

Technical Paper: Root cause analysis of deficient lockout of machines in Ontario pulp and paper operations

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Executive Summary

In November of 2019, a volunteer group of industry subject matter experts met face-to-face to conduct a risk assessment of the Ontario pulp and paper industry, and later, a root cause analysis of its top health and safety risk.

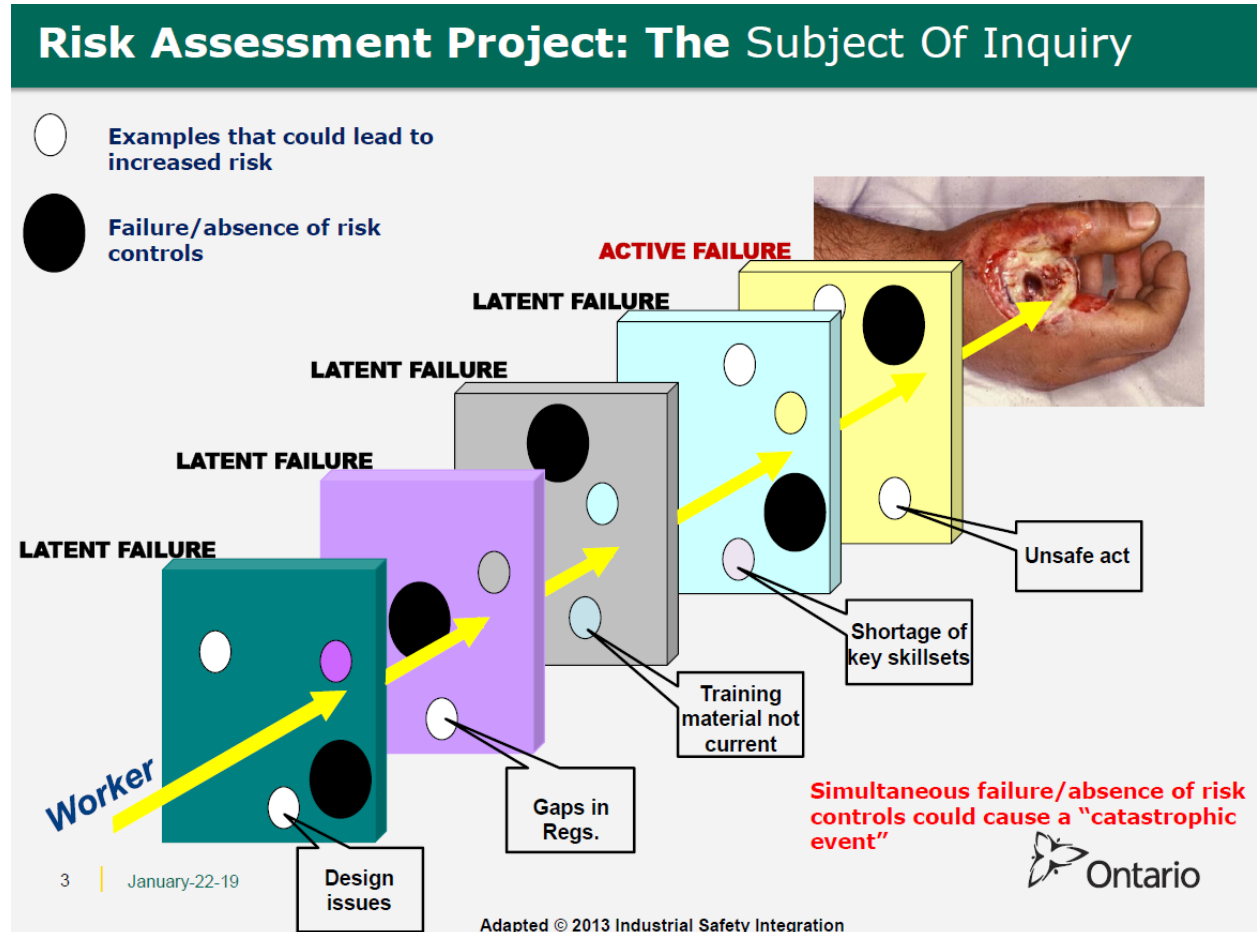
The group of 16 representatives from management, labour, government, and not-for-profit organizations, was facilitated by Sujoy Dey, Ph.D., Corporate Risk Officer at the Ministry of Labour (MOL). In advance of the workshop, each industry expert submitted their top health and safety concerns, and during risk assessment workshop, more than 79 identified risks were reviewed and discussed by the group. Both management and labour agreed the top risk was lockout

The experts' root cause analysis workshop, facilitated by Jerry Traer, CRSP, CHSC, Program Training Specialist, and Doug Brown, CRSP, CHSC, Health and Safety Specialist at Workplace Safety North, determined the top 10 causal factors for lockout in the workplace, as well as specific controls for each.

Next steps include an immediate focus on the most common systemic weaknesses regarding lockout procedures and workplace health and safety:

- A. **Effective lockout training** - Trainer competency, evaluation, site-specific and real-life scenario training, knowledge transfer
- B. **Workplace health promotion** - Address fatigue, mental health first aid, substance use
- C. **Corporate lockout policy** - Current and accurate procedures, enforcement, communication, annual review, roles/responsibilities, lockout methods (site-specific)
- D. **Development of engineered solutions** - Energy controls, artificial intelligence solutions

1. Risk Assessment Project: The Subject of Inquiry



Pictured above: The “swiss cheese” model of simultaneous failure, or absence of risk controls, that could cause a “catastrophic event.” In this model, when there are latent failures in design, gaps in regulation, outdated training material, shortage of skillsets, and an unsafe act, all the “holes” in the system line-up to potentially cause a critical injury or fatality.

2. Background: Revisiting the 2019 Risk Assessment Workshop Results

In November 2019, a volunteer group of subject matter experts met face-to-face for a pulp and paper workplace risk assessment at Workplace Safety North (WSN) headquarters in North Bay, Ontario. The group of 16 representatives from management, labour, government, and not-for-profit organizations, was facilitated by Sujoy Dey, Ph.D., Corporate Risk Officer at the Ministry of Labour, Training and Skills Development (MLTSD).

In advance of the workshop, each person submitted top health and safety concerns, so during the one-day workshop, all 79 identified risks were reviewed and discussed by the group.

When it came time for the final vote on the top risks, only the four workers and four managers from the pulp and paper industry were allowed to vote. In order to ensure an open and fair voting process, handheld electronic devices recorded votes anonymously. Both labour and management agreed: the top danger pulp and paper workers face is inadequate or improper lockout of machines.

“As they identified specific conditions and situations that could result in injury or illness, we asked the group, ‘What keeps you up at night?’” says Dr. Dey, “And both workers and managers agreed: the top three risks were lockout, occupational illnesses and guarding.”

Top 10 health and safety risks in Ontario pulp and paper operations

1. Inadequate or improper lockout of machines
2. Exposure to dust, especially paper dust
3. Exposure to chemical agents (e.g. toxic chemicals, H₂S gas, allergenic substances)
4. Exposure to unguarded moving and/or exposed parts on equipment during maintenance
5. Falls from heights
6. Structural integrity of building, ceiling falling
7. Rushing to get the work done (taking shortcuts)
8. Leaks in process lines, caustic explosions, etc.
9. Caught in or crushed by equipment during operation
10. Workplace conditions in older buildings

“Inadequate or improper lockout can have serious unintended adverse effects on the safety and well-being of workers,” says Tom Welton, WSN General Prevention Services Director, “and in the case of pulp and paper operations, inadequate or improper lockout has a high potential of serious – if not fatal – injury to workers.

“The risk assessment workshop provided direct feedback from industry experts about their perception of the workplace, and by using these leading indicators, WSN can be more proactive in providing health and safety services to industry.” says Welton.

