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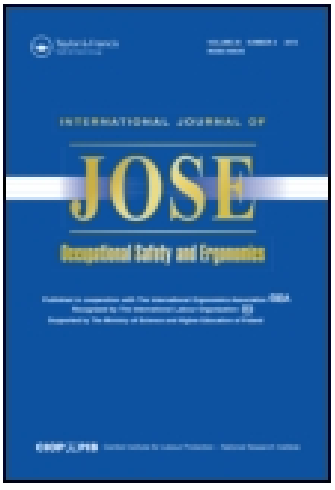

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Study on Lockout Procedures for the Safety of Workers Intervening on Equipment in the Municipal Sector in Québec

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Study on Lockout Procedures for the Safety of Workers Intervening on Equipment in the Municipal Sector in Québec

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In Québec, workers intervening in hazardous zones of machines, equipment and processes during maintenance, repairs and unjamming activities have to apply lockout procedures. Lockout procedures involve shutting down the equipment, isolating it, applying individual locks, releasing residual energies and verifying the absence of energies. Lockout has mostly been linked to industrial sectors. However, the municipal sector also faces challenges when it comes to controlling hazardous energies. The objectives of this research are to study serious accidents linked to our subject, study the application of lockout in different municipalities in Québec, identify the specificities for the municipal sector and propose some means to support the application of lockout. We will show that lockout procedures are required in different locations in municipalities and that they are currently being implemented in the municipal sector in Québec. Moreover, we propose a model which aims at facilitating the implementation of lockout procedures in the municipal sector.

lockout municipality procedure machine

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1. INTRODUCTION

In Québec, there are 1126 municipalities and the municipal sector employs ~80 000 workers [1]. Table 1 provides an overview of the number of inhabitants in the different municipalities in Québec. There are many categories of workers who intervene on different equipment and are thus exposed to numerous hazards. There are no publications on the analysis of accidents and injuries in the municipal sector in Québec, but several fatal and serious accidents linked to such interventions in municipalities have occurred and have been investigated by Québec's Occupational Health and Safety Commission (CSST). In 2008, the CSST revealed that 5225 accidents and 6 deaths occur annually during maintenance, repairs and installation of machines in Québec due to the absence of, or errors in, lockout procedures [2]. Based on article 185 of Québec's Regulation respecting occupational health and safety (ROHS), workers intervening in hazardous zones of machines and processes during maintenance, repairs and unjamming activities have to apply lockout procedures [3]. This article in the ROHS states that "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" [3]. This paper studies lockout procedures which are applied in the municipal sector in Québec to ensure the safety of workers intervening on equipment.

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TABLE 1. Municipalities in Québec in 2010 by Number of Inhabitants

Inhabitants	Municipalities	(%)	Total Population	(%)
<2000	751	(66)	654687	(8)
2000–9999	278	(25)	1140050	(15)
10000–24999	54	(5)	836747	(11)
25000–99000	33	(3)	1437583	(18)
≥100 000	10	(1)	3705964	(48)
total	1126	(100)	7775031	(100)

Notes. Source: Ministère des Affaires municipales, des Régions et de l'Occupation du territoire. Décret de population, 2010, No. 1334-2009 [Decree of population, 2010, No. 1334-2009]. Gazette officielle du Québec. 20 janvier 2010.

1.1. Overview

Equipment poses hazards of different nature (e.g., mechanical, electrical, thermal, chemical), as described in detail in Standard No. ISO 12100:2010 [4]. The purpose of lockout is to protect workers from injury from an 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.

Standard No. CSA Z460-05 defines lockout as the placement of a lock 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 in accordance with an established procedure [5]. Lockout procedures involve the following steps:

1. shutting down the equipment (i.e., switch off the equipment);
2. isolating it (i.e., turning off electrical circuit breakers, hydraulic valves, etc.);
3. applying individual locks (Figure 1) (i.e., workers apply their individual locks onto the isolating devices);
4. releasing residual energies (i.e., purging hydraulic or pneumatic circuits, discharging capacitors, lowering or securing suspended loads, etc.) and verifying the absence of energies (i.e., switching on the equipment as a test, measuring variables such as voltage, temperature, pressure, visual inspection, etc.) [5].

Simply shutting off the equipment may not completely control the hazardous energy since residual energy may still be present. Besides, even if the equipment 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. Lockout is recognized 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, and servicing and maintaining machines, equipment or processes [5]. However, Standard No. CSA Z460-05 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 [5].

Applying lockout procedures requires planning, training and resources (e.g., lockout devices, placards). A lockout program provides guidance to supervisors and employees on what is expected of them. A written program establishes the general policies and procedures for implementing lockout, and sets specific performance requirements for employers and employees. It also provides a mechanism for regulatory compliance. A written lockout 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. A lockout program usually includes the following elements [5]:

Figure 1. Individual lock applied on an electric isolating device.

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- 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;
- auditing of program elements.

