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Safety of Industrial Tools, Machines and Processes

Studies and Research Projects

REPORT **R-575**

Comparative analysis of lockout programs and procedures applied to industrial machines

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REPORT **R-575**

Comparative analysis of lockout programs and procedures applied to industrial machines

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ABSTRACT

Approximately 20 workers in Quebec were killed by dangerous machines and around 13000 accidents could be linked to machines in the province of Quebec in 2005, costing approximately 70 million $ to the Quebec Occupational Health and Safety Commission (CSST) in compensation and salary replacement. Lockout is defined in the Canadian standard, the CSA Z460-05 (2005), as the placement of a lock or tag on an energy-isolating device in accordance with an established procedure, indicating that the energy-isolating device is not to be operated until removal of the lock or tag in accordance with an established procedure. Based on article 185 of the Quebec's Occupational Health and Safety Regulation (RSST), workers intervening in hazardous zones of machines and processes during maintenance, repairs, and unjamming activities have to apply lockout procedures. This study will attempt to answer the following questions:

- Does the concept of lockout have the same meaning or definition in the literature?
- Are the legal requirements in different provinces as well as countries similar?
- Are the different standards on lockout similar?
- Are the contents of lockout programs as described by different documents similar?
- Are lockout programs in a sample of industries in Quebec complying with the legal requirements and coherent with the Canadian standard on lockout, the CSA Z460-05 (2005)?

A survey was carried out in order to collect several documents on lockout and these were:

- Standards
  - Five standards on lockout: CSA Z460-05 (2005), ANSI/ASSE Z244.1 (2003), ANSI/ASSE A10.44 (2006), CP 91 (2001) and ISO 14118 (2000);
- Regulations
  - Twenty eight regulations from different Canadian provinces and from other countries which refer to lockout;
- Books and guides
  - Six documents on lockout from six non profit, sector-based, Occupational Health and Safety (OH&S) associations in Quebec;
  - Two books on lockout: Kelley (2001) and Daoust (2003);
  - One document from the Institut National de recherche et de Sécurité (INRS) on lockout: INRS (1996); and
  - Two documents produced by the CSST on lockout: CSST (1985) and CSST (1994).

Moreover, thirty one written lockout programs from twenty-nine factories and two hospitals in Quebec were collected based on criteria such as plant size, industrial sector, number of employees and machine types. The analysis of all the seventy-five documents has revealed that:

- The concept of lockout has different meanings or definitions in the literature, especially in regulations. However, definitions for lockout which are found in standards have certain similarities.
- The legal requirements on lockout vary in different Canadian provinces and in different countries.

- Standards on lockout tend to have similar requirements, except ISO 14118 (2000). However, some differences in the standards regarding the elements of lockout programs exist.
- The contents of lockout programs, as described in different documents, vary.
- Lockout programs obtained from thirty-one factories and organisations in Quebec do not fully comply with the provincial regulation. The lockout programs have several elements which are missing when compared to CSA Z460-05 (2005).

It must also be mentioned that the study has the following limitations:

- The application of lockout by workers has not been investigated in this study. There was neither direct nor indirect observation of the application of lockout in the different enterprises. The study dealt only with the collect and analysis of several documents on lockout. As such, for example, it cannot be known whether the authorized employees perform all the steps of a lockout procedure, despite the absence of some of those steps in the written lockout documents. The actual application of lockout procedures will be covered in a different study.

- The impact on occupational health and safety as a result of the differences in the regulations was not analysed in greater extent. This will be dealt with in the next study after actual application of lockout has been observed and after obtaining a better understanding of lockout in practice. As such, much of the analysis carried out in this study was based on discrepancies in the wording and content of the different articles appearing in the regulations as well as paragraphs and sections of standards, guides and books on lockout.

It is believed that the research projects proposed in the thematic on lockout at the IRSST and described in this report will contribute in generating knowledge on lockout and will benefit enterprises in Quebec and potentially in other places as well.

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1. INTRODUCTION

In 2005, 1097 workers were killed in Canada and 337 930 were injured or suffered from illnesses linked to occupational hazards, resulting in expenses amounting to 6.8 billions $ in compensation and salary replacement [Logan, 2007]. In the province of Quebec for the same year, 223 workers were killed and 99076 were injured, amounting to 1.6 billion $ in compensation and salary replacement for the Occupational Health and Safety Commission (CSST), the workers' compensation board in Quebec. Moreover, approximately 20 workers in Quebec were killed by dangerous machines and around 13000 accidents could be linked to machines in the province in 2005, costing approximately 70 million $ to the CSST.

Based on article 185 of the Quebec's Occupational Health and Safety Regulation (RSST) [RSST, 2001], workers intervening in hazardous zones of machines and processes during maintenance, repairs, and unjamming activities have to apply lockout procedures. This article states that:

Article 185. Making secure: Subject to the provisions of section 186, before undertaking any maintenance, repair or unjamming work in a machine's danger zone, the following safety precautions shall be taken: (1) turn the machine's power supply switch to the off position, (2) bring the machine to a complete stop, and (3) each person exposed to danger locks off all the machine's sources of energy in order to avoid any accidental start-up of the machine for the duration of the work.

Moreover, article 186 of the RSST provides an alternative to lockout under specific circumstances and it states that:

Article 186. Adjustment, repair, unjamming, maintenance and apprenticeship: When a worker must access a machine's danger zone for adjustment, unjamming, maintenance, apprenticeship or repair purposes, including for detecting abnormal operations, and to do so, he must move or remove a protector, or neutralize a protective device, the machine shall only be restarted by means of a manual control or in compliance with a safety procedure specifically provided for allowing such access. This manual control or this procedure shall have the following characteristics: (1) it causes any other control mode or any other procedure, as the case may be, to become inoperative, (2) it only allows the operating of the dangerous parts of the machine by a control device requiring continuous action or a two-hand control device, and (3) it only allows the operation of these dangerous parts under enhanced security conditions, for instance, at low speed, under reduced tension, step-by-step or by separate steps.

The CSST recently revealed that in 3 years, more than 230 derogations to article 185 have been issued by inspectors. It also appears that lockout is not well known in various industrial sectors in Quebec [Côté, 2005].

1.1 RESEARCH OBJECTIVES

This study will attempt to answer the following questions:

- Does the concept of lockout have the same meaning or definition in the literature?

- Are the legal requirements in different provinces as well as countries similar?
- Are the different standards on lockout similar?
- Are the contents of lockout programs as described by different documents similar?
- Are lockout programs in a sample of industries in Quebec complying with the legal requirements and coherent with the Canadian standard on lockout, the CSA Z460-05 (2005)?

1.2 BRIEF INTRODUCTION TO LOCKOUT

Lockout is defined in CSA Z460-05 (2005) as the placement of a lock or tag on an energy-isolating device in accordance with an established procedure, indicating that the energy-isolating device is not to be operated until removal of the lock or tag in accordance with an established procedure. As such, simply shutting off a machine, equipment or process may not completely control the hazardous energy since residual energy may still be present [CSA Z460-05, 2005]. Besides, even if the machine, equipment or process has been shut down and residual energy dissipated, an accident can still occur as a result of unexpected start up due to human error or a malfunction in a control circuit [Kelley, 2001]. Moreover, a machine is defined in ISO 12100-1 (2003) as an assembly of linked parts or components, at least one of which moves, with the appropriate machine actuators, control and power circuits, joined together for a specific application, in particular for the processing, treatment, moving or packaging of a material [ISO 12100-1, 2003]. It is also well known that machines possess hazards of different nature (e.g. mechanical, electrical, thermal, chemical etc.), as described in greater detail in ISO 14121 [ISO 14121-1, 2007]. Hence, the purpose of lockout is to protect personnel from injury from the inadvertent release of hazardous energy on machines, equipment and processes. The hazardous release of energy includes unintended motion of mechanical parts, energization, start-up or release of stored energy. Lockout is recognized in CSA Z460-05 (2005) as the primary method of hazardous energy control for tasks such as erecting, installing, constructing, repairing, adjusting, inspecting, unjamming, setting up, troubleshooting, testing, cleaning, dismantling, servicing and maintaining machines, equipment or processes. However, the standard also mentions that if those tasks are integral to the production process or if traditional lockout prohibits completion of those tasks, other methods of control, based on risk assessment, can be used.

1.2.1 LOCKOUT PROGRAM

A lockout program, as described in CSAZ60-05 (2005), includes the following elements:

- Identification of the hazardous energy covered by the program;
- Identification of the types of energy isolating devices;
- Identification of the types of de-energizing devices;
- Selection and procurement of protective materials and hardware;
- Assignment of duties and responsibilities;
- Determination of shut-down, de-energization, energization and start-up sequences;

- Written lockout procedures for machines, equipment and processes;
- Training of personnel; and
- Auditing of program elements.

The lockout program provides guidance to supervisors and employees on what is expected of them. The written program establishes the company's general policies and procedures for implementing lockout as well as sets specific performance requirements for employees. It also provides the mechanism for regulatory compliance. The written program addresses the program's purpose, scope and application, defines key terms, prescribes the responsibilities of managers, supervisors and employees for implementing the program elements and outlines general lockout rules and procedures [Kelley, 2001]. Examples of written lockout programs are given in [CSA Z460-05 (2005), Kelley (2001), ANSI/ASSE Z244.1 (2003), ASP Imprimerie (2003) and ASSPPQ/ASSIFQ (2001)].

As such, Kelley provides some guidance regarding the responsibilities of managers, supervisors and employees for implementing various aspects of the program. These responsibilities should be clearly defined in the document [Kelley, 2001]. Management is generally responsible for: (i) drafting, periodically reviewing, and updating the written program, (ii) identifying the employees, machines, equipment and processes included in the program, (iii) providing the necessary protective equipment, hardware and appliances, and (iv) monitoring as well as measuring conformance with the program requirements. Supervisors are generally responsible for: (i) distributing protective equipment, hardware, and appliances and ensuring its proper use by employees, (ii) ensuring that equipment-specific procedures are established for the machines, equipment and processes in their area, (iii) ensuring that only properly trained employees perform service or maintenance under lockout and (iv) ensuring that employees under their supervision follow established lockout procedures. Employees are generally responsible for: (i) assisting in the development of equipment-specific procedures, (ii) following the procedures that have been developed, and (iii) reporting any problems associated with those procedures.

