developed?

This survey was developed in collaboration with wood pellet operations in a survey pilot program to ensure the survey language and structure were appropriate and representative of operations. Resources that were used to develop the survey include CSA (2017), NFPA 652 (2019), as well as other PSM implementation survey and audit resources (CSChE, 2013; CCPS, 2016).

Why should I complete the survey?

Your responses are very important for identifying the key focus areas for PSM. This will allow us to identify the best ways to help you enhance PSM in your organization, which can help reduce risk and improve safety in your operations.

How will my responses be used?

Responses will be collected and analyzed to identify areas of priority for improvement.

Will my responses be kept confidential?

The information being collected will be kept confidential. All data will be sanitized and presented appropriately in communications and dissemination of project results. This survey is part of a project being undertaken by Dalhousie University, Wood Pellet Association of Canada (WPAC), British Columbia Forest Safety Council (BCFSC), DustEx Research Ltd., and Obex Risk Ltd.

How long will the survey take me?

The survey will take about 30 to 60 minutes.

When should I complete the survey?

Please complete the survey by June 30th, 2022.

Who in my company should complete the survey?

The survey is designed for production superintendents, supervisors, program coordinators and managers. It should be completed by personnel that have oversight and involvement in management system development.

Will my survey progress be saved automatically as I complete it?

Yes, the survey platform (Survey Monkey) will save responses as you complete the survey.

Where can I look for more explanations of the terminology used in the survey?

Definitions of process safety terms, like conduct of operations, leading/lagging indicator, or process hazard analysis (PHA), are included with the survey question they are used in.

This document also contains definitions of the PSM elements in a glossary in Section 3. The PSM elements are numbered in the glossary and in the survey for easy reference.

How is the survey organized?

The survey structure is aligned with the CSA (Canadian Standards Association) Z767 standard (*Process safety management*). Each PSM element in the survey and glossary is numbered according to the section within CSA Z767 that the element is found.

I need help with the survey – who can I contact for assistance?

If you need assistance with completing the survey, contact the project manager, Kayleigh, at kayleigh@obexrisk.com or 782-640-9555.

How do I answer the questions, so they accurately reflect my operation?

Only answer questions based on what you have observed.

Some questions are "Yes or No" questions. When should I answer "Yes" and when should I answer "No"?

A "yes" response must be completely "yes". If any part of the question is "no", then the answer is "no." For example, if you were to answer "Yes, but..." or "Yes, except...", then the answer is "no."

Some questions also have "unsure" as an option. Answer "unsure" if it is outside of the scope of your expertise.

There may also be a "not applicable" option. Answer "not applicable" if the question does not apply to your facility. For example, if the question is asking about a dust hazard analysis (DHA) and you have not conducted one in your facility, answer "not applicable."

3. PSM Elements Glossary

This section provides an overview and definition of each of the PSM elements. The numbering included with the elements is the same as the section numbering in the CSA standard.

Process Safety Leadership – Accountability (5.1)
Senior management accountability for the PSM system including establishing process safety goal and considering process safety risks throughout facility lifecycle.

Regulations, standards, and codes (5.2)
A management system for the control of pertinent regulations, standards, and codes to ensure relevant documentation is up to date, communicated with relevant stakeholders, and consistently used throughout the organization.

Process safety culture (5.3)
The collective mindset of the organization with respect to safety and risk, including attitudes and behaviours.

Conduct of operations - senior management responsibility (5.4)
Carrying out operational and management tasks in a methodical way to achieve excellence in operations.

Process knowledge and documentation (6.1)
Process safety information, which consists of data relating to the characteristics of a process involving hazards, including hazardous materials properties, technologies and methods, equipment, and operation. This includes technical documentation, including piping and instrumentation diagrams (P&IDs), process flow diagrams, and process risk assessments.

Project review and design procedures (6.2)
Refers to the consideration of risk assessments throughout project status, including request for approval, siting decisions, and the design process.

Process risk assessment and risk reduction (6.3)
The identification and analysis of process-related hazards, documentation of hazard analyses, and implementation of risk reduction measures.

Human factors (6.4)
The consideration of the role of human factors in process safety, including aspects like human error, written procedures, fatigue management and the use of engineering controls.

Training and competence (7.1)
The system in place to ensure that personnel have the required qualifications and competencies to fulfill their roles and responsibilities and conduct their tasks safely and effectively, and includes experience, education, and training.

Management of change (7.2)
The management of risks associated with changes to design, equipment, procedures, personnel, and the organization, and includes temporary and permanent changes.

Process and equipment integrity (7.3)
Systems to ensure the integrity of the process and process equipment, including inspection, test, and maintenance (ITM) equipment, establishing safe work practices, and conducting a pre-startup safety review (PSSR) before running a new or modified process or equipment.

Emergency management planning (7.4)
This program is used to manage the consequences of hazardous scenarios that could arise from a loss of containment incident and considers regulatory requirements, standards, and industry best practices, in the preparation for and response to an emergency.

Investigation (8.1)
The program established to identify, report, investigate, and record process safety incidents. Process safety incidents include near misses as well as significant events.

Audit process (8.2)
The system for assessing the organization's current PSM program with respect to the standard (CSA Z767) to determine if the program conforms to the standard and if the PSM program is implemented and maintained.

Enhancement of process safety knowledge (8.3)
Continuous improvement of process safety knowledge through industry learnings and participation in various associations (e.g., professional, trade, labour, technical), and incorporation of advances and improvements where feasible.

Key performance indicators for process safety (8.4)
Involves the use of leading and lagging indicators that are selected and monitored to target for improvement. Leading indicators are process-focussed metrics that signify the function of operating discipline, processes, or safety barriers/controls. Leading indicators are selected to provide an early signal of potential issues or degradation of safety controls so proactive corrective actions can be conducted. Lagging indicators are outcome-focussed metrics that can signify recurring issues and include events that have taken place.

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APPENDIX D: SAFETY AUDIT AND LEADERSHIP RESOURCES

Table D-1: Advanced Safety Audit (ASA) summary

Advanced Safety Auditing was originally developed in the UK coal-mining industry, and we worked with a certified trainer that worked with the Oil and Gas Industry. Three principles underpin ASA: accurate observation, effective two-way communication, and individual goal setting. ASA training requires that auditors must demonstrate safety is of equal importance to other work priorities: if safety conflicts with other priorities, safety must always win. Audits involve observing other people at work and focusing on behaviors. Auditors attend to those aspects of work which are critical to safety, using all their senses. Following a period of observation, the auditor initiates a conversation, using an open questioning technique. Ideally the auditee should be speaking for at least 75% of the time, while the auditor listens carefully. The aim of this form of conversation is to guide the auditee to recognize any hazards and unsafe behavior and formulate solutions. Excellent work performance and safe working practices are commended. The final particularly essential element of the ASA process is to gain commitment to what the auditee will do in the future to ensure safe working and confirming any actions necessary by the Auditor. Fellow-auditors are encouraged to share learning from ASAs with as wide an audience as possible. **Ownership** When first introduced, ASA was intended as a tool for managers and supervisors and was implemented in a top-down fashion. Core platform staff were informed about ASA, and what to expect. Since then, it has become apparent that the ASA approach contains tools which are useful to everyone, and involvement has been widened by providing ASA training for, safety representatives, Health, Safety and Environment Advisors and most staff. It was recommended that Advanced Safety Audits are conducted in pairs to give confidence, support, and an opportunity for Auditors to act as a positive role model. Any member of platform staff may be asked to accompany a trained auditor, which provides a further opportunity to involve others, helps with hazard-spotting and allows demonstration and coaching of ASA techniques.

Definition of Safe / Unsafe Behaviors
ASA does not define the types of unsafe conditions or acts to be observed.

Training
To become accredited ASA trainers, several personnel initially attended a five-day train-the-trainer course. Subsequently one-day training courses were delivered for managers and supervisors at an onshore industrial training facility.

The first part of the day covers ASA principles and methods, observation and feedback skills and discussion of examples of typical unsafe acts and conditions.

Course delegates practice formulating the type of open questions they would ask, in response to slides of realistic work situations.

The afternoon consisted of conducting a mock Advanced Safety Audit in work areas at the training site. Subsequently the platform Health, Safety and Environment Advisors were also trained as trainers, and delivered half-day courses for core crew on the platform, which covered observing behaviors, how to intervene and use questioning techniques to start a conversation and how to gain commitment to any behavioral changes required.

Observation
Advanced Safety Audits are typically conducted in pairs. During an audit, observations are made of people at work and a conversation starts.

The auditors are expected to introduce themselves, explain that they are conducting an audit, and use a series of open questions to gain an understanding of the nature of the work taking place.

Through more open questioning, the auditor asks about the nature of any risks and hazards present, possible injuries and how this can be prevented. If a requirement for a change in a behaviour is identified, the auditor seeks a commitment from the auditee to change their behaviour in future. If a need for preventative follow-up action is identified, the auditor will handle that with a specific conversation and possibly training and retraining for the associate.

Establishing Baseline Performance
Baseline levels of behavioural safety were not established prior to the introduction of Advanced Safety Auditing.

