

# **Safeguarding of machinery**

Currently in preview, click buy full version

# Legal Notice for Standards

Canadian Standards Association (CSA) standards are developed through a consensus standards development process approved by the Standards Council of Canada. This process brings together volunteers representing varied viewpoints and interests to achieve consensus and develop a standard. Although CSA administers the process and establishes rules to promote fairness in achieving consensus, it does not independently test, evaluate, or verify the content of standards.

## Disclaimer and exclusion of liability

This document is provided without any representations, warranties, or conditions of any kind, express or implied, including, without limitation, implied warranties or conditions concerning this document's fitness for a particular purpose or use, its merchantability, or its non-infringement of any third party's intellectual property rights. CSA does not warrant the accuracy, completeness, or currency of any of the information published in this document. CSA makes no representations or warranties regarding this document's compliance with any applicable statute, rule, or regulation.

IN NO EVENT SHALL CSA, ITS VOLUNTEERS, MEMBERS, SUBSIDIARIES, OR AFFILIATED COMPANIES, OR THEIR EMPLOYEES, DIRECTORS, OR OFFICERS, BE LIABLE FOR ANY DIRECT, INDIRECT, OR INCIDENTAL DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES, HOWSOEVER CAUSED, INCLUDING BUT NOT LIMITED TO SPECIAL OR CONSEQUENTIAL DAMAGES, LOST REVENUE, BUSINESS INTERRUPTION, LOST OR DAMAGED DATA, OR ANY OTHER COMMERCIAL OR ECONOMIC LOSS, WHETHER BASED IN CONTRACT, TORT (INCLUDING NEGLIGENCE), OR ANY OTHER THEORY OF LIABILITY, ARISING OUT OF OR RESULTING FROM ACCESS TO OR POSSESSION OR USE OF THIS DOCUMENT, EVEN IF CSA HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES.

In publishing and making this document available, CSA is not undertaking to render professional or other service for or on behalf of any person or entity or to perform any duty owed by any person or entity to another person or entity. The information in this document is directed to those who have the appropriate degree of experience to use and apply its contents, and CSA accepts no responsibility whatsoever arising in any way from any and all use of or reliance on the information contained in this document.

CSA is a private not-for-profit company that publishes voluntary standards and related documents. CSA has no power, nor does it undertake, to enforce compliance with the contents of the standards or other documents it publishes.

## Intellectual property rights and ownership

As between CSA and the users of this document (whether it be in printed or electronic form), CSA is the owner of all works contained herein that are protected by copyright, all trade-marks (except as otherwise noted to the contrary), and all inventions and trade secrets that may be contained in this document, whether or not such inventions and trade secrets are protected by patents and applications for patents. The unauthorized use, modification, copying, or disclosure of this document may violate laws that protect CSA's intellectual property and may give rise to a right in CSA to seek legal redress for such use, modification, copying, or disclosure. CSA reserves all intellectual property rights in this document.

## Authorized use of this document

This document is being provided by CSA for informational and non-commercial use only. The user of this document is authorized to do only the following:

If this document is in electronic form:

- load this document onto a computer for the sole purpose of reviewing it;
- search and browse this document; and
- print this document.

Limited copies of this document in print or print form may be distributed only to persons who are authorized by CSA to have such copies, and only if this Legal Notice appears on each such copy.

In addition, users may not and may not permit others to

- alter this document in any way or remove this Legal Notice from the attached standard;
- sell this document without authorization from CSA; or
- make an electronic copy of the document.

If you do not agree with any of the terms and conditions contained in this Legal Notice, you may not load or use this document or make any copies of the contents hereof, and if you do make such copies, you are required to destroy them immediately. Use of this document constitutes your acceptance of the terms and conditions of this Legal Notice.



CANADIAN STANDARDS  
ASSOCIATION

# Update No. 1

## Z432-04

### November 2006

**Note:** General Instructions for CSA Standards are now called Updates. Please contact CSA Information Products Sales or visit [www.ShopCSA.ca](http://www.ShopCSA.ca) for information about the **CSA Standards Update Service**.

**Title:** *Safeguarding of machinery* — originally published March 2004

The following revisions have been formally approved and are marked by the symbol delta ( $\Delta$ ) in the margin on the attached replacement pages:

<b>Revised</b>	Technical Committee list, Clauses 3 and 9.3.3(b), and Tables 4 and A.1
<b>New</b>	None
<b>Deleted</b>	None

CSA Z432-04 originally consisted of **147 pages** (x preliminary and 137 text), each dated **March 2004**. It now consists of the following pages:

<b>March 2004</b>	iii–vi, ix, x, 1–6, 9–60, 63–74, 77–84, and 87–137
<b>November 2006</b>	vii, viii, 7, 8, 61, 62, 75, 76, 85, and 86

- Update your copy by inserting these revised pages.
- Keep the pages you remove for reference.

Currently in preview, click buy full version

**18 Training** 83

- 18.1 General 83
- 18.2 Training procedures 83
  - 18.2.1 Machinery operators 83
  - 18.2.2 Plant engineers and maintenance staff 83
- 18.3 Personal protection 83

**Annexes**

- A** (informative) — Hazards, controls, and interlocks 84
- B** (informative) — Illustrations of other hazard controls 103
- C** (informative) — Ergonomic data 128
- D** (informative) — Selection of interlocking systems 136

---

**Tables**

- 1** — Hierarchy of safeguarding controls 12
- 2** — Safeguarding selection matrix 19
- 3** — Minimum distance from hazard as a function of barrier opening size 71
- 4** — Recommended ergonomics control parameters 76

---

**Figures**

- 1** — Flow of responsibilities 1
- 2** — Schematic representation of the risk assessment/reduction process model 14
- 3** — Guidelines to help make the choice of safeguards against hazards generated by moving parts 35
- 4** — Optical PSSD: Minimum object sensitivity 68
- 5** — Graphical illustration of Table 3 72