1.2.2 LOCKOUT PROCEDURE

The lockout procedure consists of a step-by-step approach that the authorized employee follows to prevent injury from unexpected (inadvertent) start-up, energization, or release of stored energy. The main steps for a general lockout procedure taken from CSA Z460-05 (2005) are:

- Preparation for shutdown;
- Machine, equipment or process shutdown;
- Machine, equipment, or process isolation;
- Application of lockout devices;
- Controlling stored energy (de-energization);
- Verification of isolation.

Examples of lockout procedures are given in [CSA Z460-05 (2005), ANSI/ASSE Z244.1, ANSI/ASSE A10.44 (2006), CP 91 (2001), OSHA-1910.147, Kelley (2001), Daoust (2003), Préventex (2007), ASSPPQ/ASSIFQ (2001), APSAM (2006)].

1.3 RESEARCH THEMATIC ON LOCKOUT AT THE IRSST

A research thematic on lockout has been developed at the Institut de Recherche Robert-Sauvé en Santé et en Sécurité du Travail (IRSST). It consists of a series of studies which are intended to provide answers to questions such as:

- Does the concept of lockout have the same meaning or definition in the literature?
- Are the legal requirements in different provinces and countries on lockout similar?
- Are standards on lockout similar?
- Are the contents of lockout programs as described in different documents similar?
- Are lockout programs in a sample of industries in Quebec complying with the legal requirements (provincial occupational health and safety regulations)?
- Are the lockout procedures being applied in Quebec?
- Do the lockout programs and procedures in Quebec comply with recommendations presented in the scientific literature, i.e. standards, books, scientific papers?
- How to define activities or interventions where lockout needs to be used?
- What are the alternate risk reduction methods to lockout that are being used, which can be used or which are needed?
- What are the technical difficulties faced by employees when applying lockout procedures?

1.3.1 CURRENT STUDY: COMPARATIVE ANALYSIS OF LOCKOUT PROGRAMS AND PROCEDURES APPLIED TO INDUSTRIAL MACHINES

The first and current study will serve as a literature review on lockout for the research thematic. Information available on lockout from different sources including books, standards and other publications on lockout programs and procedures will be collected and analysed. The second source of information will originate from factories where lockout programs and procedures have been developed. This study will attempt to answer the following questions:

- Does the concept of lockout have the same meaning or definition in the literature?
- Are the legal requirements on lockout in different provinces and countries similar?
- Are the different standards on lockout similar?
- Are the contents of lockout programs as described in different documents similar?

- Are lockout programs in a sample of industries in Quebec complying with the legal requirements (provincial occupational health and safety regulations) and coherent with the Canadian standard on lockout, the CSA Z460-05 (2005)?

Potential outcomes for this study include: (i) a better understanding of lockout, (ii) developing criteria and tools for evaluating the application of lockout procedures, which is planned in the second study, and (iii) generating knowledge on lockout to be incorporated in various training courses in Quebec.

1.3.2 SECOND STUDY: EVALUATION OF THE APPLICATION OF LOCKOUT PROCEDURES

For unknown reasons, it happens very often that workers do not apply the existing lockout procedure. The following questions arise; (i) Are the tasks compatible with this method? (ii) Are the lockout procedures too long or too elaborate? (iii) Is it due to technical difficulties? The application of lockout and its applicability depend on various factors which are technical but also based of human behaviour. It would be interesting to explore this area on human behaviour regarding the application of lockout procedures. The objective of this research orientation is to investigate whether the procedures are being applied, are applicable and to understand the reasons for their non-application. Indirect observation of lockout procedures through interviews, as well as analysis of documents regarding audits on lockout, should help to better understand and identify the difficulties when applying lockout procedures in different industries in Quebec. Partial application, not applying lockout procedures, whether it is voluntary or not, and mistakes when applying lockout made by workers themselves or caused by the procedures, are factors to consider. Direct observation and analysis of collected information should help identify the difficulties of ergonomic, managerial, and technical in nature. A better understanding of the applicability factors or criteria for lockout procedures will result.

Outcomes include the development of tools enabling observation of the application of lockout procedures, which could be used for auditing lockout, as well as the development of criteria and tools for evaluating the applicability of lockout procedures in industries.

1.3.3 THIRD STUDY: USE OF ALTERNATIVE METHODS TO LOCKOUT PROCEDURES

If lockout procedures are not always appropriate to work situations, and if other methods are not used to ensure the safety of workers, hazardous situations at work will prevail. As mentioned earlier, in Quebec, lockout is identified in the RSST as being the method to be used for maintenance, repairs and unjamming activities. However, one of the questions often asked by people in industry is whether lockout can replace or be replaced by other risk reduction means such as interlocked guard or safety devices. In order to answer this question, the limits of lockout procedures need to be identified by the second study. The work conditions which are favourable to the application of lockout will therefore be identified. The objective of this third study will be to elaborate a tool which will help decide if lockout is appropriate for a given task. The result will be to identify criteria for establishing rules for the selection of other risk reduction methods.

As such, the outcomes of this study include the development of criteria and tools for selecting appropriate risk reduction methods.

1.3.4 FOURTH STUDY: TECHNICAL DIFFICULTIES

Technical difficulties linked to certain types of technologies such as variable speed drives, programmable systems and identification of residual energies all have a common link: how to ensure and to prove that the isolating devices have fulfilled their roles and that the energy sources have been well isolated and separated. The objective is to identify these technical difficulties and to prepare documents guiding users and workers on these matters.

Outcomes of this study include identifying means to carry out the verification step in lockout procedures and preparing technical documents in relation to typical lockout procedures on specific machines.

2. METHODOLOGY

In this study, the methodology was developed in order to:

- Determine whether the concept of lockout has the same meaning or definition in the literature;
- Determine whether the legal requirements on lockout applied to industrial machines in different provinces and countries are similar;
- Determine whether standards on lockout are similar;
- Determine whether the contents of lockout programs as described in different documents are similar; and
- Determine whether a sample of lockout programs from industries in Quebec comply with the legal requirements and are coherent with CSA Z460-05 (2005).

Therefore, a survey was carried out in order to collect documents where a complete or partial description of lockout programs and/or procedures is found. A reasonable number of documents constituting the reference sample were gathered. In order to meet the second and the third objectives of this study, the sample of documents included regulations and standards on lockout. In this study, only regulations on lockout applied to industrial machines have been considered. Specific regulations for the construction and mining sectors for example, which also refer to lockout, were not considered.

The second step in the methodology consisted of obtaining a reasonable sample of written lockout programs from factories and organisations in Quebec. Criteria such as plant size, industrial sector, number of employees and machine types were used for selecting the factories.

The third step of the methodology was to set up a grid or table in order to compare the different documents. The elements constituting the first column of the table were based mostly on standards, but additional elements from the other documents were used as well.

The final step of the methodology was to compare and analyse the various documents. This comparison was done considering classes of documents and the individual elements constituting the first column of the table.

3. RESULTS

3.1 IDENTIFICATION OF VARIOUS DOCUMENTS ON LOCKOUT

The research objectives were met by gathering information on lockout from different sources. As such, 28 regulations on lockout, presented in Table 1, and obtained from different parts of the world were identified and then analysed. Their sources are given in the references at the end of the report.

Table 1: List of regulations which were studied and their origins

Regions (5)	Countries (13)	Regulations (28)	Language used (9 in French and 19 in English)
North America (15)	Canada (13)	Federal jurisdiction	English-French
		Prince-Edward Island	English
		New Brunswick	English-French
		Nova Scotia	English
		Newfoundland and Labrador	English
		Quebec	English-French
		Ontario	English
		Manitoba	English-French
		Saskatchewan	English
		Alberta	English
		British Columbia	English
		Yukon	English
		North-West Territories	English-French
	United States (2)	OSHA	English
		California	English
Australia (2)	Australia (2)	New South Wales	English
		Victoria	English
Europe (6)	European Union (2)	Machine directive 98/37/CE	English-French
		Machine directive 89/655/CE	English-French
	France (1)		French
	Germany (1)		English
	Switzerland (1)		French
	United Kingdom (1)		English
Africa (1)	South Africa (1)		English
Asia (4)	Japan (1)		English
	India (1)		English
	Philippines (1)		English
	Singapore (1)		English

Moreover, several standards on lockout were also identified and analysed. These standards are presented in Table 2.

Table 2: List of standards on lockout which were studied

CSA-Z460	Control of hazardous energy: Lockout and other methods	2005
ANSI/ASSE Z244.1	Control of hazardous energy: Lockout/tagout and alternative methods	2003
ANSI/ASSE A10.44	Control of energy sources (lockout/tagout) for construction and demolitions operations	2006
Singapore standard CP 91	Code of practice for Lockout procedure	2001
ISO 14118	Safety of machinery —Prevention of unexpected start-up	2000

In Quebec, several Occupational Health and Safety (OH&S) associations exist. These organisations support various industrial sectors. Documents on lockout from six OH&S associations were identified and analysed. These documents are used as reference material by numerous industries. These were:

- Association sectorielle paritaire – secteur transport et entreposage (ASTE), [ASTE, 2003].
- Association paritaire pour la santé et la sécurité du travail - Secteur affaires municipales (APSAM), [APSAM, 2006].
- Préventex, [Préventex, 2007].
- Association sectorielle paritaire – Secteur imprimerie et activités connexes (ASP Imprimerie), [ASP Imprimerie, 2003].
- Associations de la santé et la sécurité des pâtes et papiers et des industries de la forêt du Québec (ASSPPQ/ASSIFQ), [ASSPPQ/ASSIFQ, 2001].
- Association sectorielle paritaire – Secteur construction (ASP Construction), [ASP Construction, 2003].

