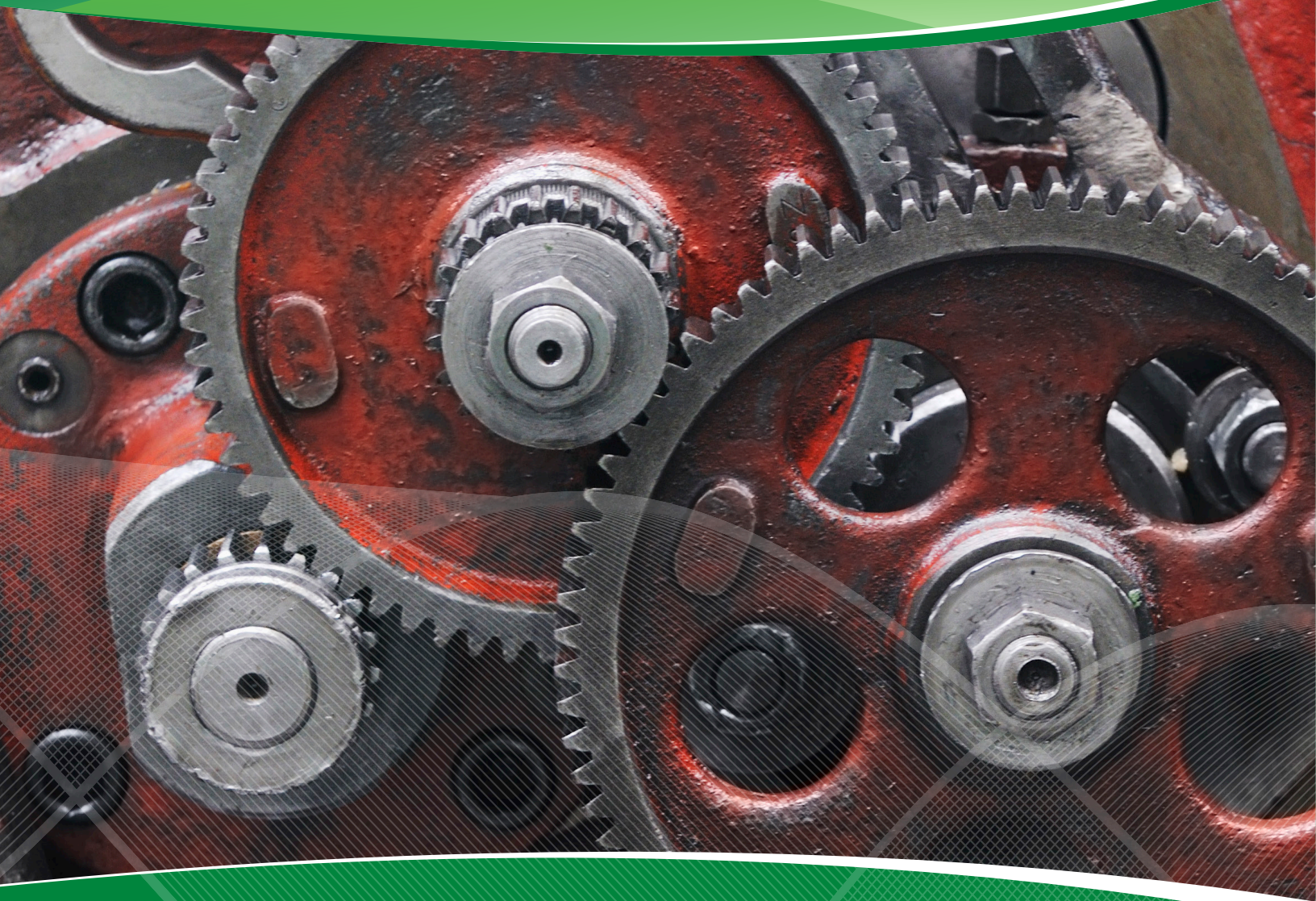
manufacturing
Safety Alliance of BC

Machine Safeguarding 1



PROGRAM MODEL

manufacturing
Safety Alliance of BC

Prepared for
The Manufacturing Safety Alliance of BC

Prepared by
UBSafe

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This publication is intended solely for internal use as an awareness and information guide. It is not intended as a statement of the standards required in any particular situation, nor is it intended that this publication should in any way advise anyone regarding legal authority to perform any activities or procedures.

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Introduction

1.1 Definition

Safeguarding refers to a variety of controls that are applied (generally) to machinery and equipment in an industrial manufacturing environment.