The results of the workshop were reviewed by the WSN advisory committee for Forestry, Paper, Printing, and Converting industries, which moved toward the next step: a detailed analysis of the root causes of inadequate or improper lockout and the creation of an effective prevention plan.

What is inadequate or improper lockout?

“Lockout or tagout” refers to specific practices and procedures to protect employees from unexpected energization or startup of machinery and equipment, or the release of hazardous energy during maintenance activities.

Proper lockout procedures require that a designated person turns off and disconnects the machinery or equipment from its energy sources before performing service or maintenance, and the authorized employee either lock or tag the energy-isolating devices to prevent the release of hazardous energy and takes steps to verify the energy has been effectively isolated.

If there is any potential for the release or accumulation of hazardous stored energy, the employer is required to ensure employees take steps to prevent any injury from the release of the stored energy.

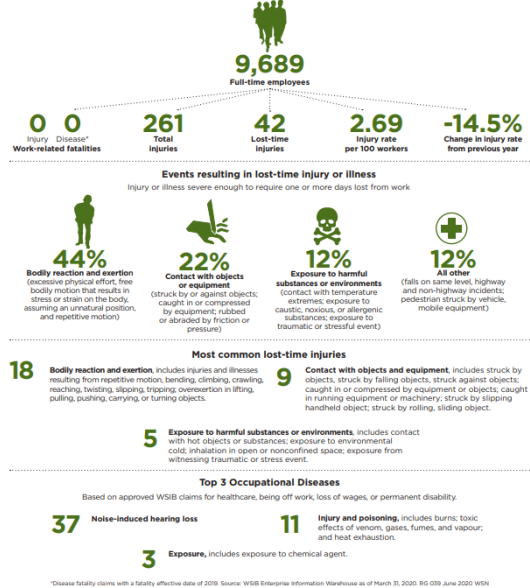
Lockout devices hold energy-isolation devices in a safe or “off” position. They provide protection by preventing machines or equipment from being turned “on” or becoming energized because they are positive restraints that no one can remove unless they have a key or other unlocking mechanism, (or through extraordinary means, such as bolt cutters).

Tagout devices, by contrast, are prominent warning devices that an authorized employee fastens to energy-isolating devices to warn employees not to reenergize the machine while they service or maintain it. Tagout devices are easier to remove and, by themselves, provide employees with less protection than lockout devices.

Inadequate or improper lockout signifies that the worker is not as protected as they think. This may be deliberate, as a worker believes they can correct the problem without proper lockout, or not, as the worker does not know their attempt to lockout the equipment was inadequate or improper.

Over the years, government- and industry-driven lockout initiatives have yielded positive outcomes, with a general decline in worker injuries and fatalities. While the trend is encouraging, incidents continue to occur, and due to machinery, the injuries are severe or fatal.

**Workplace Health and Safety Snapshot
for Ontario Pulp, Newsprint, and Specialty Papers Sector in 2019**



According to Workplace Safety and Insurance Board data, injuries involving guarding and lockout rank among the top four causes of injuries. Each statistic reflects a life changed by a preventable workplace injury – often severe and permanent. The injury could cause long-term effects on quality of life as well as a great deal of emotional distress for the worker and their family and friends.

From 2015 to 2019, 19 to 38 per cent of all injuries in the Ontario pulp and paper sector related to contact with objects or equipment, including being caught in or compressed by equipment. And according to the [2019 health and safety snapshot](#) for the sector, 22 per cent of all lost-time injuries were related to contacts with objects or equipment.

3. Root Cause Analysis: Risk Statement

Based on the results of the Ontario pulp and paper industry risk assessment, the following risk statement was selected by the Workplace Safety North Advisory Committee (Forestry, Paper, Printing, and Converting) for Root-Cause Analysis using the “Fishbone” approach:

Risk statement:

“Inadequate or improper lockout of machines, resulting in unintended or adverse effects on workers.”

4. Root Cause Analysis Workshop: A Bipartite and Collective Process

- Workshop participants were peer-recognized industry and system experts.
- Workshop process was open, transparent, and collaborative.
- All participants met virtually as Covid-19 prevented the face-to-face meetings.
- Ranking and prioritization of causal factors for inadequate or improper lockout were voted on by industry management and labour only; MOL and WSN did not vote.

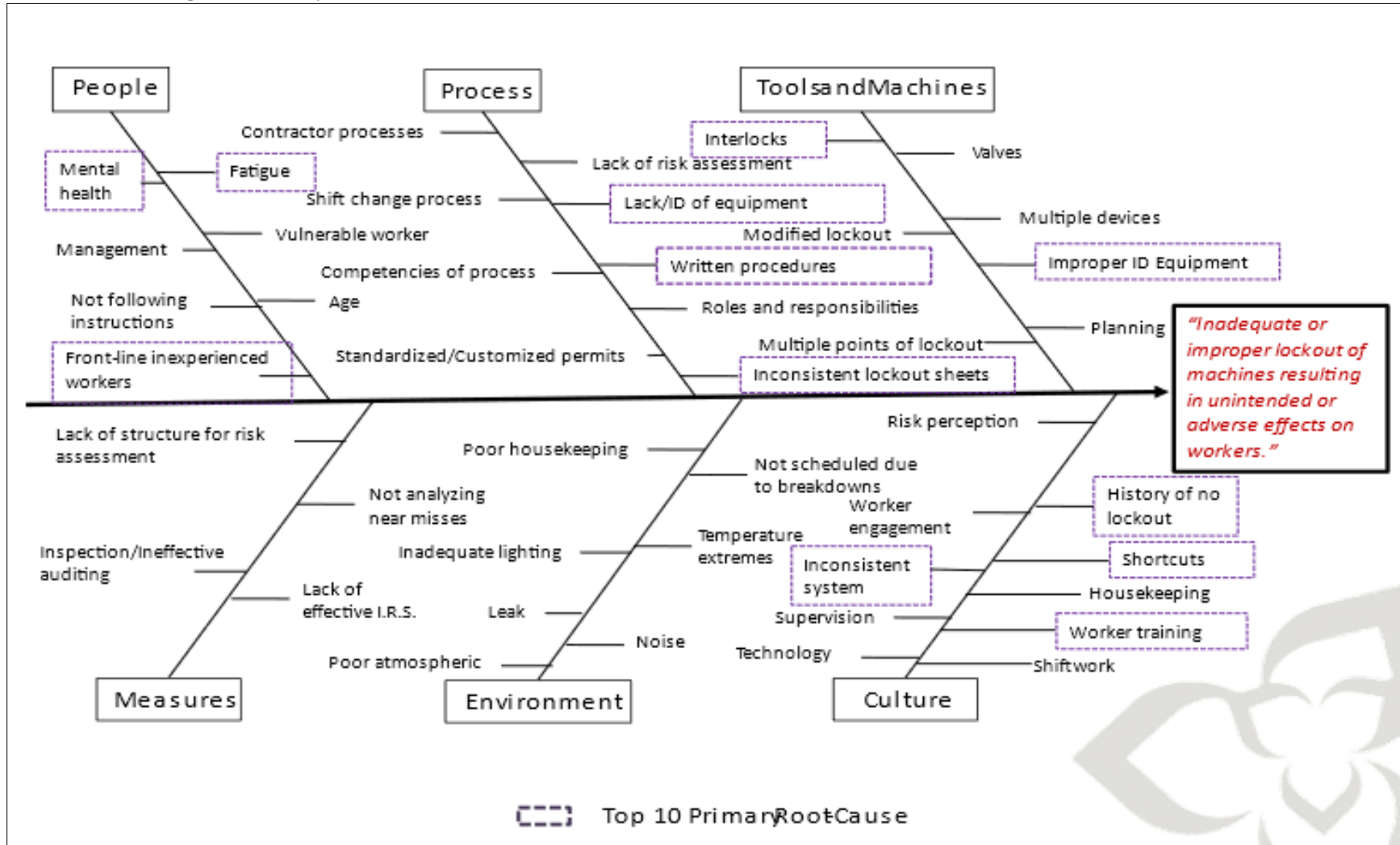
Validation of the results, in addition to workshop subject matter expert participants, included having the results presented and discussed among pulp and paper industry constituents, at health and safety meetings and WSN advisory board meetings for the Ontario forestry, paper, pulp and converting sector.