Five additional reference documents have been identified and analysed; two documents produced by the CSST, [CSST, 1985] and [CSST, 1994], two text books on lockout, namely [Daoust, 2003] and [Kelley, 2001] and a document produced by the Institut National de Recherche et de Sécurité in France (INRS), [INRS, 1996].

The research team also collected 31 lockout programs from different industrial sectors in Quebec. This was made possible by: (i) explaining the objectives of the study to industries (usually OH&S representatives), (ii) ensuring the confidentiality of the sources, (iii) visiting all the 31 plants and organisations and asking questions about the number of employees and types of machines. The researchers were at times also able to obtain a copy of the written lockout program before the visit, but usually, the lockout program was provided to the researchers on the same day. Each visit, including the question time, lasted on average no more than three hours. An overview of the industrial sectors and the number of factories or organisations which took part in this study is presented in Table 3.

Table 3: Industrial sectors and number of plants/organisations which participated in the study

Manufacturing (metal products): 8 plants Manufacturing (electrical products): 7 plants Printing: 4 plants Machine manufacturer: 3 plants Organisations: 2 hospitals	Sawmill: 2 plants Pulp and paper: 2 plants Mining: 1 plant Metal: 1 plant Chemical: 1 plant

Industries were classified as follows, based on the number of employees:

- Small enterprises (companies with 100 employees or less);
- Medium enterprises (companies with more than 100 but less than 500 employees); and
- Large enterprises (companies with more than 500 employees).

In this study, 23% of the lockout programs were obtained from small enterprises, 55% came from medium enterprises and 22% from large enterprises. Moreover, 81% of the enterprises were part of multinationals.

3.2 SETTING UP THE EXCEL SPREADSHEET

The following main themes were used for comparing the different documents and a table was set up in Excel for analysis purposes.

- Definition of lockout;
- Purpose of lockout;
- Scope;
- Design characteristics of the equipment to facilitate lockout;
- Use of locks;
- Use of locks on control devices or systems;
- Tasks or application;
- Energy type;
- Extent of lockout;
- Hardware (material) used during lockout;
- Specific requirements during lockout;
- Placard;
- Elements (steps) of lockout;
    - Sequence of the different elements of lockout;
    - Methods for the verification step of lockout;

- External service or contractor personnel;
- Training and communication;
- Review of lockout program and of its application; and
- Alternatives methods to lockout.

3.3 RESULTS WHEN COMPARING VARIOUS DOCUMENTS

3.3.1 DEFINITION OF LOCKOUT

The definition of the term lockout varies in the literature. Four classes of definitions for lockout have been identified and these are:

(i) Unable to actuate a device without authorization (usually by using locks);

(ii) Unable to actuate a device without authorization, combined with additional measures;

(iii) Locks are absent or optional;

(iv) Unclear or difficult to classify.

3.3.1.1 Unable to actuate or activate a device without authorization

In this section, some examples of various definitions of lockout which fall into this category are presented. These are:

- **[CSA Z460-05, 2005].** Lockout: The placement of a lock or tag on the energy isolating device in accordance with an established procedure, indicating that the energy isolating device shall not be operated until removal of the lock or tag in accordance with an established procedure.
- **[ANSI/ASSE Z244.1, 2003].** Lockout/tagout: The placement of a lock/tag on the energy isolating device in accordance with an established procedure, indicating that the energy isolating device shall not be operated until removal of the lock/tag in accordance with an established procedure. (The term lockout/tagout allows the use of a lockout device, a tagout device, or a combination of both.).
- **[ANSI/ASSE A10.44, 2006].** Lockout/tagout (LOTO): The placement of a lockout device and a tag (in combination) on the energy isolating device in accordance with an established procedure, indicating that the energy isolating device shall not be operated until removal of the lockout device and tagout device in accordance with an established procedure.
- **[CP 91, 2001].** Lockout: The placement of a lockout device on an energy isolating device, in accordance with an established procedure, for ensuring that the energy isolating device and the machine being controlled cannot be operated until lockout device is removed.
- **[Alberta] (Regulation).** Secure: Means ensuring that an energy isolating device cannot be released or activated by (a) removing any activating device, (b) attaching a lock to the energy isolating device that is operated by a key or similar device, or (c) attaching to the energy

isolating device a mechanism other than a lock which is designed to withstand inadvertent opening without use of excessive force, unusual measures, or destructive techniques.

- **Lockout program (one lockout program from industry)**. Lockout: A procedure whereby one or more lockout device(s) is placed on an energy-isolating device(s) to ensure that neither the energy-isolating device nor the equipment being controlled can be operated until the lockout device is removed.
- **[Kelley, 2001] and [OSHA 1910.147].** Lockout: The placement of a lockout device on an energy isolating device in accordance with an established procedure, ensuring that the isolating device and the equipment being controlled cannot be operated until the lockout device is removed.

3.3.1.2 Unable to actuate a device without authorization combined with additional measures

Examples of definitions which fall into this category are presented in this section and these are:

- **[Nova Scotia] (Regulation).** Locked out means to have (i) isolated the energy source or sources from a machine, equipment, tool or electrical installation, (ii) dissipated any residual energy in a system, and (iii) secured the isolation of the energy source or sources by an inhibiting device that is operated by a key or other process.
- **[Saskatchewan] (Regulation)**. Locked out means to have isolated the energy source or sources from equipment, to have dissipated any residual energy in a system and to have secured the isolation by a device that is operated by a key or other process.
- **[CSST, 1994].** Lockout consists of isolating all energy sources and applying personnel locks at the sources in order to prevent machine from being energized during maintenance and repairs.
- **[ASTE, 2003].** Lockout: Preventing machine from accidentally starting up by isolating all energy sources and applying a lock at the source.

3.3.1.3 Locks are absent or optional

Examples of definitions which fall into this category are presented in this section and these are:

- **[Manitoba] (Regulation).** Lockout means the disconnection, blocking or bleeding of all sources of energy that may create a motion or action by any part of a machine and its auxiliary equipment.
- **[ISO 14118, 2000].** Isolation and energy dissipation procedure which consists of all of the four following actions: a) isolating (disconnecting, separating) the machine (or defined parts of the machine) from all power supplies; b) locking (or otherwise securing), if necessary (for instance in large machines or in installations), all the isolating units in the "isolated" position; c) dissipating or restraining any stored energy which may give rise to a hazard d) verifying by using a safe working procedure that the actions taken according to a), b) and c) above have produced the desired effect.

3.3.1.4 Unclear or difficult to classify

Examples of definitions which fall into this category are presented in this section and these are:

- **Lockout program (from industry).** Lockout procedures: A series of steps taken to ensure that the equipment is at a zero energy state.
- **Lockout program (from industry).** Lockout: System which enables to prevent transmission or release of energy.
- **[Yukon] (Regulation).** Lockout means the use of a lock or locks to render machinery or equipment inoperable or use of an energy-isolating device in accordance with written procedures.
- **[British Columbia] (Regulation).** Lockout means the use of a lock or locks to render machinery or equipment inoperable or to isolate an energy source in accordance with a written procedure.
- **[California] (Regulation).** Locked out. The use of devices, positive methods and procedures, which will result in the effective isolation or securing of prime movers, machinery and equipment from mechanical, hydraulic, pneumatic, chemical, electrical, thermal or other hazardous energy sources.

3.3.2 PURPOSE OF LOCKOUT

Four distinct purposes for a lockout program have been identified after the analysis of the various documents on lockout. These are:

- To maintain workers' safety;
- To prevent an unintended release of hazardous energy (stored energy);
- To prevent unintended start-up or unintended motion; and
- To prevent contact with a hazard (ex. electrical, mechanical) when guards are removed or safety devices are bypassed or removed.

3.3.3 SCOPE

Table 4 provides an overview of the scope of lockout programs as described in different documents. It should be mentioned that the terms *machine* and *machinery* are used as synonyms in the various documents.

Table 4: Results on the scope of lockout programs

SCOPE OF LOCKOUT AS DESCRIBED IN VARIOUS DOCUMENTS	North American regulations	African , Asian and Australian regulations	European regulations	Standards	OH&S associations	Books and guides	Small enterprises	Medium enterprises	Large enterprises
Machine	73%	43%	33%	100%	67%	100%	57%	88%	57%
Machinery	40%	71%	17%	20%	33%	0%	14%	24%	29%
Equipment	60%	43%	83%	80%	100%	80%	100%	100%	100%
Electrical equipment	0%	0%	0%	0%	0%	40%	14%	0%	14%
Process	7%	0%	0%	40%	33%	60%	29%	12%	14%
Tool	13%	14%	33%	0%	33%	0%	0%	6%	14%
Electrical installation	7%	14%	0%	0%	33%	20%	0%	29%	14%
Vehicles	7%	0%	0%	0%	0%	60%	0%	0%	0%
Conduits and piping systems	13%	14%	0%	0%	83%	60%	14%	18%	57%
Energy supply system	7%	0%	0%	0%	17%	0%	14%	6%	0%
Building installation	7%	0%	33%	0%	17%	40%	0%	6%	14%

3.3.4 DESIGN CHARACTERISTICS OF EQUIPMENT TO FACILITATE LOCKOUT

3.3.4.1 Machines or equipment can be isolated from their energy sources

This requirement is found in European regulations and in 13% of North American regulations. Regulations in Prince Edward Island and India have this requirement for electrical energy only. Moreover, lockout programs obtained from industry do not mention it (except 18% of medium enterprises). All the standards (except ANSI/ASSE A10.44 (2006) and CP 91 (2001)) cover this aspect. Two OH&S associations, Kelley (2001) and the INRS (1996) mention this requirement.

3.3.4.2 Isolation devices can be locked (i.e. a locking device can be applied)

Only four regulations (OSHA 1910.147, New Brunswick, Machine Directive 98/37/CE and Germany) have this fundamental requirement. Enterprises do not mention this aspect in their program (except 18% of medium enterprises). CSA Z460-05 (2005), ANSI/ASSE Z244.1 (2003) and ISO 14118 (2000) have this requirement. Kelley (2001), INRS (1996) and two OH&S associations cover this aspect.

