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# Occupational safety during interventions in confined spaces

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ABSTRACT

The aim of this study was to examine how organizations in Quebec manage risks associated with confined space interventions. Fatal work accidents that occurred in confined spaces in Quebec between 1998 and 2011 were therefore studied using the database of the provincial workers' compensation board. Thirty-two accident investigation reports involving 40 fatalities were obtained for the target period. The risk factors studied were the time of year, type of accident, and management and design problems. The risk management practices of 15 Quebec organizations were also analyzed through semi-structured interviews and observation of confined space interventions. Organizations with different profiles were chosen to cover a wide range of confined spaces and work situations. With respect to the regulatory in force in Quebec and based on the Canadian standard on the management of work in confined spaces, the organizations visited neglected the following points, in terms of both prescribed directives and actual practices: (i) management of subcontractors, (ii) auditing how risk reduction means are used, and (iii) integration of prevention through design. The lack of guidelines limited the real effectiveness of measures pertaining to training, rescue, use of certain control measures, and the preparation of entry permits. Given the complexity and diversity of the work involved in the issuance of permits, uncertainties during their preparation can lead to poor risk assessment and eventually to inadequate risk reduction measures. This article therefore proposes an entry permit consolidating all the information needed to prepare for entry, as well as recommendations regarding the aforementioned challenges.



## 1. Introduction

In the federal and provincial occupational health and safety (OHS) regulations of Canada and Quebec respectively, a confined space refers to a space in which a worker can physically enter, but that (i) is not a regular workspace, (ii) has restricted means of access and egress, and (iii) poses risks to the worker's health and safety (Quebec Government, 2014; Government of Canada, 2014). These criteria are reiterated in various forms in most countries including the United States (29 C.F.R, Part 1910.146, 1993), the United Kingdom (Government of United Kingdom, 1997), France (Institut National de Recherche et de Sécurité, 2010) and Australia (Standards Australia, 2001). For example, reservoirs, silos, vats, access shafts, ditches, sewers, pipes, crawl spaces, and truck or freight car tanks are all potentially confined spaces from a regulatory standpoint. Work-related interventions in confined spaces concern the municipal, manufacturing, chemical, military, agricultural, and transportation sectors in particular (Rekus, 1994). In 1993, when drafting its regulation on work in confined spaces, the US Occupational Safety and Health Administration (OSHA) estimated that 4.8 million confined space entries were made annually in the United States and involved an average of 1.6 million workers and 63 deaths (29 C.F.R, Part 1910.146, 1993; ANSI/ASSE, 2009). Many potential hazards exist in confined spaces. The main ones are atmospheric (i.e. poisoning, asphyxiation, explosion), biological, and physical (e.g. mechanical, electrical, engulfment, falls, lighting, outside traffic) (NIOSH, 1994). Between 1992 and 2005, an average of nearly 38 deaths occurred per year in the United States due to poisoning or asphyxiation in confined spaces. Twenty percent of these events resulted in several deaths (Wilson et al., 2012). Other revealing statistics about the risks involved in confined space interventions were inventoried by Burlet-Vienney et al. (2014) in a literature review (e.g. Fuller and Suruda, 2000; Dorevitch et al., 2002; Beaver and Field, 2007; Riedel and Field, 2013).

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In Quebec, employers are legally bound to respect Division XXVI (sections 297 to 312) of the *Regulation respecting occupational health and safety* (ROHS) (Quebec Government, 2014) when it comes to work in confined spaces. This regulation is equivalent to OSHA 29 CFR 1910.146 in the United States. The following topics are discussed:

- the training of the workers involved and the information made available to them;
- the gathering of information, in writing, about hazards and preventive measures to be taken prior to work in a confined space;
- the use of ventilation to maintain acceptable atmospheric conditions (i.e. oxygen, contaminants, lower explosive limit);
- the management of combustible dusts presenting a fire or explosion hazard, and hot work;
- gas monitoring and measurement;
- mandatory supervision;
- tested rescue procedures that make rapid rescue possible;
- prohibition of entry into a confined space if a filling or emptying operation involving free-flow materials is under way;
- mandatory wearing of a safety harness and its attachment to a lifeline if free-flow materials are stored in the confined space.

In addition, Canadian standard CSA Z1006-10 and American standard ANSI/ASSE: Z117.1-2009 on confined spaces provide guidelines regarding the management program to be put in place, roles and responsibilities of those involved, related planning (e.g. training, emergency response plan), and program implementation (e.g. entry permits). Risk management consists of identifying hazards, assessing risks, and introducing adequate control measures. The Canadian standard defines risk assessment as "a comprehensive evaluation of the probability and degree of possible injury or damage to health in a hazardous situation, undertaken to select appropriate controls" (Canadian Standards Association, 2010). Control measures must be chosen in accordance with the following priority: (i) elimination of the hazards by design, (ii) reduction of the frequency of exposure to risks or potential harm by the use of less hazardous methods, (iii) integration of engineering controls (guards, alarms, etc.), (iv) application of administrative controls (e.g. procedures), and (v) provision of personal protective equipment (International Organization for Standardization, 2009; ANSI/ASSE, 2011). Safety design is the most effective risk reduction method and should always be favored despite the challenges involved (Fadier and De la Garza, 2006; Hale et al., 2007).

