TECHNICAL APPENDICES

TSSA PUBLIC SAFETY REPORT 2020

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Appendix I – Enhancements

In keeping with its commitment to continuous improvement and based on feedback from stakeholders (e.g., feedback obtained from board and advisory council presentations), TSSA continues to enhance the structure and style of its reporting. Based on new information and data, TSSA also enhances its processes and methodologies in analysis and reporting. Changes to this year's *Public Safety Report* affecting the results of analysis are discussed below. Structural changes are not identified, as they are considered as enhancements to the readability of the report and do not impact the analysis.

Updates:

1. The Upholstered and Stuffed Articles Program was revoked on July 1, 2019 and is, therefore, no longer included in the *Public Safety Report.*
2. The data used for the Risk of Injury or Fatality (RIF) calculation has changed. In previous editions of the *Public Safety Report,* cumulative data since fiscal year 2008 was used. To better reflect the current state of safety in Ontario, starting this edition, a 10-year period will be in effect.
3. Compliance calculations will continue to be based on a rolling five-year period. However, the compliance calculation will now be based on the mean (or average), not the median, to give a more realistic representation of the data.
4. The Boilers and Pressure Vessels (BPV) compliance rate data was removed because it was felt that it did not present a true and complete picture of the industry in Ontario.
5. TSSA's risk sources triangle has been simplified from actionable, enhanced monitoring, and core activities to high risk, medium risk and low risk.
6. Inspection risk spectrums have been simplified from a continuous multi-coloured spectrum to high risk, medium risk and low risk.
7. The title of the report has changed from the *Annual State of Public Safety Report* to *Public Safety Report*.
8. The format of the *Public Safety Report* has changed. It has been divided into three parts: a core report, featuring summary dashboards, case studies and director messages; a data tables section, featuring mostly data and figures; and a technical appendices section, featuring methodology and background information.

New Information:

1. Amusement devices and passenger ropeways (ski lifts) had operational compliance information added to their respective sections, in addition to the periodic compliance information. These devices interact with the public via an operator who have to be compliant with the codes and regulations. A good fraction of the incidents related to compliance are due to operator error rather than equipment failure, thus ensuring that the devices are operating in a compliant way is an important safety control.

Appendix J – List of Acronyms

CAD	Code Adoption Document
CO	Carbon Monoxide
DALY	Disability-Adjusted Life Year
FE/mpy	Fatality Equivalent(s)/million people/year
IDRCA	In-Depth Root Cause Analysis
PSRM	Public Safety Risk Management
RBS	Risk-Based Scheduling
RCA	Root Cause Analysis
RIDM	Risk-Informed Decision Making
RIF	Risk of Injury or Fatality
RSMP	Risk and Safety Management Plan
TTC	Time to Compliance

Appendix K – Glossary of Terms

Area of High Risk	This is a risk source that requires mitigating actions because it exceeds the risk acceptability criteria for either the general population (1.00 FE/mpy) or for sensitive sub-populations (0.30 FE/mpy). TSSA identifies these risk sources as safety issues that require risk management strategies. These strategies can include regulatory actions (such as Director's Orders), as well as advisories and bulletins, collaborative partnerships with stakeholders and public education.
Area of Medium Risk	When a risk source approaches the risk acceptability criteria, TSSA utilizes enhanced monitoring. TSSA considers these risk sources to be potentially emerging areas of risk and are monitored (including investigating specific incidents in the affected program area) and/or addressed through mitigation strategies.
Code Adoption Document (CAD)	The default regulatory instrument for mandatory requirements of general application, such as the adoption of codes and standards. This instrument is used to identify and communicate changes to TSSA-specific requirements.
Compliance Rate	The percentage of periodic inspections compliant with the *Technical Standards and Safety Act, 2000* (the Act) and its associated regulations.
Director's Order	A regulatory decision made by a statutory director under the powers given to him/her as per the Act. **Director's Order, Limited Use (s. 27)** Places limits on the operation of a thing that is found to be defective or to not comply with the conditions of its authorization after the thing is fabricated or installed. 27. *A director may,* *(a) establish the limits of operation and use of things that are found to be defective or do not conform with its authorization after fabrication or installation;* *(b) permit the operation and use of such thing within such limits as are prescribed, or if there are no such limits, as the director considers safe.* **Director's Order, Public Safety (s. 31)** Used only where there is or may be a demonstrable threat to public safety and the subject matter has not otherwise been provided for in the Act or its associated regulations. It can require regulation, use or disuse of specified things. 31. *In cases where there is or may be a demonstrable threat to public safety, a director may make an order with respect to the following matters if they have not otherwise been provided for in this Act, the regulations or a Minister's order:* *1. Requiring and establishing the form and location of notices, markings or other forms of identification to be used in conjunction with equipment or other things that are prescribed.* *2. Regulating, governing and providing for the authorization of the design, fabrication, processing, handling, installation, operation, access, use, repair, maintenance, inspection, location, construction, removing, alteration, service, testing, filling, replacement, blocking, dismantling, destruction, removal from service and transportation of any thing, whether new or used, or a part of a thing and any equipment or attachment used in connection with it.*
Disability-Adjusted Life Year (DALY)	A DALY of 1.0 is the loss of one year of healthy life of a single person due to an injury. Please see Appendix M for a full description. **Injury Burden** Quantified health impact determined by integrating injuries and fatalities observed across the population exposed to TSSA-regulated devices/technologies over a period of time. The DALY metric is used to combine injuries and fatalities into a single metric. The injury burden is expressed in the units of fatality-equivalents per exposed population (in millions) per year. Refer to Appendix M for additional details.

External Factors	Safety impact related to failures associated with factors outside the direct control of TSSA's safety system (e.g. behaviour of users/consumers of technologies and devices in lieu of their intended use, environmental/weather conditions, utility failures, etc.). Refer to Appendix O for additional details.
Fatality-Equivalent (FE)	A unit of measure obtained by integrating quantified health impacts into a single count of equivalent fatalities for benchmarking and decision-making purposes. Injury burden and Risk of Injury or Fatality are expressed in terms of Fatality-Equivalents (FEs). Refer to Appendix M for additional details.
Fiscal Year	Represents TSSA's fiscal year (May 1 – April 30), e.g., 2020 represents fiscal year 2020 (May 1, 2019 – April 30, 2020)
Health Impact	Refers qualitatively to injuries or fatalities sustained by the public exposed to TSSA-regulated devices/technologies. A health impact could be one of fatal, permanent or non-permanent injuries. **Permanent Injury** An injury sustained by an individual that partially or totally impairs the normal abilities of that individual for the rest of his/her expected remaining life. **Non-Permanent Injury** The consequence of an incident occurrence wherein there was an observed health impact that was estimated to be non-permanent based on the nature of the injury and its associated severity using a methodology developed by the World Health Organization (WHO). A non-permanent injury has no significant impact on the individual's life expectancy at the time of injury.
In-Depth Root Cause Analysis (IDRCA)	This formal approach, *In-Depth Root Cause Analysis (IDRCA),* uses Root Cause Analysis (RCA) principles to determine and document underlying causes related to occurrences under the TSSA regulatory mandate but with additional focus and effort. **Root Cause Analysis (RCA)** A method of problem solving using a specified range of approaches, tools and techniques to uncover the most basic reason (underlying cause) for an occurrence that can be reasonably identified. Refer to Appendix P for further details.
Incident Management System	A structured framework that translates the legislated regulatory responsibilities of TSSA, specifically as it pertains to incident investigations into a management system. This management system contains policies, procedures, roles and responsibilities and associated processes that enable the receipt, investigation and analysis of reported incidents and near-miss occurrences.
Incident Management Information System	A public safety decision-support information tool that enables TSSA to document the receipt, dispatch, investigation and analysis of reported incidents and near-miss occurrences and forms a component of the Incident Management System.
Inspection	An official examination of a device, system or procedure conducted by an inspector under the Act in accordance with Section 17 of the Act.

Inspection Order	The authority to issue an order comes from Section 21 of the Act and is served by an inspector to one who contravenes and/or who corrects a contravention to the Act or its associated regulations. Under this section, an inspector may also seal anything with respect to amusement devices, boilers and pressure vessels, elevating devices, fuels, operating engineers, as referred to in the regulations. Where there is or may be a demonstrable threat to public safety, whether or not the thing is subject to an authorization, an inspection order includes the specific nature of identified contravention, the conditions and actions to be taken to correct the contravention and the allowable time to comply for each identified contravention. Orders can be classified into high-, medium-, and low-risk categories, which statutory directors can define to suit the needs of their program area. With the exception of Operating Engineers, the classifications are defined below. Please see Appendix R for additional details. **High-Risk Inspection Order** Issued where noncompliance is identified and warrants an inspection order for immediate action within 0 to 10 days, for time to compliance to regulatory requirements. **Medium-Risk Inspection Order** Issued where noncompliance is identified and warrants an inspection order for action within 11 to 60 days, for time to compliance to regulatory requirements. **Low-Risk Inspection Order** Issued where a noncompliance is identified and warrants an inspection order for action within 90 days, for time to compliance to regulatory requirements.
Noncompliance with the Regulatory System	Safety impact associated with the violation of established regulatory controls (e.g., TSSA-enforced regulations). Refer to Appendix O for additional details.
Occurrence	The realization of a hazard which results in, or has the potential to result in, a consequence to people or property. **Incident** An occurrence involving a system/device/component/tradesperson under TSSA's jurisdiction, whereby a hazard is exposed resulting in a consequence to people or property. **Near-Miss** An occurrence involving a system/device/component/tradesperson under TSSA's jurisdiction, whereby a hazard is exposed demonstrating an instance of elevated exposure to risk, while in this particular instance resulting in no consequence to people or property.

Occurrence Involving…	**Door Closing** - A consequence that could result when elevator doors close and impact a user who is entering or exiting an elevator or attempting to prevent the doors from closing. **Entanglement** - A consequence that could result when a user's ski equipment becomes crossed, causing them to lose balance. Applies only to ski lifts. **Entrapment** – This depends on context. A consequence that could result when a user's clothing, footwear or accessories becomes caught in the moving parts of a device. Applies to amusement devices, elevators, escalators and moving walks and ski lifts. Can also refer to being stranded in an elevator. **Levelling** - A consequence that could result when an elevator does not level at the floor landing thereby creating a tripping hazard. **Physical Impact** - A consequence that could result when a user of a device comes into contact with the device (e.g. falling roof tiles on an elevator car). Applies to amusement devices, elevators, escalators and moving walks and ski lifts. **Trips or Falls** - A consequence that could result when a user of a device stumbles or falls upon entry into or exit from a device. Applies to amusement devices, elevators, escalators and moving walks and ski lifts.
Operational Risk	Potential risk of injury or fatality associated with the operation and maintenance of things or class of things regulated under the Act and does not account for sources of risks manifested during the design and installation stages. Operational Risk considers only those risks that can be observed during an inspection and can be addressed through the issuance of inspection orders. **High, Medium, Low Operational Risk** High-, medium-, and low-risk devices/facilities are those with inspection intervals of 6 months, 6 to 24 months and greater than or equal to 24 months respectively.
Periodic Inspection	An inspection conducted at such intervals as may be determined by the statutory director, risk-based scheduling (where applicable), or required by code or regulation for the purpose of ensuring the safe operation of the device/facility.
Potential Gaps in Regulatory System	Safety impact associated with gaps in the regulatory system or where no regulatory control exists. Refer to Appendix O for additional details.
Risk	The combination of the probability of occurrence of harm from a thing or a class of things under Section 2 of the Act and the severity of that harm.
Risk-Informed Decision Making	An approach to regulatory decision making, in which insights from probabilistic risk assessments are considered with other engineering insights. The risk-informed approach has been a key element in our regulatory success, allowing TSSA to: • Understand the nature of public safety risks; • Quickly develop preventative strategies to address safety hazards; • Target activity where it will have the greatest impact on risk; and • Improve safety outcomes generally. Refer to Appendix L for more information.

