

Equipment Lockout

A review of written lockout programs in Quebec

By Yuvin Chinniah

IN 2005, 1,097 WORKERS WERE KILLED in Canada and 337,930 were injured or suffered from illnesses linked to occupational hazards. This resulted in expenses amounting to \$6.8 billion in compensation and salary replacement (Logan & Reeder, 2007). In the province of Quebec that same year, 223 workers were killed and 99,076 were injured, accounting for \$1.6 billion in compensation and salary replacement, according to CSST, the workers' compensation board in Quebec. Moreover, on average, 20 workers in Quebec are killed by machines and 12,800 accidents can be linked to dangerous machines, costing \$71.5 million annually (CSST, 2005).

Under Article 185 of RSST, Quebec's Occupational Health and Safety Regulation (2001), workers intervening in hazardous zones of machines and processes during maintenance, repairs and unjamming activities must apply lockout procedures:

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:

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, in-

cluding for detecting abnormal operations, and to do so, he must move or remove a protector (guard), 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.

CSST recently reported that in 3 years, inspectors have cited more than 230 derogations to Article 185. It also appears that lockout is not well known in various industrial sectors in Quebec. To assess compliance with lockout mandates, sample written lockout programs from industries in Quebec were collected and analyzed.

Study Methodology

In this study, only written lockout programs were analyzed; actual application of these programs will be a future research project. Also, to collect the programs, the researcher 1) explained the objectives of the study (usually to SH&E representatives); 2) ensured the confidentiality of sources (including not showing photographs taken in presentations and/or scientific articles); and 3) visited 31 plants and organizations and asked questions about the number of employees and types of machines present.

Usually, the written lockout program was provided on the day of the industrial visit. Each visit, including the question time, lasted no more than 3 hours on average. The method, therefore, consist-

Yuvin Chinniah, Ph.D., is a professional engineer and works at the Occupational Health and Safety Research Institute Robert-Sauvé (IRSST) in Montreal, Quebec, as a research scientist in machine safety. He holds a Ph.D. in Mechanical Engineering from the University of Saskatchewan and an undergraduate degree in electrical and electronic engineering. Chinniah works in the area of safety-related control systems, lockout/tagout, risk assessment and machine safeguarding.



Abstract: Written lockout programs from industrial sites in Quebec were analyzed to assess their compliance with legal requirements and their coherence with consensus standards on the subject. Compliance was found to be lacking in many cases, and several important elements were missing when compared to industry standards.

ed essentially of collecting 31 written programs from 31 sites in the province of Quebec. These enterprises operated in the following sectors:

- manufacturing (metal products): 8 plants;
- manufacturing (electrical products): 7 plants;
- printing: 4 plants;
- machine manufacturer: 3 plants;
- sawmill: 2 plants;
- pulp and paper: 2 plants;
- mining: 1 plant;
- metal: 1 plant;
- chemical: 1 plant;
- organizations: 2 hospitals.

The sites were further classified as follows based on the number of employees:

- small enterprise: 100 employees or fewer;
- medium enterprise: more than 100 but fewer than 500 employees;
- large enterprise: more than 500 employees.

In this study, 22.6% (7) of the lockout programs were obtained from small enterprises; 54.8% (17) came from medium enterprises; and 22.6% (7) from large enterprises. Of the enterprises involved, 81% were part of a multinational company. Each participating enterprise received a detailed analysis of its written lockout program at the end of this study.

Documents such as ANSI/ASSE Z244, CSA Z460, Kelley (2001), OSHA 1910.147, Daoust (2003) and INRS (1996) were used to identify the elements to be analyzed. A spreadsheet was

created to document the following elements in the written programs analyzed:

- 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;
- placards;
- elements (steps) of lockout;
- sequence of the different lockout elements;
- methods for the verification step of lockout;

Table 1

Scope of the Lockout Programs

| Scope of the lockout program | Small enterprises | Medium enterprises | Large enterprises |
|------------------------------|-------------------|--------------------|-------------------|
| Machine | 57% | 88% | 57% |
| Machinery | 14% | 24% | 29% |
| Equipment | 100% | 100% | 100% |
| Electrical equipment | 14% | 0% | 14% |
| Process | 29% | 12% | 14% |
| Tool | 0% | 6% | 14% |
| Electrical installation | 0% | 29% | 14% |
| Vehicles | 0% | 0% | 0% |
| Pipelines | 14% | 18% | 57% |
| Energy supply system | 14% | 6% | 0% |
| Building installation | 0% | 6% | 14% |

One factor assessed during the study was the scope of lockout as described in the collected programs.

