Z460-13

Control of hazardous energy — Lockout and other methods

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Revision History

Revisions to the following clauses, tables, and figures are included in this edition.

Revision location	**Revision symbol (in margin)**
Clauses 1.1, 1.4, 5.1.1, 5.1.3, 5.2.3, 5.2.4, 5.3, 5.7, 6.1.1, 6.1.2, 6.1.3, 6.4, 7.1.1.1, 7.1.2, 7.2, 7.3.2.2.1, 7.3.2.2.2, 7.3.2.2.3, 7.3.2.3.1, 7.3.2.3.2, 7.3.2.7, 7.3.3.7.1, 7.3.3.7.2, 7.3.3.8.1, 7.3.3.8.2, 7.3.3.8.3, 7.3.3.9, 7.3.3.10.1, 7.3.3.10.2, 7.3.3.10.3, 7.3.7.1, 7.3.7.2, 7.3.7.3, 7.3.9, 7.4.2, 7.4.3, 7.4.4, 7.4.4.1, 7.4.4.2, 7.4.4.3, 7.4.4.4, 7.4.5, 7.4.6.1, 7.4.6.3, 7.4.6.5, 7.4.7.1, 7.4.8.2, 7.4.8.3, 7.5.1, 7.5.2, 7.5.2.2, 7.5.2.3, 7.5.2.4, 7.5.2.5, 7.5.3, 7.6.2.1, A.1, A.2, A.4, B.1.1, B.1.6, B.2, B.4, C.1.3.2, C.1.4, C.2.5, L, and P Tables A.1, A.3, B.2, C.1, C.7, C.8, C.9, D.1, G.1, G.3, G.4, and I.1 Figures 2, 3, and 4	Δ

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Preface

This is the second edition of CSA Z460, *Control of hazardous energy — Lockout and other methods.* It supersedes the identically titled first edition published in 2005. This Standard specifies requirements for and provides guidance on

a) the responsibilities of the principal parties involved in hazardous energy control (Clause 4);
b) the design issues that influence the effective application of control methodology (Clause 5);
c) task and hazard identification procedures (Clause 6);
d) the hazardous energy control program elements necessary for protection of authorized and affected individuals (Clause 7.3);
e) special applications where traditional methods of hazardous energy control are inappropriate or impractical (Clause 7.3.10);
f) development of other methods for tasks that are integral to the production process, including tasks where traditional lockout prohibits completion (Clause 7.4);
g) communication and training (Clause 7.5); and
h) management review to ensure the effective functioning of the hazardous energy control process (Clause 7.6).

This Standard provides for flexibility in hazardous energy control methodology decisions as part of an occupational health and safety management system (see CSA Z1000). Other methods are based on risk assessment and application of the classic hazard control hierarchy (see Clause 7.4.4). However, lockout is emphasized as the primary approach to hazardous energy control.

In the creation of this second edition, the following specified changes have been incorporated:

a) the Scope has been expanded to include mobile mechanical equipment and freeze-plug applications.
b) definitions for the following terms have been added or revised:
   i) Affected individual;
   ii) Affected individual;
   iii) Risk assessment;
   iv) Risk reduction;
   v) Zero energy state; and
   vi) Zero energy state control.
c) Clause 6.1 — added a reference to CSA Z1002.
d) Clause 7.1.1.1 — revised to better clarify users' responsibilities when it is impracticable to upgrade non-compliant machine, equipment of processes.
e) Clauses 7.3.2.1 to 7.3.2.2.3 — revised to clarify specifically who can perform energy isolations and lockout, as well as to clarify what must be done when energy isolation devices are not capable of being locked out.
f) Clauses 7.5.2.2 to 7.5.2.5 — revised to clarify new training expectations.
g) Clause 7.6.2.1 — revised to identify new minimum training frequency requirements.

By permission of the American National Standards Institute (ANSI), this Standard is based in part on ANSI/ASSE Z244.1-2003, *Control of Hazardous Energy — Lockout/Tagout and Alternative Methods.* By permission of International Organization for Standardization (ISO) TC 199, Annexes A and B are based in part on ISO 12100:2010, *Safety machinery — General principles for design — Risk assessment and risk reduction.*

In this 2013 edition, where a significant change or addition to the previous edition of this Standard has been made, the clause, table, or figure affected is identified by the symbol delta (Δ) in the margin. Users of this Standard are advised that the change markers in the text are not intended to be all-inclusive and are provided as a convenience only; such markers cannot constitute a comprehensive guide to the revisions made to this Standard. Care must therefore be taken not to rely on the change markers to determine the current requirements of this Standard. As always, users of this Standard must consider the entire Standard.

This Standard was prepared by the Technical Committee on Hazardous Energy Control, under the jurisdiction of the Strategic Steering Committee on Occupational Health and Safety, and has been formally approved by the Technical Committee.

Notes:

1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*

2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*

3) *Annex sections of this publication are intended to provide additional information, examples, and resources in support of the criteria in the body of this Standard. As some of this material has been copied from other related resource materials, it may use terminology that differs from that used in the body of this Standard.*

4) *This Standard was developed by consensus, which is defined by CSA Policy governing standardization — Code of good practice for standardization as "substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity". It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this Standard.*

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   b) *provide an explanation of circumstances surrounding the actual field condition; and*

   c) *where possible, phrase the request in such a way that a specific "yes" or "no" answer will address the issue.*

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6) *This Standard is subject to periodic review, and suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to* ***inquiries@csagroup.org*** *and include "Proposal for change" in the subject line:*

   a) *Standard designation (number);*

   b) *relevant clause, table, and/or figure number;*

   c) *wording of the proposed change; and*

   d) *rationale for the change.*

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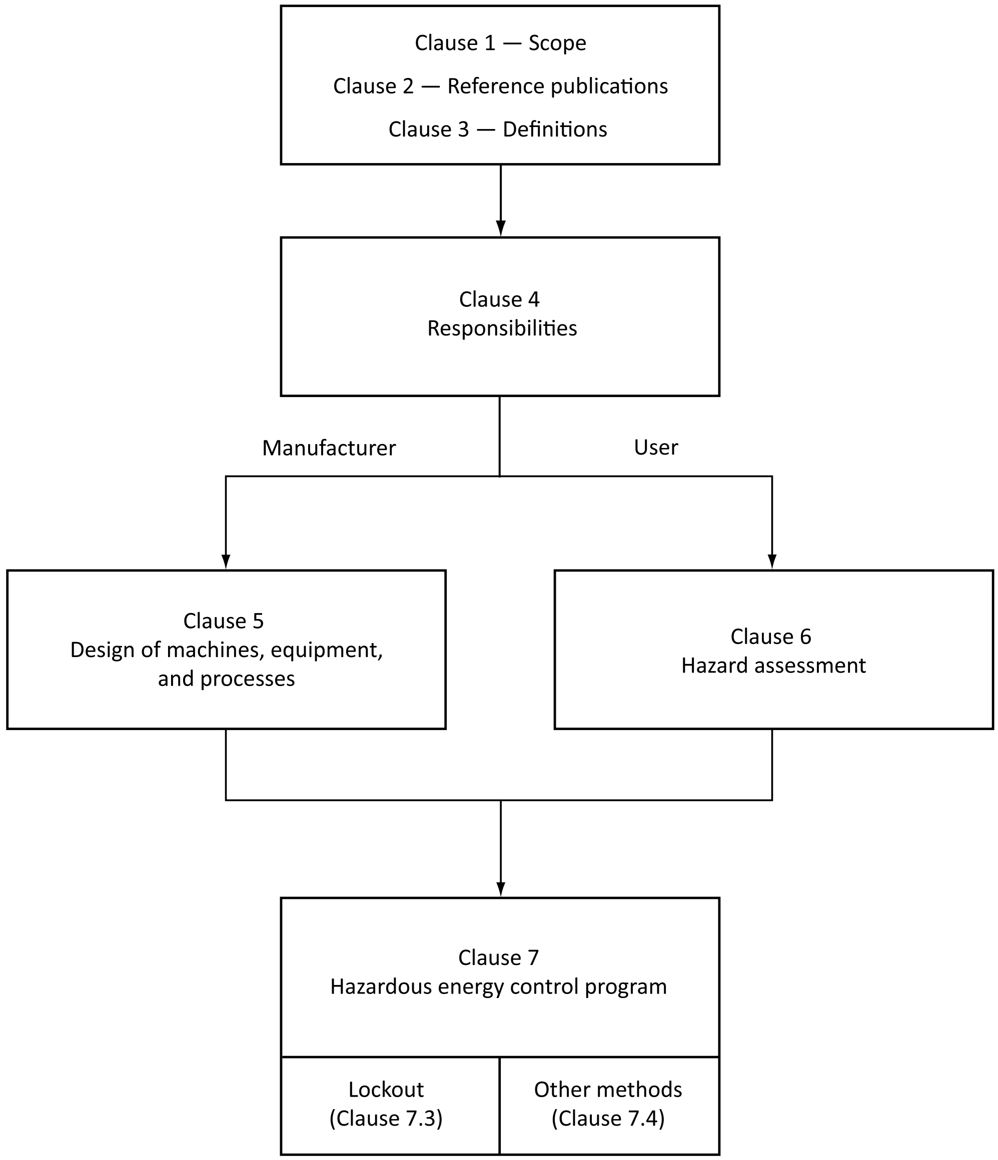
Control of hazardous energy — Lockout and other methods

0 Introduction

This Standard assigns responsibilities for hazardous energy control of machines, equipment, and processes to manufacturers, integrators, installers, and users. It is best read in its entirety for full comprehension of its requirements. Figure 1 provides a graphic representation of the organization of this Standard.

Figure 1
Organization of this Standard
(See Clause 0.)



1 Scope

∆ 1.1 Scope

This Standard specifies requirements for controlling hazardous energy associated with potentially harmful machines, equipment, and processes (including mobile machinery and equipment — see Annex L).Where a CSA Standard or other recognized Standard exists for a specific type of machinery, equipment, or process, it should be used with this Standard to provide the most effective protection.

1.2 Purpose

The purpose of this Standard is to specify requirements and performance objectives for procedures, techniques, designs, and methods to protect personnel from injury from the inadvertent release of hazardous energy. Release of hazardous energy can include any motion, energization, start-up, or release of stored energy that, from the perspective of the person(s) at risk, is either unintended or deliberate.

Lockout is recognized as the primary method of hazardous energy control. When the tasks specified in Clause 1.3 are integral to the production process (see Clause 7.4.2), or traditional lockout prohibits completion of those tasks, other methods of control that provide effective personal protection are used. These other methods are based on risk assessment (see Clause 7.4.3).

1.3 Application

This Standard applies to, but is not limited to, activities such as: erecting, installing, constructing, repairing, adjusting, inspecting, unjamming, setting up, troubleshooting, testing, cleaning, dismantling, servicing, and maintaining machines, equipment, or processes.

Safeguarding of machines and the control of energy supply systems during normal production activities are addressed in CSA Z432, CSA Z462, and other machine- and system-specific Standards.

Special considerations for work in confined spaces are addressed in CSA Z1006.

∆ 1.4 Exclusions

This Standard does not specify safety procedures for manually operated machines or equipment where the only source of energy is the individual operator himself/herself.

1.5 Terminology

In CSA Standards, “shall” is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; “should” is used to express a recommendation or that which is advised but not required; “may” is used to express an option or that which is permissible within the limits of the standard; and “can” is used to express possibility or capability. Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material. Notes to tables and figures are considered part of the table or figure and may be written as requirements. Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

2 Reference publications

This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below, including all amendments published thereto.

CSA Group

C22.2
Canadian Electrical Code, Part II

CAN/CSA-E61496-1:04 (R2009)
Safety of machinery — Electro-sensitive protective equipment — Part 1: General requirements and tests

CAN/CSA-E61496-2:04 (R2009)
Safety of machinery — Electro-sensitive protective equipment — Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)

Z432-04 (R2009)
Safeguarding of machinery

CAN/CSA-Z434-03 (R2013)
Industrial robots and robot systems — General safety requirements

Z462-12
Workplace electrical safety

Z662-11
Oil and gas pipeline systems

CAN/CSA-Z1000-06 (R2011)
Occupational health and safety management

Z1001-13
Occupational health and safety training

Z1002-12
Occupational health and safety — Hazard identification and elimination – Risk assessment and control

Z1006-10
Management of work in confined spaces

ANSI (American National Standards Institute)

B65.1-1995
Safety Standard — Printing Press Systems

B65.2-1999
Binding and Finishing Systems

Z490.1-2001
Accepted Practices for Safety, Health, and Environmental Training

ASSE (American Society of Safety Engineers)

ANSI/ASSE Z244.1-2003 (2008)
Control of Hazardous Energy — Lockout/Tagout and Alternative Methods

IEC (International Electrotechnical Commission)

61496-3:2008
Safety of machinery — Electro-sensitive protective equipment — Part 3: Particular requirements for Active Opto-electronic Protective Devices responsive to Diffuse Reflection (AOPDDR)

62061:2005
Safety of machinery — Functional safety of safety-related electrical, electronic and programmable electronic control systems

TS 62046:2008
Safety of machinery — Application of protective equipment to detect the presence of persons

ISO (International Organization for Standardization)

12100:2010
Safety of machinery — General principles for design — Risk assessment and risk reduction

13849-1:2006
Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design

13856-1:2001
Safety of machinery — Pressure-sensitive protective devices — Part 1: General principles for design and testing of pressure-sensitive mats and pressure-sensitive floors

14119:1998
Safety of machinery — Interlocking devices associated with guards — Principles for design and selection

14120:2002
Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards

SPI (The Society of the Plastics Industry, Inc.)

ANSI/SPI B151.15-2003
Extrusion Blow Molding Machines — Safety Requirements for Manufacture, Care and Use

ANSI/SPI B151.21-2003
Injection Blow Molding Machines — Safety Requirements for Manufacture, Care and Use

3 Definitions

The following definitions apply in this Standard:

Δ **Affected individuals** — persons who are not directly involved in the work requiring the hazardous energy control, but who are (or may be) located in the work area (see Clause 7.3.3.8).

Alarm — an audible or visual means for alerting personnel to an impending hazard (e.g., start-up, motion, malfunction, or failure of a machine, equipment, or process).

Authorized individual — a person who is qualified to engage in hazardous energy control because of knowledge, training, and experience and has been assigned to engage in such control.

Control — the power to direct, regulate, or restrain hazardous energy.

Control circuit — a means of initiating or interrupting energy to a machine, to equipment, or to a process. The term also applies to the circuit of a control apparatus or system that directs the performance of a machine, equipment, or a process but does not directly interrupt the flow of energy. Control circuits can be hydraulic, pneumatic, electric, or electromechanical.

Control system — the sensors, manual input and mode-selection elements, interlocking and decision-making circuitry, and output elements provided to the operating devices or mechanisms of a machine, equipment, or a process.

Danger zone — the zone in and around a machine, equipment, or a process where a hazard is created by the motion of machinery or the energization of a system.

De-energized — disconnected from all energy sources and not containing residual or stored energy.

Effective risk reduction — achievement of a risk level not likely to lead to a situation that could harm individuals.

Energized — connected to an energy supply or containing residual or stored energy.

Energy-isolating device — a mechanical device that physically prevents the transmission or release of energy, including but not limited to the following: a manually operated electrical circuit breaker; a disconnect switch; a manually operated switch by which the conductors of a circuit can be disconnected from all ungrounded supply conductors; a line valve; a block; and other devices used to block or isolate energy.

Note: *Push-button selector switches and other control-type devices are not energy-isolating devices.*

Guard — a physical barrier that prevents access to areas of a machine, equipment, or a process where a hazard exists.

Hazard — a potential source of harm to personnel.

Hazardous energy — any electrical, mechanical, hydraulic, pneumatic, chemical, nuclear, thermal, gravitational, or other energy that can harm personnel.

Information tag — a warning means and a means of attachment used in conjunction with the application of a lockout device to an energy-isolating device. It usually indicates the nature, purpose, and time of application of the lockout, as well as the identity of the authorized individual who performed the lockout.

Integrator — an individual, company, or organization responsible for assembling a group of interrelated or interacting machine, equipment, or process components.

Interlock — a device or system, whereby the status of one control or mechanism allows or prevents the operation of another.

Knowledgeable person — a person who has the appropriate expert or professional knowledge or qualifications to enable them to assess the adequacy of lockout procedures to ensure that they are in accordance with this Standard.

Δ **Lockout** — placement of a lockout device on an energy-isolating device in accordance with an established procedure.

Lockout device — a mechanical means of locking that uses an individually keyed lock to secure an energy-isolating device in a position that prevents energization of a machine, equipment, or a process.

Manufacturer — an individual, company, or organization that designs, fabricates, assembles, or supplies machines, equipment, or processes.

Modifier — an entity that changes or alters a machine, equipment, or a process.

Operator — a person responsible for operating a machine or component of a machine (including operation during maintenance).

Primary authorized individual — an authorized individual who has been assigned to perform (assume control over) a group lockout and has authority over other authorized individuals entering into a danger zone around a hazardous machine or energy system.

Remanufacturer — an individual, company, or organization that redesigns or reconstructs machines or equipment.

Δ **Risk assessment** — a comprehensive evaluation of the likelihood and degree of possible injury or damage to health in a hazardous situation, undertaken to select appropriate safeguards.

Δ **Risk reduction** — actions (i.e., use of preventive and protective measures) taken to lessen the likelihood of harm, the severity of harm, or both.

User — an individual, company, or organization that purchases, leases, or uses machines, equipment, or processes covered by this Standard and is responsible for the personnel associated with hazardous energy control (e.g., as owner, lessee, employer, or contractor).

Δ **Zero energy state** — an energy level that is not harmful to any individual.

Note: *Methods for achieving a zero energy state in a system include de-energization of electrical sources and discharging of capacitive and inductive elements (absence of voltage and current), blocking or totally releasing mechanical energy (kinetic or potential), and dissipating chemical or thermal energy.*

Δ **Zero energy state control** — a situation under which a zero energy state can be maintained without interruption while performing activities.

4 Responsibilities

4.1 Manufacturers, integrators, modifiers, and remanufacturers

Manufacturers, integrators, modifiers, and remanufacturers shall be responsible for designing, integrating, installing, and building machines, equipment, or processes so that the user can effectively control hazardous energy during activities such as, but not limited to, erecting, installing, constructing, repairing, adjusting, inspecting, unjamming, setting up, troubleshooting, testing, cleaning, dismantling, servicing, and maintaining machines, equipment, or processes.

4.2 Users

Users shall be responsible for complying with the applicable requirements of this Standard by establishing an effective program for protecting individuals from hazardous energy during the activities specified in Clause 4.1.

Note: *A user can become an integrator, modifier, or remanufacturer if the user performs the work of one those entities as defined in Clause 3.*

4.3 Authorized individuals

Authorized individuals shall be responsible for performing hazardous energy control in compliance with the program, procedures, and training provided for them by the user.

5 Design of machines, equipment, and processes

5.1 Manufacturer, integrator, modifier, and remanufacturer responsibilities

Δ 5.1.1 General

Machines, equipment, and processes shall be designed, manufactured, supplied, and installed in such a way that the user can comply with the control methodologies of this Standard. Modifications affecting energy isolation shall comply with this Standard. A risk assessment shall be performed during the engineering design stage of development to determine the need for and design sufficiency of appropriate energy-isolating devices and systems.

Note: *See Annex B for a recommended risk assessment and effective risk reduction procedure.*

5.1.2 Exposure minimization

5.1.2.1

Manufacturers, integrators, modifiers, and remanufacturers shall design and install machines, equipment, and processes in such a way that they are reliable and minimize the need for set-up, servicing, or maintenance (therefore requiring a low level of intervention).

5.1.2.2

Machines, equipment, and processes should be designed and installed in such a way that personnel are not exposed to hazardous energy during servicing and maintenance integral to production.

Note: *This can be accomplished by positioning controls outside hazardous areas, adding controls at appropriate locations, providing external lubrication points, or providing guarding.*

Δ 5.1.3 Partial energization

For functions that require partial energization, the manufacturer, integrator, modifier, or remanufacturer shall perform a risk assessment to determine the safest method of machine, equipment, or process access. When it is necessary for machines, equipment, or processes to remain partially energized (e.g., to hold parts, save information, retain heat, or provide local lighting), other control methodologies shall be provided for personnel safety.

Note: *See Annex B for a recommended risk assessment and effective risk reduction procedure.*

5.2 Energy-isolating devices

5.2.1 General

Machines, equipment, and processes shall be designed, manufactured, supplied, and installed with energy-isolating devices to enable compliance with Clause 7.3. Consideration shall be given to the intended use of the machine, equipment, or process. Energy-isolating devices shall be capable of controlling and/or dissipating hazardous energy. The devices should be an integral part of the machine, equipment, or process.

When these devices are not integral to the machine, equipment, or process, the manufacturer shall include in the installation instructions recommendations for the type and location of energy-isolating devices.

5.2.2 Capability

Energy-isolating devices shall be capable of being either locked or secured in an effective isolating position.

Note: *Examples of effective energy-isolating devices include levers with aligning lock tabs (holes), valves with aligning lock tabs, locking covers that work only when the switch is in the safe position, wheels with locking tabs and position indicators, and physical blocks with locking aligning tabs.*

Δ 5.2.3 Location

Energy-isolating devices shall be accessible and, when practicable, located to facilitate the application of lockout devices during service and maintenance.

Note: *Energy-isolating devices are best located outside hazardous areas at a convenient height for manipulation from an adjacent area normally accessible by foot (e.g., not overhead, on a ladder, within a confined space, or under machinery).*

Δ 5.2.4 Identification

All energy-isolating devices shall be labelled or marked using a standardized nomenclature and format to indicate their function unless they are located and arranged so that their purpose is clearly evident. The identification shall include the following:

a) machine, equipment, or process supplied; and
b) energy type and magnitude.

The labelling or marking shall be of sufficient durability to withstand the anticipated environment.

Note: *The potential for incidents and unplanned occurrences can be reduced if exposed individuals do not have to rely on their recollection of which isolation devices apply to which machines or systems, particularly in situations involving complex equipment. There is a greater potential for error when energy-isolation devices are unlabelled or inadequately identified.*

Where conditions such as complexity or security warrant, coded identification can be used.

Electrical boxes may be labelled directly on the box. Valves may be labelled on the valve body or with a suspended sign or tag.

Note: *Tags, embossing, engraving, and stencilling are some of the ways that labelling and marking are accomplished. The following are examples of the wording used in labels and markings:*

a) *Main Power Press 3 (480 V);*
b) *Natural Gas-Process Line 2;*
c) *Hydraulic Pump Discharge (5500 kPa); and*
d) *Bay A Compressed Air (690 kPa).*

5.2.5 Suitability

Every energy-isolating device shall be evaluated to determine its suitability for its intended application.

Δ 5.3 Special tools or devices

If special tools or devices are necessary for servicing or maintaining machines, equipment, or processes, they should be provided with the machines, equipment, or processes.

Note: *In this context, "special tools or devices" refer to those that are custom-designed for or peculiar to the machine, equipment, or process.*

5.4 Warnings and special instructions

The manufacturer shall determine whether warnings or special instructions are necessary for servicing or maintaining a machine, a piece of equipment, or a process. If the manufacturer determines that warnings or special instructions are necessary, sufficient information about such warnings or special instructions shall be provided by the manufacturer, integrator, modifier, or remanufacturer (as applicable) in the manual specified in Clause 5.6. In addition, if the manufacturer determines that the warnings or special instructions need to be part of a label, placard, or sign located in the area of the hazard, the manufacturer shall install the label, placard, or sign at the appropriate location, or supply the label, placard, or sign for later installation by the user.

5.5 Component isolation

Machine, equipment, or process installation procedures shall provide for local isolation of component parts or component systems if they are to be serviced or maintained separately. The number and location of energy-isolating devices shall be determined by the configuration of the machine, equipment, or process and its intended application.

Note: *Examples of local component isolation include machines with heating systems and other auxiliary systems that have separate sources of hazardous energy that need to be controlled.*

5.6 Documentation

The manufacturer, integrator, modifier, or remanufacturer shall provide a manual that includes the following information and instructions:

a) a description of where the energy-isolating devices are to be located and the procedures for their use (see Clause 7.3.2.3);
b) step-by-step procedures for servicing or maintenance of any machine, equipment, or process that needs to be performed under partial energization (these shall be based on a risk assessment);
c) instructions for safely addressing such conditions as malfunctions, jams, misfeeds, or other interruptions of the operation; and
d) installation instructions for the installer of the machine, equipment, or process that identify the locations of necessary energy-isolating devices.

Δ 5.7 Stored and residual energy

When stored or residual energy is determined to be a hazard, a means for non-hazardous dissipation or safe restraint of the energy shall be incorporated into the machine, equipment, or process. Devices used for dissipating stored energy shall be designed with a means or method of verifying their position and state.

Note: *For example, a bleeding device designed to safely vent hydraulic pressure to a reservoir, thus allowing a machine component to move in a controlled manner to a mechanical-rest position.*

When machinery run-down or coasting is determined to be a hazard, guarding or controls that protect against the hazard or prevent access until the motion has ceased shall be installed.

In the case of stored or residual thermal energy, warnings or instructions may be provided instead of a device to dissipate or restrain the energy if such a device is not practical. Warnings and instructions may also be omitted if the existence and location of hazardous thermal energy is readily apparent because of the function of the machine, equipment, or process.

5.8 Control integration

When hazardous energy control methods other than lockout are used during set-up, troubleshooting, or other tasks requiring energization or partial de-energization, protective systems shall be used to ensure that a device or system will stop or prevent initiation of hazardous motion or release of hazardous energy in the event of a single-component failure in the device or system.

Note: *Typical protective methods include hardware-based, control-reliable safety interlock systems (see Clause 8.2.5 of CSA Z432) and safety-rated multiple-channel programmable logic controllers (when manufactured for safety applications and applied in accordance with the manufacturer's instructions).*

5.9 Physical safeguards

Physical safeguards (e.g., pins, blanks, blocks, restraints, and chains) shall be designed to withstand all of the forces to which they will be subjected, with an appropriate safety factor as specified in applicable Standards.

6 Task and hazard identification

6.1 General

∆ 6.1.1

The essential first step in developing a hazardous energy control procedure for machines, equipment, and processes is the systematic identification of all possible hazardous situations (see Clauses 6.2 and 6.3) and how they can lead to harm during various phases of the machine/equipment/process life cycle (see Figure 2). To accomplish this, it is necessary to systematically identify the tasks to be performed as well as the hazards associated with these tasks and how they can lead to harm, particularly for various conditions or life cycle phases (e.g., construction, transport, assembly, installation, commissioning, set-up, adjustment, program verification, use in production, maintenance, troubleshooting, repair, decommissioning, and disposal). In accordance with CSA Z1002, efforts should be made to eliminate these hazards (e.g., by taking systems down to a zero energy state) or prevent exposure to them. However, where hazards cannot be eliminated or totally controlled, an assessment of residual risk should be conducted (additional information on risk assessment is contained in CSA Z1002 and ISO 12100).

∆ 6.1.2

The hazard identification and risk assessment process assumes that an existing hazard will sooner or later lead to harm if measures are not taken to eliminate or protect against it. Only when hazards are identified can steps be taken to eliminate or reduce the risks associated with them. Where a risk assessment exists and identifies the need for hazardous energy control procedures, this assessment can be used as the basis for the hazardous energy control procedure. If no risk assessment exists and other hazardous energy control methods are employed, then a complete risk assessment shall be conducted (see Clause 7.4.4 and Annex B).

∆ 6.1.3

To minimize possible biases, a team approach should be used for hazard identification and risk assessment. Although an individual may be responsible for drafting a preliminary list of hazards, a team of involved personnel — operators and maintenance and engineering personnel — should participate in the hazard identification and risk assessment effort.

6.2 Task identification

All tasks associated with the intended use and reasonably foreseeable misuse of machines, equipment, and processes shall be identified. Identification should include all phases in the life cycle of the machines, equipment, and processes in question. Task identification should take into account (but not be limited to) the following categories:

a) machine/process set-up;
b) teaching and programming;
c) tryout and start-up;
d) all modes of operation;
e) product feeding into machine/process;
f) product takeoff from machine/process;
g) process/tool changeover;
h) normal stoppages and restart;
i) unscheduled stoppages (control failure or jam) and restart;
j) emergency stoppages and restart;
k) unexpected start-up;
l) fault-finding and troubleshooting;
m) cleaning and housekeeping;
n) planned maintenance and repair; and
o) unplanned maintenance and repair.

Identification of intended use shall include consideration of the manufacturer's information for use and the user's intended use.

6.3 Hazard identification

Following task identification, all hazards, hazardous situations, and possible hazardous events associated with the tasks shall be identified.

In addition, reasonably foreseeable hazards, hazardous situations, or hazardous events not directly related to tasks shall be identified (e.g., earthquakes, lightning, excessive snow loads, noise, collapse or break-up of machinery, and hydraulic hose burst).

Note: *Annex A provides examples of hazards, hazardous situations, and hazardous events. Several methods are available for the systematic identification of hazards. Examples of hazard identification methodologies are provided by Annex C.*

Δ 6.4 Documentation

A record of each task and its associated hazards should be kept and made available, with the objective of making the record a useful tool that provides both a management record and a source of information for managers and workers.

7 Hazardous energy control program

7.1 User responsibilities

7.1.1 Equipment

∆ 7.1.1.1
When the user obtains machines, equipment, or processes (new or rebuilt), they shall comply with Clause 5. If the user obtains non-compliant equipment, the user shall, under the guidance of a knowledgeable person, upgrade the equipment so that it is compliant with Clause 5. If it is impracticable to upgrade non-compliant machines, equipment, or processes to the design requirements of Clause 5, users shall refer to Clause 7.3.2.2 carrying out any activity as stated in Clause 1.3 on such machines, equipment, or processes.