Risk of Injury or Fatality (RIF)	The injury burden predicted using a simulation model to combine the probability of occurrence of harm (estimated as occurrence rates) to someone interacting or exposed to TSSA-regulated devices/ technologies and severity of that harm. The Risk of Injury or Fatality (RIF) metric is expressed in fatality-equivalents per exposed population (expressed in millions) per year (FE/mpy). This measure of risk accounts for historical occurrences while taking into consideration the uncertainties and variability inherent in the involved parameters such as the occurrence rate, number of victims, age of each victim and types of injuries sustained. Refer to Appendix M for additional details. **Composite Risk of Injury or Fatality** A single quantified measure of risk of injury or fatality across TSSA-regulated sectors in Ontario. The estimate is only for reporting purposes and may be used for benchmarking.
Sensitive Sub populations	Populations with persons more at risk than the general population because they are less able to respond to an occurrence (e.g., in schools, retirement and long-term care homes, etc.).
Time to Compliance (TTC)	The time required for a client to have the work completed as specified in a TSSA inspector's order due to a deficiency found during an inspection. Also known as time to comply.
Trend	A statistically representative measure for the noticeable tendency or movement toward, or in, a particular direction over a measured period of time (e.g. positive trend, negative trend and no significant quarterly trend). Refer to Appendix M for additional details.

Appendix L – Risk-Informed Decision Making at TSSA

Introduction

TSSA statutory directors have general supervisory and administrative responsibility of the Act and its associated regulations to ensure the safety of Ontarians.

The *Public Safety Report* is a key component of TSSA's Risk-Informed Decision Making (RIDM) framework and provides information on the state of safety of Ontarians interacting with TSSA-regulated technologies. The *Public Safety Report* is also a public document that describes the safety strategies established by the statutory directors and those responsible for preventative and educational tools to enhance safety and reduce the risk of injury or fatality to Ontarians.

Initiated in 2007, TSSA's RIDM framework is an evidence-based, scientific approach to identifying, analyzing, measuring and managing the Risk of Injury and Fatality (RIF) to Ontarians caused through interaction with TSSA-regulated technologies, devices and products. It is a framework to assist in the effective use of available regulatory tools under the Act, through efficient allocation of TSSA's resources, and leveraging partnerships with stakeholders. As a framework, it continues to evolve to align with and lead best practices around the world.

Reducing Risks – Understanding and Managing Causes and Behaviours

The RIF to Ontarians across the different TSSA-regulated sectors is estimated primarily using information gathered through reported and investigated occurrences (incidents and near-misses) and complemented with information collected through TSSA's inspections and other regulatory oversight tools. The information collected allows TSSA to analyze the primary causes associated with occurrences, and helps statutory directors establish and implement strategies aimed at reducing risks.

The process to address risks to Ontarians is a three-stage process comprised of:

1. Risk identification (through cause categorization);
2. Risk assessment; and
3. Risk management.

This process represents the public safety risk management framework and is illustrated in Figure L1.

Figure L1: Public Safety Risk Management Framework[1]

Risk Identification	Potential Gaps in the Regulatory System: Identification of potential hazards and gaps in regulation that can be introduced by new or current technologies.
	Non-Compliance with Regulatory Systems: Identification of potential hazards by using TSSA's regulatory oversight tools for possible introduction and/or enhancement.
	External Factors: Identification of potential hazards from Human-User and Environmental factors as well as RCA exercises.
Risk Assessment	Occurrence & Injury Counts , Occurrence and Injury Trends, Observed Injury Burden, Risk of Injury or Fatality
	Compliance Rate, Compliance Trends, Inventory Risk Profile, Inspection Risk Spectrum
Risk Management	Director's Orders, Safety Orders, Code Adoption Amendments, Regulation Changes
	Risk-Based Periodic Inspections, Issued Orders
	User-Behaviour Research, Public Education Campaigns, Advocacy initiatives
	Engineering Reviews, Variance Reviews
	Audits, Targeted Inspections
	Compliance Support, Safety Advisories, Risk-Reduction Groups
	Enforcement

[1] Depending upon the nature of the risk, TSSA considers a variety of tools, such as regulation changes, technological solutions, enforcement activities, and public education to help best manage public safety risks.

1. Risk Identification

Risk is identified and then segmented into one of three primary causal categories to aid downstream strategy development and implementation. These causal categories, identified in Figure L1 and as defined in Appendix O, include the following:

Potential Gaps in Regulatory System

Advancements in regulated sectors, including emerging technologies lacking adequate regulatory oversight (including codes and standards), form one aspect of this category. Risks in such cases are typically unknown or may not be estimated due to limited data availability. However, the potential hazards with such technologies may be known or ascertained.

A subset of this category involves safety gaps that are inadequately addressed by the current regulatory system. Examples include technologies designed to older codes and standards that may be prone to fail over time.

In both cases, TSSA may be able to address the gaps through interim tools such as Director's Orders. In certain instances, TSSA may recommend the need to affect changes to regulations.

Noncompliance with Regulatory System

This category of occurrences results from actions not compliant with the regulatory requirements by those statutorily responsible for the design, manufacture, installation, operation, user interaction and/or maintenance of TSSA-regulated technologies. The level of understanding, education, required skills and training of these regulated stakeholders or responsible parties, such as owners of technologies, and installation and maintenance technicians, along with their intent to comply, affects this category of risks.

The level of regulatory oversight varies from program to program. In most instances, the regulatory expectations of TSSA are specified in the Act and its associated regulations. A key oversight function involves TSSA conducting initial and periodic inspections of devices before and during their operation.

Risks falling in this category are identified and reduced through the introduction and/or enhancement of TSSA's existing regulatory oversight tools. Increasing levels of risk in this category may require the introduction, expansion or modification of existing TSSA regulatory oversight powers such as inspections and audits. Another important regulatory tool to manage significant risks involves the use of Director's Orders and, in certain instances, regulatory changes may also be recommended. TSSA may also use advocacy tools and form collaborative partnerships with relevant stakeholders such as other government agencies, like-minded (or focused) safety organizations/associations, regulated sectors and affected parties, to raise awareness and influence behavioral change and compliance.

External Factors

Occurrences can take place despite the presence of an adequate regulatory management system. Risks in this category are typically caused by users' (such as the public) interactions with TSSA-regulated technologies. A comprehensive understanding of human factors helps TSSA set up appropriate public education/safety advocacy tools through collaborative partnerships with stakeholders including consumer advocacy groups, regulated sectors, safety organizations, etc., to reduce risk in this category.

Other reasons include environmental factors, such as weather, deliberate intent or sabotage, occurrences involving TSSA-regulated technologies but due to factors outside of TSSA's jurisdiction, etc. Typically, in such cases, other regulatory agencies may take on primary investigation and management of the risks with TSSA's technical support and expertise. In rare circumstances, changes may be made to regulatory tools to address risk.

In certain circumstances, a formal approach entitled *In-Depth Root Cause Analysis (IDRCA)* is used, which relies on Root Cause Analysis (RCA) principles to determine and document underlying causes related to occurrences under TSSA's regulatory mandate but with additional focus and effort. For additional details on this methodology, refer to Appendix P.

2. Risk Assessment

The RIF across TSSA's regulated sectors is the primary method of estimating risk to Ontarians. The RIF method uses information gathered through reported and investigated occurrences (i.e., both incidents and near-misses) and associated injuries. This information is analyzed quantitatively using an approach that integrates predictive analytics with simulations to estimate the potential risk that would be sustained by Ontarians from exposure to regulated technologies.

TSSA's risk assessment involves the collection of information through inspections conducted on regulated technologies, and other regulatory oversight tools. Noncompliance information from inspections is used to generate compliance metrics, such as the compliance rate, inspection risk spectrum and the inventory risk profile.

The intent of the risk assessment component is to assess the risk of a given source. The quantitative aspect of risk is delivered through measurement using the RIF and supplemented with the observed injury burden and activity counts. Where clean data is available (i.e., validated population counts, statistically-significant data size), specific drilldowns of risk are generated. Greater specificity in identifying risks allows TSSA to target resources specifically to address the largest source of risk and potentially reduce the risk that is intended to be managed.

3. Risk Management

After completing the risk identification and assessment processes, the identified risks in their causal categories undergo a risk management process using TSSA's existing regulatory oversight tools, which aid the statutory directors in establishing and implementing strategies aimed at reducing risks.

To aid decision-makers in selecting controls to manage and mitigate risks, Table L1 captures the hierarchy of controls.

Table L1: Control Solutions[2] to Manage and/or Mitigate Risks

CONTROL NAME	PURPOSE OF CONTROL
Elimination	Remove or eliminate hazards altogether
Substitution	Replace hazards (with less hazardous options)
Engineering	Implementation of safeguarding technologies to prevent and/or mitigate hazards and therefore minimize exposure
Administrative	Codes and regulatory changes (new and/or improvements), education, training, procedures, etc.

As indicated in Table L1, elimination is the strongest and most effective control as it physically removes the hazard, and, therefore, results in the greatest reduction in risk. However, the ability to resort to an elimination control may be restricted due to regulatory purview.

In such cases, the decision-maker would have to move down the hierarchy and evaluate the efficacy of substitution and subsequent controls. Cost-benefit analysis and stakeholder consultation are recommended in evaluating the applicability and efficacy of applying a control, or a set of controls, to a particular risk.

Conclusion

TSSA's RIDM framework is recognized and used for addressing broader public policy issues. It aligns with the recently published guideline UL2984: *Management of Public Risks – Principles and Guidelines,* a vision that was put forward by TSSA and successfully accepted by national and international bodies.

This report acts as a primary source of information for risk-informed decision making. TSSA's RIDM framework continues to assist statutory directors across all safety programs in making regular day-to-day decisions while helping tackle larger and more complex strategic regulatory decisions. An important element of the framework is continuous improvement and confirmation of decisions as new findings become available. TSSA continues to aggregate data from inspections year over year and there are times when decisions need to be revisited with up-to-date data.

[2] Adapted from Hierarchy of Controls from NIOSH, US CDC [6].

Appendix M – Metrics

Disability-Adjusted Life Year (DALY)

The Risk of Injury or Fatality (RIF) metric is determined using the Disability-Adjusted Life Year (DALY) metric. The DALY is a universal health impact metric introduced by the World Health Organization as a single measure to quantify the burden of diseases and injuries. The DALY can be thought of as equivalent years of "healthy" life lost by virtue of being in states of poor health or disability and/or due to premature fatality.

A DALY of 1.0 is the loss of one year of healthy life of a single person due to an injury. For example, a DALY of 28.1 means that 28.1 years of "healthy" life were lost due to injuries arising from all the sectors that TSSA regulates.

The expected health impact for a fatality is calculated based on the standard life expectancy at age of death in years and is based on age and sex (e.g., fatality of a male child aged 5 would translate to 70 DALY assuming an average life expectancy of 75 years). The expected health impact for an injury is calculated by multiplying the average duration of the injury by a weight factor that reflects the severity of the injury on a scale from 0 (being in perfect health) to 1 (being fatal).

Health loss is characterized by three dominant aspects of public health:

- Quality of life;
- Quantity of life; and
- Social magnitude.

The quality of life is measured by duration of injury and life expectancy of a victim. The quantity of life lost is expressed through disability weights, and the social magnitude is characterized by the number of people affected.