Feedback

During an Advanced Safety Audit, face-to-face, immediate verbal feedback about their observations is provided at the time by the auditor. One member of platform staff commented that the non-confrontational ASA style led to his acceptance that its aims are to help improve safety.

Reinforcement

At the time of the Advanced Safety Audit, safe behavior is commended by the auditor, and encouragement given to consider how to reduce risk. If required, the auditor will seek an individual commitment to change. Auditees are thanked for giving up their time to discuss safety. Reinforcement is also present when auditors are observed implementing any follow-up actions which result from the ASA conversation.

Goal Setting

A goal of two Advanced Safety Audits by senior management per offshore trip has been set. If an audit reveals a need for change, the auditee is encouraged to identify their individual goals for behavioral change and then commit to action. It is expected that an auditor will follow-up to establish if the agreed actions have been taken.

Review

The number of Advanced Safety Audits conducted is reviewed regularly against targets. To date the effectiveness of the ASA program has not been systematically reviewed.

Summary

In our process we look to catch associates doing things right and provide an R+ (positive reinforcement). This can be a little as a thumbs up or a quick thank you!

Table D-2. Online leadership resources

LinkedIn Learning	Provides online leadership classes in various lengths
Maxwell Leadership	Leadership When It Matters Most - John Maxwell
10 Steps to Leadership Development, a variety of helpful tools and resources, many of which are available at no cost on this website. List of all ten steps included in this free leadership training series.	**Step 1 - Find and Fuel Your Ambition** Find the spark that fuels your ambition to succeed. Once you find that one thing you love to do and you know your purpose, you will be unstoppable. **Step 2 - How To Define Leadership** Discover and compare leadership definitions from great leaders throughout history. No one definition is better than the other. The real question is what is your definition of being a great leader. Once you can define it, you are in a better position to attain it. **Step 3 - The Power of Relationships and Contributions** Lead a successful life through healthy relationships and by making quality contributions. Success is not about money, although money is important. Having money without feeling a sense of community is not living a successful life. **Step 4 - Take Inventory of Leadership Effectiveness** Discover the many benefits of our free leadership training, including a 360-degree leadership feedback tool. Learn what your subordinates really think of you. Are you confident that they respect you as an effective leader even when you have to make tough decisions? If not, then it's time to take inventory. **Step 5 - Seek Leadership Insights** DISC, Meyers-Briggs and Personalysis are three personality tests that companies commonly use for leadership

	development. However, they usually come with a price tag. We have a better idea! **Step 6 - Reacting vs. Responding** Great leaders are thoughtful leaders. Learn how a thoughtful response is always a better strategy than a quick or emotional reaction. **Step 7 - Make The Most of Spare Minutes** Get your 'dashboard diploma'. Listening to books on tape when driving or working out is a powerful leadership strategy. Over time you'll begin to adopt critical lessons into your daily activities and you'll soon see your performance rise to higher standards. **Step 8 - Stand On The Shoulders of Giants** Using the right leadership quotations and stories to support and drive home a key message helps employees to connect to your vision and makes clearer to them what you expect each member of the team to accomplish. **Step 9 - Building Your Library of Leadership Resources** Maintaining an educational leadership journal is a practice that pays you back multi-fold what you put into it. Learn to capture great leadership lessons, stories, tools, and resources. **Step 10 - Life Management for Success** Successfully manage the growth of your business at the same time you are accomplishing your personal goals and dreams. Discover effective time management tools to lead and maintain a higher quality work/life balance.

APPENDIX E: EXAMPLE PSM SELF-ASSESSMENT WORKSHEET TEMPLATE

PSM INTEGRATION TOOL: SELF-ASSESSMENT AND ACTION PLAN WORKSHEET

Element: ***Insert PSM Element***

1-2 sentence description of the PSM element. For more information on the element, review the CSA Z767 Process safety management standard.

For guidance on how to use this assessment, review "Managing risks in manufacturing workplaces: How to use the self-evaluation tool." (WorkSafeBC, 2022)[1]

When choosing due dates as part of the action plans for improvement, it can be helpful for determining the priority to consider factors such as:

- The anticipated effort required to close the gap and make improvements,
- The benefits expected from taking action and implementing change, and
- The urgency (e.g., perceived risk) of the improvements needing to be made.

PSM Element X Self-Assessment

1. Insert PSM gap assessment questions. ☐ Yes (formalized) ☐ Yes (informal) ☐No ☐Unsure

PSM Element X Improvement Tools and Resources[1]

Improvement Tool and Link
Insert PSM best-practices

Action plan for *PSM Element X*

[1] Customized guidance and resources will be created by WPAC and BCFSC.

Action plan for *PSM Element X*

Question number	Plans and actions needed to address gap or improve existing approach	Action owner	Due date (yyyy-mm-dd):

Complete the following table after corrective actions have been implemented.

Review of action plan for *PSM Element X*

Improvement actions taken	
How did you ensure the controls were implemented in a timely fashion? How did you prioritize your actions?	
How will you ensure the implemented controls will continue to be effective over time?	
How are workers involved in developing and implementing controls?	
How do you know that workplace decisions related to safety are effective and sustainable?	
How do you measure change to establish a new performance expectation?	
When changes are made, how are interrelated procedures, programs, and policies updated effectively?	

Is a strategy for continuous improvement in place? How does this process work?	
If you have multiple locations, are lessons learned and continuous improvements shared with other locations? How does this process work?	
Is the safety management system self-sufficient, or does it rely on specific individuals to make it function? How do you ensure the system remains self-sufficient?	
Overall effectiveness of improvement actions	

References

WorkSafeBC. (2022). *Managing Risks in Manufacturing Workplaces: How to Use the Self-Evaluation Tool*. Last accessed May 30, 2023 from https://www.worksafebc.com/en/resources/health-safety/information-sheets/managing-risks-manufacturing-how-to-use-self-evaluation

WorkSafeBC. (2023). *Enhancing Health & Safety Culture & Performance: Self-Evaluation Tool for Managing Risks in Manufacturing Workplaces*. Last accessed May 30, 2023 from https://www.worksafebc.com/resources/health-safety/checklist/managing-risks-manufacturing-assessing-mobile-equipment?lang=en&direct

APPENDIX F: EXAMPLE PSM SELF-ASSESSMENT WORKSHEET: ACCOUNTABILITY

PSM INTEGRATION TOOL: SELF-ASSESSMENT AND ACTION PLAN WORKSHEET

Element: Accountability

Accountability focusses on senior management accountability for the PSM system goals, considering process safety risks throughout the facility lifecycle.

For more information on the topic of Process Safety Leadership Accountability, review the CSA Z767 *Process safety management* standard.

For guidance on how to use this assessment, review "Managing risks in manufacturing workplaces: How to use the self-evaluation tool." (WorkSafeBC, 2022)[1]

When choosing due dates as part of the action plans for improvement, it can be helpful for determining the priority to consider factors such as:

- The anticipated effort required to close the gap and make improvements,
- The benefits expected from taking action and implementing change, and
- The urgency (e.g., perceived risk) of the improvements needing to be made.

Accountability Self-Assessment

1. Has your company established (formalized and documented) goals and objectives related to process safety at your facility? ☐ Yes (formalized) ☐ Yes (informal) ☐No ☐Unsure
2. Check all statements that apply: Senior management does the following: ☐Establishes performance requirements by setting process safety goals and objectives and makes resources available to reach these goals. ☐Sets process safety goals that encompass a range of risks (e.g., personnel, public, environment). ☐Directs decision-makers related to design to consider inherently safer design. ☐Ensures compliance with safe operating conditions through use of proper conduct of operations (*Conduct of operations is defined as carrying out tasks in a methodical way to achieve excellence in operations*).

[1] Customized guidance will be created by WPAC and BCFSC.

☐Directs the completion of risk assessments to address mechanical equipment integrity and process integrity.
3. Is an approval process established for matters relating to maintenance and production? ☐Yes (formalized process documented) ☐Yes (informal process) ☐No ☐Unsure
4. Does the approval process consider risks relating to the process? ☐Yes ☐No ☐Unsure ☐Not applicable

Accountability Improvement Tools and Resources[2]

Improvement Tool and Link
HSE (2023). Process Safety Leadership Guiding Principles
OECD (2012). Corporate Governance for Process Safety: Self-Assessment Questionnaire for Senior Leaders
Levovnik et al. (2019). The Role of Leadership in Process Safety Management System "No Process Safety Management System is an Island"
Travers, I. (2019). Practical Leadership for Process Safety Management
Control of Major Hazards (COMAH) (2018). Managing Risk - The Hazards That Can Destroy Your Business. A Guide to Leadership in Process Safety.
Control of Major Hazards (COMAH) (n.d.). Major Hazard Leadership Intervention Tool
CalOSHA (California Occupational Safety and Health) (2011). Identifying Measurable Safety Goals
Process Safety Forum (2023). Resources (Leadership Principles, Safety Leadership Charter, Lessons Learned)

Action plan for Accountability

Question number	Plans and actions needed to address gap or improve existing approach	Action owner	Due date (yyyy-mm-dd):

[2] Customized resources for WPAC operations will be developed.

Complete the following table after corrective actions have been implemented.

