



Technical Standards and Safety Authority

Annual State of Public Safety Report

2015 Edition



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Glossary of Terms

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 change or modify TSSA-specific requirements.
Compliance Rate	The percentage of inspections conducted by TSSA inspectors wherein no non-compliances (hazards) with the <i>Technical Standards and Safety Act, 2000</i> (the Act) and associated regulations are found.
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. 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 regulations. It can require regulation, use or disuse of specified things.
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 A for a full description.
External Factors	Safety impact related to failures associated with factors outside the direct control of the safety system (e.g. behaviour of users/consumers of technologies and devices in lieu of their intended use, environmental/weather conditions, utility failures).
Fatality-Equivalent	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.
Fiscal Year	Represents fiscal years (May 1 – April 30)
Health Impact	Refers qualitatively to injuries and fatalities sustained by the public exposed to TSSA regulated devices/ technologies. A health impact could be one of fatal, permanent or non-permanent injuries
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 Disability-Adjusted Life-Year metric is used to combine injuries and fatalities. The injury burden is expressed in the units of fatality-equivalents per exposed population per year.
Potential Gaps in Regulatory System	Safety impact associated with gaps in the regulatory system or where no regulatory control exists.
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 associated regulations. Under this section, an inspector may also seal any thing with respect to amusement devices, boilers and pressure vessels, elevating devices, fuels, operating engineers and upholstered or stuffed articles, as referred to in the



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	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 as high, medium, and low risk. The statutory directors may classify orders to suit the needs of their program area. With the exception of Operating Engineers, the classifications are defined as follows: High Risk Inspection Order Issued where non-compliance 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 non-compliance 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 non-compliance is identified and warrants an inspection order for action within 90 days, for time to compliance to regulatory requirements.
Non-Compliance with the Regulatory System	Safety impact associated with the violation of established regulatory controls.
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.
Occurrence	The realisation 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 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 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.
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 Potential risk of injury or fatality associated with operation and maintenance of things or class of things that may reach unacceptable levels within timeframes defined by the Statutory Director of each regulated program.
Periodic Inspection	An inspection conducted at such intervals as may be determined by the Statutory Director or required by code or regulation for the purpose of ensuring the safe operation of the device/facility.



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Permanent Injury	An injury sustained by an individual that partially or permanently impairs the normal abilities of that individual for the rest of his/her expected remaining life.
Prediction Interval	A prediction interval is an estimate of an interval into which a new observation will fall, with a certain probability, given what has already been observed. In this report, the prediction interval covers between the 5 and 95 percentiles of the measured data. Observations for those indicators lying outside the prediction intervals are made with a 95% confidence level.
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 of Injury or Fatality	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 metric is expressed in fatality-equivalents per exposed population per year. This measure of risk accounts for historic 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. 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.
Safety Order	A regulatory decision made by a Statutory Director under the powers given to him/her as per Section 14 of the Act. Director's Safety Order (s. 14) Issued to specific persons or classes of persons, to require that specified things not be used or only used in a particular way. The order can also authorize inspectors to address any imminent hazard.
Root Cause	The most basic reason (underlying cause) for an occurrence that can be reasonably identified.
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).



List of Acronyms

AD	Amusement Devices Program Area
ALARP	As Low as Reasonably Practicable
BPV	Boilers and Pressure Vessels Program Area
ED	Elevators Program Area
EM	Escalators and Moving Walks Program Area
FE/mpy	Fatality-Equivalent(s)/million people/year
FS	Fuels Safety Program
MIACC	Major Industrial Accidents Council of Canada
OE	Operating Engineers Program Area
PSRM	Public Safety Risk Management
RIDM	Risk-Informed Decision Making
SL	Ski Lifts Program Area
The Act [1]	Technical Standards and Safety Act
TSSA	Technical Standards and Safety Authority
USA	Upholstered and Stuffed Articles Program



I. Message on the State of Public Safety from Srikanth Mangalam, the Chief Advisor, Public Safety Risk Management

- Risk of injury or fatality arising from failures of regulated technologies continues to be below the risk acceptability criteria (1.00 fatality/million people/year) and reducing over time.
- Additionally, risk of injury or fatality caused across technologies periodically inspected by TSSA remains low and has reduced compared to last year.
- Risk of injury or fatality due to lack of or improper maintenance and inappropriate use of fuel burning appliances in private dwellings continue to be the largest contributor to the risk of injury or fatality and beyond acceptable levels.

Since 2008, Ontario has observed 46 fatalities, 295 permanent injuries and 6,696 non-permanent injuries, resulting in an eight-year average injury burden of approximately 0.51 fatality equivalents/million people/year¹ when exposed to TSSA-regulated technologies and devices. Additionally, approximately 1,000 occurrences take place every year without any known injuries.

Using a predictive approach developed by TSSA [2], it is estimated that the composite risk of injury or fatality to Ontarians² or the expected injury burden is approximately 1.00³ fatality-equivalent/million people/year. Measures representing the overall state of safety are provided in Table 1, and represented graphically in Figure 1 below.

Table 1: Overall state of safety measures for the period 2008 – 2015⁴.

Measure	Fiscal Year							
	2008	2009	2010	2011	2012	2013	2014	2015
Occurrences	1,724	1,578	1,551	1,553	1,613	1,771	2,487	2,114
Fatalities	7	14	2	5	4	5	9	0
Permanent Injuries	40	39	42	18	28	29	49	50
Non-Permanent Injuries	723	678	602	649	890	931	1,170	1,053
Risk of Injury or Fatality (FE/mpy)	Not Available			0.88	1.02	0.99	1.05	1.00
Observed Injury Burden (FE/mpy)	0.37	1.02	0.55	0.22	0.44	0.62	0.59	0.25
Occurrences not included in predicted risk ⁵	2,288	2,522	2,434	2,460	2,387	2,402	2,518	2,002

As indicated in Table 1, the predicted risk of injury or fatality has reduced as compared to year.

Trend analyses indicate that, while the total number of permanent injuries and fatalities do not demonstrate any significant quarterly trends, occurrences and non-permanent injuries are increasing at 4% per year.

¹ Fatality-equivalent/million people/year is a unit of measure obtained by integrating quantified health impacts into a single count of equivalent fatalities for benchmarking and decision-making purposes.

² Readers are cautioned that composite risk of injury or fatality has been established for reporting and benchmarking purposes only. Sections provided for the individual safety programs help gain an understanding of the significant causes, and more importantly, strategies for monitoring and managing risk to Ontarians.

³ Represents expected estimate of a simulated distribution, 5th and 95th percentiles are 0.58 and 1.48 fatality-equivalents per million people per year respectively.

⁴ Only considers those program areas for which predicted risk can be calculated. For additional details, please refer to the program area section. Results for previous years have also been updated, and as such, comparisons with previous versions of this report may not be appropriate.

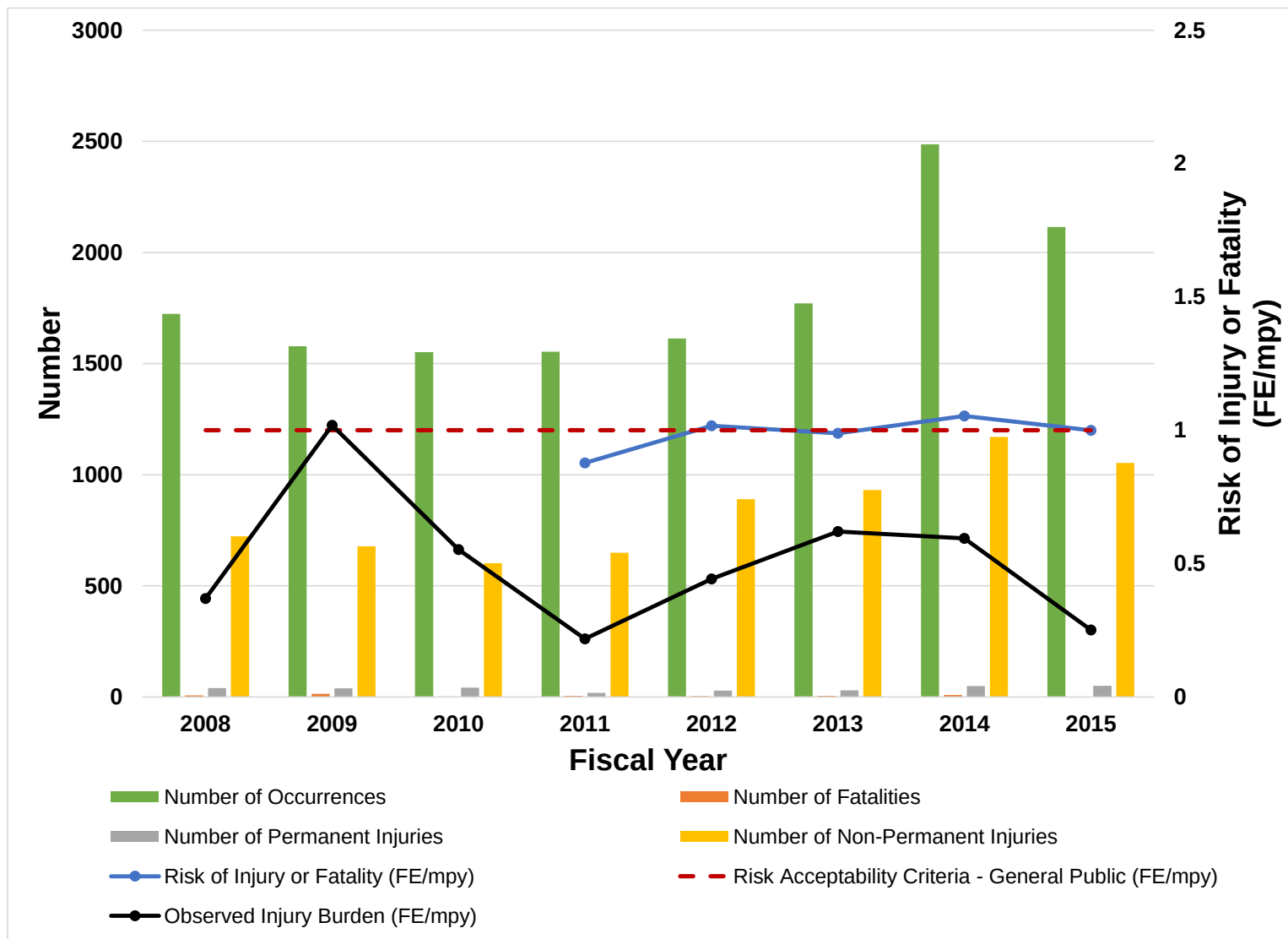
⁵ Occurrences not included in the calculation of predicted risk include pipeline strikes, BPV, OE and FS occurrences resulting in leaks, spills and discovery of petroleum product due to inadequate number of reported occurrences and/or no historic health impacts.



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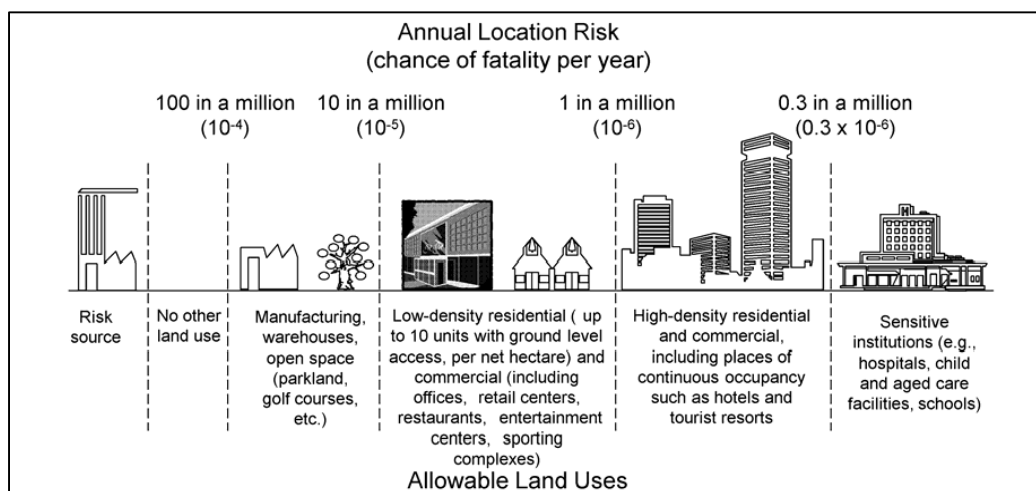
Figure 1: State of safety of regulated program areas over the last eight years.



I.1 State of Safety Highlights

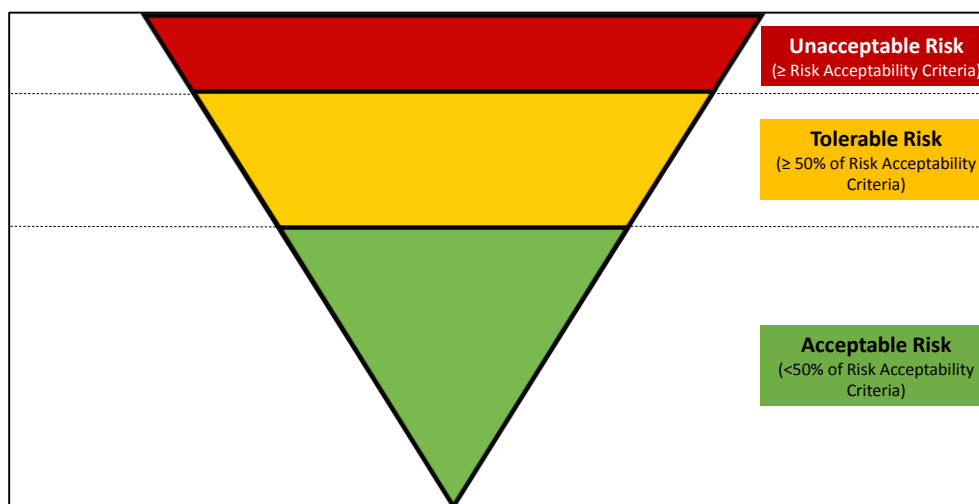
TSSA uses a risk informed approach to understand the state of safety across its regulated sectors, identify safety issues and establish priorities accordingly. The state of safety is described using a risk metric, known as risk of injury or fatality that is measured in terms of fatality-equivalents/million people/year. This measure helps compare against international benchmarks and risk acceptability criteria and set internal thresholds for decision making. TSSA has adopted the risk acceptability criteria established by the MIACC as shown in Figure 2 below for comparison purposes. Specifically, TSSA uses a criteria of 1 fatality/million people/year for evaluating risk to the general population of Ontario and a criteria of 0.3 fatalities/million people/year for evaluating risks to sensitive sub-populations.