5. Workshop Participants: Industry, Engineering, System Partners

Participants from the following organizations attended:

- Domtar
- Resolute Forest Products
- Rayonier Forest Products
- Atlantic Packaging
- Safe Engineering
- Ministry of Labour, Training and Skills Development
- Workplace Safety North

6. "Fishbone" Diagram: Primary Causal Factors



CLOSE-UP of fishbone diagram: Primary causal factors of inadequate or improper lockout of machines
 Tools and methods, culture, processes, environment, people, measures

41 Causal Factors

Priority Rank	Category	Primary Causal Factors
1	Culture/People	Worker training/Inexperienced frontline workers
2	Tools/Machines/Process	Improper lockout/Lack of identification of equipment
3	Process	Written procedure
4	Process	Inaccurate lockout sheets
5	Culture	Inconsistent lockout/Taking shortcuts
6	People	Fatigue
7	People	Mental health
8	People	Vulnerable workers
9.	Culture	History of no lockout
10.	Tools/Machines	Interlocks
11.	Measures	Near misses
12	Process	Competencies of processes
13.	Environment	Leaks
14.	Tools/Machines	Multiple devices
15.	Tools/Machines	Modified lockout
16.	Culture	Supervision
17.	Process	Standard/customized permits
18.	Tools/Machines	Multiple points of lockout
19.	Culture	Worker engagement
20.	Measures	Lack of measuring lockout-based statistics
21.	Culture	Risk perception
22.	Tools/Machines	Valves
23.	Culture	Housekeeping
24.	People	Age
25.	Measures	Inspections/ineffective auditing
26.	Environment	Inadequate lighting
27.	Measures	Lack of structure for risk assessment
28.	People	Management
29.	Measures	Lack of effective internal responsibility system
30.	Tools/Machines	Planning
31.	Environment	Poor housekeeping
32.	Environment	Not scheduled due to breakdowns
33.	Process	Shift change process
34.	Process	Roles and responsibilities
35.	Process	Lack of risk assessment
36.	Culture	Shiftwork
37.	Environment	Poor atmospheric
38.	Culture	Technology
39.	Environment	Temperature extremes
40.	Process	Contractor processes
41.	Environment	Noise

7. Top 10 Primary Causal Factors

1. **Lack of worker training and experience**
2. **Improper lockout, lack of identification of equipment** – working on wrong or live equipment
3. **Lack of written procedure**
4. **Inaccurate lockout sheets** outlining roles and responsibilities
5. **Inconsistent lockout/taking shortcuts**
6. **Fatigue** – shiftwork, long hours, workload, lack of staff
7. **Mental health** – stress, anxiety, fatigue, substance use
8. **Vulnerable workers** – young workers, new Canadians
9. **History of no lockout** – poor safety culture
10. **Interlocks** – wrong sequence, live equipment

Next, the industry group of subject matter experts got down to work to develop controls that could be put in place for the main causal factors and address the risk of inadequate or improper lockout in the workplace.

8. Critical Controls to address primary causal factors of inadequate or improper lockout of machines

*Causal factors have been merged because of similarities; controls have been merged as well.

Note: Control lists are not in any order of priority

1. Lack of worker training (Culture) and experience (People)*

- Competent trainer
- Proper evaluation that training is understood
- Effective training program – blended training with classroom and field work
- Ensure adequate timelines are developed to minimize rushed training
- Annual review
- Observation by lead hand – a ‘show-me’ audit – have several different scenarios on what/how to lockout
- Set of standardized corporate guidelines for lockout training
- Formal evaluation of new workers before they are put in positions
- Training tailored to the type of equipment in the specific plant – based on examples from that plant – Site-specific training program – energy types, steam, etc.
- Department orientation on lockout process
- Explore engineered solutions and artificial intelligence (AI solutions)
- Develop a retention program for employees
- Better knowledge transfer from experienced employees for new hires – mentorship, shadowing, induction
- Legislative module training for the pulp and paper sector
- Having a dedicated trainer for new hires

2. Improper Lockout (Tools/Machines), Lack of Identification of Equipment (Process)*

- Proper identification of equipment
- Yearly audits per facility of the durable tags to make sure there are tags and that they are legible.
- Maintenance machine files need to be kept up to date
- Lockout procedures need to be properly written for each piece of equipment
- Logbook that has a map of all the different equipment in the facility for direction and inventory purposes.
- Standardization of the tagging system so all the tags have the same shape and colour to identify easier.
- Contents of the piping identified by a colour code– line labelling
- Adequate resources i.e., Competent Lockout Coordinators or role of supervisor or front-line worker job descriptions
- Explore engineered solutions and artificial intelligence (AI solutions)

3. Lack of Written Procedure (Process)

- Develop corporate lockout policy
- Annual review of your corporate lockout policy
- Develop site-specific work instructions outlining roles and responsibilities and methods of lockout
- Validating of temporary procedures by competent workers - minimum of two

- Review process of procedures when there is a process change or incident

- Explore engineered solutions and artificial intelligence (AI solutions)

4. Inaccurate Lockout Sheets (Process)

- Validation is required by competent person(s) in the field
- Explore engineered solutions and artificial intelligence (AI solutions)

- Develop job-specific lockout sheets (outlining roles and responsibilities and methods of lockout)

5. Inconsistent Lockout (Culture), Taking Shortcuts (Culture)*

- Consistently enforcing the lockout policy by all levels
- Consistent communication from upper management that safety always goes before production
- Awareness workshop for upper management for when they are on the floor, to how to verbally communicate that it is for support only.

- Set of standardized corporate guidelines for lockout training
- Training tailored to the type of equipment in the specific plant – based on examples from that plant – Site specific training program – energy types, steam, etc.
- Department orientation on lockout process
- Sustaining consistent lockout through supervisor intervention

6. Fatigue (People)

- Ensure proper scheduling and manpower to minimize doing lockouts on overtime shifts
- Hire more people
- Education and training on recognizing the symptoms of fatigue – bring in more manpower if necessary

- Education and training for competent supervisors to recognize the symptoms of fatigue
- Taking regular breaks to cool down, regroup

7. Mental Health (People)

- Develop a policy for substance use
- Computer based training for all employees for mental health training
- Specific training for supervisors on recognizing and dealing with impairment
- Basic awareness training to all in the workplace (including how to recognize impairment)
- Inventory of safety-sensitive job tasks
- Establish an employee assistance program

- Training for management and supervisor to communicate effectively (leadership program)
- Mental Health First Aid training for everyone, specifically supervisors as well as union executives, JHSC, and shop stewards.
- Education and training on recognizing the symptoms of fatigue
- Establish an employee wellness program – encouraging fitness, healthy diet, lifestyle balance, self-awareness training

8. Vulnerable Workers – Young Workers, New Canadians (People)

- Incorporate skills-based training and government assistance through module training for vulnerable workers
- Educational awareness training on work culture differences
- Communicating that it is okay to speak up if you have concerns. (all workers to speak up when they see situations that may impact vulnerable workers)
- Create engagement sessions where open discussion occurs
- Tolerance training for all, including management
- Identify in your workplace what type of vulnerable workers you have – mentorship programs

9. History of No Lockout (Culture)

- Consistently enforcing the lockout policy
- Ensuring the lockouts are in place for the ones that did not have any
- Refresher training/review on lockout procedures and incidents
- Better communication and sharing of information in the sector
- Complete an analysis of why people do not lockout and create an engineering control to solve the issue
- Engineering controls to control the hazard energy within the CSA standards.