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1.2. Literature Review

Twenty-eight regulations on lockout from different parts of the world were identified and then analyzed. Those regulations were from Canada, the USA, Australia, several European countries, South Africa and several Asian countries. Moreover, five standards on lockout were also identified and analyzed [5, 6, 7, 8, 9]. Documents on lockout from six sector-based occupational health and safety (OHS) associations in Québec [10, 11, 12, 13, 14, 15,], two documents produced by the CSST, two text books on lockout [16, 17,], one guide produced by France's Institut National de Recherche et de Sécurité (INRS) [18] and a report from the Institut de Recherche Robert-Sauvé en Santé et en Sécurité du Travail [19] were all analyzed. Besides, 31 lockout programs from different sectors in Québec were collected. Those sectors were eight manufacturing (metallic products) plants, seven manufacturing (electrical products) plants, four printing plants, three machine manufacturing plants, two hospitals, two sawmills, two pulp and paper plants, one mining plant, one heavy metal plant and one chemical plant. Table 2 summarizes some of the results.

That study revealed that (a) the concept of lockout had different meanings or definitions in the literature, especially in regulations, but definitions of lockout in standards had certain similarities; (b) the legal requirements on lockout varied in different Canadian provinces and in different countries; (c) standards on lockout tended to have similar requirements, except for Standard No. ISO 14118:2000 [6]; (d) the contents of lockout programs, as described in different guides, varied; and (e) lockout programs obtained from 31 plants in Québec did not fully comply with the provincial regulation and had several elements which were missing when compared to Standard No. CSA Z460-05 [5].

Essentially, the study confirmed that although lockout appeared simple and easy to implement, there existed several aspects which needed to be researched. The variability associated with documents referenced by end users is believed to be a contributing factor which makes application of lockout problematic in different industries.

Given the limited amount of research on the subject, the number of scientific articles on lockout is low. In Canada and in the USA, Standard No. CSA Z460-05 [5] and Standard No. ANSI/ASSE Z244.1-2003 [7] specify, respectively, the requirements for controlling hazardous energies associated with machines. Recent publications show that the lack of lockout is an important factor in accidents involving machines in the USA [20], France [21] and the UK [22]. In 1996, the INRS published a guide on lockout of equipment [18]. In 2008, the INRS introduced the ratio of intervention time on equipment to time required to perform lockout procedures. It concluded that lockout was too often presented as a rule and could impose serious constraints, especially since the safety level that it provided was based on the correct application of procedures [23]. In addition, books explaining the different elements in a lockout program have been published [24, 25].

2. RESEARCH OBJECTIVES

So far, lockout has mostly been linked to industrial sectors. However, the municipal sector also faces challenges when it comes to controlling hazardous energies. There are numerous pieces of equipment and situations in municipalities where lockout is seen as a viable means to prevent injuries and deaths. This paper studies the application of lockout procedures in the municipalities in

TABLE 2. Partial Results of an Analysis of 75 Documents on Lockout Programs and Procedures

Subject	Regulations (%)	Standards (%)	OHSA (%)	Books & Guides (%)	Plants/Enterprises (%)
Application					
repairs	72	80	83	80	80
servicing	18	20	83	60	67
maintenance	54	80	0	20	26
unjamming	14	60	50	60	32
erecting	4	60	0	20	7
setup	11	80	17	20	23
adjustment	21	80	33	80	23
inspection and verification	22	80	33	80	32
cleaning	43	60	50	60	23
Padlocks and management of the keys					
standardization of padlocks	4	100	17	40	39
single key	0	20	67	0	38
duplicate keys	14	0	0	40	13
each employee applies their padlock	39	40	83	60	most
key remains with employee who applies padlock once it is locked	4	20	50	40	most
removal of padlock from isolating devices under abnormal circumstances	7	40	33	20	52
Elements (steps) in lockout procedure					
notification	4	80	83	80	67
shutdown	50	80	67	20	48
isolation	46	100	83	80	74
application of locks	61	100	100	100	100
dissipation	53	100	100	80	55
verification	43	100	100	100	94
External service or contractor personnel					
reference to external personnel	7	80	100	100	77
external personnel using host's lockout program	4	0	17	0	55
testing knowledge of outside personnel before they begin their task	0	0	17	20	0
Training					
documentation of training	7	40	17	20	13
retraining frequency	4	40	0	40	most
Review					
documentation of program review	7	40	17	40	16
review of application of lockout	7	60	33	40	29

Notes. OHSA = occupational health and safety associations in Québec.

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Québec, Canada. The four objectives of this study are, therefore,

- to identify the types and locations of interventions in the municipal sector requiring lockout;
- to study and analyze the application of lockout in different municipalities in Québec and identify the challenges or difficulties associated with its application;
- to analyze and compare the lockout programs developed by municipalities;
- to identify the specificities of lockout for the municipal sector.