Note: *Examples of equipment that might require upgrading include newly purchased used equipment, equipment designed to standards other than this Standard, rebuilt equipment, and equipment that is moved within or between locations.*

7.1.1.2
If the user purchases components or parts of machines, or assembles a number of machines into an integrated production line, the user assumes the role of integrator and shall meet the requirements of Clause 5. The user shall obtain equipment with isolation devices that allow authorized individuals to execute the hazardous energy control program specified in Clause 7.3.

Note: *A single energy-isolating device that supplies multiple operations or machines can, even if it meets the requirements of this Standard, create situations that encourage personnel to deviate from fulfilling the intent of this Standard. Additional isolation devices or the implementation of other hazardous energy control methods can be necessary to eliminate these situations.*

∆ 7.1.2 Program
The user shall establish a documented program for hazardous energy control that incorporates the requirements of Clauses 7.3 to 7.6. The purpose of such programs is to ensure that risk of exposure to hazards will be eliminated or minimized before any authorized individual performs any activity specified in Clause 1.3 on machines, equipment, or processes where the unexpected energizing, start-up, or release of stored energy could occur and cause injury (see Annex A). This program shall include documented task and hazard identification (see Clause 6) prior to specification of lockout procedures and a risk assessment (see Clause 7.4.3 and Annex B) prior to specification of other control methods.

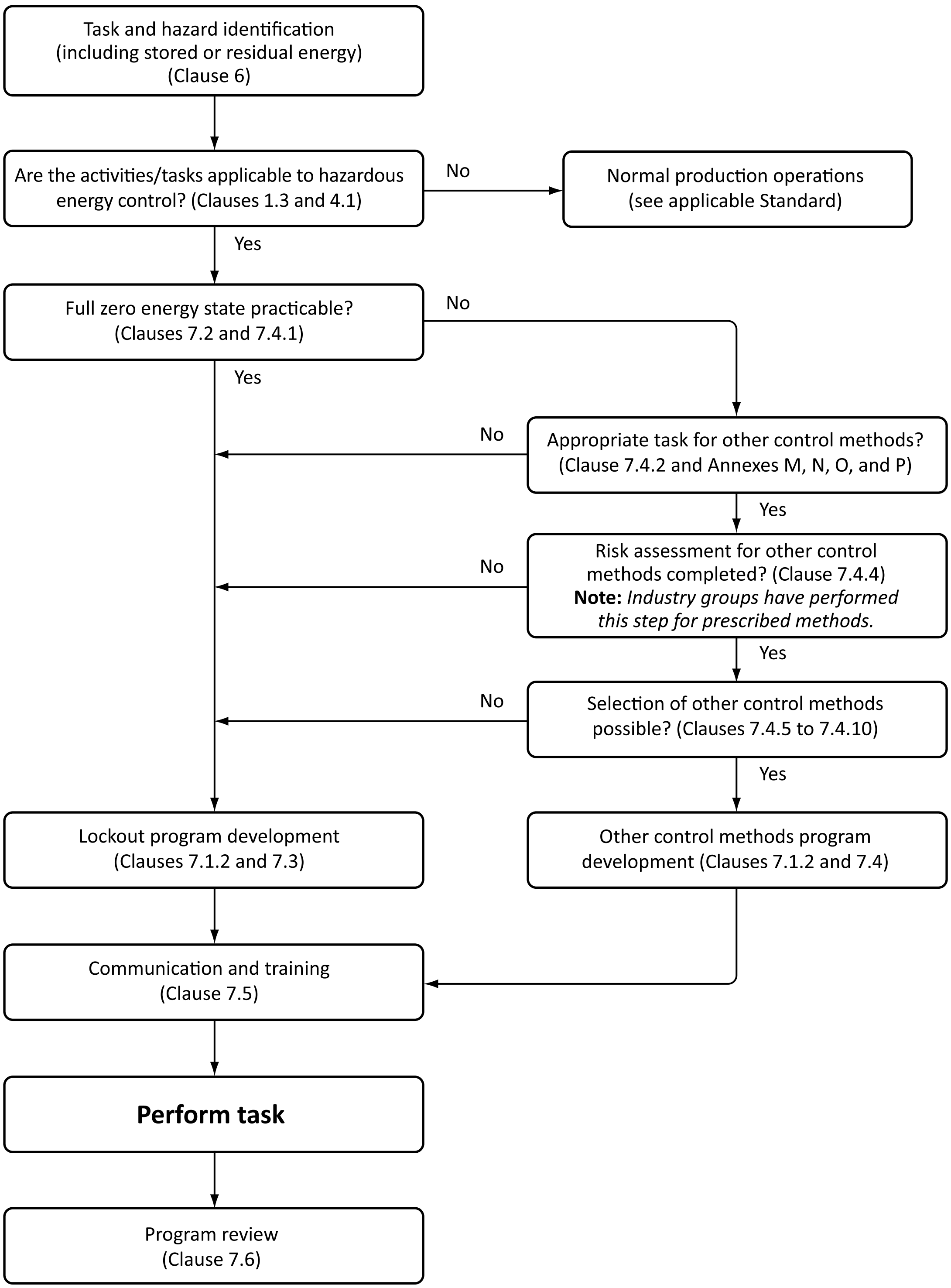
Notes:
1) *A comprehensive risk assessment can also be conducted prior to specification of a lockout procedure if the user thinks it is necessary to minimize risk of injury.*
2) *Users' assessments should consider any warnings and special instructions provided by the manufacturer or supplier.*

∆ 7.2 Methods of control
The method of hazardous energy control selected depends on whether the task can be performed under de-energized conditions or not. In all cases, the primary method of control shall be lockout, as specified in Clause 7.3. When lockout is not used for tasks associated with activities specified in Clause 1.3 that are integral to the production process, or traditional lockout prohibits the completion of those tasks, other control methodologies or procedures, or combinations thereof, as specified in Clause 7.4, shall be used to protect personnel while they are performing these tasks (i.e., achievement of effective risk reduction) (see Figure 2). However, before adopting other methods of control, the user shall conduct a risk

assessment that demonstrates the adequacy of the evaluation and the effectiveness of the protective measures (see Clause 7.4.3 and Figure 3) or use a prescribed method recognized by this Standard (see Clause 7.4 and Annexes J to L).

Δ

Figure 2
Decision logic for a hazardous energy control program
(See Clauses 6.1.1 and 7.2.)



7.3 Lockout program

7.3.1 Program contents

Lockout is a systematic program and is the primary method of hazardous energy control. A lockout program shall consist of the following elements to effectively protect personnel:

a) identification of the hazardous energy covered by the program;
b) identification of the types of energy-isolating devices;
c) identification of the types of de-energizing devices (permanently installed or portable);
d) selection and procurement of protective materials and hardware;
e) assignment of duties and responsibilities;
f) determination of shutdown, de-energization, energization, and start-up sequences;
g) documented lockout procedures for machines, equipment, and processes;
h) training of personnel; and
i) auditing of program elements.

Note: *See Figure D.1 for an example of a lockout policy and program.*

7.3.2 General requirements for lockout

7.3.2.1 Isolation and application of lockout

Energy isolation and lockout shall be performed only by authorized individuals.

7.3.2.2 Lockable/securable energy-isolating devices

Δ 7.3.2.2.1

The lockout program shall require that all energy-isolating devices used to control sources of hazardous energy are capable of being locked out.

Δ 7.3.2.2.2

When energy-isolating devices are not capable of being locked out, they shall be secured in an effective isolating position using a means that prevents the inadvertent operation of the device and tagged using an information tag.

Δ 7.3.2.2.3

Whenever an energy-isolating device is used that is not capable of being locked out, the means of securing that device shall be specified in the lockout program.

Note: *Examples of effective isolating devices include levers with aligning lock tabs (holes), valves with aligning lock holes, locking covers that work only when the switch is in the safe position, wheels with locking tabs and position indicators, and physical blocks with lockable aligning tabs.*

7.3.2.3 Hazardous energy control procedures

Δ 7.3.2.3.1

An important element of the hazardous energy control program is the development of lockout procedures and training. For each unique machine, piece of equipment, or process, detailed lockout procedures for the control of hazardous energy for all activities listed in Clause 1.3 shall be developed and documented. These lockout procedures shall be posted or otherwise readily available for authorized individuals to review and use.

Note: *Examples of machine energy control lockout procedures are provided by Figures D.2 and D.3. Sample lockout placards are shown in Annex E.*

Δ 7.3.2.3.2

Where a facility has two or more pieces of similar equipment or process lines, a single lockout procedure may be applied to all of the similar or identical pieces of equipment, machines, or process lines. The single lockout procedure shall

a) individually identify each machine or process to which it can only be applied;
b) identify and address all differences that affect the lockout of each; and
c) ensure each machine or process has been uniquely and permanently identified to match the specific lockout procedure.

Note: *For example, stamping presses of different capacities need to be locked out to change dies and the lock out procedure could be essentially identical for each. Therefore, a single lockout procedure that identifies each press and any unique steps (such as the location of isolating points), could be used for all machines identified in the procedure. Similarly, a bottling company with two similar bottling lines could have one procedure covering both lines.*

7.3.2.4 Lockout procedure elements

Lockout procedures shall clearly outline the requirements for effective isolation of the machine, equipment, or process. These procedures shall include the following:

a) identification of the machine, equipment, or process;
b) a listing of all required energy-isolating devices and their locations;
c) procedural steps for shutting down, isolating, blocking, securing, and relieving stored or residual energy;
d) procedural steps for placing and removing lockout devices;
e) requirements for verifying that isolation and de-energization have been accomplished; and
f) requirements for verifying that all personnel have been cleared from the work site(s) and that the machine, equipment, or process has been inspected to ensure that it is ready for return to service.

7.3.2.5 Lockout procedure management

7.3.2.5.1 Establishment, responsibilities, and communication

The user shall develop a program/process for developing or revising lockout procedures to address new machine, equipment, or process acquisition; changes to existing machines, equipment, or processes; correction of identified hazardous energy control deficiencies; and addition of hazardous energy control improvements.

The user shall establish responsibilities for ensuring that lockout procedures accurately reflect the current requirements and are effective in controlling machine, equipment, or process hazardous energy.

Lockout procedures shall be readily accessible to authorized individuals and may be maintained via print or electronic media or available in placard style at the machine, equipment, or process.

Note: *Lockout procedures may be supplemented by checklists where machine, equipment, or process isolation or de-energization sequence complexity or criticality warrants.*

7.3.2.5.2 Format

The user should establish guidelines for consistent formatting of lockout procedures.

7.3.2.5.3 Validation

Each lockout procedure shall be verified for its accuracy, completeness, and energy control effectiveness by a knowledgeable person before being approved for use.

7.3.2.5.4 Approval

Each lockout procedure shall be approved by the user or their designee before implementation.

7.3.2.5.5 Document maintenance

Lockout procedures shall be immediately reviewed whenever machinery or energy supplies undergo changes or modifications that can affect the lockout system and whenever deficiencies in the lockout procedure are identified. In addition, a periodic review of the lockout procedures shall be conducted by a knowledgeable person to ensure that they are current. The date of creation, revision, and update of each lockout procedure shall be maintained.

7.3.2.6 Lockout devices and associated hardware

All protective materials and hardware required to effect isolation of energy shall be provided by the user.

All lockout devices (including all tags used with lockout devices) shall
a) be uniquely identified;
b) be the only devices used for controlling hazardous energy;
c) not be used for other purposes;
d) be capable of withstanding the environment to which they are exposed;
e) be standardized within the facility in at least one of the following criteria:
   i) colour;
   ii) shape;
   iii) size; or
   iv) specific markings; and
f) be substantial enough to prevent operation of the energy-isolating device without excessive force, unusual measures, or destructive techniques, e.g., bolt cutters or other metal-cutting tools.

An information tag shall be used with each lockout device unless the lockout device itself has the required information attached.

Each lockout device, and tag if used, shall identify the authorized individual who applied the device and may include the date and reason for lockout. This information shall remain legible for the maximum period of time that exposure is expected.

The wording on locks and tags should warn of hazardous conditions and may include a “Danger” warning as well as wording such as “Do Not Start”, “Do Not Open”, “Do Not Close”, “Do Not Energize”, or “Do Not Operate”.

Note: *Some provincial occupational health and safety regulations require tags for certain applications.*

Δ 7.3.2.7 Energy-isolating device identification

All energy-isolating devices shall be labelled or marked using a standardized nomenclature and format to indicate their function unless they are located and arranged so that their purpose is clearly evident. The identification shall include the following:
a) machine, equipment, or process supplied; and
b) energy type and magnitude.

The labelling or marking shall be of sufficient durability to withstand the anticipated environment.

Note: *The potential for incidents and unplanned occurrences can be reduced if authorized individuals do not have to rely on their recollection of which isolation devices apply to which machines or systems, particularly in situations involving complex equipment. There is a greater potential for error when energy-isolating devices are unlabelled or inadequately identified.*

Where conditions such as complexity or security warrant, coded identification can be used.

Electrical boxes may be labelled directly on the box. Valves may be labelled on the valve body or with a suspended sign or tag.

Note: *Tags, embossing, engraving, and stencilling are some of the ways that labelling and marking are accomplished. The following are examples of the wording used in labels and markings:*

a) *Main Power Press 3 (480 V);*
b) *Natural Gas-Process Line 2;*
c) *Hydraulic Pump Discharge (5500 kPa); and*
d) *Bay A Compressed Air (690 kPa).*

7.3.3 Elements of energy control

7.3.3.1 Action sequence

The elements of energy control shall include the actions specified in Clauses 7.3.3.2 to 7.3.3.10 and should be performed in the same sequence as those clauses.

7.3.3.2 Identification of machine, equipment, or process

The machine, equipment, or process to be isolated shall be identified.

7.3.3.3 Preparation for machine, equipment, or process shutdown

Authorized individuals shall understand the applicable procedures, understand the hazards that need to be isolated or controlled, acquire the necessary protective materials and hardware, identify the notification requirements, identify related issues, and assess the consequences of the shutdown.

7.3.3.4 Notification of personnel

Personnel who could be affected by the shutdown of the machine, equipment, or process shall be notified before application and after removal of lockout devices.

7.3.3.5 Machine, equipment, or process shutdown

The machine, equipment, or process shall be shutdown (de-energized) using the specific established hazardous energy control procedures.

Note: *It is possible that a specific shutdown sequence will be necessary to avoid additional or increased hazard(s) to individuals as a result of the machine, equipment, or process stoppage.*

7.3.3.6 Machine, equipment, or process isolation

All energy-isolating devices that are needed to control the energy to the machine, equipment, or process to accomplish the required task(s) shall be identified and operated in a manner that isolates the machine, equipment, or process from the energy supply.

For complex machines, equipment, and processes where it is necessary to isolate power or motion for a specific component while maintaining power to control systems, support utilities, and other devices and components, sectional (localized) lockable energy-isolating devices shall be used.

Note: *Hazardous energy can exist in machines, equipment, and processes adjacent to those being worked on. In such cases, appropriate energy-isolation or other safety-related steps might be necessary.*

7.3.3.7 Controlling stored energy

Δ 7.3.3.7.1

All potentially hazardous stored, residual, or potential energy shall be de-energized, relieved, disconnected, restrained, blocked, or otherwise controlled.

Δ 7.3.3.7.2

If the device used to control stored energy is not designed to accept a lock (e.g., blocks, pins, manual live disconnect switches, and cribbing), additional measures, such as information tags, shall be taken to prevent the device from being inadvertently removed or operated.

Note: *Additional measures to prevent re-accumulation of energy (e.g., a bleed valve secured open) might be necessary to protect individuals.*

7.3.3.8 Lockout device application

Δ 7.3.3.8.1

Lockout devices shall be affixed to each energy-isolating device by authorized individuals and in a manner that will ensure that the energy-isolating device(s) remain in a position that prevents energization of the machine, equipment, or process.

Δ 7.3.3.8.2

Where only locks are used, the locks shall, at a minimum, have the authorized individual's name or means of identification applied directly to the lock. There should also be a means for determining the date and reason for lockout.

Δ 7.3.3.8.3

The application of a lockout device shall not itself create a hazard to either authorized or affected individuals.

Δ 7.3.3.9 Verification of isolation

Before starting work on machines, equipment, or processes that have been locked out, an authorized individual shall verify that isolation and de-energization have been accomplished.

Notes:

1) *Verification can be accomplished by, for example,*
   a) *testing circuitry;*
   b) *attempting system cycling;*
   c) *visually inspecting the position;*
   d) *manually trying the machinery controls, actuating devices, or locked-out mechanisms;*
   e) *monitoring movement or discharge; or*
   f) *observing bleeds, gauges, indicators, etc.*

2) *Technique(s) that provide the best degree of isolation assurance, while ensuring that no new hazards will be created, should be used.*

7.3.3.10 Return to service

Δ 7.3.3.10.1
The authorized individual assigned to return the equipment to service shall first inspect the work area to check that all personnel associated with the lockout who could be affected by re-energization have been cleared from the danger zone and are accounted for before energy is restored to the machine, equipment, or process. In addition, the authorized individual shall check that all non-essential items have been removed and that the machine, equipment, or process is operationally intact.

Δ 7.3.3.10.2
Once the authorized individual is satisfied that the machine, equipment, or process is in a ready state, each lockout device and information tag, if used, shall be removed from the energy-isolating device(s)

a) by the authorized individual who applied the lockout devices;
b) as specified in Clause 7.3.5, and the machine, equipment, or process shall then be re-energized; or
c) by a primary authorized individual as specified in Clauses 7.3.7.2 and 7.3.7.3.

The machine, equipment, or process may then be safely re-energized.

Δ 7.3.3.10.3
After the machine, equipment, or process is re-energized, and before it is started, personnel who could be affected by such action shall be notified of the imminent restart (see Clause 7.3.2.4).

Note: *This procedure assumes that the machine, equipment, or process is to be re-energized soon after the locks have been removed. If the equipment is to sit idle for a time, a separate pre-start-up process should address the notification requirements.*

7.3.4 Energy control interruption (testing)

7.3.4.1 Action sequence
In situations where lockout devices are to be temporarily removed from an energy-isolating device and from a fully or partially energized machine, equipment, or process to test, troubleshoot, or reposition the machine, equipment, or process (or a component thereof), the actions specified in Clauses 7.3.4.2 to 7.3.4.5 shall be performed in the same sequence as those clauses.

7.3.4.2 Notification of personnel
All personnel associated with the lockout of the machine, equipment, or process shall be notified of the intent to fully or partially re-energize the machine, equipment, or process.

7.3.4.3 Assessment of machine, equipment, or process
When a machine, equipment, or process is to be re-energized, the state of the maintenance work shall be assessed to ensure that the machine, equipment, or process is in a safe and ready state to be re-energized.

7.3.4.4 Approval to re-energize
Once the approval of all personnel associated with the lockout has been obtained (based on a clear understanding that they are to stand clear of the machine, equipment, or process), and all personal locks are removed from the lockout devices, the machine, equipment, or process may be fully or partially re-energized.

7.3.4.5 Re-establishment of energy control

When the energy is no longer needed, lockout shall be reapplied in accordance with Clause 7.3.3.10.

7.3.5 Lockout and tag removal when authorized individual is absent

7.3.5.1

A procedure shall be established for the safe removal of a lockout device and information tag inadvertently left on an energy-isolating device by an authorized individual who has left the workplace or is not available to remove them. For safe removal of lockout devices and tags, the site or facility shall have an approved procedure in place that identifies one or more individuals who are authorized to remove abandoned locks.

7.3.5.2

The procedure specified in Clause 7.3.5.1 shall ensure that

a) the authorized individual has left the workplace;
b) every reasonable attempt has been made to contact the authorized individual directly (e.g., by telephone); and
c) the authorized individual, if contacted, is made aware of the situation and asked to come back to the workplace to remove their locks and tags, as required.

7.3.5.3

If the authorized individual who installed the lock and tag cannot be contacted, or is not reasonably available to return to the workplace, an individual authorized to remove locks should be called on to safely remove the lock and tag (if used).

If an authorized removal is undertaken, the following steps shall be performed:

a) the status and condition of the machine, equipment, or process shall be assessed and verified to be in a state that will allow for the safe removal of the lockout device (in accordance with Clause 7.3.3.10, if applicable);
b) provisions are made to ensure that the authorized individual will be notified before returning to work that the lock and tag have been removed;
c) the individual responsible for the removal completes a lockout removal report after it has been determined that it is safe to remove the lock and tag; and
d) the lockout device and tag are removed with a witness present and secured by the individual responsible for the removal.

7.3.6 Outside service or contractor personnel

7.3.6.1 Determining relationship, responsibilities, and obligations

The host-user and the outside service or contractor shall each designate a representative responsible for determining their relationship, responsibilities, and obligations regarding hazardous energy control before the outside service or contractor starts work or provides services.

7.3.6.2 Hazard assessment

The host-user shall inform the outside service or contractor's designated representative of any special or unique hazards related to the machinery, equipment, or process to which outside service or contract personnel could be exposed.

7.3.6.3 Program coordination

All outside service or contractor programs shall be coordinated with the host-user's hazardous energy control program when there is integration of job tasks. Protection for all individuals who could be exposed to hazardous energy within the facility shall be mutually understood, communicated, and agreed upon between the parties.

Note: *Contractor programs can be similar yet different in the form they take (i.e., in their practice or hardware). To eliminate confusion or clearly differentiate and standardize on contractor-controlled lockouts, the host-user site may provide locks and tags that are coordinated with the site lock and tag system. Communication is a key element of a hazardous energy control program and a clear lock and tag identity with assigned responsibility is important.*

7.3.6.4 Communications

Before and during the course of the work, the host-user and the outside service or contractor shall keep each other informed of any activities or conditions that could adversely affect the application of hazardous energy control or the normal operation of machines, equipment, or processes.

Note: *Examples of activities or conditions that can warrant communication between the parties include interruption of energy supply, disabling of a fire protection/security system, emergency alarm systems, hazardous area ventilation, and special equipment for energy isolation.*

7.3.6.5 Temporary personnel

Temporary personnel involved in activities that require lockout shall be trained, issued locks and tags, and, depending on their job responsibilities, possess the applicable qualifications to perform work covered by this Standard.

7.3.7 Recognized lockout processes

Δ 7.3.7.1 Individual lockout

This basic approach to lockout requires each individual involved in activities requiring lockout to be knowledgeable about the hazards associated with the machine, equipment, or process to be isolated and about the isolation required to ensure their protection. Every such individual shall be accountable for ensuring before work begins that the required energy-isolating devices have been placed in the required positions and locked with their personal locks. They shall also verify before work begins that the machine, equipment, or process has been isolated and de-energized in accordance with Clause 7.3.3.9 (see Figure D.2 for an example of an individual lockout procedure).

Δ 7.3.7.2 Group lockout

When more than one authorized individual is being protected by multiple energy-isolating devices, each energy-isolating device shall be secured by a single lockout in accordance with the following steps:

a) a primary authorized individual is assigned responsibility for the lockout of each energy-isolating device;
b) the keys for the lockout devices are controlled by a lockable device (e.g., lock box or key ring) that is locked by the primary authorized individual;
c) once the lockout is applied, a verification procedure is used to determine the effectiveness of the energy isolation in accordance with Clause 7.3.3.9;
d) before authorized individuals start work, they
   i) familiarize themselves with the energy-isolating devices to be used; and
   ii) assess their adequacy for the work to be performed (using the appropriate lockout procedure);
e) authorized individuals then apply their personal lock (and tag if used) to the lockable device. Each authorized individual should request, at the time of lockout, that isolation be verified in their presence;

f) work commences only after the authorized individuals have applied their personal lock (and tag if used) to the lockable device and are confident that all hazardous energy has been isolated and locked out;
g) as the authorized individuals complete their work, they remove all non-essential items from the work site. When they are sure that they have no reason to return, they can then consider their need for isolation to have ended, following which they remove their personal lock (and tag if used) from the lockable device; and
h) when all authorized individuals have removed their personal locks and tags from the lockable device, the primary authorized individual assigned responsibility for the lockout walks down or around the isolated machine, equipment, or process to check that all authorized individuals are clear before removing the locks from the isolating devices.

Group lockout should be considered when more than two or three authorized individuals are involved or more than four or five devices require isolation. See Annex G for an example of a group lockout procedure.

Δ 7.3.7.3 Complex group lockout

A complex group lockout approach can be used when it is not practicable for a workplace to directly comply with the individual lockout approach or with the group lockout approach to hazardous energy control because of one or more of the following:
a) the physical extent of the equipment or process being serviced;
b) the relative inaccessibility of the energy-isolating devices;
c) the number of individuals performing the service and maintenance activities;
d) the number of energy-isolating devices to be isolated;
e) the length of time equipment or processes will be isolated;
f) the number of authorized individuals involved; or
g) the interdependence and interrelationship of the components in the system or between different systems.

Whenever a complex group lockout approach is used, an equivalent level (to individual lockout) of personal protection for each member of a working group shall be established through the use of individual continuous accountability methods such as work permits or control boards. An authorized individual shall verify the isolation and lockout to determine the effectiveness of the energy isolation each time it is used. See Annex G.

In workplaces where a complex group lockout system is established, approval for that system shall be sought from the regulatory authority having jurisdiction.

7.3.8 Shift or personnel changes

Procedures shall be used during shift or personnel changes to ensure the continuity of lockout or protection, including a procedure for the orderly transfer of lockout or device protection from departing to incoming authorized individuals to minimize exposure to hazards from the unexpected energization or start-up of the machine, equipment, or process or from the release of stored energy.

Note: *An example of shift or personnel changes is as follows: a supervisor/trade lock is applied to each energy-isolating device in addition to the authorized individual's or contractor's energy-isolating device. When each authorized individual or contractor has completed their shift, but the work is not completed, or when the authorized individual or contractor has to leave the workplace (e.g., to pick up parts or move to another machine), the authorized individual's lock is removed, leaving the supervisor/trade lock still applied. The sole purpose is to maintain the integrity of the lockout between authorized individuals or contractors. The supervisor/trade lock is removed when all work is completed and machinery or equipment is ready to be returned to service.*

Δ 7.3.9 Remote or non-contiguous locations

Where energy-isolation devices are in remote or non-contiguous locations, documented procedures shall be used in conjunction with written authorizations to ensure that authorized individuals performing the work verify the isolation and de-energization or re-energization through direct communication with personnel designated to perform the actual lockout. The energy-isolating devices shall be locked and the keys for the devices controlled by a lockable device that is locked by the person designated by the procedures to establish the isolation on behalf of the authorized individuals.

Note: *Examples of remote or non-contiguous locations include pipeline operations with widely spaced pump stations, offshore oil and gas production facilities connected to onshore terminals, gas distribution systems, gas wells and compressor stations, electricity generating plants, and power transmission and distribution systems.*

7.3.10 Special applications

The design of some types of equipment or process systems might inhibit the use of the established lockout procedures described in Clauses 7.3.2 to 7.3.8. In these cases, other methods of hazardous energy control, as specified in Clause 7.4, shall be used to prevent the unexpected movement or motion of equipment or to minimize the risk of a hazardous condition or event. Users should obtain the recognized Standard(s) for their machines, equipment, and processes to determine whether or not other control methods are necessary.

7.3.11 Freeze plug technology

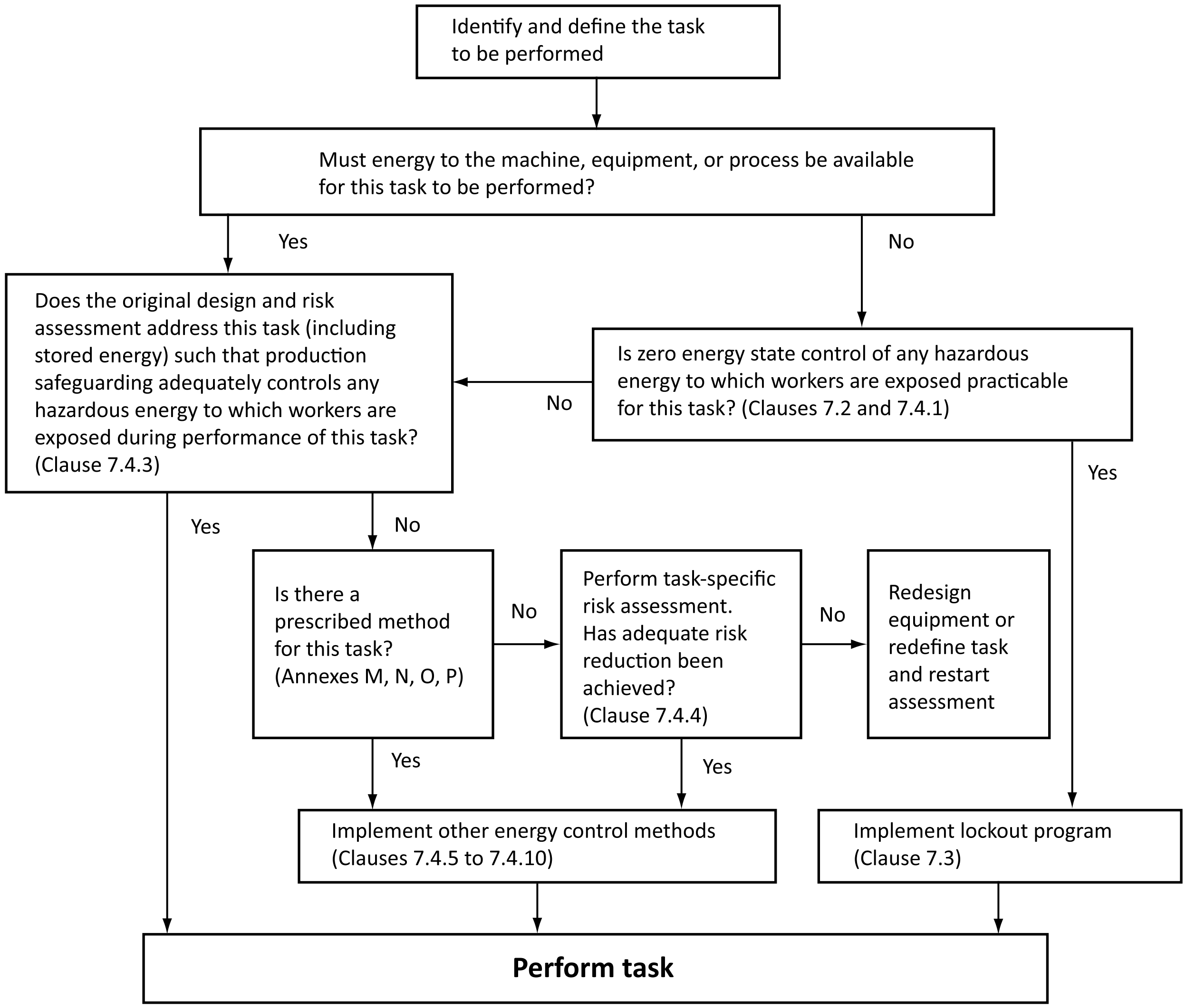
Freeze plug technology for isolating piping systems shall provide the same degree of protection for exposed personnel and essentially follow the requirements of Clause 7.2 for the lockout of hazardous energy sources. See Annex H for additional guidance.