Figure 2: MIACC risk acceptability criteria.



Additionally, for the purposes of better understanding the sources of risk and helping establish priorities, TSSA has adapted the use of ALARP principles, which was originally created in the UK⁶ and is widely used to assist in decision making. As shown in Figure 3 below, ALARP helps map risks into regions or zones ranging from unacceptable, tolerable to acceptable.

Figure 3: TSSA adaptation of ALARP principles for classifying risk sources.



⁶ <http://www.hse.gov.uk/risk/theory/alarpglance.htm>



Sources of risk identified as being in the unacceptable (red) zone are considered to exceed the acceptability levels defined in the MIACC criteria. These sources of risk exceed the risk acceptability criteria for the general population or for sensitive subpopulations and are deemed to be unacceptable. TSSA identifies these sources of risk as immediate safety priorities.

TSSA has chosen to use a criteria equivalent to or greater than 50% of the risk acceptability criteria to represent the tolerable (yellow) zone also known as the ALARP zone. These sources of risk are below the risk acceptability criteria for the general public or for sensitive subpopulations, and are deemed to be tolerable. TSSA considers these sources of risk as potentially emerging areas and are monitored and/or addressed through mitigation strategies. As suggested under ALARP principles, decisions to address these sources of risk will take into account factors such as cost-benefit, stakeholder points of view, effectiveness, etc.

Sources of risk less than 50% of the risk acceptability criteria are identified to fall under the acceptable (green) zone. Those sources of risk are deemed to be within broadly acceptable levels and do not require immediate mitigation strategies. While TSSA considers these sources as not being of immediate concern, it continues to monitor and oversee these sources using the various regulatory tools available.

Figure 4 below provides a more comprehensive view of the risk of injury or fatality across the different TSSA regulated safety sectors.

Figure 4: Risk of Injury or Fatality across regulated program areas.

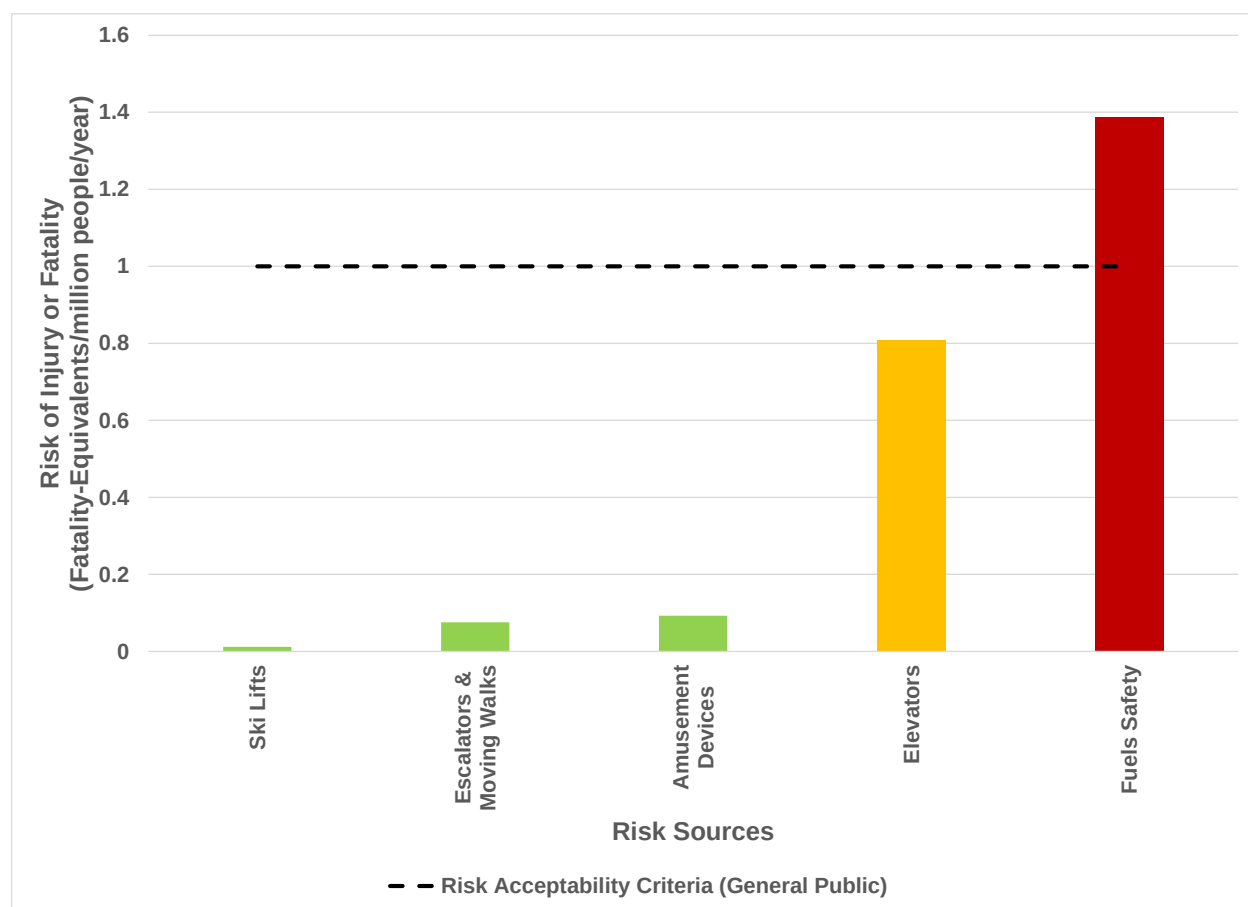
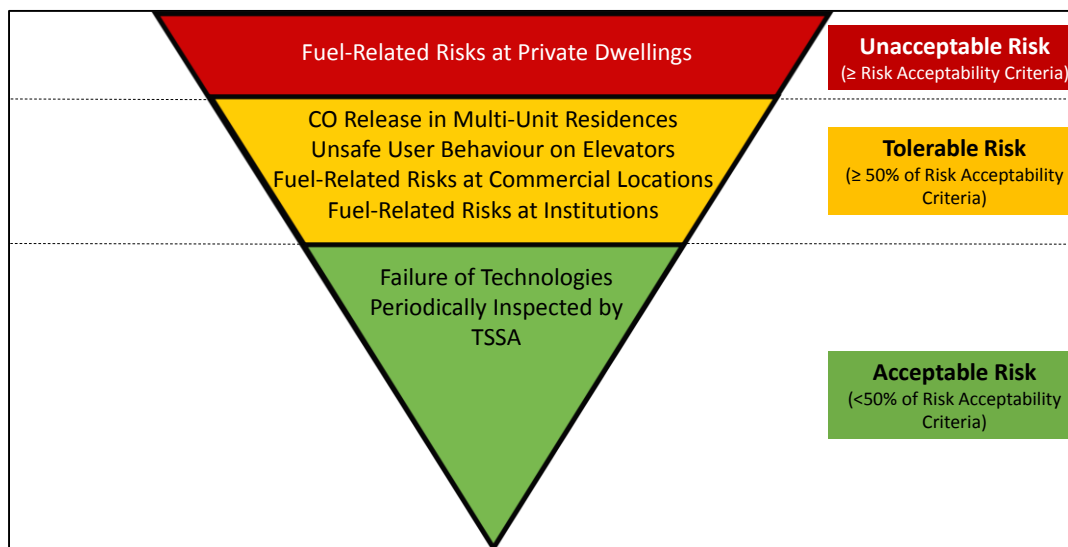


Figure 5 below provides an illustration of the sources of risk better understood using ALARP principles. Observations and significant highlights based on this view of risk profile, including those areas seeing a risk reduction, and those areas that are of potential concern as compared to the previous year are discussed further below.

Figure 5: TSSA's sources of risk and priorities.



Sources of Risk of Injury or Fatality in Unacceptable Zone

The following is the source of risk within the TSSA regulated sectors that is identified to be unacceptable as it exceeds the defined threshold levels. This source of risk remains TSSA's most significant safety priority.

A. Risk of Injury or Fatality at Private Dwellings due to Fuel Burning Appliances

Risk of injury or fatality due to poor installation and/or lack of maintenance and improper use of fuel burning appliances such as furnaces, water heaters, and boilers at private dwellings is predicted as 1.96 fatality-equivalents/million people/year. Exposure to unacceptable levels of carbon monoxide formed due to improper combustion of fuel used by these heating appliances at private dwellings continues to remain the single largest source of risk across all TSSA regulated sectors. Causes for this risk source range from poor installation of appliances, lack of or inadequate periodic maintenance to the improper use of appliances not designed for indoor operation. Carbon monoxide is an odourless gas that, at unacceptable levels, can cause health impacts ranging from nausea to death. Fires and explosions, while secondary in impact to carbon monoxide poisonings, have also been observed resulting from aforementioned causes.

TSSA has addressed one such source relating to natural draft vented boilers by requiring tighter design and maintenance requirements. While this strategy has had a positive effect wherein homeowners have proactively complied with maintenance requirements, it remains an issue with un-maintained appliances.

Sources of Risk of Injury or Fatality in Tolerable Zone:

As indicated above, these sources of risk are within the tolerable zones and are identified as emerging risks that require either monitoring and/or addressing to prevent them from becoming unacceptable in the future.

A. Risk of Injury or Fatality due to from carbon monoxide exposures at Multi-Residential Locations

The risk of injury or fatality due to carbon monoxide poisoning at multi-residential locations is predicted as 0.86 fatality-equivalents/million people/year, and has increased by 3% since last year. The risk of injury or fatality continues to be due to improper maintenance, installation and use of fuel burning appliances. Multi-residential locations including condominiums and rental apartments.



B. Risk of Injury or Fatality due to unsafe passenger behaviour on Elevators

Risk of injury or fatality resulting from unsafe behavior on elevators is predicted as 0.66 fatality-equivalents/million people/year and has decreased by approximately 13% from last year. However, it remains close to unacceptable levels of risk of injury or fatality. Such occurrences are increasing by 21% per year and largely take place at residential locations involving rental and condominium units, which on their own account for nearly 35% of occurrences related to elevators. Additionally, there is an increasing trend in the number of occurrences related to elevator car doors closing on passengers of 9% per year. Factors such as a distracted users is identified as primary cause for such occurrences.

C. Risk of Injury or Fatality due to fuel burning appliances at Commercial Establishments

The risk of injury or fatality at commercial establishments is predicted as 0.58 fatality-equivalents/million people/year. Though the risk has decreased by 3% since the last year, it remains close to unacceptable levels. Poor maintenance practices for appliances, such as stoves and ovens at food service locations including restaurants and bakeries posed the most risk. Damage to gas supply lines (risers, meters, regulators etc.), also contribute to occurrences at these locations.

D. Reduction in Risk of Injury or Fatality due to Fuel Burning Appliances at Institutions and Locations with Sensitive Sub-Populations

The risk of injury or fatality due to poor installation, maintenance or use of fuel burning appliances at institutions such as hospitals, nursing homes, retirement homes, schools etc. that house Ontario's vulnerable population was identified as an area of concern in the 2012 version of this report. The acceptability threshold at these locations⁷ [3] is recognized to be lower than that of the general population [4, 5] of exposure as the ability to evacuate the residents at these locations during emergencies is more challenging. The risk of injury or fatality has reduced by 13% compared to last year and remains below the more stringent threshold.

Sources of Risk in Acceptable Zone:

Sources of risk that demonstrate low levels of risk of injury or fatality fall into this category. In general, sources of risk caused by operation and maintenance of technologies periodically inspected by TSSA continue to remain within acceptable levels and have decreased since last year. In particular, during the course of 2015, and in comparison with the previous year, the following significant observations can be made:

A. Reduction in Risk of Injury of Fatality at Fuels Storage and Dispensing Licensed Facilities

The risk of injury or fatality to Ontarians at fuels storage and dispensing sites has reduced as compared to last year. These retail sites, storing and dispensing liquid and propane fuel, are licensed by TSSA and inspected periodically. Of particular interest is the continuing low number of occurrences at propane storage and dispensing sites, as well as a corresponding increase in the compliance rate compared to last year. A regulatory change made in 2014 removed annual inspection requirements for these facilities. These facilities are now inspected using a risk informed approach.

B. Reduction in Risk of Injury or Fatality resulting from maintenance and operation of Elevators and Amusement Rides

The risk of injury or fatality to Ontarians due to non-compliance with regulatory requirements largely related to maintenance and operation of elevators and amusement rides remains low and has reduced by 25% and 39% respectively as compared to last year. TSSA conducts periodic inspections of these technologies and devices on a periodic basis and, in particular, uses a risk informed approach to determining the frequency of inspections for elevating devices. TSSA has also introduced several multi-year risk reduction strategies to address safety concerns related to older technologies in the elevating devices program intended to further reduce the level of risk.