3. METHODOLOGY

3.1. Overview of Methodology

The method used to meet the research objectives was made up of five parts. Firstly, accidents in the municipal sector in Québec were analyzed. This part described hazardous situations and locations in the municipal sector linked to interventions on equipment. Secondly, a literature review identified documents with a complete or partial description of lockout in the municipal sector. Standards, regulations, guides, scientific articles, training documentation and labour laws for different trade associations were targeted. The research was conducted in 2010 with keywords (e.g., lockout, lockout program, municipality, city) on different databases including Compendex[1], Inspec[2] and ScienceDirect[3]. Thirdly, a questionnaire was prepared and used to collect data during site visits. The criteria for selecting the municipalities were the size (i.e., number of inhabitants), the types and locations of interventions, and the equipment involved. Fourthly, the written lockout programs of the municipalities were analyzed and compared. Finally, data gathered during the site visits were compiled, analyzed and discussed.

3.2. Survey of Accidents

First, a statistical portrait of accidents in the municipal sector in Québec was determined from a database of the CSST based on the following criteria:

- injuries accepted by the CSST which occurred in 1998–2007;
- injuries associated with "local government services"; and
- injuries limited to traumatic accidents (musculoskeletal disorders and occupational diseases were excluded).

Moreover, a survey of accidents linked to the presence of hazardous energies was carried out with the CSST database of investigation reports on serious and fatal accidents [26]. This survey was limited to the following criteria:

- the accident took place in 1985–2009 in Québec and was investigated;
- the employer was a municipality, a subcontractor of a municipality, a public transit company or a company whose activities were similar to those of a municipality during the accident;
- the accident was related to the control of hazardous energy.

In addition, the database of the INRS was explored with the same criteria for the category "local government authorities and hospitals" [27].

Finally, 14 serious workplace accidents were selected. Those accidents had caused nine deaths and five serious injuries (four amputations, one burn). A municipality was the employer in seven cases, a subcontractor of a municipality in three cases, a public transit company in one case and a body similar to a municipality was the employer in three cases. A brief description of each accident follows.

1. A worker was struck by a soil aerator and trapped in the rear structure of the tractor as he tried to unjam the towing attachment.
2. The upper limbs of a worker were wrapped around the agitator of an abrasive spreader, which is used on roads and highways in winter, while it was being cleaned.
3. A worker was fatally caught in the drive shaft of a snow blower while he was removing snow on the windshield.

[1] http://www.ei.org/compendex
[2] http://www.ebscohost.com/academic/inspec
[3] http://www.sciencedirect.com/

4. A worker lost his life while he was disconnecting a fuse in a lighting fixture for a softball field.
5. A worker was electrocuted while he was removing electrical cables in a manhole.
6. A worker was caught in the drive shaft of his truck while he was working on the hydraulic valve of the pump that operated the dump.
7. A worker was entangled by a sand screw in a water treatment plant.
8. A worker went under his truck, with the engine running, to adjust the pressure on a seal and was caught in the drive shaft.
9. A worker was caught in machinery while he was trying to remove the salt accumulated at the end of the longitudinal conveyor of a tractor-spreader.
10. In an electrical room, a worker applied a cleaning agent on the top of the circuit isolator. He was hurt by an electric arc.
11. A worker lost his balance during the inspection of an ice resurfacer. He lost two of his fingers.
12. A spreader-truck operator tried to put back the blades of the conveyor with his right hand while the conveyor was running. His arm was caught in the conveyor.
13. A worker intervened on a live electrical transformer and was electrocuted.
14. In an incineration plant, a worker was cleaning a moving conveyor and had his arm wrapped around the drum.

3.3. Types of Documents

An analysis of 26 references which described lockout procedures with reference to the municipal sector was carried out. The references were 14 guides, eight leaflets, one book, one standard, one article and one video. The principal themes which were covered by those references were general works in a municipality, water treatment, waste treatment, mobile equipment, natural gas, arena, confined space, legal aspects, ventilation, parks and green zones, and lockout in general.

3.4. Site Visits: Planning and Questionnaire

In conformity with the rules and regulations of the ethics committee at École Polytechnique de Montréal and at the Institut de Recherche Robert-Sauvé en Santé et en Sécurité du Travail, a certificate was obtained prior to starting the research. An information and consent form was sent to all participants well in advance. In that form, the researchers explained the objectives of the study, estimated the duration of the visits and detailed the nature of their participation, informed the participants of their rights to withdraw from the study at any time without any consequences and outlined the measures taken by the research team to ensure the confidentially of the sources of data which would be gathered. Table 3 outlines the plan of a visit. Two members of the research team filled in the questionnaire; they interviewed the OHS representative or the manager and the worker or workers (authorized to perform lockout). Afterwards, the two members of the research team confronted, compared and validated the data collected.

The main topics in the questionnaire follow.