The expected health impact in units of DALY can be calculated by the following equation:

(Short-term Weight * Short-term Duration) +
(Fraction Long-term) * (Long-term Weight * Long-term Duration)

There are four injury types categorized in the TSSA database:

i) Fatality;
ii) Permanent injury;
iii) Non-permanent injury; and
iv) No injury.

The permanent and non-permanent injuries are further characterized by 28 specific types of injury descriptions. In the above equation, disability weights, fraction long-term and short-term durations, associated with the various injury descriptions, have been adopted and/or modified from the Australian Burden of Disease and Injury Study [9]. The long-term duration is the expected life expectancy at the time of injury and is applicable in the case of a permanent injury.

Consider the following hypothetical example to better understand the evaluation of expected health impact. Assume a male victim sustains a spinal injury at the age of 30 years due to the malfunctioning of a regulated technology. Using the cohort life expectancy of 48.1 years for males aged 25 to 34, the equivalent healthy years lost due to the spinal injury can be calculated as 21.31 DALYs by using the above equation. In this calculation, the short-term weight of 0 and duration of 0 years were used respectively, and the fraction long-term and long-term duration parameters were taken to be 1 and 0.443 respectively.

Injury Burden

The observed health impact is quantified based on each victim's age and injury type in denominations of DALY and is then scaled by the time period under study, the median life expectancy and the exposed population to determine the injury burden in units of fatality-equivalents per exposed population per year. Note that the scaling factors are dynamic and subject to change year-over-year or once every five years during a nation-wide census update.

This edition of the *Public Safety Report* includes the observed injury burden expressed using actual DALYs, as well as the risk of injury or fatality. The former reflects the health impact experienced in a given year, while the latter is a prediction of the injury burden expected in the future based on historical data.

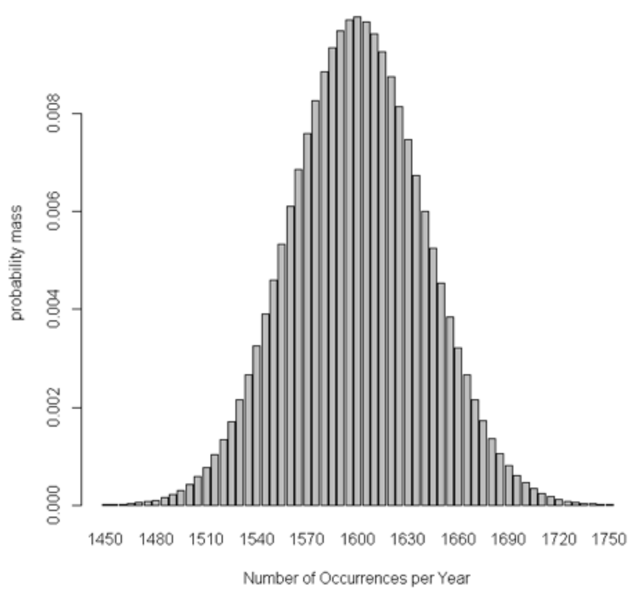
Risk of Injury or Fatality

The Risk of Injury or Fatality (RIF) approach determines predicted injury burden by accounting for historical occurrences while taking into consideration the uncertainties and variability inherent in the involved parameters and predicts the future state of safety in terms of fatality-equivalents per exposed population per year. The rationale behind this approach is that there is a potential for some of the occurrences without health impacts to manifest themselves as incidents with injuries and fatalities in the future. A simulation approach is used to conduct the predictions based on actual observations. Parametric uncertainties are taken as probability distributions which are then input into the prediction model:

(a) One major uncertainty is in the actual number of occurrences. This attribute is subject to reporting bias which means that an unknown fraction of incidents goes unreported to TSSA. The randomness is assumed to follow a Poisson distribution[3] with the observed occurrence rate as the input parameter.

Figure M1 illustrates the breadth of uncertainty in the occurrence rate when, for example, 1,600 occurrences a year are observed on average.

Figure M1: Probability Mass Distribution of the Occurrence Rate (Example)

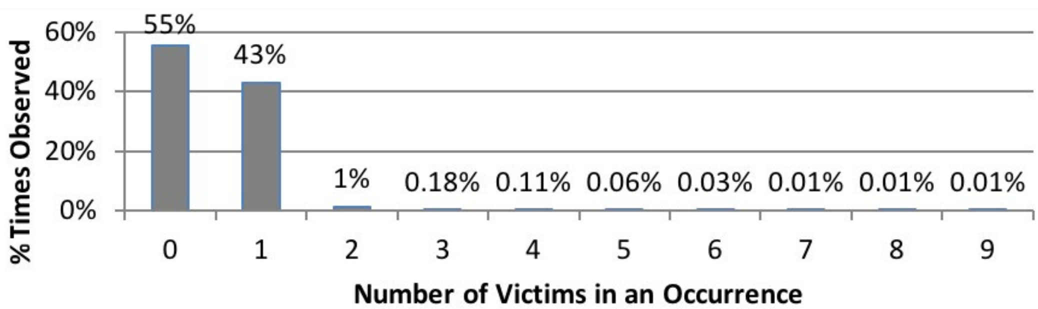


[3] https://en.wikipedia.org/wiki/Poisson_distribution

(b) The number of victims involved in an occurrence is assumed to be a discrete empirical probability distribution constructed from historical observations. This scheme ensures that extreme tail events are assigned a minimal probability, instead of assuming that they are equally likely compared to the most representative estimate.

Figure M2 illustrates the victim count distribution for a typical composite TSSA State of Safety prediction. The example shows that there are no victims involved in 55% of the cases, one victim involved in 43% of the occurrences and as high as nine victims in less than 0.01% of the occurrences.

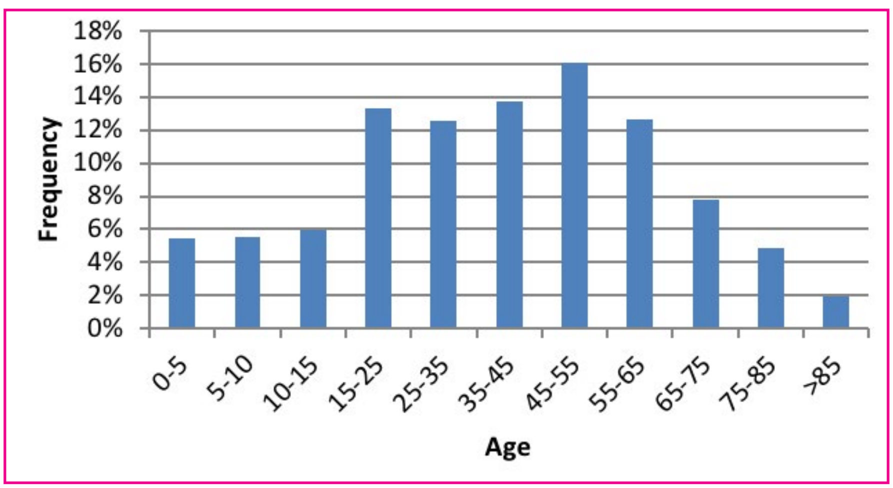
Figure M2: Frequency of the Number of Victims in an Occurrence (Example)



(c) The age of a victim is also uncertain, and the range is between that of being an infant and an elderly person. It is sampled from an age-based population census estimate from Statistics Canada.

Ontarians aged 15 – 65 constitute about 70% of the population as seen in Figure M3 and are more likely to be victims of an occurrence than otherwise.

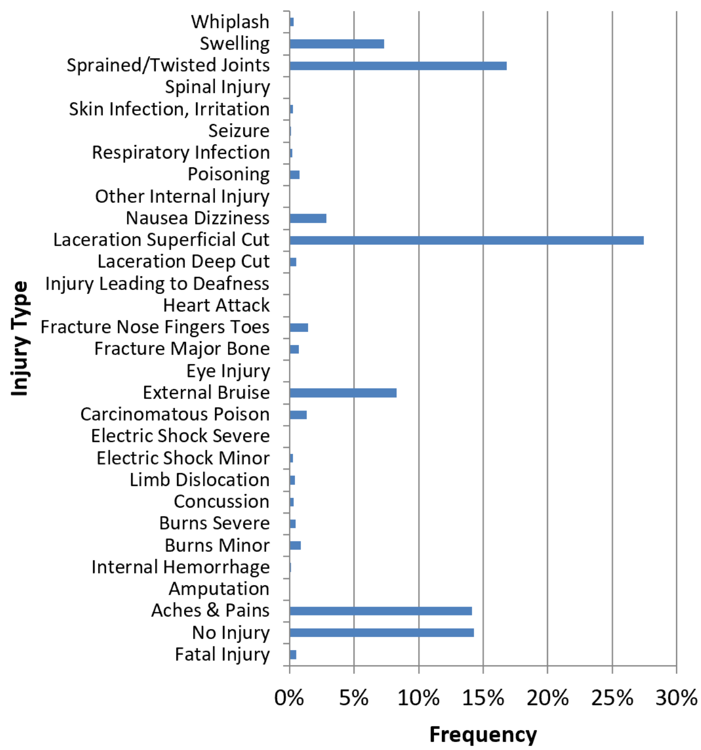
Figure M3: Age Distribution for Predicted Risk Simulation (Example)



(d) The number and type of injuries is sampled from a distribution constructed out of observations. This distribution is dependent on the program and the specific occurrence type under consideration.

An injured victim is likely to sustain superficial cuts, sprains, aches and pains or no injury at all more often than a fatal injury as seen in Figure M4. The distribution is for illustrative purposes only and varies depending on the regulated sector under study.

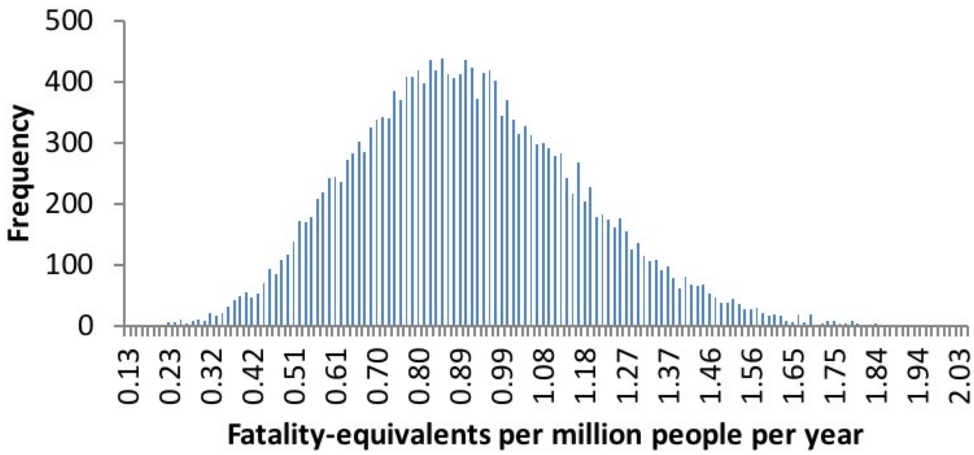
Figure M4: Injury Distribution for the Composite Risk of Injury or Fatality (Example)



In fiscal year 2019, the calculation was updated to improve accuracy and reduce numerical instabilities. In particular, the victim and number of injury distributions now rely on empirical distributions rather than uniform distributions.