Review of action plan for Accountability

Improvement actions taken	
How did you ensure the controls were implemented in a timely fashion? How did you prioritize your actions?	
How will you ensure the implemented controls will continue to be effective over time?	
How are workers involved in developing and implementing controls?	
How do you know that workplace decisions related to safety are effective and sustainable?	
How do you measure change to establish a new performance expectation?	
When changes are made, how are interrelated procedures, programs, and policies updated effectively?	
Is a strategy for continuous improvement in place? How does this process work?	
If you have multiple locations, are lessons learned and continuous improvements shared with other locations? How does this process work?	
Is the safety management system self-sufficient, or does it rely on specific individuals to make it function? How do you ensure the system remains self-sufficient?	
Overall effectiveness of improvement actions	

References

WorkSafeBC. (2022). *Managing Risks in Manufacturing Workplaces: How to Use the Self-Evaluation Tool.* Last accessed May 30, 2023 from https://www.worksafebc.com/en/resources/health-safety/information-sheets/managing-risks-manufacturing-how-to-use-self-evaluation

WorkSafeBC. (2023). *Enhancing Health & Safety Culture & Performance: Self-Evaluation Tool for Managing Risks in Manufacturing Workplaces.* Last accessed May 30, 2023 from https://www.worksafebc.com/resources/health-safety/checklist/managing-risks-manufacturing-assessing-mobile-equipment?lang=en&direct

APPENDIX G: EXAMPLE PSM SELF-ASSESSMENT WORKSHEET: PROCESS SAFETY CULTURE

PSM INTEGRATION TOOL: SELF-ASSESSMENT AND ACTION PLAN WORKSHEET

Element: Process Safety Culture

Process safety culture is the collective mindset of the organization with respect to safety and risk, including attitudes and behaviours.

For more information on the topic of Process Safety Culture, review the CSA Z767 *Process safety management* standard.

For guidance on how to use this assessment, review "Managing risks in manufacturing workplaces: How to use the self-evaluation tool." (WorkSafeBC, 2022)[1]

When choosing due dates as part of the action plans for improvement, it can be helpful for determining the priority to consider factors such as:

- The anticipated effort required to close the gap and make improvements,
- The benefits expected from taking action and implementing change, and
- The urgency (e.g., perceived risk) of the improvements needing to be made.

Process Safety Culture Self-Assessment

1. Is process safety leadership and competency a core value of all management? ☐ Yes (formalized) ☐ Yes (informal) ☐No ☐Somewhat ☐Unsure
2. Is there a visible and active commitment to process safety from all levels of management? ☐ Yes (formalized) ☐ Yes (informal) ☐No ☐Somewhat ☐Unsure
3. As it relates to process safety culture, check all statements that apply: ☐Company policy states that process safety is a representation of successful operations. ☐Management regularly reviews key performance indicators (KPIs) to support the process safety management system ☐Management ensures that corrective actions from risk assessments, incident investigations, and audits are addressed. ☐Not applicable.

[1] Customized guidance will be created by WPAC and BCFSC.

4. Is there an understanding of the consequences that could arise from a process safety incident (e.g., loss of control) and the impact it may have on personnel, property and the environment? ☐Yes ☐No ☐Somewhat ☐Unsure
5. Do personnel (including operators, maintenance technicians, electricians, and instrumentation specialists) follow conduct of operation requirements? *Conduct of operations is defined as carrying out tasks in a methodical way to achieve excellence in operations.* ☐Yes ☐No ☐Somewhat ☐Unsure
6. Do personnel (including operators, maintenance technicians, electricians, and instrumentation specialists) contact their supervisors if they have a concern about any gaps, issues, or incidents with the process safety system? Check all that apply. ☐ Failures in maintenance ☐ Failure of work permits ☐ Bypasses of any safety systems (e.g., spark detectors) ☐ Operating the process beyond safe operating limits ☐ Not applicable.
7. Do personnel (including operators, maintenance technicians, electricians and instrumentation specialists) have the responsibility and authority to stop unsafe work or operations? ☐Yes ☐No ☐Somewhat ☐Unsure
8. Is there open and effective communication regarding process safety? ☐Yes ☐No ☐Somewhat ☐Unsure
9. Is there open communication between all people in the organization (operations, management) around the following process safety aspects? Check all that apply. ☐ Process safety goals ☐ Process safety issues and concerns ☐ Process safety incidents ☐ Process safety near misses ☐ Process safety performance
10. Does management respond in a timely way to the following (check all that apply)? ☐ Process safety issues and concerns

☐ Process safety incidents

☐ Process safety near misses

11. Are process safety issues and concerns communicated with operational personnel (operators, maintenance technicians, electricians, and instrumentation specialists) in a timely way?

☐Yes ☐No ☐Somewhat ☐Unsure

12. Are relevant process safety-related issues and incidents at other organizations or facilities communicated with relevant stakeholders (e.g., operators, supervisors) in a timely way?

☐Yes ☐No ☐Somewhat ☐Unsure

13. How strongly is the following statement communicated and demonstrated throughout the organization: "Management and workers both hold responsibility for the role they play in preventing a process safety incident."

☐Strongly ☐Somewhat ☐Little

14. Is there a system and process in place for senior management to engage with and consult personnel and workers on the implementation of the management system?

☐ Yes (formalized) ☐ Yes (informal) ☐No ☐Unsure

15. Does management maintain a sense of vulnerability that a process safety incident (loss of control) can occur?

☐Yes ☐No ☐Somewhat ☐Unsure

16. Do workers maintain a sense of vulnerability that a process safety incident (loss of control) can occur?

☐Yes ☐No ☐Somewhat ☐Unsure

17. Does the organization have initiatives to prevent/avoid complacency? Check all that apply:

☐ Regular safety meetings and briefings

☐ Refresher training

☐ Development, sharing, or review of safety bulletins, factsheets, or newsletters

☐ Sharing and discussion of process safety incidents and near misses

☐ Other (specify):

Process Safety Culture Improvement Tools and Resources [2]

Improvement Tool and Link
Transport Canada (2021). Example Safety Culture Policy Statement
Manufacturing Safety Alliance of British Columbia (MSABC) (n.d.). Safety Culture: A Guide to Effective Measurement and Improvement
Energy Institute (2023). Hearts and Minds Safety Culture Toolkit
Energy Institute (2023). Hearts and Minds Safety Culture: Chronic Unease Video
Contra Costa County Health Services (CCHS) (2011). Safety Culture Assessments Overview
Contra Costa County Health Services (CCHS) (2011). Safety Culture Assessments Guidance and Example
WorkSafe Queensland (2023): Safety Climate and Safety Culture Videos, Assessment Guidance, Factsheet (Safety culture, climate and leadership), Factsheet (Getting the most out of your safety climate survey)
DuPont (2010). Safety Culture Survey Example: DuPont Safety Perception Survey
Contra Costa County Health Services (CCHS) (2011a). Safety Culture Survey Example: Baker Panel Report
Center for Chemical Process Safety (CCPS) (2021). Building Process Safety Culture Tool Kit: Tools to Enhance Process Safety Performance
WorkSafeBC (2023b). Enhancing Health & Safety Culture & Performance
HSE (2023). Organisational Culture: Guidance
HSE (n.d., a). Extract from Inspectors' Human Factors Toolkit: Safety Culture Questions

Action Plans for Process Safety Culture

Question number	Plans and actions needed to address gap or improve existing approach	Action owner	Due date (yyyy-mm-dd):

[2] Customized guidance will be created by WPAC and BCFSC.

Complete the following table after corrective actions have been implemented.

Review of action plan for Process Safety Culture

Improvement actions taken	
How did you ensure the controls were implemented in a timely fashion? How did you prioritize your actions?	
How will you ensure the implemented controls will continue to be effective over time?	
How are workers involved in developing and implementing controls?	
How do you know that workplace decisions related to safety are effective and sustainable?	
How do you measure change to establish a new performance expectation?	
When changes are made, how are interrelated procedures, programs, and policies updated effectively?	
Is a strategy for continuous improvement in place? How does this process work?	
If you have multiple locations, are lessons learned and continuous improvements shared with other locations? How does this process work?	
Is the safety management system self-sufficient, or does it rely on specific individuals to make it function? How do you ensure the system remains self-sufficient?	
Overall effectiveness of improvement actions	

References

WorkSafeBC. (2022). *Managing Risks in Manufacturing Workplaces: How to Use the Self-Evaluation Tool*. Last accessed May 30, 2023 from https://www.worksafebc.com/en/resources/health-safety/information-sheets/managing-risks-manufacturing-how-to-use-self-evaluation

WorkSafeBC. (2023). *Enhancing Health & Safety Culture & Performance: Self-Evaluation Tool for Managing Risks in Manufacturing Workplaces*. Last accessed May 30, 2023 from https://www.worksafebc.com/resources/health-safety/checklist/managing-risks-manufacturing-assessing-mobile-equipment?lang=en&direct

APPENDIX H: EXAMPLE PSM SELF-ASSESSMENT WORKSHEET: MANAGEMENT OF CHANGE

PSM INTEGRATION TOOL: SELF-ASSESSMENT AND ACTION PLAN WORKSHEET

Element: Management of Change

Management of change (MOC) aims to manage risks associated with changes to design, equipment, procedures, personnel, and the organization, and includes temporary and permanent changes.

