Risk Informed Decision Making by a Public Safety Regulatory Authority in Canada: A Case Study involving Risk Based Scheduling of Periodic Inspections

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ABSTRACT

The Technical Standards and Safety Authority (TSSA) is an independent, not-for-profit organization that administers and enforces public safety laws associated with Amusement Devices, Elevating Devices, Boilers and Pressure Vessels, Fuels, Operating Engineers, and Upholstery and Stuffed Articles, under Ontario's Technical Standards and Safety Act through an administrative agreement with the province of Ontario in Canada. TSSA has introduced a risk informed decision-making framework across a wide variety of safety activities in each of the regulated sectors. One of these activities involves periodic engineering inspections of facilities and equipment during operation to ensure that the devices continue to operate safely. The inspection process reviews how the equipment and technology are being used, operated and maintained, and identifies any non-compliance to safety codes and regulations. TSSA has designed and implemented risk-based inspection scheduling models across most of its industry sectors to ensure that devices that present the highest risk to the public are inspected more often while low-risk units are assigned longer inspection cycles. The model development and implementation was carried out in three stages: 1) Concept development based on identification of risk factors representing the devices and equipment, human-device interaction, and location; 2) Model design using a semi-quantitative risk assessment approach; and 3) Implementation, including automated scheduling, monitoring, and measurement. This presentation will describe the three stages with specific reference to the model developed for the elevating devices sector.

INTRODUCTION

TSSA is a self-funded, not-for-profit safety organization that was created by the Government of Ontario in 1996 and delegated by the provincial Ministry of Consumer & Business Services to administer and enforce public safety legislation within the province. Specifically, TSSA administers the Technical Standards and Safety Act of Ontario (1).

The Authority delivers its risk-based, prevention-oriented safety services throughout the province, which encompasses a geographic area larger than France and Spain combined. Ontario is ethnically diverse, with a population of more than 12 million. Within its borders, TSSA regulates safety in the following sectors:

- amusement rides;
- elevators, escalators and ski lifts;
- hydrocarbon fuels (natural gas, petroleum, propane);

- boilers, pressure vessels and operating engineers (individuals who maintain power plants and associated equipment);
- upholstered and stuffed articles, such as mattresses and plush toys.

In carrying out its mandate, the Authority delivers a variety of services, the most resource-intensive of which is the inspection of facilities and equipment—when they are manufactured, during installation and periodically, while they are in operation.

TSSA's activities that cover both mandated core activities and voluntary preventive services include:

- Inspection of facilities and equipment
- Auditing of equipment manufacturers to ensure conformance with quality assurance requirements
- Review and registration of engineering designs
- Training and Certification of trades-persons operating in the regulated sectors
- Licensing regulated facilities and equipment, registering contractors
- Investigation of incidents, issuing directives and prosecution
- Participation in Codes, Standards and Regulations development and amendment
- Training and education on safe practices for both the public and industry personnel

TSSA has evolved its public safety management model with the introduction of a risk informed decision making (RIDM) framework that aims to utilize sound risk management principles as a key element of its public safety decision making process. As a result, TSSA is at various stages of integrating risk assessment processes into our core activities such as inspections and investigations. This paper discusses one such application that deals with TSSA periodic inspection activity involving planning inspections of devices and equipment in some the safety sectors that it regulates.

Specifically, TSSA's *Risk-Based Inspection Model* currently implemented in the Elevating Devices and partly in the Fuels Sector is illustrated as an example of an activity that uses risk assessment processes to assist in effectively and efficiently scheduling planned inspections on the basis of the levels of risk posed by the devices and facilities.