The programs analyzed through this study covered a variety of industrial tasks conducted at the participating facilities.

Table 2

Tasks Described in the Different Lockout Programs

| Tasks as described in various documents | Small enterprises | Medium enterprises | Large enterprises |
|---|-------------------|--------------------|-------------------|
| All intervention or human intervention or tasks, work, etc. | 43% | 41% | 43% |
| Repairs | 71% | 82% | 86% |
| Servicing | 57% | 76% | 57% |
| Maintenance | 43% | 24% | 14% |
| Unjamming | 14% | 41% | 29% |
| Erecting | 0% | 12% | 0% |
| Installation | 0% | 24% | 43% |
| Construction | 14% | 6% | 14% |
| Adjustment | 0% | 24% | 43% |
| Tuning | 0% | 12% | 0% |
| Inspection and verification | 0% | 35% | 57% |
| Troubleshooting, investigative work, fault finding | 14% | 6% | 0% |
| Test | 0% | 6% | 0% |
| Clean | 14% | 18% | 43% |
| Dismantled | 0% | 6% | 0% |
| Lubrication | 0% | 6% | 14% |
| Modification | 29% | 18% | 14% |
| Operation or normal production or utilization | 0% | 18% | 0% |
| Tool change | 0% | 6% | 14% |
| Setting up | 0% | 0% | 14% |
| Stop production—shut down | 14% | 6% | 0% |
| Electrical work | 0% | 6% | 0% |
| Line breaking activities | 0% | 0% | 14% |
| Accessing a hazardous zone | 0% | 6% | 0% |

- external service or contractor personnel;
- training and communication;
- review of lockout program and its application;
- alternative methods to lockout.

Analysis of Written Program Elements Purpose

Analysis of the various programs identified four distinct purposes: 1) to maintain workers' safety; 2) to prevent an unintended release of hazardous (stored) energy; 3) to prevent unintended start-up or unintended motion; and 4) to prevent contact with a hazard (e.g., electrical or mechanical) when guards are removed or safety devices are bypassed or removed.

Scope

Table 1 (p. 39) provides an overview of the scope of lockout as described in collected programs.

Equipment Design Characteristics

Review of the design characteristics of machines, equipment and processes mentioned in the different lockout programs revealed that 18% of medium enterprises stated in their programs that all energized equipment should have an isolating energy device to allow for lockout regardless of energy form. Also, 18%

of medium enterprises mentioned that the isolating devices can be locked (i.e., a locking device can be applied). None of the programs indicated that the isolating devices must be identified or labelled and that energy dissipation devices are required.

Locks

All the lockout programs referred to the use of locks as the means for locking. Analysis revealed that only five programs clearly referred to applying locks on power circuits and not to control circuits (e.g., push button, selector switches).

Application

Table 2 reviews application of lockout—those tasks for which it is required as described in the programs analyzed.

Energy Type

To perform lockout, workers must identify hazardous energies present on the equipment. Table 3 lists the types of energy covered in the programs analyzed. The programs specified the energy types, except for two programs that referred to electrical energy only.

Extent of Lockout

All the analyzed programs required isolation and dissipation of all energies present in the equipment as compared to isolation of parts of the equipment or of specific energies relevant to the intervention.

Lockout Hardware

Table 4 presents the characteristics of all applicable protective materials and hardware required to isolate hazardous energies, as described in the programs analyzed.

Specific Requirements

Table 5 (p. 42) presents additional requirements specific to lockout procedures described in the programs analyzed.

Placards

Analysis of provisions regarding the use of placards and their management revealed the following:

- 14% small, 6% medium and 29% large enterprises state in their program that all equipment needs a placard;
- 29% small, 6% medium and 29% large enterprises require in their written programs that placards be validated before use;
- 14% small, 12% medium and 43% large enterprises require that placards are updated.