⁷ 0.3×10^{-6} according to the PSM Division, CSChE. Major Industrial Accidents Council of Canada (MIACC) Criteria for land-use planning (2008).



TSSA Risk Informed Decision Making

TSSA's risk informed decision-making (RIDM) framework, initiated in 2007, is an evidence-based, scientific approach to identifying, analyzing, and measuring, and managing risk of injury or fatality 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 resources, and leveraging partnerships with stakeholders. This annual state of public safety report acts a primary source of information for risk informed decision making. TSSA's RIDM framework continues to assist the statutory directors across all the safety programs in making regular day-to-day decisions while helping tackle larger and more complex strategic regulatory decisions. Some key highlights of RIDM based work during the past fiscal year have included:

- Successful implementation of a risk informed inspection scheduling process for propane storage and dispensing facilities that has received broad stakeholder support and acceptance. This process has helped TSSA focus its inspection efforts based on risk while providing incentives to industry with better compliance records.
- Issuance of risk informed director's orders to address leveling hazards associated with older elevators with single speed motor controls requiring that all single speed elevators need to be updated to include a closed loop braking system. The completion dates for this work have been staggered between 2018 and 2021 with those devices presenting the highest risk being addressed first.
- Implementation of a "special buildings" initiatives designed to address safety risks due to fuel burning appliances at institutions with vulnerable populations with an initial focus on retirement and long-term care homes.
- Supporting the economic growth of the liquefied natural gas sector by developing and implementing interim approval strategies for new storage dispensing facilities using a risk and safety management plan approach, in absence of a specific regulatory framework for the sector.
- Continued development and enhancement of patented and patent pending risk assessment and root cause analysis tools supporting TSSA inspectors and investigators (Appendix B of this report showcases on such tool on root cause analysis as part of TSSA's continued aspiration for being a transparent and innovative regulator).

In its continued effort of seeking external validation of its RIDM framework and as part of its benchmarking initiative, TSSA has actively worked further evolving the field of public risk management by:

- Influencing the development of national guideline for managing risk in the public interest, which is expected to be completed and available by the end of 2016.
- Supported and influenced enhancements to several international risk assessment standards.
- Entered into formal partnerships with regulators nationally and internationally for sharing risk information and best practices in risk assessment.



II. Introduction

Statutory Directors appointed by TSSA have regulatory powers and obligations to effectively administer the Technical Standards and Safety Act (the Act) [1] and its associated regulations to ensure the safety of Ontarians. The Chief Advisor, Public Safety Risk Management is responsible for providing strategic advice and information to the Statutory Directors for them to make risk-informed decisions to reduce the risk of injury or fatality to Ontarians.

The *Annual State of Public Safety report* (ASPR) is a key component of the RIDM framework and acts as a primary source of knowledge on the safety of Ontarians resulting from TSSA-regulated technologies and its management. The ASPR is also a public facing document that describes the current and future strategies established by the Statutory Directors and those responsible for preventative and educational tools to enhance safety and reduce risk of injury or fatality to Ontarians.

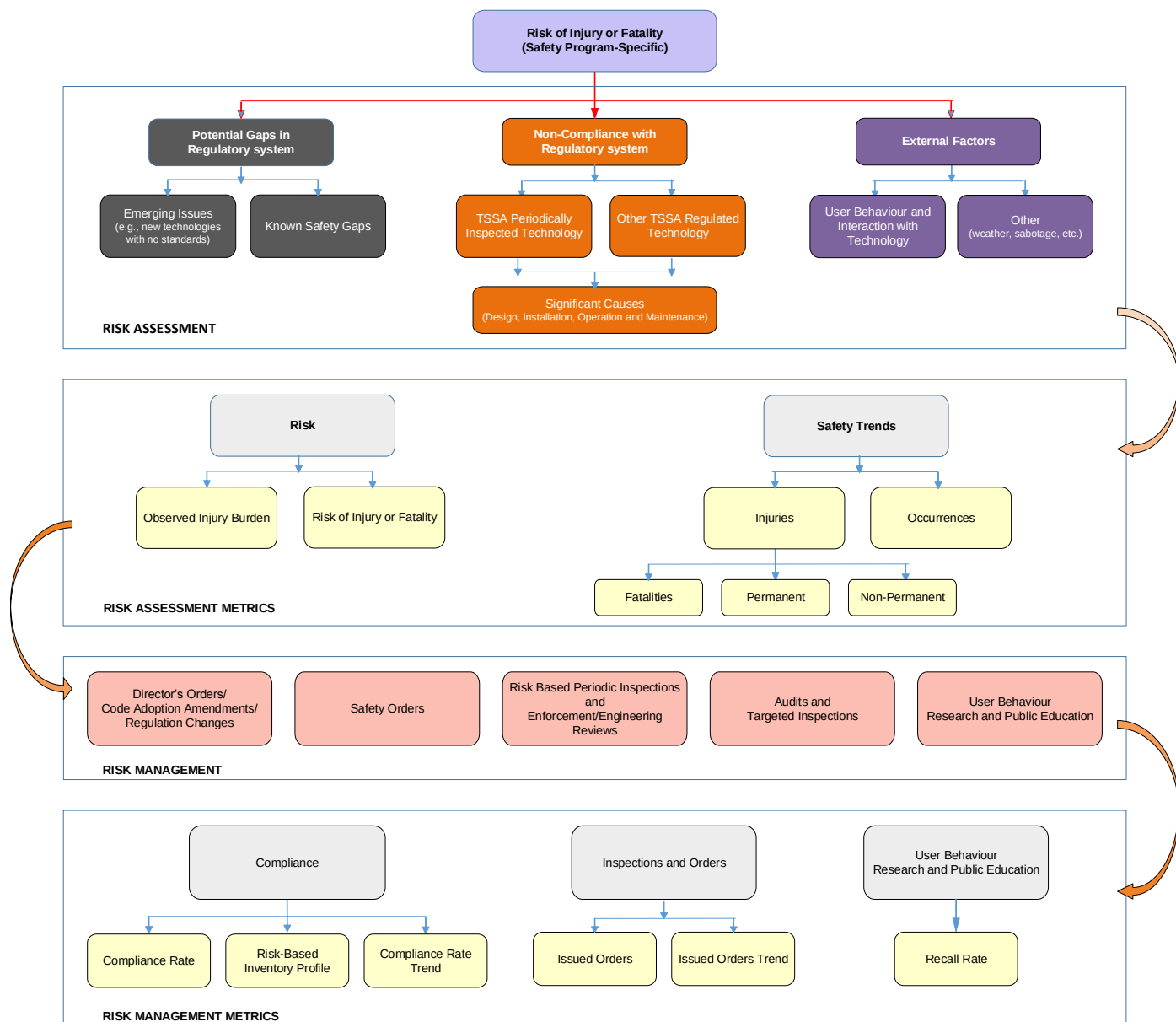
This year's version of the ASPR, while presenting the current state of safety for a eight-year period ending April 30, 2015, continues to focus on providing a deeper understanding of the causes and behaviours contributing to the overall level of risk. Throughout this report, all references to specific years refer to fiscal year.

II.1 Reducing Risk of Injury or Fatality – Understanding and Managing Causes and Behaviours

Risk of injury or fatality 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 inspections and other regulatory oversight tools. The information collected allows TSSA to analyze the primary causes associated with the risk that helps Statutory Directors establish and implement strategies aimed at reducing risk.

This two stage process of assessing and managing risk depicts the public safety risk management framework that can best be illustrated using Figure 6 shown below. The three primary causal categories (as defined in Appendix C), leading to public safety risk include the following.

Figure 6: Public Safety Risk Management Framework.



II.1.1 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.

Another 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 above-mentioned 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 effect changes to regulations.



II.1.2 Non-Compliance with Regulatory System

This category of occurrences involve failures resulting from non-compliance with the regulatory requirements by those statutorily responsible for design, manufacture, installation, operation and/or maintenance of TSSA regulated technologies and devices. The level of understanding, education, required skills and training of these regulated stakeholders or responsible parties such as owners of technologies, installation and maintenance technicians, along with their intent to comply, affect this category of risks.

The level and type of TSSA regulatory oversight of these activities varies from program to program. In most instances, the regulatory expectations of TSSA are specified in the Act [1] and its associated regulations. A key oversight function involves TSSA 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 introduction, expansion or modification to 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.

II.1.3 External Factors

Occurrences take place despite the presence of an adequate regulatory management system. Risks in this category are typically caused due to use of technologies and devices by users, such as members of the general public in lieu of their intended purpose. Examples include improper maintenance of residential heating equipment, such as furnaces due to poor or inadequate understanding of the risks which contribute significantly to risks in this category. A comprehensive understanding of user behaviour helps TSSA set up appropriate public education tools to reduce risk in this category. A detailed description of TSSA's innovative approach to understanding and modifying user behaviour is provided in Appendix D of this section of the ASPR.

Other reasons under this category may 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 TSSA's regulatory tools to address the risk.



Enhancements to the Annual State of Public Safety Report

In line with its commitment to continuous improvement and based on feedback from stakeholders, TSSA continues to enhance the structure and style of reporting. Based on new information and data, TSSA also enhances its processes and methodologies in analysis and reporting. Changes to this year's ASPR affecting the results of analysis are discussed herewith. Structural changes are not identified as they are considered as enhancements to the readability of the report and do not impact the analysis.

TSSA's estimate of predicted risk of injury or fatality is based on a mathematical model that uses various sources of data, including occurrence details, historic occurrence rates, types, and extent of injuries sustained by victims in the past, and the number of injured victims. TSSA has updated calculations of predicted risk of injury or fatality to account for new data for these variables while continuing to duly account for uncertainty. These updated calculations were made to include occurrences that were previously still under investigation. ***As such, results for previous years have been updated, and comparisons with previous versions of this report are not appropriate.*** It is expected that differences in calculations reported in previous years will reduce over time as data handling practices improve at TSSA. Details of the enhanced methodology and the specific changes are included in Appendix A.

TSSA uses a rolling five-year period for measurement and reporting of compliance information for this version of the report. For more details on statistical analysis, please refer to Appendix E.

As a part of this year's report, TSSA has created a new visual representation of sources of risk across regulated program areas, which is predicated on its proximity to, or their exceedance of risk acceptability criteria. In creating this visual, TSSA has strived to transparently illustrate the means taken to identify and prioritise key safety areas. Adapting internationally used ALARP principles, sources of risk portrayed in red represent those risk sources which exceed the acceptability levels. These are considered to be unacceptable and have been identified as key safety priorities. Sources of risk portrayed in yellow represent those sources of risk that fall within 50% of the acceptability criteria. They are considered to be tolerable and have been identified as potentially emerging areas of risk and are monitored and/or addressed through mitigation strategies. Finally sources of risk portrayed in green represent those sources of risk less than 50% of the acceptability criteria. They are considered to be acceptable and have been identified as not being of immediate concern, it continues to monitor and oversee these sources using the various regulatory tools available.

Additionally, the main sources of risk in each program area have been visually represented in a causal pathway. This approach helps to better understand the detailed causal reasoning associated with the sources of risk.

As part of TSSA's commitment to continuous improvement, the Operating Engineers Safety Program Area, in collaboration with the Public Safety Risk Management team, has reassessed their inspection orders to better reflect the level of safety associated with these non-compliances.

Assumptions and Sources of Uncertainty

It is important to note that analysis on compliance trends will be provided over a rolling five-year period, in alignment with TSSA's strategic planning process, which typically sets safety strategies within a five-year horizon. This allows for appropriate measurement and reporting on the effectiveness of these strategies. Trend analysis on occurrences will be 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 makes every effort to ensure a high level of data integrity and continuously works toward improving the integrity of all data collected for the purposes of reporting. To this effect, TSSA takes every precaution to ensure the accuracy and quality of data presented in the *Annual State of Public Safety Report*. As such, TSSA has implemented a Quality Management System (QMS) to ensure accurate presentation of public safety information. The QMS is based on ISO 9001:2008 principles and requirements to assure transparency, data integrity and quality of the information in the report. Occasionally, it is necessary to make restatements to



results reported in previous years, typically a result of timeframe factors such as information received subsequent to the issuance of the report, localized reporting lags for periodic data, and other issues.

Analysis involving prediction of health impacts and those conducted as part of safety risk assessments have identified and quantitatively accounted for additional sources of uncertainties. Explicitly stated predictions in this report typically represent expected values after accounting for such known sources of uncertainties. In line with its commitment to transparency, TSSA also began reporting on the range of expected values associated with these measures to give readers a better idea on the uncertainty surrounding these estimates.

Analysis involving reported and inspected occurrences may be significantly impacted by reporting biases, defined in Appendix A. 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.

Acknowledgement

TSSA would like to express gratitude to its inspectors and engineers for collecting and documenting valuable pieces of information and data through their inspections and investigations that has been used to develop this report. Thanks also to its Research and Education team for providing information on the activities and outcomes related to their User Behaviour research, and its Information Services team for providing the tools and advice for extracting data.

TSSA would like to especially acknowledge the Public Safety Risk Management (PSRM) team for producing this report. In particular, TSSA is thankful to Public Safety Performance Analyst Kavitha Ravindran, Public Safety Risk Advisors Dr. Robert Wiersma, Dwight Reid, Jorge Larez and Lency Abraham for helping in the analysis and development of the report, and to Public Safety Risk Advisor Supraja Sridharan for leading the project. TSSA would like to thank Project Coordinator, Christine Ho for conducting quality assurance on wording in the report.

The PSRM team would like to thank Ellen White, Kristian Kennedy and Greg Kerr with the Stakeholder Relations team who helped in the preparation of the report.