3.3.4.3 Identification or labelling of isolating devices

None of the regulations covers this aspect. Only one factory mentions it. Standards on lockout, Daoust (2003), Kelley (2001) and INRS (1996), as well as two OH&S associations mention the identification or labelling of isolating devices.

3.3.4.4 Need for energy dissipating devices

Only 67% of European regulations mention the need for dissipating devices. Lockout programs from factories and OH&S associations do not mention these devices. Only three standards (i.e. CSA Z460-05 (2005), ANSI/ASSE Z244.1 (2003) and ISO 14118 (2000)) and two guides and books (i.e. Kelley (2001) and INRS (1996)) mention the need for these devices.

3.3.5 USE OF LOCKS

It has been observed that the use of locks is clearly specified in all regulations, except in European regulations and in three regulations in Canada (i.e. Quebec, Ontario and Federal). OSHA.1910.147 and California accept the use of locks or padlocks and of tags but refer to this practice as tagout. ANSI/ASSE Z244.1 (2003) and ANSI/ASSE A10.44 (2006) require the use of locks and of locking mechanisms. CSA Z460-05 (2005), ISO 14118 (2000) and CP 91 (2001) accept locks. All the lockout programs from industry refer to the use of locks as means for locking. The six OH&S associations, Daoust (2003), Kelley (2001), CSST (1994), CSST (1985) and INRS (1996) have this requirement for locking.

3.3.6 USE OF LOCKS ON CONTROL SYSTEMS

It has been observed that regulations in Newfoundland and North-West Territories clearly prohibit the use of locks on control systems for locking purposes during lockout. These regulations clearly state that the locking of individual control buttons or switches on a console shall not be accepted as compliance with the regulations. OSHA 1910.147 clearly states that push buttons, selector switches and other control circuit devices are not energy isolating devices. On the other hand, the Japanese regulation refers to locking of the start up device (button) of the equipment. The remaining regulations do not cover this aspect. CSA Z460-05 (2005) and CP 91 (2001), as well as one OH&S association and Kelley (2001) clearly indicate that applying locks to control system is not lockout. The analysis of lockout programs from industry revealed that only five factories specified using locks on power circuits and not control circuits.

3.3.7 APPLICATION

The tasks for which lockout has to be applied vary a lot but essentially, all documents tend to include repairs, maintenance and servicing. Quebec's regulation requires lockout for unjamming activities as well. However, tasks such as work and start-up are also referred in one regulation. Table 5 summarises the different results obtained when comparing the various documents based on the tasks for which lockout has to be applied.

Table 5: Application of lockout

TASKS AS DESCRIBED IN VARIOUS DOCUMENTS	Regulations in North America	Regulations in Africa, Asia, Australia	Regulations in Europe	Standards	OH&S associations	Books and guides	Small enterprises	Medium enterprises	Large enterprises
All intervention or human intervention or tasks, work, etc.	0%	0%	0%	20%	33%	20%	43%	41%	43%
Repairs	87%	57%	50%	80%	83%	80%	71%	82%	86%
Servicing	27%	0%	17%	20%	83%	60%	57%	76%	57%
Maintenance	60%	29%	67%	80%	0%	20%	43%	24%	14%
Unjamming	27%	0%	0%	60%	50%	60%	14%	41%	29%
Erecting	7%	0%	0%	60%	0%	20%	0%	12%	0%
Installation and set up	20%	0%	0%	80%	17%	20%	0%	24%	43%
Construction	7%	0%	0%	80%	0%	20%	14%	6%	14%
Adjustment	33%	14%	0%	80%	33%	80%	0%	24%	43%
Tuning	7%	0%	33%	20%	17%	0%	0%	12%	0%
Inspection and verification	20%	29%	17%	80%	33%	80%	0%	35%	57%
Trouble-shooting, investigative work and fault finding	0%	0%	0%	40%	0%	0%	14%	6%	0%
Test	27%	0%	0%	60%	0%	0%	0%	6%	0%
Clean	47%	43%	33%	60%	50%	60%	14%	18%	43%
Dismantled	7%	0%	0%	40%	0%	0%	0%	6%	0%
Demolition	0%	0%	0%	20%	0%	0%	0%	0%	0%
Lubrication	13%	14 %	17%	20%	0%	0%	0%	6%	14%
Modification	7%	0%	17%	40%	0%	0%	29%	18%	14%
Replacement	0%	0%	0%	0%	0%	20%	0%	0%	0%
Stopped	7%	0%	0%	0%	0%	0%	0%	0%	0%
Stored	7%	0%	0%	0%	0%	0%	0%	0%	0%
Handled	7%	0%	0%	0%	0%	0%	0%	0%	0%
Operation or normal production	20%	0%	0%	40%	0%	40%	0%	18%	0%
Assembly	7%	0%	0%	0%	0%	0%	0%	0%	0%
Start-up	7%	0%	0%	0%	0%	0%	0%	0%	0%
Work	7%	0%	0%	0%	0%	0%	0%	0%	0%
Tool change	7%	0%	0%	20%	0%	0%	0%	6%	14%
Setting up	13%	0%	0%	60%	0%	0%	0%	0%	14%
Visit	0%	0%	17%	0%	0%	0%	0%	0%	0%
Work on power circuits	0%	0%	0%	20%	0%	0%	0%	0%	0%
Stop production-shut down	0%	0%	0%	20%	0%	0%	14%	6%	0%
Electrical work	0%	0%	0%	0%	0%	0%	0%	6%	0%
Line breaking activities	0%	0%	0%	0%	0%	20%	0%	0%	14%
Accessing a hazardous zone	0%	0%	0%	0%	0%	0%	0%	6%	0%

3.3.8 ENERGY TYPE

The types of energy covered in the various documents on lockout are shown in Table 6. It has been observed that regulations in Ontario or the federal regulation in Canada, as well as Japanese regulation do not refer to any hazardous energy. Moreover, regulations in Quebec and in Europe refer to locking all the energies without specifying which type of energy. Lockout programs in industry tend to specify the energy types, except for two programs which referred to electrical energy only.

Table 6: Hazardous energy referred to in various documents on lockout

TYPES OF HAZARDOUS ENERGIES	Regulations in North America	Regulations in Asia and Australia	Regulations in Africa,	Regulations in Europe	Standards	OH&S associations	Books and guides	Small enterprises	Medium enterprises	Large enterprises	Total (75)
Electrical energy, including statics	33%	14%	0%	100%	100%	100%	71%	88%	86%	64%	
Hydraulic energy, including liquids under pressure, oil and water	33%	0%	0%	100%	100%	100%	43%	71%	71%	55%	
Pneumatic energy including gas, compressed air and vacuum	47%	0%	0%	100%	100%	100%	43%	76%	71%	59%	
Mechanical energy including potential energy, inertia, and kinetic energy	60%	0%	0%	80%	100%	80%	43%	65%	71%	56%	
Chemical energy including hazardous chemicals and substances	47%	0%	0%	80%	100%	100%	29%	47%	86%	51%	
Thermal energy	33%	0%	0%	80%	67%	40%	29%	35%	43%	35%	
Vapour	0%	0%	0%	0%	83%	60%	14%	35%	43%	24%	
Inflammable products including petroleum products, oil, coal and natural gas	0%	0%	0%	0%	0%	20%	0%	12%	14%	5%	
Gravity	7%	0%	0%	60%	33%	80%	14%	35%	43%	27%	
Radiation including nuclear energy, radioactive energy and electromagnetic waves	7%	0%	0%	40%	67%	40%	0%	24%	43%	22%	
Biological energy	0%	0%	0%	0%	0%	20%	0%	0%	0%	1%	
Effects of wind, air and water	0%	0%	0%	20%	0%	20%	0%	0%	0%	3%	

3.3.9 EXTENT OF LOCKOUT

Several documents require isolation and dissipation of all energies found in the equipment. Some documents refer to lockout of parts of the equipment or specific energies relevant to the intervention. Regulations in North America including Quebec's regulation, lockout programs from enterprises, the CSST (1994) and four OH&S associations require the lockout of all energies. Standards such as CSA Z460-05 (2005) and ANSI/ASSE Z244.1 (2003) target

hazardous energies relevant to the intervention, unlike the standard from Singapore i.e. CP 91 (2001), which targets all energies. Daoust (2003) and Kelley (2001) also refer to the isolation of energies relevant to the intervention.

3.3.10 LOCKOUT HARDWARE

3.3.10.1 Standardisation of padlocks and lockout hardware

Standardisation is required to easily identify lockout hardware and for safety reasons. Table 7 provides an overview of this requirement for lockout as mentioned in various documents.

Table 7: Standardisation of padlocks and lockout hardware

Regulations	None of the regulations, except OSHA 1910.147		
Standards	All standards except ISO 14118 (2000)		
OH&S associations	One OH&S association refers to the use of standardised hardware		
Books and guides	Kelley (2001) and Daoust (2003)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	Not covered	35%	86%

3.3.10.2 Combination locks versus keyed locks

Table 8 provides an overview of this requirement for lockout as mentioned in various documents.

Table 8: Combination locks versus keyed locks

Regulations	Only British Columbia and Yukon prohibit the use of combination locks. OSHA 1910.147 on the other hand clearly allows the use of such locks.
Standards	Standards require the use of keyed locks except CP 91 (2001) which clearly allows the use of combination locks
OH&S associations	Three OH&S associations prohibit the use of combination locks.
Books and guides	Kelley (2001) clearly states that combination locks can be used.
Lockout programs from enterprises	None of the lockout programs from industry refers to the use of combination locks.

3.3.10.3 Identification of locks

Table 9 provides an overview of this requirement for lockout as mentioned in various documents.

Table 9: Identification of locks

Regulations	Only 60% of regulations, all from North America		
Standards	All the standards except ISO 14118 (2000)		
OH&S associations	All OH&S associations		
Books and guides	Daoust (2003), Kelley (2001), CSST (1985) and CSST (1994)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	57%	65%	100%

3.3.10.4 Exclusive or reserved use

Table 10 provides an overview of this requirement for lockout as mentioned in various documents.