# Technical Committee on Safeguarding of Machinery

<b>T. Eastwood</b>	NCC Electronics, Cambridge, Ontario	<i>Chair</i>
<b>C. Newton</b>	Dominion Power Press Equipment Limited, Burlington, Ontario	<i>Vice-Chair</i>
<b>B. Arger</b>	Banner Engineering Corp., Orangeville, Ontario	
Δ <b>T. Balazs</b>	Tenneco Automotive, Cambridge, Ontario	
<b>D. Boone</b>	Canadian Auto Workers, Toronto, Ontario	
<b>B. Bouckley</b>	General Motors Corporation, Warren, Michigan, USA	<i>Associate</i>
<b>R. Bourbonnière</b>	Institut de recherche en santé et en sécurité du travail du Québec, Montréal, Québec	<i>Associate</i>
<b>W. Brigger</b>	Dominion Power Press Equipment Limited, Burlington, Ontario	<i>Associate</i>
<b>B. Byrne</b>	Cross Huller-North America, Sterling Heights, Michigan, USA	
<b>A. Chim</b>	Takson Engineering Inc., Toronto, Ontario	
<b>R. Estok</b>	Stelco Inc., Hamilton, Ontario	
<b>J. Hansen</b>	Canadian Auto Workers, Windsor, Ontario	
<b>G. Hildebrand</b>	Manitoba Department of Labour and Immigration, Winnipeg, Manitoba	
<b>N. Hutchison</b>	USWA National Office, Toronto, Ontario	
<b>J. Lofice</b>	Co-Ex-Tec Industries, Concord, Ontario	
<b>G. Mansour</b>	Ontario Ministry of Labour, Toronto, Ontario	
<b>A. Martin</b>	Dofasco Inc., Hamilton, Ontario	

**Lockout** — a procedure that disconnects, blocks, or bleeds off all sources of energy (electrical, pneumatic, steam, hydraulics, mechanical, stored, or any other source of energy) that may create a motion or action by any part of the machinery and/or its auxiliary equipment and places a lock on the disconnect device or at the point of disconnect.

**Machinery** — an assembly of linked parts or components, at least one of which moves, with the appropriate machine actuators, control and energy circuits, etc. joined together for a specific application, in particular for the processing, treatment, moving, or packaging of a material.

**Maintainability** (of a machine) — the ability of a machine to be maintained in a state, or restored to such a state, that enables it to fulfill its intended use, the necessary actions (maintenance) being carried out according to specified means.

**Manufacturer** — an entity that designs, assembles, reconstructs, or modifies machines or systems.

**Note:** Under certain circumstances (i.e., acting as a builder, modifier, or integrator), the user may also be considered as a manufacturer.

**Mechanical restraint device** — a device that is designed to hold back or pull back an individual and/or machine component in order to ensure that the individual's body cannot enter the danger zone during the machine actuating sequence.

Δ **Operator** — the person responsible for the operation (including operation during maintenance activities) of a machine or component of a machine.

**Presence-sensing device (PSD)** — a safeguarding device designed and constructed to create a sensing field that, when penetrated, produces a signal intended to stop hazardous machine motion within the area protected by the field.

**Protective device** — any machine device that is designed to prevent or limit possible harm to a person.

**Protective measure** — a measure intended and implemented to achieve risk reduction.

**Pull-back (pull-out) device** — a device that is attached to the hands and wrists of the operator and includes attachments for each of the operator's hands to be used in place of the operator's hands within the danger zone.

**Rebuilt machinery** — machines that have been overhauled or restored.

**Redeployed machinery** — machines that have been relocated (i.e., moved to a different work site or building).

**Reliability** (of a machine) — the ability of a machine or its components or equipment to perform a required function under specified conditions and for a given period of time without failing.

**Residual risk** — risk remaining after protective measures have been taken.

**Risk** (of harm to an individual) — a combination of the probability and the degree of the possible injury or damage to health in a hazardous situation.

**Risk analysis** — a combination of the determination of the limits of the machine, hazard identification, and risk estimation.

**Risk assessment** — the overall process of risk analysis and risk evaluation.

**Risk estimation** — a judgment, on the basis of risk analysis, of whether adequate risk reduction has been achieved.

**Safe distance** — a method of workpiece positioning and operator location that eliminates the need for the operator to be in or near the hazardous area during the hazardous portion of the machine cycle.

**Safe opening** — a method of safeguarding that limits the access to the hazardous area by the size of the openings or by closing off access when the workpiece is in place in the machine tool.

**Safe working practice** — a safe system of work, i.e., a method of working that eliminates or reduces the risk of injury.

**Safeguard** — a guard or safety device designed to protect persons from danger.

**Safeguarding** — safety measures consisting of the use of specific technical means, called safeguards (guards, safety devices), to protect persons from hazards that cannot be reasonably removed or sufficiently limited by design.

**Safety device** — a device other than a guard that eliminates or reduces risk, alone or associated with a guard.

**Safety function** — a function of a machine whose failure can increase the risk of injury.

**Scotch** — a mechanical restraint device placed manually or automatically between two parts of machinery and capable of preventing them from closing under gravity or energy.

**Stopping time** — the total time elapsed between the introduction of a stop command and the end of hazardous motion.

**Trip device** — a mechanism that causes hazardous machine elements to stop (or ensures an otherwise safe condition) when a person or a part of his/her body goes beyond a predetermined limit.

Trip devices can be

- (a) mechanically actuated, e.g., trip wires, telescopic probes, pressure sensitive devices; or
- (b) non-mechanically actuated, e.g., opto-electronic devices, devices using capacitive or ultrasonic means to achieve detection.

**Two-hand control device** — a device that requires the concurrent use of both of the operator's hands to both initiate and continue the machine cycle during the hazardous portion of the machine cycle.

**Unintended/unexpected start-up** — any start-up that, because of its unexpected nature, generates a hazard (e.g., a start command resulting directly from a system failure, an external influence, or restoration of power).

**Use** — any activity involving machinery including starting, stopping, programming, setting, transporting, repairing, modifying, maintaining, servicing, and cleaning.

**User** — an individual or company that purchases or uses the machine, system, or related equipment.

**Note:** Under certain circumstances (e.g., acting as a builder, modifier, or integrator), the user may also be considered as a manufacturer.