7.4 Other hazardous energy control methods

7.4.1 General

Traditional lockout to a full zero energy state is not practicable in all situations. When lockout affects tasks that are integral to the production process by design, or traditional lockout prohibits the completion of specific tasks, other hazardous energy control methods shall be used (see Figure 3). Control options such as those specified in Clauses 7.4.6 to 7.4.10 shall be used in accordance with the hierarchy specified in Clause 7.4.5 to ensure effective protection (see Figure 4).

Δ **Figure 3**
Decision logic for selecting method of hazardous energy control
(See Clauses 7.2, 7.4.1, and L.1.)



Δ 7.4.2 Appropriate tasks for other control methods

To be considered integral to production, designed tasks shall exhibit most of the following characteristics:

a) of short duration;
b) relatively minor in nature;
c) occurring frequently during the shift or production day;
d) usually performed by operators, set-up persons, and maintenance personnel;
e) represent predetermined cyclical activities;
f) minimally interrupt the operation of the production process;
g) exist even when optimal operating levels are achieved; and
h) require task-specific personnel training.

Δ 7.4.3 Selection of other control methods

The user shall select other control methods that are designed so that effective risk reduction has been achieved as specified in Clause 7.4.4. The risk assessment shall take into consideration the fact that it is possible that existing safeguards provided with the machine, equipment, or process will need to be removed or modified to perform a given task. The other control method selected shall have detailed procedures developed and documented for the control of hazardous energy.

Notes:

1) *Activities that might be performed using other energy control methods include, but are not limited to, lubrication, tool changes, minor cleaning, clearing, troubleshooting, adjustments, inspection, and set-up.*
2) *It is important to select the correct devices for the application. A review will ensure that proper safety devices such as those specified in Clauses 7.4.4 to 7.4.7 are used. If the review identifies an application where special engineered devices such as blocks, racks, supports, or pins are required, these devices should be designed and built using appropriate safety factors.*
3) *It is understood that it is possible that a risk assessment will have been completed by industry organizations in the design of prescribed methods recognized by this Standard (see Annexes J to L). If a prescribed method is selected as appropriate for a specific task, the user need not conduct another risk assessment in order to determine that effective risk reduction has been achieved.*

∆ 7.4.4 Risk assessment for other hazardous energy control procedures

Note: *This Standard does not require a specific risk assessment methodology, but includes Annexes B and C as examples to illustrate the analytical concept that can be necessary to ensure that any other method(s) selected provide effective risk reduction for the exposed individuals. Refer to CSA Z1002 and ISO 12100 for guidance on conducting risk assessments.*

∆ 7.4.4.1 Risk estimation

After the hazard assessment (Clause 6) has been conducted, and before other energy control methods are implemented (Clause 7.4.5), a task-specific risk estimation shall be performed.

Risk, in relation to the considered hazard, is a function of the severity of harm that can result from the considered hazard and the likelihood of occurrence of that harm. The likelihood of occurrence depends on the exposure of person(s) to the hazard, the frequency and duration of a hazardous event, and the possibility of avoiding or limiting the harm.

Note: *ISO 12100 lists many of the factors that need to be considered when estimating severity and likelihood of occurrence.*

∆ 7.4.4.2 Risk evaluation

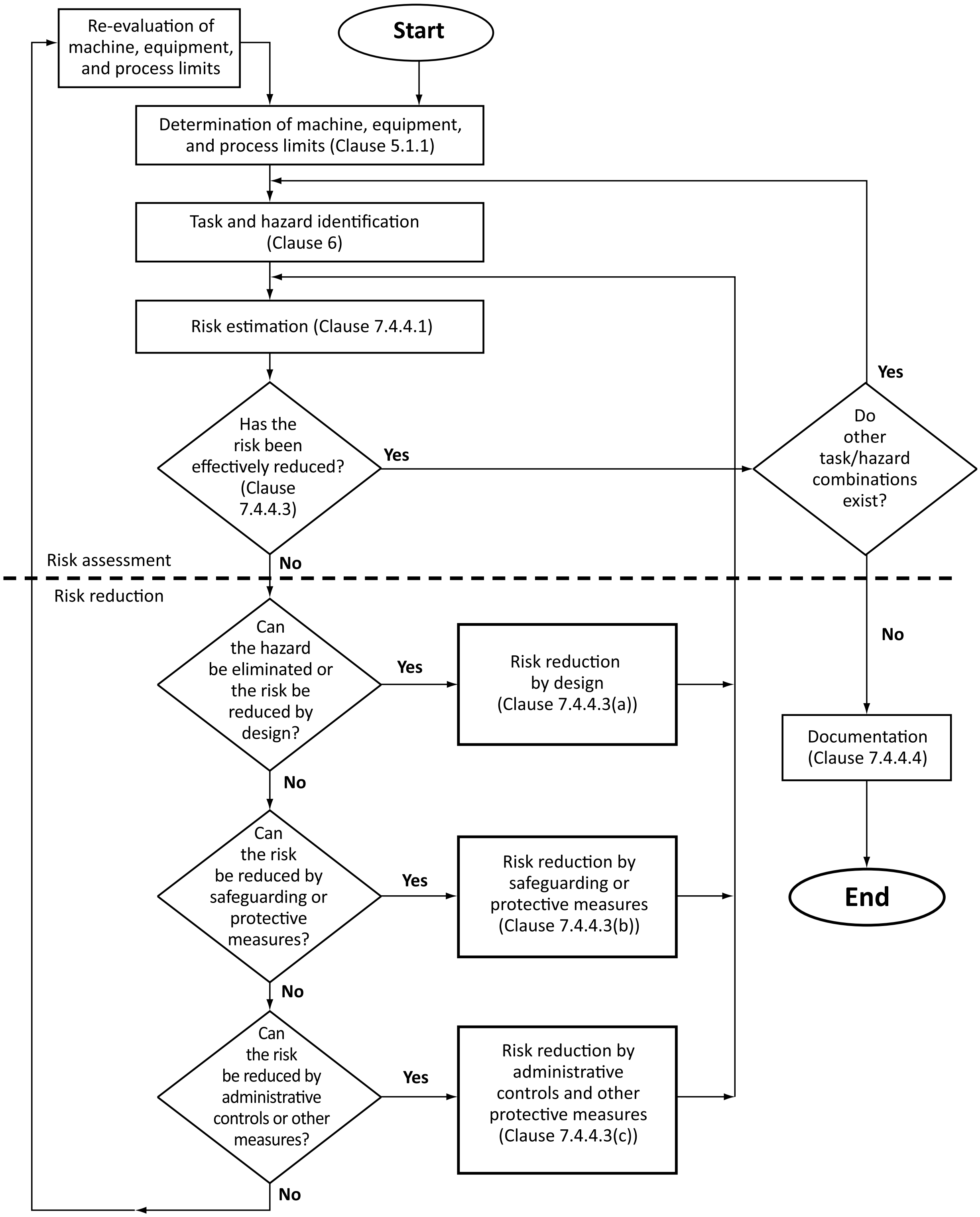
After risk estimation, a risk evaluation shall be carried out to determine whether risk reduction is required or effective risk reduction has been achieved. If risk reduction is required, the appropriate protective measures shall be selected and applied, and the procedure repeated (see Figure 4). During this iterative process, it is important for the user to check whether additional hazards are created when new protective measures are applied. If additional hazards do occur, they shall be added to the list of identified hazards.

The achievement of effective risk reduction and a favourable outcome of risk comparison, applied when practicable, gives confidence that risk has been effectively reduced.

To minimize possible biases, a team approach should be used. Although an individual may be responsible for drafting a preliminary list of hazards, a team of involved personnel — operators and maintenance and engineering personnel — should participate in the hazard assessment effort.

Δ

Figure 4
Schematic representation of the risk assessment/reduction process model
(See Clauses 7.4.1, 7.4.4.2, and 7.4.4.4.)



Δ 7.4.4.3 Risk reduction

Achievement of effective risk reduction shall involve application of the following, in the following order:

a) elimination or reduction of the risk by system design, substitution of less hazardous materials and substances, or application of ergonomic principles;
b) reduction of the risk by application of safeguarding and complementary protective measures that effectively reduce risk for the intended use and are appropriate for the application; and
c) providing, when the application of safeguarding or other protective measures is not practicable, information for safe use, including notice of any residual risk that can exist. This information shall include, but not be limited to, the following:
   i) the operating procedures for the use of the machines, equipment, or processes, which shall be consistent with the ability of personnel who use the machines, equipment, or processes or other persons who can be exposed to the hazards associated with the machines, equipment, or processes;
   ii) the recommended safe working practices for the use of the machines, equipment, or processes and the related training requirements; and
   iii) all residual risks in the different phases of the life of the machines, equipment, or processes.

If, after these risk reduction methods are applied, effective risk reduction cannot be achieved, use of a lockout procedure should be considered. If a lockout procedure cannot be used and effective risk reduction cannot be achieved using other control methods, the activity or task should not be performed.

Note: *ISO 12100 provides practical guidance on risk assessment and risk reduction.*

Δ 7.4.4.4 Documentation

The procedure followed and the results achieved shall be documented for the risk assessment. This documentation shall include the following, as applicable:

a) the machines, equipment, or processes for which the assessment has been made (e.g., specifications, limits, intended use) and any relevant assumptions that have been made (e.g., loads, strengths, safety factors);
b) the hazards identified, as follows:
   i) the hazardous situations identified; and
   ii) the hazardous events considered;
c) the information on which the risk assessment was based, as follows:
   i) the data used and the sources (e.g., accident histories, experiences gained from risk reduction applied to similar machinery); and
   ii) the uncertainty associated with the data and its impact on the risk assessment;
d) the objectives to be achieved by protective measures;
e) the protective measures implemented to eliminate identified hazards or reduce risk (e.g., measures taken from Standards or other specifications);
f) the residual risks associated with the machines, equipment, or processes;
g) the result of the final risk evaluation (see Figure 4); and
h) any forms completed during the assessment, e.g., of the type included in Annex C.

Δ 7.4.5 Hierarchy of implementation

A hierarchical process shall be employed in selecting other hazardous energy control methods. This process shall be based on the following order of preference:

a) eliminate the hazard through design;
b) use the engineered safeguards specified in Clause 7.4.6;
c) use the warning and alerting techniques specified in Clause 7.4.7;
d) use the administrative controls specified in Clauses 7.4.8 and 7.4.9; and

e) use the personal protective equipment specified in Clause 7.4.10.

Once a control method has been selected in accordance with Items (b) to (e), a communication and training strategy shall be developed and implemented (see Clause 7.5).

Note: *The objective of this process is to select the highest feasible level of control. In many cases, application of a single control methodology is unable to provide an effective level of protection for personnel. It might be necessary to use a combination of the methods specified in Clauses 7.4.6 to 7.4.10 to provide effective protection.*

7.4.6 Engineered safeguards

∆ 7.4.6.1 General

When using an engineered safeguard as an element of an energy control method, the user shall use quality components appropriate for the application, incorporate control system integrity, consider the effectiveness and failure modes of the device(s), assess the possible residual risks, and assess the possibility that the safeguard might be defeated or bypassed. Engineered safeguards shall provide a level of protection equivalent to lockout to prevent the unexpected energization of equipment being serviced.

Note: *General guidance on engineered safeguards can be found in CSA Z432 and ISO 12100.*

7.4.6.2 Individual personal control

The user shall provide a means of individual personal control to prevent exposure to the hazardous energy.

Note: *Examples include locks, pendants, and locking guards as well as location and proximity to control devices.*

∆ 7.4.6.3 Control system integrity

When control systems are used as part of safeguarding intended for use during set-up, troubleshooting, or other tasks requiring energization or partial de-energization, the level of risk shall be determined by identifying the involved tasks, hazards, potential severity of injury, and exposure. Under all circumstances, the authorized individual shall have personal control over the means for maintaining the control system in a protective mode.

Notes:

1) *Greater potential for injury, more frequent access, and more direct contact with the hazard are all factors resulting in greater risk and require a higher level of integrity.*
2) *Guidance on control system integrity can be found in CSA Z432, ISO 13849-1, and IEC 62061.*

7.4.6.4 Area scanners

Area scanners detect objects or persons entering the sensing field (hazardous area). They are typically used for covering large or irregularly shaped areas.

Note: *Design guidance can be found in CAN/CSA-E61496-1 and IEC 61496-3. Application information can be found in IEC TS 62046.*

∆ 7.4.6.5 Guards

Two types of guards — fixed and movable — are considered in this Standard. Guards that do not have to be opened frequently are usually fixed in such a way that tools are required for their removal. In accordance with CSA Z432, movable guards shall be interlocked. Guards shall not create additional hazards to personnel.

Note: *General guidance can be found in CSA Z432 and ISO 12100. Guidance on specific guarding methods can be found in ISO 14119 and ISO 14120.*

7.4.6.6 Hold-to-run devices

Hold-to-run devices require application of direct pressure to one or more buttons or switches by one or both hands. If the button or switch is released, a signal is sent to the control system. These devices only protect the individual using the device.

Note: *Three-position (centre-enable) devices offer additional protection to the holder by sending an "off" signal to the control if the device is released or fully compressed.*

7.4.6.7 Light curtains and single opto-electronic beams

Light curtains and single opto-electronic beam devices create a sensing plane composed of one or more transmitting elements and one or more receiving elements. When an object or person interrupts one or more beams, the device sends a signal to the control system.

Note: *Design guidance can be found in CAN/CSA-E61496-1 and CAN/CSA-E61496-2. Application information can be found in IEC TS 62046.*

7.4.6.8 Pressure mats

Pressure mats are used to detect the presence of a person or object on a surface used for walking. A signal is sent to the control system when downward pressure is applied to the mat.

Note: *Design guidance can be found in ISO 13856-1. Application information can be found in IEC TS 62046.*

7.4.6.9 Safety-rated switches

Safety-related switches are tamper-resistant and mechanically actuated devices with positively driven multiple contacts. Magnetic switches may be safety rated if they are coded and have monitored contacts.

7.4.6.10 Stop devices

Stop devices are usually push buttons, cables, or position or edge sensors that activate a switch. A signal is sent to the control system when the device is activated.

7.4.6.11 Trapped key devices

Trapped key devices are mechanically attached to power circuits, switches, valves, and access points and require operators to follow a predetermined sequence of actions. Keys are captive or free in electro-mechanical and mechanical interlocks, depending on the condition of the equipment or process.

Note: *Annex M provides examples of trapped key use.*

7.4.7 Warning and alerting techniques

∆ 7.4.7.1 General

Warning or alerting techniques shall be implemented when a risk assessment indicates that their use would be beneficial or where engineered safeguards alone do not provide an effective level of protection. Some techniques that should be considered are specified in Clauses 7.4.7.2 to 7.4.7.5.

7.4.7.2 Attendant

An attendant may be used in addition to other control methods to warn exposed personnel of problems or monitor the effectiveness of the applied safeguard.

7.4.7.3 Automated warning systems

Automated audible or visual devices may be used individually or in combination to warn personnel of potentially hazardous conditions.

7.4.7.4 Barricades
Barricades may be used (in conjunction with warning signs, placards, and tags if applicable) to prevent access to a hazardous area.

7.4.7.5 Warning signs, placards, and tags
Warning signs, placards, and tags may be used to warn personnel where hazards exist.

7.4.8 Administrative controls (safe work procedures and practices)

7.4.8.1 Safe work procedures
When a risk assessment indicates their use would be beneficial or engineered safeguards, warning and alerting techniques, or both do not provide an effective level of protection, administrative controls such as safe work procedures and practices shall be developed and implemented. The factors specified in Clauses 7.4.8.2 to 7.4.8.4 shall be considered when safe work procedures and practices are being developed.

Δ 7.4.8.2 Apparel, jewellery, and hair
Loose clothing, dangling jewellery, unsecured long hair, etc. that could come into contact with moving machinery or equipment or become entangled during a fall, shall not be allowed (see CSA Z432). Exposed conductive articles of jewellery and clothing, including metalized aprons, cloth with conductive thread, and metal headgear, shall not be allowed to be worn where they present an electrical contact hazard (see also CSA Z462).

Δ 7.4.8.3 Illumination
Sufficient illumination for the task to be performed safely shall be available.

7.4.8.4 Preparation for work
All authorized individuals involved with the task or activity shall, before starting the work, review applicable existing hazards, documented practices, and documented control measures.

7.4.9 Administrative controls (training)
Training on the use of other control methods shall be conducted in accordance with Clause 7.5.2.

7.4.10 Personal protective equipment
When a risk assessment indicates their use would be beneficial or engineered safeguards, warning and alerting techniques, safe work procedures and practices, or combinations thereof do not provide an effective level of protection, authorized individuals shall be protected from injury by appropriate personal protective equipment.

7.5 Communication and training

Δ 7.5.1 Communication and awareness
Users shall be responsible for informing all individuals about the provisions of the hazardous energy control program to an appropriate level. Users shall also be responsible for informing appropriate individuals about aspects of the hazardous energy control program such as changes in the program, incident experiences, progress against the plan to achieve effective risk reduction, performance data, and auditing results.

Δ 7.5.2 Training

Note: *Information on developing effective training programs can be found in CSA Z1001.*

7.5.2.1 Authorized individuals

The user shall provide initial training that will assist all authorized individuals to understand the purpose and function of the control program to an extent appropriate for the level of hazard exposure they will possibly encounter. The training program shall comply with the following requirements:

a) Individual training shall be carried out prior to authorized individuals performing service and maintenance tasks or being potentially exposed to hazardous energy.
b) Training shall be specific to the user's documented program.
c) The training program shall be developed using applicable manufacturer's documentation, industry best practices, regulatory requirements, and input from authorized individuals.
d) Each authorized individual shall receive training related to the type and magnitude of the energy available in the workplace.
e) Each authorized individual shall receive training related to the type of energy that might be encountered during servicing or maintenance and the methods or means to control and isolate that energy and verify its controlled state.
f) Training shall include samples of machine-specific procedures and enable personnel to interpret and implement procedures developed in Clause 7.3.2.2.
g) The user shall document that all initial and additional training has been conducted. The documentation shall include the name, date(s) of training, and the training topic(s) for each individual trained. Documentation of the information covered during training sessions should be maintained.

Δ 7.5.2.2 Affected individuals

The user shall provide initial training that will assist all affected individuals to understand the purpose and function of the hazardous energy control program to the extent appropriate to the level of hazard exposure they will possibly encounter. The training program shall comply with the following requirements:

a) Training shall be specific to the user's program.
b) Training shall include an understanding of potential hazards to themselves and authorized individuals.
c) Training shall be carried out prior to affected individuals being located in the work area.
d) The user shall document that all initial and additional training has been conducted. The document shall include the name, date(s) of training, and the training topic(s) for each individual trained. Documentation of the information covered during training sessions should be maintained.

Δ 7.5.2.3 Nature of training

The user should avoid exclusive use of generic training programs to ensure that individuals adequately understand the user's program (oriented toward the particular needs of the workplace).

Δ 7.5.2.4 Training methods

Training methods may include, but shall not be limited to, formal instruction (direct instructor contact), computer-based or interactive training, simulations, and practical demonstrated applications.

Δ 7.5.2.5 Periodic refresher training

Every effort should be made to structure training so that it can be understood by all individuals regardless of their level of education, primary language, or abilities. Individuals shall receive periodic refresher training, at intervals not to exceed 3 years, to maintain an appropriate level of understanding and shall receive additional training if:

a) supervision or inspections indicate that the individual is not complying with a hazardous energy control program;
b) changed or new technology, equipment, job assignment, or procedures necessitate the use of a hazardous energy control program that is different from that the individual would normally use; or
c) the individual needs to employ a hazardous energy control program that is not normally used during regular job duties.

The content of this refresher training shall be based on known hazards and risk assessment for the planned work activities and working conditions.

Δ 7.5.3 Assessment of training

The user shall assess the effectiveness of the training in a way that ensures that authorized individuals demonstrate

a) knowledge of the program;
b) recognition and understanding of hazardous energy types; and
c) use of appropriate energy control procedures.

Authorized individuals who do not demonstrate an adequate level of knowledge or use of appropriate energy control procedures shall be retrained.

Note: *Information on assessment training programs can be found in CSA Z1001.*

7.6 Program review

7.6.1 General

The user shall assess the condition and effectiveness of each element of the hazardous energy control program at regular intervals of three years or less (see Clause 7.2). The assessment shall include, at a minimum, the documented program; specific machine, equipment, or process procedures; lockout hardware; energy-isolating devices; other hazardous energy control methods; and communication and training.

7.6.2 Program monitoring and measurement

Δ 7.6.2.1

The user shall determine the frequency for monitoring and measuring each element of the hazardous energy control program.

This monitoring and measuring frequency shall be at regular intervals of three years or less.

Note: *Various methods can be used to determine whether the program has appropriate content, describes current conditions, and is properly executed.*

7.6.2.2

Monitoring, measuring, and assessing components should be included in the program review. A measurement system that is capable of providing qualitative and quantitative feedback on hazardous energy control performance should be established. Emphasis should be placed on both operational and maintenance personnel who are directly involved in hazardous energy control application.

7.6.2.3

Criteria that provide a basis for repetitive measurement should be established. Management should compare results and determine whether there is a positive or negative change in any program element. A summary should include trends, variances, rates of compliance, key findings and observations, and recommendations for program improvement.

7.6.3 Application of specific procedures

Compliance with specific hazardous energy control procedures (machine, equipment, or process) is critical. Therefore, the user shall establish a continual auditing plan that will provide current information on maintenance of application effectiveness. The user shall be responsible for executing the auditing plan to verify that complete compliance is occurring. Auditing shall be conducted at least annually and documentation shall be maintained for at least three years.

The user should determine the frequency of monitoring (e.g., monthly) and an appropriate specific hazardous energy control procedure application sample size. The application effectiveness audits should be random and address all shifts, days of operation, groups, non-standard work situations, and individual personnel. Knowledgeable personnel should conduct visual observations of authorized individuals performing specific hazardous energy control tasks. These observations should include feedback to the authorized individuals and documentation of the findings and any recommended improvements.

Note: *See Annex N for a sample tag removal form resulting from an observation of an improperly applied or poorly managed lock.*

7.6.4 Performance feedback

The user shall establish a system for providing both positive and negative feedback on the hazardous energy control program to supervisors and other appropriate personnel. Where deficiencies are found, corrective action shall be taken and the appropriate individuals informed of the required improvements.

Annex A (informative)
Examples of hazards, hazardous situations, and hazardous events

Note: *This Annex is not a mandatory part of this Standard.*

Δ A.1 General

This Annex presents, in tabular form, examples of hazards (Table A.1), of tasks whose performance can create hazardous situations (Table A.2), and of hazardous events (Table A.3), in order to clarify these concepts and help the manufacturer and user identify hazards (see Clause 6).

The tabular lists of hazards, hazardous situations, and hazardous events are not exhaustive and are not presented in any order of priority. Therefore, the designer should identify and document any other hazard, hazardous situation, or hazardous event in the machine, equipment, or process.

Note: *Additional guidance can be found in CSA Z1002 and ISO 12100.*

Δ A.2 Examples of hazards

Table A.1 groups hazards according to their type and lists possible origins and consequences for each type. It also lists applicable clauses in the ISO 12100 machinery risk assessment and reduction standard. The use of one or more of the columns in Table A.1 to assess hazards depends on the degree of detail needed for describing a hazard.

All hazards should be documented, even if the risk associated with them appears to have been sufficiently reduced by a protective measure suggested for reducing the risk associated with another hazard. Otherwise, there is the danger that if the documented hazard is eliminated or protected against in a different way, the undocumented hazard will be neglected. In the same way, it is not very profitable to accurately describe all of the identified hazards in a hazard zone if the protective measure in mind is effective against all of them (e.g., a guard can be effective against several kinds of mechanical hazards and also against noise and substance emissions). In such cases, it is enough to use only one of the columns in Table A.1.

Δ

Table A.1*
Examples of hazards
(See Clauses A.1–A.3 and L.3.)

Hazard type	Possible origin	Possible consequences	ISO 12100 Clause references
Mechanical	Acceleration, deceleration; Angular parts; Approach of a moving element to a fixed part; Cutting parts; Elastic elements; Falling objects; Gravity; Height from the ground; High pressure; Moving elements; Rotating elements; Rough, slippery surface; Sharp edges; Stability; Strength; Vacuum	- Being run over; - Being thrown; - Crushing; - Cutting or severing; - Drawing-in or trapping; - Entanglement; - Friction or abrasion; - Impact; - Injection; - Shearing; - Slipping, tripping, and falling; - Stabbing or puncture; - Suffocation	6.2.2.1 6.2.2.2 6.2.3(a) 6.2.3(b) 6.2.6 6.3.1 6.3.2 6.3.3 6.3.5.2 6.3.5.4 6.3.5.5 6.3.5.6 6.4.1 6.4.3 6.4.4 6.4.5
Electrical	Arc; Electrostatic phenomena; Live parts; Not enough distance to live parts under high voltage; Overload; Parts that have become live under faulty conditions; Short-circuit; Thermal radiation	- Burn; - Chemical effects; - Electrocution; - Falling or being thrown; - Fire; - Projection of molten particles; - Shock	6.2.9 6.3.2 6.3.3.2 6.3.5.4 6.4.4 6.4.5
Thermal	Explosion; Flame; Objects or materials with a high or low temperature; Radiation from heat sources	- Burn; - Dehydration; - Discomfort; - Frostbite; - Injuries from radiant heat; - Scald	6.2.4(b) 6.2.8(c) 6.3.2.7 6.3.3.2.1 6.3.4.5
Generated by noise	Cavitation phenomena; Exhausting system; Gas leaking at high speed; Manufacturing process (stamping, cutting, etc.); Moving parts; Scraping of surfaces; Unbalanced rotating parts; Whistling pneumatics; Worn parts	- Discomfort; - Loss of awareness; - Loss of balance; - Permanent hearing loss; - Stress; - Tinnitus; - Tiredness; - Any other consequence (e.g., mechanical, electrical) as a consequence of interference with speech communication or with acoustic signals	6.2.2.2 6.2.3(c) 6.2.4(c) 6.2.8(c) 6.3.1 6.3.2.1(b) 6.3.2.5.1 6.3.3.2.1 6.3.4.2 6.4.3 6.4.5.1(b) & (c)

(Continued)

Table A.1* (Continued)

Hazard type	Possible origin	Possible consequences	ISO 12100 Clause references
Generated by vibration	Cavitation phenomena; Incorrect alignment of moving parts; Mobile equipment; Scraping of surfaces; Unbalanced rotating parts; Vibrating equipment; Worn parts	- Discomfort; - Low-back morbidity; - Neurological disorder; - Osteo-articular disorder; - Trauma of the spine; - Vascular disorder	6.2.2.2 6.2.3(c) 6.2.8(c) 6.3.3.2.1 6.3.4.3 6.4.5.1(c)
Generated by radiation	Ionizing radiation source; Low-frequency electromagnetic radiation; Optical radiation (infrared, visible, and ultraviolet), including laser; Radio-frequency; electromagnetic radiation	- Burn; - Effects on reproductive capability; - Genetic mutation; - Functional disorder (headache, insomnia, nervous breakdown, etc.)	6.2.2.2 6.2.3(c) 6.3.3.2.1 6.3.4.5 6.4.5.1(c)
Generated by materials and substances	Aerosol; Biological or microbiological (viral or bacterial agent); Combustible material; Dust; Explosive; Fibre; Flammable material; Fluid; Fumes; Gas; Mist; Oxidizing material	- Cancer; - Corrosion; - Effects on reproductive capability; - Explosion; - Fire; - Infection; - Irritation; - Mutation; - Poisoning; - Respiratory insufficiency (asphyxia, sensitization)	6.2.2.2 6.2.3(b) 6.2.3(c) 6.2.4(a) 6.2.4(b) 6.3.1 6.3.3.2.1 6.3.4.4 6.4.5.1(c) 6.4.5.1(g)
Related to ergonomics	Access; Design, location, or identification of control devices; Design or location of indicators and visual displays units; Effort; Flicker, dazzle, shadow, stroboscopic effect; Local lighting Mental overload/underload; Posture; Repetitive activity; Visibility	- Discomfort; - Fatigue; - Musculoskeletal disorder; - Stress; - Any other consequence (e.g., mechanical, electrical) resulting from human error	6.2.2.1 6.2.7 6.2.8 6.2.11.8.1 6.3.2.1 6.3.3.2.1

(Continued)

Table A.1* (Concluded)

Hazard type	Possible origin	Possible consequences	ISO 12100 Clause references
Associated with the environment in which the machine, equipment, or process is used	Dust; Electromagneticdisturbance; Fog; Lightning; Moisture; Pollution; Snow; Temperature; Water; Wind	- Burns; - Discomfort; - Mild disease; - Slips and falls; - Any other consequence resulting from the effect of environmental conditions on the machine, equipment, or process	6.2.6 6.2.11.11 6.3.2.1 6.4.5.1(b)
Combination of hazards	Example: Repetitive activity combined with effort and high environmental temperature	- Examples: Dehydration, loss of awareness, heat, and shock	–

** Source: ISO 12100, Table B.1.*

A.3 Examples of tasks in which performance can create a hazardous situation

Table A.2 lists tasks whose performance can create a hazardous situation by exposing a person to one or more of the hazards specified in Table A.1. These tasks are performed in and around machines, equipment, and processes. In Table A.2 they are grouped in accordance with the phase in the life cycle of the machine, equipment, or process.