The OHS regulation in British Columbia defines a safeguard as follows:

"Safeguard" means the use of a guard, a safety device, a shield, an awareness barrier, warning signs, or other appropriate means, either singly or in combination, to provide effective protection to workers from hazards; [OHS Regulation 12.1 Definitions].

The purpose of a safeguard is to reliably protect a worker from danger. Where safeguarding is applied, risk reduction is achieved in part by the reliability of the devices used in conjunction with the performance level of the circuit they are integrated to.

1.2 Objectives of this model

This program model is intended to aid employers in understanding management and administration in the overall safeguarding process including legislative requirements here in British Columbia such as:

1. **Regulation**

- OHS Regulation in British Columbia
- Maintenance Lockout VS Production Safeguarding
- Safeguarding requirement in OSSE certification

2. **Safeguarding Controls**

- Risk Assessment
- The Hierarchy of Safeguarding Controls
- Training
- Maintenance and Monitoring
- Project Prioritization

Regulation

2.1 OHS Regulation in British Columbia

Excerpts from the OHS regulation in British Columbia require that employers provide safeguarding of their equipment as follows;

12.2 Safeguarding requirement

Unless elsewhere provided for in this Occupational Health and Safety Regulation, the employer must ensure that machinery and equipment is fitted with adequate safeguards which:

(a) Protect a worker from contact with hazardous power transmission parts,
(b) Ensure that a worker cannot access a hazardous point of operation, and
(c) Safely contain any material ejected by the work process, which could be hazardous to a worker.

It is important to note that the safeguarding requirement is independent of age of manufacture of the machine or date of installation.

12.3 Standards

The application, design, construction and use of safeguards, including an opening in a guard and the reach distance to a hazardous part, must meet the requirements of CSA Standard Z432-94, Safeguarding of Machinery.

The legislated revision of the standard is the 1994 version. Legally speaking, the 1994 revision is the enforceable standard. Practically speaking, you should ensure that this standard is followed with respect to mechanical guarding heights and distance requirements.

There are further safeguarding requirements within the regulation. In some cases standards for specific types of machinery are legislated (i.e. ANSI/ASME B20.1-1993 is the legislated conveyor standard). The CSA Z432 general equipment standard is still applicable, however safeguarding techniques are prescriptively given in other standards and areas of the regulation.

2.2 Maintenance Lockout VS Production Safeguarding

Safeguarding protects workers when machinery or equipment is in operation. Lockout protects workers when machinery or equipment is down for maintenance.

A high level summary of the lockout requirement is that when a maintenance task (as defined by the regulation) is being performed on machinery or equipment, lockout is required (zero energy state). Safeguarding is in some cases an intermediate energy state whereby hazardous motions and potential are controlled, but the complete machine may not be in a zero energy state.

Maintenance tasks are defined in the regulation as follows:

"Maintenance" means work performed to keep machinery or equipment in a safe operating condition, including installing, repairing, cleaning, lubricating and the clearing of obstructions to the normal flow of material; [OHS Regulation 10.1 Definitions]

Safeguarding can be used as an alternate form of lockout to perform specific maintenance tasks under regulation 10.10. This generally is a preferential method for performing tasks such as clearing jams in equipment as lockout can be time consuming and result in sequencing or start-up delays in equipment and processes.

10.10 Alternative procedures

1 If lockout of energy isolating devices as required by section 10.3 is not practicable

a. In the case of a power system as defined in Part 19 (Electrical Safety), the requirements of that Part must be followed

b. In the case of mobile equipment as defined in Part 16 (Mobile Equipment), the requirements of that Part must be followed

c. In the case of machinery or equipment designed and equipped with effective control system isolating devices, the devices must be locked out as required by sections 10.4 to 10.9, and 10.10(2), and

d. In an emergency, the energy isolating devices or control system devices must be effectively controlled to prevent inadvertent start up or hazardous energy release.

2 Control system isolating devices and the procedures for using them must be approved in writing by the Board, and must be used by workers qualified and authorized to carry out the work.

Note that approval is required by the board (WorkSafeBC). The specifics of this approval are contained in guideline 10.10. It is recommended to obtain a third party validation report for the approval process. In guideline 10.10 you'll find that the performance level of the safeguarding system is measured against CSA Z432-2004 or ISO 13849. These are current safeguarding standards – so while CSA Z432-94 is the legislated minimum, any interlocking circuits will be measured against the current standard revision.