Elements of Lockout

The following six steps in lockout procedures were noted in the programs analyzed:

- notification (57% small, 76% medium, 57% large enterprises);
- shutdown (43% small, 41% medium, 71% large);
- isolation (71% small, 82% medium, 57% large);
- applying locks (all programs collected);
- dissipation (29% small, 59% medium, 71% large);
- verification (86% small, 94% medium, 100% large).

In addition, it was noted that a minority of sites (14% small, 6% medium, 14% large) had a predetermined sequence for applying lockout procedures. In addition, a large majority of lockout programs (86% small, 94% medium, 86% large) provided at least one method or a combination of methods for the verification step. Those methods referred to manually trying the machinery controls, a visual inspection, the use of measuring instruments or a combination of methods.

Return to Service

The different steps for returning to service noted in the written programs analyzed are as follows:

- verification of personnel (43% small, 76% medium, 29% large enterprises);
- verification of equipment (57% small, 71% medium, 43% large);
- removal of locks (57% small, 82% medium, 100% large);
- reenergize (57% small, 76% medium, 14% large);
- notification of personnel (86% small, 53% medium, 86% large);
- return to service (14% small, 35% medium, 14% large).

External Service or Contractor Personnel

The researcher noted different elements relative to external service:

- reference to external service or contractor personnel (43% small, 82% medium, 100% large enterprises);
- outside personnel using host's lockout program (29% small, 65% medium, 71% large).

Testing the knowledge of outside personnel was not covered in the programs analyzed.

Training & Communication

The collected programs were analyzed with respect to lockout training and requirements:

- reference to training and/or communication on lockout (43% small, 71% medium, 100% large enterprises);
- training specific to lockout program (14% of small enterprises only);
- type of training (12% medium enterprises only);
- documentation of training (14% small, 12% medium, 14% large);
- retraining (14% small, 12% medium, 29% large).

Review of Lockout Program & Its Application

With respect to a formal review of the lockout program and its application, the following observations were noted:

- Identifying individual(s) responsible for enforcement

Table 3

Hazardous Energy in Various Documents

| Hazardous energy in various documents | Small enterprises | Medium enterprises | Large enterprises |
|--|-------------------|--------------------|-------------------|
| Electrical energy, including static | 71% | 88% | 86% |
| Hydraulic energy, including liquids under pressure, oil and water | 43% | 71% | 71% |
| Pneumatic energy including gas, compressed air and vacuum | 43% | 76% | 71% |
| Mechanical energy including potential energy, inertia and kinetic energy | 43% | 65% | 71% |
| Chemical energy including hazardous chemicals and substances | 29% | 47% | 86% |
| Thermal energy | 29% | 35% | 43% |
| Vapor | 14% | 35% | 43% |
| Inflammable products including petroleum products, oil, coal and natural gas | 0% | 12% | 14% |
| Gravity | 14% | 35% | 43% |
| Radiation including nuclear energy, radioactive energy and electromagnetic waves | 0% | 24% | 43% |

The analyzed programs covered various types of energy present in the participating facilities (Table 3) and also described applicable protective materials and hardware required to isolate hazardous energy (Table 4).

Table 4

Lockout Hardware Characteristics

| Lockout hardware | Small enterprises | Medium enterprises | Large enterprises |
|--|-------------------|--------------------|-------------------|
| Standardization of padlocks and lockout hardware | 0% | 35% | 86% |
| Use of combination locks instead of personnel keyed locks | 0% | 0% | 0% |
| Identification of locks | 57% | 65% | 100% |
| Exclusive or reserved use | 0% | 24% | 29% |
| Lock register | 14% | 14% | 35% |
| Single key for lock | 43% | 29% | 57% |
| Safekeeping of double of key | 14% | 12% | 14% |
| Hardware allowing lockout by several employees (e.g., use of hasp and lockout box) | 86% | 94% | 100% |

ing program application was covered in 14% of small, 47% of medium and 71% of large enterprises.

- Review of the lockout program appeared in 14% of small, 29% of medium and all the large enterprises.

- Review of program application was present in 43% of small, 24% of medium and 29% of large enterprises.

- Documentation of program review was found in 14% of small, 12% of medium and 29% of large enterprises.