Table 10: Exclusive or reserved use of lockout hardware for lockout purposes

Regulations	One regulation: OSHA 1910.147
Standards	All standards except ISO 14118 (2000)
OH&S associations	One OH&S association
Books and guides	Kelley (2001)
Lockout programs from enterprises	A minority of lockout programs

3.3.10.5 Lock register

Table 11 provides an overview of this requirement for lockout as mentioned in various documents.

Table 11: Use of lock register

Regulations	One regulation: Alberta		
Standards	None of the standards		
OH&S associations	Five OH&S associations		
Books and guides	Daoust (2003) and CSST (1994)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	14%	14%	35%

3.3.10.6 Single key for lock

Table 12 provides an overview of this requirement for lockout as mentioned in various documents.

Table 12: Single key for lock

Regulations	None of the regulations		
Standards	Only ANSI/ASSE ZA10.44 (2006) covers this aspect		
OH&S associations	Four OH&S associations prohibit the duplication of keys and the use of duplicated keys.		
Books and guides	None of the books and guides		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	43%	29%	57%

3.3.10.7 Safekeeping of double of key

Table 13 provides an overview of this requirement for lockout as mentioned in various documents.

Table 13: Safekeeping of double of key

Regulations	Only four regulations. • British Columbia and Yukon require that a supervisor or a manager keeps the duplicated key. • Saskatchewan and Manitoba state that the double of the key should be kept in a place accessible only to an authorized person.
Standards	None of the standards
OH&S associations	None of the OH&S associations
Books and guides	The CSST (1994) mentions that the person responsible for lockout in a company can have the second key in his possession. Daoust (2003) mentions that the second key can be kept at the security service of the company.
Lockout programs from enterprises	Only four lockout programs cover this aspect. Generally the double of the key is kept in the maintenance department or by the supervisor or foreman

3.3.10.8 Hardware allowing lockout by several employees (e.g. hasp, box)

Table 14 provides an overview of this requirement for lockout as mentioned in various documents.

Table 14: Hardware allowing lockout by several employees

Regulations	Only 27% of regulations, all in North America
Standards	All the standards except ISO 14118 (2000)
OH&S associations	All the OH&S associations
Books and guides	All books and guides except CSST (1985)
Lockout programs from enterprises	Almost all lockout programs

3.3.11 SPECIFIC REQUIREMENTS

3.3.11.1 Each authorized employee applies his lock himself

Table 15 provides an overview of this requirement for lockout as mentioned in various documents.

Table 15: Each authorized employee applies his lock himself

Regulations	39% of regulations, all in Canada
Standards	Only CSA Z460-05 (2005) and CP 91 (2001)
OH&S associations	Five OH&S associations
Books and guides	INRS (1996), Kelley (2001) and CSST (1994)
Lockout programs from enterprises	The majority of lockout programs

3.3.11.2 Systematic use of tags with locks

Table 16 provides an overview of this requirement for lockout as mentioned in various documents.

Table 16: Systematic use of tags with locks

Regulations	31% of regulations (all in Canada)
Standards	Only ANSI/ASSE A10.44 (2006) and CP 91 (2001)
OH&S associations	All OH&S associations
Books and guides	All books and guides except Kelley (2001)
Lockout programs from enterprises	About half of the lockout programs

3.3.11.3 Locking the energy-dissipation devices

Table 17 provides an overview of this requirement for lockout as mentioned in various documents.

Table 17: Locking the energy-dissipation devices

Regulations	None of the regulations
Standards	Only CSA Z460-05 (2005)
OH&S associations	None of the OH&S associations
Books and guides	INRS (1996) and Kelley (2001)
Lockout programs from enterprises	One lockout program

3.3.11.4 Rules on the use of multi-hasps

Table 18 provides an overview of this requirement for lockout as mentioned in various documents.

Table 18: Rules on the use of multi-hasps

Regulations	None of the regulations
Standards	None of the standards
OH&S associations	Four OH&S associations
Books and guides	None of the books and guides
Lockout programs from enterprises	A minority of lockout programs

3.3.11.5 Key remaining with the authorized personnel applying his lock once locking is done

Table 19 provides an overview of this requirement for lockout as mentioned in various documents.

Table 19: Key remaining with the authorized personnel applying his lock once locking is done

Regulations	Only Yukon
Standards	Only ANSI/ASSE A10.44 (2006)
OH&S associations	Three OH&S associations
Books and guides	Only CSST (1985) and (1994)
Lockout programs from enterprises	A minority of lockout programs

3.3.11.6 Removing lock from isolating devices under normal circumstances

Table 20 provides an overview of this requirement for lockout as mentioned in various documents.

Table 20: Removing lock from isolating devices under normal circumstances

Regulations	Only OSHA and 77% of Canadian regulations		
Standards	All standards except ISO 14118 (2000)		
OH&S associations	Three OH&S associations		
Books and guides	Kelley (2001) and CSST (1994)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	29%	71%	43%

3.3.11.7 Removing lock from isolating devices under abnormal circumstances

Table 21 provides an overview of this requirement for lockout as mentioned in various documents.

Table 21: Removing lock from isolating devices under abnormal circumstances

Regulations	73% of regulations from North America
Standards	All standards except ISO 14118 (2000)
OH&S associations	All OH&S associations
Books and guides	Daoust (2003), Kelley (2001) and CSST (1994)
Lockout programs from enterprises	The majority of lockout programs

3.3.11.8 Communicating with the employee before removing his lock under abnormal circumstances

Table 22 provides an overview of this requirement for lockout as mentioned in various documents.

Table 22: Communication with the employee before removing his lock under abnormal circumstances

Regulations	40% of regulations from North America
Standards	All standards except CP 91 (2001) and ISO 14118 (2000)
OH&S associations	All OH&S associations
Books and guides	Kelley (2001)
Lockout programs from enterprises	The majority of lockout programs

3.3.11.9 Verification of the equipment before it is returned to service under abnormal circumstances

Table 23 provides an overview of this requirement for lockout as mentioned in various documents.

Table 23: Verification of the equipment before it is returned to service under abnormal circumstances

Regulations	69% of regulations from North America
Standards	All standards except ISO 14118 (2000) and CP 91 (2001)
OH&S associations	Five OH&S associations
Books and guides	CSST (1994)
Lockout programs from enterprises	The majority (i.e. 70%) of lockout programs

3.3.11.10 Witnesses of one or more steps in the lockout procedure under abnormal circumstances

Table 24 provides an overview of this requirement for lockout as mentioned in various documents.

Table 24: Witnesses of one or more steps in the lockout procedure under abnormal circumstances

Regulations	None of the regulations		
Standards	Only CSA Z460-05 (2005)		
OH&S associations	One OH&S association		
Books and guides	None of the documents		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	43 %	41 %	57 %

3.3.11.11 Communicating with the employee after having removed his lock under abnormal circumstances

Table 25 provides an overview of this requirement for lockout as mentioned in various documents.

Table 25: Communicating with the employee after having removed his lock under abnormal circumstances

Regulations	Four regulations from North America		
Standards	All standards except CP 91 (2001) and ISO 14118 (2000)		
OH&S associations	None of the OH&S associations		
Books and guides	Kelley (2001)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	Not covered	18 %	29 %

3.3.11.12 Documentation of the removal of a lock under abnormal circumstances

Table 26 provides an overview of this requirement for lockout as mentioned in various documents.

Table 26: Documentation of the removal of a lock under abnormal circumstances

Regulations	Two regulations from North America: Manitoba and Saskatchewan		
Standards	Two standards: CSA Z460-05 (2005) and ANSI/ASSE A10.44 (2006)		
OH&S associations	Two OH&S associations		
Books and guides	Kelley (2001)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	14%	53%	86%

3.3.12 PLACARDS

3.3.12.1 All equipment need a placard

Table 27 provides an overview of this requirement for lockout as mentioned in various documents.

Table 27: All equipment need a placard

Regulations	Two regulations: OSHA 1910.147 and California		
Standards	All the standards		
OH&S associations	Two OH&S associations		
Books and guides	Kelley (2001)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	14%	6%	29%

3.3.12.2 Validation of placards before use

Table 28 provides an overview of this requirement for lockout as mentioned in various documents.

Table 28: Validation of placards before use

Regulations	None of the regulations		
Standards	Two standards: CSA Z460-05 (2005) and ANSI/ASSE Z244.1 (2003)		
OH&S associations	Two OH&S associations		
Books and guides	Daoust (2003)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	29%	6%	29%

3.3.12.3 Updating placards including the occasions and the frequencies

Table 29 provides an overview of this requirement for lockout as mentioned in various documents.

Table 29: Updating placards including the occasions and the frequencies

Regulations	Only California		
Standards	Three standards: CSA Z460-05 (2005), ANSI/ASSE Z244.1 (2003) and ANSI/ASSE A10.44 (2006)		
OH&S associations	Two OH&S associations		
Books and guides	Kelley (2001) and Daoust (2003)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	14%	12%	43%

3.3.13 ELEMENTS OF LOCKOUT

3.3.13.1 Different elements or steps in a lockout procedure

Table 30 shows the different elements of a lockout procedure which have been observed in the various documents. These elements are: (i) notification of personnel, (ii) shutdown of machine, equipment or process, (iii) isolation, (iv) applying locks to isolation devices, (v) dissipating residual energies, and (vi) verification.

Table 30: Different elements in a lockout procedure

	Regulations				Standards		Others		Enterprises		
	Quebec	North America	Africa, Asia Australia	Europe	North America	All	OH&S associations	Books and guides	Small enterprises	Medium enterprises	Large enterprises
Notification	0%	7%	0%	0%	100%	80%	83%	80%	57%	76%	57%
Shutdown	100%	67%	43%	17%	100%	80%	67%	20%	43%	41%	71%
Isolation	0%	73%	29%	0%	100%	100%	83%	80%	71%	82%	57%
Applying locks	100%	100%	29%	0%	100%	100%	100%	100%	100%	100%	100%
Dissipation	100%	93%	14%	0%	100%	100%	100%	80%	29%	59%	71%
Verification	0%	80%	0%	0%	100%	100%	100%	100%	86%	94%	100%

3.3.13.2 A pre-determined fixed sequence of elements/steps for lockout

Table 31 provides an overview of this requirement for lockout as mentioned in various documents.