2.3 Safeguarding requirement in OSSE certification

Has the organization adequately safeguarded machinery/equipment (excluding mobile equipment)?

The scoring Instructions can be found on the following page.

Document Review

C.13.1.1 Has the organization carried out an assessment to identify required safeguards? If yes, award 20 points. (0-20)

C.13.1.2 Does the organization have written instructions for the mandatory use of safeguards? If yes, award 10 points. (0-10)

C.13.1.3 Does the organization perform inspections to ensure safeguards are in place and maintained? If yes, award 10 points. (0-10)

C.13.1.4 Is there a written process to report missing safeguards? If yes, award 5 points. (0-5)

Observation

C.13.1.5 Are safeguards being used as required? Professional judgment required (0-20)

Interview

C.13.1.6 Interview workers to ensure that they are aware of the importance of using safeguards. Award a maximum of 10 points based on the percentage of positive responses. (1-20% = 2 points, 21-40% = 4 points ...81-100% = 10 points) (0-10)

C.13.1.7 Interview supervisors to ensure they enforce the use of safeguards. Award a maximum of 10 points based on the percentage of positive responses. (1-20% = 2 points, 21-40% = 4 points ...81-100% = 10 points) (0-10).

The employer must ensure that machinery and equipment is fitted with adequate safeguards, which protects a worker from contact with hazardous power transmission parts, ensures that a worker cannot access a hazardous point of operation, and safely contain any material ejected by the work process, which could be hazardous to a worker.

This new section applies but is not limited to:
Rotating hazards; gears and sprockets; reciprocating machinery; drive belts; flywheels and pulleys.

Safeguarding, risk assessment analysis, and a maintenance program are all part of OSSE certification requirements. The information will be verified through three different methods documentation review, observation, and interviews.

The OSSE certifications requires organizations to perform and document a risk assessment to identify the required safeguards, implement them and provide training for the written instructions regarding the mandatory use of safeguards.

Routine inspections must be performed to ensure that safeguards are in place and maintained, and a written process must be available to report missing safeguards.

Professional judgment using inspection and monitoring data is required to confirm that safeguards are being used as required. Workers must be are aware through proper training and education of the importance of using safeguards, and that supervisors are enforcing the use of safeguards.

Safeguarding Controls

3.1 Risk Assessment

A safeguarding risk assessment must be performed to decide upon risk level faced and the performance of the safeguard to meet the level of risk faced. While there are many types of risk assessment analysis methods, it is best to choose one that will help ensure that the solutions will meet the requirements of the legislated standard. The risk assessment model from CSA Z432-04 is shown in Table 2.

Table 2
Safeguarding selection matrix
(See Clause 5.6.1.)

Severity of Injury	Exposure	Avoidance	Safeguard Performance.*	Circuit Performance	European Category
Serious	Frequent	Not Likely	Hazard elimination or hazard substitution.	Control Reliable	Category 3 and 4
		Likely		Control Reliable	Category 3 and 4
	Infrequent	Not likely	Engineering controls preventing access to the hazard, or stopping the hazard, e.g., fixed guards, interlocked barrier guards, light curtains, safety mats, or other presence sensing devices.	Control Reliable	Category 3 and 4
		Likely		Single channel with monitoring	Category 2
Slight	Frequent	Not likely		Single channel	Category 1
		Likely	Non-interlocked barriers, clearance, procedures, and equipment.	Single channel	Category 1
	Infrequent	Not likely		Simple	Category B
		Likely	Administrative controls.	Simple	Category B

** All safeguarding methods should be considered at all risk levels, starting with "hazard elimination or hazard substitution".*

***Note:** There is no intent to imply that circuit performance classifications are equivalent to ISO 13849-1 machinery categories. See Table A.2 for example descriptions of risk factor categories.*

Taken From CSA Z434-2003 Revised by MSABC

There are more recent models in the CSA risk assessment standard CSA-Z1002-12 and the international standard ISO 13849. However, following the model noted above and utilizing it correctly will give the assessor a guideline to what is required for compliance.

The Circuit Performance category defines the reliability of the safeguarding circuit and the required reliability of devices used in that circuit. Technical individuals will be required to select the devices and design the safeguarding circuits to be in accordance with the standard. Reviewing these circuits and devices is part of the approval process by WorkSafeBC discussed earlier.

The European Category column lists the rating of the safety components that must be used in the safety circuit to meet the appropriate circuit performance. Components with a higher category rating may be used, however the overall integrity rating of a safety circuit is only affected by the components with the lowest category number.