- Identification of the individual(s) conducting the lockout review was covered in 43% of small, 18% of medium and 14% of large enterprises.

Alternative Methods

One lockout program from a large enterprise referred to not applying lockout to cord-and-plug-connected equipment. Furthermore, some programs (43% small, 59% medium, 29% large) referred to the use of alternative methods to lockout.

The analyzed programs contained requirements specific to lockout procedures (Table 5). However, the study results indicate that most of the programs do not fully comply with RSST and contain major weaknesses when compared to CSA Z460 or ANSI/ASSE Z244 (Table 6).

Table 5
Specific Requirements of Lockout

| Specific requirements | Small enterprises | Medium enterprises | Large enterprises |
|--|-------------------|--------------------|-------------------|
| Each authorized employee applies his/her own lock | 71% | 82% | 71% |
| Systematic use of tags with locks | 43% | 59% | 57% |
| Locking of energy dissipation devices | 0% | 6% | 0% |
| Rules on the use of multihasps | 0% | 29% | 14% |
| Key remaining with the authorized personnel applying his/her lock once locking is done | 29% | 18% | 29% |
| Removing lock from isolating devices under normal circumstances | 29% | 71% | 43% |
| Removing lock from isolating devices under abnormal circumstances | 71% | 100% | 100% |
| Communicating with employee before removing his/her lock under abnormal circumstances | 71% | 100% | 86% |
| Verification of the equipment before it is returned to service | 71% | 76% | 71% |
| Witnesses of one or more steps in the lockout procedure | 43% | 41% | 57% |
| Communicating with the employee after having removed his/her lock under abnormal circumstances | 0% | 18% | 29% |
| Documentation of the removal of a lock under abnormal circumstances | 14% | 53% | 86% |

Analysis & Discussion

As shown in Table 6, it can be determined that most of the analyzed lockout programs do not fully comply with RSST and contain major weaknesses when compared to CSA Z460 or ANSI/ASSE Z244. Certain elements (scope, energy type, application, removal of lock in absence of authorized employee, sequence of energy control and sequence of return to service) are found in almost all of the written programs analyzed, but with varying levels of details.

However, key elements absent from these programs are the program review, program monitoring and alternate methods. This is problematic for several reasons.

- Without a program review, it is difficult to maintain a current, active lockout program.

- Performance feedback is not monitored and deficiencies are not corrected.

- Without alternative methods of energy control, it is unclear what methods workers use when lockout cannot be applied to machines, equipment and processes.

The researcher also noted that the lockout programs from small enterprises lacked important elements such as continuity in lockout, outside service, and training and communication. This is problematic since small enterprises may be dealing with external service and contractors without considering the need to cover this aspect in their lockout programs.

Regarding communication and training, it is also interesting to note that the need for individual training, program-

Table 6
Comparison of Key Requirements in Standards & Lockout Programs

| Some key themes in CSAZ460-05 and ANSI Z244.1-2003 | 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% |
| Procedure for specific energy control | 43% | 71% | 86% |
| Continuity in lockout | 57% | 82% | 86% |
| Outside service | 43% | 82% | 100% |
| Training and communication | 43% | 71% | 71% |
| Program review | 14% | 29% | 29% |
| Program monitoring | 43% | 29% | 29% |
| Alternative methods | 43% | 59% | 29% |

specific training, theoretical and practical training, knowledge assessment and program use are absent from the small enterprise programs analyzed.

In addition, CSA Z460 was published in 2005. When speaking with SH&E personnel, the researcher noted that many were not necessarily aware of the standard. Individuals in charge of drafting the written programs had diverse backgrounds (e.g., engineering student in training, human resources staff, industrial hygienist) and often did not refer to CSA Z460, ANSI/ASSE Z244 or industry references [e.g., Kelley (2001)]. Instead, the programs were based on material obtained from training courses, other lockout programs and Internet resources. A small number of programs were clearly inspired by OSHA 1910.147.

In some cases, the analyzed programs were quite recent, while in other cases, the programs had been updated several times over the years. Generally, no reference documents such as standards or regulations were provided in the written lockout programs.