For more information on the topic of Management of Change, review the CSA Z767 *Process safety management* standard.

For guidance on how to use this assessment, review "Managing risks in manufacturing workplaces: How to use the self-evaluation tool." (WorkSafeBC, 2022)[1]

When choosing due dates as part of the action plans for improvement, it can be helpful for determining the priority to consider factors such as:

- The anticipated effort required to close the gap and make improvements,
- The benefits expected from taking action and implementing change, and
- The urgency (e.g., perceived risk) of the improvements needing to be made.

Management of Change Self-Assessment

1. Is a management of change (MOC) program in place? ☐ Yes (formalized) ☐ Yes (informal) ☐No ☐Unsure
2. Does the MOC system manage risks associated with the following changes? Check all that apply: ☐Design changes ☐Equipment changes ☐Procedural changes ☐Organizational changes ☐Not applicable
3. If an MOC system is present, does it consider the following aspects? Check all that apply. ☐States what a change is.

[1] Customized guidance will be created by WPAC and BCFSC.

☐States what type a given change is (emergency or temporary).

☐States what replacement-in-kind (RIK) is (which is not included in MOC).

☐Considers changes in operating procedures or safe operating limits.

☐Considers changes in the structure of the organization and staffing.

☐A process for reviewing and approving changes.

☐Includes a risk assessment of the change.

☐Includes the communication of the change with relevant stakeholders before the change is made.

☐ Includes any necessary training of relevant stakeholders before the change is made.

☐ Includes a procedure for implementing an emergency change, as well as communicating with relevant personnel in a timely manner

☐ States the documentation needed for a change including:

a. ☐ Explanation of proposed change,
b. ☐ Change authorization,
c. ☐ Training requirements,
d. ☐ Up-to-date drawings,
e. ☐ Confirmation that change was implemented as design intended

☐Not applicable.

4. Does the MOC system manage temporary changes?

☐Yes (formalized process documented) ☐Yes (informal process) ☐No ☐Unsure

☐Not applicable

5. Does the MOC system use any of the following considerations to manage temporary changes? Check all that apply.

☐ A time limit/timeframe is set

☐ A process for review and approval if the temporary change needs a time extension

☐ A process to return the equipment or system back to the original state when the temporary change has ended (e.g., removing any temporary installations).

☐ Not applicable

6. If there have been instances of temporary changes being permanently implemented, are the following considerations made? Check all that apply.

☐ Changes for other lifecycles (e.g., maintenance turnaround)

☐ Changes to documents and procedures

☐ Changes to supporting programs

☐ Not applicable

7. **Is the hierarchy of controls and inherently safer design (ISD) options considered during management of change?** ☐Yes (formalized process documented) ☐Yes (informal process) ☐No ☐Sometimes ☐Unsure ☐Not applicable

Management of Change Improvement Tools and Resources[2]

Improvement Tool and Link
Example of Management of Change Plan[3]
SAFER (n.d.). Combustible Dust Management Assessment Handout
Occupational Health and Safety Administration (OSHA) (2019a). MOC Guidelines
CCPS (2021). Golden Rules for Combustible Dust
PSM Egypt (2022). Management of Change Guideline
CSChE (2004). Managing the Health and Safety Impacts of Organizational Change
NFPA 652 (2019). Standard on the Fundamentals of Combustible Dust
NFPA 664 (2020). Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities
Penn State (2016b). Process Safety Management: Management of Change Form

Action plan for Management of Change

Question number	Plans and actions needed to address gap or improve existing approach	Action owner	Due date (yyyy-mm-dd):

[2] Customized resources for WPAC operations will be developed.
[3] Found in Appendix O of Report "Integrating Process Safety Management into Canadian Wood Pellet Facilities that Generate Combustible Wood Dust."

Complete the following table after corrective actions have been implemented.

Review of action plan for Management of Change

Improvement actions taken	
How did you ensure the controls were implemented in a timely fashion? How did you prioritize your actions?	
How will you ensure the implemented controls will continue to be effective over time?	
How are workers involved in developing and implementing controls?	
How do you know that workplace decisions related to safety are effective and sustainable?	
How do you measure change to establish a new performance expectation?	
When changes are made, how are interrelated procedures, programs, and policies updated effectively?	
Is a strategy for continuous improvement in place? How does this process work?	
If you have multiple locations, are lessons learned and continuous improvements shared with other locations? How does this process work?	
Is the safety management system self-sufficient, or does it rely on specific individuals to make it function? How do you ensure the system remains self-sufficient?	
Overall effectiveness of improvement actions	

References

WorkSafeBC. (2022). *Managing Risks in Manufacturing Workplaces: How to Use the Self-Evaluation Tool.* Last accessed May 30, 2023 from https://www.worksafebc.com/en/resources/health-safety/information-sheets/managing-risks-manufacturing-how-to-use-self-evaluation

WorkSafeBC. (2023). *Enhancing Health & Safety Culture & Performance: Self-Evaluation Tool for Managing Risks in Manufacturing Workplaces*. Last accessed May 30, 2023 from https://www.worksafebc.com/resources/health-safety/checklist/managing-risks-manufacturing-assessing-mobile-equipment?lang=en&direct

APPENDIX I: EXAMPLE PSM SELF-ASSESSMENT WORKSHEET: KEY PERFORMANCE INDICATORS

PSM INTEGRATION TOOL: SELF-ASSESSMENT AND ACTION PLAN WORKSHEET

Element: Key performance indicators (KPIs)

Key performance indicators (KPIs) focusses on the use of leading and lagging indicators that are selected and monitored to target for improvement. Leading indicators are process-focussed metrics that signify the function of operating discipline, processes, or safety barriers/controls. Leading indicators are selected to provide an early signal of potential issues or degradation of safety controls so proactive corrective actions can be conducted. Lagging indicators are outcome-focussed metrics that can signify recurring issues and include events that have taken place.

For more information on the topic of KPIs for process safety, review the CSA Z767 *Process safety management* standard.

For guidance on how to use this assessment, review "Managing risks in manufacturing workplaces: How to use the self-evaluation tool." (WorkSafeBC, 2022)[1]

When choosing due dates as part of the action plans for improvement, it can be helpful for determining the priority to consider factors such as:

- The anticipated effort required to close the gap and make improvements,
- The benefits expected from taking action and implementing change, and
- The urgency (e.g., perceived risk) of the improvements needing to be made.

KPIs Self-Assessment

1. Have you identified leading and lagging key performance indicators (KPIs) for process safety at your facility? ☐ Yes ☐No ☐Unsure
2. Are unsafe behaviours or inadequate operational discipline measured? Operational discipline is defined as the performance of all tasks correctly every time. ☐ Yes ☐No ☐Unsure
3. Are process safety near misses tracked? These may include, for example, small fires, system failures or instrumentation failure that could lead to an incident. ☐ Yes ☐No ☐Somewhat ☐Unsure

[1] Customized guidance will be created by WPAC and BCFSC.

4. **Are near misses collected and used for lessons learned, enhancing awareness, and improving process safety culture?** ☐ Yes ☐No ☐Somewhat ☐Unsure
5. **When selecting key performance indicators, which of the following are considered? Check all that apply.** ☐ Not applicable - process safety key performance indicators have not been selected. ☐ Indicators refer to process safety critical equipment and items that influence system performance. ☐ Indicators advance process safety performance improvement and learning. ☐ Indicators are relatively easy to implement, measure, and understood by stakeholders. ☐ Indicators can be used for benchmarking. ☐ Other (specify):

KPIs Improvement Tools and Resources[2]

Improvement Tool and Link
HSE (2006). Developing Process Safety Indicators A Step-By-Step Guide for Chemical and Major Hazard Industries
Fanelli, P. (2014). Process Safety Performance Indicators for a Fuel Storage Site: A Worked Example
Chemical Business Association (2018). Safety Performance Leading Indicators
Center for Chemical Process Safety (CCPS) (2022): Process Safety Metrics Guide for Leading and Lagging Indicators (Version 4.1)

Action plan for KPIs

Question number	Plans and actions needed to address gap or improve existing approach	Action owner	Due date (yyyy-mm-dd):

[2] Customized resources for WPAC operations will be developed.

Complete the following table after corrective actions have been implemented.

Review of action plan for KPIs

Improvement actions taken	
How did you ensure the controls were implemented in a timely fashion? How did you prioritize your actions?	
How will you ensure the implemented controls will continue to be effective over time?	
How are workers involved in developing and implementing controls?	
How do you know that workplace decisions related to safety are effective and sustainable?	
How do you measure change to establish a new performance expectation?	
When changes are made, how are interrelated procedures, programs, and policies updated effectively?	
Is a strategy for continuous improvement in place? How does this process work?	
If you have multiple locations, are lessons learned and continuous improvements shared with other locations? How does this process work?	
Is the safety management system self-sufficient, or does it rely on specific individuals to make it function? How do you ensure the system remains self-sufficient?	