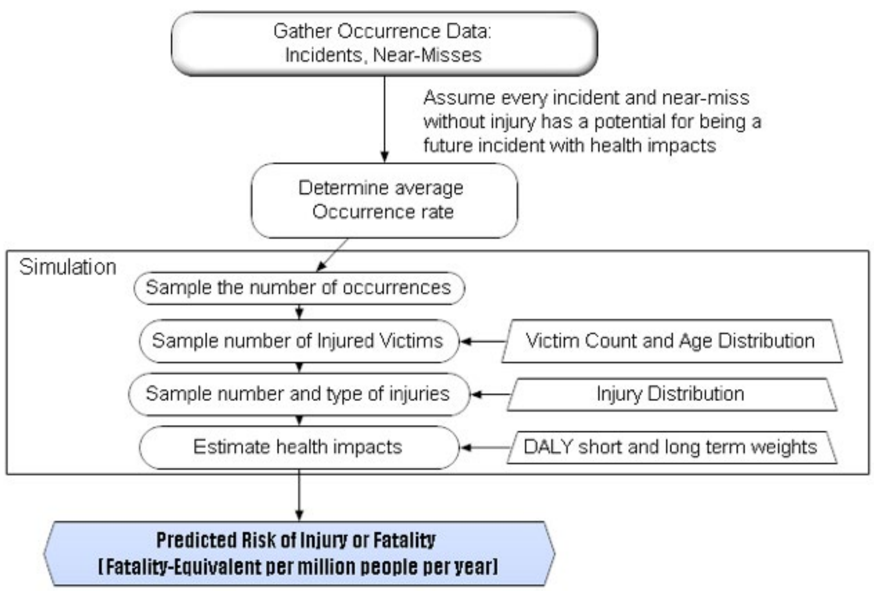
The end result of a risk simulation is a frequency distribution of predicted health impacts as exemplified in Figure M5. The mean value is used for reporting purposes in the report. In Figure M5, the respective estimate is 0.91 fatality-equivalents/million people/year. Note that the risk of injury or fatality is expected to be somewhat larger than the corresponding observed risk. This is a result of the model design to consider near-misses as potential incidents and to ensure that a larger set of uncertainties are incorporated into the model that are not exhaustively captured in the actual observations.

Figure M5: Risk of Injury or Fatality Distribution (Example)



The procedure followed to determine the anticipated health impacts is shown in Figure M6.

Figure M6: Flowchart to Predict Future Health Impacts



Statistical Methods

The statistical analysis of the time-series data in this report includes data analysis and trend tests.

When presenting data, it is often desirable to know whether the measured indicator is increasing or decreasing over time. While time-series plots tempt the reader to make visual assumptions on the behaviour of variables over time, trend tests allow for rigorous statistical hypotheses testing. This has three additional advantages over graphical data analysis:

- It ensures a systematic, consistent method of data analysis;
- It yields a measure of the increase or decrease over time; and
- It presents a measure of the strength of the evidence (the p-value).

The current format of the *Public Safety Report* does not include the p-value explicitly, but it is used as a step in the trend analysis.

The Mann-Kendall test[4] is a non-parametric trend test and does not require any assumption of normality or canonical distributions in the data. This test is robust and allows missing data to be present in the analysis.

The trend analysis presented in this report considers the predominantly seasonal nature of the operation of devices (i.e., amusement devices and ski lifts). The trend analysis confirms and takes into account seasonality while establishing historical patterns of safety and compliance performance.

There are many instances where seasonality is the source of variation in the response variable. As such, this report uses Kruskal-Wallis[5] statistics for testing seasonality in the time series, which was done using Minitab 17© software. The assertions of any of these tests are made with 95% confidence and if evidence is found for seasonality, then the Seasonal Mann-Kendall trend test is used instead of the Mann-Kendall test.

While the trend tests are performed on the quarterly data, this data is aggregated annually for communication purposes.

[4] https://en.wikipedia.org/wiki/Trend_analysis

[5] https://en.wikipedia.org/wiki/Kruskal%E2%80%93Wallis_one-way_analysis_of_variance

Assumptions and Sources of Uncertainty

The analysis of compliance trends is provided over a rolling five-year period, which aligns with TSSA's Strategic Planning process. This approach allows for appropriate measurement and reporting on the effectiveness of these strategies. Trend analysis on incidents and near-miss occurrences is based on an indefinite period, limited by the nature and quality of information available in TSSA's database. This will help in better understanding the changing risk profile over extended periods of time.

In producing this report, TSSA's Public Safety Risk Management (PSRM) team of the Strategic Analytics department has made every effort to ensure a high level of quality control over its calculations and methodologies. To this effect, TSSA takes every precaution to ensure the accuracy and quality of data presented in the *Public Safety Report.* Intrinsically, PSRM developed a Quality Management System in 2012 to ensure accurate presentation of public safety information. Occasionally, it is necessary to make restatements to results reported in previous years, typically a result of timeframe factors, such as information received subsequently to the issuance of the report, localized reporting lags for periodic data, investigations completed, and other issues.

Analysis involving reported and inspected incidents and near-miss occurrences may be impacted by reporting biases. Due to the varied nature of reporting across the different regulated sectors, TSSA is currently unable to quantify the level of reporting bias and is, therefore, not currently in a position to account for this uncertainty.

Some figures were created using numbers that have been rounded off for ease of display and, as such, some totals may not add up fully or may exceed the 100^{th} percentile.

The average rate of injury and the observed injury burden figures are assumed on a fixed Ontario population size of 14,446,515[6] in the calculation, resulting in some degree of uncertainty. However, it is not considered to be significant.

Occasionally, data records can be misclassified. For example, an amusement device occurrence might be mistakenly entered into the database as an elevating device occurrence. This would not affect the overall RIF calculation, but would be filtered out for the program RIF calculation. Misclassified data such as this would be followed up with the relevant program so the data can be corrected for future editions of the *Public Safety Report.* In addition, data records may have missing or inaccurate information, such as a victim's age being unknown in an occurrence report. When a victim's age is unknown, the risk software assumes an average age. If age information is later found to be inaccurate, then this would again be followed up with the relevant program to modify the database, so it could be corrected for future editions of the *Public Safety Report.* Assumptions can also be made while entering data. For example, a decision will need to be made on whether an injury should be described as a "minor" or a "severe" burn, which requires some degree of interpretation. TSSA makes every effort to minimize these sources of uncertainty and makes corrections, if applicable, when they are discovered.

This report contains occurrences that were reported and had their investigations completed, and had their data entered into TSSA's information system. It does not include ongoing inspections or investigations. Accordingly, this may result in a slight underreporting in some numbers. Since TSSA aims for a prompt turn-around time, it is expected that the impact is largely isolated to the results for the most recent year (in this case, fiscal year 2019).

[6] The population of Ontario in Q1 2019 was 14,446,515 per Statistics Canada (ref: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000901)

Appendix N – Risk-Based Inspection Scheduling

Introduction

TSSA conducts periodic inspections of devices and facilities administered under the Act, based on prescribed intervals set in regulations or at the discretion of the statutory director responsible for the specific regulations using the director's powers laid out in the Act and/or the regulations. As part of TSSA's RIDM framework, TSSA has adopted to use a risk-informed approach to schedule the frequency of inspections when not prescribed. This scientific and evidence-based approach helps TSSA to focus its resource allocation efforts on the basis of safety risk to Ontarians while ensuring objectivity, consistency, fairness and transparency.

TSSA's patented approach for risk-based scheduling (RBS) of devices and facilities is based on the noncompliance observed (hereafter "orders issued") during inspections, as well as occurrences caused by noncompliance with regulations. Devices or facilities that have had no occurrences caused by noncompliance with regulatory requirements, and/or a relatively small number of low-risk noncompliances found during inspections are likely to be inspected at longer intervals. Short inspection intervals would be recommended for devices or facilities that have many high-risk orders issued against them and/or have occurrences caused by noncompliance with regulations.

Not only can the RBS method inform inspection scheduling, it gives an indication as to the estimated risk profile in a particular area of concern. In cases where the regulations specify intervals, RBS profiles can be generated exclusively for reporting purposes (e.g., amusement devices, liquid fuels). Since not all programs use RBS for scheduling, it is reported instead as the Inventory Risk Profile.

The RBS 2.5 Model

TSSA initially developed and obtained a patent for the model (RBS 2.0) in 2013. However, since that time, TSSA has been making enhancements to the model based on implementation in the field and new information and this appendix describes the most up-to-date version (v. 2.5).

The conceptual basis for the model involves a mathematical aggregation of orders issued during inspections and enforcement actions. Risk scores are determined for all orders, drawing primarily on the standard orders risk assessment (see Appendix R); the key difference being when determining the recommended time to compliance (TTC), the risk is defined as *frequency x consequence* while for the RBS the risk is defined as *probability x consequence*. In the case of the determination of the TTC, the objective is to determine the time by when the aggregated consequences of potential occurrences due to an observed noncompliance (if left unaddressed) could reach a threshold. However, the objective of RBS is to determine the time by when the probable accumulation of noncompliance would result in a cumulative consequence. For orders where no risk score is currently available or not determined (e.g. non-standard orders), the issued TTC is used as a surrogate to derive a risk score based on the median risk score of all standard orders with a similar TTC.

The RBS calculation considers all orders issued over the past three periodic inspections and any other applicable inspection activities in that time interval. For instance, if Device A has periodic inspections conducted in 2012, 2014, and 2016, then any additional inspections, such as enforcement actions and ad-hoc inspections, since 2012 will be included. These order scores are then summed to arrive at an inspection risk score. Devices with occurrences caused by noncompliance with regulations are additionally penalized by assigning each occurrence a DALY value based on the most likely significant consequence (or the 99.5th percentile of all injury-carrying occurrences) and adding this value to the inspection risk score. A time-weighted average of the inspection risk scores and the time duration between inspections is calculated to arrive at a device or facility risk score.

It is assumed that the facility/device risk is close to zero immediately after a periodic inspection. It is also assumed that, in the absence of inspections, the perceived risk gradually accumulates over time due to unobserved noncompliance at a rate specific to a facility/device based on historical observations. The rate is determined based on the following factors:

1. Probable Occurrence Rate for Facility/Device - This is determined by dividing the Facility/Device Risk Score by the average health impacts (measured in fatality-equivalents) per occurrence based on incident history across all facilities/devices and all occurrences with known health impacts.
2. Shape Factor (p) – This provides the shape of the curve that helps determine the rate of accumulation of the perceived risk over time. It is determined by fitting an appropriate statistical distribution to observed time to occurrence since the last inspection. The shape factor is applied to all facilities/devices.

A cumulative risk curve is constructed for each facility/device based on the facility/device specific occurrence rate (described above) and the shape factor. The recommended periodic inspection interval is obtained from the curve as the time to chance of a fraction of one fatality-equivalent as determined by the statutory director. A tolerability interval is obtained from the curve as the time to chance of one fatality-equivalent.

For operational reasons and to address uncertainty in the risk estimates, the statutory director sets the maximum and minimum inspection intervals (for example, statutory director for the Elevators Safety Program Area has set the minimum and maximum intervals at six months and five years respectively). The inspection intervals of high-, medium-, and low-risk devices/facilities are as in Table N1.

Table N1: Inspection Intervals of High/Medium/Low Risk Facilities

RISK BIN	INSPECTION INTERVAL (MONTHS)
High	6
Medium	6 - 24
Low	24 or more

For most applications the risk acceptability threshold is kept constant, but as per the Auditor General of Ontario's recommendation, there is a variable risk threshold for propane facilities such that the acceptable level of risk is dependant on surrounding land use. For example, a facility with sensitive receptors in its hazard radius has a risk threshold 3% of that which is used in a remote/industrial area. Similarly, a facility in a high-density residential area has a risk threshold 10% of that which is used in a remote/industrial area. If TSSA can gather this sort of information on other types of sites, it would consider extending this approach to other technologies.