Table A.2*
Examples of tasks in which performance can create a hazardous situation
(See Clauses A.1 and A.3 and Figure C.8.)

Life cycle phase(s) of machine, equipment, or process	**Tasks**
Construction	- Assembly; - Testing
Transportation	- Lifting; - Loading; - Packing; - Transportation; - Unloading; - Unpacking
Assembly and installation; commissioning	- Adjustment of the machine/equipment/process and its components; - Assembly of the machine/equipment/process; - Connecting to disposal system (e.g., exhaust system, waste water installation); - Connecting to power supply (e.g., electric power supply, compressed air); - Demonstration; - Feeding, filling, and loading of ancillary fluids (e.g., lubricant, grease, glue); - Fencing; - Fixing and anchoring; - Preparing for installation (e.g., foundations, vibration isolators); - Running the machine/equipment/process without charge; - Trials with load or maximum load
Setting; teaching/programming; process changeover	- Adjustment and setting of protective devices and other components; - Adjustment and setting verification of functional parameters of the machine/equipment/process (e.g., speed, pressure, force, travelling limits); - Clamping/fastening the workpiece; - Feeding, filling, and loading of raw material; Functional test and trials; - Mounting, changing, or setting tools; - Programming verification; - Verification of the final product

(Continued)

Table A.2* (Concluded)

Life cycle phase(s) of machine, equipment, or process	Tasks
Operation	- Clamping/fastening the workpiece; - Control/inspection; - Driving the machine; - Feeding, filling, and loading of raw material; - Manual loading/unloading; - Minor adjustments and setting of functional parameters of the machine/equipment/process (e.g., speed, pressure, force, travelling limits); - Minor interventions during operation (e.g., removing waste material, eliminating jams, local cleaning); - Operating manual controls; - Restarting the machine after stopping/interruption; - Supervision; - Verification of the final product
Cleaning; maintenance fault-finding; troubleshooting decommissioning; dismantling	- Adjustment; - Dismounting parts, components, and devices; - Housekeeping (e.g., cleaning, sanitation); - Isolation and energy dissipation; - Lubrication; - Replacement of tools; - Replacement of wearing parts; - Resetting; - Restoring fluid levels; - Verification of parts, components, and devices
	- Adjustment; - Dismounting parts, components, and devices; - Fault-finding; - Isolation and energy dissipation; - Recovering from control and protective devices failure; - Recovering from jam; - Repairing; - Replacement of parts, components, and devices; - Rescue of trapped persons; - Resetting; - Verification of parts, components, and devices
	- Disconnection and energy dissipation; - Dismantling; - Lifting; - Loading; - Packing; - Transportation; - Unloading

* *Source: ISO 12100, Table B.3.*

Δ A.4 Examples of hazardous events

Table A.3 lists the more common hazardous events occurring around machines, equipment, or processes. It also lists applicable clauses in the ISO 12100 machinery risk assessment and reduction standard. Hazardous events should be considered along with the related events or conditions causing their occurrence in order to make a more effective choice of adequate protective measures.

In addition, the fact that hazardous events can have multiple causes should be considered. For instance, contact with moving parts due to an unexpected start-up can be caused by an unintentional actuation of a control device or by a fault in the control system.

Every cause can, in turn, be the result of another event or combination of events (chain of events). In practice, this analysis stops when the identified causes are meaningful in the frame of risk assessment (i.e., they point to a faulty condition for which there are known risk-reduction measures).

Δ

Table A.3*
Examples of hazardous events
(See Clauses A.1 and A.4.)

Origin of event	Type of event	ISO 12100 Clause references
Shape and/or superficial finishing of accessible parts of a machine	Contact with open ends; Contact with rough surfaces; Contact with sharp edges and corners or with protruding parts	6.2.2.1
Moving parts of a machine	Access to or contact with moving parts	6.2.2, 6.2.14, 6.2.15 6.3.1, 6.3.2, 6.3.3 6.3.5.2, 6.3.5.3, 6.3.5.4 6.4.3, 6.4.4, 6.4.5
Kinetic energy and/or potential energy (gravity) of a machine, of parts of a machine, or of tools or materials used, processed, or handled	Objects falling or ejected; Explosion	6.2.3, 6.2.5 6.2.10, 6.2.11, 6.2.12 6.3.2.1, 6.3.2.2 6.3.2.7 6.3.3 6.3.5.2, 6.3.5.4, 6.3.5.5 6.4.4, 6.4.5
Stability of a machine or parts of a machine	Loss of stability	6.2.3(a) and (b) 6.2.6 6.3.2.6, 6.3.2.7 6.4.3, 6.4.4, 6.4.5
Mechanical strength of parts of a machine, tools, etc.	Break-up during operation	6.2.3(a) & (b) 6.2.11, 6.2.12 6.3.2, 6.3.2.7 6.3.3.1, 6.3.3.2, 6.3.3.3 6.3.5.2 6.4.4, 6.4.5
Pneumatic or hydraulic equipment	Displacement of moving elements; Projection of high-pressure fluids; Uncontrolled movements	6.2.3(a) and (b) 6.2.10, 6.2.13, 6.3.2.7 6.3.3.1, 6.3.3.2, 6.3.3.3 6.3.5.4 6.4.4, 6.4.5
Electrical equipment	Direct contact; Disruptive discharge; Electric arc; Fire; Indirect contact; Short-circuit	6.2.4(a) 6.2.9, 6.2.12 6.3.2, 6.3.3 6.3.5.4 6.4.4, 6.4.5

(Continued)

Table A.3* (Concluded)

Origin of event	Type of event	ISO 12100 Clause references
Control system	Dropping or ejection of a moving part of a machine or of a workpiece clamped by a machine; Failure to stop moving parts; Machine action resulting from inhibition (defeat or failure) of protective devices; Uncontrolled movements (including speed changes); Unintended or unexpected start-up	6.2.5 6.2.11, 6.2.12, 6.2.13 6.3.5.2, 6.3.5.3, 6.3.5.4 6.4.3, 6.4.4, 6.4.5
Materials, substances, or physical factors (e.g., temperature, noise, vibration, radiation)	Contact with objects at a high or low temperature; Emission of a noise level that can be hazardous; Emission of a noise level that can interfere with speech communication or acoustic signals; Emission of a substance that can be hazardous; Emission of a vibration level that can be hazardous; Emission of radiation fields that can be hazardous; Strong environmental conditions	6.2.2.2 6.2.3(c) 6.2.4 6.2.8 6.3.1 6.3.3.2 6.3.4 6.4.3, 6.4.4, 6.4.5
Workstation or work process design	Excessive effort; Human errors/misbehaviour (unintentional or deliberate induced by the design); Loss of direct visibility of the working area; Painful and tiring postures; Repetitive handling at high frequency	6.2.2.1 6.2.7, 6.2.8 6.2.11.8 6.3.5.5, 6.3.5.6 6.4.3, 6.4.4, 6.4.5

* *Source: ISO 12100, Table B.4.*

Annex B (informative)
Risk assessment and risk reduction procedure

Notes:
1) *This Annex is not a mandatory part of this Standard.*
Δ 2) *This Annex is based in part on Annex A of ANSI/ASSE Z244.1.*

B.1 Risk assessment procedure

Δ B.1.1 General

Risk assessment is an analytical tool consisting of a number of discrete steps intended to ensure that hazards are properly identified, that associated risks are evaluated, and that appropriate measures are taken to effectively reduce those risks. Typical elements of a risk assessment procedure include the steps specified in Clause B.2 and illustrated in Figure B.1.

Notes:
1) *Details on specific risk assessment methodologies can be found in CSA Z432 and ISO 12100.*
2) *Figure B.2 provides an example of a risk assessment procedure for other control methods.*

B.1.2 Identify all tasks

All tasks and activities should be considered. Examples of activities for which tasks should be identified include set-up, installation, removal, maintenance, operation, adjustment, cleaning, troubleshooting, and programming.

B.1.3 Identify hazards

Hazards (e.g., mechanical, electrical, thermal, pneumatic, hydraulic, radiation, residual or stored energy, motion, fuel, and human factor hazards) associated with each task should be considered. It is possible that associated hazards for a particular task not related to hazardous energy release will also need to be reviewed.

Consideration should include human error, management system deficiencies, and foreseeable improper use of equipment.

B.1.4 Assess the potential consequences

The potential severity of injury to everyone who could be harmed by the hazards, including persons not involved in operating the machine, equipment, or process who could be affected by the task should be assessed. The maximum severity of the possible injury should be considered for each task.

B.1.5 Assess the potential exposure to the hazards

The potential exposure of all persons to the identified hazards should be assessed. This assessment should consider the nature, duration, and frequency of exposure to the hazards. Consideration should also be given to the number of persons subjected to the exposure.

Δ B.1.6 Assess the likelihood of occurrence

The likelihood of occurrence of the hazardous event should be determined by assessing the following factors:

a) safeguards, safety devices, and safety systems either in use or to be used;
b) reliability history and failure mode;
c) operational or maintenance demands of the task;

d) possibility of defeat or failure of safeguards;
e) accident history relating to the particular task, activity, machine, equipment, or process;
f) the competence of everyone performing the task; and
g) the working environment.

B.1.7 Evaluate the risk

The information specified in Clauses B.1.2 to B.1.6 should be evaluated for each identified hazard and task to determine the level of risk. Based on this process, a determination of the acceptability of the risk level can be made. The determination may involve risk comparisons, consensus appraisals, or informed value judgments.

Δ B.2 Achievement of effective risk reduction

If the evaluation in specified in Clause B.1.7 determines that the risk has been effectively reduced, the process is complete until a review is required (see Clause B.5). If it is determined that the risk has not been effectively reduced, the risk-reduction procedure specified in Clause B.3 should be implemented.

B.3 Risk-reduction implementation

B.3.1 Risk-reduction process

Risk reduction is a hierarchical process employed to reduce or control risk by elimination through design, use of engineered safeguards, awareness means (including warning and alerting techniques), administrative controls (including safe work procedures and training), and use of personal protective equipment. Often, for a particular machine, piece of equipment, or process, the solution can include aspects of each of these elements. The risk-reduction process should involve appropriate personnel, be documented, and adhere to the process specified in Clauses B.3.2 to B.3.6 and illustrated in Figure B.1.

The following questions should be asked to determine the adequacy of the risk-reduction process:
a) Is the safety level adequate? Can the task be performed without causing injury or damage to health?
b) Have appropriate safety measures been taken for all tasks or activities? Are the measures compatible with each other?
c) Do the safety measures generate any new, unexpected hazards or problems?

B.3.2 Risk reduction by design

Risk reduction should first attempt to eliminate the hazard through design. The primary objective in implementing design features is to eliminate hazards or reduce their risk by substitution.

B.3.3 Risk reduction by use of engineered safeguards

Safeguards or safety devices should be used to protect personnel from hazards that cannot be reasonably eliminated or sufficiently reduced by design.

Safeguards or safety devices and the safety control system (electrical, pneumatic, hydraulic, etc.) should be of a suitable reliability for the required risk reduction.

Note: *Examples of engineered safeguards include guards (both fixed and interlocked), trapped key devices, trip devices (light curtains, laser scanners, pressure mats, safety-rated switches, etc.). Safety devices include, for example, emergency stop buttons and enabling or hold-to-run devices.*

B.3.4 Risk reduction by use of warning and alerting techniques

Warning and alerting techniques should be used to protect personnel from hazards that cannot be reasonably eliminated or sufficiently reduced by design, engineered safeguards, or both.

Note: *Examples of warning and alerting techniques include attendants, audible and visual signals, barricades, signs, and tags.*

B.3.5 Risk reduction by use of administrative controls

Additional risk reduction is achieved by the use of administrative controls, including safe work procedures, standard practices and checklists, and training. These should be used to control risk that cannot be reasonably eliminated or sufficiently reduced by the use of design, engineered safeguards, warning and alerting techniques, or a combination of these elements. Training should be used as a complement to all of the risk-reduction methods described in this Annex.

Note: *Examples of safe work procedures, practices, and training include standard operating instructions, illumination, pre-job review, and establishing safe distances from a hazard. Examples of types of training that can be used to develop proficiency of authorized individuals include computer-based training, simulations, drills, classroom instruction, and exercises.*

B.3.6 Risk reduction by use of personal protective equipment

Additional risk reduction is achieved by effective use of prescribed personal protective equipment (PPE). Strong administrative procedures need to be in place for PPE to be an effective safeguard.

Note: *Examples of PPE include safety eyewear and faceshields, protective footwear, protective gloves (insulating or cut resistant), hearing protection, and protective headgear.*

Δ B.4 Repetition of the risk-assessment procedure

When the risk-reduction procedure has been completed, the risk-assessment procedure should be repeated (see Clause B.1). The chosen risk-reduction methods (including the factors specified in Clause B.1.6), any new tasks generated, and any new hazards generated should be considered.

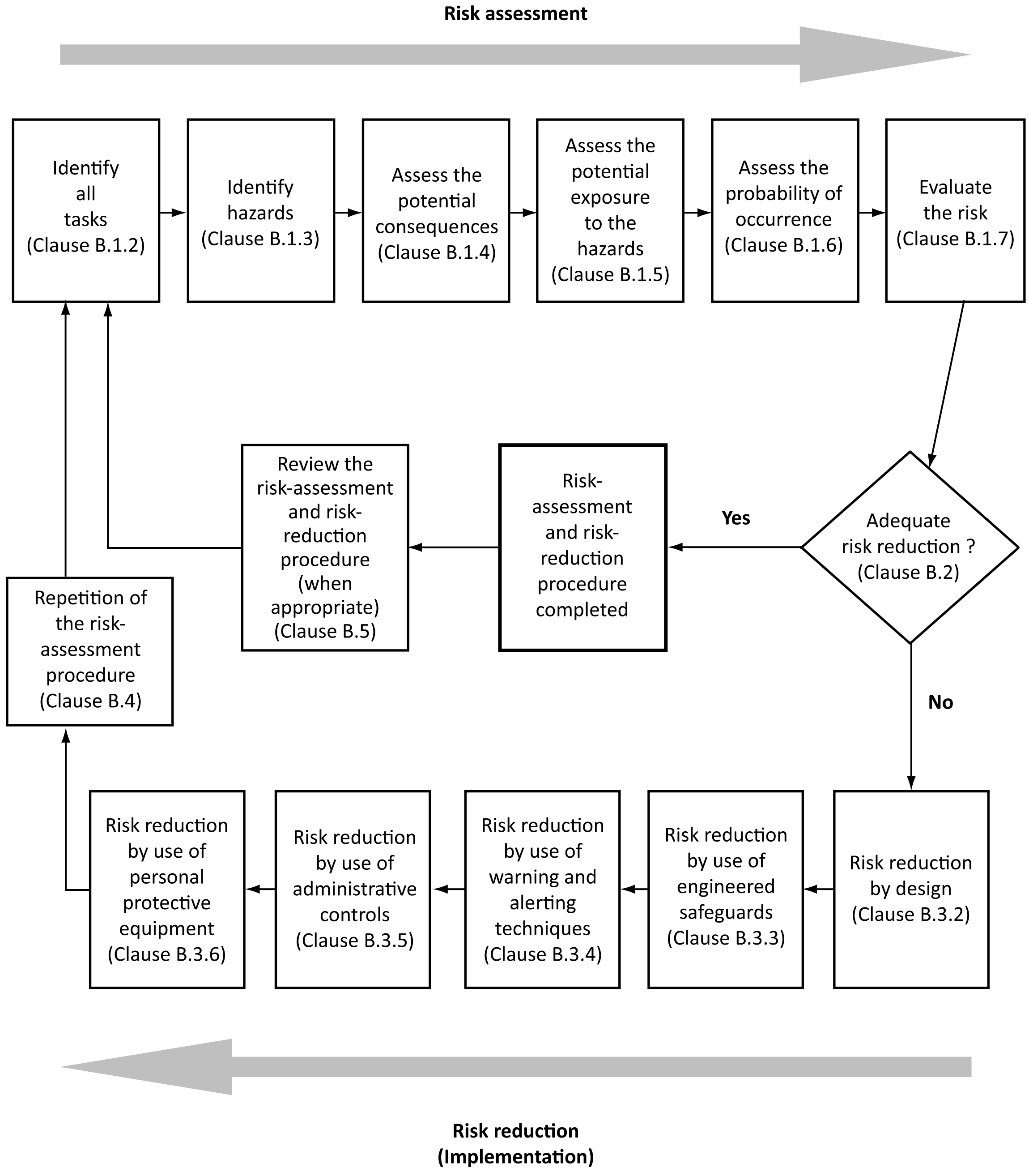
If the risk has been effectively reduced, the process is complete until a review is required (see Clause B.5).If the risk is not yet effectively reduced, the risk-reduction procedure specified in Clause B.3 should be repeated, followed by a repetition of the risk-assessment procedure described in this Clause.

B.5 Review of risk-assessment and risk-reduction procedure

The risk-assessment and risk-reduction procedure should be reviewed under the following circumstances:

a) following its implementation (to ensure that effective solutions are in place);
b) following an incident or near miss;
c) whenever new tasks or activities are required;
d) whenever there are modifications to the machine, equipment, or process; and
e) periodically.

Figure B.1
The risk-assessment and risk-reduction procedure
(See Clauses B.1.1 and B.3.1.)



Δ

Figure B.2
Example of a risk assessment for other control methods
(See Clause B.1.1.)

Department: 26 Operation: Block machining
Task: Tool change — Mill cutter at station 12 left.

Task	Hazards	Severity/ exposure	Risk level	Protective measures (other control methods)
Identify replacement tool	Cuts from sharp tooling	Moderate/ periodic	Moderate	Gloves and procedures
Inspect tool	Cuts from sharp tooling	Moderate/ periodic	Moderate	Gloves and procedures
Remove old cutter	Crushing from transfer bar movement	Catastrophic/ periodic	High	Interlocked guard with trapped key
	Crushing, entanglement, cuts from mill cutter movement if energized	Serious/periodic	High	Interlocked guard with trapped key
	Cuts from sharp tooling	Moderate/ periodic	Moderate	Gloves and tool assist
	Coolant in eyes	Moderate/ periodic	Moderate	Chemical goggles
	Burn from hot cutter	Moderate/ periodic	Moderate	Procedures and gloves
Install new cutter	Crushing from transfer bar movement	Catastrophic/ periodic;	High	Interlocked guard with trapped key
	Crushing, entanglement, cuts from mill cutter movement if energized	Serious/periodic	High	Interlocked guard with trapped key
	Cuts from sharp tooling	Moderate/ periodic	Moderate	Gloves and tool assist

Note: *The severity and likelihood estimations are based on a machine with no safeguards in place. All risks are initially determined to be ineffectively reduced without additional safeguarding.*

Annex C (informative)
Examples of hazard identification and risk assessment methodologies

Note: *This Annex is not a mandatory part of this Standard.*

C.1 Methodology for a bagel slicer

C.1.1 General

This example is based on a power bagel slicer operated by employees under the age of 18. The bagel slicer is equipped with a circular blade. This risk assessment addresses the bagel slicer in general and does not represent an assessment of a particular employer's use of the machine.

C.1.2 Workplace observation

C.1.2.1 General

Three levels of protection are provided:
a) an adjustable barrier guard;
b) warning signs; and
c) the manufacturer's recommended safe operating procedures.

C.1.2.2 Barrier guard

The bagel chute is a long four-sided box that fully encloses the blade on the sides. The 13 × 8 cm ends of the chute are open. The blade is thin, with a 23 cm diameter and a wavy edge. The distance to the nearest point on the circular blade is 32 cm from the top opening and 3 in from the bottom opening. The blade operates at a high rotational speed and coasts to a stop (no brake). The bottom edge of the chute's feed opening is 46 cm from the countertop. The bottom edge of the chute's outlet opening is 10 cm from the countertop. The top opening is about chest height (1.3 m). The guard opening size and the distance from the opening to the blade permit a hand to extend in to touch the blade.

C.1.2.3 Warning sign

A label warning of and pointing to the sharp circular blade is affixed to the side of the machine.

C.1.2.4 Safe operating procedures

It is the employer's responsibility to provide training and supervision to ensure that the manufacturer's safety recommendations are followed.

C.1.3 The risk assessment method

C.1.3.1

A machinery risk assessment for youth operating the bagel slicer was performed. The safety perspective adopted was that the risk of injury is a function of the tasks performed and the hazards of those tasks for a given set of protective measures.

The sharp circular blade on this machine was viewed in the context of exposure during tasks. The analysis was limited to contact with the spinning blade being the only real hazard during performance of three tasks, i.e., normal bagel slicing, clearing jammed bagels, and cleaning the bagel slicer.

The most severe injury that could result from performance of these tasks was a deep finger laceration. Although the manufacturer specified safe operating procedures, it is recognized that the availability of such procedures does not guarantee that workers will be trained in their use, nor that workers will follow the procedures even if trained.

Δ C.1.3.2

A national injury data collection service database was searched to identify injury cases associated with bagel or bun slicers. The database is based on a nationally representative sample of 67 hospital emergency departments. Although several slicer-related injuries were treated at in-scope hospitals, it was not possible to estimate the numbers of bagel slicer injuries nationally. Many of the injury records identified the machine involved only as a slicer and were undoubtedly related to meat slicers. There were insufficient case descriptions and too few cases to provide a reliable national estimate. It should be noted that although the in-scope sample was of sufficient size to provide estimates of injuries associated with a variety of work machines, tools, and pieces of equipment, it possibly was not of sufficient size for estimating relatively infrequent injuries associated with specific types of equipment. There was, therefore, insufficient data on injuries from bagel or bun slicers to proceed with a quantitative risk assessment. The manufacturer claimed that the product had been on the market for ten years without any reports of injury or legal actions.

Given these data limitations, a categorical approach to risk assessment was followed. Risk assessment is a process by which the intended use of a machine, the tasks and hazards, and the level of risk are determined. A software-based procedure suited to machinery risk assessment was adopted because of its ease of use and the clarity of the reports it generates. This program leads the analyst through the generally recognized information steps of a risk assessment, i.e., define the work tasks performed, determine the hazards posed by those tasks, estimate the severity of injury from the hazards, and estimate the likelihood that the injury will occur. This information was then entered into the machinery risk level matrix.

The risk assessment considered the current level of guarding and available video training for using the bagel slicer as well as risk control measures for other machines presenting similar hazards. Five team members evaluated the hazardous situations and determined how likely specific risky behaviours were. The likelihood levels used in the assessment were as follows:

a) probable: likely or certain to occur;
b) possible: could occur (but not probable);
c) unlikely: unlikely to occur; and
d) negligible: occurrence so remote as to be essentially zero.

The full range of employees was considered, i.e., of both genders and of various body types. The assessment assumed that the employees had received an education sufficient for employment in a fast food establishment.

Δ C.1.4 Results

Figure C.1 shows that the risk level is low for all of the task/hazard combinations associated with this bagel slicer. For all task/hazard combinations the injury severity is slight (normally reversible with no more than one week of lost work time) and the likelihood is in the unlikely range (due to there being no need to access the hazard area with power on, and no available reports of injury, but low awareness of risk and low experience level of users). The three existing protective measures (the guard, the warning sign, and the training video) are satisfactory for protection at the low risk level.

Δ

Figure C.1
Example of a hazard assessment for a bagel slicer job
(See Clause C.1.4.)

Date							
Application	Bagel slicer						
Description	All operators						
Limits	Considers only the hazard of contact with the moving blade. The most severe injury is laceration of fingertip. Forceful pushing is not needed and being pulled into the blade is not a factor. No kickback hazard. Blade edge for soft bread.						
Sources	(1) The machine manufacturer provides safe operating procedures. (2) A good training program and supervision are assumed. (3) The administration makes observations and takes photos.						
Guide sentence	When performing task, the user could be injured by the hazard due to the failure mode.						
	Initial assessment			**Final assessment**			
User/task	**Hazard/failure mode**	**Severity/ likelihood**	**Risk level**	**Risk reduction methods**	**Severity/ likelihood**	**Risk level**	**Status/ responsibili-ty**
Operator/ normal operation	Ergonomics/human factors; deviations from safe work practices — ignores training not to reach in at top to push bagel through	Moderate/ likely	Moderate	Enclosure/barriers, warning labels, standard procedures, instruction manuals	Moderate/ unlikely	Low	Complete/ manufacturer
Operator/ normal operation	Ergonomics/human factors; human error — misunderstands seriousness of blade hazard — reaches in at top to push bagel through	Moderate/ likely	Moderate	Enclosure/barriers, warning labels, standard procedures, instruction manuals	Moderate/ unlikely	Low	Complete/ manufacturer

(Continued)

Figure C.1 (Concluded)

	Initial assessment			Final assessment			
User/task	**Hazard/failure mode**	**Severity/ likelihood**	**Risk level**	**Risk reduction methods**	**Severity/ likelihood**	**Risk level**	**Status/ responsibili-ty**
Operator/basic troubleshooting	Ergonomics/human factors; deviation from safe work practices — ignores training not to reach in at bottom to pull out bagel	Moderate/ likely	Moderate	Enclosure/barriers, warning labels, standard procedures, instruction manuals	Moderate/ unlikely	Low	Complete/ manufacturer
Operator/basic troubleshooting	Ergonomics/human factors; human error — forgets blade is coasting and reaches in	Moderate/ likely	Moderate	Enclosure/barriers, warning labels, standard procedures, instruction manuals	Moderate/ unlikely	Low	Complete/ manufacturer
Operator/ cleanup	Ergonomics/human factors; deviation from safe work practices — ignores training and normally opens and cleans slicer when it is plugged in	Moderate/ likely	Moderate	Warning labels, standard procedures, instruction manuals, supervision	Moderate/ unlikely	Low	Complete/ manufacturer/ employer
Operator/ cleanup	Ergonomics/human factors; human error — forgets to unplug and inadvertently hits “power on” switch	Moderate/ likely	Moderate	Warning labels, standard procedures, instruction manuals, supervision	Moderate/ unlikely	Low	Complete/ manufacturer/ employer
Operator/ cleanup	Ergonomics/human factors; distracted/ inattentive to task — another person or event diverts attention and start switch is inadvertently hit	Moderate/ likely	Moderate	Warning labels, standard procedures, instruction manuals, supervision	Moderate/ unlikely	Low	Complete/ manufacturer/ employer

The following were four important considerations for the review panel:

a) this machine eliminates the risks created by holding a bagel in one hand and using a kitchen knife with the other hand to slice bagels;

b) the regulatory authority accepts the risks incurred by employees operating single-loaf power bread slicers. Both machines are used in such a way that the hands are well clear of the machine when baked goods are fed into the blade(s);

c) although meat slicers use a similar circular blade, fingers are often near the blade and accordingly many injuries show up in the injury data; and

d) this machine is not considered to present risks equivalent to those presented by operation of a woodworking saw with a circular blade. The blade alone does not create risk, but should be considered with respect to the exposure to injury during task performance. For the circular blade on this bagel slicer, the exposure to injury is totally different from the exposure to injury associated with the circular blade on most woodworking saws. There is no kickback hazard and there is no need for fingers to repetitively feed material near the blade.

C.1.5 Conclusion

Operating and cleaning a power bagel slicer that has a circular blade and enclosed feed chute presents a low risk to employees. The existing protective measures (the guard, the warning sign, and the safe operating procedures) contribute to this low risk rating. Adding automatic feeding and ejection devices would not appreciably reduce the risk level.

Table C.1 presents the risk matrix used for this risk assessment.

Table C.1
Risk matrix
(See Clause C.1.5.)

	Severity			
Likelihood	**Catastrophic**	**Serious**	**Moderate**	**Minimal**
Probable	High	High	Moderate	Low
Possible	High	High	Moderate	Low
Unlikely	Moderate	Moderate	Low	Low
Negligible	Low	Low	Low	Low

C.2 Methodology for an industrial robot

C.2.1 General

The process described in Clauses C.2.2 to C.2.11 has been validated and found to provide an acceptable and reliable means for conducting a risk assessment.

C.2.2 Organizing of risk assessment

One of the keys to performing a successful risk assessment is participation by individuals who routinely work with and on the equipment. At a minimum, this should include the following types of personnel:

a) operators and their representative(s);

b) maintenance and technical personnel (i.e., skilled tradespeople such as electricians, riggers, and toolmakers and personnel responsible for setting up and programming computers); and
c) engineering and management personnel (e.g., process or system engineers, design engineers, and safety and human resource specialists).

The optimum group size for a risk assessment is four to eight individuals chosen from the categories specified in Items (a) to (c).

The other key individual is the person performing the risk assessment. This person should have experience working with groups, knowledge of group dynamics, and familiarity with the machine, equipment, or process being evaluated.

The suggested process for soliciting input on the tasks and hazards associated with a machine, piece of equipment, or process is to organize these individuals into a brainstorming team. With the team assembled around a conference table, the process begins.