Overall effectiveness of improvement actions	

References

WorkSafeBC. (2022). *Managing Risks in Manufacturing Workplaces: How to Use the Self-Evaluation Tool*. Last accessed May 30, 2023 from https://www.worksafebc.com/en/resources/health-safety/information-sheets/managing-risks-manufacturing-how-to-use-self-evaluation

WorkSafeBC. (2023). *Enhancing Health & Safety Culture & Performance: Self-Evaluation Tool for Managing Risks in Manufacturing Workplaces*. Last accessed May 30, 2023 from https://www.worksafebc.com/resources/health-safety/checklist/managing-risks-manufacturing-assessing-mobile-equipment?lang=en&direct

APPENDIX J: PROCESS SAFETY MANAGEMENT FACTSHEET

2023

PROCESS SAFETY MANAGEMENT (PSM) IN WOOD PRODUCTS MANUFACTURING

PSM OVERVIEW

INTRODUCTION TO PSM

PSM is the use of management principles and systems to identify, understand, avoid, and control process hazards to prevent, mitigate, prepare for, respond to, and recover from process-related incidents.

PSM provides wood products manufacturing facilities a framework to address risk associated with combustible dust to prevent loss-producing incidents, including fires and explosions.

PSM ELEMENTS

The CSA Z767 Process Safety Management Standard is a 16-element system.

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

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PSM ELEMENTS GLOSSARY

Accountability: Senior management accountability for the PSM system including establishing process safety goals and considering process safety risks throughout the facility lifecycle.

Regulations, standards, and codes: Management system for the control of pertinent regulations, standards, and codes to ensure relevant documentation is up to date, communicated with relevant stakeholders, and consistently used throughout the organization.

Process safety culture: Collective mindset of the organization with respect to safety and risk, including attitudes and behaviours.

Conduct of operations - senior management responsibility: Carrying out operational and management tasks in a methodical way to achieve excellence in operations.

Process knowledge and documentation: Process safety information, which consists of data relating to the characteristics of a process involving hazards, including hazardous materials properties, technologies and methods, equipment, and operation. This includes technical documentation, including piping and instrumentation diagrams (P&IDs), process flow diagrams, and process risk assessments.

Project review and design procedures: Consideration of risk assessments throughout project status, including request for approval, siting decisions, and the design process.

Process risk assessment and risk reduction: Identification and analysis of process-related hazards, documentation of hazard analyses, and implementation of risk reduction measures.

Human factors: Consideration of the role of human factors in process safety, including aspects like human error, written procedures, fatigue management and the use of engineering controls.

Training and competence: System in place to ensure that personnel have the required qualifications and competencies to fulfill their roles and responsibilities and conduct their tasks safely and effectively; includes experience, education, and training.

Management of change: Management of risks associated with changes to design, equipment, procedures, personnel, and the organization; and includes temporary and permanent changes.

Process and equipment integrity: Systems to ensure the integrity of the process and process equipment, including inspection, testing, and maintenance (ITM) of equipment, establishing safe work practices, and conducting a pre-startup safety review (PSSR) before running a new or modified process or equipment.

Emergency management planning: Program used to manage the consequences of hazardous scenarios that could arise from a loss of containment incident considering regulatory requirements, standards, and industry best practices, in the preparation for and response to an emergency.

Investigation: Program established to identify, report, investigate, and record process safety incidents. Process safety incidents include near misses as well as significant events.

Audit process: System for assessing the organization's current PSM program with respect to the standard (CSA Z767) to determine if the program conforms to the standard and if the PSM program is implemented and maintained.

Enhancement of process safety knowledge: Continuous improvement of process safety knowledge through industry learnings and participation in various associations (e.g., professional, trade, labour, technical), and incorporation of advances and improvements where feasible.

Key performance indicators for process safety: Use of leading and lagging indicators that are selected and monitored to target for improvement. Leading indicators are process-focussed metrics that signify the function of operating discipline, processes, or safety barriers/controls. Leading indicators are selected to provide an early signal of potential issues or degradation of safety controls so proactive corrective actions can be conducted. Lagging indicators are outcome-focussed metrics that can signify recurring issues and include events that have taken place.

BUSINESS BENEFITS OF PROCESS SAFETY MANAGEMENT

Corporate Social Responsibility – enhances image, reputation, and brand, which makes company more attractive

Business Flexibility – preserves resources that could be used to focus on growth because companies are welcomed by communities

Loss Prevention – prevents injuries and avoids major losses and environmental damage

Sustainable Growth – boosts productivity, delivers high-quality products on-time at lower cost, and contributes to shareholder value

Leadership Excellence – ensures consistency and reliability, which carries over to other business areas through involved leadership and management

MEASURABLE BENEFITS OF PSM

Increases in productivity

Reduction in production costs

Reduction in maintenance costs

Reduction in capital budget

Reduction in insurance costs

NEXT STEPS FOR WPAC MEMBERS

Building on the research results of an Innovation at Work project (funded by WorkSafeBC), the BC Forest Council and WPAC will support operations for the implementation of PSM, which will involve activities focussed on outcomes including:

- A PSM implementation guide, workplan and timelines,
- Self-assessment worksheets and action plans, and
- PSM procedures and policies.

RESOURCES

Process Safety Initiative (WorkSafeBC)

CSA Z767-17 Process Safety Management Standard (CSA Group)

References:

CCPS (Center for Chemical Process Safety). (2016). Guidelines for Implementing Process Safety Management. American Institute of Chemical Engineers (AIChE), New York, New York.

CCPS (Center for Chemical Process Safety). (2018). The Business Case for Process Safety. American Institute of Chemical Engineers (AIChE), New York, New York. Last retrieved April 14, 2023 from https://www.aiche.org/ccps/about/business-case-process-safety

CSA (Canadian Standards Association). (2017). Process safety management. CSA-Z767-17, National Standard of Canada. Toronto, ON: CSA Group.

APPENDIX K: ACCOUNTABILITY FACTSHEET

2023

PROCESS SAFETY MANAGEMENT (PSM) IN WOOD PRODUCTS MANUFACTURING

ACCOUNTABILITY

INTRODUCTION TO ACCOUNTABILITY

Accountability refers to senior management responsibility for the PSM system including establishing process safety goals and considering process safety risks throughout the facility lifecycle.

Accountability is an element of process safety management (PSM). The CSA Z767 *Process Safety Management* framework is shown below; accountability is highlighted.

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

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CONSIDER ACCOUNTABILITY IN YOUR OPERATION

- Has your company established goals and objectives related to process safety at your facility?
- Who is accountable for setting processes safety goals, making sure they are visible and understood by relevant stakeholders, and requiring adherence to safety programs at your facility?
- Is an approval process established for matters relating to maintenance and production? Does the approval process consider risks relating to the process?

NEXT STEPS FOR WPAC MEMBERS

Building on the research results of an Innovation at Work project (funded by WorkSafeBC), the BC Forest Council and WPAC will support operations for the implementation of PSM, which will involve activities focussed on outcomes including:

- Process safety goals that includes the engagement of frontline workers and operators,
- An accountability self-assessment worksheet and action plan, and
- An accountability policy.

RESOURCES

Process Safety Initiative (WorkSafeBC)

CSA Z767-17 Process Safety Management Standard

SELECTED ACCOUNTABILITY RESOURCES

Best Practice/Resource and Link
HSE (2023). Process Safety Leadership Guiding Principles
OECD (2012). Corporate Governance for Process Safety: Self-Assessment Questionnaire for Senior Leaders
Levovnik et al. (2019). The Role of Leadership in Process Safety Management System “No Process Safety Management System is an Island”
Travers, I. (2019). Practical Leadership for Process Safety Management
Control of Major Hazards (COMAH) (2018). Managing Risk - The Hazards That Can Destroy Your Business. A Guide to Leadership in Process Safety.
Control of Major Hazards (COMAH) (n.d.). Major Hazard Leadership Intervention Tool
CalOSHA (California Occupational Safety and Health) (2011). Identifying Measurable Safety Goals
Process Safety Forum (2023). Resources (Leadership Principles, Safety Leadership Charter, Lessons Learned)

APPENDIX L: PROCESS SAFETY CULTURE FACTSHEET

2023

PROCESS SAFETY MANAGEMENT (PSM) IN WOOD PRODUCTS MANUFACTURING

PROCESS SAFETY CULTURE

INTRODUCTION TO PROCESS SAFETY CULTURE

Process safety culture is the collective mindset of the organization with respect to safety and risk, including attitudes and behaviours.

Process safety culture is an element of process safety management (PSM). The CSA Z767 *Process Safety Management* framework is shown below; process safety culture is highlighted.

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

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CONSIDER PROCESS SAFETY CULTURE IN YOUR OPERATION

- Has process safety been formally identified as a core value at your facility?
- Do organizational policies include statements establishing process safety as a measure of successful operations?
- Are workers encouraged to raise (through supervisors or otherwise) concerns regarding deficiencies in the process safety system? Examples include failures in maintenance, failure of permit to work, safety system bypasses, and operating outside of safe operating limits.
- Are workers informed and encouraged that they have the responsibility and authority to initiate stoppages of unsafe work or operations?