Table 31: A pre-determined fixed sequence of steps for lockout

Regulations	Only OSHA 1910.147
Standards	Only CP 91 (2001)
OH&S associations	None of the OH&S associations
Books and guides	None of the books and guides
Lockout programs from enterprises	Only 10% of lockout programs

3.3.13.3 Methods for the verification step of lockout

Table 32 provides an overview of this requirement for lockout as mentioned in various documents.

Table 32: Methods for the verification step of lockout

Regulations	27% of North American regulations
Standards	All standards
OH&S associations	All OH&S associations
Books and guides	All books and guides
Lockout programs from enterprises	A large majority of lockout programs

3.3.13.4 Steps for returning to service

Table 33 shows the different steps for returning to service as observed in various documents.

Table 33: Steps for returning to service

	Small enterprises	Medium enterprises	Large enterprises	Books and guides	N. American regulations	Africa, Asia, and Australia regulations	European regulation	Standards	N. American standards	OH&S associations
Verification of personnel	43%	76%	29%	80%	20%	0%	0%	80%	100%	83%
Verification of equipment	57%	71%	43%	60%	7%	0%	0%	80%	100%	67%
Removal of locks	57%	82%	100%	80%	40%	0%	0%	80%	100%	100%
Re-energize	57%	76%	14%	60%	13%	0%	0%	60%	67%	33%
Notification of personnel	86%	53%	86%	80%	13%	0%	0%	60%	67%	50%
Return to service	14%	35%	14%	0%	27%	0%	0%	40%	67%	50%

3.3.14 EXTERNAL SERVICE OR CONTRACTOR PERSONNEL

3.3.14.1 Reference to external service or contractor personnel

Table 34 provides an overview of this requirement for lockout as mentioned in various documents.

Table 34: Reference to external service or contractor personnel

Regulations	Two regulations: OSHA 1910.147 and California		
Standards	All standards except ISO 14118 (2000)		
OH&S associations	All OH&S associations		
Books and guides	All books and guides		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	43 %	82 %	100 %

3.3.14.2 Outside personnel using host's lockout program

Table 35 provides an overview of this requirement for lockout as mentioned in various documents.

Table 35: Outside personnel using host's lockout program

Regulations	One regulation (California)		
Standards	None of the standards		
OH&S associations	One OH&S association		
Books and guides	None of the documents		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	29%	65 %	57%

3.3.14.3 Testing knowledge of outside personnel on lockout before they begin their tasks

Table 36 provides an overview of this requirement for lockout as mentioned in various documents.

Table 36: Testing knowledge of outside personnel on lockout before they begin their tasks

Regulations	None of the regulations
Standards	None of the standards
OH&S associations	One OH&S association
Books and guides	Only INRS (1996)
Lockout programs from enterprises	None of the lockout programs

3.3.15 TRAINING AND COMMUNICATION

3.3.15.1 Reference to training and/or communication on lockout

Table 37 provides an overview of this requirement for lockout as mentioned in various documents.

Table 37: Reference to training and/or communication on lockout

Regulations	A minority of regulations (i.e. 27% of regulations in North America, 14% of regulations from Africa, Asia and Australia and 17% of regulations from Europe)		
Standards	All standards except ISO 14118 (2000)		
OH&S associations	All OH&S associations		
Books and guides	All books and guides except CSST (1985)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	43 %	71 %	100 %

3.3.15.2 Training specific to lockout program

Table 38 provides an overview of this requirement for lockout as mentioned in various documents.

Table 38: Training specific to lockout program

Regulations	None of the regulations
Standards	Two standards: CSA Z460-05 (2005) and ANSI/ASSE Z244.1 (2003)
OH&S associations	None of the OH&S associations
Books and guides	Kelley (2001)
Lockout programs from enterprises	One lockout program

3.3.15.3 Type of training (theoretical and practical)

Table 39 provides an overview of this requirement for lockout as mentioned in various documents.

Table 39: Type of training (theoretical and practical)

Regulations	None of the regulations
Standards	None of the standards
OH&S associations	One OH&S association
Books and guides	Kelley (2001) and INRS (1996)
Lockout programs from enterprises	Two lockout programs

3.3.15.4 Documentation of training

Table 40 provides an overview of this requirement for lockout as mentioned in various documents.

Table 40: Documentation of training

Regulations	Two regulations: OSHA 1910.147 and California		
Standards	Two standards: CSA Z460-05 (2005) and ANSI/ASSE Z244.1 (2003)		
OH&S associations	One OH&S association		
Books and guides	Kelley (2001)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	14 %	12 %	14 %

3.3.15.5 Retraining frequency

Table 41 provides an overview of this requirement for lockout as mentioned in various documents.

Table 41: Retraining frequency

Regulations	Only OSHA 1910.147
Standards	Two standards: CSA Z460-05 (2005) and ANSI/ASSE Z244.1 (2003)
OH&S associations	None of the OH&S associations
Books and guides	Daoust (2003) and Kelley (2001)
Lockout programs from enterprises	A minority of lockout programs

3.3.16 REVIEW OF LOCKOUT PROGRAM AND OF ITS APPLICATION

3.3.16.1 Identifying individual(s) responsible for enforcing the application of lockout program

Table 42 provides an overview of this requirement for lockout as mentioned in various documents.

Table 42: Identifying individual(s) responsible for enforcing the application of lockout program

Regulations	None of the regulations		
Standards	None of the standards		
OH&S associations	Four OH&S associations		
Books and guides	Kelley (2001)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	14 %	47 %	71 %

3.3.16.2 Review of program

Table 43 provides an overview of this requirement for lockout as mentioned in various documents.

Table 43: Review of program

Regulations	None of the regulations		
Standards	Three standards: CSA Z460-05 (2005), ANSI/ASSE Z244.1 (2003) and CP 91 (2001)		
OH&S associations	Four OH&S associations		
Books and guides	Daoust (2003) and Kelley (2001)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	14%	29%	29%

3.3.16.3 Review of application of lockout program

Table 44 provides an overview of this requirement for lockout as mentioned in various documents.

Table 44: Review of application of lockout program

Regulations	Two regulations: OSHA 1910.147 and California		
Standards	Three standards: CSA Z460-05 (2005), ANSI/ASSE Z244.1 (2003) and ANSI/ASSE A10.44 (2006)		
OH&S associations	Two OH&S associations		
Books and guides	Daoust (2003) and Kelley (2001)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	43 %	24 %	29 %

3.3.16.4 Documentation of lockout review

Table 45 provides an overview of this requirement for lockout as mentioned in various documents.

Table 45: Documentation of lockout review

Regulations	Two regulations: OSHA 1910.147 and California		
Standards	Two standards: CSA Z460-05 (2005) and ANSI/ASSE Z244.1 (2003)		
OH&S associations	One OH&S association		
Books and guides	Daoust (2003) and Kelley (2001)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	14 %	12 %	29 %

3.3.16.5 Identifying individual(s) carrying out the lockout review

Table 46 provides an overview of this requirement for lockout as mentioned in various documents.

Table 46: Identifying individual(s) carrying out the lockout review

Regulations	Two regulations: OSHA 1910.147 and California		
Standards	None of the standards		
OH&S associations	One OH&S association		
Books and guides	Kelley (2001)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	43 %	18 %	14 %

3.3.17 ALTERNATIVE METHODS

3.3.17.1 Not applying lockout to cord and plug connected equipment

Table 47 provides an overview of this requirement for lockout as mentioned in various documents.

Table 47: Not applying lockout to cord and plug connected equipment

Regulations	27% of regulations in North America and 33% of regulations in Europe
Standards	Two standards: ISO 14118 (2000) and ANSI/ASSE Z244.1 (2003)
OH&S associations	None of the OH&S associations
Books and guides	Kelley (2001)
Lockout programs from enterprises	One lockout program

For this requirement, the exposure to hazards of unexpected energization or start up of the equipment is controlled by the unplugging of the equipment from the energy source and by the plug being under exclusive control of the employee performing the task.

3.3.17.2 Alternative methods to lockout

Table 48 provides an overview of this requirement for lockout as mentioned in various documents.

Table 48: Alternative methods to lockout

Regulations	The majority of regulations		
Standards	All standards		
OH&S associations	Five OH&S associations		
Books and guides	All books and guides except CSST (1985)		
Lockout programs from enterprises	*Small enterprises*	*Medium enterprises*	*Large enterprises*
	43 %	59 %	29 %

4. ANALYSIS AND DISCUSSIONS

4.1 COMPARATIVE ANALYSIS OF DEFINITIONS OF LOCKOUT

Based on the various definitions of lockout, it appears that the concept of lockout differs in the literature. However, the different standards on lockout have similar definitions of lockout partly because similar references were used by the technical committees when drafting these standards. The definitions of lockout in the regulations vary. Provincial health and safety regulations in Canada rarely refer to any standards on lockout. Regulations are the minimum legal requirements that need to be achieved and a complete and elaborate definition of lockout will provide some guidance to individuals in factories and organisations who are responsible for drafting and implementing a lockout program. In Quebec for instance, the regulation refers to lockout without defining what is lockout. This can lead to misinterpretation and misunderstanding. As such, in this study, the different definitions of lockout were grouped into four classes.

4.1.1 UNABLE TO ACTUATE A DEVICE WITHOUT AUTHORIZATION (USUALLY BY USING LOCKS)

These definitions generally include the use of a lock and the placement of the lock on an energy isolating device. However, these definitions do not provide sufficient information on, for example, individually keyed locks, having an individual applying his personal lock and keeping control of his key at all times, isolation of different types of energies, need for a written lockout program and so on.

4.1.2 UNABLE TO ACTUATE A DEVICE WITHOUT AUTHORIZATION, COMBINED WITH ADDITIONAL MEASURES

These definitions include the use of locks as well as additional important steps in a lockout procedure such as isolation, dissipation or even specifying the tasks for which lockout is needed. Once again these definitions lack clarity. For example, the verification step or the need for a written program is missing.