**Workpiece** — any piece of material placed into the machine tool for the purpose of having work performed upon it.

## 4 Application

### 4.1 General

#### 4.1.1 New machinery

This Standard is intended to be applied to newly manufactured and newly installed machinery. The aim of this Standard is to promote a high standard of machinery safety during use. The Standard describes and illustrates a variety of safety measures and explains methods by which it is possible to assess which

- (c) Common mode failures shall be taken into account when the probability of such a failure occurring is significant.
- (d) The single fault should be detected at time of failure. If not practicable, the failure shall be detected at the next demand upon the safety function.
- (e) These safety control systems shall be independent of the normal program control (function) and shall be designed to be not easily defeated nor easily bypassed without detection.

### 8.3 Safety-related software- and firmware-based controllers

Software- and firmware-based controllers used in place of hardware-based components with safety-related devices shall

- (a) be designed such that any single safety-related component or firmware failure shall
  - (i) lead to the shutdown of the system in a safe state; and
  - (ii) prevent subsequent automatic operation until the component failure has been corrected,

**Note:** Firmware is that executive control program code provided by the manufacturer of the component in a non-volatile internal storage mode and is not changeable by the user.
- (b) supply the same degree of safety achieved by using hardwired/hardware components in accordance with Clause 8.2.5. For example, this degree of safety may be achieved by using microprocessor redundancy, microprocessor diversity, and self-checking; and
- (c) be certified by a Nationally Recognized Testing Laboratory (NRTL) or Standards Council of Canada (SCC)-accredited testing laboratory to an approved standard applicable for safety devices.

### 8.4 Control comparison (ANSI vs CEN)

ANSI/CSA* index	Safeguard performance	Circuit performance	CEN/ISO† category
R1	Hazard elimination or hazard substitution	Control reliable	Category 3 and 4
R2A	Engineering controls preventing access to the hazard, or stopping the hazard, e.g., interlocked barrier guard, light curtains, safety mats, or either a presence-sensing device	Control reliable	Category 3 and 4
R2B		Single channel; with monitoring	Category 2
R2C		Single channel	Category 1
R3A	Non-interlocked barrier clearance, procedures, and equipment	Single channel	Category 1
R3B		Simple	Category B
R4	Awareness training	Simple	Category B

\*Based on ANSI B11 TR3

†Based on ISO 13849-1

**Note:** There is no intent to imply that circuit performance classifications are equivalent to CEN/ISO machinery categories.

## 9 Performance requirements for safeguarding devices

### 9.1 General

Safeguarding devices shall be designed and constructed with the goal of preventing any part of the body from reaching a danger point or area. Machine guards should take into account the physical characteristics of the people involved and, in particular, their abilities to reach through openings and over or around barriers or guards. The performance requirements of these devices are described in Clauses 9.2 to 9.4. See Clause 10 for their application requirements.

## 9.2 Barrier guards, fixed and interlocked

Barriers shall

- (a) be constructed to withstand operational forces and environmental conditions;
- (b) be free of sharp edges and projections and not themselves create a hazard; and
- (c) provide a means for secure attachment.

## 9.3 Interlocking safeguarding devices

### 9.3.1 General

Safeguarding devices that are used for interlocking shall

- (a) have a key, plug, or actuating device that is not easily duplicated;
- (b) be tamper-resistant and not be defeated intentionally without tools;
- (c) provide a means for secure attachment; and
- (d) be provided with documentation stating:
  - (i) the standards with which the device is compliant;
  - (ii) the standards against which the device is independently certified; and
  - (iii) that the control system performance complies with the criteria for one of the four control systems types listed in Clause 8.2.

### 9.3.2 Mechanical devices

Mechanical devices (typically including, but not limited to, transfer or captive/trapped key interlocking) shall

- (a) have a physical link between the energy source of a hazard and the locking mechanism to allow the removal of the key or actuating device only when the hazard has been controlled. The removal of the key or actuating device shall prevent reinstatement of the hazard; and
- (b) provide a mechanical lock for the guard at the point of access, which can only be unlocked by the key or actuating device described in Item (a). This lock shall trap or retain the key or actuating device when the guard is opened, and only release the key or actuating device when the guard is closed and locked.

### 9.3.3 Electrical devices

Electrical devices, with or without guard locking (including, but not limited to, safety switches, captive key systems, and magnetically actuated switches) shall

- (a) be provided with detailed information about the point in the travel of the actuating device where the switching action of the contacts occurs;
 

**Note:** Depending on the switch and the installation, the amount of travel before switching may differ significantly. For example, without the information, a hinge-mounted switch may be improperly installed such that the door could open and a person could enter before switching occurs.
- Δ (b) either be in compliance with Clause 8.2.5, and upon failure detection, successive automatic operation shall be prevented until the component failure has been corrected or shall be designed for positive opening (positive break) operation such that opening the contacts signals a stop; and
 

**Note:** Positive opening (positive break) operation is the full separation (opening) of a closed contact through a non-resilient linkage (e.g., not dependent on springs) due to movement from the home (engaged) position. (See Figure B.13.)
- (c) in the case of guard-locking devices, hold the guard closed and locked until the hazard has ceased. These devices, when provided, shall provide a method to
  - (i) manually unlock the device in the event of power failure; and
  - (ii) monitor the state of the locking mechanism. The manufacturer shall separately state the safety controls performance, in accordance with Clause 8.2, of the locking portion of the guard-locking device.

## 12.8 Displays

### 12.8.1 Indicators, dials, and displays

Indicators, dials, and visual display units shall be designed and located so that

- (a) they fit within the parameters and characteristics of human perception and cognition;
- (b) the information displayed can be detected, identified, and interpreted conveniently;
- (c) the operator can read displays of primary importance from the control position;
- (d) as far as possible, they are located close to the controls that affect them; and
- (e) critical information is presented through auditory or other forms of annunciation when predetermined limits have been exceeded.

**Note:** *Materials temperature in an injection machine may be considered to be critical information. However, it needs to be fitted with alarms and signals only when it deviates from a set norm.*

### 12.8.2 Analog displays

#### 12.8.2.1

Analog displays are preferable to digital displays unless highly accurate, quantitative information is required.