In general, each safety device must be Category 3 or 4 rated to be integrated into a control reliable circuit. The control reliable circuit then consists of a safety controller and safety actuators, which disable the energy source. Examples are shown in the appendices of this report. The general approach to the various hazardous energies is as follows:

Electrical
Dual force guided contactors are placed in series in the energy source. When pilot signals are controlled, this takes the form of removing PLC output card power or individual outputs (generally speaking). For three phase loads (such as motors), the dual contactors are placed in the three-phase between the actuator / drive and the motor. Where possible, 'safe torque off' technology can be used in newer drive systems. This is either part of the drive system or an optional safety component, which is a safety rated device.

Pneumatic
Where possible pneumatic energy should be dissipated with either a safety rated valve (Z432-04) or dual standard valves with pressure switch feedback (Z432-94). In some cases, energy cannot be practicably dissipated (i.e. load holding). In this case the pilot signals of the pneumatic valves are controlled electrically and generally a secondary means of safety is applied (i.e. rod lock, pilot operated check valve, etc.). The residual pneumatic energy must be identified and ensure that lockout procedures achieve a zero energy state!

Hydraulic

Hydraulic is much the same as pneumatic, but should generally be approached with caution where pilot interlocking is employed as practicable. Typically, ensure that the pressure source is blocked and system pressure is drained back to tank via safety rated monitored valves. Specifically located pressure relief, bypass and possibly blocking valves may be required.

Gravity

There is an order of effective means of controlling gravity with progressively increasing residual hazards. The residual hazards can be excluded by following ISO 13849 part 2 guidelines but this requires a fair bit of due diligence and documentation. Each of these methods must be in conjunction with control system interlocking for redundancy and diversity.

- Mechanical restraint – monitored insertion of a block or pin whereby barrier guard access remains locked until the restraint system is in place (forced lockout).
- Shot pin or ratcheting catch system - an example of this is in use on automotive lifts (car hoist). A mechanical catch ratchets up, and must be retracted to lower. When a control reliable safety system controls the mechanical catch as a redundant safety, this is the most fail safe method.
- Rod lock or monitored pilot operated check valve - this is also a good method, however the residual risk is mechanical failure of the cylinder connection point, or leakage in the cylinder itself.
- Pilot system interlocking - this does not deal with the energy source but ensures that the actuator will not change state. Residual pressure in the system must be identified and this should be used as a last resort.

Table A.2
Example descriptions of risk factor categories
(See Table 2.)