1. Lockout program

- specific to the municipal site or to the municipality;
- date it was written, revised, reason why it was drafted and by whom;
- the way it is used and made available to workers;

TABLE 3. Plan of a Site Visit

Steps	Description	Duration (min)
1. Introduction	explanation and signatures on an information and consent form	15
2. Question time	discussion and filling in the questionnaire	90–120
3. Observation	observation of lockout at various sites	60–90
4. Debriefing	general discussion on the data collected and the visit list of documents collected or to be obtained later	30

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- when and why it is audited;

2. The application of lockout procedures at the site

- activities or interventions, e.g., maintenance, repairs, unjamming, inspection, setup;
- persons applying the procedures;
- types of equipment involved;

3. Roles and responsibilities

- organization and assignment of the different roles and responsibilities;

4. Training on lockout

- types of training sessions conducted, e.g., practical, theoretical, mentorship;
- list of people who received training;
- frequency of retraining and reasons for it;

5. Material for lockout

- codification of isolating devices;
- isolating devices suitable for lockout;
- accessibility of isolating devices;
- location of lockout station;
- types of lockout devices used, e.g., individual locks, tags, lockout box, duplicate of keys for locks;
- types of lockout carried out, i.e., individual, group implying use of a lockout box, group complex implying use of more than one lockout box;
- the number of lockout placards already in use or to be made;
- use of a placard for an equipment or for a particular task;
- use of a lockout software;
- criteria for choosing commercially available software;
- development, validation and revision of placards;
- continuity for lockout, i.e., change of shift of personnel and intervention not over;
- absence of authorized employee, e.g., a person forgets to remove his lock at the end of the intervention and leaves the premises;

6. Audit of lockout

- audit of the application of lockout;
- reasons behind the audit, frequency and documentation;
- communication of the results;

7. External personnel and lockout

- use of host's lockout program by external personnel or their own program;
- training of external personnel;

8. Difficulties experienced in the application of lockout.

3.5. Analysis of Lockout Program

A grid similar to the one developed by Chinniah, Champoux, Burlet-Vienney, et al. was used in this analysis [19]. The analysis was limited to the presence or the absence of information in the lockout programs from the municipalities. In the present study, the main themes expected in a lockout program were included in the first column of the grid and the subsequent columns were used to analyze the different programs collected from the municipalities.

4. RESULTS

4.1. Accidents in Municipal Sector

The statistical portrait of traumatic accidents for local government services in Québec over 1998–2007 reveals that

- on average, each year, there were 3087 traumatic accidents, costing 12.7 million CAD[1];
- by comparison, in 2006, traumatic accidents for local government services accounted for 4.4% of all traumatic accidents in Québec, while workers of local government services represent only 1.9% of all full-time workers;
- the caught-in-between category represented 1814 cases and cost 7.2 million CAD over the study period (sixth category, the first being related to falls). Indeed, according to Bulzacchelli, Vernick, Sorock, et al., this

[1] 1 CAD = 0.96 USD = 0.72 EUR

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category is most closely linked with the problem of machine safety and control of hazardous energy [21].

These statistics confirm that the municipal sector is a high-risk sector. It is also necessary to analyze the circumstances under which these accidents occurred. Information on the context of severe and fatal accidents related to running or energized equipment follows.

Type of worker

vehicle driver	5
electrician	3
cleaning operative	1
worker in public works	4
mechanic	1

Season

winter	7
spring	1
summer	3
fall	1
information unavailable	2

Location

public works	5
parks and green zones	2
water treatment	1
public transit	1
workshop	3
waste treatment	1
arena	1

Worker's activity during the accident

cleaning	6
unjamming	2
servicing/repairs/setup	4
Inspection	2

Causal agent

mobile equipment	8
fixed machinery	2
live electrical parts	4

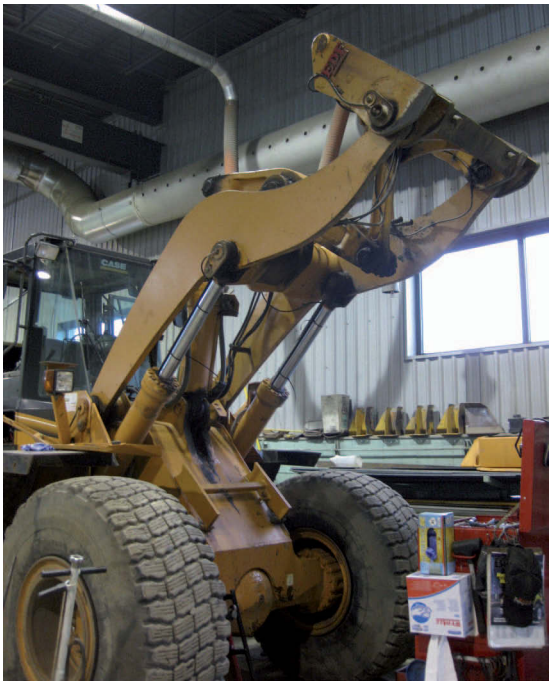
Hazardous energy

mechanical/hydraulic	10
electrical	4

Seven workers worked alone, another seven in a team. There were no lockout procedures in any of those cases.