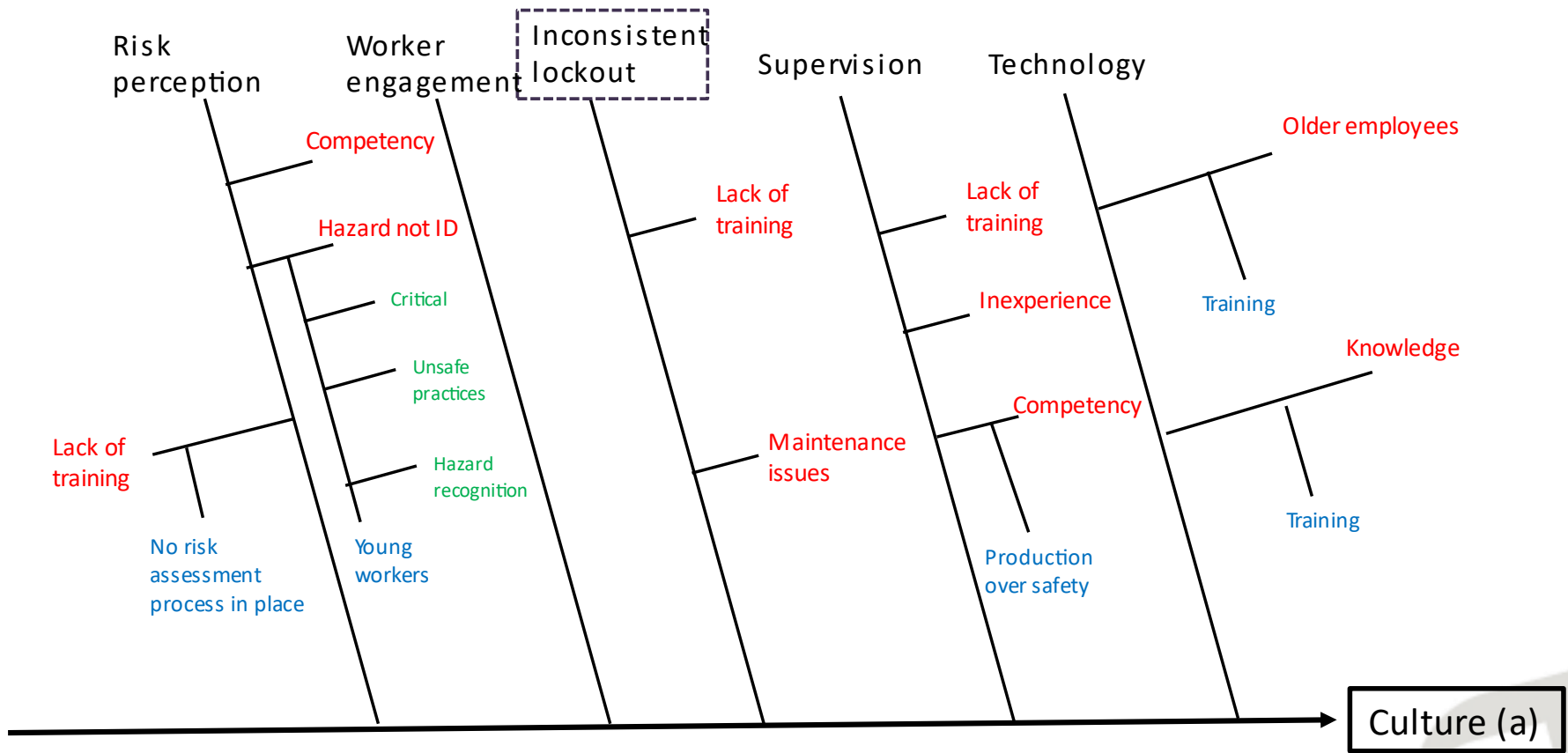
10. Interlocks (Tools/Machines)

- Safety interlocking systems need to be designed or reviewed by a professional engineer.
- Conduct a risk assessment and health and safety review to list the tasks that the interlock is designed to protect
- Education training for the operator, supervisor, and maintenance personnel on the differences between the functions of interlocks, lockout, and emergency stop, and for specific equipment which have interlocks.

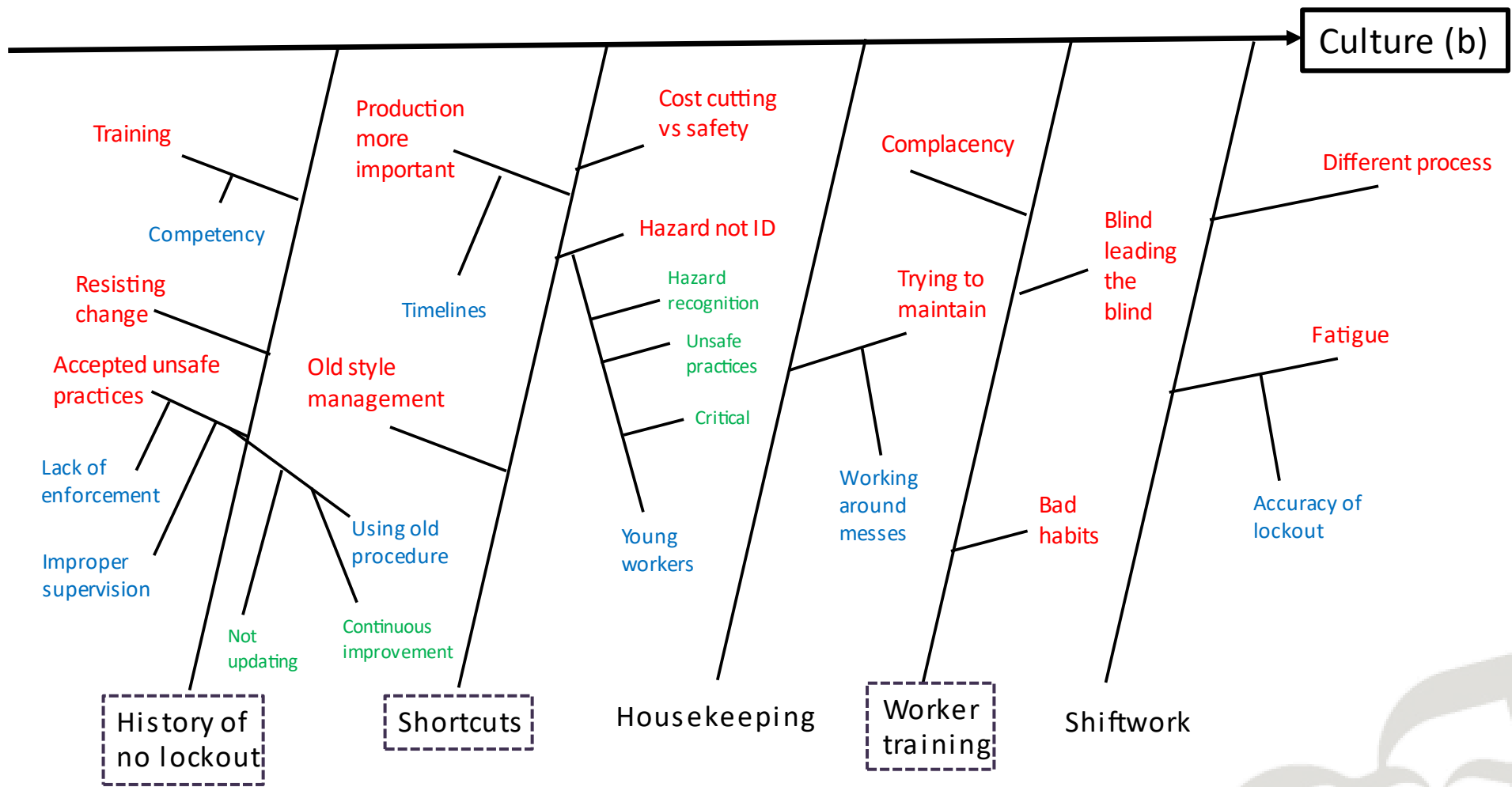
9. Next Steps: What to focus on immediately

Based on a scan of controls identified for the top 10 primary causal factors, it is beneficial, as a start, to focus right away on the following mitigation actions to address current systemic weaknesses.