C.2.3 Step 1: Task identification

Using group dynamics and the brainstorming technique, a list of all tasks performed in the application should be developed (see Figure C.2 for an example). Include all operator (load/unload), maintenance (troubleshooting, repair, preventive maintenance), cleanup, and quality tasks. Include all tasks performed daily, weekly, monthly, quarterly, semi-annually, annually, bi-annually, etc. Include both planned and unplanned tasks.

Figure C.2
Task identification
(See Clauses C.2.3 and C.2.6.)

No.	Task	Hazards	Notes
1	Tip or cap change		
2	Repair cables and hoses		
3	[Add further tasks as necessary]		
4			
5			

Once the list is developed, each task should be sequentially numbered and the list placed in a location convenient for everyone to refer to (such as on a wall) during the remaining steps in the process.

C.2.4 Step 2: Hazard identification

Continuing the same brainstorming technique, users should select the first task off the task list and develop a comprehensive list of all hazards associated with that task (see Figure C.3 for an example). As new tasks or hazards are identified, they should be added to the appropriate lists. Each hazard should be sequentially numbered.

Figure C.3
Hazard identification
(See Clause C.2.4.)

No.	Hazard	Severity	Exposure	Avoidance
1	Struck by robot			
2	Eye hazard; chemical in water			
3	Slip/fall at same level			
4	Fall from height (ladder)			
5	Pinch point between robot and turntable			
6	[Add further hazards as necessary]			
7				
8				

∆ C.2.5 Step 3: Risk determination

For each hazard, users should have the group identify (on a consensus basis) the severity, exposure, and likelihood of avoidance based on specified criteria such as those illustrated in Figure C.4.

Figure C.4
Hazard severity/exposure/avoidance categories
(See Clause C.2.5 and Figures C.7–C.9.)

No.	Hazard	Severity	Exposure	Avoidance
1	Struck by robot	S2	E2	A2
2	Eye hazard; chemical in water	S1	E2	A1
3	Slip/fall at same level	S2	E2	A1
4	Fall from height (ladder)	S2	E1	A2
5	Pinch point between robot and turntable	S2	E1	A2
6	[Add further hazards as necessary]			
7				
8				

Factor	Value		
Severity	S2	Serious injury	Fatality, normally irreversible, or requires more than first aid
	S1	Slight injury	Normally reversible or requires only first aid
Exposure	E2	Frequent exposure	Typically, exposure to the hazard more than once an hour*
	E1	Infrequent exposure	Typically, exposure to the hazard less than once a day or shift*
Avoidance	A2	Not likely	Worker cannot move out of way, inadequate reaction time, or machine speed greater than 250 mm/s
	A1	Likely	Worker can move out of way, sufficient warning/reaction time, or machine speed less than 250 mm/s

** Exposure can be affected by the frequency that the task is performed or by the duration of the task. Determining frequency of access can require a judgment by the person(s) performing the risk assessment. Access can range from cyclical-production-related tasks to maintenance tasks associated with periodic maintenance. When one is determining proper safeguards, it should be noted that serious injuries have resulted from infrequent tasks.*
Avoidance can be affected by reducing the speed of the hazard to give sufficient warning/reaction time, by the application of a category R2 (see ISO 12100-1 and ISO 12100-2) risk-reduction safeguard, or by installation of awareness devices.

C.2.6 Step 4: Documentation of risk variables

Users should go back to the task list (see Figure C.2), add the associated hazards, and identify any changes to severity, exposure, or avoidance based on the specific task (see Figure C.5).

Figure C.5
Documentation of risk variables
(See Clause C.2.6.)

No.	Task	Hazards	Notes
1	Tip or cap change	1,3	
2	Repair cables and hoses	1,2,3,4,5	Exposure changes to E1 due to frequency task is performed
3	[Add further tasks as necessary]		
4			
5			

Figure C.6 provides a sample spreadsheet that combines the risk variables.

Figure C.6
Spreadsheet example
(See Clause C.2.6.)

Sequence no.	Task description	Hazards	Before safeguard selection				Solution	After safeguard installation			
			Severity (S1 or S2)	Exposure (E1 or E2)	Avoidance (A1 or A2)	Risk level		Severity (S1 or S2)	Exposure (E1 or E2)	Avoidance (A1 or A2)	Risk level

C.2.7 Step 5: Identification of risk-reduction level

For each task and hazard combination, and before applying safeguards, a decision matrix similar to that in Figure C.7 should be used to identify the risk-reduction level.

Δ

Figure C.7
Risk-reduction decision matrix for use before safeguard selection

(See Clauses C.2.7 and C.2.8 and Figure C.8.)

Seq no.	Task	Hazard	Before safeguard selection				Solution	After safeguard installation			
			Severity (S1 or S2)	**Exposure (E1 or E2)**	**Avoidance (A1 or A2)**	**Risk level**		**Severity (S1 or S2)**	**Exposure (E1 or E2)**	**Avoidance (A1 or A2)**	**Risk level**
1	Tip or cap change	Struck by robot	S2	E2	A2	R1					
1	Tip or cap change	Slip/fall at same level	S2	E2	A1	R2A					
2	Repair cables and hoses	Struck by robot	S2	E1	A2	R2A					
2	Repair cables and hoses	Eye hazard; chemical in water	S1	E1	A2	R3B					
2	Repair cables and hoses	Slip/fall at same level	S2	E1	A1	R2B					
2	Repair cables and hoses	Fall from height (ladder)	S2	E1	A2	R2A					
2	Repair cables and hoses	Pinch point between robot and turntable	S2	E1	A2	R2A					

Severity	Exposure	Avoidance	Risk-reduction level
S2 Serious injury More than first aid	E2 Frequent exposure	A2 Not Likely	R1
		A1 Likely	R2A
	E1 Infrequent exposure	A2 Not Likely	R2A
		A1 Likely	R2B

(Continued)

Figure C.7 (Concluded)

Seq no.	Task	Hazard	Before safeguard selection				Solution	After safeguard installation			
			Severity (S1 or S2)	Exposure (E1 or E2)	Avoidance (A1 or A2)	Risk level		Severity (S1 or S2)	Exposure (E1 or E2)	Avoidance (A1 or A2)	Risk level
S1 Slight injury First aid		E2 Frequent exposure				A2 Not Likely			R2C		
						A1 Likely			R3A		
		E1 Infrequent exposure				A2 Not Likely			R3B		
						A1 Likely			R4		

Notes:

1) *This Figure assumes that no safeguards are installed.*

2) *See Figure C.4 for an explanation of the S (severity), E (exposure), and A (avoidance) codes. See CSA Z432, ISO 12100-1, and ISO 12100-2 for an explanation of the R (risk-reduction level) codes.*

This process should be repeated until all task and hazard combinations are listed. Add any additional hazards sequentially. Be aware that the exposure and avoidance can change for the same hazard based on the different tasks.

C.2.8 Step 6: Selection of safeguards

An appropriate safeguard for each task and hazard combination should be selected based on the risk-reduction level determined in accordance with the risk-reduction decision matrix (see Figure C.7). Use a safeguard selection matrix similar to that in Figure C.8 to determine the safeguard and circuit performance required based on severity, exposure, and avoidance criteria. Select overall safeguarding for the machine, equipment, or process based on the highest risk-reduction level of task and hazard combinations.

Δ

Figure C.8
Safeguard selection matrix

(See Clause C.2.8.)

Seq no.	Task	Hazard	Before safeguard selection				Solution	After safeguard installation			
			Severity (S1 or S2)	**Exposure (E1 or E2)**	**Avoidance (A1 or A2)**	**Risk level**		**Severity (S1 or S2)**	**Exposure (E1 or E2)**	**Avoidance (A1 or A2)**	**Risk level**
1	Tip or cap change	Struck by robot	S2	E2	A2	R1	Prevents access, install interlocked gate guard				
1	Tip or cap change	Slip/fall at same level	S2	E2	A1	R2A	Install anti-skid deck				
2	Repair cables and hoses	Struck by robot	S2	E1	A2	R2A	Prevent access, install interlocked gate guard				
2	Repair cables and hoses	Eye hazard; chemical in water	S1	E1	A2	R3B	Use protective eyewear				
2	Repair cables and hoses	Slip/fall at same level	S2	E1	A1	R2B	Install anti-skid deck				
2	Repair cables and hoses	Fall from height (ladder)	S2	E1	A2	R2A	Install railings, use work platform rather than ladder				
2	Repair cables and hoses	Pinch point between robot and turntable	S2	E1	A2	R2A	Install safety mat where clearance is not provided				

(Continued)

Figure C.8 (Concluded)

Seq no.	Task	Hazard	Before safeguard selection				Solution	After safeguard installation			
			Severity (S1 or S2)	Exposure (E1 or E2)	Avoidance (A1 or A2)	Risk level		Severity (S1 or S2)	Exposure (E1 or E2)	Avoidance (A1 or A2)	Risk level
Category			Safeguard performance						Risk-reduction level		
R1			Hazard elimination or hazard substitution						Control reliable or Category 4		
R2A			Engineering controls preventing access to the hazard or stopping the hazard, e.g., interlocked barrier guards, light curtains, safety mats, or other presence-sensing devices						Control reliable or Category 3		
R2B (S2, E1, A2)									Category 3		
R2B (S2, E1, A1)									Single channel with monitoring or Category 2		
R2C									Single channel or Category 1		
R3A			Non-interlocked barriers, clearance, procedures, and equipment						Single channel or Category 1		
R3B									Simple or Category 1		
R4			Awareness means						Simple or Category 1		

Notes:

1) *Safeguard selection matrices and risk-reduction decision matrices (see Figure C.7) are primarily intended for machinery- and equipment-related task and hazard combinations. Certain task and hazard combinations, such as material-related tasks that include exposure to sharp parts, thermal hazards, and ergonomic hazards, require the application of the highest level of feasible safeguarding based on the hierarchy of controls (see Table A.2) and fall outside the scope of this Figure and Figure C.7. Appropriate standards and regulations should be consulted in addition to CSA Z432, ISO 12100-1, and ISO 12100-2.*

2) *See Figure C.4 for an explanation of the S (severity), E (exposure), and A (avoidance) codes. See CSA Z432, ISO 12100-1, and ISO 12100-2 for an explanation of the R (risk-reduction level) codes.*

C.2.9 Step 7: Verification of selections

After all safeguards are identified, Steps 1 to 6 (Clauses C.2.3 to C.2.8) should be repeated using a safeguard selection validation matrix similar to that in Figure C.9 to ensure that all hazards have been addressed and any remaining hazards are at a tolerable level, i.e., at a reasonable level of risk that a person would normally expect to incur (e.g., drive a vehicle). This is considered residual risk, i.e., risks that can be identified with warning signs, but for which one would not install an active safeguard to prevent access or interaction.

Δ

Figure C.9
Safeguard selection validation matrix for use after safeguard installation

(See Clause C.2.9.)

Seq no.	Task	Hazard	Before safeguard selection				Solution	After safeguard installation			
			Severity (S1 or S2)	**Exposure (E1 or E2)**	**Avoidance (A1 or A2)**	**Risk level**		**Severity (S1 or S2)**	**Exposure (E1 or E2)**	**Avoidance (A1 or A2)**	**Risk level**
1	Tip or cap change	Struck by robot	S2	E2	A2	R1	Prevents access, install inter-locked gate guard	S2	E1	A1	R3A
1	Tip or cap change	Slip/fall at same level	S2	E2	A1	R2A	Install anti-skid deck	S2	E1	A1	R3A
2	Repair cables and hoses	Struck by robot	S2	E1	A2	R2A	Prevent access, install inter-locked gate guard	S2	E1	A1	R3A
2	Repair cables and hoses	Eye hazard; chemical in water	S1	E1	A2	R3B	Use protective eyewear	S1	E1	A1	R4
2	Repair cables and hoses	Slip/fall at same level	S2	E1	A1	R2B	Install anti-skid deck	S1	E1	A1	R4

(Continued)

Figure C.9 (Continued)

Seq no.	Task	Hazard	Before safeguard selection				Solution	After safeguard installation			
			Severity (S1 or S2)	Exposure (E1 or E2)	Avoidance (A1 or A2)	Risk level		Severity (S1 or S2)	Exposure (E1 or E2)	Avoidance (A1 or A2)	Risk level
2	Repair cables and hoses	Fall from height (ladder)	S2	E1	A2	R2A	Install railings, use work platform rather than ladder	S2	E1	A1	R3A
2	Repair cables and hoses	Pinch point between robot and turntable	S2	E1	A2	R2A	Install safety mat where clearance is not provided	S2	E1	A1	R3A

Exposure	Avoidance	Severity	Risk-reduction level
E2 Frequent exposure	A2 Not likely	S2 Serious injury	R1
		S1 Slight injury	R2C
	A1 Likely	S2 Serious injury	R2A
		S1 Slight injury	R2A

(Continued)

Figure C.9 (Concluded)

<table>
<tr><th rowspan="2">Seq no.</th><th rowspan="2">Task</th><th rowspan="2">Hazard</th><th colspan="4">Before safeguard selection</th><th rowspan="2">Solution</th><th colspan="4">After safeguard installation</th></tr>
<tr><th>Severity (S1 or S2)</th><th>Exposure (E1 or E2)</th><th>Avoidance (A1 or A2)</th><th>Risk level</th><th>Severity (S1 or S2)</th><th>Exposure (E1 or E2)</th><th>Avoidance (A1 or A2)</th><th>Risk level</th></tr>
<tr><td colspan="3" rowspan="4">E1 Infrequent exposure</td><td colspan="3" rowspan="2">A2 Not likely</td><td colspan="3">S2 Serious injury</td><td colspan="3">R2A</td></tr>
<tr><td colspan="3">S1 Slight injury</td><td colspan="3">R3B</td></tr>
<tr><td colspan="3" rowspan="2">A1 Likely</td><td colspan="3">S2 Serious injury</td><td colspan="3">R3A</td></tr>
<tr><td colspan="3">S1 Slight injury</td><td colspan="3">R4</td></tr>
</table>

Notes:

1) *Exposure can be affected by the frequency that the task is performed or by the duration of the task. Determining frequency of access can require a judgment by the person(s) performing the risk assessment. Access can range from cyclical-production-related tasks to maintenance tasks associated with periodic maintenance. When one is determining proper safeguards, it should be noted that serious injuries have resulted from infrequent tasks.*

2) *Avoidance can be affected by reducing the speed of the hazard to give sufficient warning/reaction time, by the application of a category R2 (see ISO 12100-1 and ISO 12100-2) risk-reduction safeguard, or by installation of awareness devices.*

3) *See Figure C.4 for an explanation of the S (severity), E (exposure), and A (avoidance) codes. See CSA Z432, ISO 12100-1, and ISO 12100-2 for an explanation of the R (risk-reduction level) codes.*

C.2.10 Step 8: Validation

Once the selected safeguards are installed, their functional operation should be verified to ensure that they are providing the desired risk reduction. Use this information to feedback safeguarding selections into the design-in process for future equipment.

C.2.11 Step 9: Documentation

A risk assessment should be performed at all stages of development of the machine, equipment, or process.

These risk assessments are living documents and should be handed down through each stage in the development cycle for inclusion in the risk assessment at that stage.

Annex D (informative)
Sample lockout policy and program, sample general lockout procedure (individual lockout), and sample approved energy control procedure

Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *This Annex is based in part on Annex B of ANSI/ASSE Z244.1.*

Δ

Figure D.1
Sample lockout policy and program
(See Clause 7.3.1.)

Purpose

The purpose of this lockout policy and program is to establish a procedure-based lockout process to prevent inadvertent release or transmission of machine, equipment, or process energy.

Objectives

The objectives are as follows:
a) to prevent inadvertent operation or energization of the machine, equipment, or process in order to protect personnel;
b) to establish methods for achieving zero energy state; and
c) to comply with applicable regulatory standards.

Scope

A. Application

This policy applies to
a) activities such as, but not limited to, erecting, installing, constructing, repairing, adjusting, inspecting, cleaning, operating, and maintaining the machines, equipment, and processes; and
b) energy sources such as, but not limited to, electrical, mechanical, hydraulic, pneumatic, chemical, radiation, thermal, and compressed air energy sources, energy stored in springs, and potential energy from suspended parts (gravity).

B. Installation design requirement

Whenever replacement or major repair, renovation, or modification of a machine, a piece of equipment, or a process is performed, and whenever new machines, equipment, or processes are installed, energy-isolating devices must be designed to accept a lockout device that will positively secure them in the isolated position.

Definitions

(Continued)

Figure D.1 (Continued)

Affected employee — a person whose job requires him or her to operate or use a machine, a piece of equipment, or a process on which servicing or maintenance is being performed under lockout.

Authorized employee — a person who locks out machines, equipment, or processes to service or perform maintenance on the machines, equipment, or processes.

Capable of being locked out (with respect to an energy-isolating device) — an energy-isolating device that is designed with a hasp or other means of attachment to which, or through which, a lock can be affixed or, if it has a locking mechanism, built into it. Other energy-isolating devices are also considered capable of being locked out if lockout can be achieved without the need to dismantle, rebuild, or replace the energy-isolating device or permanently alter its energy control capability.

Caution tag — a warning tag or other device, and its means of attachment, used to warn employees of an existing or potential hazard. In addition to the warning, its wording also identifies who applied the tag.

Energy-isolating device — a mechanical device that physically prevents the transmission or release of energy, including but not limited to the following:
a) a manually operated electrical circuit breaker;
b) a disconnect switch;
c) a manually operated switch by which the conductors of a circuit can be disconnected from all ungrounded supply conductors and no pole can be operated independently;
d) a line valve;
e) a block;
f) a blank; and
g) any similar device used to block or isolate energy.
This term does not include push button, selector switch, and other control-circuit-type devices.

Lockout — placement of a lockout device on an energy-isolating device in accordance with an established procedure to ensure that the energy-isolating device and the equipment being controlled cannot be operated until the lockout device is removed.

Lockout device — a positive means (e.g., a lock) that secures an energy-isolating device in a position that prevents the inadvertent re-energizing of a machine, piece of equipment, or process.

Other employee — a person whose job requires him or her to work in an area where machine, equipment, or process servicing or maintenance is being performed.

Primary authorized employee — a person assigned as the lead authorized employee under the group lockout process to apply and coordinate removal of the lockout of a machine, piece of equipment, or process on which work will be performed.

Principal authorized employee — a person assigned responsibility for a crew or work group under the group lockout process when more than one work group is involved.

Servicing/maintenance — workplace activities such as constructing, installing, setting up, adjusting, inspecting, modifying, maintaining, and servicing machines, equipment, or processes. These activities include lubrication, cleaning or unjamming of machines or equipment, and making adjustments to tool changes where the employee could be exposed to the unexpected energization or start-up of a machine or piece of equipment or to the release of hazardous energy.

Procedure

(Continued)

Figure D.1 (Continued)

A. Lockout system

Each facility must develop a documented lockout policy that incorporates the following elements:

1. Principles

The following principles apply:

a) All personnel (hourly and salary) must comply with the provisions of the lockout system. Supervisors must enforce the use of personnel locks (and tags where required) to ensure the protection of all personnel required to perform tasks where exposure to unexpected energization can occur.
b) The locks (and tags if used) must be standardized throughout the facility and be recognized as the only authorized method of locking out hazardous energy sources. Locks (and tags if used) as part of the lockout system must not be used for any purpose other than personal protection.
c) Individual locks (and tags if used) must be applied and removed by each person exposed to the potential for unexpected release of energy, other than in special situations where facility procedures have been developed to control the hazardous energy sources.
d) Where equipment is lockable, use of a lock must be required of all exposed personnel.
e) Where equipment is not lockable, special hazardous energy control procedures must be used.
f) When locks are used in the lockout application, they may be accompanied by tags, as follows:
   i) locks used for personnel protection may be accompanied by employee tags; and
   ii) locks used to protect against hazards may be accompanied by caution tags.
g) Energy-isolating devices must be clearly labelled or identified to indicate their function, in accordance with the nomenclature and/or identifiers used in the procedures that specify their use. Such identification is necessary to reduce possible errors in applying the lockout.
h) The lockout of electrical energy sources must occur at the circuit disconnect switch.
i) The use of electrical control circuitry to accomplish lockout is to be prohibited because it does not offer positive personnel protection. Examples:
   i) electrical shorts (water in lines and some types of dust can create a path to complete the control circuit);
   ii) vibration or switch component failure; and
   iii) remote or interlocked switches not affected by control circuitry.

2. Protective appliances

The following requirements apply to protective appliances:

a) Locks must be purchased specifically for lockout applications. They must be of such design and durability that removal by other than normal means requires excessive force or unusual techniques. In addition, they must possess individual keying capability.
b) The following tag appliances must be used to provide warnings or information:
   i) An employee tag (if used) must be used only for personnel protection in conjunction with a lockout device, must be clearly distinguishable from caution tags, and must include a legend such as “DO NOT START”, “DO NOT OPERATE”, or a similar directive that informs employees working in the area not to start up the equipment.
   ii) A caution tag (if used) must warn of hazards. Caution tags are provided to preserve the integrity of employee tags. They do not indicate that the applier is currently exposed to the unexpected release or transmission of energy.
c) Multi-hasp. An appliance that accommodates one or more locks to secure an energy-isolating device.

Note: *Some exposures can require additional protective techniques or mechanical safeguards.*

(Continued)

Figure D.1 (Continued)

3. Application and exposure survey

Each facility must conduct an application survey, as follows, to determine whether the machine, equipment, or process can be safely isolated:

a) The survey should determine whether energy-isolating devices are available, adequate, and practically located for positive protection.
b) Once identified, the energy-isolating devices to be used should be clearly marked in the field and documented procedures created to identify the need to use these devices whenever a person is performing tasks identified as requiring de-energization of the machine, equipment, or process.
c) A plan must be developed to correct the surveyed deficiencies (if any) or provide interim alternative protection to make the lockout system effective until the deficiencies have been corrected.

Each facility must conduct an exposure survey to determine which tasks are being performed while the equipment is energized, e.g., cleaning rolls and removing jams. Each situation shall be evaluated to determine whether the task can be accomplished with the power off or, alternatively, which method needs to be used to reduce employee risk.

4. Responsibilities

The following responsibilities shall apply:

a) Management is to be responsible for developing, implementing, and administering an effective lockout system.
b) All employees are to be responsible for complying with the provisions of the facility lockout system.
c) Affected employees are to be aware of lockout procedures used to guard against unexpected start-ups.
d) Only authorized individuals are to operate energy-isolating devices and place locks (and tags if used) on controls to prevent unexpected start-ups.
e) Other employees who work in the area where lockout procedures are used are to be instructed about their purpose and prohibited from attempting to restart machines, pieces of equipment, or processes that are locked out.

B. System use

1. Preparations for lockout

The following preparations for lockout must be undertaken:

a) All personnel affected by the intended lockout must be notified by the supervisor or authorized employee before commencing any work.
b) A method must be established to permit access to the machine, equipment, or process. This method should involve acknowledgement and release by the individual(s) responsible for the machine, equipment, or process.
c) A pre-job plan must be developed to ensure appropriate lockout when the complexity of the machine, equipment, or process or the nature and scope of the work warrants (e.g., job objectives and involved machine, equipment, or process; estimated job duration; crafts involved; type, number, and location of energy-isolating devices; start-up provisions).

(Continued)

Figure D.1 (Continued)

2. Application of lockout

Lockout must be applied as follows:

a) Appropriate machine, equipment, and process shutdown procedures must be used to deactivate operating controls or return them to the neutral mode.
b) An authorized individual using appropriate machine, equipment, or process energy-isolating procedures must then be assigned to operate or position the energy-isolating devices in a manner that isolates the machine, equipment, or process from the energy source(s).
c) Locks and tags, if used, must be applied to each energy-isolating device by authorized individuals, as follows:
   i) lockout devices must be attached in such a manner as to positively position the energy-isolating device(s) in the isolated position; and
   ii) tags, if used, must be completed by the applier and attached to the energy-isolating device(s).
d) After lockout application and before commencement of work, one or more of the following actions must be taken to prove that the machine, equipment, or process has been de-energized and cannot be restarted:
   i) the machine, equipment, or process controls (push buttons, switches, etc.) is operated to verify that energy isolation has been accomplished. Controls must be deactivated or returned to the neutral mode after test;
   ii) the machine, equipment, or process is checked by test instruments or visual inspection to verify that energy isolation has been accomplished; and
   iii) the machine, equipment, or process is checked for any residual energy. If residual energy is detected or suspected, action must be taken to relieve or prevent re-energization.

   Note: *This can require the installation of temporary grounds and/or mechanical blocks.*

3. Release from lockout

Lockout must be released as follows:

a) Each lock (and tag if used) must be removed by the authorized individual who applied it before leaving the job. A procedure must be developed to deal with instances where employees have left the job site without clearing their personal lock/tag.
b) The individual responsible for the machine, equipment, or process (the affected employee) must be notified when the work is complete and the overall lockout has been cleared.
c) Before machine, equipment, or process re-energization, the work area must be visually inspected by an authorized individual to check that all personnel are clear of the work site, all non-essential items have been removed, and all components are operationally intact.

4. Specific procedures

Each facility must develop specific energy-isolation procedures for major machines, pieces of equipment, processes, components, utilities, etc. A “Lockout checklist for energy isolation” or “Job safety analysis” is suitable for this requirement.

(Continued)

Figure D.1 (Continued)

C. Special lockout situations

1. Lockout interruption (energized testing)

In situations where energy-isolating devices are locked out and it is necessary to test or position the machine, equipment, or process, the following sequence applies:

a) ensure that the machine, equipment, or process components are operationally intact;
b) remove any temporary de-energization devices;
c) clear the machine, equipment, equipment, or process of tools and materials;
d) clear personnel;
e) clear the energy-isolating device(s) of locks and tags (if used in accordance with established procedures);
f) proceed with test;
g) de-energize, relock, and tag (if a tag is used) energy-isolating device(s);
h) operate controls, etc., to verify energy isolation;
i) reapply any temporary de-energizing devices; and
j) allow work to restart.

2. Exposure of non-company personnel

Company and outside employers (contractors, etc.) must inform each other of their lockout procedures.

Each facility must ensure that its employees understand and comply with the requirements of the outside employer's or mutually agreed upon energy control procedures.

3. Multiple personnel protection (group lockout)

For major machine, equipment, or process overhauls, rebuilds, etc. that require crew, craft, department, or other group lockout, a system that affords employees a level of protection equivalent to that provided by personal lockout must be in place.

4. High-voltage work

Written procedures must be developed to describe the lockout measures necessary when employees are required to work on high-voltage circuits or equipment (above 600 V).

5. Shift change

Facilities must develop documented procedures to accommodate situations where it is necessary to continue lockout of a machine, piece of equipment, or process into subsequent shifts.

Exception

Unique requirements for machine, equipment, or process service (e.g., jogging, threading coil/stock) can necessitate employee activity under energized conditions. Each such task must be evaluated to provide safeguarding techniques to protect employees from machine, equipment, or process exposures.

(Continued)

Figure D.1 (Concluded)

Education and training

Education and training must be undertaken as follows:

a) Training must be provided before assignment to ensure that employees understand the purpose and function of the plant lockout program and that the knowledge and skills required for the safe application, use, and removal of energy controls are acquired. The training must include the essential elements of the following:
   i) each affected employee must be instructed in the purpose and use of the energy control procedure;
   ii) each authorized employee must receive training in the recognition of applicable hazardous energy sources, the type and magnitude of the energy available in the workplace, the methods and means necessary for energy isolation and control, and the means of verification of control; and
   iii) other employees whose work operations are or could be in an area where energy control procedures could be used must be instructed about the procedures and about the prohibition relating to attempts to restart or re-energize machines or equipment that are locked out.

b) Retraining must be provided annually to re-establish employee proficiency with control methods and procedures, as follows:
   i) retraining must be provided for all affected and authorized employees whenever there is a change in job assignments, a change in machines, equipment, or processes that presents a new hazard, a change in the energy control procedures, or a revision of control methods; and
   ii) additional retraining must be conducted whenever periodic audits (see below) reveal, or supervisory observations give reason to believe, that there are deviations from or inadequacies in an employee's knowledge or use of energy control procedures.

c) Plant documentation must certify that employee training has been accomplished and is being kept up-to-date. The certification must record each employee's name, clock number, and dates of training

Management controls

Each facility must develop and document a formal compliance audit of the lockout and other energy control procedures semi-annually to ensure that employees are knowledgeable about and use the designated procedures. The documentation must identify the machine, equipment, or process on which the energy control procedure was being used; the date of the inspection; the employees included in the inspection; and the person performing the inspection.

An authorized management employee must perform annual audits. The amount of lockout auditing should adequately represent the size of the plant and the number of authorized employees.

The audits must be designed to correct any observed deviations or inadequacies.

Where lockout is used for energy control, the audit must include a review by the inspector and each authorized employee of that employee's responsibilities under the energy control procedure being audited.

Where lockout procedures are used, other employees whose work operations are or could be in the area must be contacted by the inspector to ensure that they are aware of and understand the purpose of the procedures.

Figure D.2
Sample general lockout procedure (individual lockout)
(See Clauses 7.3.2.3.1and 7.3.7.1.)

Purpose

The purpose of this procedure is to prevent injury to employees from inadvertent start-up, energization, or release of stored energy during the servicing or maintenance of machines, equipment, or processes. It incorporates the minimum procedural requirements for locking, clearing, and verification to prevent injury from an inadvertent start-up or release of energy or material.