4.1.3 LOCKS ARE UNNEEDED OR OPTIONAL

These definitions tend to incorporate various aspects of a lockout procedure, for e.g. isolation, dissipation and verification. However, individual locks need not necessarily be placed on isolating devices. The reasons for not using locks or similar devices are unclear. One definition mentions that the use of lock can be necessary in large machines or in installations, when many workers are intervening at the same time and when several hazardous zones of the machine are not visible.

4.1.4 UNCLEAR OR DIFFICULT TO CLASSIFY

These definitions for lockout can be the purpose of lockout (for e.g. when referring to lockout as a series of steps taken to ensure that the equipment at a zero energy state). These definitions can

also be interpreted as using locks on control systems (for e.g. defining lockout as use of a lock or locks to render machine or equipment inoperable or to isolate an energy source in accordance with a written procedure).

4.2 COMPARATIVE ANALYSIS OF REGULATIONS

The contents of regulations have been analysed with respect to the different elements which were considered. Table 49 presents an overview of the results obtained when comparing some main points on lockout or referring to lockout. It is observed that many regulations, including those in North America, do not cover different aspects of lockout such as the sequence of return to service, continuity in lockout, outside service, training and communication, program review and application review. However other points such as the scope, the energy type, the tasks, the sequence of energy control and the alternative methods are covered in the majority of North American regulations. Detailed analysis of the documents has showed that OSHA 1910.147 is by far the most complete in terms of topics covered pertaining to lockout. Regulations in Quebec, Ontario and the federal regulation in Canada do not cover two thirds of these themes. The remaining Canadian provinces have about half of these themes covered. Quebec's regulation contains only the (i) scope, (ii) energy (without mentioning the energy types), (iii) application, (iv) sequence of energy control and (v) the alternatives. Thus it can be argued that provincial regulations in Canada, including Quebec, lack many themes of lockout. As such, program review, application review and outside service are absent from ten provincial regulations in Canada, as well as from the federal regulation. The scope, sequence of lockout and alternatives appear in all Canadian regulations. Moreover, in Canada, only New Brunswick and Yukon refer to training on lockout. Therefore the absence of clear guidance on lockout opens the door to misinterpretations.

Furthermore, for the regulations outside North America, the scope of lockout is provided in all regulations. Regulations from Japan, Australia, Philippines and South Africa do not refer to hazardous energies. The application or tasks for lockout are given in all regulations except in United Kingdom, South Africa, Switzerland and India. Alternatives to lockout are covered in all the regulations except in India. Once again, elements of lockout such as the review of lockout program, review of application, outside service, training (covered only in Singapore and France outside North America) are not included in most of the regulations.

Table 49: Themes on lockout in regulations

Themes	Proportion of regulations which mention these themes		
	North America	Europe	Africa, Asia and Australia
Scope (machines, equipment processes)	100%	100%	100%
Energy type	87%	0%	29%
Application (activities, tasks)	100%	67%	57%
Removal of lock in absence of authorized individual	73%	0%	0%
Sequence of energy control	100%	17%	57%
Sequence of return to service	53%	17%	0%
Continuity in lockout	33%	0%	0%
Outside service	13%	0%	0%
Training and communication	27%	17%	14%
Program review	0%	0%	0%
Application review	13%	0%	0%
Alternative methods	100%	100%	86%

Therefore, it can be determined that the legal requirements on lockout vary in different countries**.** Moreover, in Europe, it seems that the concept of lockout is quite different since the need for written lockout programs is not mentioned in the regulations. Even in North America where lockout is found in numerous regulations, important variations exist when considering the different Canadian provincial and territorial regulations.

4.3 COMPARATIVE ANALYSIS OF STANDARDS

The contents of five standards have been analysed with respect to the different elements which were considered. Table 50 presents an overview of the results obtained when comparing some main points from the five standards on lockout.

It can be observed that CSA Z460-05 (2005) and ANSI/ASSE Z244.1 (2003) address the same main themes in relation to lockout. This is not surprising since the CSA Z460-05 (2005) is based in part on ANSI/ASSE Z244.1 (2003), which is itself based on OSHA 1910.147. Furthermore, the Singapore Standard CP 91 (2001) also refers to ANSI/ASSE Z244.1 (1982) and to OSHA 1910.147. The ANSI/ASSE A10.44 (2006) standard does not indicate any reference documents. As such these four standards cover the same general themes.

However, ISO 14118 (2000) mentions isolation and energy dissipation without referring to written lockout programs. This standard is intended for machine manufacturers and requires that machines possess means intended for isolation and energy dissipation. This standard, which is used mainly in Europe, mentions that locking is optional.

There is convergence of four lockout standards towards what constitutes lockout. Therefore it can be determined that four standards on lockout possess certain similarities except for ISO 14118 (2000).

Table 50: Themes on lockout in five standards

Themes on lockout	Standards					Proportion of standards which deal with this theme
	CSA Z460-05 (2005)	ANSI/ASSE Z244.1 (2003)	ANSI/ASSE A10.44 (2006)	CP 91 (2001)	ISO 14118 (2000)	
Scope	Yes	Yes	Yes	Yes	Yes	100%
Energy type	Yes	Yes	Yes	Yes	Yes	100%
Application (activities, tasks)	Yes	Yes	Yes	Yes	Yes	100%
Removal of lock in absence of authorized individual	Yes	Yes	Yes	Yes	No	80%
Sequence of energy control	Yes	Yes	Yes	Yes	Yes	100%
Sequence of return to service	Yes	Yes	Yes	Yes	No	80%
Continuity in lockout	Yes	Yes	Yes	Yes	No	80%
Outside service	Yes	Yes	Yes	Yes	No	80%
Training and communication	Yes	Yes	Yes	Yes	No	80%
Program review	Yes	Yes	No	Unclear	No	40%
Application review	Yes	Yes	Unclear	Yes	No	60%
Alternative methods	Yes	Yes	Yes	Yes	Yes	100%
Proportion of themes in each standard	100%	100%	83%	92%	42%	

4.4 COMPARATIVE ANALYSIS OF LOCKOUT PROGRAMS FROM QUEBEC

In this study, thirty-one lockout programs from enterprises have been analysed. Table 51 presents the main results when comparing the different lockout programs. It can be determined that the majority of lockout programs from industry does not fully comply with the RSST and has elements which are missing when compared to CSA Z460-05 (2005).

It is observed that the (i) scope, (ii) energy type, (iii) application, (iv) lock removal in absence of authorized employee, (v) sequence of energy control and (vi) sequence of return to service are found in almost all the written lockout programs that were analysed. However, the main points which are missing from the programs of all three groups of enterprises are: (i) program review, (ii) application review and (iii) alternative methods. Without a program review, it is unclear how the enterprises maintain the lockout program updated and alive. The performance feedback of the lockout program is not monitored and deficiencies are not corrected. Without alternative methods of energy control, it is unclear at this point what methods workers use during tasks where traditional lockout prevents the completion of those tasks.

Moreover, it was observed that the small enterprises lack important points such as (i) continuity in lockout, (ii) outside service, and (iii) training and communication. It is unclear if lockout is used by workers from the small enterprises and by outside personnel when the tasks are integrated. Regarding communication and training, it is also interesting to note that the need for individual training, program specific training, theoretical and practical training, assessment of the knowledge and of the use of the program, is absent from the written lockout programs from small enterprises.

In addition, it was found that individuals were not necessarily aware of the existence of the CSA Z460-05 (2005) standard on lockout which has been published in 2005. Moreover, individuals drafting the written programs had diverse backgrounds (for e.g. engineering student on training, human resource personnel, hygienist). The lockout programs were based on material obtained from training courses, on existing lockout programs from another plants, from material obtained from the internet and sometimes from Daoust (2003), the CSST (1985 and 1994) and from the OH&S associations.

Quebec's health and safety regulation requires the use of lockout during maintenance, repairs and unjamming activities. However, only 14% of small enterprises, 41% of medium enterprises and 29% of large enterprises mentioned the use of lockout during unjamming activities in their lockout programs. Moreover, three OH&S associations did not include unjamming activities as applicable for lockout.

Besides, the written lockout programs were quite recent in some cases and in other cases have been updated several times throughout the years. Generally, no references such as standards or books were included in the written lockout programs.

In addition, steps such as the notification of the affected personnel, shutdown, isolation and dissipation were absent from some lockout programs. However, the step involving the application of locks remains the only step which was found in all the lockout programs. Regarding the steps for returning to service, it was observed that important steps such as the verification of personnel, verification of equipment and re-energizing were absent in some of the programs.

Since actual observation of the application of lockout procedures has not taken place, it cannot be known whether the authorized employees perform all the steps of a lockout procedure, despite the absence of some of those steps in the written lockout documents.

Table 51: Themes found when comparing different lockout programs

Themes	Enterprises		
	Small enterprises	Medium enterprises	Large enterprises
Scope (machines, equipment processes)	100%	100%	100%
Energy type	86%	100%	100%
Application (activities, tasks)	100%	94%	100%
Removal of lock in absence of authorized individual	71%	100%	100%
Sequence of energy control	100%	100%	100%
Sequence of return to service	86%	100%	100%
Continuity in lockout	57%	82%	86%
Outside service	43%	82%	100%
Training and communication	43%	71%	71%
Program review	14%	29%	29%
Application review	43%	24%	29%
Alternative methods	43%	59%	29%
Proportion of themes found in lockout program	66%	78%	79%

4.5 COMPARATIVE ANALYSIS OF OH&S ASSOCIATIONS

Table 52 summarises the results obtained when comparing all the documents produced by six OH&S associations in Quebec. OH&S associations are non-profit organisations which provide support to industries found in their sectors, often by offering training services to their clients. These documents, which are used as reference material in Quebec, cover most of the important themes (except one document) but with varying levels of details. It can be observed that the program review and the application review are absent in some documents. Moreover, training on lockout is covered in all the documents.