III. Program-Specific State of Safety and Compliance and TSSA Strategies

III.1 Boilers and Pressure Vessels

The Boilers and Pressure Vessels Safety Program area operates within a strong regulatory and standards infrastructure, which provides effective protection for the public from any incidents involving pressure vessels. TSSA is involved in all aspects of the lifecycle of pressure vessels: from design, to manufacture, to installation, to operation and maintenance, to decommissioning – plus the certification of all boiler inspections.

Boilers and pressure vessels include equipment that produces and distributes hot water, steam, compressed air, and other compressed liquids and gases used in commerce and industry. TSSA is responsible for regulating all pressure retaining components manufactured or used in Ontario, with a commitment to ensuring the safety of boilers, pressure vessels and piping systems. TSSA conducts periodic inspections on uninsured boilers and pressure vessels in Ontario. The remaining insured boilers and pressure vessels are inspected by insurance companies licensed to underwrite boiler and machinery insurance. TSSA is responsible for the certification of the inspectors employed by the insurance companies.

Incidents involving this type of equipment and associated piping are infrequent. Nevertheless, cracked and corroded vessels or piping can leak or rupture, producing a variety of safety problems, including poisonings, suffocations, fires or explosions. Ruptures can be catastrophic and may immediately threaten life and property. The safe design, installation, operation, and maintenance of pressure vessels, in accordance with appropriate codes and standards, are essential to public safety. TSSA's activities help ensure that safeguards are in place for the lifecycle of this type of equipment.

III.1.1 Risk Assessment

There have been 12 occurrences, two permanent injuries and one non-permanent injury attributed to regulated boilers, pressure vessels and piping systems in the province over the last eight years.

In 2015, there was one occurrence involving a new process at a manufacturing plant, for which there were no operating procedures. The occurrence resulted in a pressure vessel failure, and no health impacts were sustained.

Due to limited data on occurrences and health impacts, estimates of risk or trends associated with occurrences cannot be currently established.

III.1.2 Risk Management – Message from Mike Adams, Statutory Director of BPV and OE

TSSA conducts periodic inspections of uninsured boilers and pressure vessels to determine the level of compliance in the province of Ontario. The frequency of those inspections is specified in the Code Adoption Document associated with the Ontario Regulation 220/01 (Boilers and Pressure Vessels). TSSA deals with non-compliance by requiring the owners/operators to address observed non-conformances within an appropriate timeframe through the issuance of inspection orders. This periodic inspection process contributes to the preventative management of risk associated with boilers and pressure vessels.

Table BPV-1 provides information on key indicators associated with the results of the periodic inspections. The compliance rate measured over the last five years is 96% and does not demonstrate any significant quarterly trend.



Table BPV-1: State of compliance for uninsured boilers and pressure vessels as of 2015.

Measure	Measured over a Five-Year Period
Compliance Rate ⁸	96%
Observed Trend in Compliance Rate	No significant quarterly trend
Compliance Rate Prediction Interval – Lower Bound	87%
Compliance Rate Prediction Interval – Upper Bound	100%

During each inspection where a non-compliance was found, an inspector may choose to issue one or more orders. Inspection data indicate 91% of non-compliant inspections had only one order was issued. Additionally, there were no non-compliant inspections where five or more orders were issued.

The compliance rate is an accurate reflection of the safety of boilers and pressure vessels in Ontario. Although the 96% TSSA compliance rate applies only to uninsured BPVs, similar compliance rates were confirmed for insured BPVs at the most recent BPV Advisory Council. As well, the National Board reported a compliance rate in the 90% range for the 652,392 inspections performed in North America during the period: 1 April, 2014 to 31 March, 2015.

⁸ Median of quarterly compliance rates over five years.



III.2 Operating Engineers

Operating engineers, also known as power engineers in jurisdictions outside Ontario, are certified professional power plant operators who oversee the provision of energy, climate control, electric power or other utilities for thermal-electric generating stations, industrial processes and facilities. They manage, operate and maintain boilers, steam turbines and engines, gas compression plants, refrigeration plants, and associated mechanical and electrical systems in power generation, industrial processes and environmental system plants.

Depending upon the size of a specific facility, operating engineers may also manage, operate and maintain all physical facility operations. Large power plants have several operating engineers for each shift, designated as shift engineers and assistant shift engineers. In all cases, a chief operating engineer is responsible for the entire plant management, operation and maintenance. The Operating Engineers Safety Program area is responsible for registering, inspecting and regulating the safety of approximately 3,000 plants in Ontario, as well as examining and certifying nearly 12,700 operating engineers and operators to confirm their qualifications. These activities ensure that all operating engineers and operators in Ontario have the skills and knowledge to safely manage, operate and maintain registered power plants.

III.2.1 Risk Assessment

One permanent injury and six occurrences were reported over the last eight years. There was one occurrence that took place during 2015, involving an operator error wherein a mechanic removed a pipe plug, resulting in a release of ammonia into the surrounding area. The cause was attributed to improper and negligent work practices on the part of the operator.

Due to limited data, estimates of risk of injury or fatality or trends based on past occurrences cannot be currently established involving registered operating plants.

III.2.2 Risk Management – Message from Mike Adams, Statutory Director of BPV and OE

TSSA conducts periodic inspections of approximately 3,000 registered operating plants in Ontario. These periodic inspections assist in maintaining a low to negligible risk of injury or fatality to Ontarians that may result from non-compliance with the regulatory requirements. TSSA uses a risk-based inspection scheduling process [6] to determine the frequency of inspections of all registered plants. Data collected through these inspections helps prioritize frequency of inspections and to proactively manage risk of injury or fatality.

Using a risk-based approach, the entire inventory are inspected at least once over a two-year period. TSSA deals with observed non-compliances by issuing inspection orders to the owner/operator to address these non-compliances within an appropriate timeframe. This periodic inspection process contributes to the preventative management of risk of injury or fatality associated with operating plants.

Table OE-1 provides information on key indicators associated with the results of the periodic inspections. The compliance rate measured over the last five years is 40% and does not demonstrate any significant quarterly trend.



Table OE-1: State of compliance for operating plants as of 2015.

Compliance Measure	Measured over a Five-Year Period
5-Year Compliance Rate ⁹	40%
Annual Compliance Rate Trend	No significant quarterly trend
Compliance Rate Prediction Interval – Lower Bound	30%
Compliance Rate Prediction Interval – Upper Bound	50%

Increasing trends in compliance rates have been observed through periodic inspections conducted at Low Pressure Watertube Low Water Volume Power Plant and multi-residential locations of 10% per year and 8% per year. These two types comprise 0.3% and 1.2% of the total inventory of plants respectively. Additionally, decreasing trends in compliance rates have been observed in High Pressure Steam Plants of 4% per year and comprise 11% of the total inventory.

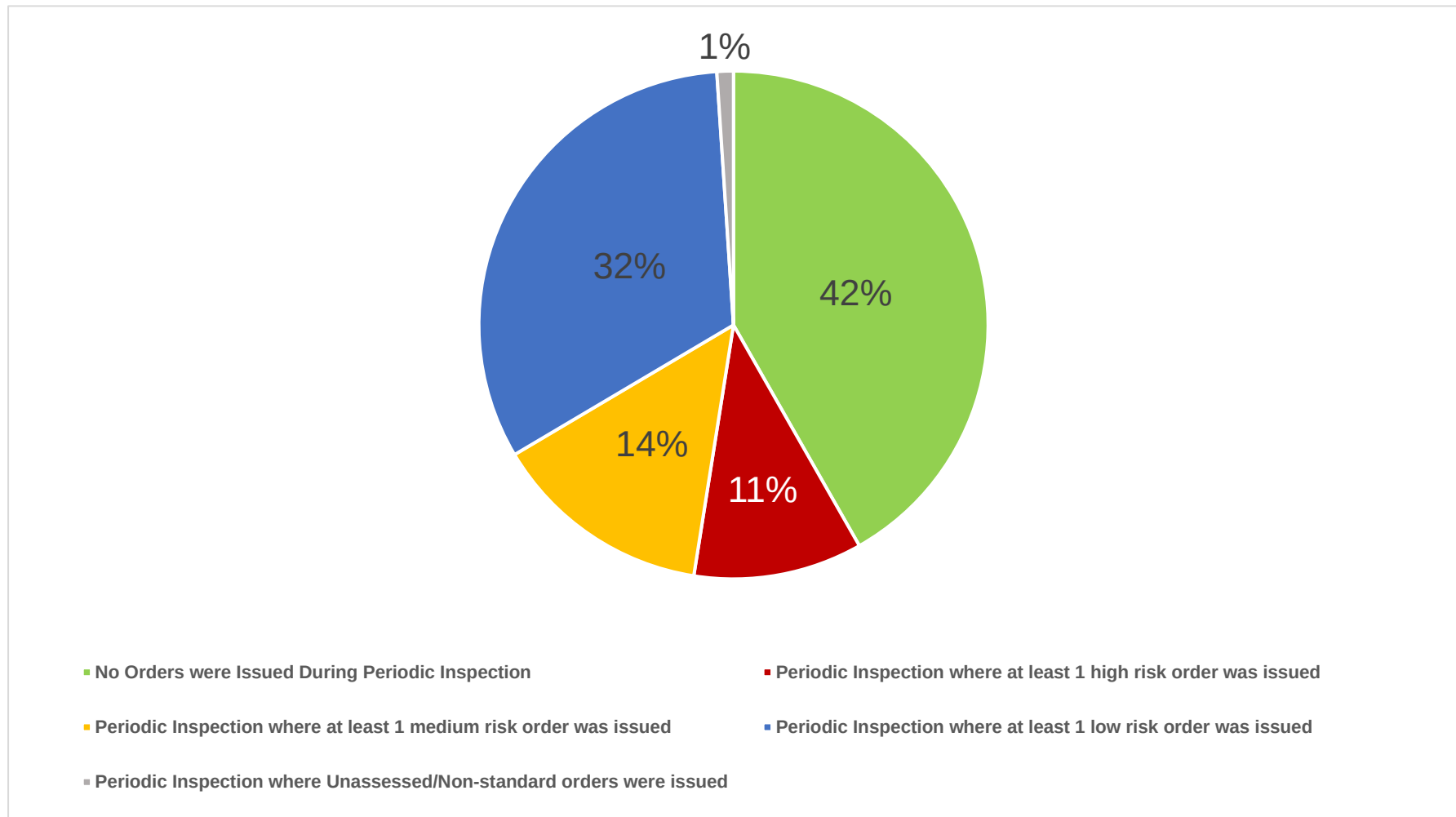
Assessment of Periodic Inspection Outcomes (May 1, 2010 – April 30, 2015)

Over the five-year period, 42% of periodic inspections conducted were fully compliant. As indicated graphically in Figure OE-1, 11% of these inspections resulted in at least one high risk order being issued. Additionally, 32% of these inspections resulted in low risk orders being issued. For additional details, please refer to Appendix F.

⁹ Median of quarterly compliance rates over five years.



Figure OE-1: Distribution of Periodic Inspections Conducted on Operating Plants (May 1, 2010 – April 30, 2015).





As indicated in Table OE-2, it was determined that 7% of orders issued during this time period were high risk. There was no demonstrable trend in the percentage of high-risk orders issued. Examples of these non-compliances include failure to have proper seals and tags on safety valves, and activation of audio and visual alarms when guarded controls have been activated.

74% of orders issued during this time period were deemed as low risk. There was no demonstrable trend in the percentage of low risk orders issued. Examples of these non-compliances include internal and external inspection requirements for registered boilers, identification of valves and piping systems, and recording of testing requirements.

Table OE-2: Distribution of Orders Issued Through Periodic Inspections Conducted on Operating Plants (May 1, 2010 – April 30, 2015)

Measure	Measure over Period
Percentage of High Risk Orders Issued	7%
Percentage of Medium Risk Orders Issued	13%
Percentage of Low Risk Orders Issued	74%
Unassessed	5%

During each inspection where a non-compliance was found, an inspector may choose to issue one or more orders. Inspection data indicate 31% of non-compliant inspections had only one order was issued. Additionally, 18% of non-compliant inspections had five or more orders issued.

The Operating Engineers Safety Program area continues to benefit from the application of RIDM in scheduling periodic inspections.

At first glance, a non-compliance rate of 60% for OE periodic inspections might be interpreted as a significant safety issue. However, that is not the case for OE. The nature of OE Periodic Inspections is primarily administrative, supported by the fact that 87% of orders are medium to low risk. One main contributor to the high non-compliance rate is the fact that, from May 2014 to April 2015, 1,611 plants were re-registered due to changes in plant components. These re-registrations are counted as orders and thus designate said plants as non-compliant. Plants routinely change out their equipment, so it is not unexpected that the non-compliance rate is higher. It is the high risk orders that the program focuses upon.

The one occurrence that took place during 2015 was attributable to operator error, assisted by a questionable design practice found on the oil refill line to an ammonia compressor. An unnecessary t-plug connection was confused as a t-valve, and the maintainer opened the valve whilst topping up the oil in the compressor, thus eventually opening the ammonia circuit to atmosphere and releasing ammonia. This design flaw has since been added to the OE Inspector's inspection routine such that all units found with said flaw are to be issued orders to correct the piping.



III.3 Amusement Devices

TSSA regulates approximately 2,300 permitted amusement devices in Ontario by ensuring all rides conform to the Act and applicable regulations, codes and standards. TSSA reviews and registers rides, issues permits for each ride in the current operating season, licenses operators, conducts inspections and incident investigations, and delivers public awareness campaigns throughout the province. Amusement devices under TSSA's jurisdiction include: roller coasters, Ferris wheels, merry-go-rounds (and other circular motion rides), water slides, flume rides, dry slides, go-karts, bumper carts, inflatables (inflatable bouncers), bungee devices, bungee-assisted bounces, zip lines (track and cable rides), and other generic spinning and whirling rides.