Steps to follow

The following steps must be followed in the general lockout procedure:

a) Step 1: Preparation for shutdown — Employees authorized to lock out machines, equipment, or processes must identify the type and magnitude of the energy to be controlled, all hazards (including stored energy), and the method or means of controlling the energy. They must also notify all affected persons in the area that the equipment is to be shut down and locked out.
b) Step 2: Machine, equipment, or process shutdown — The machine, equipment, or process must be shut down by following established shutdown procedures.
c) Step 3: Machine, equipment, or process isolation — The machine, equipment, or process must be isolated by following established isolation procedures that specify the use of disconnect switches, line valves, blocks, blanks, removal of spools, capping of lines, etc. as required. The devices that are required for isolation should be listed using the same identifiers (nomenclature) used to indicate their function in the field.
d) Step 4: Application of lockout devices — Locks must be applied to each of the isolation devices used to establish the isolation. Each employee working on the machine, equipment, or process must be responsible for attaching their personal locks without exception. To facilitate this requirement, a multi-hasp must be applied whenever necessary for the application of more than one lock
e) Step 5: Stored energy (de-energization) — Once the necessary lockout devices have been applied, all potentially hazardous stored or residual energy must be relieved, blocked, bled, restrained, or rendered safe by the authorized individuals involved with the work. Each worker involved must check that this has been done.
f) Step 6: Verification of isolation — Before starting work (i.e., after isolation and de-energization), an authorized individual must perform either a test of all of the start buttons and other activating controls, as well as a potential check of all electrical supplies to ensure that the equipment has been de-energized. The authorized person must ensure that all controls are returned to the “off” or neutral position after trying to start.
g) Step 7: Release from lockout control — Before restoring energy to the machine, equipment, or process, the authorized person must check that all temporary de-energization measures or devices have been terminated or removed, that the machine, equipment, or process is operationally intact, that all necessary guards have been reinstalled, and that all tools used during servicing or maintenance have been removed. Once this is done, an authorized employee must ensure that all other employees, affected employees, and authorized employees are clear and have been told that the energy to the machine, equipment, or process will be restored. Locks used to isolate the machine, equipment, or process may then be removed by the authorized employees involved in the servicing or maintenance and the energy restored.

(Continued)

Figure D.2 (Concluded)

Special considerations

The following special considerations apply:

a) No changes, adjustments, or repairs that require shutting down the machine, equipment, or process are to be made without permission of the operator (affected employee) or operating supervisor in charge. The machine, equipment, or process must be turned over to repair crews (authorized employees) before the work begins.

b) If more than one authorized employee works on the same machine, equipment, or process, each person must attach their lock.

c) When an authorized employee is reassigned from an incomplete job and the machine, equipment, or process needs to remain locked out, the authorized employee involved must notify their supervisor before removing their lock. The supervisor must then lock out the machine, equipment, or process or arrange for such lockout before the first employee removes their lock.

d) No attempt is to be made by anyone to operate a control device to which a lock is attached or to defeat the purpose of the lockout devices.

e) When a job is to be extended from one shift to another, the relieving authorized employee or the supervisor must attach their lock(s) to the lockout device(s) being used before the employee going off shift removes their lock(s). If the supervisor rather than the employee coming on shift places their lock(s) on the device, the employee coming on shift must place their lock(s) on the device before starting work.

f) If an employee leaves lock(s) on a machine, piece of equipment, or process and cannot be found, the supervisor may have the lock(s) removed only after following the lock removal procedure for an absent worker.

g) When requested by operating personnel, maintenance personnel shall perform electrical disconnects. The authorized employees assigned to perform the work must go with the person making the disconnect to observe the disconnection. Once the disconnect has been accomplished, the authorized individual must attach their personal lock to the energy-isolating device.

h) When personnel are locking out electrical disconnects, a test (operation of start switches or push buttons) or approved form of load verification must be performed to ensure that the correct isolating device has been used.

i) In no case is anyone to be assigned to remove another employee's lockout device except the supervisor specified in Item (f).

j) Locks for use under the lockout process must not be used for any purpose other than as specified in this procedure.

k) A supervisor must lock out all machines, equipment, and processes when they are to be out of service for 8 h or longer.

l) Outside contractors must be trained in the lockout procedure and be required to follow it.

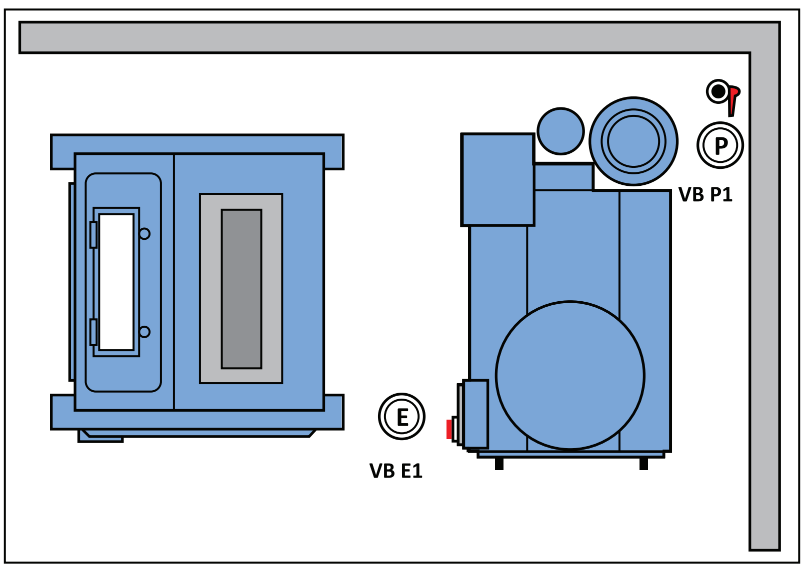
Figure D.3
Sample approved energy control procedure
(See Clause 7.3.2.3.1.)

DEPARTMENT:
Unit 3
Heat Treat

VERSION #:
2002

REFERENCE #:
157

POINT OF CONTACT:
Supervisor



Hazardous Energy

Type	Magnitude	Identifier
Electrical	415 volts	VB E1
Pneumatic	100 psi	VB P1

Required Safety Equipment

ID Tag(s)	(2)
Interlocking hasp(s)	(2)
Padlock(s)	(2)
Ball valve lockout(s)	(1)

Machine: VacuBlast Cabinet w/Dust Extractor — BLS1004, DEX103

(Continued)

Figure D.3 (Concluded)

Shutdown procedures:

a) Notify all affected employees that a lockout is going to be used and provide the reason for its application. The authorized employee(s) who will be relying on the lockout must know the type and magnitude of energy that the machine uses and must understand the associated hazards.
b) Electrical: press the "Stop" button to completely de-energize the machine.

Isolation procedures:

a) Electrical (VB E1):
Located between the two machines.
Turn the main electrical isolator (VB E1) to the "Off" position to isolate the electrical power.
b) Pneumatics (VB P1):
Located on the right side of the machine.
Rotate the main air service valve (VB P1) to the "Closed" position to block the air service.

Lockout procedures:

a) Electrical (VB E1):
Check that the main electrical isolator (VB E1) is in the "Off" position and apply lockout using an interlocking hasp and padlock.
b) Pneumatics (VB P1):
Check that the main air service valve (VB P1) is in the "Closed" position and apply lockout using a ball valve lockout, interlocking hasp, and padlock.

Verification procedures:

a) Electrical:
Once the lockout has been applied, verify your isolation by performing the following:
  i) Turn the vacuum blaster start and stop switch (VB S1) to "Start".
  ii) Ensure that the machine does not start.
  iii) Turn the vacuum blaster start and stop switch (VB S1) to "Off".
b) Pneumatics:
Verify isolation and dissipation of the air service by observing that the flow of air ceases.

Returning to service:

a) Authorized employee(s) must check the machine and the immediate area around the machine to ensure that non-essential items have been removed and that the machine components are operationally intact.
b) Check the work area to ensure that all employees have been safely positioned or removed from the work area.
c) Electrical (VB E1):
Remove the padlock and interlocking hasp from the main electrical isolator (VB E1) and turn the main electrical isolator (VB E1) to the "On" position.
d) Pneumatics (VB P1):
Remove the ball valve lockout, interlocking hasp, and padlock from the main air service valve (VB P1) and rotate the main air service valve (VB P1) to the "Open" position.
e) Notify affected employees that maintenance has been completed and the machine is available for service.

Annex E (informative)
Sample lockout placards

Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *This Annex is based in part on Annex D of ANSI/ASSE Z244.1.*

Figure E.1
Placard for single-point (electrical) lockout
(See Clause 7.3.2.3.1.)

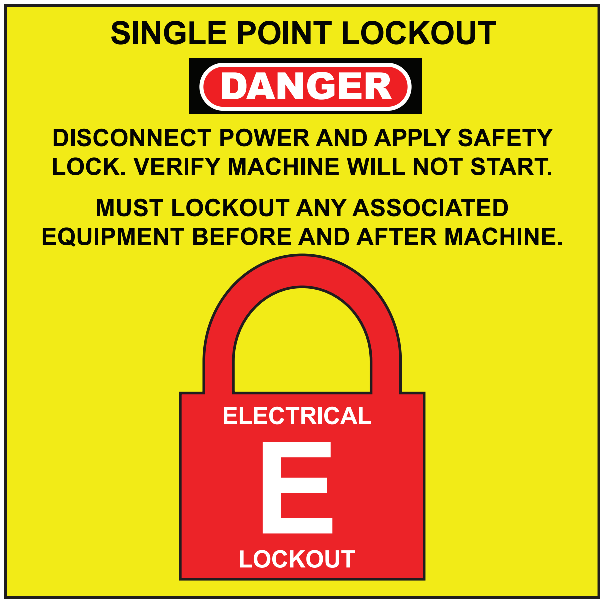
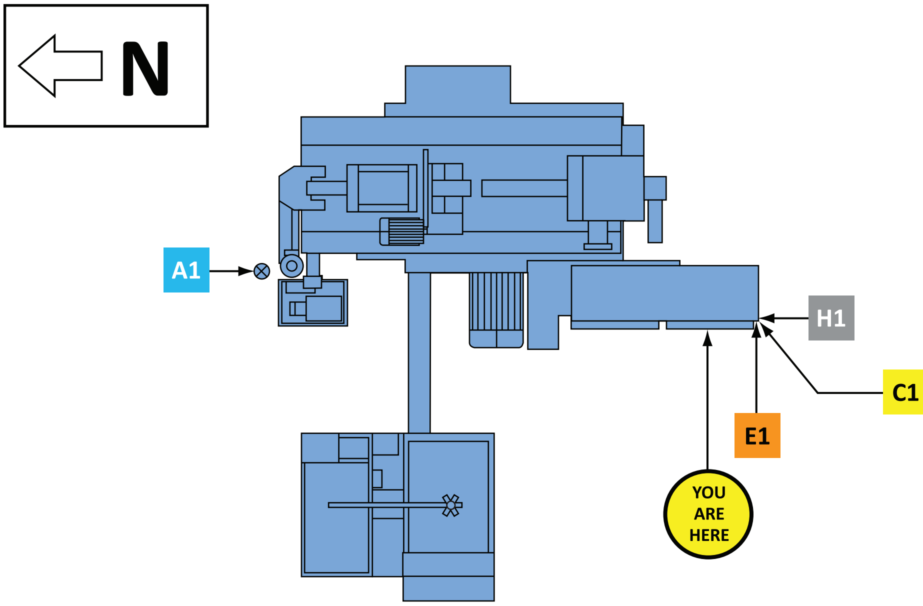


Figure E.2
KOYO KC centreless grinder
(See Clause 7.3.2.3.1.)

LOCKS REQUIRED * 4	LOCKOUT	Bay Location D-7
	KOYO KC Centreless Grinder	
	OP 180 — Turbine Shaft Groove Grind	BT# 45158

BEFORE SERVICING THIS MACHINE, NOTIFY AFFECTED PERSONNEL



FOLLOW SHUTDOWN PROCEDURES

Energy Source	Location	Perform Action	You Must Verify
* ELECTRICAL MAIN DISCONNECT	E1 ON PANEL	PLACE DISCONNECT IN OFF POSITION. ATTACH MULTIPLE LOCKOUT DEVICE, LOCK AND TAG.	ATTEMPT TO RESTART SYSTEM. SYSTEM MUST NOT START.
* AIR MAIN SUPPLY	A1 SIDE OF UNIT	CLOSE LOCKOUT VALVE SLOWLY, ATTACH MULTIPLE LOCKOUT DEVICE, LOCK AND TAG.	VISUALLY CONFIRM LOCKOUT VALVE IS IN CLOSED POSITION. CONFIRM ZERO (0) POUNDS OF PRESSURE.
* HYDRAULIC MAIN SUPPLY	H1 NEAR PANEL	CLOSE MANUAL VALVE SLOWLY, ATTACH MULTIPLE LOCKOUT DEVICE, LOCK AND TAG.	VISUALLY CONFIRM LOCKOUT VALVE IS IN CLOSED POSITION. ENSURE GAUGE READS (0) ZERO PSI. DOES NOT HOLD RESIDUAL PRESSURE.
* CHEMICAL COOLANT SUPPLY	C1 NEAR PANEL	CLOSE MANUAL VALVE. ATTACH MULTIPLE LOCKOUT DEVICE, LOCK AND TAG.	VISUALLY INSPECT FOR NO FLUID MOVEMENT IN MACHINE.

FOLLOW START UP PROCEDURES

STOP

IF LOCKOUT ENERGY CONTROL CANNOT BE PERFORMED / VERIFIED — STOP AND NOTIFY YOUR SUPERVISOR

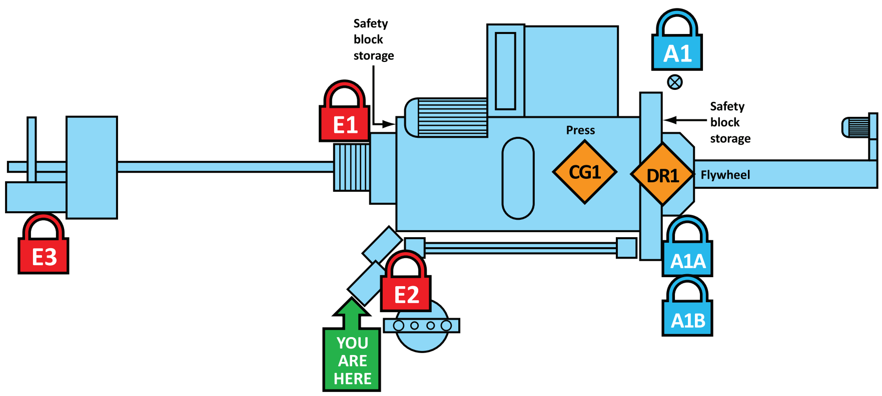
Figure E.3
#7 150 ton punch press
(See Clause 7.3.2.3.1.)

XYZ Mfg. Co.

Safety Lockout

#7 150 TON PUNCH PRESS

NOTICE — **ONLY PROPERLY TRAINED AND AUTHORIZED PERSONNEL SHALL CONDUCT LOCKOUT PROCEDURES** — **NOTICE**



ALWAYS PERFORM A MACHINE STOP BEFORE LOCKING OUT DISCONNECTS

ENERGY SOURCE	LOCKOUT LOCATION	PROCEDURES FOR LOCKING OUT AND/OR RELEASING ENERGIES	VERIFY PROCEDURE
Main Electrical Disconnect 480 V AC	E1 — 150 Ton Punch Press Main Electrical Disconnect	Place disconnect switch in the off position and apply safety lock and tag.	Attempt to start equipment powered by this disconnect. The equipment must not start and no action should occur.
Main Electrical Disconnect 110 V AC	E2 — Coil Feeder Main Electrical Disconnect	Place disconnect switch in the off position and apply safety lock and tag.	Attempt to start equipment powered by this disconnect. The equipment must not start and no action should occur.
Main Electrical Disconnect 110 V AC	E3 — Coil Handler Main Electrical Disconnect	Place disconnect switch in the off position and apply safety lock and tag.	Attempt to start equipment powered by this disconnect. The equipment must not start and no action should occur.
Main Air Shut-off 100 PSI	A1 — 150 Ton Punch Press Main Air Supply Shut-off Valve	Close shut-off valve. Install a lockable device over valve handle and apply safety lock. Manually vent air pressure.	Observe pressure gauge moving from operating pressure to 0 PSI, <u>or</u> if no gauge is present, attempt to manually operate equipment associated with this valve. The equipment must not operate.
Main Air Shut-off 100 PSI	A1A — Clutch Main Air Supply Shut-off Valve	Close shut-off valve and apply safety lock and tag.	Observe pressure gauge moving from operating pressure to 0 PSI, <u>or</u> if no gauge is present, attempt to manually operate equipment associated with this valve. The equipment must not operate.
Main Air Shut-off 100 PSI	A1B — Counterbalance Main Air Supply Shut-off Valve	Close shut-off valve and apply safety lock and tag.	Observe pressure gauge moving from operating pressure to 0 PSI, <u>or</u> if no gauge is present, attempt to manually operate equipment associated with this valve. The equipment must not operate.
Control Gravity	CG1 — Control Vertical Axis of Press	Place vertical axis of equipment into full bottom position and properly block or install safety pin through fixture holes.	Visually confirm equipment is fully bottomed out and properly blocked or that safety pin is properly installed and mechanical motion is eliminated.
Dissipate Rotation	DR1 — Dissipate Rotation of Flywheel	Wait for motion to cease. Apply blocking device if necessary.	Visually confirm that motion has stopped and, if applicable, that blocking device is installed.

IF SYSTEM CANNOT BE LOCKED OUT OR IF SYSTEM FAILS VERIFICATION, CONTACT YOUR SUPERVISOR.

Figure E.4
Unload crew cab conveyor system
(See Clause 7.3.2.3.1.)

UNLOAD CREW CAB CONVEYOR SYSTEM

NOTICE

This primary machine may have more than one type of primary energy and multiple sources of the same primary energy, including electrical, hydraulic, pneumatic, gas, water, steam, chemical, etc. — Lock it out!

This primary machine may have multiple stored energy sources, including motion, gravity, spring, extreme heat or cold, trapped pressure, capacitor, etc. — Release it!

If this primary machine has associate machinery, you must also read the ECPL plates of these machines. — Lock it out! Release it!

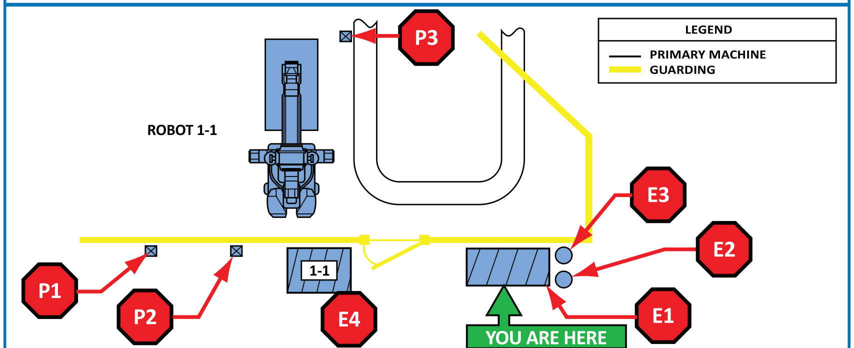
Do not work on this machine unless you have had energy control and power lockout (ECPL) training and thoroughly understand the procedures explained below and in the lockout manual.

Unless otherwise specified below, to restart this machine, verify that safeguards are replaced, non-essential items removed, controls neutralized, and personnel are clear, then reverse the lockout procedure and notify affected employees.

If you have any questions regarding proper lockout procedures, ask your advisor or supervisor or contact the safety department.

NOTICE

CHECK IT! PREP IT! LOCK IT! RELEASE IT! VERIFY IT!

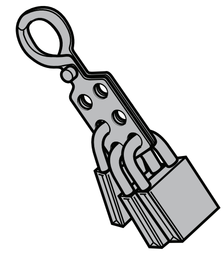


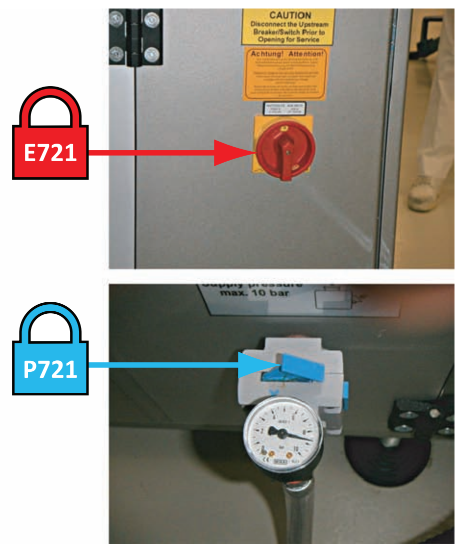
ENERGY TYPE AND SOURCE	LOCKOUT LOCATION	PROCEDURE FOR LOCKING OUT AND / OR RELEASING ENERGIES	VERIFY PROCEDURES
ELECTRICAL 480 V	E1 MAIN ELECTRICAL DISCONNECT	PLACE DISCONNECT HANDLE IN OFF POSITION. ATTACH MULTIPLE LOCKOUT DEVICE. LOCK AND TAG. DANGER: LINE SIDE OF DISCONNECT REMAINS ENERGIZED.	ATTEMPT TO RESTART THE SYSTEM. THE SYSTEM MUST NOT START. VISUALLY VERIFY OPEN DISCONNECT AND LOCKING DEVICE INSTALLED.
ELECTRICAL 480 V	E2 PLC DISCONNECT	PLACE DISCONNECT HANDLE IN OFF POSITION. ATTACH MULTIPLE LOCKOUT DEVICE. LOCK AND TAG. DANGER: LINE SIDE OF DISCONNECT REMAINS ENERGIZED.	ATTEMPT TO RESTART THE SYSTEM. THE SYSTEM MUST NOT START. VISUALLY VERIFY OPEN DISCONNECT AND LOCKING DEVICE INSTALLED.
ELECTRICAL 480 V	E3 LIGHTING DISCONNECT	PLACE DISCONNECT HANDLE IN OFF POSITION. ATTACH MULTIPLE LOCKOUT DEVICE. LOCK AND TAG. DANGER: LINE SIDE OF DISCONNECT REMAINS ENERGIZED.	ATTEMPT TO RESTART THE SYSTEM. THE SYSTEM MUST NOT START. VISUALLY VERIFY OPEN DISCONNECT AND LOCKING DEVICE INSTALLED.
ELECTRICAL 480 V	E4 ROBOT #1 DISCONNECT	PLACE DISCONNECT HANDLE IN OFF POSITION. ATTACH MULTIPLE LOCKOUT DEVICE. LOCK AND TAG. DANGER: LINE SIDE OF DISCONNECT REMAINS ENERGIZED.	ATTEMPT TO RESTART THE SYSTEM. THE SYSTEM MUST NOT START. VISUALLY VERIFY OPEN DISCONNECT AND LOCKING DEVICE INSTALLED.
PNEUMATIC	P1 ROBOT AIR SUPPLY	SLOWLY CLOSE LOCKOUT VALVE TO RELEASE AIR PRESSURE GRADUALLY. ATTACH MULTIPLE LOCKOUT DEVICE, LOCK AND TAG.	VERIFY THAT THE VALVE IS CLOSED AND THE LOCKOUT DEVICE IS PROPERLY ATTACHED.
PNEUMATIC	P2 AIR SUPPLY CONVEYOR THIS END	SLOWLY CLOSE LOCKOUT VALVE TO RELEASE AIR PRESSURE GRADUALLY. ATTACH MULTIPLE LOCKOUT DEVICE, LOCK AND TAG.	VERIFY THAT THE VALVE IS CLOSED AND THE LOCKOUT DEVICE IS PROPERLY ATTACHED.
PNEUMATIC	P3 AIR SUPPLY CONVEYOR FAR END	SLOWLY CLOSE LOCKOUT VALVE TO RELEASE AIR PRESSURE GRADUALLY. ATTACH MULTIPLE LOCKOUT DEVICE, LOCK AND TAG.	VERIFY THAT THE VALVE IS CLOSED AND THE LOCKOUT DEVICE IS PROPERLY ATTACHED.

MANUFACTURER: ____________
DESCRIPTION: UNLOAD CREW CAB CONVEYOR SYSTEM
DEPARTMENT: N/A
CONTROLS: N/A
MANAGEMENT SIGNATURE: ____________

P/N#: N/A
S/N#: N/A
MECHANICAL: N/A
ELECTRICAL: N/A
PNEUMATIC: N/A
LUBRICATION: N/A
COOLANT: N/A

Figure E.5
Line bundler 721
(See Clause 7.3.2.3.1.)

XYZ Mfg. Co.	**Safety Lockout** Line Bundler 721 **ONLY TRAINED AND AUTHORIZED PERSONNEL SHALL CONDUCT SAFETY LOCKOUT PROCEDURES**	



ALWAYS PERFORM A MACHINE STOP BEFORE LOCKING OUT DISCONNECTS

ENERGY TYPE AND SOURCE	I.D. TAG	PROCEDURES FOR LOCKING OUT AND/OR RELEASING ENERGIES	VERIFICATION PROCEDURES
400 V main disconnect switch located on back side of machine	E721	Place disconnect switch in the off and position attach lockout device, lock, and tag.	Attempt to start equipment powered by this disconnect switch. The equipment must not start and no action shall occur.
120 PSI main pneumatic shut-off valve located on back side of machine	P721	Place valve in the off position and apply lockout device, lock, and tag.	Visually confirm that shut-off valve is in the off position and locked.

IF SYSTEM CANNOT BE LOCKED OUT OR IF SYSTEM FAILS VERIFICATION, CONTACT YOUR SUPERVISOR DATE:

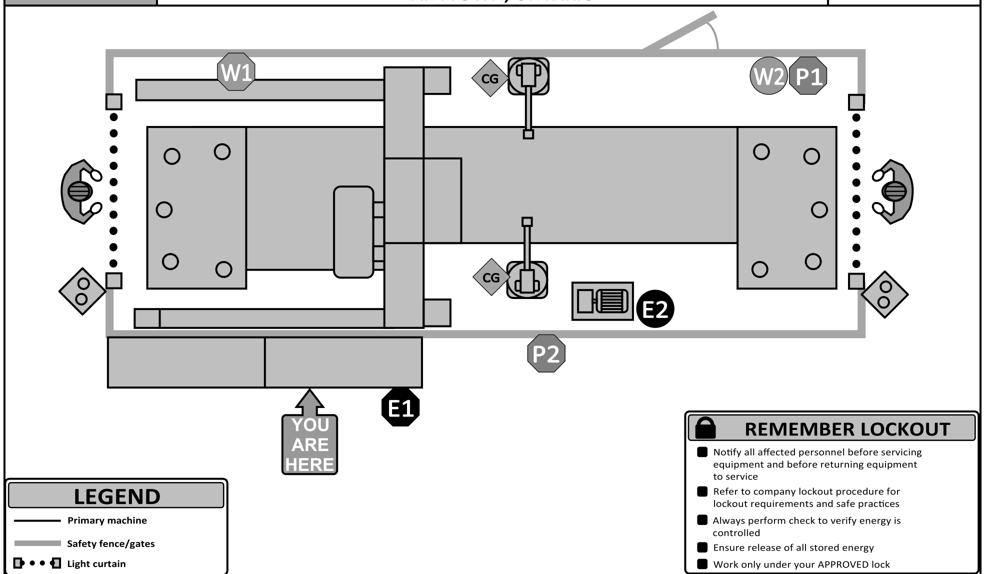
Figure E.6
Waterjet system
(See Clause 7.3.2.3.1.)

REMEMBER LOCKOUT

Safety Lockout

WATERJET SYSTEM

ANYTOWN, ONTARIO



ALWAYS PERFORM CONTROLLED SHUTDOWN BEFORE LOCKING OUT DISCONNECTS

ENERGY TYPE AND SOURCE	LOCKOUT LOCATION		PROCEDURE FOR LOCKING OUT AND/OR RELEASING ENERGIES	VERIFY PROCEDURE
ELECTRICAL 480 V	E1	MAIN WATERJET SYSTEM ELECTRICAL DISCONNECT	PLACE DISCONNECT SWITCH IN THE OFF POSITION AND APPLY SAFETY LOCK. SHUTS OFF ELECTRICAL POWER TO THE WATERJET SYSTEMS CIRCUITS.	TEST THE WATERJET SYSTEM ELECTRICAL CIRCUITS AND INDICATORS POWERED BY THIS DISCONNECT SWITCH. THEY SHOULD NOT TURN ON AND NO ACTION SHOULD OCCUR. ATTEMPT TO START OR OPERATE THE EQUIPMENT.
ELECTRICAL 480 V	E2	BOOSTER PUMP ELECTRICAL DISCONNECT	PLACE DISCONNECT SWITCH IN THE OFF POSITION AND APPLY SAFETY LOCK. SHUTS OFF ELECTRICAL POWER TO THE BOOSTER PUMP CIRCUITS.	TEST THE BOOSTER PUMP ELECTRICAL CIRCUITS AND INDICATORS POWERED BY THIS DISCONNECT SWITCH. THEY SHOULD NOT TURN ON AND NO ACTION SHOULD OCCUR. ATTEMPT TO START OR OPERATE THE EQUIPMENT.
PNEUMATIC 110 PSI	P1	MAIN WATERJET SYSTEM AIR SUPPLY SHUT-OFF VALVE	CLOSE SHUT-OFF VALVE AND APPLY SAFETY LOCK. ISOLATES AIR PRESSURE FROM THE WATERJET SYSTEM CIRCUITS. VENTS THE COMPRESSED AIR PRESSURE AUTOMATICALLY.	VISUALLY INSPECT ASSOCIATED AIR PRESSURE GAUGE. OBSERVE GAUGE MOVING FROM OPERATING PRESSURE TO 0. LISTEN FOR THE RELEASE OF AIR PRESSURE.
PNEUMATIC 110 PSI	P2	MAIN ROBOTS AIR SUPPLY SHUT-OFF VALVE	CLOSE SHUT-OFF VALVE AND APPLY SAFETY LOCK. ISOLATES AIR PRESSURE FROM THE ROBOTS CIRCUITS. VENTS THE COMPRESSED AIR PRESSURE AUTOMATICALLY.	VISUALLY INSPECT ASSOCIATED AIR PRESSURE GAUGE. OBSERVE GAUGE MOVING FROM OPERATING PRESSURE TO 0. LISTEN FOR THE RELEASE OF AIR PRESSURE.
WATER 60 PSI	W1	MAIN WATERJET HIGH-PRESSURE SYSTEM WATER SUPPLY INLET SHUT-OFF VALVE	CLOSE SHUT-OFF VALVE AND APPLY SAFETY LOCK. STOPS WATER FLOW TO THE WATERJET HIGH-PRESSURE SYSTEM WATER SUPPLY/INLET SYSTEM CIRCUITS.	VISUALLY CONFIRM THAT WATERJET HIGH-PRESSURE SYSTEM WATER SUPPLY/INLET SHUT-OFF VALVE IS IN THE OFF POSITION AND LOCKED. MANUALLY RELEASE LINE PRESSURE.
WATER 40 PSI	W2	WATER CONTAINMENT TANK WATER RETURN/OUTLET SHUT-OFF VALVE	CLOSE SHUT-OFF VALVE AND APPLY SAFETY LOCK. STOPS WATER BACKFLOW TO THE WATER CONTAINMENT TANK WATER RETURN/OUTLET SYSTEM CIRCUITS.	VISUALLY CONFIRM THAT WATER CONTAINMENT TANK WATER RETURN/OUTLET SHUT-OFF VALVE IS IN THE OFF POSITION AND LOCKED. MANUALLY RELEASE LINE PRESSURE.
CONTROL GRAVITY	CG	ROBOT FIXTURE SUPPORT, BLOCK, OR BOTTOM OUT EQUIPMENT (TWO PLACES)	SUPPORT, BLOCK, OR BOTTOM OUT THE ROBOT FIXTURE TO PREVENT ANY UNPREDICTABLE MOVEMENT.	VISUALLY CONFIRM THAT THE EQUIPMENT IS SUPPORTED, BLOCKED, OR BOTTOMED OUT.