[6] The population of Ontario in Q1 2019 was 14,446,515 per Statistics Canada (ref: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000901)

Appendix O – Causal Analysis Categories

TSSA designates occurrences with a root cause into three categories. The description of each category and the associated mapping of root cause information are listed below. Occurrences that do not have an established root cause after inspection are contained in a fourth category: root cause not established.

Potential Gaps in Regulatory System

Occurrences in this causal category indicate potential areas in need of regulatory change or improvement. They are consistent with the regulatory gap and impact analysis currently used by the Ministry of Government and Consumer Services to effectively improve the regulatory system without imposing unnecessary additional regulatory burden.

Table 01: Causes Contained in the Potential Gaps in Regulatory System Category

CATEGORY	DEFINITION	SUB-CATEGORIES
Design	Factors related to the engineering outline and physical make-up of a device for its intended purpose.	• Defective or inadequate design. • Defective/inadequate safety features, or devices.
Management	Factors related to the levels of responsibility that are accountable for specific activities, programs and systems of operation.	• Gaps in the regulatory management system.

Noncompliance with Regulatory System

Occurrences in this causal category most appropriately reflect TSSA's effectiveness in administering the safety system and obtaining compliance. They allow TSSA to allocate enforcement resources to areas of greatest risk.

Table 02: Causes Contained in the Noncompliance with Regulatory System Category

CATEGORY	DEFINITION	SUB-CATEGORIES
Design	Factors related to the engineering outline and physical make-up of a device for its intended purpose.	• Inappropriate equipment or material selection. • Inappropriate drawing, specification or data.
Equipment/ Material/ Component	Factors related to a device (machinery), the physical constituents of a device (material used or make-up) or a specific unit of an overall device of machinery.	• Defective, failed, or malfunctioning equipment. • Defective or failed component, including safety devices. • Defective or failed material. • Defective assembly. • Electrical or instrument noise or malfunction. • Contamination of material, component or equipment.
Human Factors	Factors related to actions or inactions of humans in the execution of activities in the operation of equipment or in the general work environment.	• Inadequate or unsafe operating environment. • Failure to follow maintenance procedures. • Failure to follow operating procedures. • Failure to follow installation procedures. • Inappropriate plant operator attendance. • Incomplete or inadequate internal communication. • Incomplete or inadequate external communication.
Maintenance Procedures	Factors related to repair and upkeep activities required for the preservation of a device during its useful lifecycle.	• Defective or inadequate maintenance procedures. • Lack of maintenance procedures.
Management	Factors related to the levels of responsibility that are accountable for specific activities, programs and systems of operation.	• Inadequate or defective management systems. • Lack of management systems. • Improper or negligent work practices.
Procedures	Factors related to guidelines that outline how specific activities should be executed.	• Defective or inadequate operating procedures. • Lack of operating procedures. • Lack of or inadequate safety procedures. • Defective or inadequate installation procedures. • Lack of installation procedures.
Training	Factors related to documented programs that prepare employees for the proper execution of specific work activities as required.	• Lack of training programs. • Defective or inadequate training programs.

External Factors

Occurrences in this causal category indicate those outside the control or influence of TSSA. This category prevents misrepresentation of TSSA's performance with respect to compliance or the effectiveness of provincial regulations and allows for the identification of other mitigation measures.

Table 03: Causes Contained in the External Factors Category

CATEGORY	DEFINITION	SUB-CATEGORIES
External Events	Events representing occurrences beyond human control or TSSA regulatory control.	• Weather or other environmental conditions. • Utilities disruption or failure. • External incidents. • Sabotage, terrorism, vandalism or theft. • Noncompliance with non-TSSA regulations.
Human Factors	Refers to the use of regulated technology by a user in a manner that TSSA cannot reasonably know or anticipate and may result in an occurrence.	• Special conditions. • Failure to follow user instructions. • Deliberate intent or sabotage.

Appendix P – In-Depth Root Cause Analysis

"A director shall order such investigation as he or she considers necessary on being notified of an accident or incident."

Technical Standard and Safety Act; 2000, c. 16, s. 25.

Introduction

TSSA administers this requirement in accordance with its risk-informed incident management policy and the associated Incident Management System that facilitates a decision-making process applicable to all types of occurrences (i.e., incidents or near-misses). The Incident Management System deals with all stages, starting from the time an occurrence is reported an inspector dispatching decision is made, all the way to the determination of cause for the occurrence and any future actions, including prosecutions. Information is collected and documented through the entire process using TSSA's unique Incident Management Information System.

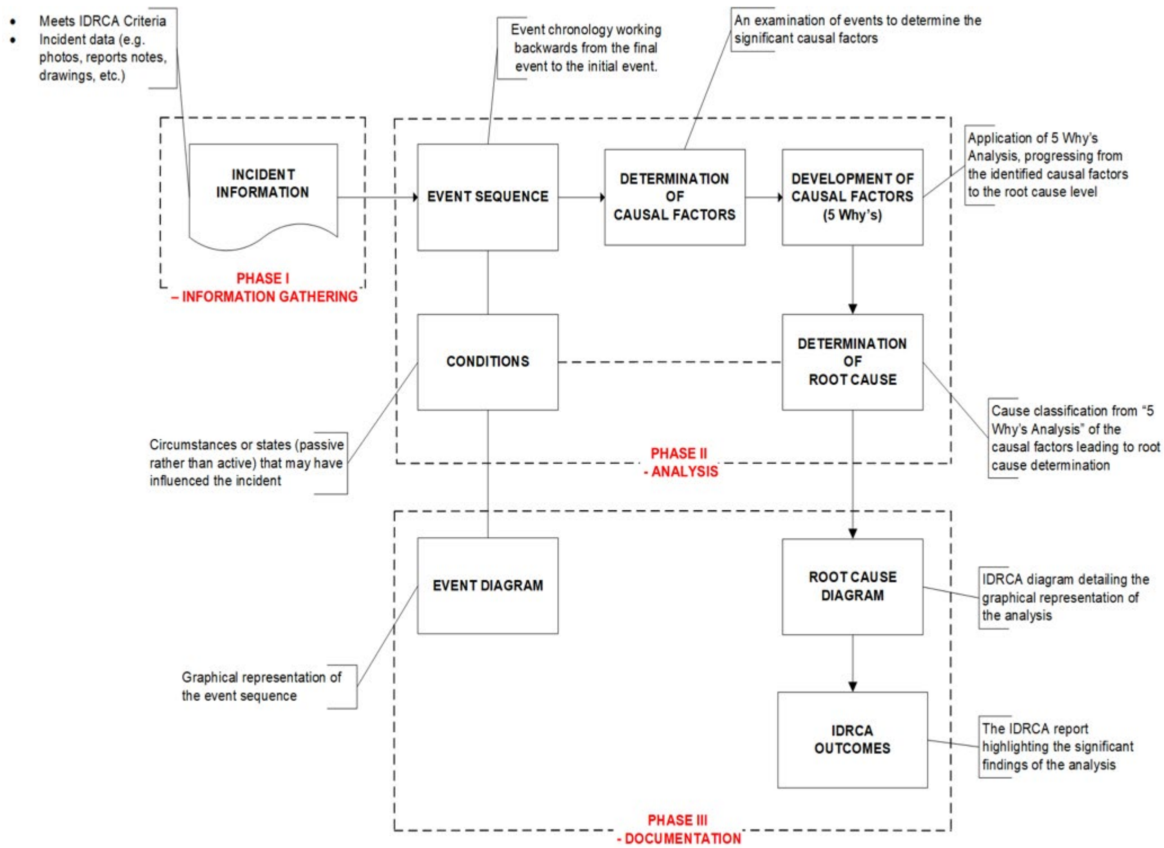
A key aspect of the Incident Management System is the determination of cause(s) for occurrences, as this helps TSSA in addressing any potential gaps in the safety system and reducing risk to Ontarians. Investigations, due to the nature of most occurrences, tend to be completed by inspectors' basic analyses to determine cause(s). However, where a root cause cannot be determined by an inspector alone, and also depending on the nature of the reported occurrences, their level of complexity, the effort in determining cause varies. In recognition of this variability and its associated importance, TSSA has developed a best-practice investigation methodology for occurrences that meet the in-depth criteria. This formal approach, In-Depth Root Cause Analysis (IDRCA), uses Root Cause Analysis (RCA) principles to determine and document underlying causes related to occurrences under the TSSA regulatory mandate but with additional focus and effort (see Figure P1). To this effect, TSSA has internally developed a formal process that has significantly improved the efficiency and quality of the RCA exercise. This analysis allows for the development of strategies to prevent and/or mitigate re-occurrence of such incidents by providing useful data to assist in informing further safety decision making.

The ultimate objective of the IDRCA process is to determine all causal factors and not to identify blame. An additional benefit of the IDRCA is that it has provided useful information to other processes (e.g., risk assessments, Director's Orders, etc.) to enhance safety decision making.

For an occurrence to be classified as requiring an IDRCA, it has to meet the following criteria:

1. Fatality (i.e. where the health impact from an occurrence included death of a victim); and/or
2. Where regulatory and the root cause could not be determined by the inspector alone (i.e., complex scenarios noncompliance); and/or
3. Where the inspector and/or those involved in the occurrence inspection believe(s) that there is a high potential for re-occurrence in the future involving similar equipment/circumstances.
4. Other reasons as determined to be appropriate by TSSA investigators including nature and magnitude of consequences associated with the occurrence (e.g., multiple permanent injuries, disruptions, extensive media/political coverage etc.).

Figure P1: In-depth root cause analysis flowchart



The IDCRA Process

The IDRCA tool, developed by TSSA, is used to document the entire analysis exercise where occurrence information is recorded in a logical manner to assist in the validation and accuracy of incident data.

The IDRCA is conducted in three phases:

Phase I - Information Gathering
Phase II - Analysis
Phase III - Documentation

(a) Incident Information Documentation – TSSA inspectors are trained to and follow standard operating procedures while collecting necessary incident information. This phase consists of gathering and documenting all possible data/details the inspector is able to collect from the occurrence. An illustration of this phase is shown in Figures P2 – P4 below:

Figure P2: Relevant Conditions (at the Time of the Occurrence)