The analysis of these accidents emphasizes that mobile equipment, e.g., truck, spreader, tractor (Figure 2), and electrical installations are often

(a)



(b)

Figure 2. Examples of mobile equipment used in municipalities: (a) a loader, (b) a snow blower.

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involved. These accidents also illustrate the variety of work activities to be considered in a municipality to control hazardous energy, e.g., cleaning a conveyor in an incineration plant, repairing the lighting system of a softball field.

4.2. Locations and Equipment Where Lockout May Be Needed

Lockout procedures are required in different locations and departments in a municipality. Workers may intervene on equipment found indoors or outdoors and those interventions usually occur at the seven locations described in Table 4. The different equipment can be grouped into electrical installations, vehicles (i.e., mobile equipment), fixed machinery, conduits, heating ventilation and air conditioning (HVAC) and confined spaces.

4.3. Types of Workers

In the municipal sector, workers intervene on equipment during various activities. Examples of workers who need to apply lockout procedures for their safety are electricians, mechanics, HVAC technicians, drivers of different vehicles and machinery who intervene on site, operators in water treatment plants, workers in garbage processing plants, workers involved in road works and those intervening in confined spaces. In addition, firefighters may be required to apply lockout procedures during their interventions for their own safety. For example, during rescue missions in confined spaces, around machinery or electrical distribution systems, firefighters may need to ensure that they are in control of hazardous energies.

External personnel or contractors intervene regularly on equipment in the municipal sector. In some municipalities, external personnel carries out entire garbage collection and processing, street lighting, snow removal and diving operations in water treatment plants. The municipality has a legal obligation to ensure that those interventions are carried out safely. The municipality needs to identify the hazards, ensure that workers have the required expertise, monitor work and penalize deviations from established procedures.

4.4. Site Visits

Eventually, 12 municipalities in Québec were included in the study based on the criteria detailed in section 3.1. The study took place mainly in large municipalities, from September 2010 to

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TABLE 4. Overview of Locations and Equipment Where Lockout Is Required

Location	Description	Specific Equipment
Water treatment plants	drinking water plants, sewage plants, pumping stations, etc.	pumps, motors, mixers, compressors (pneumatic valves), equipment involved in screening, settling, ozonation, filtration, etc.
Garbage treatment plants	incinerator, landfills, dumping grounds, recycling facilities, composting plants	loaders, furnaces, compactors, conveyors, etc.
Public municipal buildings	leisure and sports facilities, e.g., swimming pools, skating arenas, baseball fields; offices, libraries; services facilities, e.g., firefighting and police stations	pumps, filtration systems, boilers, refrigeration systems, ice resurfacers, heating ventilation and air conditioning, lighting, etc.
Workshops and garages	mechanical and wood working, garage for vehicle repairs, municipal parking lots	lathes, presses, drills, bench saws, bridge cranes, vehicle lifts, presses, compressors, tractors, salt spreaders, snow blowers, snow removers, etc.
Public works	snow removal, road works, street lighting, garbage collection, electricity, arboriculture	salt spreaders, snow blowers, snow removers, front loaders, backhoes, garbage trucks, etc.
Parks and green zones	cutting grass, trimming trees, collecting fallen leaves, removing and controlling weeds	lawnmowers, aerators, tractor, shredder, etc.
Public transit systems	maintenance of public transit systems, including stations	buses, subways, trains, workshops, electrical installations for trains, etc.

April 2011 (Table 5). Twenty-three municipal sites in eight regions were visited (Table 6). In total, the questionnaire was used when interviewing 5 directors, 8 OHS personnel, 9 supervisors, 7 workers (e.g., operator, technician and electrician) and 1 labour representative. Ten municipalities had lockout programs, two used lockout procedures without programs or placards. Only seven municipalities used placards.

4.5. Analysis of Lockout Programs

The 10 lockout programs collected were analyzed. It was found that (a) eight programs were drafted within the past 3 years, (b) six programs were still at an implementation phase and (c) five programs were drafted following an intervention of the provincial OHS regulatory body, the CSST, as a result of a work accident or activities to ensure compliance with regulations on confined spaces. Five municipalities drafted lockout programs based on reasons such as the arrival of new managers familiar or experienced in lockout procedures, and an increased use of remote controlled equipment (e.g., valves in water treatment and distribution), which is an incentive to apply lockout procedures. All programs covered most themes pertaining to lockout. Two municipalities missed the audit, training and communication aspects associated with lockout. Most programs (eight out of 10) were personalized and adapted to the municipality (i.e., no generic programs were used). For instance, the names, roles and responsibilities of persons were stated, the equipment and locations were identified and illustrated, and codification of the equipment was described.