IF SYSTEM CANNOT BE LOCKED OUT OR IF SYSTEM FAILS VERIFICATION, CONTACT YOUR SUPERVISOR. STOP

HEALTH & SAFETY REVIEW		MANAGEMENT REVIEW	
APPROVAL NAME	____________	APPROVAL NAME	____________
DATE	____________	DATE	____________

(Continued)

Figure E.6 (Continued)

WATER

MAIN WATERJET HIGH-PRESSURE SYSTEM WATER SUPPLY/INLET SHUT-OFF VALVE

ENERGY CONTROL POINT

W1

PROCEDURE FOR LOCKING OUT AND/OR RELEASING ENERGIES

CLOSE SHUT-OFF VALVE AND APPLY SAFETY LOCK. STOPS WATER FLOW TO THE WATERJET HIGH-PRESSURE SYSTEM WATER SUPPLY/INLET SYSTEM CIRCUITS.

VERIFY PROCEDURE

VISUALLY CONFIRM THAT WATERJET HIGH-PRESSURE SYSTEM WATER SUPPLY/INLET SHUT-OFF VALVE IS IN THE OFF POSITION AND LOCKED. MANUALLY RELEASE LINE PRESSURE.

CONTROL GRAVITY

ROBOT FIXTURE SUPPORT, BLOCK, OR BOTTOM OUT EQUIPMENT

ENERGY CONTROL POINT

CG

PROCEDURE FOR LOCKING OUT AND/OR RELEASING ENERGIES

SUPPORT, BLOCK, OR BOTTOM OUT THE ROBOT FIXTURE TO PREVENT ANY UNPREDICTABLE MOVEMENT.

VERIFY PROCEDURE

VISUALLY CONFIRM THAT THE EQUIPMENT IS SUPPORTED, BLOCKED, OR BOTTOMED OUT.

WATER

WATER CONTAINMENT TANK WATER RETURN/OUTLET SHUT-OFF VALVE

ENERGY CONTROL POINT

W2

PROCEDURE FOR LOCKING OUT AND/OR RELEASING ENERGIES

CLOSE SHUT-OFF VALVE AND APPLY SAFETY LOCK. STOPS WATER BACKFLOW TO THE WATER CONTAINMENT TANK WATER RETURN/OUTLET SYSTEM CIRCUITS.

VERIFY PROCEDURE

VISUALLY CONFIRM THAT WATER CONTAINMENT TANK WATER RETURN/OUTLET SHUT-OFF VALVE IS IN THE OFF POSITION AND LOCKED. MANUALLY RELEASE LINE PRESSURE.

CONTROL GRAVITY

ROBOT FIXTURE SUPPORT, BLOCK, OR BOTTOM OUT EQUIPMENT

ENERGY CONTROL POINT

CG

PROCEDURE FOR LOCKING OUT AND/OR RELEASING ENERGIES

SUPPORT, BLOCK, OR BOTTOM OUT THE ROBOT FIXTURE TO PREVENT ANY UNPREDICTABLE MOVEMENT.

VERIFY PROCEDURE

VISUALLY CONFIRM THAT THE EQUIPMENT IS SUPPORTED, BLOCKED, OR BOTTOMED OUT.

(Continued)

Figure E.6 (Concluded)

ELECTRICAL

MAIN WATERJET SYSTEM ELECTRICAL DISCONNECT

ENERGY CONTROL POINT

E1

PROCEDURE FOR LOCKING OUT AND/OR RELEASING ENERGIES

PLACE DISCONNECT SWITCH IN THE OFF POSITION AND APPLY SAFETY LOCK. SHUTS OFF ELECTRICAL POWER TO THE WATERJET SYSTEM CIRCUITS.

VERIFY PROCEDURE

TEST THE WATERJET SYSTEM ELECTRICAL CIRCUITS AND INDICATORS POWERED BY THIS DISCONNECT SWITCH. THEY SHOULD NOT TURN ON AND NO ACTION SHOULD OCCUR. ATTEMPT TO START OR OPERATE THE EQUIPMENT.

PNEUMATIC

MAIN WATERJET SYSTEM AIR SUPPLY SHUT-OFF VALVE

ENERGY CONTROL POINT

P1

PROCEDURE FOR LOCKING OUT AND/OR RELEASING ENERGIES

CLOSE SHUT-OFF VALVE AND APPLY SAFETY LOCK. ISOLATES AIR PRESSURE FROM THE WATERJET SYSTEM CIRCUITS. VENTS THE COMPRESSED AIR PRESSURE AUTOMATICALLY.

VERIFY PROCEDURE

VISUALLY INSPECT ASSOCIATED AIR PRESSURE GAUGE. OBSERVE GAUGE MOVING FROM OPERATING PRESSURE TO 0. LISTEN FOR THE RELEASE OF AIR PRESSURE.

ELECTRICAL

BOOSTER PUMP ELECTRICAL DISCONNECT

ENERGY CONTROL POINT

E2

PROCEDURE FOR LOCKING OUT AND/OR RELEASING ENERGIES

PLACE DISCONNECT SWITCH IN THE OFF POSITION AND APPLY SAFETY LOCK. SHUTS OFF ELECTRICAL POWER TO THE BOOSTER PUMP CIRCUITS.

VERIFY PROCEDURE

TEST THE BOOSTER PUMP ELECTRICAL CIRCUITS AND INDICATORS POWERED BY THIS DISCONNECT SWITCH. THEY SHOULD NOT TURN ON AND NO ACTION SHOULD OCCUR. ATTEMPT TO START OR OPERATE THE EQUIPMENT.

PNEUMATIC

MAIN ROBOTS AIR SUPPLY SHUT-OFF VALVE

ENERGY CONTROL POINT

P2

PROCEDURE FOR LOCKING OUT AND/OR RELEASING ENERGIES

CLOSE SHUT-OFF VALVE AND APPLY SAFETY LOCK. ISOLATES AIR PRESSURE FROM THE ROBOTS CIRCUITS. VENTS THE COMPRESSED AIR PRESSURE AUTOMATICALLY.

VERIFY PROCEDURE

VISUALLY INSPECT ASSOCIATED AIR PRESSURE GAUGE. OBSERVE GAUGE MOVING FROM OPERATING PRESSURE TO 0. LISTEN FOR THE RELEASE OF AIR PRESSURE.

Annex F (informative) ***Sample lockout device and information tag removal report and sample warning notice***

Note: *This Annex is not a mandatory part of this Standard.*

Figure F.1
Sample lockout device and information tag removal report

Lockout device and information tag removal report

Department: ____

Shift: ____

Authorized employer's name: ____

Machine, equipment, or process:____

Time and date lockout device and information tag was discovered to have been left on: ______

Reasons for removal of lock and tag: ____
____

Confirmed that the authorized employee has left the site and/or facility? Yes □ No □

Supervisor's initials: ___________________________Time and date: ________________________

Attempts made to contact the authorized employee?: Yes □ No □

□ Authorized employee has been contacted and is returning to the workplace to remove the lockout device and tag. Procedure ends, exit procedure, file form for future reference.

Supervisor's initials: ___________________________Time and date: ________________________

□ Authorized employee cannot be contacted and/or is unwilling to return to the site and/or facility to remove the lockout device and tag.

Supervisory personnel may authorize removal of the lock and tag once

- The status and condition of the machine, equipment, or process are assessed and verified to be in a state that will allow for the safe removal of the lockout device

  Supervisor's initials: ________________________ Time and date: ______________________

- Provisions are in place to prevent the authorized employee from resuming work at this facility without notification of the fact that their lock and tag has been removed

  Supervisor's initials: ________________________ Time and date: ______________________

Supervisory personnel can now remove the lock and tag.

Supervisor's initials: ___________________________Time and date: ________________________

Witness: ____

Figure F.2
Sample warning notice

Notice to employee

Name: ______________________________

Lockout device and information tag removed

Section

____

Lockout policy

Please report to your immediate supervisor

Date: ______________________________

Supervisor: ______________________________

Annex G (informative)
Sample group lockout procedure

Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *This Annex is based in part on Annex E of ANSI/ASSE Z244.1.*

Δ **Figure G.1**
Sample group lockout procedure
(See Clauses 7.3.7.2 and 7.3.7.3.)

Group lockout procedural structure

When more than one authorized employee is being protected by multiple energy-isolating devices, each energy-isolating device can itself be secured by a single lockout under the following conditions:

a) A primary authorized employee is selected to exercise primary responsibility for implementation and coordination of the lockout of hazardous energy sources
b) The primary authorized employee coordinates with equipment operators before and after completion of servicing and maintenance operations that require lockout.
c) A verification system is implemented to ensure the continued isolation and de-energization of hazardous energy sources.
d) Each authorized employee required to perform work under the established isolation is assured of their right to verify individually that the hazardous energy has been isolated and/or de-energized. Authorized individuals then apply their personal lock (and tag if used) to the lockable device. Each authorized individual should request, at the time of lockout, that isolation be verified in their presence.
e) When more than one crew, craft, department, etc. is involved, each group of servicing/maintenance personnel is accounted for by a principal authorized employee representing the group. Each principal authorized employee is responsible to the primary authorized employee for maintaining accountability of each worker in that group in compliance with company procedure. No one is allowed to sign on or off for another person or attach or remove another person's lockout device unless the provisions of an approved lock removal procedure have been met.

Group lockout (lockbox procedures)

Group lockout using lockbox (lockable devices) techniques usually involves the following:

a) company or general locks for isolating devices;
b) multiple lockout devices (multi-hasps);
c) lockable devices (lockboxes or key rings);
d) multi-level lockable devices (lockboxes, key rings, or cabinets);
e) primary and principal control locks (master job locks);
f) personal locks; and
g) multiple group control methods.

Figure G.2 depicts a lockout board (complete set-up for group lockout isolation) that incorporates these elements.

(Continued)

Figure G.1 (Continued)

Group lockout examples (in increasing order of complexity)

Example 1: Simple group lockout

Under a lockbox procedure, company-provided lock(s) are placed on each lockout device by a primary authorized individual once the device has been operated to isolate the energy source. The key(s) are then placed in a lockbox. Next, each authorized employee assigned to the job affixes their personal lock to the lockbox. As a member of a group, each assigned authorized employee verifies that all hazardous energy has been rendered safe. The lockout devices cannot be removed or the energy-isolating device turned on until the appropriate key is matched to its lock. When all work is complete, and before restoring energy to the equipment, the primary authorized individual checks that all temporary de-energization measures and devices have been terminated or removed, that the equipment is operationally intact, that all necessary guards have been reinstalled, and that all tools used during servicing and maintenance have been removed. Once this is complete, the primary authorized individual checks that all other employees, affected employees, and authorized employees are clear and have been told that energy to the equipment will be restored. Locks and tags, if used, may then be removed by the authorized employees involved in the servicing or maintenance and the energy restored.

Example 2: Multiple group lockout

After each energy-isolating device is locked out and the keys placed in a master lockbox, each servicing/maintenance group principal authorized employee places their personal lock on the master lockbox. Then, each principal authorized employee inserts their key into a satellite lockbox, to which each authorized employee in that group affixes their personal lock and tag (if used). As a member of a group, each assigned authorized employee verifies that all hazardous energy has been rendered safe. Only after the servicing/maintenance functions of the subgroup have been concluded and the personal locks and tags (if used) of the respective employees have been removed from the satellite lockbox can the principal authorized employee remove their lock from the master lockbox.
Figure G.3 illustrates a scheme for establishing such a lockout structure.

(Continued)

Figure G.1 (Concluded)

Example 3: Shift control measures for group/multiple group lockout

During operations to be conducted over more than one shift (or even many days or weeks) the following system (or a variation thereof) may be used. The group lockout specified in Example 1 or Example 2 is applied. Before any authorized personnel apply their personal locks to the lockbox, a job-lock is applied by the supervisor or manager of the shift. The key for the job-lock is controlled by the supervisor or manager on behalf of the company. Once applied, the group lockout is positioned as being ready for use. All authorized employees involved in the work are then allowed to apply their personal locks and perform all of the normally required checks to ensure that the hazardous energy has been rendered safe before starting work. This allows authorized work groups or work facilities to use the group lockout, as required, until the work is completed. Once all of the work is completed and verified by the supervisor or shift manager, the isolation can be removed, as long as all of the personal locks have been removed from the lockbox.

Figure G.4 illustrates schemes for both change-of-shift and extended-period lockout.

Example 4: Multiple group lockout using pyramiding controls

Pyramiding control methods are sometimes used to expedite application of an isolation. Instead of one group isolation being applied, a number of group isolations are applied at various locations in the plant or on a production line, which, when combined, make up the required isolation for the work to be done. Personnel security is managed by establishing a hierarchy of lockout control in which no single individual has the authority or ability to move or remove any energy-isolation device without the approval of all of the workers involved in the servicing or maintenance.

Figure G.5 illustrates a scheme for establishing such a lockout structure. In this scheme, three groups of employees are involved in the energy-isolation activity to perform servicing or maintenance. Twelve employees (A–L) are involved. Eighteen energy-isolating devices (1–18) are applied to effect the required isolation, which then is systematically locked by the authorized employees involved in the maintenance, as follows:

a) Step 1: Employees (A–D) in Group A operate energy-isolating devices (1–6) in Zone 1 and lock using company or equipment locks.
b) Step 2: Keys from company or equipment locks are placed in the Zone 1 lockbox. The primary authorized individual for work group “A” applies a master lock to the Zone 1 lockbox.
c) Step 3: The primary authorized individual for work group “A” takes the master lock key from the Zone 1 lockbox and deposits it in the master job lockbox.
d) Step 4: Work groups “B” and “C” follow Steps 1 to 3 for Zones 2 and 3, respectively.
e) Step 5: Once all master keys for Zones 1, 2, and 3 have been deposited in the master job lockbox, the supervisor or shift manager places a job lock on the master job lockbox and retains the master job lockbox key for shift control purposes.
f) Step 6: Each primary authorized individual for work groups A, B, and C then places a group lock on the master lockbox, takes the key back to the job site, and places the key in a work group lockbox that can then be locked by each authorized individual involved in the work.

Note: *A number of variations are possible in this type of control pyramid to achieve the end result, i.e., personal security for all potentially exposed personnel.*

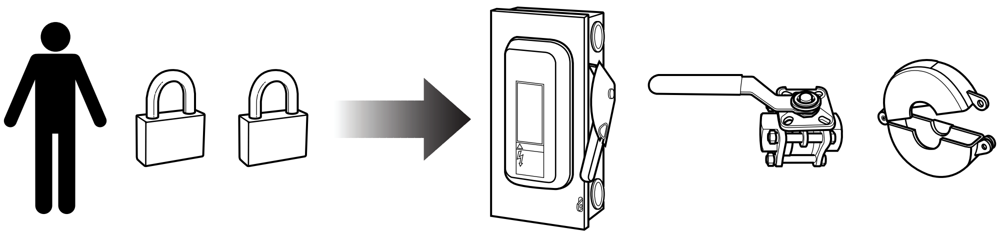
Figure G.2
Standard lockout board
(See Clauses 7.3.7.2 and 7.3.7.3 and Figure G.1.)

Δ

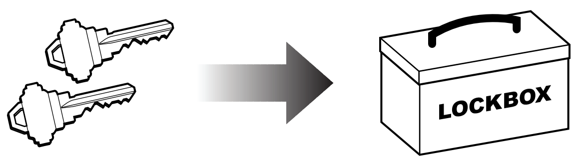
Figure G.3
Simple group lockout

(See Clauses 7.3.7.2 and 7.3.7.3 and Figure G.1.)

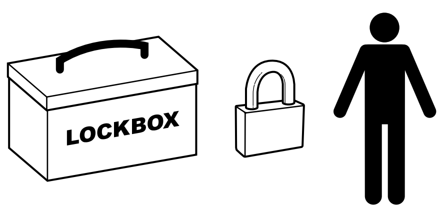
1. Primary authorized individual applies lockout to each energy-isolating device (company or general locks).



2. Keys to the applied locks are placed in a lockable device, i.e., lockbox.

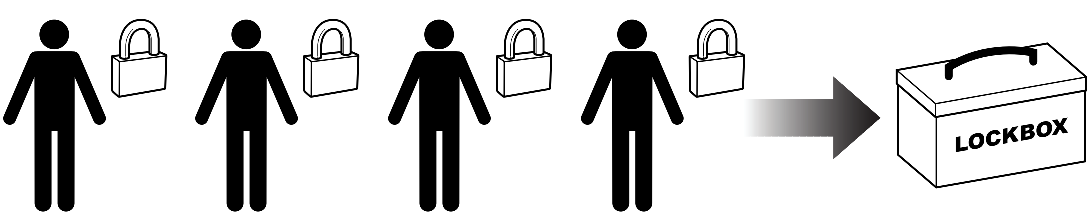


3. Lockable device (i.e., lockbox) is locked by primary authorized individual with their personal lock.



4(a) A verification procedure is used to determine the effectiveness of energy isolation.
4(b) Before authorized individuals start work, they familiarize themselves with the energy-isolating devices to be used; and assess their adequacy for the work to be performed.

5. Authorized individuals then apply their personal lock (and tag if used) to the lockable device, i.e., lockbox



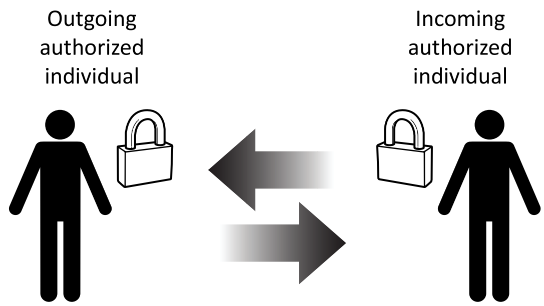
6. Work commences only after authorized individuals have applied their personal lock (and tag if used) to the lockable device- (i.e., lockbox) and are confident that all hazardous energy has been isolated and locked out

Δ

Figure G.4
Indirect change of shift or lockout during an extended period
(See Clauses 7.3.7.2 and 7.3.7.3 and Figure G.1.)

Direct change of shift or lockout during an extended period

Incoming authorized and outgoing authorized individuals are in contact with each other and simply exchange information, incoming installs their personal lock(s) and outgoing removes their lock(s) on the energy- isolating device(s).

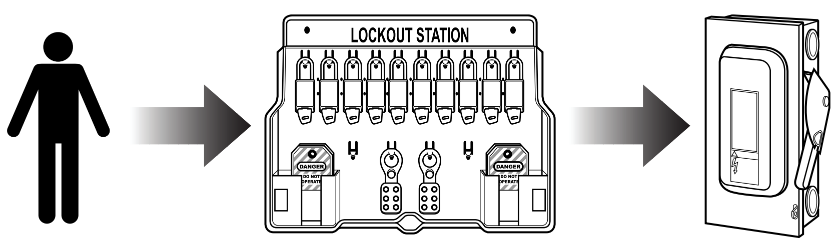


Indirect change of shift or lockout during an extended period

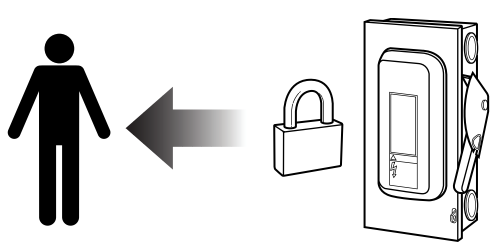
Incoming and outgoing authorized individuals are not in contact.

1. Outgoing authorized individual installs a departmental or trade lock(s) onto energy-isolating device (s). This lock may be obtained from a lockout board or station located at a centralized location.

Note: *These particular locks may be keyed alike between a department or specific trade, i.e., electrician, millwright, etc. Or the key(s) to the departmental or trade lock may be placed back on the lockout board or centre.*



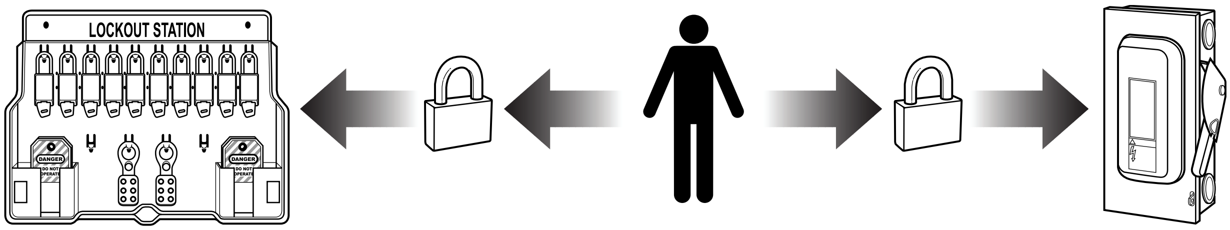
2. Outgoing authorized individual removes their personal lock(s) from energy-isolating device(s).



(Continued)

Figure G.4 (Concluded)

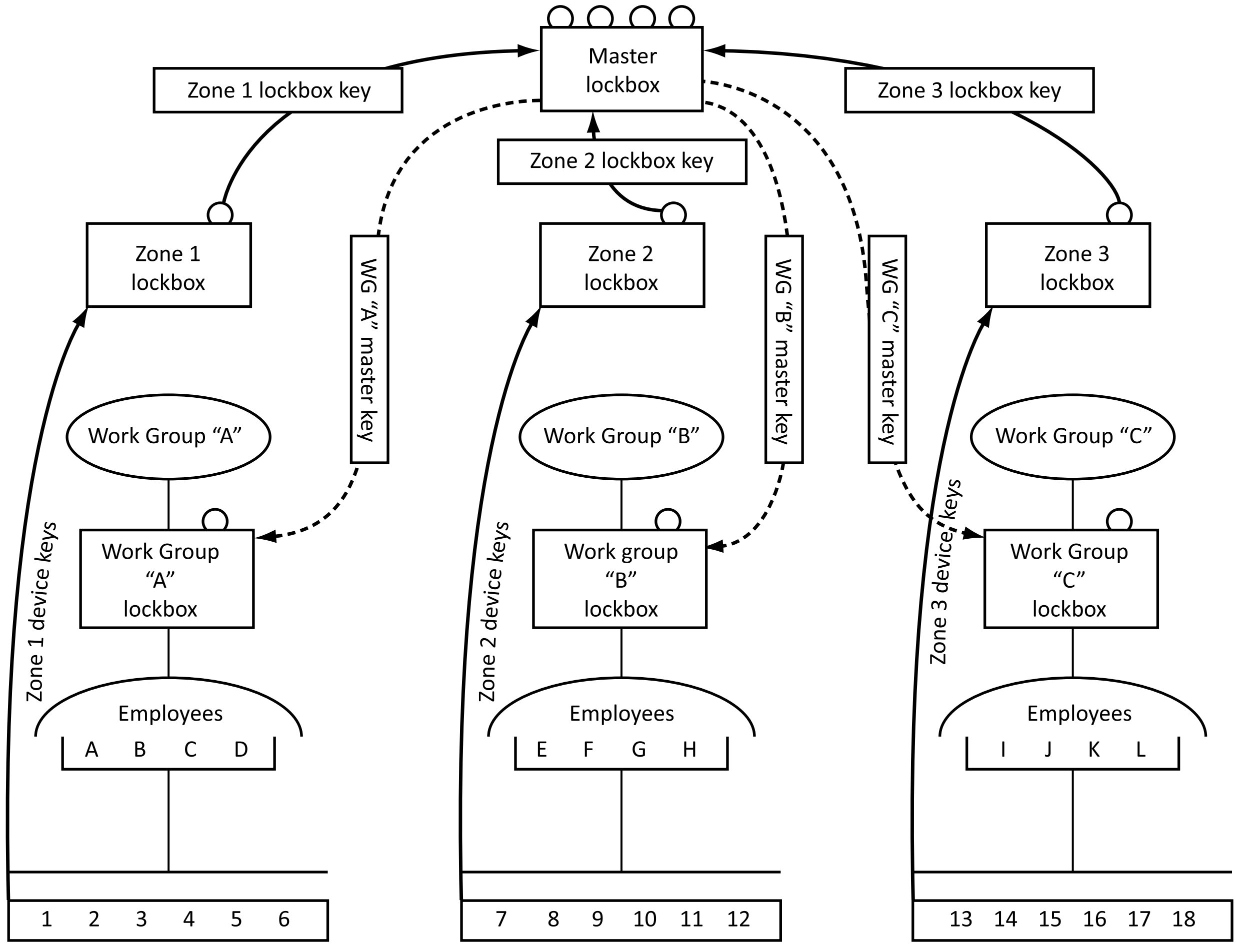
3. Incoming authorized individual installs their personal lock(s) on energy-isolating device(s) and removes Departmental or trade lock(s) and places them back on lockout board or centre



Note: *Lockout must not be interrupted during a change of shift or during an extended period. The intent of the departmental or trade lock is more for equipment protection, as opposed to worker protection.*

Figure G.5
Group lockout security pyramid for complex isolation

(See Clauses 7.3.7.2 and 7.3.7.3 and Figure G.1.)



Annex H (informative)
Complex group lockout (permit systems)

Note: *This Annex is not a mandatory part of this Standard.*

H.1
Petroleum, chemical, steel, electrical generation/distribution, and industrial gas production, among others, involve operations in which adaptation and modification of normal group lockout procedures is needed to ensure the safety of employees performing service and maintenance. To provide greater worker safety through implementation of a more feasible system, and to accommodate the special constraints of this Standard's requirement for ensuring that employees enjoy a level of protection equivalent to that provided by the use of a personal lockout device, a complex group lockout procedure may be implemented if it is justified by company documentation and has been reviewed and accepted by the authorities having jurisdiction.

H.2
Lockout, blanking, blocking, and similar practices are often supplemented in the situations described in Clause H.1 by the work permits and a system of continuous worker accountability. In evaluating whether the machine, piece of equipment, or process being serviced or maintained is so complex as to necessitate use of a complex group lockout procedure in lieu of a normal group lockout procedure, the following factors (which often occur simultaneously) are among those that need to be evaluated:
a) the size of the machine, equipment, or process;
b) the degree of inaccessibility of the energy-isolating devices;
c) the number of employees performing service and maintenance;
d) the number of energy-isolating devices to be isolated;
e) the length of time the machine, equipment, or process will be isolated;
f) the number of authorized individuals involved; and
g) the interdependence and interrelationship of the components in the system or between different systems.

H.3
Complex group lockout also necessitates the following (at a minimum):
a) if a device is designed by the manufacturer to be locked, it needs to be locked;
b) all electrical devices rated at 300 V or more and used for energy isolation need to be locked, blocked, or visibly grounded; and
c) each work group authorized to work under the protection provided by complex group lockout needs to apply a work group lock to the lockable device.

H.4
After the machine, equipment, or process is shut down and the hazardous energy has been controlled, maintenance, servicing, and operating personnel need to verify that isolation has been effective. The authorized employee or designated person in charge of the work group walks through the affected work area to verify isolation. If there is a potential for release or reaccumulation of hazardous energy, verification of isolation needs to continue. Service and maintenance workers can further verify the effectiveness of the isolation by attempting procedures that are used in the work (e.g., using a bleeder valve to verify depressurization or using flange-breaking techniques). Throughout the servicing or maintenance, operations personnel normally maintain control of the machine, equipment, or process.

The use of a work permit system (in which each employee or the designated person in charge personally signing on and off the job and applying their work group lock to a lockable device ensures continuing employee accountability and control), combined with verification of hazardous energy control, work procedures, and walk-through, is an acceptable approach to compliance with the group lockout and shift transfer provisions of this Standard.

H.5

H.5.1

The scenarios specified in Clauses H.5.2 and H.5.3 illustrate two control methods that may be used during isolation of hazardous energy in complex processes and comply with the group lockout requirements of this Standard.