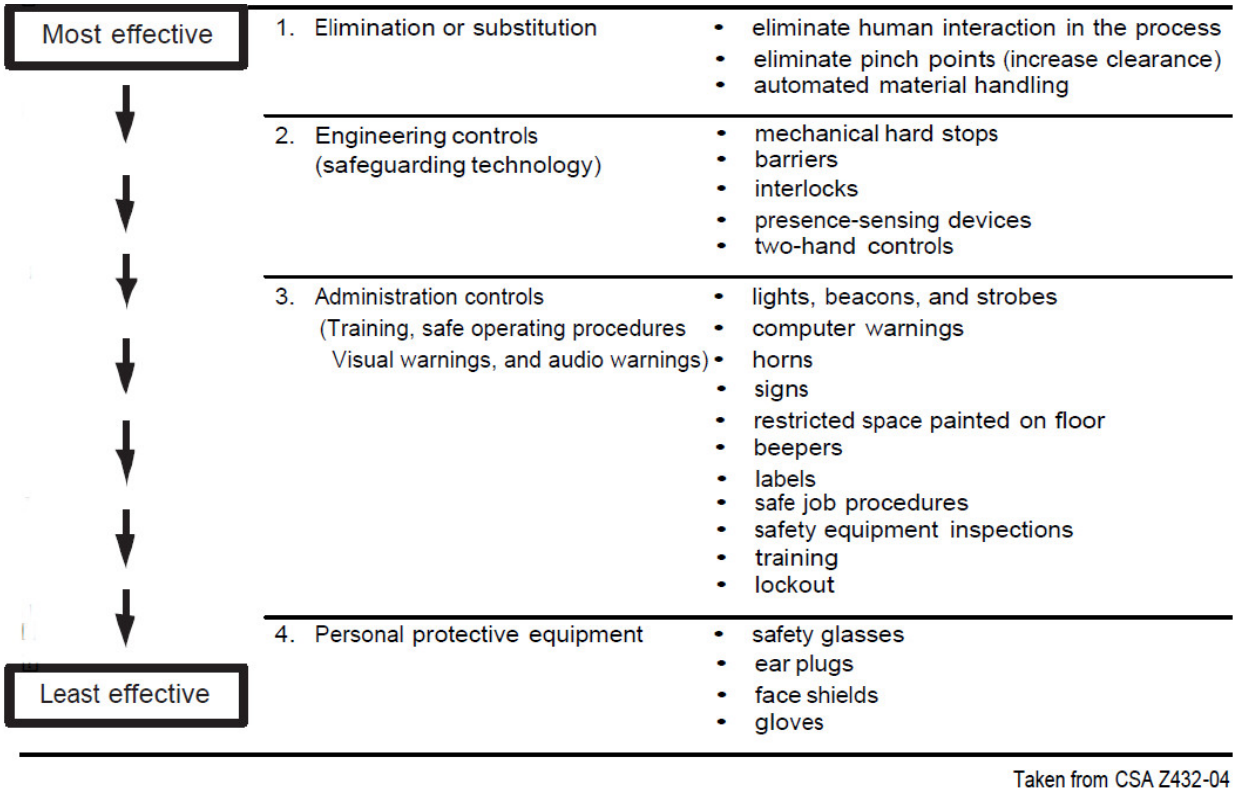
Factor	Category		Criteria
Severity	S2	Serious injury	Fatality, irreversible injury, loss of consciousness, loss of sight, limb amputation, severe laceration, or broken bone.
	S1	Slight injury	Normally reversible, or requires only first-aid treatment.
Exposure	E2	Frequent exposure	Typically, exposure to the hazard more than once per hour.
	E1	Infrequent exposure	Typically, exposure to the hazard less than once per day or shift.
Avoidance	A2	Not likely	Cannot move out of way; or inadequate reaction time; or machine speed greater than 250 mm/s.
	A1	Likely	Can move out of way; or sufficient warning/reaction time; or machine speed less than 250 mm/s.

Taken from CSA Z432-04

The risk assessment process is key to culture change within the organization and buy-in from the operating and maintenance staff persons. Performing the risk assessment must be done with a team that is comprised of persons knowledgeable in the tasks performed and the machine elements. If available, the machine manufacturer working with the user will yield the best results. Having operation and maintenance team members on the risk assessment team is the minimum requirement for the assessment to be effective, however, the more view points represented, the few professional biases will affect the outcome. Having a team of 3-4 people with different interaction with the machinery is best.

3.2 The Hierarchy of Safeguarding Controls

Safeguarding controls must be selected in the hierarchal order from most effective to least effective. Note that the risk assessment will define the minimal requirement to meet the standard, however elimination must always be considered first.
(See Clause 5.2.3.)



Taken from CSA Z432-04 Revised by MSABC

Note that lockout as a primary safeguard is low on the effectiveness scale. Further, note where procedures are shown to be the minimum effective control to meet the standard in the risk assessment matrix. Procedures are only effective to control low level hazards.

3.3 Training

The process never ends with engineering controls or the various safeguards listed. Other controls such as training and procedures must compliment the safeguards. With safeguards present on machines the operating procedures, maintenance procedures, lockout procedures, etc. will all be affected.

It is the responsibility of management and supervision to ensure that the procedures are updated and that personnel are training in the use of the new technologies and their maintenance.

3.4 Maintenance and Monitoring

Safeguarding systems must be tested periodically to ensure that they are still functioning correctly and that changes have not occurred. It is impossible to safeguard against the determined. Primarily for this reason, periodic testing must occur.

An example of a testing method is inserted below. In the left column is listed every safety device on the machine. In the top column are the machine control elements that are connected to hazardous energy sources. The body of the form indicates whether the element is expected to be on or off (this requires technical analysis of circuit diagrams to design the spreadsheet).