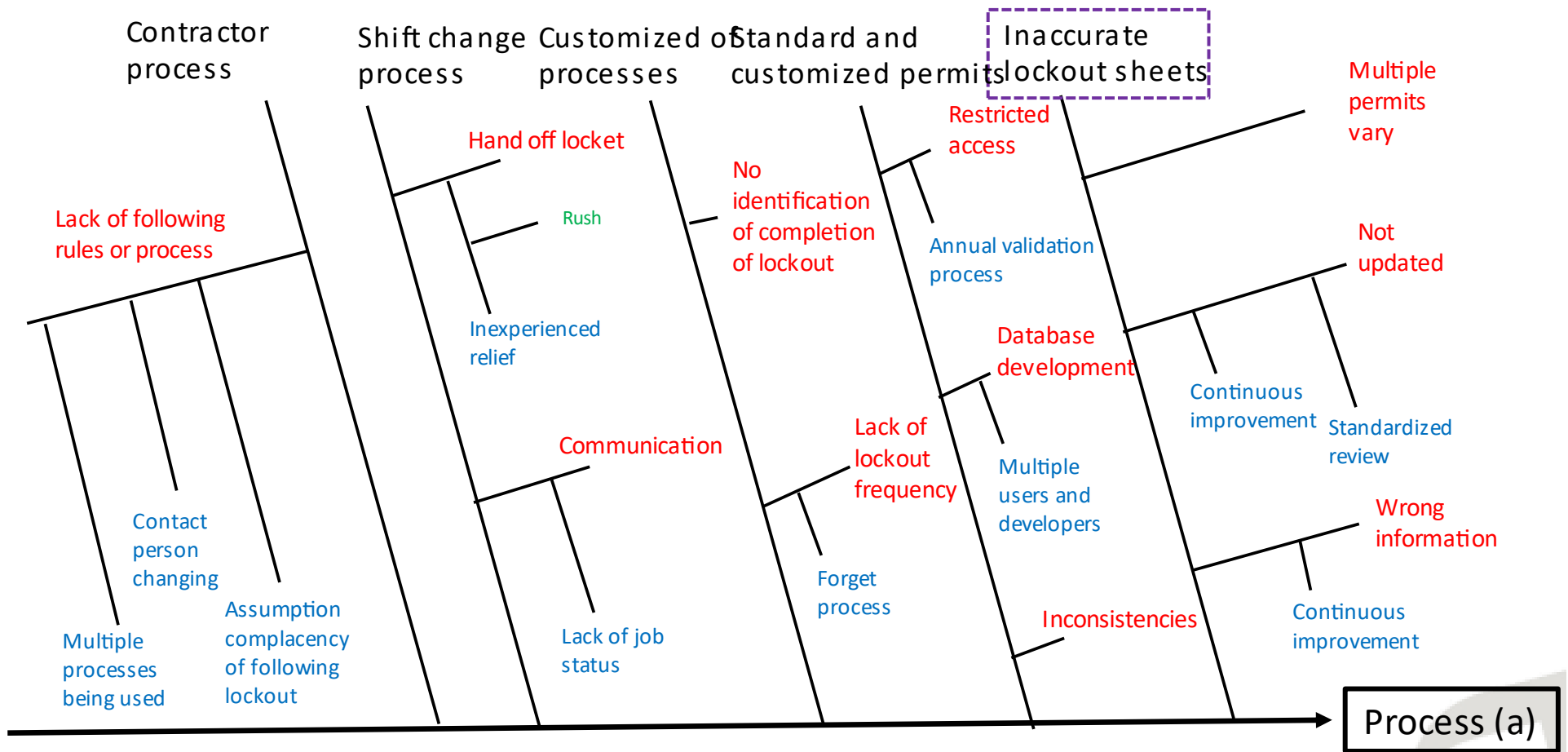
- E. **Effective lockout training** - Trainer competency, evaluation, site-specific & real-life scenario training, knowledge transfer
- F. **Workplace health promotion** - Fatigue, mental health first-aid, substance use
- G. **Corporate lockout policy** - Enforcement, communication, annual review, roles/responsibilities, lockout methods (site-specific)
- H. **Development of engineered solutions** - Energy controls, artificial intelligence solutions



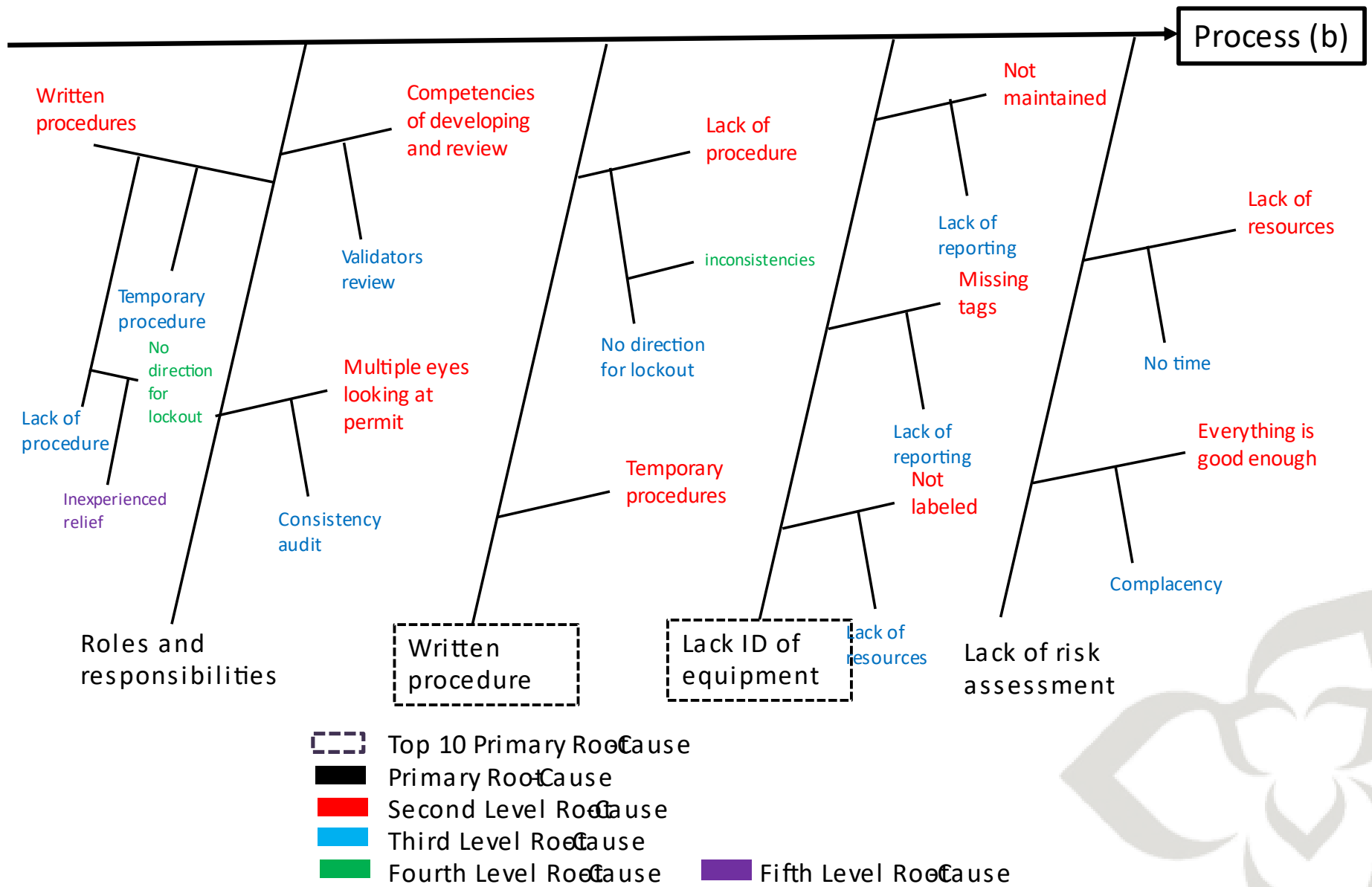
- Top 10 Primary Root Cause
- Primary Root Cause
- Second Level Root Cause
- Third Level Root Cause
- Fourth Level Root Cause