NEXT STEPS FOR WPAC MEMBERS

Building on the research results of an Innovation at Work project (funded by WorkSafeBC), the BC Forest Council and WPAC will support operations for the implementation of PSM, which will involve activities focussed on outcomes including:

- A process safety culture survey to measure and track the effectiveness of your culture,
- A process safety culture self-assessment worksheet and action plan, and
- A process safety culture policy.

RESOURCES

Process Safety Initiative (WorkSafeBC)

CSA Z767-17 Process Safety Management Standard (CSA Group)

SELECTED PROCESS SAFETY CULTURE RESOURCES

Best Practice/Resource and Link
Transport Canada (2021). Example Safety Culture Policy Statement
Energy Institute (2023a). Hearts and Minds Safety Culture Toolkit
Energy Institute (2023b). Hearts and Minds Safety Culture: Chronic Unease Video
WorkSafe Queensland (2023): Safety Climate and Safety Culture Videos and Guides
CCHS (2011a). Safety Culture Survey Example: Baker Panel Report
Contra Costa County Health Services (CCHS) (2011b). Safety Culture Assessments Overview
Center for Chemical Process Safety (CCPS) (2021). Building Process Safety Culture Tool Kit: Tools to Enhance Process Safety Performance
HSE (2023). Organisational Culture: Guidance

APPENDIX M: MANAGEMENT OF CHANGE FACTSHEET

MANAGEMENT OF CHANGE

INTRODUCTION TO MANAGEMENT OF CHANGE

Management of change (MOC) is the management of risks associated with changes to design, equipment, procedures, personnel, and the organization, and includes temporary and permanent changes.

MOC is an element of process safety management (PSM). The CSA Z767 *Process Safety Management* framework is shown below; MOC is highlighted.

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

CONSIDER MANAGEMENT OF CHANGE IN YOUR OPERATION

- Do you have a formal MOC process?
- Does the MOC system define what constitutes a change at the facility and is covered under the program?
- Does the MOC system manage temporary changes?
- If temporary changes are being permanently implemented, is there a process to make changes to maintenance turnaround, documents and procedures, and other supporting programs?

NEXT STEPS FOR WPAC MEMBERS

Building on the research results of an Innovation at Work project (funded by WorkSafeBC), the BC Forest Council and WPAC will support operations for the implementation of PSM, which will involve activities focussed on outcomes including:

- An MOC self-assessment worksheet and action plan, and
- A formalized MOC program and form.

RESOURCES

Process Safety Initiative (WorkSafeBC)

CSA Z767-17 Process Safety Management Standard (CSA Group)

SELECTED MANAGEMENT OF CHANGE RESOURCES

Best Practice/Resource and Link
SAFER (n.d.). Combustible Dust Management Assessment Handout
Occupational Health and Safety Administration (OSHA) (2019a). MOC Guidelines
CCPS (2021). Golden Rules for Combustible Dust
PSM Egypt (2022). Management of Change Guideline
CSChE (2004). Managing the Health and Safety Impacts of Organizational Change
NFPA 652 (2019). Standard on the Fundamentals of Combustible Dust
NFPA 664 (2020). Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities
Penn State (2016). Process Safety Management: Management of Change Form

APPENDIX N: KEY PERFORMANCE INDICATORS FACTSHEET

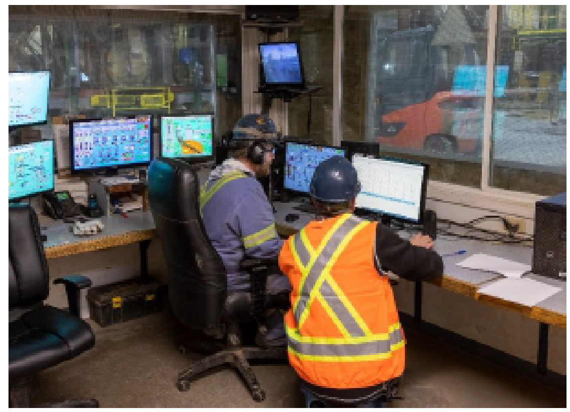
2023

PROCESS SAFETY MANAGEMENT (PSM) IN WOOD PRODUCTS MANUFACTURING

KEY PERFORMANCE INDICATORS

INTRODUCTION TO PROCESS SAFETY KEY PERFORMANCE INDICATORS

Process safety key performance indicators (KPIs) involves the use of leading and lagging indicators that are selected and monitored to target for improvement. Leading indicators are process-focussed metrics that signify the function of operating discipline, processes, or safety barriers/controls. Leading indicators are selected to provide an early signal of potential issues or degradation of safety controls so proactive corrective actions can be conducted. Lagging indicators are outcome-focussed metrics that can signify recurring issues and include events that have taken place.



KPIs is an element of process safety management (PSM). The CSA Z767 *Process Safety Management* framework is shown below; KPIs is highlighted.

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

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CONSIDER KEY PERFORMANCE INDICATORS IN YOUR OPERATION

● Have you identified leading and lagging key performance indicators (KPIs) for process safety at your facility?

● Are process safety near misses tracked? These may include, for example, small fires, system failures or instrumentation failure that could lead to an incident.

● When selecting key performance indicators, which of the following are considered?

- Indicators that refer to process safety critical equipment and items that influence system performance.
- Indicators that advance process safety performance improvement and learning.
- Indicators that are relatively easy to implement, measure, and understood by stakeholders.
- Indicators that can be used for benchmarking.

NEXT STEPS FOR WPAC MEMBERS

Building on the research results of an Innovation at Work project (funded by WorkSafeBC), the BC Forest Council and WPAC will support operations for the implementation of PSM, which will involve activities focussed on outcomes including the development of:

- Site-specific and industry benchmarking process safety KPIs,
- A KPIs self-assessment worksheet and action plan, and
- A KPIs policy.

Additionally, KPIs to monitor and track the progress of integrating PSM elements will be developed.

RESOURCES

Process Safety Initiative (WorkSafeBC)

CSA Z767-17 Process Safety Management Standard (CSA Group)

SELECTED KEY PERFORMANCE INDICATORS RESOURCES

Best Practice/Resource and Link
HSE (2006). Developing Process Safety Indicators: A Step-By-Step Guide for Chemical and Major Hazard Industries
Fanelli, P. (2014). Process Safety Performance Indicators for a Fuel Storage Site: A Worked Example
Chemical Business Association (2018). Safety Performance Leading Indicators
Center for Chemical Process Safety (CCPS) (2022): Process Safety Metrics Guide for Leading and Lagging Indicators (Version 4.1)

APPENDIX O: SAFETY CULTURE QUESTIONS ADAPTED FROM DUPONT

Table O-1: Safety culture survey questions adapted from DuPont Safety Perception Survey (DuPont, 2010)

Category	Safety Culture Survey Question
Leadership	To what extent in your organization is safety an integral part of equipment and facility design, operating practices, and job training-not something that is added later?
	a. Does your organization have well-established, readily available, written safety values (beliefs and principles)? b. Check the statement below that best describes your organization's written safety values. - Are up-to-date and influential - Have some influence - Have little or no influence
	How is disciplinary action used when people don't follow safety rules? "Disciplinary action" could range from a verbal caution through more severe action such as termination.
	What priority do others give to safety?
	What priority do you personally give safety?
	To what extent can injuries be prevented?
	a. In the past year, how active were you in safety improvement activities such as serving on a committee, participating in an incident investigation, or helping put together safety rules? b. In the last two years, have you participated in a safety committee or team? For example, a site safety and health committee, rules/procedures committee, safe driving committee or a task force to review area safety rules.
	To what extent does your organization recognize safety achievements and celebrate good safety performance?
Structure	a. What is the quality of the safety rules in your organization? High-quality rules are up-to-date and clearly written and help people do their work well and safely. b. To what extent are the safety rules of your organization obeyed?
	Rate the effectiveness of the safety structures in your workplace (safety committees, systems, organizational procedures, etc.).

	Rate the effectiveness of the safety staff (people) in your organization (the safety supervisor, the safety advisors, safety specialists, etc.).
	Respond to this statement: "In my organization, supervisors and managers are held accountable for preventing injuries and safety incidents in their area, and safety performance has a direct effect on their performance rating, advancement, and pay." (respond on sliding scale strongly agree to strongly disagree)
	To what extent are you satisfied with the overall safety performance of your organization?
	How well do you know your organization's safety goals and performance?
	At what point does safety improvement cost more than the economic benefits it provides? (Possible economic benefits of safety are reduced costs of injuries and lost working time, better morale and product quality, improved production, etc.)
	How would a strong, long-term effort for safety excellence affect excellence in other areas, such as quality, productivity, costs, and profits?
Processes and Actions	To what extent are injuries, safety incidents, and near misses investigated and the recommendations acted upon?
	How do you rate the safety of the physical facilities in your area?
	To what extent do you feel empowered and expected to take action to prevent injuries and ensure the safety of yourself and others? This includes stopping work, shutting down equipment, and making suggestions or taking steps to fix the safety of the job, knowing that you'll be supported by your supervision for your action.
	a. To what extent are you personally involved in organized, regularly scheduled safety audits (observation of work activity) and inspections of the workplace? b. How do you rate the quality and effectiveness of the safety audit and inspection system? Consider frequency, thoroughness, extent of participation, extent to which safety behavior (not just physical conditions) is observed, thoroughness of follow-up, and overall effectiveness in helping to develop a safer workplace.