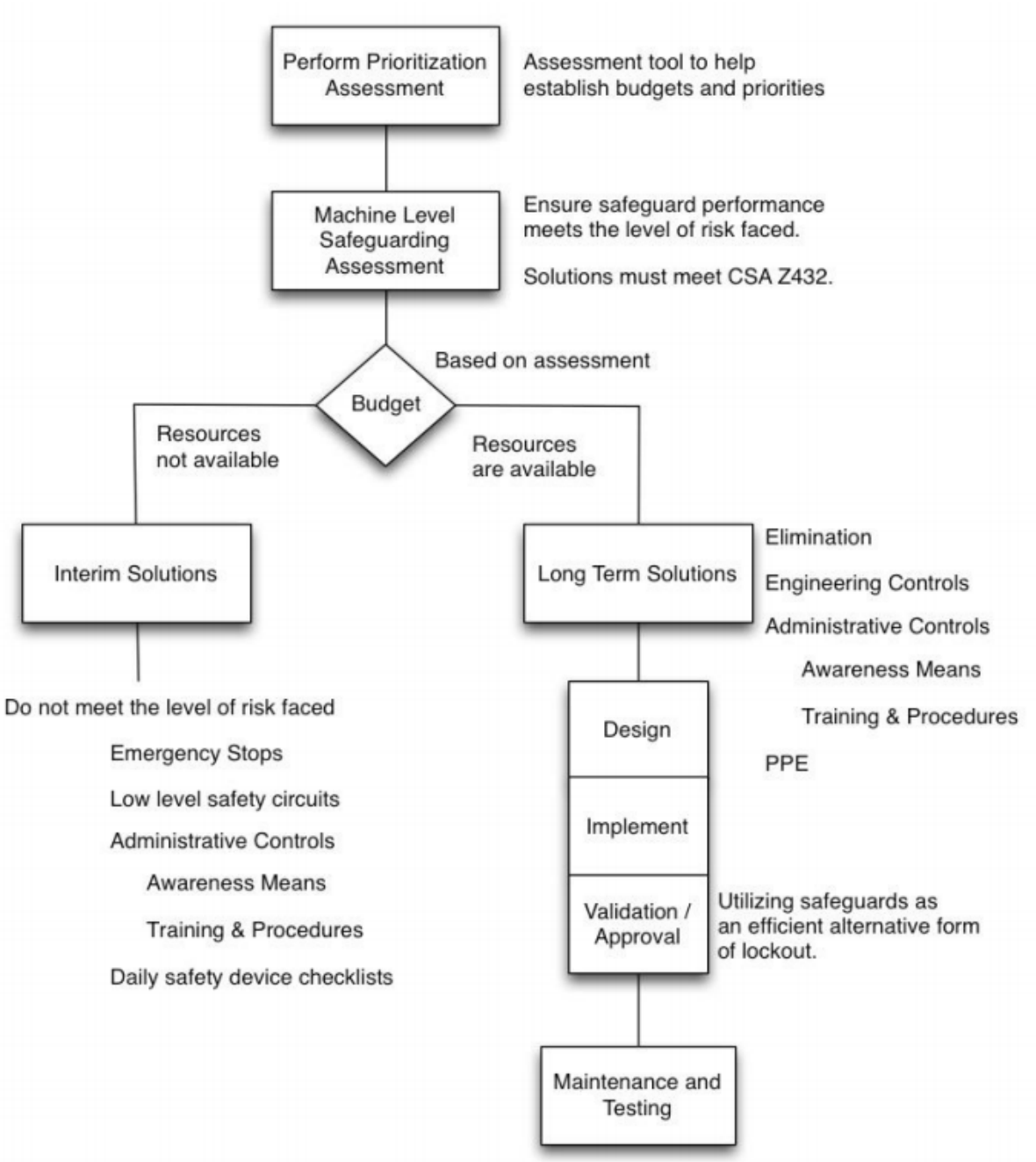
SAFETY SYSTEM FUNCTIONAL TEST

Equipment	611 Press

Device Test									
Tag	Device	Action	Expected Results						Y/N	Remarks/Comments
			K1	K2	K3	K4	K8	K9		
SS1	Door #1	Open Door	X	X	X	X	-	-		
SS2	Door #2	Open Door	X	X	X	X	-	-		
SS3	Door #3	Open Door	X	X	X	X	-	-		
SS4	Door #4	Open Door	X	X	X	X	-	-		
SS5	Door #5/6	Open Door	X	X	X	X	-	-		
SS6	Door #7	Open Door	X	X	X	X	-	-		
SS7	Door #8	Open Door	X	X	X	X	-	-		
SS8	Finger Guard #1	Remove Guard	-	-	-	-	X	X		
SS9	Finger Guard #2	Remove Guard	-	-	-	-	X	X		
SS10	Finger Guard #3	Remove Guard	-	-	-	-	X	X		
	Pan Guard (#3)	Remove Pan	-	-	-	-	X	X		
SS11	Finger Guard #4	Remove Guard	-	-	-	-	X	X		
	Pan Guard (#4)	Remove Pan	-	-	-	-	X	X		
ES1	Emergency Stop #1	Activate E-Stop	X	X	X	X	X	X		
ES2	Emergency Stop #2	Activate E-Stop	X	X	X	X	X	X		
ES3	Emergency Stop #3	Activate E-Stop	X	X	X	X	X	X		
ES4	Emergency Stop #4	Activate E-Stop	X	X	X	X	X	X		
ES5	Emergency Stop #5	Activate E-Stop	X	X	X	X	X	X		
ES6	Emergency Stop #6	Activate E-Stop	X	X	X	X	X	X		
ES7	Emergency Stop #7	Activate E-Stop	X	X	X	X	X	X		
ES8	Emergency Stop #8	Activate E-Stop	X	X	X	X	X	X		
ED1	Enable Station #1	Position 1	X	X	X	X	-	-		
ED1	Enable Station #1	Position 3	X	X	X	X	-	-		
ED2	Enable Station #2	Position 1	X	X	X	X	-	-		
ED2	Enable Station #2	Position 3	X	X	X	X	-	-		
SS12	Pistol Sensor	Remove from switch	X	X	X	X	-	-		faults after 2min when displaced
ED3	Enable Station #3	Position 1	X	X	X	X	-	-		
ED3	Enable Station #3	Position 3	X	X	X	X	-	-		
ED4	Enable Station #4	Position 1	X	X	X	X	-	-		
ED4	Enable Station #4	Position 3	X	X	X	X	-	-		
During each test attempt to reset the safety system with fault present and start the equipment in Auto. **X indicates the safety contactor opens**										

When a validation report is performed by a third party for the required WorkSafeBC approval process, this functional test form should be included as part of the deliverable.

3.5 Project Prioritization



3.5.1 Prioritize by risk level -quick but basic

It is difficult to prioritize projects without completed assessments, but due to budgetary constraints this might need to be done. Performing a basic risk assessment, as the one provided by WorkSafeBC is a good way to quickly prioritize based on safety levels. The model is below.