5. DISCUSSION

This section provides a discussion about the organizational and technical issues identified during the site visits. Subsequently, a model for implementing lockout programs in municipalities is proposed based on the different success factors observed.

5.1. Organizational Issues

It seems that most municipalities in Québec are currently at the implementation phase of lockout. The programs are not drafted, placards are not ready or are not being used and codification of equipment is underway. There exists an opportunity for municipalities to benefit from the expertise of those ahead in this area. Sharing information on the subject will not only prevent a repetition of

TABLE 5. Details on the Municipalities Visited

Inhabitants	Visits	Municipal Workers	Estimated Placards to Produce
2000–9999	1	<25	20
10 000–24 999	1	25–200	200
25 000–99 999	4	200–1000	1500
>100 000	6	>1000	3000

Notes. No municipalities with under 2000 inhabitants were visited.

TABLE 6. Description of Municipal Sites

Municipal Site	Actually Visited	Initially Planned
Drinking water plant	5	2
Sewage plant	4	2
Pumping station and water distribution/road works	4	2
Garage/mechanical workshop	1	3
Arena	1	2
Municipal building (workshops, firefighting station)	3	1
Leisure-related (swimming pool, skiing station)	2	1
Garbage incinerator	1	1
Electrical distribution	2	1
total	23	15

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similar errors but will also ensure that innovations developed in one municipality can be transferred to others. There are potential gains in terms of training personnel, choosing and purchasing lockout material, etc. The municipalities have reported five topics related to organizational issues which are detailed in the next sections.

5.1.1. Resistance to change and employee participation

Implementing lockout programs leads to changes in working methods. Municipalities have reported that workers tend to resist changes in their working methods brought by lockout procedures. The municipalities with the highest success rate with lockout ensured active employee participation by forming an enlarged committee with representatives from most if not all departments. Workers made suggestions pertaining to codification of equipment, difficulties in particular tasks and types of lockout devices. Those suggestions were considered. Management did not impose a generic lockout program but implicated workers in all the steps. Active employee involvement enhances understanding of the procedures. Communication with employees results in the identification of deficiencies in the program and procedures as well as opportunities for improvement. Workers also need to be held accountable and understand the consequences for violating lockout procedures. Disciplinary policies need to be developed and enforced.

5.1.2. External resources to implement the lockout program

The use of external resources (i.e., companies specializing in lockout) to implement the lockout program in the municipality needs to be careful. Municipalities where lockout procedures were applied regularly had their workers fully involved in the process. The workers developed a sense of ownership and pride in the program. The municipalities allocated internal resources to identifying isolating devices and seized this opportunity to keep this expertise within its workforce. Better knowledge of existing installations and equipment implies easier troubleshooting, increased safety for municipal workers and for external personnel intervening on equipment. Internal resources were also allocated to drafting the placards and strengthening the implication of workers in the implementation of lockout. Some municipalities relied on external resources to implement their lockout programs. However, since the electrical and mechanical schematics of the plants were not up-to-date or were nonexistent, the external resources had to survey existing installations and equipment before the codification phase. Since the external personnel were not familiar with the premises, local resources were allocated for guidance. It is a common mistake to underestimate the work associated with implementing lockout programs. Municipalities which performed better in terms of the application of lockout allocated internal resources to survey equipment, codify energy isolating devices and write lockout placards.

5.1.3. Lockout software

Table 5 shows that the number of placards can be quite high depending on the size of the municipality and the number of workers. The use of specialized lockout software to create, access and revise placards is appealing. However, municipalities have reported that such software can be expensive and lack flexibility. The suppliers of the software revise placards, which can be expensive. Users have reported that greater flexibility in revising placards is necessary when equipment has been modified, errors have been detected or existing installations have evolved. The most successful municipalities used placards created with widely available commercial software.

5.1.4. Large number of locations and services

One specificity of lockout in municipalities is the large number of locations and services involved. Lockout is traditionally confined to a building (e.g., a factory). Thus, lockout in water treatment plants tends to be the starting point for many, if not all, municipalities. Other locations such as workshops, incinerators and garages behave similarly. They may all have one or more lockout

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stations per building with easy access to a computer and a printer for printing placards. However, municipal workers and external personnel also intervene outdoors, in remote areas, to repair equipment (i.e., with no prior planning). In those situations, workers find that access to placards and to lockout devices can be a challenge. Solutions, which have been observed, include having a lockout station in a truck used as a mobile workshop; printing placards or getting them at a predetermined location; keeping all placards in a truck; and using portable interactive electronic pads with access to the Internet. Workers can also face additional risk when intervening alone in remote areas. Besides, some interventions can implicate more than one municipality. One such example is the water distribution system, which can be integrated between two municipalities. When interventions on shared equipment or remote controlled equipment take place, the lockout procedures have to consider those aspects. In addition, some interventions take place outdoors and the hazards are not always easy to identify (e.g., underground electric cables in parks). Lockout procedures have to be adapted to those scenarios by reminding the employer and employees to obtain all the necessary information and clearances before the intervention. Moreover, it was observed that having representatives from all departments and services in the municipality in the lockout committee or working group tended to increase the likelihood that lockout was accepted and harmonized throughout the municipality.