	How much formal, structured training have you received in process safety in the last two years?
	a. How often are safety meetings held in your workplace? b. Do you attend the safety meetings regularly? c. How do you rate the quality and effectiveness of the safety meetings?
	To what extent is "off-the-job" safety dealt with in your workplace safety program?

APPENDIX P: EXAMPLE OF MANAGEMENT OF CHANGE PLAN

This example has been adapted from confidential resources. This serves as an example of an MOC plan that may be appropriate for wood pellet operations.

1. Background

Management of Change procedures have been developed for the plant. These procedures are in place to ensure changes to the equipment, staffing, operations and other matters are performed without negatively affecting the operation or safety of the plant. The necessary definitions, responsibilities and procedures are provided below.

2. Management of Change Procedures

This is a system to evaluate, authorize, and document changes before they are made to ensure that the changes made do not adversely affect the safe operation of the facility. It is used to understand the overall impact to an operating system and to apply appropriate controls for eliminating or reducing identified risks to acceptable levels. Assigning accountability for identifying and controlling hazards associated with change is a key activity.

Management of Change (MOC) applies to any permanent or temporary change during the design, construction, installation, operation, maintenance, modification, and decommissioning of the facility.

2.1. Management of Change Exclusions

MOC does not include equipment “replacement in-kind”. During the normal operation of the plant equipment wear and failure will require replacement. The replacement of this equipment must be done by the associated discipline (Electrical, Mechanical) and commissioned and documented appropriately.

A Management of Change is not required for the following:

- “Replacement in Kind”. To qualify as a “replacement in kind”, the new item must satisfy the design specifications and intent of the item being replaced (e.g.: a pump of the same size/type/construction/orientation/general weight but a different manufacturer),

- Changes in operation that are within approved design limits, defined in the plant operating manuals (if operating manuals allow operation between 16-35° C and you stay within that range).
- Non-structural building modifications that do not disrupt the process, process equipment, or require changes to equipment (e.g.: painting or carpeting an office, changing a door in an office)
- Re-issuance of a procedure, flow sheet or drawing as a result of a correction of a typographical error or obvious mistake on the original version.
- Cosmetic changes to a procedure, flow sheet or drawing, in which the contents are rearranged to clarify the procedure or to expand information.

2.2. Initiating a Change

Initiating a change can be done by anyone involved in the operation of the plant. Often field experience is the best source of ideas to improve the safety and reliability of the equipment. A Request for Information (RFI) should be sent to the Plant Chief, for review and preparation of basis for the change.

Accumulation of RFI's is the most efficient and cost effective approach unless there is a serious safety issue that should be dealt with immediately.

2.3. MOC Scope

The following items are within the scope requiring MOC processes to be followed:

- P&ID drawings are the basis for the facility intended operation. Any instrument, registered piping, or equipment change must follow MOC procedures. Electrical schematics are the basis for the control system. Changes must be noted and records updated to ensure serviceability of equipment at a later date.
- PLC programs are key to plant operation. Logic sequences have been designed specifically for safe operation. The facility has been provided with the ability to access the logic for ease of operation[11]. It is possible to disable critical safeties through the PLC software if unauthorized access were to occur. Thus, changes must be restricted and properly documented. Therefore, a policy of implementing a PLC logic password must be implemented and documented to

[11] The ability to access PLC logic would be determined or confirmed by a given facility and managed accordingly.

ensure that only changes to the PLC logic approved through the MOC process are carried out.
- Human Machine Interfaces (HMIs) provide the interaction between the operator and the equipment. Operators have been trained in the use of the HMI. Changes to the HMI must also be controlled through the MOC process.
- Mechanical or process changes that deviate from original design (addition of new equipment, or modification of existing equipment designs) will follow the MOC process.

2.4. <u>Authority for Equipment Changes</u>

Authority for equipment changes will involve the following people who are required to review and approve[12]:

- Owner/Operator Management representative
- Designated Plant Chief

2.5. <u>Awareness of Change Restrictions</u>

Awareness of change restrictions will be implemented by the owner/operator. This will involve all personnel involved in the maintenance and operation of the facility. Sample listing would be:

- Shift electricians and millwrights who have the responsibility to respond on short notice.
- Subcontractors brought in to perform equipment service and modifications.
- Equipment vendors supplying auxiliary equipment that may modify operation or consume energy from the facility.

2.6. <u>Management of Change Implementation</u>

1. Assess the change: Assessment of the change on original design intent by OEM including the effect on other equipment by OEM.
2. Design: Design of the change by OEM

[12] This may also include other personnel identified by a given plant, such as an engineering managers

3. Conduct hazard and risk assessment: A hazard and risk assessment[13]on the affected systems will be carried out with the OEM, the Plant Chief, and at least one other company representative. Only those systems/nodes affected by the change will need to be reviewed and updated. Risk assessment will also be undertaken following the methodology in the HAZOP study documents.
4. Perform installation/implementation: By associated discipline.
5. Complete commissioning: By qualified personnel.
6. Change documentation: This involves the update of drawings (as built), training manuals, standard operating procedures, preventative maintenance schedules, checklists/forms, and any other pertinent documentation.
7. Train operations personnel and acknowledge change: By each operator by signing the Management of Change matrix.
8. Inform any relevant authorities: Inform any authorities as required of any equipment, process or other changes made under the MOC process. The plant shall submit details of the change as well as confirmation of review and approval of the changes by the individuals designated under the “Authority of equipment changes” indicated above. Changes to the SMP (safety management program) document will be undertaken if required. Any SMP changes shall be submitted to the authority for review and approval.

Figure P-1 is an example flow chart for a management of change process for equipment. Equipment change implementation and training must be completed.

[13] Examples include HAZOP, bow tie analysis, what-if checklist, and (LOPA) (layers of protection analysis)

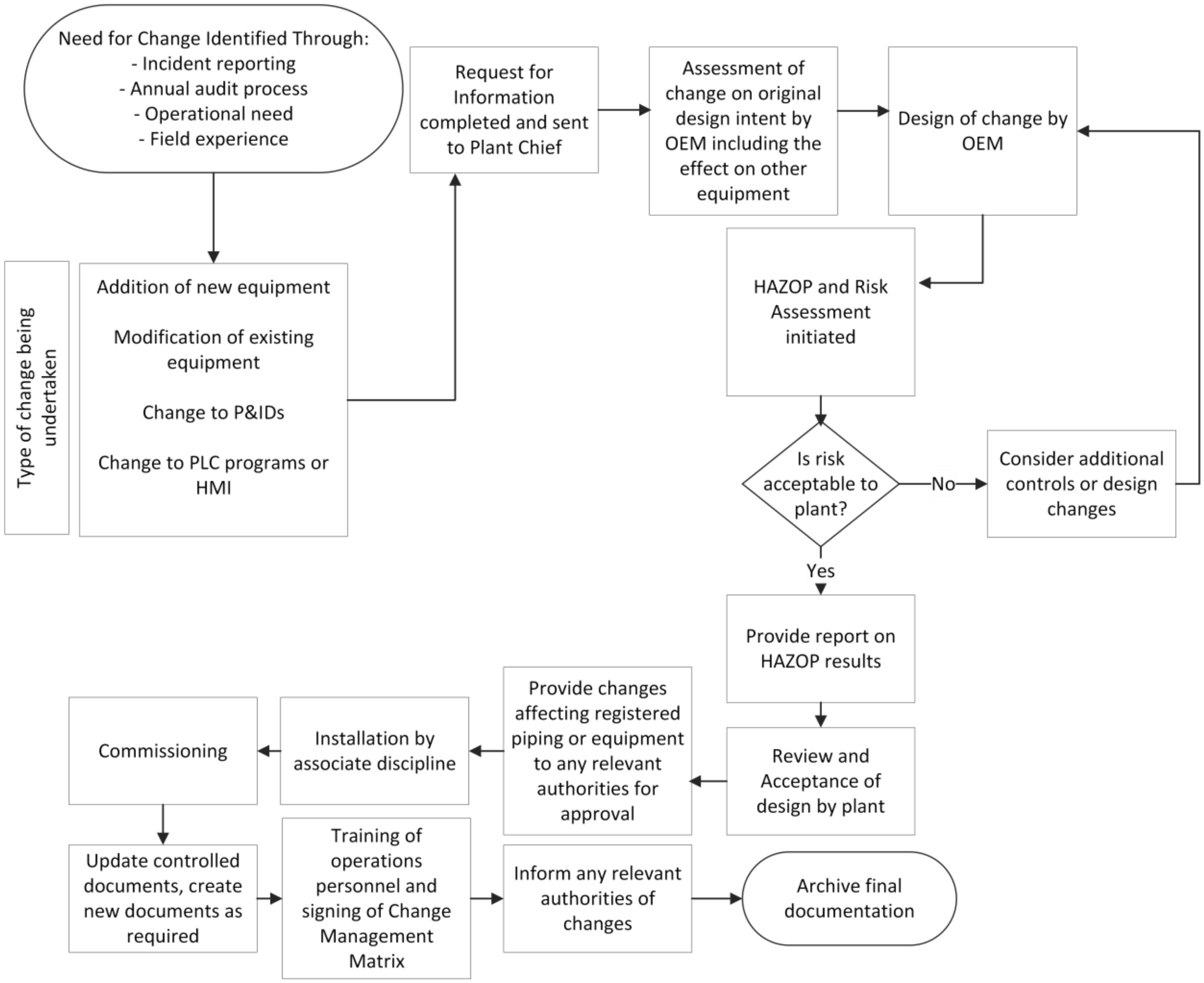

Figure P-1. Example of process flow diagram for management of change process

2.7. <u>Change in Key Personnel</u>

Change in key personnel (i.e., Plant Chief), will be the responsibility of the plant. The plant will maintain continuity of appropriately trained Plant Chief. A change in Plant Chief requires notification of any relevant authorities, after the new Plant Chief has completed all the requirements in the Competency Based Training Plan.