THE RISK MANAGEMENT PROBLEM - SCHEDULING PERIODIC INSPECTIONS

Periodic inspections refer to those activities undertaken by TSSA inspectors that involve reviews of the usage, operation and maintenance of equipment and technology that are under regulatory purview and identifies any non-compliance to safety codes and regulations. The necessity for establishing intervals for such inspections is critical in ensuring safe operations of the equipment and technology. The significance of establishing intervals is highlighted in the regulations under the Technical Standards and Safety Act. An example of one such requirement is depicted in the Elevating Devices Regulation, O. Reg. 209/01, s. 44 (1). It states that "*An elevating device shall be inspected by an inspector at such intervals as may be determined by the director for the purpose of ensuring the safe operation of the device*".

The other significant reasons for scheduling periodic inspections include:

- Enhance risk information by obtaining timely, accurate information regarding the locations and devices we inspect;
- Maintain focus of inspections on the highest risk sites and equipment;
- Effectively manage available human resources through better planning and efficiency.

TSSA is responsible for regulating the following devices:

- 175,000 boilers and pressure vessels
- 15,000 operating engineers and operators
- 800 amusement devices
- 41,000 elevators
- 1,800 escalators
- 225 ski lifts
- 120,000 km of liquid and gaseous fuels pipelines
- 9,200 retail gas stations
- 7,600 licensed fuel storage & dispensing sites
- All residential fuels appliances in Ontario (including home furnaces and hot-water heaters)

When the Ontario Government first created TSSA, the original strength of 140 safety inspectors were unable to inspect all devices in all regulated industry sectors to a high level of service quality. It was recognized that the greatest organizational challenge was to learn how to maximize the effectiveness of these limited resources to assess and reduce public safety risk.

PROPOSED RISK MANAGEMENT SOLUTION

The scheduling challenge was addressed by developing and implementing *Risk-Based Inspection Models* that help the inspectors focus their attention on facilities and devices that pose the highest safety risk. Due to the complexity and differing levels of maturities of industry in safety management, this concept has been introduced in a phased manner across the sectors. Elevating devices and some elements of the fuels sector currently have fully implemented models in place. While the implementation of the original model for elevating devices occurred in 1996, significant enhancements including the assignment of levels of risk were made to model in FY2005. The model in the fuels sector was implemented in FY2005 as well. Similar models in other sectors are being introduced periodically. These models have four major components.

Component 1: Risk information database

To understand the inspection needs of the industry sectors for which TSSA is responsible, an information database to collect and store detailed, high-quality risk information on relevant devices and facilities was developed and maintained on TSSA Information System. This Information System consists of both a mainframe component called POSSE, and remote access software called RANGER. Risk information collected includes:

- equipment characteristics, such as type and age of equipment, type of operation, etc.;
- human characteristics, such as deficiencies in overall operation and maintenance of equipment, level of operator training; and,
- location characteristics, such as the physical environment.

Fig. 1 provides a snapshot of the POSSE/Ranger screen associated with the information collected by the inspector during the inspections.