5.1.5. Supervision of external personnel

The implementation of lockout procedures is an opportunity to improve the management of external personnel with respect to OHS and due diligence. Municipalities need to ensure that all outside service or contractor lockout programs are co-ordinated with their own programs. The training of external personnel needs to be ensured by including this aspect in the contracts. Information on the different hazards to which external personnel can be exposed needs to be clearly communicated. Municipalities also need to decide which lockout devices are to be used during interventions (i.e., those of external personnel or of the municipality). Ideally, external personnel must be accompanied by a municipal worker who knows the installations or the equipment to ensure at least a minimum level of supervision. To enforce the lockout programs, municipalities need to have clear sanctions against external personnel for deviations from the prescribed working methods.

5.1.6. Lockout of equipment and confined space

Using lockout procedures in water treatment plants and in public works is often included in the confined spaces entry permits. They are closely linked since lockout needs to be applied before workers enter those spaces. One municipality harmonized lockout procedures and entry permits. The hazards and isolating devices were presented similarly, making their identification by workers easier. Moreover, the two separate forms were integrated. Obtaining permits and placards was also standardized and made identical, simplifying their management.

5.2. Technical Issues

The municipalities have also reported two topics related to technical issues, which are detailed in sections 5.2.1. and 5.2.3.

5.2.1. Lockout of mobile equipment

The analysis of accidents involving equipment in the municipal sector has revealed that mobile equipment represents serious hazards to workers. Several injuries and deaths could be linked to interventions on energized or running mobile equipment. However, it was observed that municipalities, which tended to focus mainly on fixed equipment, put little emphasis on lockout on such equipment. In fact, only one municipality had lockout procedures for mobile equipment. There are vehicles and mobile equipment which do not possess unique ignition keys (i.e., several vehicles and equipment having identical ignition keys). For such equipment, locking the isolator switch at the battery is a possible solution. For vehicles with a unique ignition key, a lockout box

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in the cabin where the key will be placed and several workers can apply their individual lock can be used. Locking vehicles also implies that all energies (e.g., mechanical, pneumatic electrical, thermal and hydraulic) are controlled and rendered safe. Moreover, residual energies need to be controlled. As such, suspended loads and elevated buckets need to be lowered or supported with appropriate fixtures, hydraulic circuits need to be purged, batteries used for powering engine cooling systems have to be isolated and parking brakes for vehicles need to be applied.

5.2.2. Locking hardware nonexistent or inadequate

All municipalities have reported difficulties in applying lockout procedures to water cut-off valves. Those valves are usually found at a certain depth on the streets. To close or open the valves, workers need to remove the cover of the manholes and use special tools. The problem is that no locking device exists for those valves. Varying diameters of the access conduits and ice in winter complicate matters. The risk associated with such interventions is high. Accidents and incidents have been reported whereby workers were hit by the projected tool when opening valves (because of high water pressure) and nearly drowned since the manholes filled up rapidly. One municipality uses a color code on covers (Figure 3) to indicate that the valve is closed and that workers are intervening on the distribution system. Moreover, it has been observed that locking devices used in municipalities were not always adapted. The valves in water plants have various shapes and sizes, and not all valves can be easily locked despite the existence of several types of commercially available locking devices for valves. Some municipalities have developed their own locking devices (i.e., custom-made lockout devices), e.g., valves with square-shaped actuators were problematic. In one municipality, workers drilled two holes, one at each side of the actuator to seat adaptable lockable pliers, thus preventing the opening of the valve (i.e., the use of the handle).

Figure 3. Color codes on covers to indicate whether the water cut-off valve underneath is open or closed.

5.3. Implementation of Lockout

On the basis of the observations and discussions during the site visits as well as the literature (e.g., Standard No. CSA Z460-05 [5]), a model for implementing lockout programs in municipalities is proposed. The model consists of several steps, which can be carried sequentially. Those steps are listed in sections 5.3.1. through 5.3.11.

5.3.1. Identify and mandate an internal resource responsible for a lockout program

This individual will work preferably full time depending on the size of the municipality and the number of pieces of equipment. Ideally, this resource has to be familiar with (a) project management (e.g., diagnosing the situation, formulating clear objectives, monitoring) and (b) change management (e.g., resistance to change management). External resources can be used to accompany the municipality in the implementation of lockout and preferably not as alternatives.

5.3.2. Set up a lockout committee

In larger municipalities, subcommittees can be created to liaise with the main committee. Municipalities need to encourage workers to participate from the beginning and to clearly explain to them the objectives of lockout and the benefits in terms of their safety. Here, too, external resources can be used to guide the members of the committee but not as a replacement or an alternative. Municipalities have to resist the urge to contract out the implementation of a lockout program completely since the long-term gains are questionable.