The trend analysis presented in this section should consider the predominantly seasonal nature of the operation of these devices. The trend analysis confirmed and took into account seasonality while establishing historical patterns of safety and compliance performance.

III.3.1 Risk Assessment

Based on actual injuries over the past eight years, the average rate of injury is 17.7 injuries/million people/year and no fatalities have been reported over the measured period. Using TSSA's approach to integrating injuries and fatalities, this corresponds to an eight-year average injury burden of approximately 0.03 fatality-equivalents/million people/year, representing a decrease from last year. Based on the 2,300 devices in the province, this translates to an observed injury burden of 1.71×10^{-4} fatality-equivalents/device/year.

Based on all occurrences over the past eight years, TSSA's predictive [2] model estimates the risk of injury or fatality to Ontarians using amusement devices to be 0.09^{10} fatality-equivalents/million people/year, as indicated in Table AD-1 below. Based on the 2,300 devices in the province, This translates to a risk of 5.32×10^{-4} fatality-equivalents/device/year. Figure AD-1 illustrates these historical observations graphically.

Table AD-1: State of safety measures for amusement devices for the period 2008 – 2015.

Measure	Fiscal Year							
	2008	2009	2010	2011	2012	2013	2014	2015
Occurrences	89	64	88	99	213	326	519	556
Fatalities	0	0	0	0	0	0	0	0
Permanent Injuries	8	10	7	3	5	9	26	22
Non-Permanent Injuries	70	58	72	85	203	310	451	497
Risk of Injury or Fatality (FE/mpy)	Not Available			0.09	0.15	0.13	0.13	0.09
Observed Injury Burden (FE/mpy)	0.01	0.03	0.08	0.00	0.06	0.01	0.04	0.02

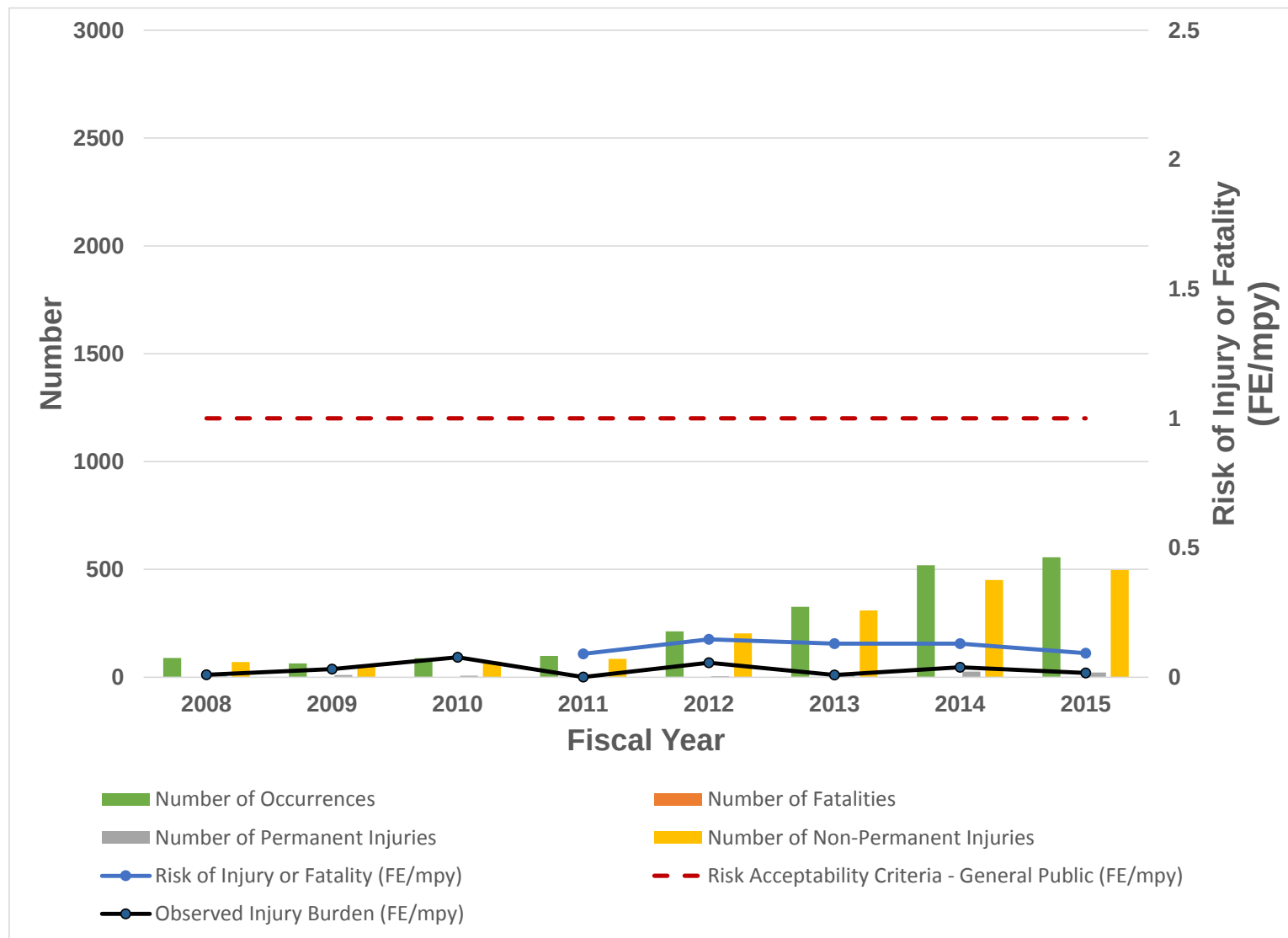
¹⁰ Represents expected estimate of a simulated distribution; 5th and 95th percentiles are 0.02 and 0.23 fatality-equivalents per million people per year respectively.



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Figure AD-1: State of safety Across Amusement Devices over the last eight years.





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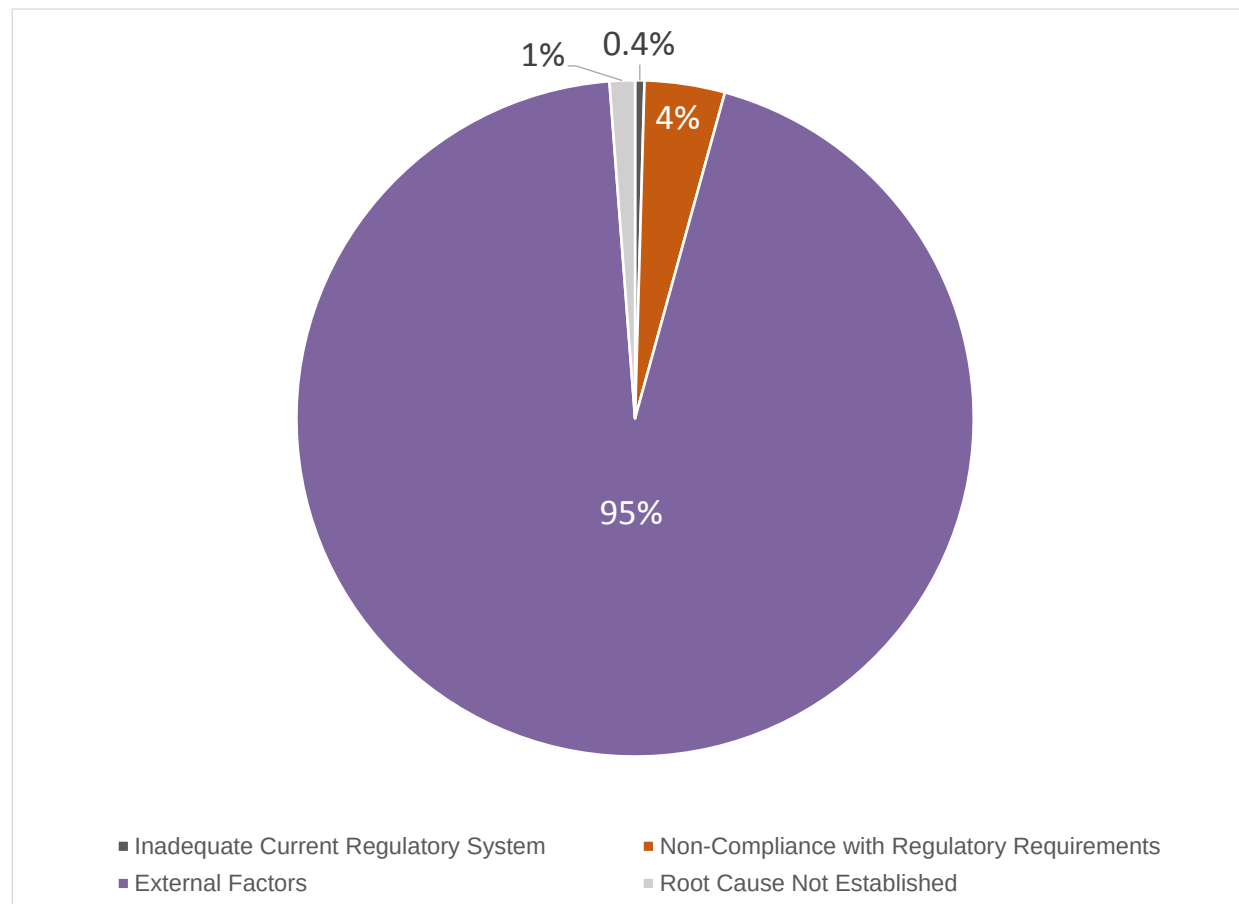
There are increasing trends in the number of occurrences and the number of non-permanent injuries of 8% per year each. These increases are primarily due to increased reporting by major operators.

Figure AD-2 graphically illustrates the risk of injury or fatality as of 2015 by causal category.

Figure AD-3 illustrates the top issues related to amusement devices in terms of their causal pathway.



Figure AD-2: Risk of Injury or Fatality in amusement devices by cause (based on period ending 2015).



RISKS BY CAUSAL CATEGORY

Potential Gaps in Regulatory System

- No new safety issues

Non-Compliance

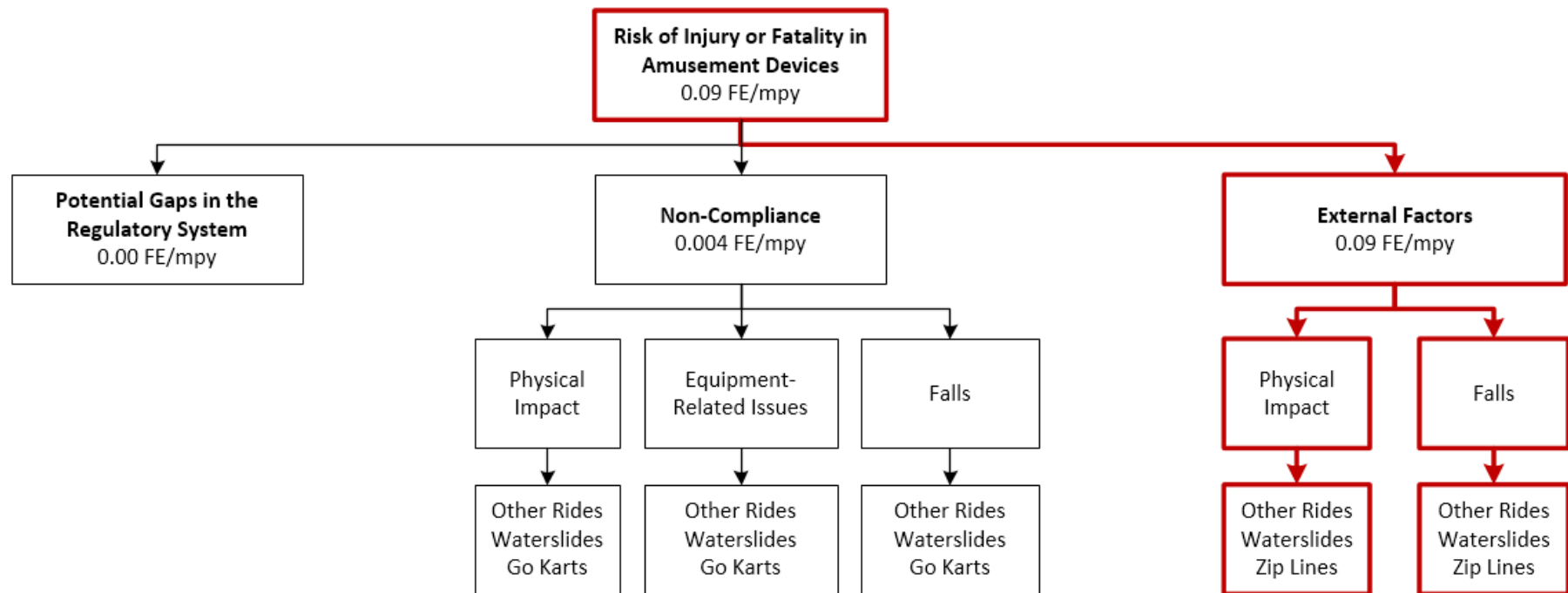
- Occurrences ↓9% per year
- Top Issues: physical impact, equipment-related issues, falls
- Top Devices: miscellaneous amusement rides, waterslides, Go Karts

External Factors

- Occurrences ↑10% per year
- Caused by user behaviour
- Top Issues: physical impact, falls
- Top Devices: miscellaneous amusement rides, waterslides, zip lines



Figure AD-3: Causal Pathway of amusement device safety issues.





Risk of Injury or Fatality due to External Factors

Approximately 95% of the risk caused over the past eight years is due to factors external to the regulatory environment. There is an increasing trend in the number of occurrences of 10% per year. In particular, 94% of all amusement device occurrences were due to user behaviour.