H.5.2

The following is Scenario #1:

a) Complex process equipment scheduled for servicing/maintenance operations is generally identified by plant supervision. Plant supervision personnel issue work orders for the operations to be performed.
b) In most instances where complex process equipment is to be serviced or maintained, the process equipment operators can be expected to conduct the shutdown procedure on account of their in-depth knowledge of the equipment and the need to conduct the shutdown procedure in a safe, efficient, and specific sequence.
c) The operations personnel normally prepare the equipment for lockout as they proceed. They identify the locations for blanks and blocks by placing operations locks and/or tags on the equipment. They can be expected to isolate the hazardous energy and drain and flush fluids from the process equipment in accordance with a standard procedure or a work permit procedure, with the final phase being the establishment of the lockout permit and associated lockable device.
d) On completion of shutdown, the operations personnel review the intended job with the servicing and maintenance crews and ensure that the crews fully understand the energy controls necessary to safely conduct the servicing and maintenance. During or immediately after review of the job, the crews apply their locks to the lockable device and/or special isolating devices at previously identified equipment locations in accordance with the work permit procedure.
e) Line openings necessary for isolation of the equipment are normally permitted only by special work permits issued by operations personnel. (Such line openings should be monitored by operations personnel as an added safety measure.)
f) All of the steps specified in Items (a) to (e) should be documented in accordance with a master system of accountability, and the records retained at the primary equipment control station for the duration of the job. The master system of accountability can use a master tag or permit form signed by all service and maintenance workers once they fully comprehend the details of the job and the energy-isolation devices actuated or put in place.
g) After the system has been rendered safe, the authorized employees verify energy controls.
h) Specific work functions are controlled by work permits issued for each shift or by signing in and out on a single work permit. Every day, each assigned authorized employee signs in on the work permit and applies their work group lock to the lockable device at the start of work; at the end of work, they sign out and removes their work group lock. The permit, which includes the date and time of sign in and sign out, is retained by the crew supervisor who, on completion of the permit requirements, returns the permit to the operations supervisor. Work permits can extend beyond a single shift and accordingly be the responsibility of several supervisors.

i) On completion of the tasks required by the work permit, the authorized employees' names are signed off the master tag or permit forms by their supervisor once all employees have signed out on the work permit. The work permit is then attached to the master tag so that accountability of exposed workers is maintained.
j) As the work is completed by the various crews, the work permits and the accountability of personnel are reconciled jointly by the primary authorized employee and the operations supervisor.
k) Inspection audits are conducted during the work.
l) On completion of all work, the equipment is returned to the operations personnel after the maintenance and servicing crews have removed their locks from the lockable device and/or special isolating devices at previously identified equipment locations in accordance with the work permit procedure.
m) At this time, all authorized employees who were assigned to the tasks are again accounted for and it is verified that they are clear of the equipment area.
n) After the completion of the servicing and maintenance work, operations personnel remove the locks and/or tags originally placed to identify energy isolation.
o) Operations personnel then begin checkout, verification, and testing of the equipment before it is returned to production service.

H.5.3

The following is Scenario #2:
a) When work that requires removing hazardous energy from all or part of an operating system is to be performed, a work request is submitted to the operating authority that has exclusive administrative control of all or the relevant part of the operating system.
b) The operating authority determines the operations that are to be performed (switching, valving, tagging, etc.) and documents the sequence of operations to be performed.
c) An authorized employee is then assigned to perform the operations and creates an isolated zone by installing locks and/or tags to each device to guarantee their position. A master lock/tag (lockable device) is then established for the operating authority.
d) The operating authority informs the person in charge of performing the work that the isolation and locking/tagging have been performed That person then presents themself to the operating authority to receive and review the isolation steps (typically noted on a uniquely numbered permit or work order) that have been performed. The person in charge of performing the work then signs on to a clearance sheet and applies their work group lock to the master lock/tag (lockable device).

   Note: *The "person in charge" is the supervisor, foreperson, or lead worker, depending on agreements and past practice.*
e) The person in charge then reports to the work location, or to another central meeting place, and confers with everyone who will perform the work. A job briefing is conducted and includes a thorough review and a walk-down, by the personnel who will perform the work, of the principal isolation points and locking/tagging that has been performed. The personnel who will perform the work then (e.g., sign a work permit/master tag) places a personal identification card on an energy-operating device, or initial a work log at the work site.
f) On completion of the work, all personnel who have performed work take a reverse step (e.g., signing off the work permit/master tag, removing the personal identification card, or initialing the work log to indicate that they are finished and clear of the work site). After all personnel have taken the steps necessary to remove themselves from the lockout, the person in charge must perform a walk-down to ensure that all work is completed and that all personnel are clear of the work site and have been instructed to stay clear of the work site.
g) The person in charge then reports back to the operating authority in person, reports on the status of the work (completed), signs off on the clearance sheet, removes the work group lock from the

lockable device, and releases the clearance back to the operating authority, who then assigns an authorized employee to remove the master lock/tag (lockable device) and the associated locks and/or tags from the devices used for isolation, with the authorized employee performing the necessary steps to return the system to service.

Annex I (informative)
Remote low-voltage lockable systems

Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *This Annex is based in part on Annex G of ANSI/ASSE Z244.1.*

I.1 Purpose

A remotely located isolation device that controls and monitors electromechanical energy control systems can provide an acceptable alternative to hazardous-energy-isolation devices located in inaccessible or inconvenient locations on machines, equipment, or processes. This alternative provides conveniently located lockable activation devices that are user-friendly, accept a padlock for personal control, and are located at multiple process points, therefore encouraging the proper application of lockout protection.

I.2 Description

Remote low-voltage lockable system technology uses a dedicated system of lockable low-voltage switches located at multiple locations around a production machine. Each lockable switch is able to achieve control of hazardous energy and verification of a safe state. The low-voltage lockable circuit typically controls physically secure electromechanical power contactor(s) that remove the incoming power from an upstream main disconnect switch. These units use diversity, redundancy, and monitoring methods to ensure proper activation and deactivation of power and verification circuits for fault-free operation. If a fault such as non-simultaneous activation of a component occurs and is sensed, the system will not allow reactivation of the machine nor will it give an indication of a safe state until the remote lockable system is repaired. Typically, physical access to the components of the remote lockable system device is limited to designated qualified persons; the internal control circuits are electrically isolated from the components and circuits of the production machine for which the device provides the control of hazardous energy. These remote lockable systems are devices that are installed and maintained by qualified personnel in accordance with the manufacturer's guidelines. (See Figure I.1 for an example of a remote lockable system.)

Δ

Figure I.1
Remote lockable system (from Annex R of CSA Z462-12)
(See Clause I.2.)

R.3.3 Disconnects and fuses

Disconnect switches are commonly used in substations to isolate electrical equipment or systems. These switches can be manually operated or motor operated and can be load-break or non-load-break design. Normally non-load-break switches are interlocked with a circuit breaker. The following safety considerations should be observed:

a) Disconnect switches are only to be operated as designed. Some might not be suitable for operation under load.
b) Disconnect switches can contain stored energy in the form of compressed operating springs; this energy must be discharged prior to maintenance activities.
c) Before relying on an open disconnect, its position should be visually verified and steps should be taken to prevent inadvertent closure. Remote operation of motor operated disconnects should be addressed/prevented as part of safe electrical work planning.
d) Safe work planning involving motor operated disconnects should address the presence of an additional control voltage source(s) and isolation thereof if appropriate.
e) Rubber insulating gloves with leather protectors should be used when performing switching operations.

Annex J (informative)
Other control methods involving trapped key interlock systems

Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *This Annex is based in part on Annex K of ANSI/ASSE Z244.1.*

J.1 Example 1: Other method of control for machines or equipment with run down time

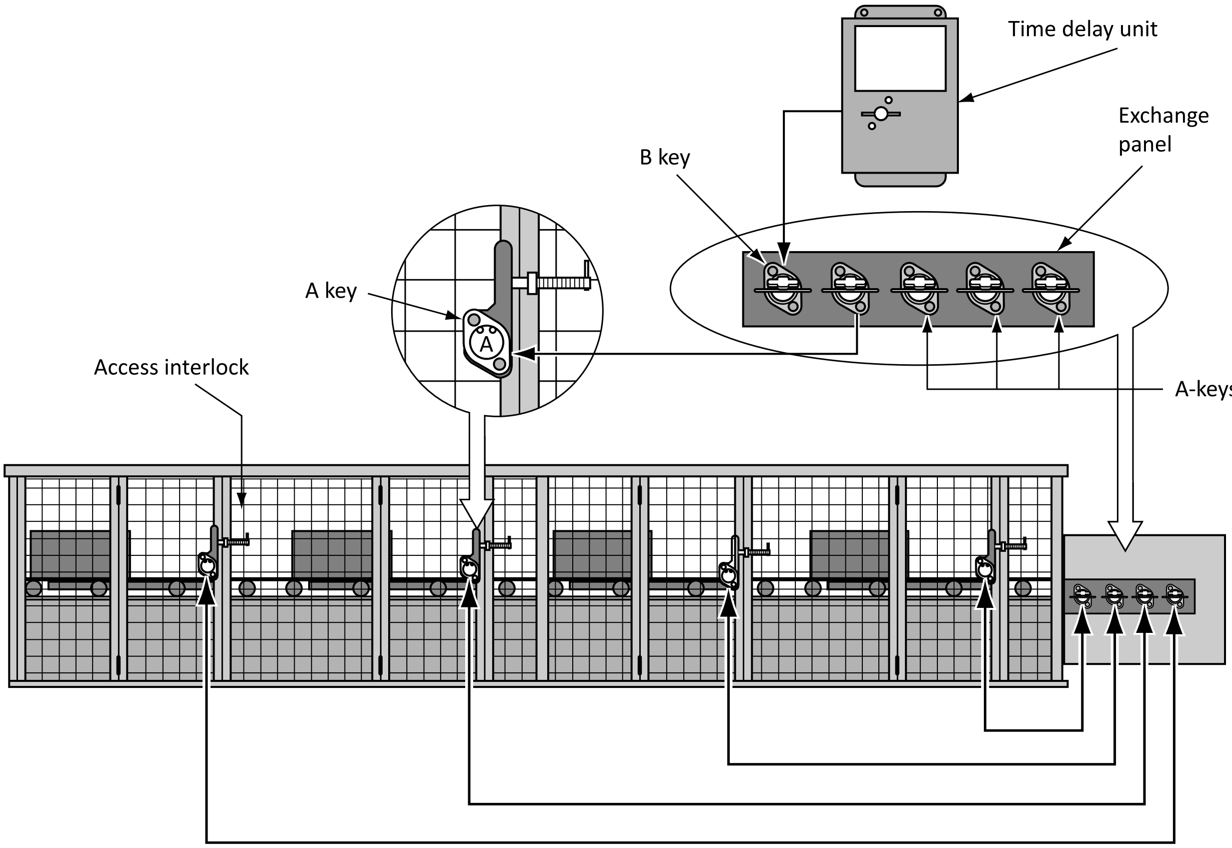
Many machines still pose a hazard because of residual motion even after energy sources have been isolated. Examples include rotating equipment, flywheels, and machines with heavy components that require more time to stop.

A trapped key interlock system incorporating a time delay feature can mitigate the hazard. The steps are as follows (see Figure J.1):

a) The knob on the time delay unit is turned to isolate power to the machine or equipment. This starts the timer.
b) After the pre-set time has elapsed, the B Key releases from the time delay unit.
c) The B Key is inserted, turned, and trapped into the mechanical key exchange panel. This allows the four A Keys to be turned and removed from the key exchange panel. The B Key is trapped in the panel.
d) The A Keys are taken to the access interlocks and inserted, turned, and trapped, allowing the door to be opened. While the doors are open, the A keys are trapped.
e) To restart the machine, the process described in Items (a) to (d) is reversed.

Figure J.1
Other method of control for machines or equipment with run down time

(See Clause J.1.)



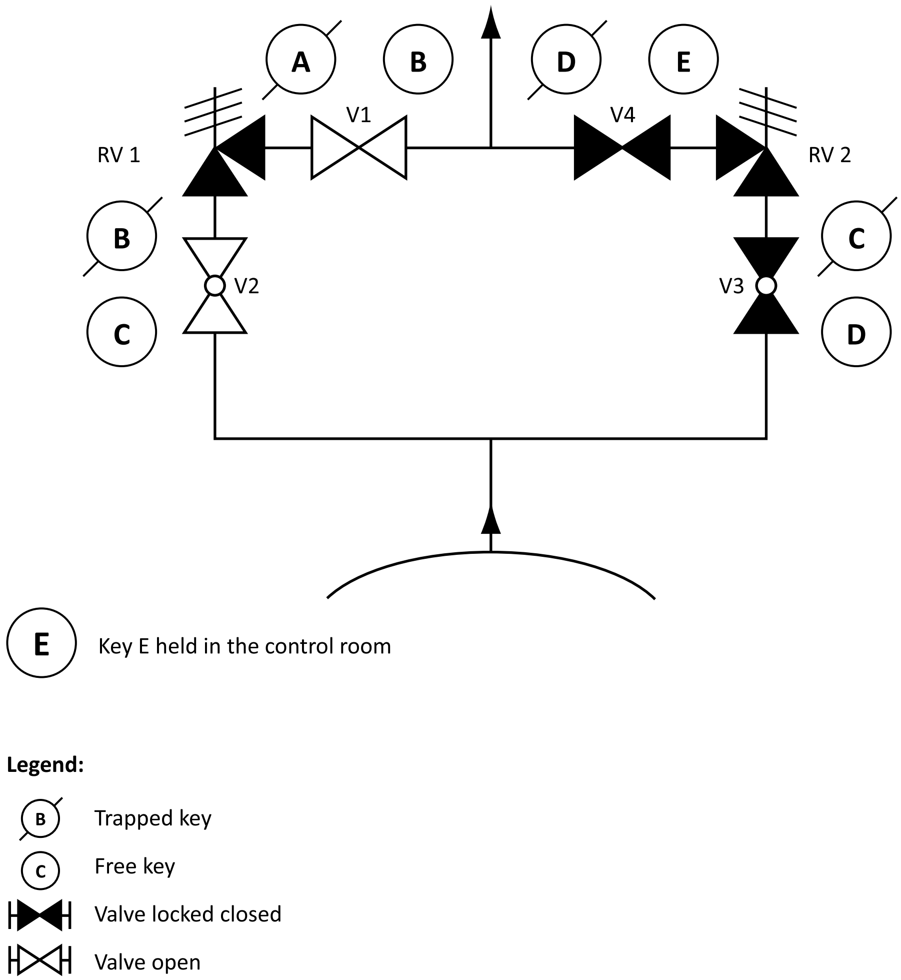
J.2 Example 2: Other method for dual pressure-relief valve piping systems

Dual pressure-relief valve systems are used in the chemical, petrochemical, oil, and gas industries, among others. The rationale for redundant relief is that the operational relief valve can be isolated and serviced or maintained without having to shut down the whole process. The potential danger is that an operator could isolate the in-service relief valve before commissioning the spare relief valve, thereby failing to create a relief path for pressure buildup in the system.

A trapped key interlock system mechanically ensures that at least one relief path is always open. The steps are as follows (see Figure J.2):

a) System is shown with Relief Valve 1 (RV1) in service and Relief Valve 2 (RV2) isolated.
b) Take Key E to the outlet block valve (V4) for RV2 and insert, unlocking V4. Open V4. Remove Key D, locking V4 open.
c) Take Key D to the inlet block valve (V3) for RV2 and insert, unlocking V3. Open V3. Remove Key C, locking V3 open.
d) Take Key C to the inlet valve (V2) for RV1 and insert, unlocking V2. Close V2. Remove Key B, locking V2 closed.
e) Take Key B to the outlet block valve (V1) for RV1 and insert, unlocking V1. Close V1. Remove Key A, locking V1 closed.
f) Return Key E to the control room. RV1 is now isolated for maintenance and RV2 is in service.

Figure J.2
System incorporating two pressure-relief valves and four block valves
(See Clause J.2.)



Annex K (informative)
Special method for freeze plug applications

Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *This Annex is based in part on Annex F of ANSI/ASSE Z244.1.*

K.1 Purpose

Freeze plug or stop technology, used successfully for many years in industry, provides a non-intrusive method for isolating piping systems. Line freezing does not require permanent modification or welding of the piping system. It can be used as a secondary isolation seal for additional protection. Piping systems containing water, hydrocarbons, or any chemical with a suitable freeze point and no flow can be isolated with freeze plug methods.

Pipe freezing applications make possible the replacement, repair, or addition of valves; isolation of work zones; avoidance of drain downs; and maintenance of the integrity of critical systems and system operating pressures.

K.2 Method

When a freeze plug is applied, users should ensure that the requirements of Clause 5.4 are complied with and personnel applying the freeze plug, as well as service and maintenance personnel who could be exposed to the freeze, are protected by and comply with the following safeguards:

a) An attendant is present at the freeze point(s) whenever authorized individuals are exposed to possible contact with liquids in the piping system.
b) Cryogenic supply systems are equipped with low-level warning alarms and a cryogenic supply sufficient for the duration of the work is on hand.
c) Exposed authorized individuals attach personal tags/locks at the freeze point(s) to indicate their presence and prohibit the cessation of the freeze before any removal by those attaching the protective devices.

   Note: *This is not necessary if the freeze point(s) are controlled by a complex group lockout permit process.*
d) Personnel applying the freeze immediately communicate to exposed authorized individuals any change in conditions that could place them at risk.
e) If the authorized individuals performing the servicing or maintenance work are out of sight of the personnel responsible for the application and continuity of the freeze, an effective means of communication is established (i.e., headsets or radios).
f) If the area of the freeze application is an enclosed or confined space that precludes reasonable air changes or is substantially obstructed, continuous oxygen monitoring is conducted and adequate ventilation or supplemental oxygen is provided.
g) Protective practices are used to safeguard personnel during a planned release or unplanned ejection of the plug.

Δ Annex L (informative) Example applications for mobile equipment and machinery

Note: *This Annex is not a mandatory part of this Standard.*

L.1 Purpose

This Annex is intended to assist users in determining whether maintenance work on their mobile equipment is covered by this Standard, identify some of the considerations regarding the hazards associated with performing the work, and assist in the selection of lockout methods or in the risk assessment process and use of other control methods. This Annex is based on the decision process found in Clause 7.4.1 and Figure 3.

L.2 Examples of Mobile Equipment

Mobile equipment comes in many forms and varieties and is used in almost all industry sectors. Examples of mobile equipment include, but are not limited to:

a) front-end loaders;
b) dozers;
c) backhoes;
d) excavators;
e) skidders;
f) forwarders;
g) tree-harvesters;
h) scrapers;
i) compactors;
j) rollers;
k) graders;
l) agricultural tractors and industrial tractors;
m) lift trucks;
n) walkie pallet stackers;
o) transportation vehicles;
p) autonomous vehicles (no operator);
q) self-powered man lifts and hoists;
r) burnishers and auto-scrubbers;
s) aircraft;
t) equipment on rails;
u) mobile cranes; and
v) marine vessels.

L.3 Process

1. Identify and define the task

The extent of the maintenance to be performed and if energy to the equipment is required to perform the task need to be determined.

Examples of tasks include, but are not limited to

a) inspection of components;

b) diagnostic testing;
c) mechanical repair;
d) maintenance and lubrication;
e) minor component replacement;
f) major component replacement;
g) changing chains/linkages; and
h) checking for oil/fluid leak.

2. Identify and assess the hazardous energies associated with the task

Maintaining mobile equipment requires the equipment to be placed in a zero energy state before the work begins (unless the energy is required to perform the task) which requires all hazards associated to be considered and addressed.

When identifying hazards things to consider include
a) energy sources, (see Annex A, Table A.1);
b) pressurized fluids and air, (accumulators, hydraulic systems, air surge tanks, etc);
c) potential mechanical energy, (stored energy such as springs, gravity, etc);
d) kinetic energy of machine members;
e) loose or freely moveable machine components;
f) moveable material or work pieces that are supported, retained or controlled by a machine and that could move or cause the machine to move; and
g) remote-start capability.

3. Perform the task

The hazards identified must be locked out as found in Clause 7.3.2.2 or, if lockout is not practicable, or energy is required to perform the task, complete a risk assessment (Clause 7.4.4) and use other control methods as found in Clause 7.4.3.

Other control methods could include
a) lowering outriggers;
b) removing fuel source;
c) disabling start circuits;
d) mechanical blocking;
e) chocking wheels; and
f) dissipating thermal energy.

4. Task Complete

As with all equipment, return to service following maintenance is an important step in the process. The process found in Clause 7.3.3.10 should be followed to ensure this is done safely.

L.4 Examples

The following are included as examples of processes in use in industry. They are not intended for use by others without specific and individual assessment of the mobile equipment in question.

Table L.1
Tree harvester
(See Clause L.4.)

Interventions	Mechanical hydraulic pilot valve	Equipment motor	Electric master Switch	Manual hydraulic valve	Computer	Mechanical blocking (A-B-C-D)	Work instructions (1-2-3…)
Mechanical repair	Locked	Closed	Locked	N/A	N/A		1-3-4-5-6-7-8 +13
Maintenance and lubrication	Locked	Closed	Locked	N/A	N/A		1-3-4-5-6-7-8
Change chain							
Change chain (alone)	Locked	Operating	Unlocked	N/A	N/A		12-4-5-7
Regulate pressure	Unlocked	Operating	Unlocked	N/A	N/A	A	9-10-11-14
Check oil leak	Unlocked	Operating	Unlocked	N/A	N/A	A	9-10-11-14
Adjustment of potentiometer							
Adjustment of measuring wheel	Locked	Operating	Unlocked	N/A	N/A	A	1-2-4-5-7-14
Adjustment	Unlocked	Operating	Unlocked	N/A	N/A	N/A	9-10-11

Work instructions:
1. Lower the boom to the ground.
2. Shut off all felling head components (rollers, clamps, etc.).
3. Position felling head on the ground face down (rollers and opened clamps).
4. Close the safety arm (electro-hydraulic arm, hydraulic pilot).
5. Shut off the mechanical hydraulic master valve.
6. Shut off motor and lock master switch with individual padlocks.
7. Make sure there is no more power by testing the controls.
8. Sign and date the lockout tag.
9. Maintain a virtual safety parameter of 3 m from felling heads.
10. Stay within sight of the operator (when two workers on the job).
11. Keep a radius of 30 m during testing, or test in a safe zone.
12. Position the boom and the felling head (± 1 m from ground) in a stable position.
13. Shut off the manual hydraulic valves.

14. Mechanical blocking:
a) anti roll-over apparatus;
b) roller mechanism;
c) clamp and blade mechanism;
d) chain mechanism; and
e) holding mechanism for the plow.

For all mechanical work:
- Wear individual protective equipment required for the type of repair.
- Place the machine and felling head in a stable position.
- Mount and dismount using 3 contact points.
- Work to be done in a flat, dry, well lit work area free of debris.
- Remain within sight and use radio (simplex) or manual signals (when two operators).

Individual locks removal procedure:
1. Each employee must remove his individual lock, get out of the danger zone, and inform the operator to start the machine. If a person is missing, go to Step 2).
2. Locate the person by radio, telephone, or CB and have him remove his lock. If it is impossible to reach the person, go to Step 3).
3. Call your supervisor.
4. The supervisor assesses the workplace and makes sure that nobody is in danger.
5. The supervisor authorizes the removal of the lock, and the machine can then be restarted.

Last update:

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Prepared by:

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Accepted by:

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Annex M (informative)
Other control method for the printing industry

Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *This Annex is based in part on Annex H of ANSI/ASSE Z244.1.*

M.1 Introduction

In the printing industry, many tasks that are integral to production need to be performed using motion. The industry has developed a methodology employing a combination of engineered safeguards, warning devices, procedures, and safe work practices to provide effective protection in situations where lockout is not practicable. It is known in the industry as the "inch-safe-service" method.

Printing presses and other large equipment in the printing and binding industries, such as saddle and perfect binding systems, are equipped with control stations containing, at a minimum, a stop/safe or stop/safe/ready push button. Motion control stations also include an inch button that enables slow machine motion while the button is held down. These control stations are electrically linked to an audible or area light warning system that provides an audible or visual indication of the machine's state and impending motion. The inch-safe-service procedure is employed by personnel who operate the equipment and, in combination with the stop control, warning system, and guards, provides effective protection to personnel.

Note: *For a description of the safety systems used in printing presses, see ANSI B65.1. For binding and finishing systems, see ANSI B65.2.*

M.2 Inch-safe-service procedure

The following procedure is used:

a) Before any minor servicing is performed, the machine is stopped by activating a stop/safe or stop/safe/ready push button.
b) Servicing is performed with the machine in a "safe" condition.
c) The inch button is then activated, which starts an audible alarm that warns of impending machine motion.
d) After a delay, the machine moves to the next position.
e) The stop/safe button is depressed and minor servicing is again performed.
f) The process is repeated as many times as necessary.

Annex N (informative)
Other control method for the plastics industry

Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *This Annex is based in part on Annex I of ANSI/ASSE Z244.1.*

N.1 Set-up (no motion)

On plastics moulding machines where it is necessary to maintain heat to a plasticating unit or power to a programmable logic controller or microprocessor during set-up, a separate lockable energy-isolating device for a motor, pump, or other equipment that could expose an employee to a hazard should be used.

For a plastics moulding machine that complies with applicable safety standards, the controlling safety gate should be locked in the open position, with the power source(s) used for controlling motion and movement in the mould area turned off. When accumulators are used, they should automatically dump pressure to tank when the hydraulic pump motors are de-energized.

N.2 Effects of gravity

In situations where dangerous movements in the mould area could be produced by the effect of gravity, a mechanical restraint device should be used.

N.3 Extrusion blow and injection blow moulding machines (set-up with motion)

During setting operations, when movement is necessary with the operator's safety gate open, the requirements specified in Clause 6.5 of ANSI/SPI B151.15 and Clause 6.5 of ANSI/SPI B151.21 should be followed. These Clauses (which are identical) read as follows:

1. An operating mode selector shall be provided that can be locked in the set-up mode with a removable key. The selector shall be hard wired and monitored to insure proper operations.
2. The key for the mode selector shall only be issued to person(s) trained in the set-up operations.
3. Hazardous movement/motion required for the setting shall only be possible by means of a hold-to-run control.

Note: *Such movement/motion required for setting might be that of:*
a) *the blow mold and its parts*
b) *the blow pin or blow needle*
c) *individual blow station (multi-station machines)*
d) *rotary wheel*
e) *parison drop.*

4. When the hold-to-run control device is fitted on a portable control unit, it shall be capable of being taken into the point of operation. An enabling device and an additional emergency stopping device shall be fitted on such a control unit. The emergency stopping device shall act on all hazardous movements associated with setting operations.
5. When the hold-to-run control device is not on a portable unit, it shall be permanently fixed in such a position that the set-up person has a clear view of the point of operation.
6. A hold-to-run control device shall only be operable when the mode selector device is in the setting mode.
7. The setting speed shall be designed not to exceed 1 inch/second (25mm/second).
8. A pneumatic drive for setting movements that create a hazard shall not be permitted to function in this mode.
9. Valves that could override set-up speed restrictions through activation by hand or tool shall be made inaccessible (e.g., guarding).

Annex O (informative) ***Other control method for robotic applications***

Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *This Annex is based in part on Annex J of ANSI/ASSE Z244.1.*

O.1

Robotic applications present the unique combination of a dynamic workspace for the machine as well as specific process hazards. Personnel can be exposed to hazardous energy in a number of routine situations such as robot teaching, robot servicing, minor tool changes, removal of jams, and troubleshooting. Requirements for effective control of hazardous energy in robotic applications are specified in CAN/CSA-Z434.

When access to the safeguarded space of a robot or robot system is necessary while power is available, specific safeguards or safeguarding procedures are established and used to prevent injury. All are based on the premise that the personnel performing tasks have total control of the robot or robot system, including all peripheral equipment and process hazards.

Protection methods for a typical task can include
a) disabling the automatic task program;
b) isolating the hazardous energy to the drive motors;
c) using motion-enabling devices for each person entering safeguarded space; and
d) ensuring that the emergency stop circuit remains functional.

In addition, certain tasks can be performed by placing the robot arm in a predetermined position, or by using devices such as blocks and pins to prevent potentially hazardous motion.

Δ Annex P (informative)
Other control methods for work on pressurized pipelines (hot-tapping)

Notes:
1) *This Annex is not a mandatory part of this Standard.*
2) *CSA Z662 also contains information on hot-tap procedures and requirements.*

P.1 Introduction

"Hot-tapping" is a popular term for work done on a pipeline while the pipeline is still energized. It is a process for making a connection to an energized system by which an attachment is made to a pipe, pressure vessel, or tank, and in which the boundary is cut with a specially designed tool. Hot-taps can be very hazardous; therefore alternatives in location (under operating conditions) and timing (shutdown work) must be evaluated before any hot-tapping procedure is implemented.

The hot-tap procedure can only be used once it has been concluded that this is the most appropriate method to complete the work required. The procedure will need to be a rigorous and systemic series of tasks and requirements that will consider design, fabrication, quality control, and safe installation, as well as the need for formal technical and managerial approvals as required.

A hot-tap procedure may be used whenever it is proposed to make an attachment to piping, pressure vessels, or tanks, and to cut the boundary while exposed to hazardous energy. This also applies to stopples and all mechanical line plugging procedures.

Cutting into a de-energized system with the use of hot-tap equipment is not considered to be hot-tapping and is not under the scope of this Annex.

P.2 Procedure requirements

The following should be considered as part of the hot-tap procedure;

a) A detailed consideration of any special circumstances that may be involved, including the applicable risk assessment for that circumstance. Some examples of what would be special circumstances include;
   i) piping contents are explosive in nature;
   ii) piping is used for hydrogen service;
   iii) piping contents are toxic; and
   iv) piping is considered to be of thin-wall construction (less than 3/16 inch thick).
b) A detailed description of the sequence of events, including who is involved for each event.
c) A description of the responsibilities for each party involved, such as equipment design approvals, determination of worker qualifications and knowledge, required risk assessments, and compilation of check lists.
d) Specifications for testing and inspection of the installed equipment at each appropriate stage of the hot-tap procedure, and before the equipment is returned to normal service.