#### 12.8.2.2

Analog displays shall be used unless the output will change rapidly or when the direction of change is key information.

## 12.9 Controls

### 12.9.1

Position controls shall be positioned and spaced so as to provide safe and easy operation. There shall be adequate clearance between each control and other parts of the machinery. Controls should be so placed that the operator can reach them easily without stretching or moving from the normal working position. (See Table 4 for recommended ergonomic control parameters.) The controls most frequently used should be placed in the most accessible positions. To reduce the possibility of error when an operator changes from one unit of machinery to another of similar type, a standard layout should, where practicable, be adopted for machinery and work situations having the same pattern of operation.

### 12.9.2

Start controls shall be shrouded, gated, or so positioned that they cannot be operated inadvertently.

### 12.9.3

A stop control shall be positioned near each start control.

### 12.9.4

Where more than one control station is provided, these shall be arranged to take account of any increased risk to people who may be affected by the operation of one of the controls. This should be achieved by providing positive control circuit selection at the master control station overriding all other controls, so that the start control can be transferred from one position to another. Handles, hand-wheels, and levers shall be so positioned that when the operator is operating them other controls cannot inadvertently be operated. Two-hand controls shall be so placed, separated, and protected as to prevent them from being operated by any means other than two hands.

### 12.9.5

Controls shall be designed so that they follow the ergonomic principles (see Table 4) and take into consideration the use of personal protective equipment.

**12.9.6**

When controls are hand activated and used, they shall be located so as not to require awkward working postures (see Clause 12.4).

**12.9.7**

Controls that are used to initiate operations shall be of appropriate size and shape and be free of sharp edges to prevent injury to the operator's hand. Controls should not be right- or left-handed biased.

**12.9.8**

The efforts required to activate controls shall be sufficient to avoid accidental activation and kept low enough to prevent operator fatigue.

Δ

**Table 4**  
**Recommended ergonomics control parameters**  
(See Clauses 12.9.1, 12.9.5, and 12.10.2.)

Dimension	Dual palm buttons	Foot control
Surface	Mushroom/dome-shaped	Slip-resistant tread
Diameter	50–60 mm (1.976–2.36 in)	50–80 mm (1.97–3.15 in)
Horizontal location	< 250 mm (10 in) in front of operator	Directly in front
Vertical location	0.90–1.15 m (35–45 in) above standing surface	Pedal height of 12–65 mm (0.5–2.5 in)
Control separation	300–400 mm (12–18.7 in) symmetrical in front of the body	Operable by either foot
Force	4–16 N (0.90–3.60 lbf)	15–80 N (3.37–17.87 lbf)

**12.10 Foot-operated controls****12.10.1**

Foot-operated controls, other than for an emergency stop, shall be adequately shrouded or otherwise arranged to prevent, as far as possible, accidental operation from any cause. Pedals should not be of greater width than that required for foot operation. Movable pedals should be shrouded to permit access from one direction only. Mechanical foot-operated controls that require additional forces, and would not create a hazard when accidentally applied, do not require shrouding.

**12.10.2**

Foot controls shall be operable by either leg and shall not require ankle movement greater than 25 degrees from the neutral position in either direction. The vertical height and travel distance of the foot control shall be kept to a minimum to reduce leg movement and allow a balanced posture (see Table 4 for recommended ergonomic control parameters).

**12.10.3**

A foot pedal shall be of sufficient size and texture to prevent slippage.

Δ

**Table A.1 (Continued)**

Hazards and hazardous situations	Clause references
<b>Hazards generated by noise</b> , resulting in: Hearing loss (deafness), other physiological disorders (e.g., loss of balance, loss of awareness)	6.1.4.3
<b>Hazards generated by vibration</b> Use of hand-held machines resulting in a variety of neurological and vascular disorders Whole body vibration, particularly when combined with poor postures	6.1.4.4
<b>Hazards generated by radiation</b> Low frequency, radio frequency radiation, microwaves Infrared, visible, and ultraviolet light X- and gamma rays Alpha, beta rays, electron or ion beams, neutrons	6.1.4.5
Lasers	6.1.4.6, 11
<b>Hazards generated by materials and substances</b> (and their constituent elements) processed or used by the machine Hazards from contact with or inhalation of harmful fluids, gases, mists, fumes, and dusts Fire or explosion hazard Biological or microbiological (viral or bacterial) hazards	6.1.4.7
<b>Hazards generated by neglecting ergonomic principles in machine design</b> as, e.g., hazards from Unhealthy postures or excessive effort Inadequate consideration of hand–arm or foot–leg anthropometry Neglected use of personal protective equipment Inadequate local lighting Mental overload and underload, stress Human error, human behaviour Inadequate design, location, or identification of manual controls Inadequate design or location of visual display units Inadequate design, visibility of working and/or hazard zone	6.1.4.8, 12
<b>Combination of hazards</b>	6.1.4.9
<b>Unexpected start-up, unexpected overrun/overspeed</b> (or any similar malfunction) from Failure/disorder of the control system	6.2.1.8.1.3
Restoration of energy supply after an interruption	6.2.1.8.2
External influences on electrical equipment (e.g., EMF)	6.2.1.9.4
Other external influences (gravity, wind, etc.)	6.2.1.9.1
Errors in the software	6.2.1.9.9
Errors made by the operator (due to mismatch of the machine with human characteristics and abilities, see <a href="#">Clause 12</a> )	6.2.1.9.10

*(Continued)*

**Table A.1 (Concluded)**

Hazards and hazardous situations	Clause references
<b>Impossibility of stopping the machine in the best possible conditions</b>	6.1.3.3
<b>Variations in the rotational speed of tools</b>	—
<b>Failure of the energy source</b>	7.8.1
<b>Failure of the control circuit</b>	6.2.1.9.10.5
<b>Errors of fitting</b>	—
<b>Break-up during operation</b>	—
<b>Falling or ejected objects or fluids</b>	6.2.3.2.1
<b>Loss of stability/overturning of the machine</b>	6.1.3.3
<b>Slip, trip, and fall of persons</b> (related to the machine)	6.1.3.4
<b>Pace of work</b>	12.7
<b>Excessive overtime and fatigue</b>	—
<b>Operator trapping hazard</b>	—

**Note:** This list has been taken from Annex A of ISO 14121 and is used with permission.

# ***CSA Standards Update Service***

***Z432-04***

***March 2004***

**Title:** *Safeguarding of machinery*

**Pagination:** **147 pages** (x preliminary and 137 text), each dated **March 2004**

Automatic notifications about any updates to this publication are available.