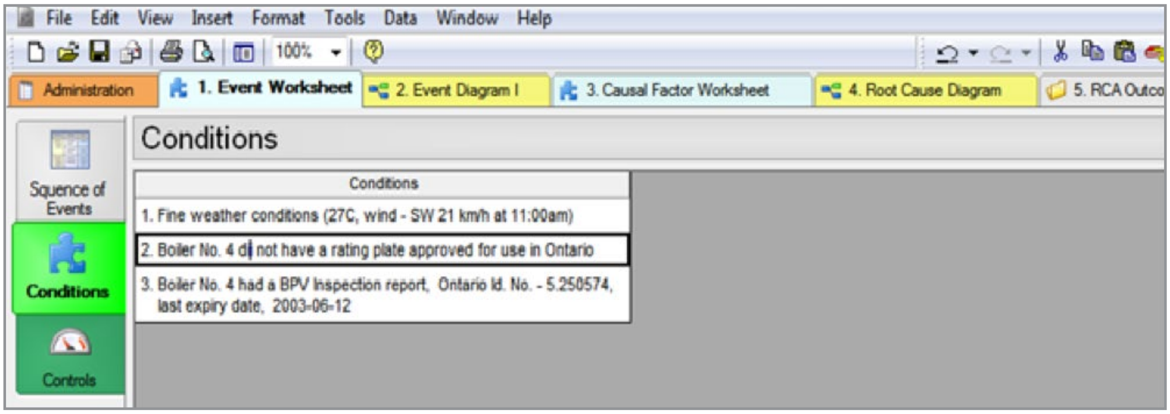


Figure P3: Incident Information – Data Collection

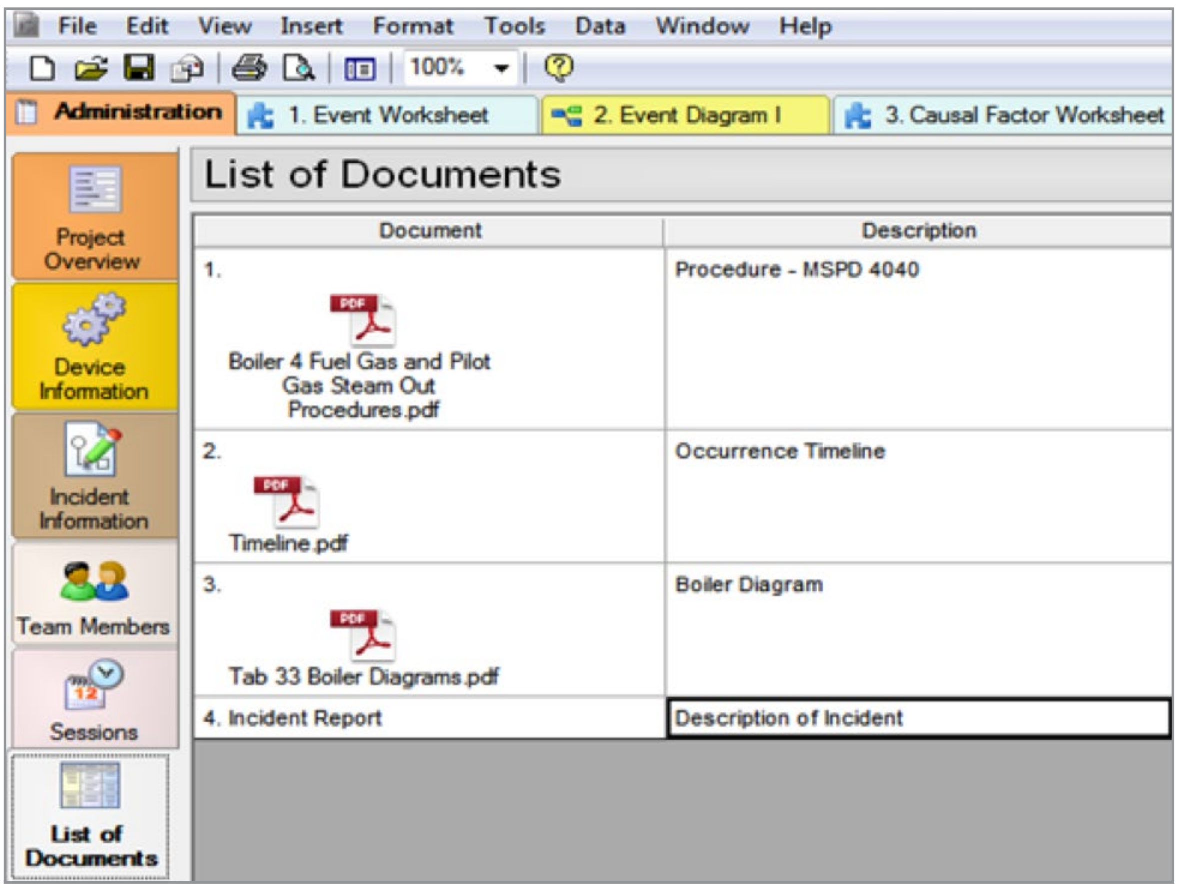
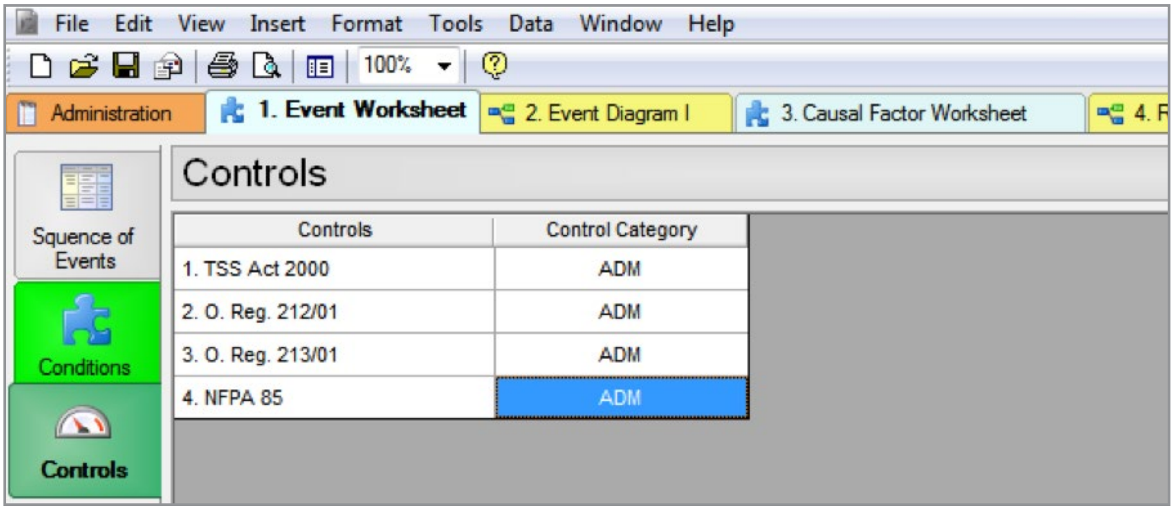


Figure P4: Relevant Controls (Regulatory or Other Controls)



(b) Root Cause Analysis – This phase involves the application of a best practice analysis approach to determine and evaluate significant events, conditions and causal factors. These findings are documented in a structured manner for the determination of cause based on the evidence by determining the sequence of events (i.e., in chronological order) by working sequentially and visually documenting the combination of events leading to the final event (see Figures P5 and P6). The analysis of each occurrence/final event is achieved by the evaluation of identified causal factors to determine the Direct Cause and followed by application of the "5 Whys Principle?" (see Figure P7 - e.g. asking why or how this could happen?) to determine the root cause. This procedure is followed for each causal factor chain identified until all the contributing causes are identified, and the team is satisfied it has captured all related scenarios. TSSA's root cause analysis policy requires that a single root cause be established, if possible, for each occurrence.

Figure P5: Sequence of Events (Chronological Order)

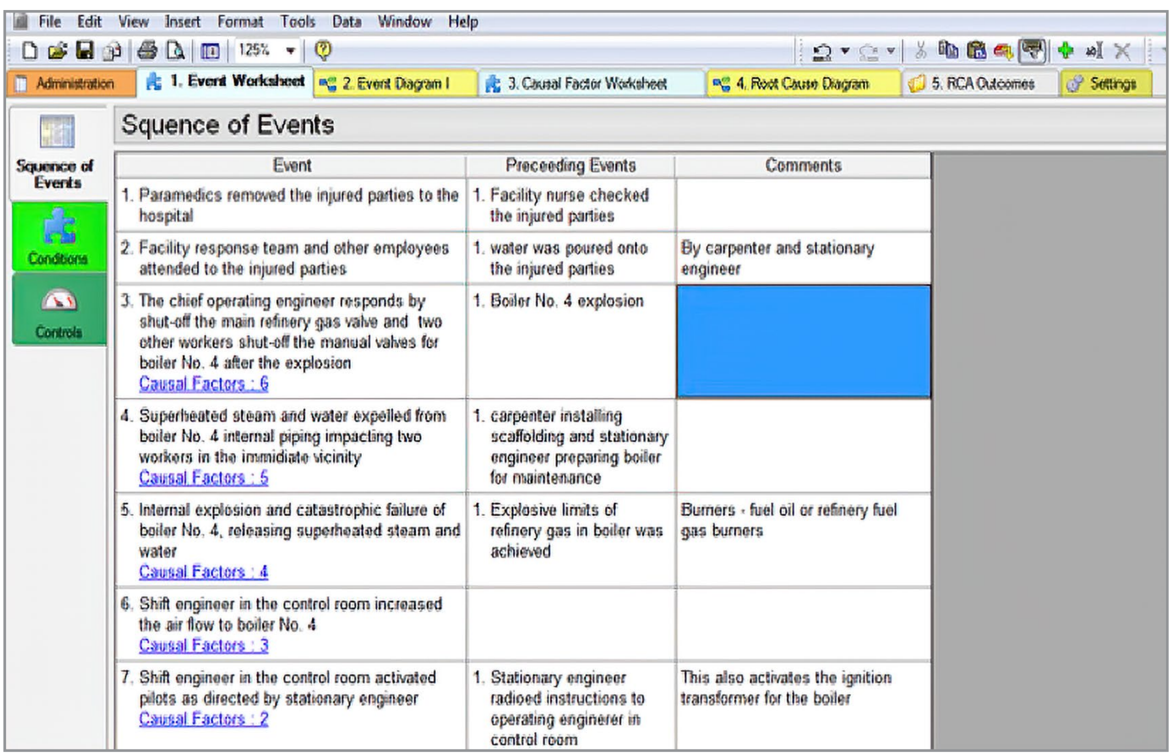


Figure P6: Sequence of Events – Event Diagram

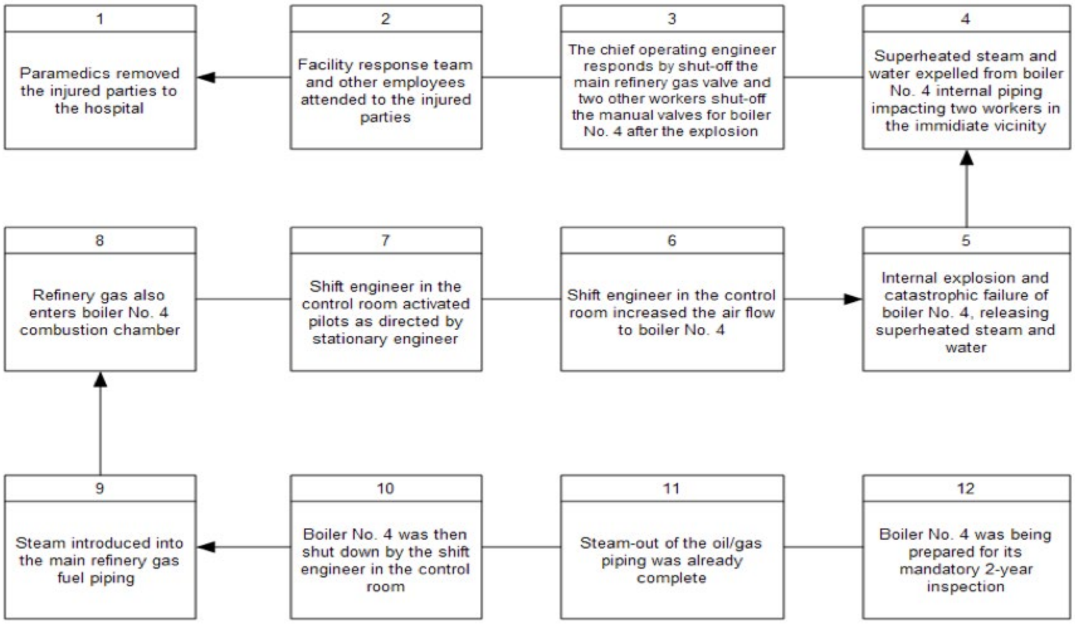


Figure P7: Analysis of Causal Factors - 5 Whys approach

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Administration | 1. Event Worksheet | 2. Event Diagram I | 3. Causal Factor Worksheet | 4. Root Cause Diagram | 5. RCA Outcomes | Settings