However, when confronted with the actual constraints and limited resources in the field, all these regulatory and normative measures can prove difficult to implement. For example, when assessing the risks associated with confined spaces, theoretically the following points must be taken into account: (i) the physical characteristics, configuration, and location of the confined space, (ii) the past use and contents of the confined space, (iii) the work to be carried out and duration of the intervention, (iv) the number of entrants and their physical and psychological condition, (v) interactions among the various hazards, (vi) variations in conditions over time, and (vii) rescue conditions (ANSI/ASSE, 2009; Burlet-Vienney et al., 2014). In addition, the problem of delays in firefighters' interventions during rescue operations in confined spaces was raised by Wilson et al. (2012), as were problems with the identification of risks in certain situations: ocean transportation of wood pallets (Svedberg et al., 2008), aircraft fuel tank repair (Carlton and Smith, 2000), shielded metal arc welding in an enclosed area (Harris et al., 2005) or work in a vessel of a gas carrier (Lucas et al., 2010).

The primary aim of this study was therefore to examine how organizations in Quebec manage risks associated with confined space interventions. Another aim was to propose a generic entry permit that incorporates an exhaustive list of risk factors to be considered prior to a confined space intervention. To achieve these aims, fatal work accidents occurring in confined spaces in Quebec between 1998 and 2011 and the risk-management practices of 15 Quebec organizations were investigated. This work provides a better understanding of the risk factors and risk management practices associated with confined spaces.

## 2. Methods

### 2.1. Fatal work accidents in Quebec – selection criteria

The database of the provincial workers' compensation board (known as the Commission en santé et en sécurité du travail du Québec, or the CSST), which insures 85% of the active workforce, was consulted in September 2013 (CSST, 2014) in order to compile statistics on fatal work accidents occurring in confined spaces between 1998 and 2011 in Quebec. The CSST investigates all fatal accidents that occur within the province and fall under its jurisdiction, with the exception of road accidents and assaults.

The originality of this study lies in the fact that all the investigation reports for serious and fatal accidents (819) occurring during the target period were consulted. No keyword extraction was performed, as it generally excludes certain confined space accidents unrelated to atmospheric hazards. The reports pertaining to confined space interventions were selected on the basis of the definition of confined space provided in section 1 of Quebec's *Regulation respecting occupational health and safety* (ROHS).[1] Two researchers performed the selection for the most contentious cases. The analysis of the accident investigation reports concerned primarily the (i) date of the event, (ii) industry sector, (iii) type of confined space, (iv) main causes, (v) presence of work and rescue procedures, and (vi) design-related elements.

Thirty-two investigation reports were retained for the target period, i.e. approximately 4% of the files consulted (32/819). These events caused the deaths of 40 people, or an average of almost three deaths a year. Nearly 20% (6/32) of these events caused multiple deaths, three involving rescue attempts and three others involving several entrants who were carrying out work at the time of the accident. The 40 people involved in these accidents included two employers, six managers, 31 operators/technicians, and one outside observer.

As shown in Fig. 1, there appears to be a downward trend in the number of deaths per year, with 28 deaths occurring between 1998 and 2004 and only 12 deaths over the same number of years between 2005 and 2011. The introduction in 2001 into Quebec's ROHS of sections on work in confined spaces may have significantly influenced this decline.

An analysis of all occupational injuries in confined spaces in Quebec, not just fatal accidents, was planned for the purpose of obtaining complementary information. However, the coding of the details on the confined space work situations did not allow for such an analysis, thus depriving both OHS personnel and researchers of an important source of data on this topic.

[1] Any area that is completely or partially enclosed, especially a reservoir, a silo, a vat, a hopper, a chamber, a vault, a tank, a sewer including a ditch and a temporary manure storage ditch, a pipe, a chimney, an access shaft, a truck or freight car tank, which has the following inherent conditions: (1) is not designed for human occupation, nor intended to be, but may occasionally be occupied for the performance of work; (2) access to which can only be had by a restricted entrance/exit; (3) can represent a risk for the health and safety of anyone who enters, owing to any one of the following factors: (*a*) its design, construction or location, except for the entrance/exit provided for in paragraph 2; (*b*) its atmosphere or insufficiency of natural or mechanical ventilation; (*c*) the materials or substances that it contains; (*d*) or other related hazards.