User behaviour on roller coasters, circular rides, and other forms of rides at theme parks and fairs account for approximately 50% of all occurrences related to external factors, and are demonstrating an increasing trend of 16% per year. These increases are driven specifically by behaviours on coaster rides and circular rides, which are demonstrating increasing trends of 5% per year and 12% per year respectively.

User behaviour on waterslides account for approximately 33% of all occurrences related to external factors, and account for 39% of overall risk in amusement devices. Waterslides represent 11% of the total provincial inventory. User related occurrences on zip lines account for approximately 11% of all occurrences related to external factors, and account for 8% of overall risk in amusement devices and zip lines represent 6% of the total provincial inventory. Unsafe riding on Go Karts account for approximately 6% of all occurrences related to external factors, and account for 7% of overall risk in amusement devices. Go karts account for 2% of the total provincial inventory.

Since the second quarter of fiscal year 2009/2010, just over 40% of all external factor related occurrences involved physical impacts being sustained by users, followed by just over 20% of related occurrences resulting in falls.

45% of external factor occurrences, which resulted in users sustaining a physical impact, involved head injuries. Other injuries include hand and leg injuries which were sustained while making contact with slides, restraints and passenger carrying units (PCUs), pulleys, cables, landings, trees, and restraints.

Of external factor occurrences, which resulted in users sustaining falls, 51% resulted in head injuries. Leg injuries were sustained while making contact with tubes during loading and unloading operations.

Risk of Injury or Fatality due to Non-Compliance with Regulatory System

Approximately 4% of the risk caused over the past eight years is due to non-compliance with regulatory requirements. There is a decreasing trend in the number of occurrences of 9% per year.

Amusement Rides, including coaster and circular rides, account for just under 60% of all occurrences related to non-compliance, followed by just under 30% involving waterslides, and just under 10% involving Go Karts.

Since the second quarter of fiscal year 2009/2010, approximately 30% of occurrences related to non-compliance took place due to physical impact, followed by equipment-related issues and falls.

Risk of Injury or Fatality due to Potential Gaps in Regulatory System

Approximately 1% of the risk caused over the past eight years is due to an inadequate regulatory system. There have been no occurrences of this nature reported since August 2011, and there were no new safety issues requiring further action by the safety program.

III.3.2 Risk Management – Message from Roger Neate, Statutory Director, AD Safety Program

Managing Risks due to External Factors

Approximately 95% of occurrences on amusement devices are related to user behaviour. Water slides account for approximately 30% of amusement device occurrences and approximately 60% of all health impacts. To assist in mitigating these risks, TSSA continues its multi-year public engagement strategies focusing on water slides users and specifically the most at risk users (10-14 years old). Based on enhanced positive results over the past two years, TSSA continues to refine and deliver its positive behaviour reward campaigns at a number of major water parks across Ontario. Based on on-site observational data, this approach achieves positive behavioural change with 10-20% improvements. Building on the success of TSSA's on-site public education strategies, a new initiative, the Safety Ambassador program, was piloted with two water parks. This involves incorporating TSSA



engagement strategy into training for water park staff. The goal is to equip park staff with additional engagement techniques that will assist them in delivering positive safety messaging to users at their locations.

Three initiatives were conducted between June 2014 - September 2014: TSSA partnered with seven operators to deliver key safety messages to the high risk users (10-14 years old) through its successful on-site water park public safety campaign. Through the Safety Ambassador Program, TSSA trained over 550 park staff to incorporate TSSA's positive reinforcement strategy to promote enhanced safety behaviours. A summer day camp pilot program was designed and implemented to engage the high risk group with variety of safety messages with a particular emphasis on water slides.

TSSA will continue to execute its on-site programs at major water parks and, to the extent possible considering resources available, will seek opportunities to extend the reach of this successful public education strategy. TSSA is also continuing to explore other engagement opportunities specifically related to the most at risk group (10-14 years old water park users) as it recognizes that a multi-dimensional strategy using a variety of platforms offers additional means to reduce public safety risks associated with user behaviour at water parks.

TSSA will continue to work with major operators of theme parks and fairs to improve the quality of reporting and also to obtain ridership data so that the predicted risks can be better contextualized in terms of number of users actually exposed to injuries.

Managing Risks due to Non-Compliance in Regulatory System

TSSA conducts periodic inspections of all amusement devices annually to oversee and manage the state of compliance across approximately 2,300 permitted amusement devices in the province of Ontario. Amusement device operations are generally seasonal in nature with a few devices operating all year round. TSSA deals with non-compliances by requiring the owner/operator to address observed failures within an appropriate timeframe through the issuance of inspection orders. This periodic inspection process contributes to the preventative management of risk associated with amusement devices as evidenced by a decreasing trend in the observed occurrences due to non-compliances.

For amusement devices, the ride operators perform an important role in ensuring that the users are adhering to the rules for safe riding. Part of the TSSA inspection is to witness the operation of the ride and verify that operating procedures are being followed, thus managing the risk of non-compliance.

Table AD-2 provides information on key indicators associated with periodic inspection results. The compliance rate measured over the last five years is 64% and demonstrates no significant quarterly trend.

Table AD-2: State of compliance for amusement devices as of 2015.

Compliance Measure	Measured Over a Five-Year Period
5-Year Median Compliance Rate	64%
Compliance Rate Trend (Annual)	No Trend
Compliance Rate Prediction Interval - Lower Bound	N/A
Compliance Rate Prediction Interval - Upper Bound	N/A

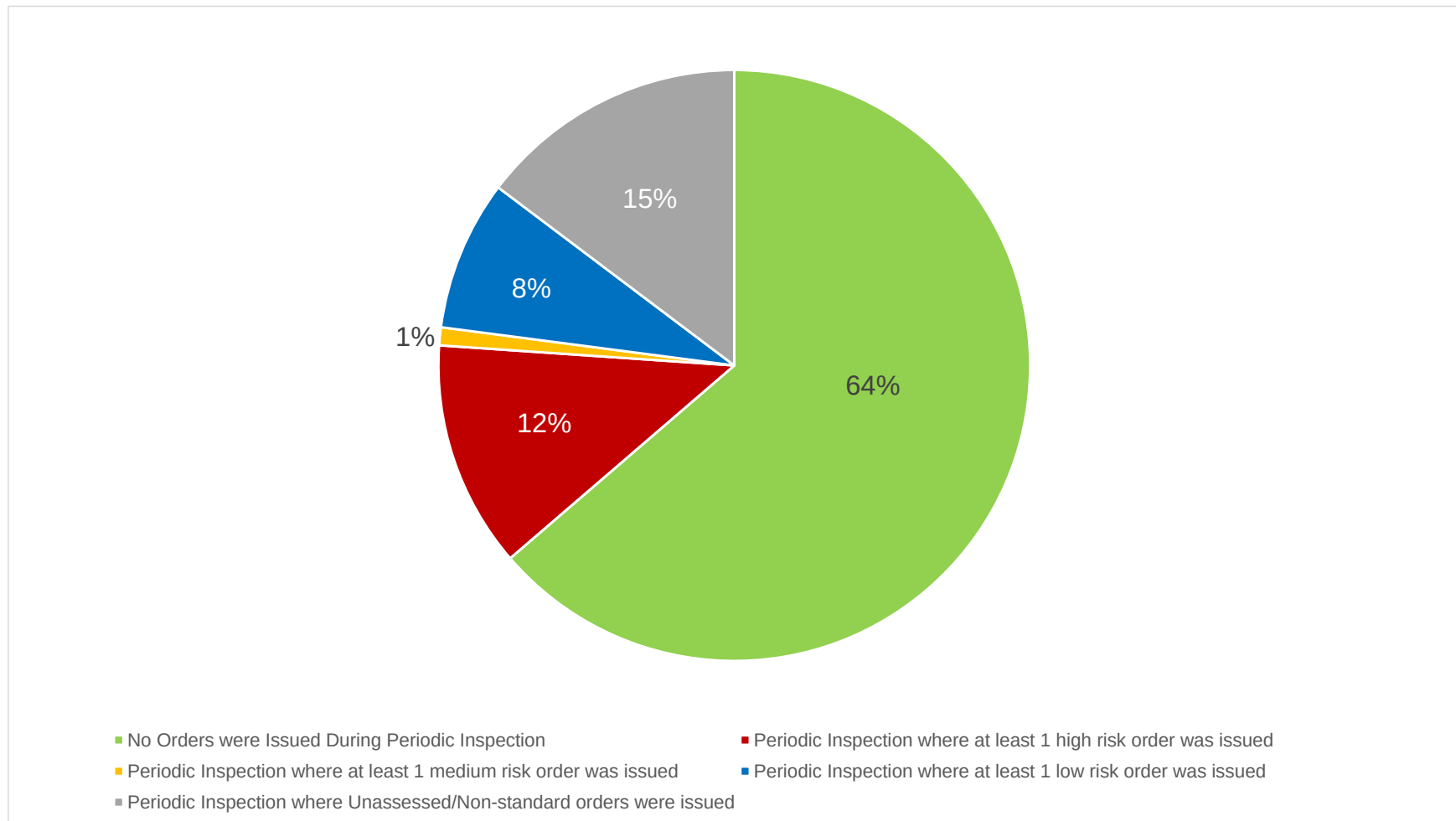
Periodic inspections conducted on waterslides indicate an increasing compliance rate trend of 4% per year. A decreasing trend in compliance rate has been observed with inflatable rides of 4% per year.

Assessment of Periodic Inspection Outcomes (December 2, 2013 – April 30, 2015)

Over the above indicated period, 2,346 periodic inspections have been conducted, of which 64% were fully compliant. In all, 2,559 orders have been issued through these inspections. This is shown graphically in Figure AD-4, 12% of these inspections resulted in at least one high risk order being issued. Additionally, 8% of these inspections resulted in low risk orders being issued. For additional details, please refer to Appendix F.



Figure AD-4: Distribution of Periodic Inspections Conducted on Amusement Rides (December 2, 2013- April 30, 2015).





As indicated in Table AD-3, it was determined that 19% of orders issued during this time period were high risk. The top three non-compliances found related to repairing holes or tears in inflatable structures, ensuring operation of lap bar restraint components and repairing cracks at welds.

Additionally, 19% of orders issued during this time period were deemed as low risk. The top three non-compliances found related to permanently affixing an AD plate to the device in question, record of training provision requirements and log book requirements.

Table AD-3: Distribution of Orders Issued through periodic inspections conducted on amusement devices (December 2, 2013 – April 30, 2015).

Measure	Measure over Period
Number of Orders Issued	2,599
Percentage of High Risk Orders Issued	19%
Percentage of Medium Risk Orders Issued	3%
Percentage of Low Risk Orders Issued	19%
Percentage of Unassessed Orders Issued	59%

The TSSA is continuing with its ongoing initiative to review and assess the risk of all orders.

During each inspection where a non-compliance was found, an inspector may choose to issue one or more orders. Inspection data indicate 39% of non-compliant inspections had only one order was issued. Additionally, 18% of non-compliant inspections had five or more orders issued.

Managing Risks due to Potential Gaps in Regulatory System

No potential safety issues or gaps requiring action were identified.



III.4 Elevators

TSSA regulates approximately 53,900 elevators in Ontario to ensure all devices conform to the Act, and applicable regulations, codes and standards. TSSA reviews and registers elevating devices, issues licences, conducts inspections and performs incident investigations. These devices include elevators (passenger, freight, hand-powered, observation, sidewalk, temporary elevators, and limited use/limited application elevators), dumbwaiters, material and freight platform lifts (type A and B), lifts for persons with physical disabilities, man-lifts, construction hoists, incline lifts, stage lifts, and parking garage lifts.

III.4.1 Risk Assessment

Based on actual injuries and fatalities over the past eight years, the average rates of injury and fatality are 10.2 injuries/million people/year and 0.05 fatalities/million people/year. Using TSSA's approach to integrating injuries and fatalities, this corresponds to an eight-year average injury burden of approximately 0.06 fatality-equivalents/million people/year, representing an increase from last year. Based on 53,900 elevators in the province, this translates to an observed injury burden of 1.44×10^{-5} fatality-equivalents/device/year.

Based on all occurrences over the past eight years, TSSA's predictive [2] model estimates the risk of injury or fatality to Ontarians using elevators to be 0.81^{11} fatality-equivalents/million people/year, as indicated in Table ED-1 below. Based on 53,900 elevators in the province, this translates to a device risk of 1.95×10^{-4} fatality-equivalents/device/year. Figure ED-1 illustrates these historical observations graphically.

Table ED-1: State of safety measures for elevators for the period 2008 – 2015.

Measure	Fiscal Year							
	2008	2009	2010	2011	2012	2013	2014	2015
Occurrences	193	172	193	204	339	377	486	444
Fatalities	1	0	0	1	2	1	0	0
Permanent Injuries	6	3	7	4	12	11	7	8
Non-Permanent Injuries	106	83	100	104	166	145	182	119
Risk of Injury or Fatality (FE/mpy)	Not Available			0.33	1.01	1.22	0.96	0.81
Observed Injury Burden (FE/mpy)	0.01	0.01	0.00	0.01	0.20	0.09	0.01	0.14

There are increasing trends in the number of occurrences and the number of non-permanent injuries of 15% per year and 6% per year respectively. These increases primarily due to improved reporting practices to the TSSA. Despite these increasing trends, there is a 16% decrease in the risk of injury or fatality when compared with the 2014 fiscal year. This is driven by a reduced rate of increase of occurrences and non-permanent injuries. As of the 2014 fiscal year, the number of occurrences were increasing at 17% per year and the number of non-permanent injuries were increasing at 10% per year. Figure ED-2 graphically illustrates the risk of injury or fatality as of the 2015 fiscal year by causal category. Figure ED-3 illustrates the top issues related to elevators shown by their causal pathway.

¹¹ Represents expected estimate of a simulated distribution; 5th and 95th percentiles are 0.40 and 1.28 fatality-equivalents per million people per year respectively.