Table 52: Themes found in six documents produced by six OH&S associations in Quebec

Themes on lockout	OH&S associations in Quebec						Proportion of the documents which deal with these themes
	APSAM (2006)	ASSPPQ/ASSIFQ (2001)	ASP Imprimerie (2003)	Préventex (2007)	ASP Construction (2004)	ASTE (2003)	
Scope (machines, equipment processes)	Yes	Yes	Yes	Yes	Yes	Yes	100%
Energy (type)	Yes	Yes	Yes	Yes	Yes	Yes	100%
Application (activities, tasks)	Yes	Yes	Yes	Yes	Yes	No	83%
Removal of lock in absence of authorized individual	Yes	Yes	Yes	Yes	Yes	Yes	100%
Sequence of energy control	Yes	Yes	Yes	Yes	Yes	Yes	100%
Sequence of return to service	Yes	Yes	Yes	Yes	Yes	Yes	100%
Continuity in lockout	Yes	Yes	Yes	Yes	No	No	67%
Outside service	Yes	Yes	Yes	Yes	Yes	Yes	100%
Training and communication	Yes	Yes	Yes	Yes	Yes	Yes	100%
Program review	Yes	Yes	Yes	Yes	No	No	67%
Application review	Yes	Yes	No	No	No	No	33%
Alternative methods	Yes	Yes	Yes	Yes	Yes	No	83%
Proportion of themes included in the document of each OH&S associations	100%	100%	92%	92%	75%	58%	

5. CONCLUSIONS

This study has revealed that:

- The concept of lockout has different meanings or definitions in the literature, especially in regulations. However, definitions of lockout which are found in standards have certain similarities.
- The legal requirements on lockout vary in different Canadian provinces and in different countries.
- Standards on lockout tend to have similar requirements, except ISO 14118 (2000). However, some differences in the standards regarding the elements of lockout programs exist.
- The contents of lockout programs, as described in different documents, vary.
- Lockout programs obtained from thirty-one factories and organisations in Quebec do not fully comply with the provincial regulation. The lockout programs have several elements which are missing when compared to CSA Z460-05 (2005).

Moreover, it seems that the concept of lockout is different in Europe as compared to North America, mainly with respect to: (i) the requirement for written lockout programs, (ii) the placement of individual locks on energy isolating devices and (iii) the need for equipment designed to facilitate lockout. In addition, regulations on lockout from Africa, Asia and Australia are not very extensive and do not cover as many themes as OSHA 1910.147-The Control of Hazardous Energy (Lockout/Tagout) which was issued on September 1, 1989.

Besides, standards on lockout seem to be coherent and have a lot of similarities, except for ISO 14118 (2000) which places lockout as one risk reduction method among others. One simple reason which can explain the similarities among American, Canadian and Singaporean standards is that identical seed documents might have been used when the various standards were drafted.

This study also identified some points not found or unclear in CSA Z460-05 (2005), the Canadian standard, on lockout but which are covered in other documents. Examples of such points are:

- Need for authorized personnel to keep the key under his/her control at all times;
- The number of key(s) per lock;
- Management of the double of the key when applicable (i.e. where to keep it, who keeps it, when to use it, who uses it);
- Lockout program to use when dealing with external personnel who have their own lockout program;
- Testing the knowledge of external personnel on lockout before starting work;
- Type of training (i.e. theoretical, practical, mentorship) of the authorized personnel;
- The systematic use of tags with locks which are identified; and
- The lock register.

In addition, lockout is defined in CSA Z460-05 (2005) as the placement of a lock or tag on an energy-isolating device in accordance with an established procedure, indicating that the energy-isolating device is not to be operated until removal of the lock or tag in accordance with an established procedure. However, it should be noted that the use of tags is generally referred to as tagout in other documents such as ANSI/ASSE Z244.1 (2003) and OSHA 1910.147.

The sample of lockout programs from industry which were collected and studied revealed several interesting points. Examples of such points are:

- Some written programs are quite recent despite the fact that the regulation in Quebec exists since many years and requires lockout of machinery for maintenance, repairs and unjamming activities;
- Certain aspects of lockout are missing in the programs. Examples are (i) design characteristics of new or upgraded equipment in order to enhance lockout (i.e. having energy isolating and dissipating devices which are readily accessible and easily locked), (ii) program review as well as program application review, (iii) training and (iv) alternatives to lockout;
- CSA Z460-05 (2005) or other standards on lockout are not usually used as references;
- Programs obtained from small enterprises had fewer elements on lockout than those from large enterprises;
- Electrical energy was referred to in almost all the programs as compared to thermal energy as well as gravitational energy which were least referred to; and
- The management of the duplicate of keys used to remove locks under special circumstances (i.e. who keeps them, when to use them, where to keep them) is missing or is not clear.

It must also be mentioned that the study has the following limitations:

- The application of lockout by workers has not been investigated in this study. There was neither direct nor indirect observation of the application of lockout in the different enterprises. The study dealt only with the collect and analysis of several documents on lockout. As such, for example, it cannot be known whether the authorized employees perform all the steps of a lockout procedure, despite the absence of some of those steps in the written lockout documents. The actual application of lockout procedures will be covered in a different study.

- The impact on occupational health and safety as a result of the differences in the regulations was not analysed in greater extent. This will be dealt with in the next study after actual application of lockout has been observed and after obtaining a better understanding of lockout in practice. As such, much of the analysis carried out in this study was based on discrepancies in the wording and content of the different articles appearing in the regulations as well as paragraphs and sections of standards, guides and books on lockout.

It is believed that the research projects proposed in the thematic on lockout at the IRSST and described in this report will contribute in generating knowledge on lockout and will benefit enterprises in Quebec and potentially in other places as well.

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APPENDIX A: DEFINITIONS

Affected employee: An employee whose job requires him/her to operate or use a machine or equipment on which servicing or maintenance is being performed under lockout, or whose job requires him/her to work in an area in which such servicing or maintenance is being performed.

Authorized employee (individual): A person who locks out machine or equipment in order to perform servicing or maintenance on that machine or equipment.

Energized: Connected to an energy source 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 manually operated disconnect switch, a hydraulic valve, a pneumatic valve, a line valve, a block and similar device used to block or isolate energy. As such, control circuit type devices such as push buttons, control switches are NOT energy isolating devices.

Lockout: The placement of a lockout device on an energy isolating device, in accordance with an established procedure, ensuring that the energy isolating device and the equipment being controlled cannot be operated until the lockout device is removed.

Lockout device: A device that utilises a positive means such as a lock, to hold an energy isolating device in a safe position and prevent the energizing of a machine or equipment.

Tagout: The placement of a tagout device on an energy isolating device, in accordance with an established procedure, to indicate that the energy isolating device and the equipment being controlled may not be operated until the tagout device is removed.

Tagout device: A prominent writing device, such as a tag and a means of attachment, which can be securely fastened to an energy isolating device in accordance with an established procedure, to indicate that the energy isolating device and the equipment being controlled may not be operated until the tagout device is removed.

APPENDIX B: EXCEPTIONS TO LOCKOUT

B.1 Exceptions to documenting the energy control procedure (lockout procedure) are described in OSHA 1910.147

The employer need not document the required procedure for a particular machine or equipment when ALL of the following elements exist:

1) The machine or equipment has no potential for stored or residual energy or reaccumulation of stored energy after shut down which could endanger employees;
2) The machine or equipment has a single energy source which can be readily identified and isolated;
3) The isolation and locking out of that energy source will completely de-energize and deactivate the machine or equipment;
4) The machine or equipment is isolated from that energy source and locked out during servicing or maintenance;
5) A single lockout device will achieve a locked-out condition;
6) The lockout device is under the exclusive control of the authorized employee performing the servicing and maintenance;
7) The servicing or maintenance does not create hazards for other employees; and
8) The employer, in utilizing this exception, has had no accidents involving the unexpected activation or reenergization of the machine or equipment during servicing or maintenance.

B.2 Exception for cord and plug connected electric equipment as described in OSHA 1910.147

Work on cord and plug connected electric equipment for which exposure to the hazards of unexpected energization or start up of the equipment is controlled by the unplugging of the equipment from the energy source and by the plug being under the exclusive control of the employee performing the servicing or maintenance.

B.3 Exception for using tagout instead of lockout (OSHA 1910.147)

If the energy isolating device is not capable of being locked out, the employer’s energy control program [consisting of energy control procedures, employee training and periodic inspections] shall utilize a tagout system

B.4 Exception for the type of activities (OSHA 1910.147 (a)(2)(ii))

Minor tool changes and adjustments, and other minor servicing activities, which take place during normal production operations, are not covered by the standard if they are routine, repetitive, and integral to the use of the equipment for production, provided that the work is performed by using alternative measures which provide effective protection.

Kelley argues that (i) extensive disassembly of the machinery or equipment, (ii) removal of any parts of the equipment such as guards which restrict access to moving mechanical parts or energized electrical equipment, or (iii) in some cases, more that a single person to perform the operation, is NOT considered minor.

B.5. Exception to the exemption of normal production operations from lockout/tagout (OSHA 1910.147(a)(2)(ii))

Servicing and/or maintenance performed during normal production operations are subject to the standard only if

- An employee is required to remove or bypass a safety guard or other safety device, or
- An employee is required to place any part of his/her body into an area on a machine or piece of equipment where work is actually performed on the material being processed (the point of operation) or where an associated danger zone exists during a machine operating cycle.

B.6 Exception to the removal of lockout device by authorized employee who applied the device (OSHA)

Each lockout device shall be removed from each energy isolating device by the employee who applied the device. When the authorized employee who applied the lockout device is not available to remove it, that device may be removed under the direction of the employer provided that some specific procedures and training for such removal have been developed, documented and incorporated into the employer's energy control program. The employer shall demonstrate that the specific procedure provides equivalent safety to the removal of the device by the authorized employee who applied it. The specific procedure shall include at least the following elements:

- Verification by the employer that the authorized employee who applied the device is not at the facility;
- Making all reasonable efforts to contact the authorized employee to inform him/her that his/her lockout device has been removed; and
- Ensuring that the authorized employee has this knowledge before he/she resumes work at that facility.