The main purpose of a risk assessment is to decide which machine should be given priority, and which parts of the machine should be safeguarded first.

Machine Risk Assessment Survey

Company Name	**Date of Survey**	**Survey done by:**		
ABC Food Processors Ltd.	March 10, 2005	1. Raj Nagal (supervisor) 2. Bill Knight (maintenance) 3. Lindsay Hall (operator)		
Machine Name	**Machine Function**			
Integrated Wrapping Line	Tray Wrapper			
Identify and describe *every* hazardous machine motion or harmful condition to which the worker's body parts are exposed (e.g., rotating shafts, in-running nip points, shearing parts, reciprocating parts, punching action, impact hazards, flying debris, abrasive surfaces, electrical hazards, hot/toxic fluids, vapours, emissions, radiation). Be as descriptive and detailed as possible.	**Describe the worst injury that would reasonably occur due to each hazard.** Use the following descriptions as a guide: • **Fatal** • **Major** (normally irreversible: permanent spinal damage, loss of sight, amputation/crushing, respiratory damage) • **Serious** (normally reversible: loss of consciousness, burns, fractures) • **Minor** (bruising, cuts, light abrasions)	**Estimated severity of injury:** Minor = 1 Serious = 5 Major = 7 Fatal = 10	**Estimated likelihood of injury** (see Note 1): Unlikely = 1 Possible = 5 Probable = 7 Certain = 10	**Estimated level of risk** (see Note 2): Estimated severity × estimated likelihood
1. Initial infeed belt creates pinch point near front roller.	Minor bruising of fingers	1	5	5
2. Crushing hazard between tray wrap film folder arms and machine frame	Amputation injury to fingers or severe crushing of hands	7	7	49
3. Outfeed tray/film heat belt is very hot	Burns to hands	5	5	25
4. Web belt drive unit for outfeed belt has no guard – infrequent access required	Bruising of fingertips	1	5	5

Note: Gathering this information may require repeated observations, especially when determining what the worker does when normal production flow is interrupted.

Figure 2.1.
Sample completed machine risk assessment survey form, with hierarchy of safeguarding controls to be used.

This model can be performed quickly and will result in a risk level that helps prioritization. This model can also prove useful for defining and implementing interim control measures that will not necessarily meet the level of risk faced but may be necessary on a short-term basis.