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Figure ED-1: State of safety across elevators over the last eight years.

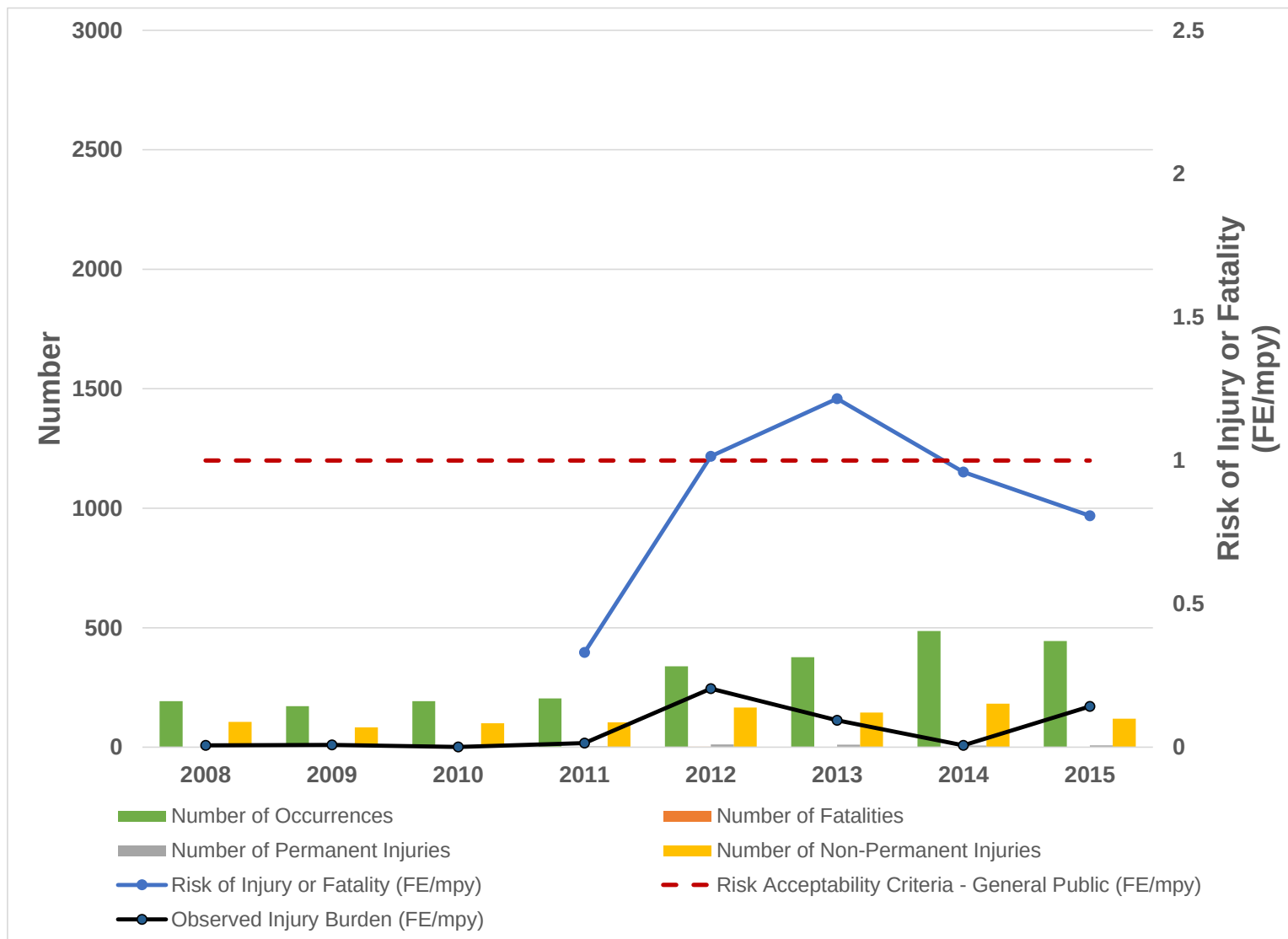
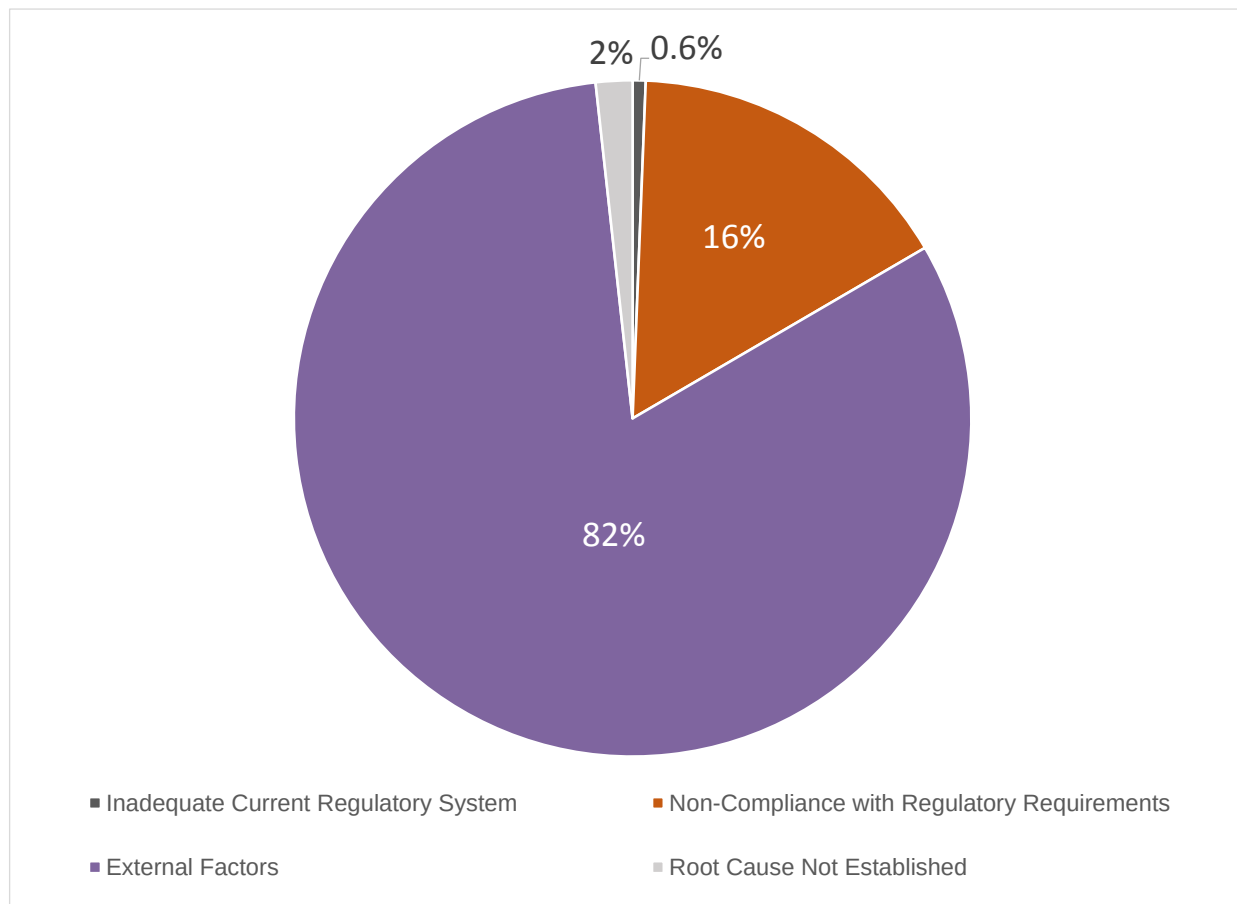




Figure ED-2: Risk of Injury or Fatality in elevators by cause (based on period ending 2015).



RISKS BY CAUSAL CATEGORY

Potential Gaps in Regulatory System

- No new safety issues
- Increasing trends in occurrences involving older technologies

Non-Compliance

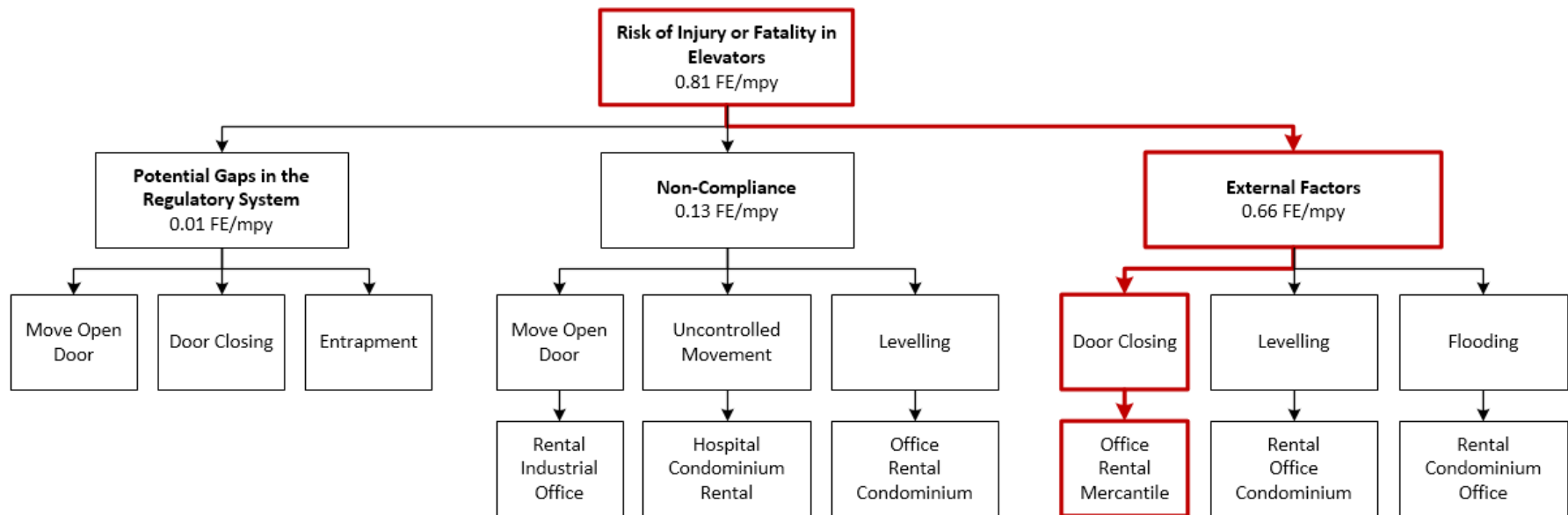
- Occurrences ↓8% per year
- Top Issues: elevator car moving with open doors, uncontrolled movement, levelling
- Top Locations: industrial, rental locations, offices, hospitals, condominiums

External Factors

- Occurrences ↑21% per year
- Caused by user behaviour
- Top Issues: door closing, levelling, flooding
- Top Locations: mercantile, rental locations, offices, condominiums



Figure ED-3: Causal Pathway of elevator safety issues.





Risk of Injury or Fatality due to External Factors

Approximately 82% of the risk caused over the past eight years is due to external factors, and represents a risk of injury or fatality of 0.66 fatality-equivalents/million people/year. There is an increasing trend in the number of occurrences of 21% per year. Roughly 80% of all elevator occurrences were due to user behaviour. The top three causes of occurrences in this category are related elevator doors closing on passengers, levelling issues and flooding, representing 32%, 24% and 13% of risks related to external factors respectively.

Elevator Doors Closing on Passengers

21% of elevator occurrences related to external factors took place as a result of rushing and/or distracted passengers being struck by door closing on them while they attempted to get into elevators. There is an increasing trend with these type of occurrences of 9% per year. 25% of these type of occurrences took place in offices, followed by 19% in rental locations and 17% in mercantile locations. Elevators in mercantile locations represent 4% of the total provincial inventory, followed by offices (19%) and rental locations (20%).

Levelling

Approximately 70% of occurrences related to external factors occurred as a result of passengers' slips, trips and falls while exiting or entering elevators primarily at rental locations, office locations and in condominiums. These occurrences include older technologies, such as single and two speed motor controls, which are known to get out of level in certain conditions.

Flooding

While no health impacts are associated with these occurrences, these occurrences involved water getting into elevators and elevator shafts and causing damage and carried the potential of carrying injuries due to electrical and physical hazards.

Risk of Injury or Fatality due to Non-Compliance with Regulatory System

Approximately 16% of the risk caused over the past eight years is due to non-compliance with regulatory requirements, and represents a risk of injury or fatality of 0.13 fatality-equivalents/million people/year. There is a decreasing trend in the number of occurrences of 8% per year.

30% of occurrences in this category took place in residential locations, followed by offices (23%) and hospitals (12%). The top three causes of occurrences related to leveling, uncontrolled movement and elevator cars moving with open doors, represent 23%, 18% and 15% of occurrences respectively, and 14%, 12% and 46% of risk respectively.

Levelling-related non-compliances included single and two-speed motor control elevators. The TSSA is aware of this safety issue, and has completed a risk assessment on the subject. Non-compliance occurrences due to elevator cars moving with open doors and uncontrolled movement are being analysed to better understand and determine whether further action is required.

Risk of Injury or Fatality due to Potential Gaps in Regulatory System

Less than 1% of the risk caused over the past eight years is due to potential gaps in the regulatory system. There is no demonstrable trend in the number of occurrences and injuries.

Known safety issues related to these occurrences include the elevator cars moving with the open doors and entrapment. In particular, occurrences related to the elevator cars moving with open doors represent 37% of risk in this category.

Occurrences related to elevator car door closing on passengers represent 18% of elevator risk in this category.

Increasing trends have been observed in the number of occurrences covering all three causal categories involving older technologies. Occurrences related to single speed and two speed motor control are both increasing at rates of 23% per year.