Causal Factors	CF Category	1. Why this happened?	Cause Category	Comments	2. Why this happened?	Cause Category	Comment	3. Why this happened?	Cause Category	Comment	4. Why this happened?	Cause Category	Comment	5. Why this happened?	Cause Category	Comm
1. Steam introduced into the main refinery gas fuel piping Squence of Events - Event 9	Equipment	1. To clean out the refinery gas line - but refinery gas is also introduced as well as steam RCA Outcomes: 3	CONTRIBUTING CAUSE	steam used as per procedure (Shell - MSPD 4040)	1. To clean piping of hydrocarbon residue - but refinery gas fills the combustion chamber RCA Outcomes: 4	CONTRIBUTING CAUSE	The main refinery gas valve should have been closed blanked-off as per procudure (Shell - MSPD 4040)	1. The main refinery fuel gas valve was in the open position RCA Outcomes: 6	CONTRIBUTING CAUSE	The main refinery gas valve was not closed or blanked-off (Shell - MSPD 4040)	1. The main refinery gas valve was not closed as per procedure RCA Outcomes: 7	CONTRIBUTING CAUSE	No documentation for verification of lock-out/tag-out as required by procedures	1. The stationary engineer did not shut-off and lock-out the main refinery gas valve RCA Outcomes: 1	ROOT CAUSE	The stationa engine was trai and qua (see trai records) Other va had Loc and Tag the keys were lef the lock found)
2. Shift engineer in the control room activated pilots as directed by stationary engineer Squence of Events - Event 7	Personnel	1. To vent off residual refinery gas from the pilot line piping		The ignition transformer continuously sparks when activated	1. To clean piping of hydrocarbon residue			1. To return the boiler to "zero energy" state for maintenance			1. For mandatory inspection of Boiler					
3. Shift engineer in the control room	Personnel	1. To expell unburnt refinery	CONTRIBUTING CAUSE		1. To ensure unburnt gas will not		To eliminate the									

(c) Report Preparation – The final phase the IDRCA process involves preparing a report that documents the findings and provides conclusions and recommendations. The tool itself can summarize the entire exercise including, all administrative details and the documentation of evidence, analysis deliberations and graphical representation of all causal findings in the process (see Figures P8 – P10). A summary report is developed when all phases are completed by the IDRCA facilitator and submitted to the program statutory director including relevant recommendations and conclusions.

Figure P8: IDRCA Diagram

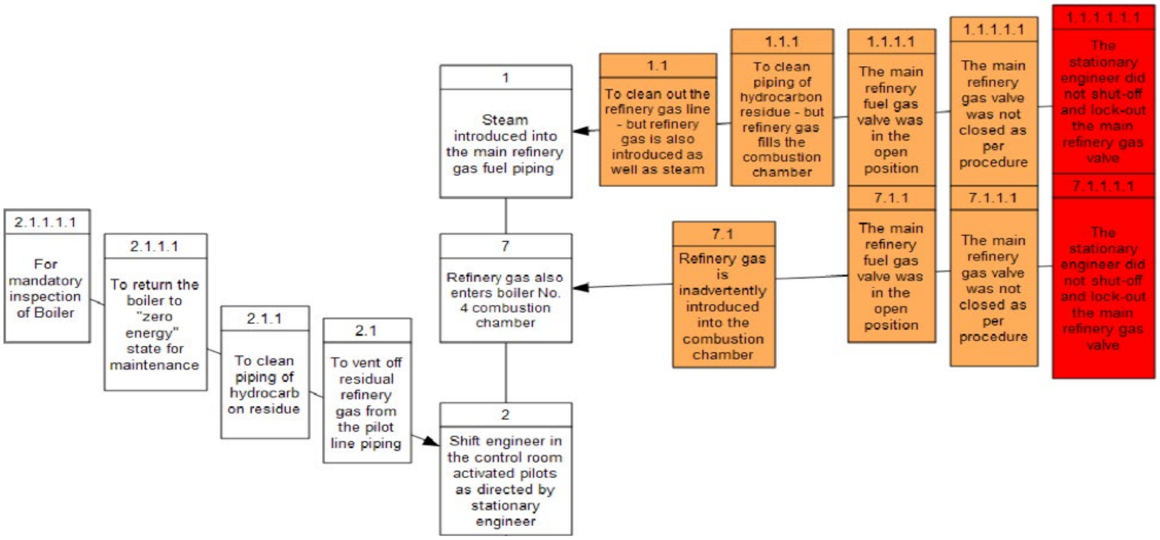


Figure P9: IDRCA Outcomes

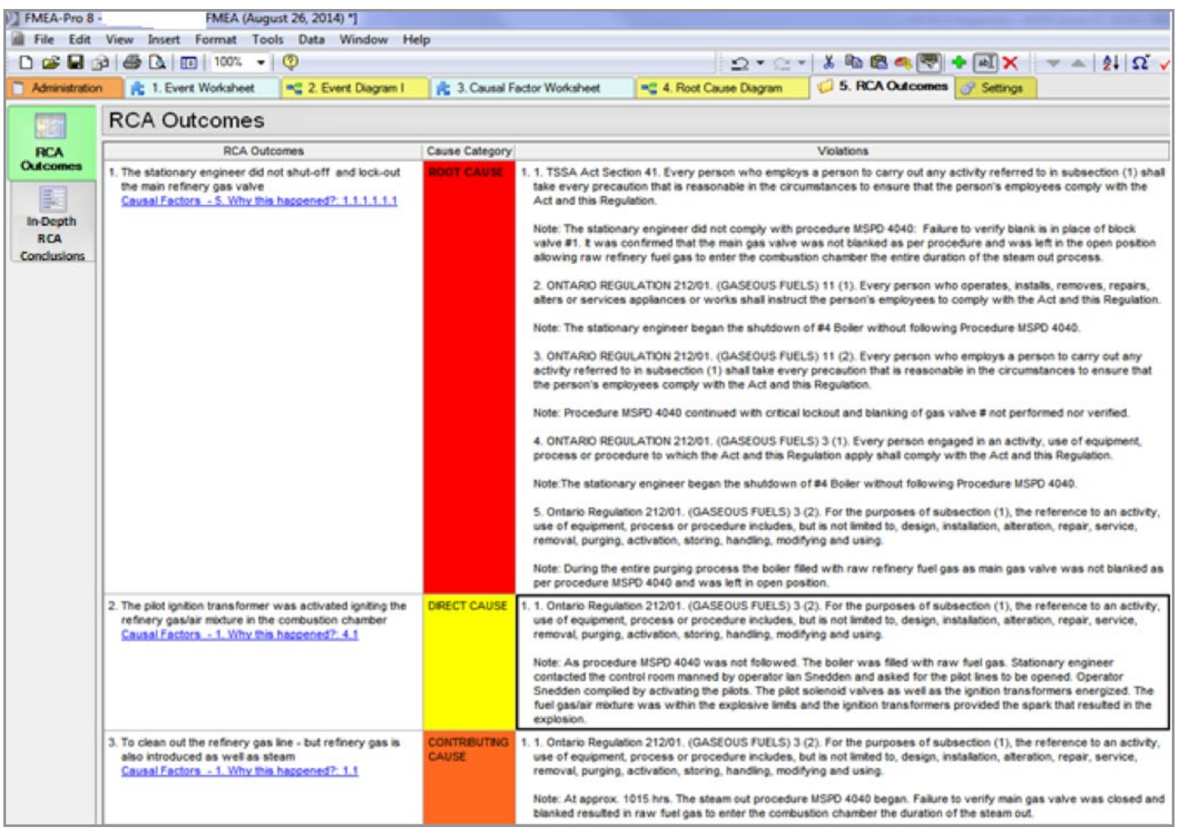
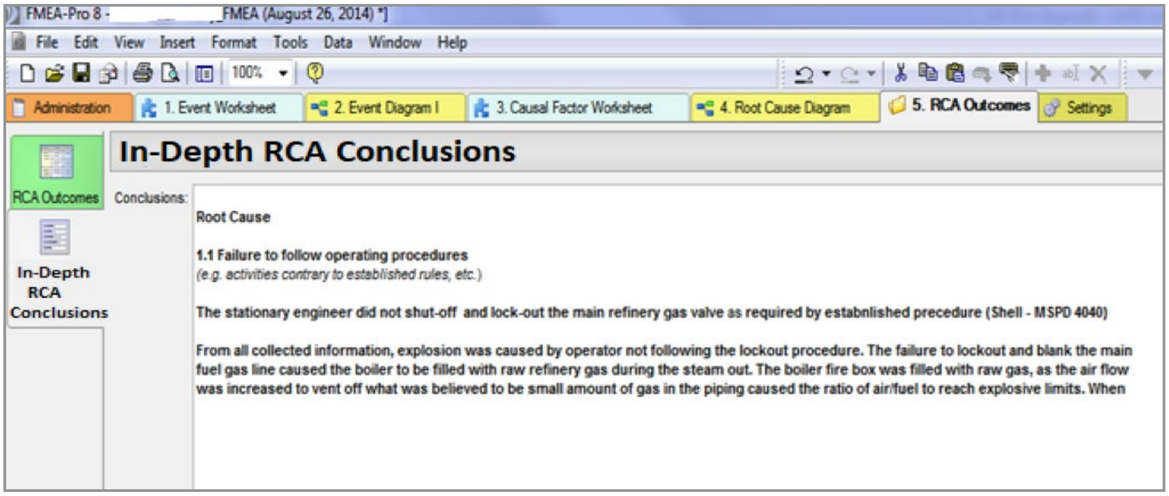


Figure P10: IDRCA conclusions



The IDRCA Team - Roles and responsibilities

The IDRCA team works independently of any outside influence to ensure findings are determined and evaluated purely based on the evidence collected and is made up of the following roles and responsibilities:

Facilitator

The PSRM team at TSSA provides facilitation for the IDRCA process to ensure the consistent application of the methodology and the elimination of gaps by continuously focusing the group's attention and technical expertise on the facts and relevant issues. This also includes challenging the safety program experts on the incident details and analysis outcomes, the elimination of personal assumptions of causes and overall IDRCA management. The facilitator develops the summary report with the significant findings of the IDRCA for reporting purposes.

Safety Program Experts

The safety program provides the resources required (i.e., IDRCA team – engineers, inspectors, etc.) for the execution of the IDRCA exercise. This ensures all information related to event sequencing and causal chains are determined in a systematic and consistent manner for the determination of cause.

- Investigator – safety program lead for the analysis of the incident information collected.
- Inspector – assigned to the occurrence inspection and is responsible for the collection and reporting of all related incident information, including the responsibility of appropriately completing and documenting the IDRCA results.
- Engineer - technical support as technology expert (e.g., design lifecycle and operational functions, etc.) pertaining to the system/equipment/component associated with the occurrence.
- Safety program technical specialist – additional safety program subject matter experts.

IDRCA – Examples at TSSA

Below are a few examples of completed IDRCA on incidents that have provided useful information to safety programs for further safety issue management.

1. Elevator (IDRCA Criteria – Fatality)

Entrapment and then self-extraction from an elevator car stopped between floors. Victim jumped from elevator onto floor landing and fell into the elevator shaft, falling six floors to the pit.

Root Cause

Gaps in the regulatory management system. No means of restricting the possibility or potential for passengers to self-extract from an elevator car, stopped away from the unlocking zone.

Conclusions

It was determined that the elevator motor was operating in an overload condition at the time of the occurrence, which caused the car to stop between floors (i.e., within design specifications). The actions of the passengers could have been prevented if a physical safeguard was in place on the elevator car to prevent the passengers from opening the doors to a position where self-extraction was possible.

Recommendations

TSSA completed a risk assessment to determine if there is a broader safety issue requiring attention related to the hazards of elevator self-extraction as a next step to estimate the associated risks. The focus was on older design technology, where entrapment is an acceptable feature for an elevator car stopping between floors due to the detection of an abnormal condition.