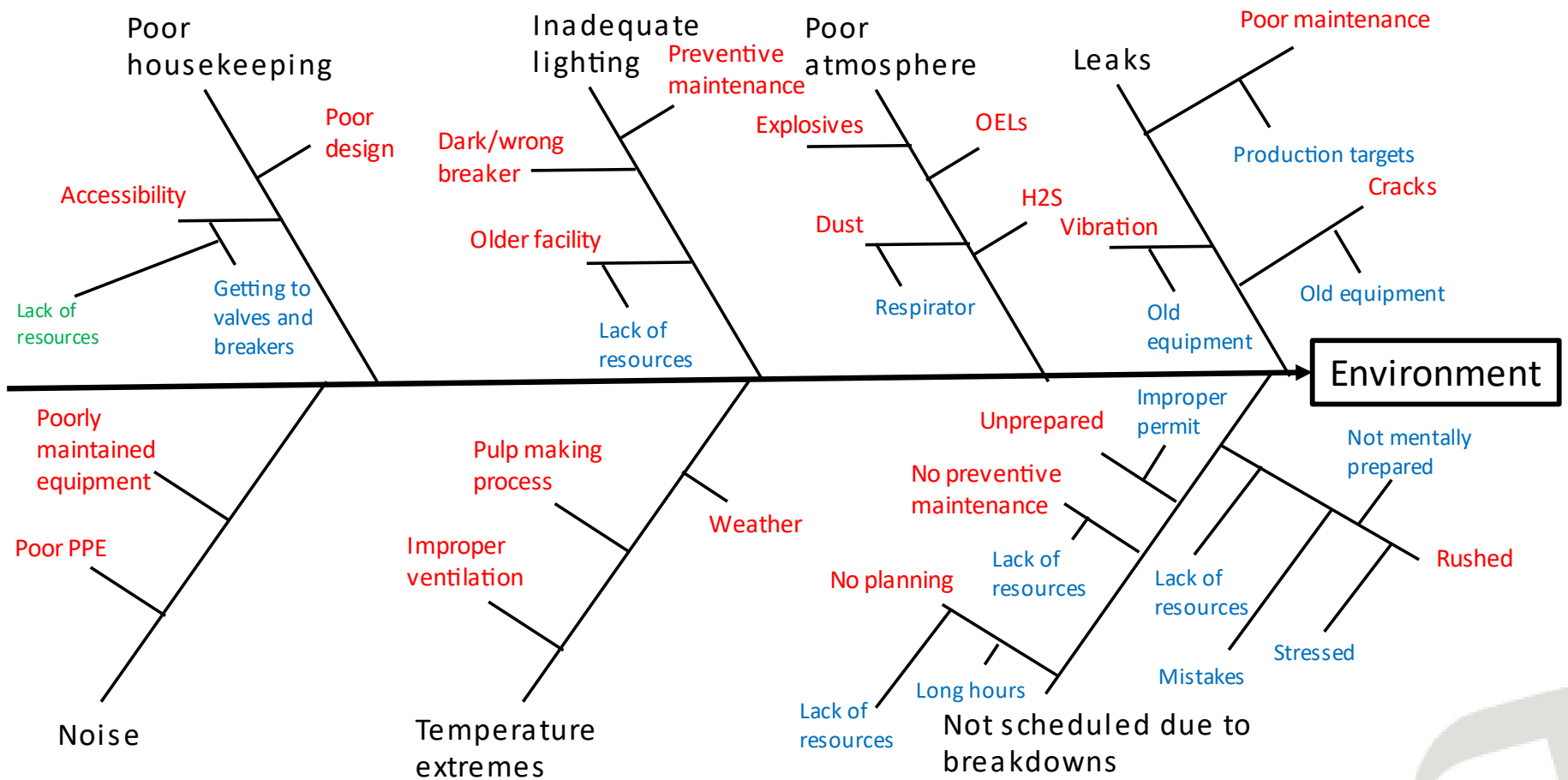


- Top 10 Primary Root Cause
- Primary Root Cause
- Second Level Root Cause
- Third Level Root Cause
- Fourth Level Root Cause