Recommended safeguarding to eliminate or reduce the risk to an acceptable level (see Note 3)	
1. *Realign belt to eliminate pinch point.*	3. *Lower exhaust ventilation capture hood a few inches to close off access to this hazard. Place warning decal near burn hazard.*
2. *Design and install interlock gate guard over moving arms; operator can then make minor adjustment without locking out.*	4. *Extend side flange to enclose access to chair-sprocket drive.*

Note 1. The following factors may be useful when estimating the likelihood of injury:

- Machine cycle speed
- Hand feeding with foot control
- Operator training and experience
- Boredom factor (repetition)
- History of jams and misfeeds resulting in frequent access to danger areas of the machine
- Previous injuries on this machine or machines of this type

Note 2. Use the estimated level of risk to set the priority for implementing safeguarding measures. The higher the estimated level of risk, the more urgent it is to implement safeguarding solutions.

Note 3. Always follow the hierarchy of safeguarding controls regardless of the perceived level of risk.

Taken from Safeguarding Machinery and Equipment General Requirements (WorkSafeBC)

3.5.2 Prioritize by existing safeguards – technical but basic

This model can be useful in a larger organization where several pieces of equipment exist with varying levels of safeguarding existing. This helps integrators and safeguarding service providers establish a budget for the client to move forward with safeguarding projects.

Safeguarding Exists	Inidicates if safeguards are currently present
O	Safeguards present
X	No safeguards present
Safeguarding Deficiencies	Inidicates if safeguards are adequate and effective
O	Safeguarding in place and generally meets Z432 requirements
Δ	Safeguarding in place but some areas missing guards or does not appaear to meet reach around, under, through, over requirements
X	Safeguards missing or completely inadequate
Safety Devices	Inidicates if safety devices are present where required
O	Safety devices in place and appear to be safety rated
Δ	Some devices in place or non-safety rated, bolted hatches or doors
X	No devices in place where interlocking required
Safety Circuits	Indicates if safety components were witnessed in the control panel
O	Safety components present, generally appear to be safety rated and the correct components (i.e. safety relay, dual contactors, etc.)
Δ	Circuit appears to exist but not the correct performance level (i.e. wired to PLC) or some devices missing
X	No safet circuit or completely inadequate
Safeguarding or Validation report	
O	Report has been completed and plan in place
X	No report completed

Line	Machine / Area
O	Good - Scores 1 in the total
Δ	Mediocre - Scores 5 in the total
X	Bad - Scores 10 in the total

Safeguarding Exists	Safeguarding Deficiencies	Safety Devices	Safety Circuits	Safeguarding or Validation Report	Total Score
O	Δ	O	O	X	18
O	O	O	O	O	5
O	X	X	Δ	O	27
O	Δ			X	16
O	Δ	Δ	Δ	O	17
X	X	X	X	O	41
O	Δ	Δ	Δ	O	17
X	X	X	X	X	50
O	Δ	Δ	Δ	O	17
O	Δ	O	O	X	18

Notes

Restricted space likely not correctly established / controlled, some minor guarding deficiencies
Project completed
Areas outside of recent project - some minor barrier guarding, some interlock guards, lanes - refer to report
Hazard levels not clear
No barrier guards, light beam w/ no safety circuit exists
Major deficiencies, major hazards

3.5.3 Prioritize with complete safeguarding risk assessment – the right way

When a complete machine safeguarding report with risk assessment is performed, the interim solutions and long term solutions should be clearly defined with sufficient technical detail (electrical, mechanical, hydraulic, pneumatic) that projects can be planned, budgeted and scheduled. Internal resources, external resources and communication to WorkSafeBC can be performed with this report.

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About us

The Manufacturing Safety Alliance of BC, formerly known as FIOSA-MIOSA Safety Alliance of BC, was established in December 2007 to reduce the high injury rate in the food and manufacturing industries.

Our mission

We are catalysts for improving workplace health and safety within the BC Manufacturing Industry. Our leading edge health and safety programs, services and tools enable companies to make a difference in the lives of their employees – every day.

Our vision

Partnering with BC's industry leaders to achieve cultural change that ensures safe workplaces for all employees. The Manufacturing Safety Alliance of BC strives to accomplish our mission and vision through the delivery of a variety of core services including:

- Training in areas such as occupational health and safety (OHS) leadership, program building, and auditing.
- Consultation and advisory services.
- The certifying partner for the Occupational Safety Standard of Excellence (OSSE) in partnership with WorkSafeBC.

For more information please contact us:

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