One point of interest is the RSST requirement to conduct lockout during maintenance, repair and unjamming activities. It was observed that only 14% of small enterprises, 41% of medium enterprises and 29% of large enterprises complied fully with this requirement. Regarding the steps for energy control, it is interesting to note that important steps such as notification of affected personnel, shutdown, isolation and dissipation are absent from some programs. The step involving the application or placement of locks is the only step found in all of the analyzed programs, followed by the verification step (i.e., start-up test), which is included in almost all the programs.

At this time, it cannot be known whether employees perform all the required lockout steps despite some of those steps being absent from the written documents. It also seems that individuals have a concept of lockout that involves the use of locks, but this concept is not always clear because at times the researcher observed during industrial visits that locks were applied to control switch buttons and/or the key for the lock was either left in the lock or placed next to it.

Regarding the steps for returning equipment to service, it was noted that important steps such as the verification of personnel, verification of equipment and reenergizing are absent in some of the programs analyzed. Often, in smaller industries, the company's SH&E representative is responsible for developing, implementing and maintaining the program. In larger companies, a task group and consultants can be called on to assist with these functions.

Conclusion

To evaluate lockout programs in a sample of industries in Quebec with respect to the legal requirements and CSA Z460, 31 lockout programs from different industrial sectors were collected and analyzed. It was found that the programs complied partially with the regulation but missed some important elements found in the standard.

The sample of programs studied revealed several interesting points, including the following:

- Some written lockout programs have been drafted recently.

- Important topics such as the design characteristics of new or upgraded equipment in order to enhance lockout (e.g., with energy-isolating devices, energy-dissipating devices, energy-isolating devices that are readily accessible and easily locked) are often missing.

- Program review as well as program application review, training and alternatives are absent in many written lockout programs.

- CSA Z460 or other established standards on lockout are not usually used as reference documents.

- Lockout programs obtained from small enterprises lacked more elements than those obtained from large enterprises.

- Electrical energy was referred to in almost all the programs, while thermal energy and gravitational energy were referred to less often.

- Management of duplicate keys used to remove locks under special circumstances (who stores and uses) and the need for the authorized personnel to keep the key under their control at all times is crucial to safety. Key duplication is often overlooked in written programs, yet is practiced in many enterprises. This can be a dangerous practice if not properly managed.

IRSST's proposed research projects on lockout will generate knowledge on the subject and will help industry develop practical solutions to facilitate and ensure the application of lockout programs and procedures in enterprises of all sizes. ■

References

- ANSI/ASSE. (2003). Control of hazardous energy, Lockout/tagout and alternative methods (ANSI/ASSE Z244.1-2003). Des Plaines, IL: ASSE.
- Canadian Standards Association (CSA). (2005). Control of hazardous energy: Lockout and other methods (CSA Z460-05). Mississauga, Ontario: Author.
- CSST. (2005). Action plan: Machine safety. Montreal, Quebec: Author. Retrieved Dec. 21, 2009, from http://www.cssst.qc.ca/asp/securite_machines/Flash/lancement_plan_action.swf.
- Daoust, A. (2003). *Le cadenassage, une question de survie (Lockout, a matter of survival)*. Le Groupe de Communication Sansectra Inc.
- Government of Quebec. (2001). Règlement sur la santé et la sécurité du travail (RSST, Quebec's Occupational Health and Safety Regulation, Décret 885-2001). Montreal, Quebec: Author.
- Institut National de Recherche et de Sécurité (INRS). (1996). Consignation et déconsignation, Institut national de recherche et de sécurité. Paris, France: Author.
- Kelley, S. (2001). *Lockout/tagout: A practical approach*. Des Plaines, IL: ASSE.
- Logan, R. & Reeder, P. (2007). Occupational injuries and diseases in Canada, 1996-2005: Injury rates and costs to the economy. Ottawa, Ontario: Human Resources and Social Development Canada. Retrieved Dec. 21, 2009, from http://www.hrsdc.gc.ca/en/labour/publications/health_safety/pdf/oidc.pdf.
- Mutawe, A., Tsunehara, R. & Glaspey, L. (2002, Feb.). OSHA's lockout/tagout standards: A review of key requirements. *Professional Safety*, 47(2), 20-24.
- OSHA. (1996). The control of hazardous energy (lockout/tagout) (29 CFR 1910.147). Washington, DC: U.S. Department of Labor, Author.