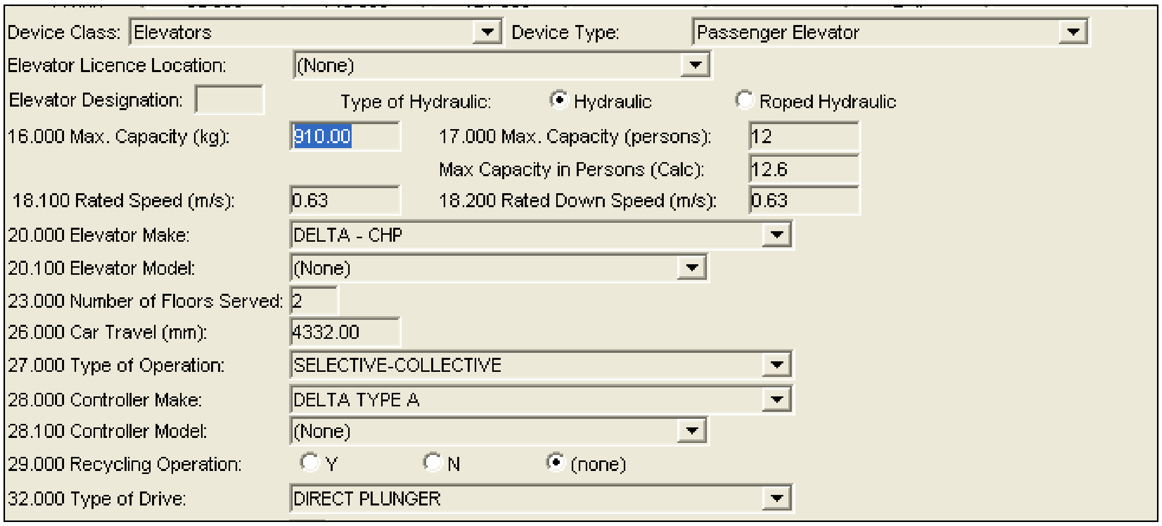
Device Class: Elevators
Device Type: Passenger Elevator
Elevator Licence Location: (None)
Elevator Designation:
Type of Hydraulic: Hydraulic / Roped Hydraulic
16.000 Max. Capacity (kg): 910.00
17.000 Max. Capacity (persons): 12
Max Capacity in Persons (Calc): 12.6
18.100 Rated Speed (m/s): 0.63
18.200 Rated Down Speed (m/s): 0.63
20.000 Elevator Make: DELTA - CHP
20.100 Elevator Model: (None)
23.000 Number of Floors Served: 2
26.000 Car Travel (mm): 4332.00
27.000 Type of Operation: SELECTIVE-COLLECTIVE
28.000 Controller Make: DELTA TYPE A
28.100 Controller Model: (None)
29.000 Recycling Operation: Y / N / (none)
32.000 Type of Drive: DIRECT PLUNGER

Fig. 1. Screen snapshot from inspection database

Component 2: Risk Assessment

TSSA risk and business analysis functions use information collected in the database to analyze and classify each site as to its potential risk to the public. For instance, as the agency responsible for elevator safety inspections in Ontario, each elevator is assigned a specific level of risk on the basis of factors that include:

- age of the elevator;
- quality of contractor maintenance measured a function of the number of safety directives issued to them over a defined period and the number of devices maintained by them during this period;
- frequency and severity of safety problems found as indicated by the safety directives issued to them and hazard ranking methodology; and,
- type of building in which the elevator is operating.

These risk factors are scored for every device in question using rating criteria developed on the basis of the anticipated impact on the overall level of risk. The determination of the rating criteria are based on historical information such as incidents or engineering judgment.

Component 3: Translating Risk Scores to Inspection Cycles

Devices are categorized into 5 different risk categories based on a 5x5 risk matrix concept. Each of the categories is assigned an inspection cycle that is optimally established using boundary conditions related to the earliest and latest possible inspection frequencies. The boundary conditions vary from program to program and in some cases are specified in the regulations.

Based on the combination of risk scores and inspection associated cycles, and the last inspection date, Inspectors receive an inspection schedule determined by means of a computer algorithm in POSSE and next scheduled inspection date associated with the devices. These schedules are automatically generated and assigned to inspectors based on their geographic regions.

Fig. 2 provides a illustrative representation of the estimation of the next inspection date for a particular device that has been recently inspected. As discussed earlier, the next inspection date is a key outcome of the model that is calculated based on the risk factors information assigned by an inspector during the current inspection of the device in question.