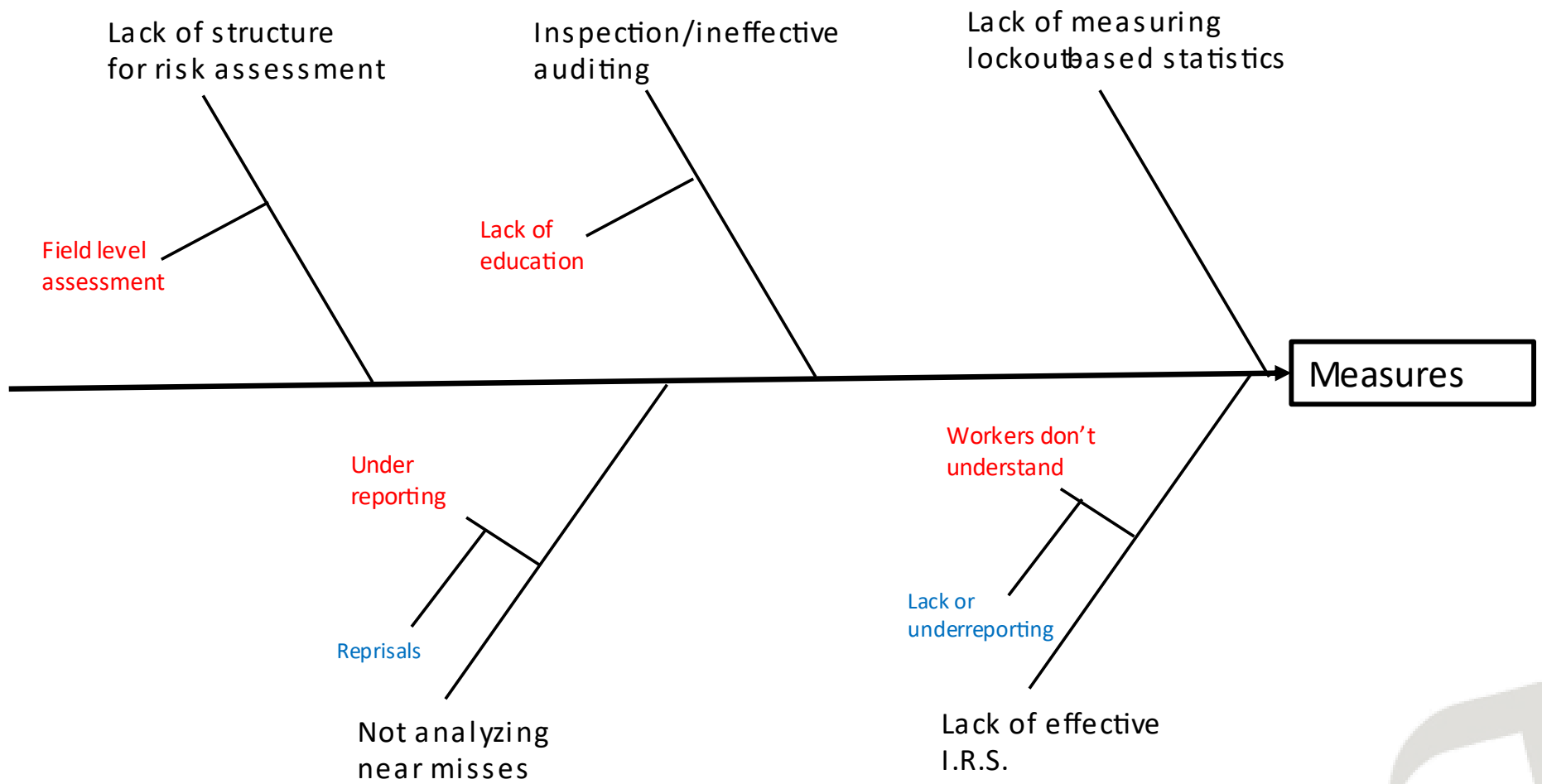


- Top 10 Primary Root Cause
- Primary Root Cause
- Second Level Root Cause
- Third Level Root Cause
- Fourth Level Root Cause

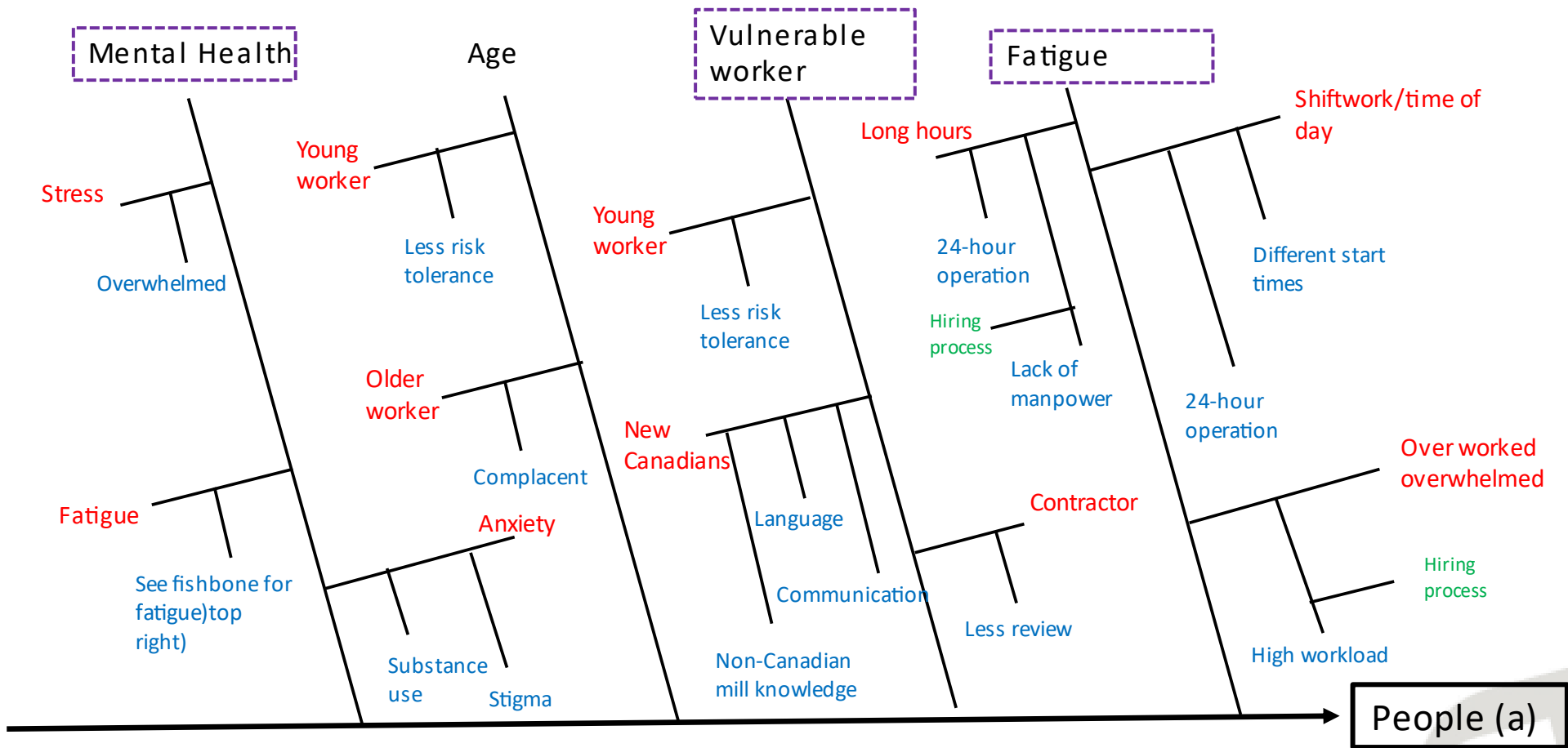




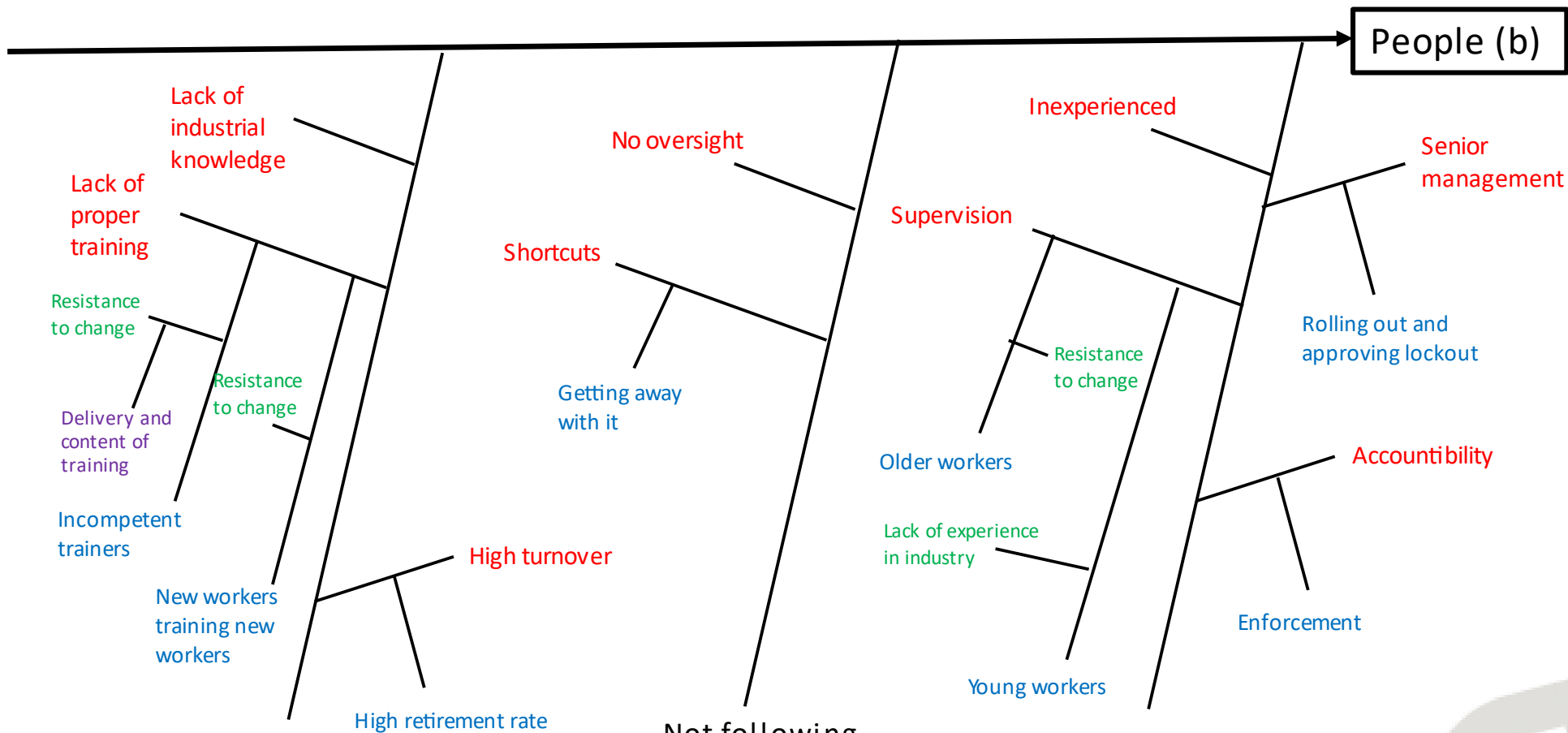
- Top 10 Primary Root Cause
- Primary Root Cause
- Second Level Root Cause
- Third Level Root Cause
- Fourth Level Root Cause