- To register for e-mail notifications, and/or to download any existing updates in PDF, enter the Online Store at **www.csa.ca** and click on **My Account** on the navigation bar.

The **List ID** for this document is **2015606**.

- To receive printed updates, please complete and return the attached card.



Name \_\_\_\_\_

Organization \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_

Province/State \_\_\_\_\_

Country \_\_\_\_\_ Postal/Zip Code \_\_\_\_\_

E-mail \_\_\_\_\_

I consent to CSA collecting and using the above information to send me updates relating to this publication.

Visit CSA's policy on privacy at [www.csagroup.org/legal](http://www.csagroup.org/legal) to find out how we protect your personal information.

***Z432-04***

Affranchir  
suffisamment

Place  
Stamp Here

**ASSOCIATION CANADIENNE DE  
NORMALISATION**  
BUREAU CENTRAL DE L'INFORMATION  
5060, SPECTRUM WAY, BUREAU 100  
MISSISSAUGA ON L4W 5N6  
CANADA

**CANADIAN STANDARDS  
ASSOCIATION**  
CONSOLIDATED MAILING LIST  
5060 SPECTRUM WAY, SUITE 100  
MISSISSAUGA ON L4W 5N6  
CANADA

*CSA Standard*

*Z432-04*  
***Safeguarding of machinery***



**CANADIAN STANDARDS  
ASSOCIATION**

®Registered trade-mark of Canadian Standards Association

*Published in March 2004 by Canadian Standards Association  
A not-for-profit private sector organization  
5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6  
1-800-463-6727 • 416-747-4044*

***Visit our Online Store at [www.csa.ca](http://www.csa.ca)***

ISBN 1-55397-481-6

**Technical Editor:** Dave Shanahan

© Canadian Standards Association — 2004

*All rights reserved. No part of this publication may be reproduced in any form whatsoever without the prior permission of the publisher.*

# Contents

Technical Committee on Safeguarding of Machinery *viii*

Preface *x*

## **0 Introduction** 1

### **1 Scope** 2

- 1.1 General 2
- 1.2 Exclusions 2
- 1.3 Purpose 2
- 1.4 Interaction with other standards 2
- 1.5 Terminology 2
- 1.6 Measurements 2

## **2 Reference publications** 2

## **3 Definitions** 5

## **4 Application** 8

- 4.1 General 8
  - 4.1.1 New machinery 8
  - 4.1.2 Rebuilt or redeployed machinery 9
- 4.2 Strategy for selecting safety measures 9
  - 4.2.1 General 9
  - 4.2.2 Selection of safety measures 10
  - 4.2.3 Phases of machine life 10

## **5 Risk assessment and reduction** 10

- 5.1 Risk assessment 10
- 5.2 Responsibilities for risk assessment and risk reduction 11
  - 5.2.1 General approach 11
  - 5.2.2 Manufacturer and user responsibilities 11
  - 5.2.3 Design techniques hierarchy 11
  - 5.2.4 User's designs 12
- 5.3 Risk assessment methodology 12
  - 5.3.1 Determining the limits of the machine or system 12
  - 5.3.2 Affected personnel when identifying tasks and hazards 13
- 5.4 Identifying the hazards 15
  - 5.4.1 General 15
  - 5.4.2 Task identification 15
  - 5.4.3 Associated hazards 15
  - 5.4.4 Tasks 15
  - 5.4.5 Similar risk assessment 15
- 5.5 Estimating the risk from the hazard 15
  - 5.5.1 General 15
  - 5.5.2 Severity of injury 16
  - 5.5.3 Probability of injury 16
  - 5.5.4 Overall risk estimation 17
- 5.6 Risk reduction 17
  - 5.6.1 General 17
  - 5.6.2 Eliminate the hazard or reduce the risk by design 17
  - 5.6.3 Apply safeguards 17

5.6.4	Implement administrative controls or other protective measures	18
5.6.5	Example	18
5.6.6	Disabling safeguards	19
5.6.7	New tasks	19
5.6.8	Modifications	19
5.6.9	Achievement of adequate risk reduction	19
5.7	Documentation	19
5.7.1	General	19
5.7.2	Manufacturer documentation	20
5.7.3	User documentation	20
5.7.4	Co-operation between manufacturer and user	20
<b>6</b>	<b>Basic concepts and general safety considerations for design</b>	<b>20</b>
6.1	Hazards to be considered when designing machinery	20
6.1.1	General	20
6.1.2	Using standardized measurement methods	20
6.1.3	Mechanical hazards	21
6.1.4	Other hazards	22
6.1.5	Linking mechanical and non-mechanical hazards	23
6.1.6	Strategies for reducing risk	24
6.2	Technical principles	24
6.2.1	Intrinsic design measures	24
6.2.2	Safeguarding and complementary protective measures	34
6.2.3	Requirements for design and construction of guards and protective devices	38
6.2.4	Information for use	42
6.2.5	Complementary protective measures	46
<b>7</b>	<b>Mechanical design and controls</b>	<b>49</b>
7.1	General	49
7.2	Mechanical restraint device	49
7.3	Down-stroking platens	49
7.4	Particular measures for repetitive-cycle hand-fed machines	49
7.4.1	General	49
7.4.2	Random stop machines	49
7.5	Rotating shafts, spindles, and couplings	50
7.6	Hydraulic and pneumatic systems	50
7.7	Electrical systems	50
7.8	Workholding devices	50
7.8.1	Energy loss during operation	50
7.8.2	Clamping for automatic machinery	50
7.8.3	Prevention of inadvertent unclamping of the workpiece	50
7.9	Lifting, handling, and transport	50
7.10	Lubrication	51
7.11	Hygiene	51
7.12	Safety colours and symbols	51
7.13	Operating stations	51
7.14	Platforms and steps	52
7.15	Access for adjustment, lubrication, and maintenance	52
7.16	Interlocking of pneumatic and hydraulic systems	53
7.17	Emergency stop	53
7.17.1	General	53
7.17.2	Emergency stop device design	53
7.17.3	Emergency stop pull-cords	53
7.18	Cables and pipes	54
7.19	Lighting	54