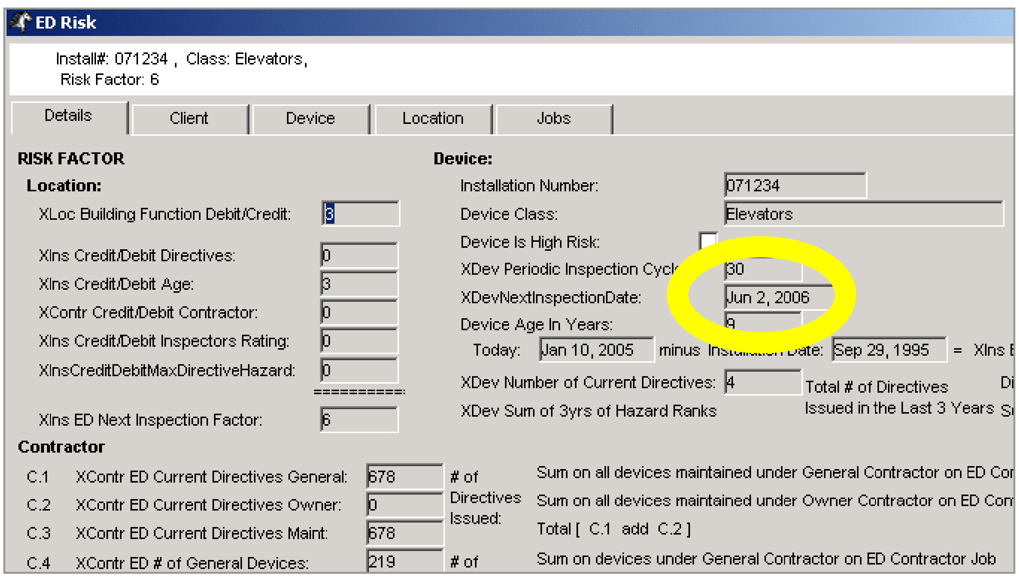

Fig. 2. Screen snapshot from inspection database

The intervals of TSSA inspection for these high-risk elevators can be as short as six months in the worst cases. Conversely, lower risk elevators can be inspected at intervals as long as three years.

Component 4: Real-time monitoring

Our ability to transfer information back and forth from the field helps ensure that our assessment of risk remains real-time and accurate. When risk levels change, the frequency of inspection is adjusted accordingly. This ensures greater accuracy in future inspection scheduling.

Inspectors modify and update risks for devices as they inspect, using our remote access RANGER software. Furthermore, any critical safety problem immediately generates a follow-up inspection to ensure regulatory compliance.

The ability to maintain a current risk profile of devices also gives a safety incentive to building owners. Since a building owner pays for elevator inspections, the possibility of being inspected less frequently is a financial incentive to safe elevator operation and maintenance.

PERFORMANCE METRICS USED TO MEASURE RESULTS

Before the development of inspection models, no metrics existed to measure the quality and impact of inspections. The current model has the capability of generating certain indicators to evaluate and monitor the quality and consequences of periodic inspections.

The five major metrics some of which are under development—information on safety risks, inspection focus, level of resource planning, resource efficiency and level of safety improvement —are discussed in this section.

Information on Safety Risks

TSSA's ability to identify and assess safety risks are dependent on the information available. TSSA has recently begun analyzing the information gathered through its inspection activity particularly in trying to understand cause-effect relationship when directives are used. This would help TSSA in enhancing its safety decision making and addressing cause of non-compliances.

TSSA publishes the *State of Safety Report* annually to outline major safety risks in each sector and the various risk control activities undertaken to address these risks. This report is available on the website (http://www.tssa.org/about_tssa/pdf/2003SOPS.pdf) and in hard copy.

Inspection Focus

This metric provides information on the focus of inspection efforts with regards to highest risk sites and devices. Before the model was developed, inspectors chose sites and devices for inspection at random. The risk-based focus of the model, however, categorizes all sites and devices on the basis of the risk they pose to public safety. As a result, inspectors are assigned sites and associated inspection according to risk.

For example, in the fiscal year 2005, 886 out of 43,818 active elevators in Ontario were assessed at the highest level of risk, based on risk factors such as age, previous inspection history and quality of maintenance. Prior to the implementation of the inspection model these highest-risk elevators would have been inspected on average every two years, as were all other elevators no matter what the level of risk. In the current fiscal year, TSSA has inspected the highest-risk elevators every six months: lowest-risk units every three years.

In another example, 737 of 43,818 active elevators are deemed to be at the lowest level of risk.