Risk Assessment Outcomes

The estimated risk was found to be unacceptable if both the door restrictor and apron are either absent or inadequately fitted. It was determined that door restrictors are quite effective at reducing the frequency of successful self-extractions in an elevator; therefore, it would be best to mandate the proper functionality of either or both of door restrictors and aprons.

As a result, a Director's Order (see Figure P11) was issued on April 15, 2015 to address this issue.

Figure P11: Director's Order – Car Platform Apron Requirements for Existing Passenger Elevators (260/14 r1, 04/15/2015)

Elevating and Amusement Devices Safety Division	Ref. No.: 260 / 14	Rev. No.: 1
DIRECTOR'S SAFETY ORDER	Date: March 17, 2014	Date: April 15, 2015

IN THE MATTER OF:

THE *TECHNICAL STANDARDS AND SAFETY ACT, 2000*, S.O. 2000, c. 16 (the "Act")

- and -

ONTARIO REGULATION 209/01 (Elevating Devices) made under the Act

Subject: Car Platform Apron Requirements for Existing Passenger Elevators
Applicable to: All Owners of Existing Passenger Elevators and All Elevator Contractors

The Director, Elevating Devices Regulation (O.Reg. 209/01) pursuant to his authority under section 14 of the *Technical Standards & Safety Act, 2000* hereby orders the following:

1. PLATFORM APRON REQUIREMENTS

1.1. Per the provisions of the Elevating Devices Code Adoption Document (CAD), section 3.10 establishes requirements for car platform aprons on existing passenger elevators for a given occupancy class.

3.10 Platform Apron Requirements *(166/01)*

3.10.1 Every passenger elevator installed before the 1st day of May, 1981 and currently operated in an apartment building, condominium apartment building or educational institution and every passenger elevator installed after that date in any building, shall be provided at the entrance side with a smooth apron made of metal not less than 1.5 millimetres thick, or made of material of equivalent strength and stiffness, reinforced and braced to the car platform such that:

(a) it does not extend less than the full width of the widest hoistway door opening;

(b) it has a straight vertical face, extending below the floor surface of the car-platform, of not less than 1,200 millimetres, except that for an existing elevator this may be reduced where the hoistway pit is not deep enough to accommodate a larger vertical face;

2. Elevator Serious Injury (IDRCA Criteria - Where regulatory noncompliance and the root cause could not be determined by the inspector alone)

An elderly man entered the fifth-floor lobby, to descend on the elevator parked with its doors open. As he attempted to step into the elevator, the car moved away and descended with the doors open. The victim fell into the elevator shaft and was trapped between the car door header and the hoistway enclosure as the car descended to the first floor. He sustained serious injuries to his head, arms, and legs as result of this incident. An elevator mechanic was working on the elevator at the time of the incident.

Root Cause

Display of unsafe working practices (i.e., failure to follow maintenance procedures - *activities contrary to established rules).*

Conclusion

It was determined that the elevator mechanic did not demonstrate proper understanding of established safety procedures and standards applicable to the device on which he undertook to perform work. This included noncompliance with the various Director's Orders issued related to the use of jumpers on elevating devices during maintenance, inspection, testing and repair. Also identified were multiple violations of the Field Employee Safety Handbook, the B44/07 codes and Ontario's Regulations for Elevating Devices.

TSSA applied appropriate regulatory sanctions against the mechanic for this incident. No additional recommendations were made for this occurrence.

3. Motor Vehicle Fire (IDRCA Criteria - Where the inspector and/or those involved in the occurrence inspection believes that there is a potential for reoccurrence in the future involving similar equipment/circumstances)

A customer at a gas station refueling a car overfilled the tank causing a fuel spill. The spilled fuel was ignited resulting in a fire at the car as well as the fuel pump. No injuries were incurred by the customer, but the car was burned up and the pump damaged by the fire.

Root Cause

Inadequate or defective management systems (e.g., hazard identification, monitoring, etc.).

- Lack of proper maintenance of gas dispensing components at pump.

Conclusion

It was determined that the owner of the gas station ignored previous complaints about the nozzle at the pump before the incident happened.

Recommendations

TSSA will continue to monitor similar incidents and complete a risk assessment as a next step to determine if there is a broader safety issue requiring attention and to estimate the risks related to gas pump nozzle failures as a component of the fuel dispensing system.

Appendix Q – Collaborators in Safety

TSSA has worked with many organizations and groups to help keep Ontarians safe. This includes, but is not limited to:

Regulatory

- Electrical Safety Authority
- Ministry of Government and Consumer Services
- Ministry of Labour
- Ministry of Long-Term Care
- Ministry of the Environment, Conservation and Parks
- Ministry of Training, Colleges and Universities
- Office of the Fire Marshal and Emergency Management
- Ontario One Call
- Ontario Regional Common Ground Alliance
- Retirement Homes Regulatory Authority

Industry

- Advisory Councils:
    - Boilers & Pressure Vessels Advisory Council
    - Operating Engineers Advisory Council
    - Amusement Devices Advisory Council
    - Elevating Devices Advisory Council
    - Ski Lifts Advisory Council
    - Liquid Fuels Advisory Council
    - Natural Gas Advisory Council
    - Propane Advisory Council
    - Consumers Advisory Council
- Training and Certification Advisory Boards
- Risk Reduction Groups
- Field Advisory Committees

Appendix R – Risk-Informed Inspection Order Management

Introduction

Section 17 of the Act provides powers to TSSA inspectors to conduct inspections to ensure that "things" regulated under the Act are used, operated, installed, made, manufactured, repaired, renovated or offered for sale are in compliance with this Act and its associated regulations.

During an inspection, Section 21 of the Act requires inspectors to issue inspection orders against noncompliance that is observed. The Act also requires inspectors to specify the time period in which the noncompliance should be addressed. This "Time to Compliance" (TTC) is an essential component of the inspection process.

Consistent with Risk-Informed Decision Making (RIDM) principles, TSSA has established a risk-informed inspection order policy, which provides guidance for establishing:

- The requirements or necessary preconditions or circumstances for issuing an order pursuant to Section 21 of the Act;
- Risk-informed criteria for deeming a thing under the Act as unsafe, as posing an immediate hazard or a demonstrable threat to public safety (Section 21.1 and Section 21.2 of the Act);
- Risk-informed criteria for determining time for compliance with terms of inspection order (Section 21.1(a) and Section 21.2 of the Act); and
- Minimum criteria for type and content of an inspection order issued to a contravener (Section 21.4 of the Act).

In implementing this policy, TSSA has established standardized inspection orders for the various safety program areas. Using its risk assessment methodology, TSSA has also established the TTCs associated with these standardized inspection orders. Previously, only inspectors from the elevating and amusement devices and the operating engineers' programs have the standardized inspection orders and associated TTCs available to choose from electronically during inspections. In the past year, a mobile phone app has been deployed to allow fuels inspectors to use standard orders. BPV inspectors will have standard orders configured for use in the upcoming year. For the purposes of analysis and reporting, the actual TTCs issued by inspectors is used to estimate the risk of non-standard inspection orders.

Elements of Standardized Inspection Orders

1.1 Standard Order Master List

The most basic element of the standardized inspection orders framework is a list of inspection orders themselves. An inspection order master list is developed and maintained by each safety program, based on the Act, applicable regulations and codes, using a program-specific standardized format structure. An example of a standard order is the following in the case of escalators in Table R1.

Table R1: Escalators and Moving Walks Standard Order Example

ORDER ID	DIRECTIVE TEXT	CODE REFERENCE
XE0414	Repair/replace the damaged skirt panel.	CSA B44-10 (8.6.8.5) "The exposed surface of the skirt panels adjacent to the steps, if not made from, shall be treated with, a friction-reducing material. Damaged skirt or dynamic skirt panels shall be replaced or repaired."

Program areas may have multiple lists, divided into the various types for things they inspect. For instance, elevating devices may have a list for dumbwaiters and a separate list for construction hoists.

The final implementation of this step is completed when they are uploaded to TSSA's computer system and are available for use to the inspectors.

1.2 Risk Characterization – Determination of Time to Compliance

Risk Assessment

Once there is an established list of orders available for an inspector, the next step is to assess how much risk each order carries to determine the TTC that the inspectors are recommended to issue. Recall that risk is defined by the combination of frequency of harm and the severity of that harm. The technique to determine the TTC is a three-step process. In the first step, frequency and severity of possible consequences (occurrences) if an inspector observed noncompliance were allowed to persist, is determined. In the second step, risk threshold is determined for each occurrence type so as to analyze the time at which the occurrence type intersects the threshold. Given the time of possible occurrence of each occurrence type posing maximum risk, the third step entails determining the TTC by choosing the time that corresponds to an occurrence type that could potentially occur at the earliest time.

TSSA assesses orders using an expert panel of inspectors, engineers, and public safety risk specialists. Initial groundwork is laid out by developing a risk assessment template, which helps guide the thinking of the panel through the process. The template, developed internally by TSSA, guides the expert panel in determining the possible outcome(s) of noncompliance, the likelihood of the outcomes, and severity of the health impacts associated with the outcomes. Evidence including past incident history is used to guide the process, if available, and to help ascertain the severity of health impacts associated with the outcomes. Orders with no conceivable health impacts are deemed to be "administrative" orders with a risk score of zero.

This process is vetted with external stakeholders and experts as appropriate and relevant. The conceptual approach has also been presented at several conferences.

Once the likelihoods and severities are established, a mathematical prediction model developed by TSSA combines these quantities, in addition to observed occurrence data to derive two outputs; the risk score for each standardized inspection order, and the associated TTC. Additionally, this process also provides the basic inputs required for establishing inspection intervals for devices that are currently on a risk-informed periodic inspection schedule.

The predicted TTC is made available for implementation and use including for analysis purposes using risk bins and referred to throughout this report. Table I2 provides an illustration of a risk bin for each TTC range (note that zero risk, administrative orders are low risk regardless of their TTC).

Table R2: Risk Bins And Corresponding TTC Ranges Across Program Areas

RISK BIN	TTC RANGE (OPERATING ENGINEERS)	TTC RANGE (ALL OTHER PROGRAMS)
High	0 – 10 days	0 – 10 days
Medium	11 – 29 days	11 – 60 days
Low	More than 29 days	More than 60 days

Recently TSSA did an overhaul of its inspection order assessment process. Likelihood and severities are still estimated, but there is an increased reliance of data (i.e., incident data, failure rate data, etc.). Furthermore, the interface for the estimating likelihood and severity have been reconfigured to better guide the expert panel.

Appendix S – References

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Appendix T – Risk Model Peer Group

In fiscal year 2019, TSSA engaged technical and regulatory experts in a peer engagement of its risk model. The input and feedback of the following individuals was extremely useful as TSSA continues to identify ways to strengthen how it uses data to make risk-informed decisions.

1. Joel Moody - Chief Public Safety Officer and Senior Director – Policy and Innovation, ***Electrical Safety Authority***
2. Abraham Van Poortvleit - Vice President, Data Analytics and Decision Science, ***Technical Safety BC***
3. Isabelle Roy – Chief Risk Management – ***Transport Canada***
4. Darren Jette - Policy/Economic Officer - ***Transport Canada, Transportation of Dangerous Goods***
5. Rena Chung - Manager, Toxicology and Exposure Assessment - ***Director, Environmental and Occupational Health***
6. Nina Purcell - Former Director, Regulatory Delivery & Wales - ***UK Food Standards Agency***
7. Mayy Habayeb - Professor, ***School of Engineering and Applied Science - ICET Centennial College*** - Speciality: Big Data Analysis, Machine Learning Algorithms