- 7.20 Interaction with other machinery 54
- 7.21 Coolant and swarf 54
- 7.22 Electromagnetic interference 54
- 7.23 Controls for machinery setting or adjustment and for feeding material where safeguards are displaced or removed 55
  - 7.23.1 General 55
  - 7.23.2 Hold-to-run control 55
  - 7.23.3 Enabling devices 55
  - 7.23.4 Limited movement devices 56
- 7.24 Safeguard-operator interface principles 56
- 7.25 Warning signals 56
- 7.26 Indicators 57
- 7.27 Braking systems 57
  - 7.27.1 General 57
  - 7.27.2 Mechanical (friction) braking systems 57
  - 7.27.3 Electrodynamic braking systems 58
- 7.28 Clutches 59
- 7.29 Safety catches, overrun, runback, and fall-back protection devices 59
- 7.30 Counterweights and similar devices 59

## **8 Performance requirements for safety control systems 59**

- 8.1 General 59
- 8.2 Safety control system performance criteria 60
  - 8.2.1 General 60
  - 8.2.2 Simple 60
  - 8.2.3 Single channel 60
  - 8.2.4 Single channel with monitoring 60
  - 8.2.5 Control reliable 60
- 8.3 Safety-related software- and firmware-based controllers 61
- 8.4 Control comparison (ANSI vs CEN) 61

## **9 Performance requirements for safeguarding devices 61**

- 9.1 General 61
- 9.2 Barrier guards, fixed and interlocked 62
- 9.3 Interlocking safeguarding devices 62
  - 9.3.1 General 62
  - 9.3.2 Mechanical devices 62
  - 9.3.3 Electrical devices 62
- 9.4 Requirements for other safeguarding devices that signal a stop 63
  - 9.4.1 General 63
  - 9.4.2 Safety light curtains/screens 63
  - 9.4.3 Area scanning safeguarding devices 63
  - 9.4.4 Radio frequency (RF)/capacitance safeguarding devices 63
  - 9.4.5 Safety mat systems 64
  - 9.4.6 Single and multiple beam safety systems 64
  - 9.4.7 Two-hand control systems 64

## **10 Application requirements for safeguarding devices 65**

- 10.1 General 65
- 10.2 Barrier guards, fixed and interlocked 65
  - 10.2.1 General 65
  - 10.2.2 Barrier guards, interlocked 65
  - 10.2.3 Guard (barrier) portion 65
  - 10.2.4 Interlocking portion 65
- 10.3 Requirements for other safeguarding devices that signal a stop 66

- 10.4 Safety light curtains/screens 66
- 10.5 Area scanning safeguarding devices 67
- 10.6 Radio frequency (RF)/capacitance safeguarding devices 67
- 10.7 Safety mat systems 67
- 10.8 Single and multiple beam safety systems 68
- 10.9 Two-hand control systems 68
- 10.10 Operator restraint devices 69
  - 10.10.1 General 69
  - 10.10.2 Pull-back device (or pull-out device) 69
  - 10.10.3 Hold-back (hold-out or fixed restraining) device 70
- 10.11 Safeguarding device safety distance 70
- 10.12 Minimum distance from hazard 71

## **11 Lasers 73**

## **12 Ergonomics 73**

- 12.1 General 73
- 12.2 Body sizes and shapes 74
- 12.3 Adjustable features 74
- 12.4 Working postures 74
- 12.5 Visual considerations 74
- 12.6 Physical effort 74
  - 12.6.1 Exerted muscle force 74
  - 12.6.2 Maximum force and/or speed 74
- 12.7 Machine pace 74
- 12.8 Displays 75
  - 12.8.1 Indicators, dials, and displays 75
  - 12.8.2 Analog displays 75
- 12.9 Controls 75
- 12.10 Foot-operated controls 76

## **13 Environmental considerations 77**

- 13.1 Hygiene and guard design 77
- 13.2 Electromagnetic interference 77
- 13.3 Moving parts of machinery 77

## **14 Maintenance 77**

- 14.1 Access to machinery for maintenance 77
- 14.2 Operational maintenance of safeguards 78
- 14.3 Waste and spillage removal 78
- 14.4 User responsibility 78

## **15 Safe work practices 79**

- 15.1 General 79
- 15.2 Work practices 79
  - 15.2.1 General 79
  - 15.2.2 Practices for working machinery 79

## **16 Supervisory control 81**

- 16.1 General 81
- 16.2 Permit-to-work systems 81

## **17 Information and communication 82**

- 17.1 General 82
- 17.2 Instruction placards and warning labels 82
- 17.3 Installation, operation, and maintenance instructions 82

**18 Training** 83

- 18.1 General 83
- 18.2 Training procedures 83
  - 18.2.1 Machinery operators 83
  - 18.2.2 Plant engineers and maintenance staff 83
- 18.3 Personal protection 83

**Annexes**

- A** (informative) — Hazards, controls, and interlocks 84
- B** (informative) — Illustrations of other hazard controls 103
- C** (informative) — Ergonomic data 128
- D** (informative) — Selection of interlocking systems 136

---

**Tables**

- 1** — Hierarchy of safeguarding controls 12
- 2** — Safeguarding selection matrix 19
- 3** — Minimum distance from hazard as a function of barrier opening size 71
- 4** — Recommended ergonomics control parameters 76

---

**Figures**

- 1** — Flow of responsibilities 1
- 2** — Schematic representation of the risk assessment/reduction process model 14
- 3** — Guidelines to help make the choice of safeguards against hazards generated by moving parts 35
- 4** — Optical PSSD: Minimum object sensitivity 68
- 5** — Graphical illustration of Table 3 72