Continuity of facility ownership would also affect the operational plans. It is expected that under new owners the plant would be operated to the same or better standard.

2.8. <u>Close Out of Change</u>

The implementation of the change must be done in a timely fashion so that all those involved remain aware of the status. The change will not be considered complete until:

- Final documentation is archived (OEM maintains an electronic copy of all drawings, documents, and program files on a server. The customer is encouraged to maintain similar archive files).
- Changes affecting registered piping or equipment will be forwarded to authorities for approval and file update.

It will be the responsibility of the Plant Chief to ensure the MOC process has been followed and fully completed. To ensure the changes have been communicated throughout the operations team, the Assistant Plant Chief and each System Operator will add their initials to the necessary column in a Change Management matrix signaling that they have read and understood the changes.

APPENDIX Q: PRE-STARTUP SAFETY REVIEW (PSSR) EXAMPLE

This pre-startup safety review (PSSR) checklist is an example adopted from Marsh (2016). Specific facilities will need to change or add to it according to site-specific conditions, equipment, process, and terminology. Checklist questions shown here are a sample; any additional checklist questions need to be identified and added by specific sites.

Notes:

1. Complete a PSSR after completion of mechanical work and before commissioning and start-up.
2. A PSSR should be done before temporary changes, as well as after the facility is returned to its original state.
3. The PSSR is led by the area owner representative or person otherwise assigned (e.g., project leader, management of change coordinator)
4. An action needs to be initiated if an answer to any of the checklist items is "no". The action would be completed before or after startup accordingly.
5. The PSSR team is not required to review the plant design or process hazards reviews. With respect to the following checklist, the PSSR team verifies that the item was considered in the design and that any pending actions from the design and process hazards reviews were completed, and reviews the facility for visual conformity to the requirements outlined.

Subject Matter/Discipline Representative[14]	**PSSR Team Names**	**Signature**	**Date**
Operations specialist designate (PSSR team leader unless otherwise assigned)			
Project engineer			
Mechanical maintenance			
Electrical maintenance			
Instrumentation and/or DCS specialist (if appropriate)			
Process engineer			
MOC coordinator			
Operations representative			

[14] One person can fulfill multiple roles/disciplines

Initiator of the project or change			
Inspection (if appropriate)			
Construction engineer (if appropriate)			
Safety department representative (if appropriate)			
Environmental specialist (if appropriate)			
Industrial hygiene/ergonomics specialist (if appropriate)			
Others specify: ___________________________			

Item	Checklist Questions (Sample only)	Yes	No	N/A	Action required
A	**General**				
	Does equipment condition allow safe access for operation, inspection/ maintenance?				
	Are pre-commissioning punch list items completed?				
	Have adequate provisions been made for the technical or supervisory support during initial operation?				
	Have spare parts been obtained?				
	Have all unwanted scaffoldings been removed?				
	Has availability of utilities been checked for safe startup?				
	Has communication been done with other facilities/units to ensure that they are operating in a way that does not affect safe startup (e.g., supply of feedstock, flaring, utilities, emergency operations)?				
	Add or modify additional questions on a site-specific level				

Item	Checklist Questions (Sample only)	Yes	No	N/A	Action required
B	**Documentation and Training**				
	Have standard operating procedures been provided?				
	Have any special procedures been provided (examples are sampling methods, equipment lubrication)?				
	Has standard operating procedure training been carried out?				
	Have safe operating limits been determined and made available?				
	Have special procedures for commissioning or first-time startup been provided and reviewed?				
	Have changes been adequately communicated to adjacent units or other affected groups?				
	Has the plant plot plan been updated?				
	Have P&IDs, process flow diagrams (PFDs) and other applicable process safety information key documents been “red-lined-marked” for changes?				
	Have all inspection related documents/drawings, records and testing been updated (including positive materials identification)?				
	Have all the red-lined drawings being handed over in turn-over packages for all relevant disciplines?				
	Have training equipment needs been considered and purchased for this project?				
	Has vendor literature on equipment been filed properly in operation, inspection/maintenance areas?				
	Has the training been completed, documented, and input into the training records system?				
	Add or modify additional questions on a site-specific level				

Item	Checklist Questions (Sample only)	Yes	No	N/A	Action required
C	**Safety, Health and Fire Protection**				
	Has safety equipment (e.g., fire extinguishers, fire detectors, eye washes, safety showers, breathing equipment, alarm boxes) been provided and located where needed? Have they been checked and are they operational?				
	Is unobstructed access to safety and fire protection equipment provided?				
	Is deluge water system provided, if required?				
	Have areas with potential for exposure to high noise levels been identified and warning signs put in place?				
	Have emergency response plans and scenarios been updated to reflect the new facilities, and available at both the new/modified installation and at the fire and emergency response centers?				
	Is ventilation in working order and inspected?				
	Have the abandoned foundations and supports been removed to prevent trip hazards?				
	Are all openings in the platform adequately sized for pipe penetration and properly banded?				
	Add or modify additional questions on a site-specific level				

Item	Checklist Questions (Sample only)	Yes	No	N/A	Action required
D	**Waste Stream and Environment and Utility Systems**				
	Are bunding, draining, and curbing provided in accordance with design?				
	Have provisions been made for disposal of all wastes (i.e., drums, bags, filter elements, liquid residues)?				

	Will runoff rainwater be contained if it becomes chemically contaminated?				
	Have sewers been sealed correctly and vents adequately located?				
	Add or modify additional questions on a site-specific level				

Item	Checklist Questions (Sample only)	Yes	No	N/A	Action required
E	**Piping, Hoses, Valves and Vessels**				
	Have piping, valves and vessels been pressure tested?				
	Have cross-tied lines (pump headers, utility lines, etc.) been avoided where contamination, pressure, or temperature problems are likely?				
	Has a line-by-line review been conducted to ensure that the piping is installed as specified?				
	Have new fixed equipment such as pressure vessels, tanks, piping, hoses, injection points etc., been identified (tag numbered) and added to the inspection programs?				
	Is cathodic protection information available to be used for relevant preventative maintenance and testing programs?				
	Are there any pipeline dead-legs which might lead to corrosion or freezing? Have these been put on the inspection register?				
	Add or modify additional questions on a site-specific level				

Item	Checklist Questions (Sample only)	Yes	No	N/A	Action required
F	**Safety and Relief Facilities**				
	Have safety valves been inspected, tested and tagged?				
	Are block and bypass valves of safety valves car sealed?				

	Are relief devices directed away from personnel?				
	Is safety valve inlet and outlet piping supported to avoid undue stress on the safety valve?				
	Are rupture discs correctly tagged? Are they installed facing the correct direction with respect to flow?				
	Add or modify additional questions on a site-specific level				

Item	Checklist Questions (Sample only)	Yes	No	N/A	Action required
G	**Rotating and Mechanical Equipment**				
	Have special precautions for safe operation been adequately specified?				
	Is the drive unit grounded?				
	Have the lubricants and seal fluids been properly changed?				
	Add or modify additional questions on a site-specific level				

Item	Checklist Questions (Sample only)	Yes	No	N/A	Action required
H	**Electrical Systems**				
	Have start/stop switches and electrical switchgear/Motor Control Centre (MCC) been properly labeled?				
	Can electrical equipment be isolated safely for repair work?				
	Do lockout provisions exist both at the switchgear/MCC and at the start/stop switch?				
	Have conduit fittings been properly sealed?				
	Have electrical protective relays and safety devices been calibrated?				
	Has electrical equipment been designed and selected to meet hazardous area classification requirements.				

	Does the electrical construction meet the plant standards?				
	Add or modify additional questions on a site-specific level				

Item	**Checklist Questions (Sample only)**	**Yes**	**No**	**N/A**	**Action required**
I	**Control Systems**				
	Has the fail-safe function of valves been properly installed? Are mechanical stops (if provided) properly tested?				
	Are interlocks, alarms and logic provided in accordance with approved specifications?				
	Is instrument tubing adequately supported and leak tested?				
	Are bolts on explosion proof enclosures and conduits seals and covers installed?				
	Do all the control system equipment, instrumentation and analyzer construction meet the plant standards?				
	Add or modify additional questions on a site-specific level				

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