Fig. 3 provides the current risk profile of all elevating devices in terms of the current frequency of inspections. As evident, over 55% of the devices have a current inspection cycle of 24 months or above. Correspondingly, this means that a majority of devices fall under the acceptable level of risk category.

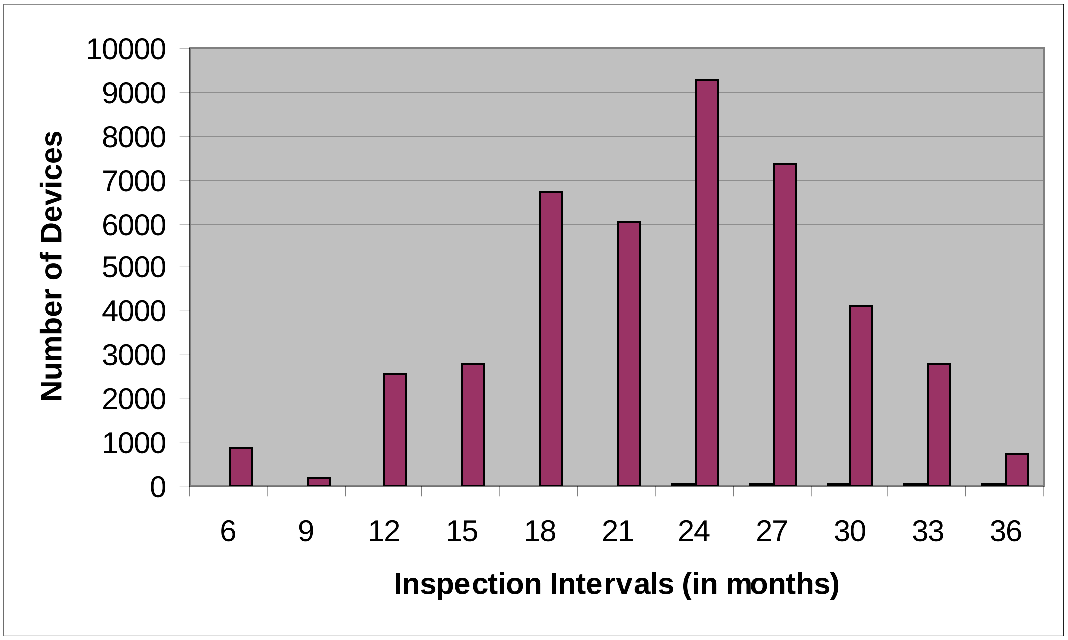

Fig. 3. Distribution of risk-based inspection intervals (in months) for all elevating devices – FY 2005

Better resource planning

Metrics are in place to demonstrate that resources allocated as per the risk-based inspection models are successfully applied. TSSA calculates the percentage inspections scheduled by our risk-based model. This allows us to monitor the level of planned versus unplanned resources.

For example, 98.5% of completed TSSA inspections were scheduled (by the risk model) during the period until November of 2004 while only 1.5% of inspections were unscheduled. Before TSSA developed the risk-based inspection model, all inspections were unscheduled.

Better resource efficiency

The key metric that measures resource efficiency is the average number of inspections per inspector. Also, the development of software to manage risk-based inspections, such as RANGER, has streamlined the workflow process for inspectors, thereby improving the efficiency of inspections.

The average number of periodic inspections per inspector has increased by 15% since 2001 (at an annualized rate of 5%), indicating an improvement in resource efficiency resulting from risk-focused inspections.

Furthermore, while the number of full-time TSSA inspectors has not changed during this period, the number of devices in the province of Ontario has increased annually by almost 2.2%.

CONCLUSION

TSSA's risk-based inspection models have greatly increased the quality of the Authority's safety inspection work over the past eight years and have allowed it to better fulfill its mandate. These models have permitted the TSSA to operate effectively (despite a growth in the number of regulated installations) with resources that have remained largely stable over the past eight years.

REFERENCE

1. Technical Standards and Safety Act, 2000, Queen's Printer for Ontario (2001).