# ***Technical Committee on Safeguarding of Machinery***

<b>T. Eastwood</b>	NCC Electronics, Cambridge, Ontario	<i>Chair</i>
<b>C. Newton</b>	Dominion Power Press Equipment Limited, Burlington, Ontario	<i>Vice-Chair</i>
<b>B. Arger</b>	Banner Engineering Corp., Orangeville, Ontario	
<b>D. Boone</b>	Canadian Auto Workers, Toronto, Ontario	
<b>B. Bouckley</b>	General Motors Corporation, Warren, Michigan, USA	<i>Associate</i>
<b>R. Bourbonnière</b>	Institut de recherche en santé et en sécurité du travail du Québec, Montréal, Québec	<i>Associate</i>
<b>W. Brigger</b>	Dominion Power Press Equipment Limited, Burlington, Ontario	<i>Associate</i>
<b>B. Byrne</b>	Cross Huller-North America, Sterling Heights, Michigan, USA	
<b>A. Chim</b>	Takson Engineering Inc., Toronto, Ontario	
<b>R. Estok</b>	Stelco Inc., Hamilton, Ontario	
<b>J. Hansen</b>	Canadian Auto Workers, Windsor, Ontario	
<b>G. Hildebrand</b>	Manitoba Department of Labour and Immigration, Winnipeg, Manitoba	
<b>N. Hutchison</b>	USWA National Office, Toronto, Ontario	
<b>J. Locicero</b>	Co-Ex-Tec Industries, Concord, Ontario	
<b>G.F. Mansour</b>	Ontario Ministry of Labour, Toronto, Ontario	
<b>A. Martin</b>	Dofasco Inc., Hamilton, Ontario	

<b>S. Massé</b>	Institut de recherche en santé et en sécurité du travail du Québec, Montréal, Québec	
<b>G. McCaughey</b>	University of Manitoba, Winnipeg, Manitoba	<i>Associate</i>
<b>B. McGillion</b>	General Motors of Canada Limited, St. Catharines, Ontario	
<b>W. McMahon</b>	Auscan Consultants, Burlington, Ontario	
<b>J.W. Mitchell</b>	Stantec Consulting Ltd., Windsor, Ontario	
<b>J. Murphy</b>	Vickers Warnick Limited, Stoney Creek, Ontario	
<b>T. Norton</b>	Absolute Engineering Solutions Inc., Kitchener, Ontario	
<b>R.F. Pfeiffer</b>	Karmax Heavy Stamping, Milton, Ontario	<i>Associate</i>
<b>A. Pietrzyk</b>	Rockwell Automation Inc./Allen-Bradley, Mayfield Heights, Ohio, USA	<i>Associate</i>
<b>M. Ruelle</b>	Workers' Compensation Board of BC, Surrey, British Columbia	
<b>W. Schilke</b>	Ontario Ministry of Labour, Ottawa, Ontario	<i>Associate</i>
<b>T. Schimek</b>	Dofasco Inc., Hamilton, Ontario	<i>Associate</i>
<b>R.J. Sitarz</b>	Daimler Chrysler Canada Inc., Windsor, Ontario	<i>Associate</i>
<b>J. Van Kessel</b>	JVK Industrial Automation, Cambridge, Ontario	
<b>M.P. Whitson</b>	Industrial Accident Prevention Association, Toronto, Ontario	<i>Associate</i>
<b>R.A. Zobolotny</b>	Industrial Accident Prevention Association, Toronto, Ontario	
<b>D. Shanahan</b>	CSA, Mississauga, Ontario	<i>Project Manager</i>

# Preface

This is the second edition of CSA Z432, *Safeguarding of machinery*. It supersedes the previous edition published in 1994.

This Standard specifies requirements for the design, manufacture (including remanufacture and rebuilding), installation, maintenance, operation, and safeguarding of industrial equipment to prevent injuries and accidents and enhance the safety of personnel who operate, assemble, and maintain machinery.

The scope of this new edition has been expanded to incorporate new international Standards on machinery design and performance and to provide additional information for the identification of hazards, including non-mechanical hazard(s). It contains the methodology for performing a comprehensive risk assessment. As indicated in [Clause 4](#), this Standard is intended to be applied to newly manufactured, rebuilt, and redeployed machinery. However, it could also be used to set upgrade targets for existing machinery. This Standard provides advice on the basic principles of safeguarding and safety control performance to the extent that a manufacturing engineer, plant engineer, manager, or safety personnel may be able to interpret the advice and apply it to any particular machinery. Additional illustrations are used to demonstrate the general application of these principles, although alternative safeguarding solutions may be equally effective.

The need for a new edition was prompted by the changing technology related to these machines and the wish of stakeholders, including regulators, employers, manufacturers, and labour, for a document that would reflect the latest thinking concerning operator and equipment safety. It was the intent of the Technical Committee to harmonize, where possible and where appropriate, with international Standards. For that reason, parts of this Standard are based on the following international Standards: ISO 12100 Parts 1 and 2, ISO 14121, ANSI B11 TR3, and BSI PD 5304.

This Standard was prepared by the Technical Committee on Safeguarding of Machinery, under the jurisdiction of the Strategic Steering Committee on Occupational Health and Safety, and has been formally approved by the Technical Committee. It will be submitted to the Standards Council of Canada for approval as a National Standard of Canada.