5.3.3. Identify hazardous energy and equipment

Hazardous energies associated with different equipment need to be identified. If the plans and schematics are not up-to-date, municipalities need to seize this opportunity to update or acquire such information. Internal resources have to be given preference. This also ensures that the knowledge about the equipment and installations is transferred from older to younger workers. Vehicles, remote controlled equipment and equipment shared with other municipalities need to be included at this stage.

5.3.4. Develop a written lockout program

Municipalities have to personalize their lockout programs as far as possible (e.g., list places, equipment, names of workers, protective hardware, codification, sample placards). They need to avoid using generic programs, which are difficult to understand by workers and which become obsolete. The different roles and responsibilities should be stated clearly.

5.3.5. Identify and codify isolating devices

It seems be to interesting to harmonize the codification of energy isolating devices in different departments of the same municipality. New isolating devices have to be added when needed, while taking into account proximity, distance covered by workers and accessibility (e.g., heights). The means for codification need to consider the immediate environment of the equipment, e.g., noncorrosive plastic tags can be used to codify isolating devices in water treatment plants, where chorine is present.

5.3.6. Survey interventions

A survey of different interventions taking place needs to be carried out and later linked to lockout placards. At this stage, particular situations such as outdoor interventions, confined spaces and working alone need to be considered.

5.3.7. Prepare placards

Placards can be prepared with appropriate software, based on the needs of the municipality. Municipalities need to consider one important criterion: flexibility in accessing, revising and updating placards. An attempt can also be made at harmonizing entry permits in confined spaces and lockout placards.

5.3.8. Acquire protective hardware

Municipalities need to acquire protective hardware and organize it. Accessibility issues for mobile intervention teams have to be anticipated and the solutions include having a lockout station in the vehicle and some means to access placards such as (a) hard copies (i.e., binders) in the vehicle, (b) a portable computer with a printer in the vehicle or (c) a touch screen pad with wireless communication. Municipalities need to anticipate difficulties linked to isolating devices such as street valves, square-end valves and others. Solutions include using custom-made lockout devices, adding isolating devices which are easily locked or using other working methods.

5.3.9. Validate placards

Once placards have been prepared, they need to be validated. The validation process has to include placards for remote areas, working alone and placards used by mobile intervention teams. The consequences of errors in the lockout procedures for those interventions can be severe.

5.3.10. Communicate, inform and train

Municipalities need to provide practical training to reinforce theoretical knowledge. The level of training provided must be commensurate with employees' job assignments. The literacy rates and level of education of workers in municipalities need to be considered. Training sessions need to include diagrams, pictures and practical demonstrations to increase their effectiveness. Frequent retraining is necessary since municipal workers may change departments. Training also needs to include external personnel whenever possible.

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5.3.11. Audit

Audits are required to keep the lockout program alive. They ensure continued improvement of the system. Modalities (i.e., who, when, indicators, etc.) must be provided in the lockout program to improve the probability that audits will be effective. Errors detected in placards during audits can be corrected and procedures can be tested. It is desirable to audit external personnel and contractors as well, given their implication in municipalities. The program review and revision is an essential feedback mechanism for the application of lockout procedures.

6. CONCLUSIONS

In most developed countries, lockout procedures are required by local authorities when workers carry out maintenance, repairs and unjamming activities on equipment. In this paper, the safety of workers intervening on equipment in the municipal sector in Québec has been studied by focusing on lockout procedures. It is believed that lockout procedures can make interventions on equipment safer. This study analyzed some accidents involving equipment in the municipal sector in Québec. An overview of the types and locations of possible interventions in the municipal sector requiring lockout has been presented. A comparative analysis of the lockout programs developed by municipalities was carried out. The application of lockout in different municipalities in Québec, as well as the challenges or difficulties associated, were studied. It was observed that lockout was at the implementation stage in most municipalities studied. Municipalities need to implement and apply lockout procedures to comply with the ROHS. Some critical factors for effective lockout programs are outlined and advice is provided on ways of avoiding pitfalls. Additional effort is necessary to develop lockout procedures for vehicles and mobile machineries. A model for implementing lockout programs specific to municipalities was also developed. Although only 12 municipalities (23 municipal sites) were studied, the results tend to reflect the reality of most municipalities in Québec. The follow-up committee, which accompanied the researchers and which consisted of different parties in the municipal sector in Québec, validated the findings. For completeness, it must also be mentioned that actual application of lockout procedures was only observed when workers simulated them and/or when locks were already found on isolating devices. There were neither unexpected nor planned interventions on equipment during the site visits. This study can serve as a starting point for municipalities in Québec when implementing lockout programs, and can benefit municipalities in other provinces in Canada and those found in other countries.

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