- Top 10 Primary Root Cause
- Primary Root Cause
- Second Level Root Cause
- Third Level Root Cause
- Fourth Level Root Cause



- Top 10 Primary Root Cause
- Primary Root Cause
- Second Level Root Cause
- Third Level Root Cause
- Fourth Level Root Cause



Frontline inexperienced workers

- Top 10 Primary Root Cause
- Primary Root Cause
- Second Level Root Cause
- Third Level Root Cause
- Fourth Level Root Cause
- Fifth Level Root Cause

Not following instructions

Management

Supervision

11. Appendix A: Risk Assessment Methods/Standards

1. Bayesian Analysis
2. Bow-tie analysis
3. Brainstorming (e.g. what-if)
4. Business impact analysis
5. Cause and effect analysis
6. Checklists
7. Computer Hazard and Operability Studies (HAZOP)
8. Consequence Analysis (or Cause-Consequence Analysis)
9. Likelihood/Consequence matrix
10. Construction Hazard Assessment and Implication Review (CHAIR)
11. Decision tree
12. Delphi technique
13. Energy Barrier Analysis (or Energy Trace Barrier Analysis)
14. Environmental risk assessment
15. Event tree analysis
16. Failure Mode and Effect Analysis (FMEA)
17. Failure mode, effect and criticality analysis
18. Fault Tree Analysis
19. Fishbone (Ishikawa) Analysis

20. Hazard analysis and critical control points
21. Hazard and Operability studies (HAZOP)
22. Human Error Analysis (HEA)
23. Human reliability analysis
24. Job Safety Analysis (JSA)
25. Level of Protection Analysis (LOPA)
26. Markov analysis
27. Monte Carlo Analysis
28. Preliminary Hazard Analysis (PHA)
29. Reliability centered maintenance
30. Scenario analysis
31. Sneak circuit analysis
32. Structured/semi-structured interviews
33. SWIFT (i.e. structured what-if)
34. Systemic Cause Analysis Technique (SCAT)
35. Workplace Risk Assessment and Control (WRAC)

Risk Management Standards:

1. Risk Management Principles and Guidelines (ISO 31000:2018)
2. Risk Assessment Techniques (ISO/IEC 31010:2009)
3. OH&S Hazard Identification and Elimination and Risk Assessment and Control (CSA Z1002)
4. Process Safety Management (CSA Z767-17)
5. Enterprise Risk Management (COSO 2004)
6. Global Minerals Industry Risk Management (GMIRM)
7. International Council on Mining & Metals (ICMM)

12. Appendix B: Workshop Contacts

For additional information or questions, please contact:

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13. Appendix C: Poster: Top 10 causes of deficient lockout of machines in Ontario pulp and paper operations

Top 10 root causes of deficient lockout in Ontario pulp and paper operations

Inadequate or improper lockout of machines is top health and safety risk

As identified by workers, supervisors, and employers in the Ontario pulp, newsprint, and specialty paper sector through a Ministry of Labour, Training and Skills Development (MLTSD)-facilitated risk assessment and root-cause analysis workshops in partnership with Workplace Safety North.

<div style="text-align: center; margin-bottom: 10px;">  </div> <p>1. Lack of worker training and experience</p>	<div style="text-align: center; margin-bottom: 10px;">  </div> <p>6. Fatigue - shiftwork, lack of staff, workload, long hours</p>
<div style="text-align: center; margin-bottom: 10px;">  </div> <p>2. Improper lockout, lack of identification of equipment - working on wrong or live equipment</p>	<div style="text-align: center; margin-bottom: 10px;">  </div> <p>7. Mental health - stress, fatigue, substance use, anxiety</p>
<div style="text-align: center; margin-bottom: 10px;">  </div> <p>3. Lack of written procedure</p>	<div style="text-align: center; margin-bottom: 10px;">  </div> <p>8. Vulnerable workers - new Canadians, young workers</p>
<div style="text-align: center; margin-bottom: 10px;">  </div> <p>4. Inaccurate lockout sheets outlining roles and responsibilities</p>	<div style="text-align: center; margin-bottom: 10px;">  </div> <p>9. History of no lockout - poor safety culture</p>
<div style="text-align: center; margin-bottom: 10px;">  </div> <p>5. Inconsistent lockout, taking shortcuts</p>	<div style="text-align: center; margin-bottom: 10px;">  </div> <p>10. Interlocks - wrong sequence, live equipment</p>

The internal responsibility system (IRS) is a system where everyone shares responsibility for occupational health and safety that is appropriate to their role and function within the workplace. All workplace parties — including employers, managers, supervisors, and workers — need to do their part to raise awareness of risks, and follow and promote safety procedures to help make workplaces safer.

For a detailed list of critical controls you can put in place, read the technical paper: Root cause analysis report of deficient lockout of machines in Ontario pulp and paper operations.

For more information, please contact your WSN Health and Safety Specialist or visit workplacesafetynorth.ca



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14. Appendix D: Poster: Top 10 causes of deficient machine lockout in Ontario pulp and paper operations



TOP 10 HEALTH AND SAFETY RISKS IN PULP, NEWSPRINT, AND SPECIALTY PAPER SECTOR

As identified by workers, supervisors, and employers in the Ontario pulp and paper industry through a risk assessment workshop facilitated by the Ministry of Labour, Training and Skills Development in partnership with Workplace Safety North.

<p> 1. Inadequate or improper lock out of machines.</p> <p> 2. Exposure to dust, especially paper dust.</p> <p> 3. Exposure to chemical agents (e.g. toxic chemicals, H2S gas, allergenic substances).</p> <p> 4. Exposure to unguarded moving and exposed parts on equipment during maintenance.</p> <p> 5. Falls from heights.</p>	<p> 6. Structural integrity of building.</p> <p> 7. Rushing to get the work done (taking shortcuts).</p> <p> 8. Leaks in process lines, caustic explosions, etc.</p> <p> 9. Caught in or crushed by equipment during operation.</p> <p> 10. Workplace conditions in older buildings.</p>
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