March 2004

## Notes:

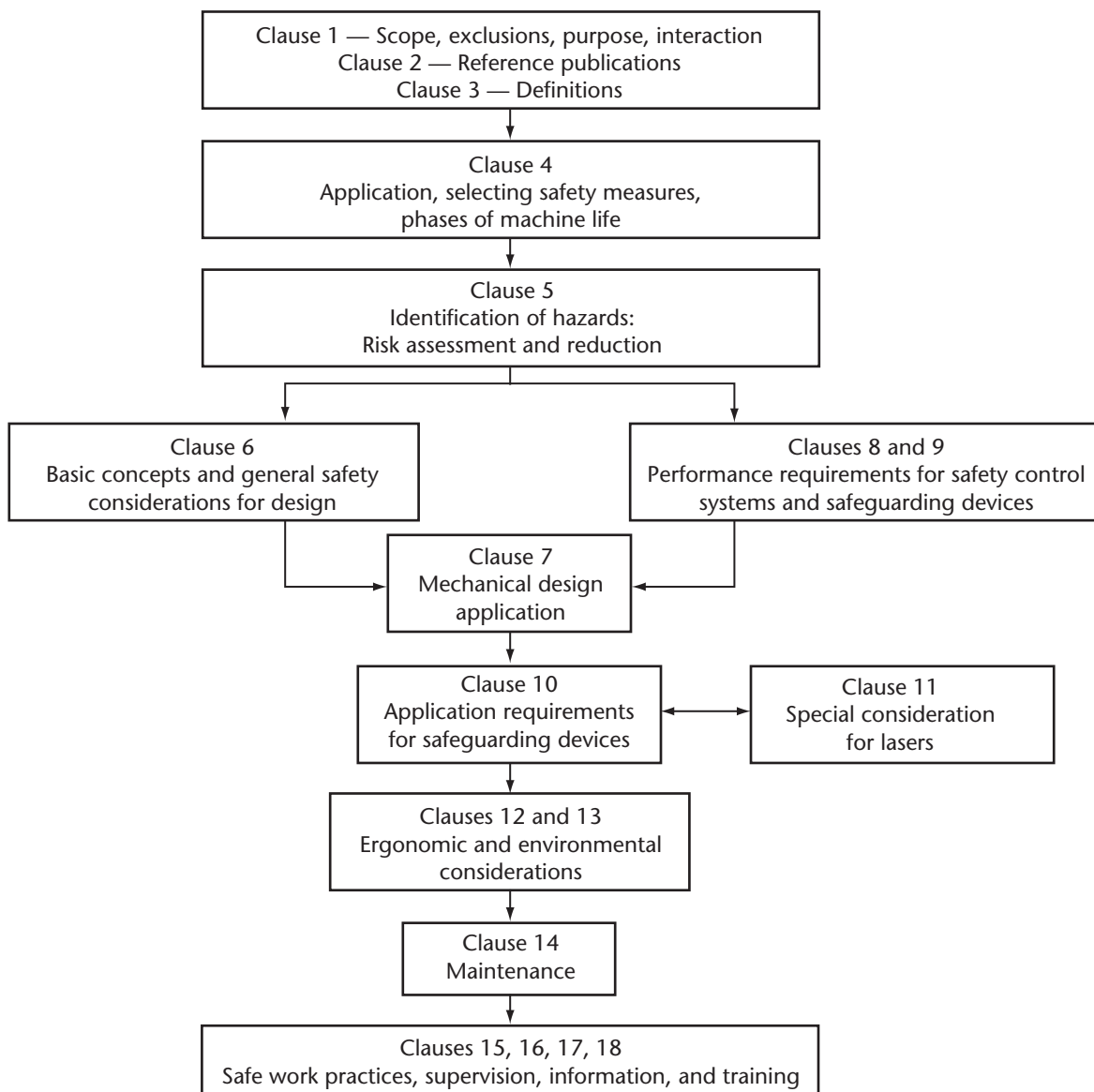
- (1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*
- (2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*
- (3) *This publication 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 publication.*
- (4) *CSA Standards are subject to periodic review, and suggestions for their improvement will be referred to the appropriate committee.*
- (5) *All enquiries regarding this Standard, including requests for interpretation, should be addressed to Canadian Standards Association, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6.*
  - Requests for interpretation should*
    - (a) define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;*
    - (b) provide an explanation of circumstances surrounding the actual field condition; and*
    - (c) be phrased where possible to permit a specific “yes” or “no” answer.**Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization and are published in CSA’s periodical Info Update, which is available on the CSA Web site at [www.csa.ca](http://www.csa.ca).*

# Z432-04

## Safeguarding of machinery

### 0 Introduction

This Standard assigns responsibilities for machinery safety to manufacturers, integrators, installers, and the user. Proper safeguarding of personnel is determined utilizing the methodology in [Clause 5](#), Risk assessment and reduction. The Standard is best read in its entirety for full comprehension of requirements. [Figure 1](#) gives a graphic presentation of the flow of responsibilities as outlined in the Standard.



**Figure 1**  
**Flow of responsibilities**  
(See [Clause 0](#).)

# 1 Scope

## 1.1 General

This Standard applies to the protection of persons from the hazards arising from the use of mobile or stationary machinery. It provides the criteria to be observed and the description, selection, and application of guards and safety devices. Where a current CSA Standard exists for a specific type of machinery (e.g., CAN/CSA-B167, CAN/CSA-B354.2, CAN/CSA-M424.1, Z142, Z248, and CAN/CSA-Z434), it is to be used in conjunction with this Standard to provide the most effective protection to the particular situation.

## 1.2 Exclusions

This Standard does not apply to portable hand tools.

## 1.3 Purpose

This Standard is intended for those who design, build, modify, install, use, operate, or maintain machinery, machinery guarding, or safety devices. It is also intended to be used by those concerned with information, instruction, and training in safe working practices.

## 1.4 Interaction with other standards

Machinery safeguarding is not performed in isolation from other protective measures. Typically, industrial machinery is installed in workplaces where other associated activities take place (e.g., movement of materials, cables, pipes, and hoses supplying power, gases, and liquids, and workers on foot and operating vehicles). Other machinery and work environment standards applicable to any place where this Standard is being implemented should therefore be reviewed.

## 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; and “may” is used to express an option or that which is permissible within the limits of the standard. 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. Legends to equations and figures are considered requirements.

## 1.6 Measurements

The values given in SI (metric) units are the standard. The values given in parentheses are for information only.

# 2 Reference publications

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

### **CSA (Canadian Standards Association)**

CAN/CSA-B167-96 (R2002)

*Safety Standard for Maintenance and Inspection of Overhead Cranes, Gantry Cranes, Monorails, Hoists, and Trolleys*

CAN/CSA-B354.2-01

*Self-Propelled Elevating Work Platforms*

C22.1-02

*Canadian Electrical Code, Part I*