The TSSA has applied risk informed decision-making framework to assess the risk associated with ascending car over-speeding and unintended car movement observed in aging single speed passenger elevators. The assessment was undertaken as part of a Risk Reduction Group (RRG) in 2010, and was completed in 2014. A Director's Order has been issued which will be discussed in further detail in the Risk Management section.

III.4.2 Risk Management – Message from Roger Neate, Statutory Director, ED Safety Program

Managing Risks due to External Factors

Since user behaviour continues to be the dominant root cause of elevator incidents, TSSA has a number of public engagement initiatives aimed at curbing unsafe behaviour on elevators.

These initiatives focus on digital and print media campaigns targeted at high risk users in addition to signage in high traffic areas. Based on website statistics and the receptiveness of the audiences which received the printed materials, these initiatives appear to be effective. In addition to these program, research in the form of surveys and interviews is used to refine campaigns for 2015/2016. Please see Appendix D for more details.

Managing Risks due to Non-Compliance in Regulatory System

TSSA conducts periodic inspections of all elevators on a risk-based approach to oversee and manage the state of compliance across approximately 53,900 elevators in the province of Ontario. TSSA deals with non-compliances by requiring the owner/operator to address observed failures within an appropriate timeframe through the issuance of inspection orders. This periodic inspection process contributes to the preventative management of risk associated with elevators as evidenced by the decreasing trend in the number of occurrences taking place due to non-compliant elevators.

Table ED-2 provides information on key indicators associated with the results of the periodic inspections. The compliance rate measured over the last five years is 29% and demonstrates a decreasing trend of 4% per year.

Table ED-2: State of compliance for elevators as of 2015.

Compliance Measure	Measured Over a Five-Year Period
5-Year Median Compliance Rate	29%
Compliance Rate Trend (Annual)	-4%
Compliance Rate Prediction Interval - Lower Bound	20%
Compliance Rate Prediction Interval - Upper Bound	39%

There is an increasing trend in the compliance rate observed through periodic inspections conducted at office buildings of 6% per year. Decreasing trends in compliance rates have been generally observed across elevators in all other building types.

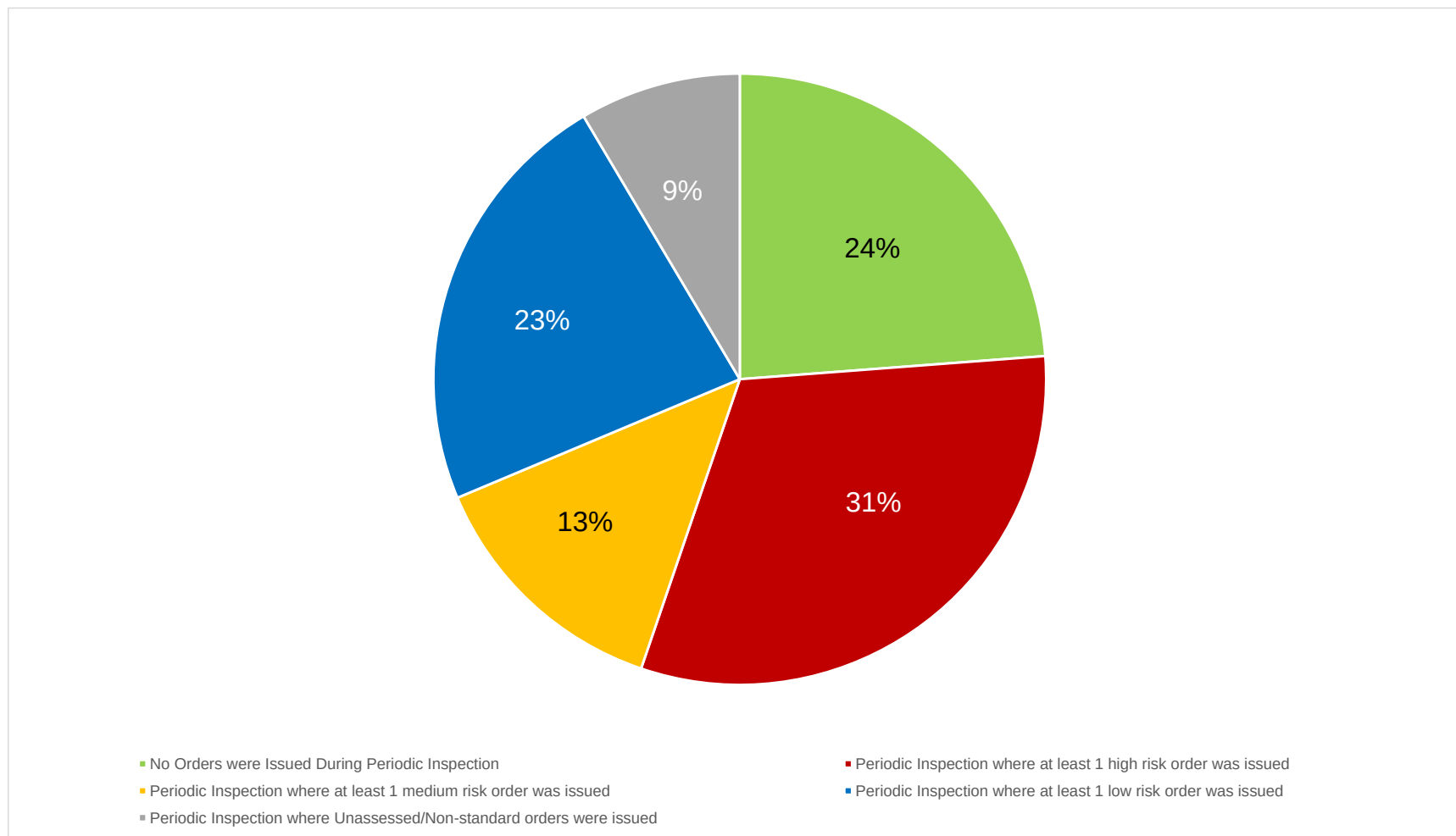
Decreasing trends in compliance rates have been observed with construction hoists, passenger elevators, elevating devices for persons with physical disabilities and material freight devices of 5% per year, 3% per year, 2% per year and 3% per year respectively.

Assessment of Periodic Inspection Outcomes (December 2, 2013 – April 30, 2015)

Over the above indicated period, 25,943 periodic inspections have been conducted, of which 24% were fully compliant; 94,627 orders have been issued through these inspections. As indicated graphically in Figure ED-4, 31% of these inspections resulted in at least one high risk order being issued. Additionally, 23% of these inspections resulted in low risk orders being issued. For additional details, please refer to Appendix F.



Figure ED-4: Distribution of periodic inspections conducted on elevators (December 2, 2013 – April 30, 2015).





As indicated in Table ED-3, it was determined that 15% of orders issued during this time period were high risk. In particular, 19 devices have had at least one high-risk order issued through two separate periodic inspections. Nine of these devices were located in rental buildings, followed by five in condominiums. The top three non-compliances found were related to provision of car top guard rail requirements (Director's Order 245/10), annual examination requirements of driving-machine brakes and annual testing requirements of landing and car doors.

Additionally, 48% of orders issued during this time period were deemed as low risk. The top three non-compliances found were related to annual testing requirements of safeties, annual examination requirements of wire ropes and generic requirements for compliance.

**Table ED-3: Distribution of orders issued through periodic inspections conducted on elevators
(December 2, 2013 – April 30, 2015)**

Measure	Measure over Period
Number of Orders Issued	94,627
Percentage of High Risk Orders Issued	15%
Percentage of Medium Risk Orders Issued	15%
Percentage of Low Risk Orders Issued	48%
Percentage of Unassessed Orders Issued	23%

The TSSA is continuing with its ongoing initiative to review and assess the risk of all orders.

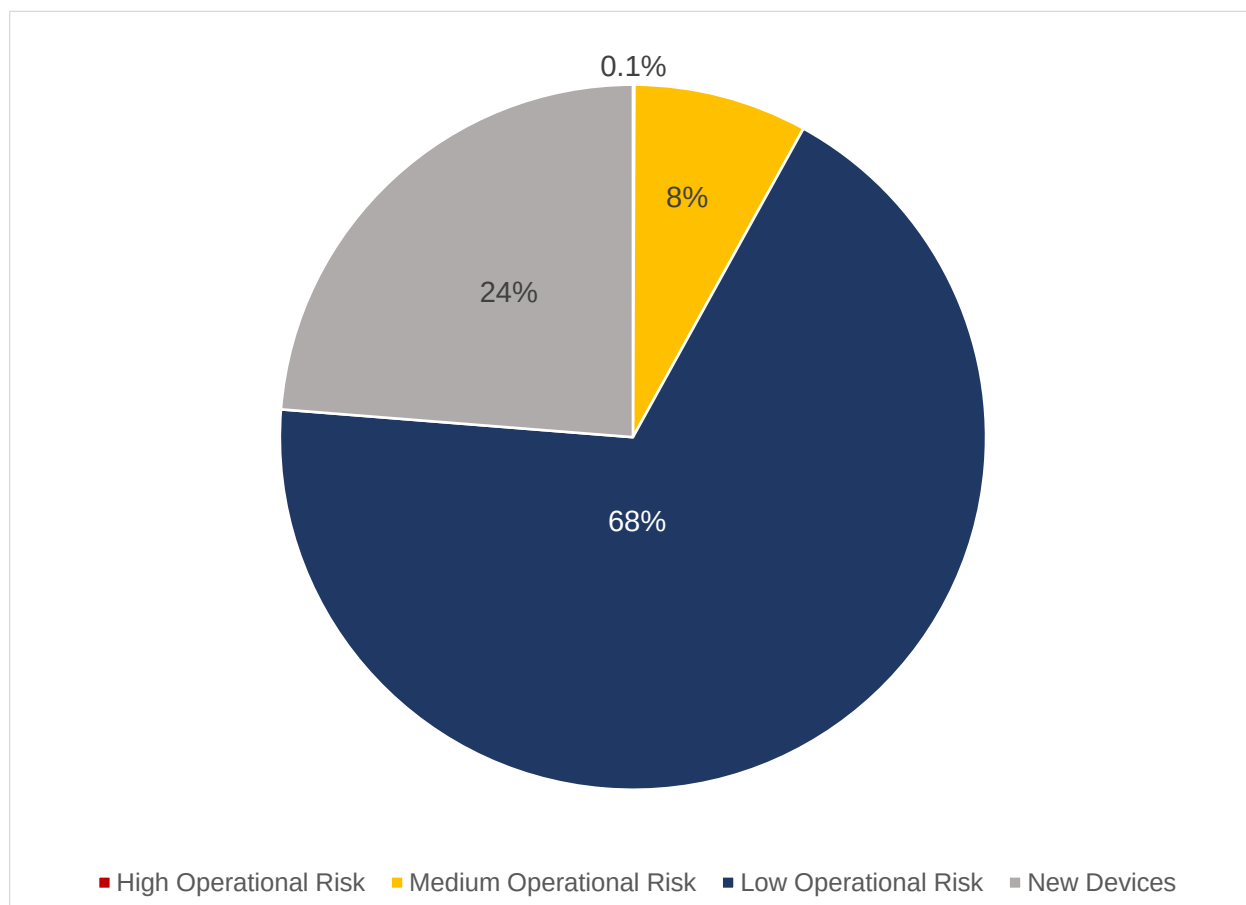
During each inspection where a non-compliance was found, an inspector may choose to issue one or more orders. Inspection data indicate 21% of non-compliant inspections had only one order was issued. Additionally, 39% of non-compliant inspections had five or more orders issued.

Figure ED-5 shows the percentage distribution of the risk profile of elevators in the province of Ontario as per TSSA's risk-based scheduling model as of June 2015 (RBS2.5) [6].

As indicated in Figure ED-5, approximately 68% of the active elevators in the province, based on their past compliance history, are identified as being low operational risk. 8% of active elevators in the province, based on their past compliance history, are identified as being medium operational risk. Finally 0.1% of active elevators in the province, based on their past compliance history, are identified as being high operational risk. Nearly 55% of these high-risk devices are located in rental buildings, which form 20% of the total provincial inventory. Newer devices which have not yet had three periodic inspections have not been assessed and make up the 24% of devices which have been qualified in risk bins.



Figure ED-5: Distribution of elevators in the Province of Ontario (RBS2.5).



TSSA continues to evaluate its risk informed inspection scheduling model and, based on recent data on compliance, occurrence history, and the corresponding risk profile of the inventory, is in the process of implementing changes to the frequency of inspections during the current fiscal year. The changes will entail more frequent inspections of high risk elevators while incentivizing those elevators with high levels of compliance with a lower frequency. The anticipated outcomes of these changes include further decrease in the trends of occurrences due to non-compliances and improvements in the levels of compliance. TSSA will continue to monitor the effectiveness of these changes.

While periodic inspections are an important tool to ensure compliance, TSSA expects that the regulated parties are aware of their obligations, informed of their performances and meet regulatory expectations in a timely manner. In this regard, TSSA has proactively begun engaging major contractors by providing them with statistics on non-compliances directly related to their performance and requiring them to provide clear, time-bound strategies for improving compliance levels. TSSA will monitor the effectiveness of these strategies and expects to see a reduction in non-compliances over time. Additionally, TSSA has also introduced a contracting rating system that will be shared with the individual contractors. This strategy is expected to act as an incentive for contractor to exceed expectations and performance levels while providing a clear choice to elevator owners.

Managing Risks due to Potential Gaps in Regulatory System

While, no new potential safety issues or gaps requiring action were identified during the past year, TSSA has made several policy decisions to address known safety issues related to aging technologies.

The TSSA is continuing to work with industry stakeholders to address three previously identified gaps in the regulatory system. Having completed a detailed risk assessment of aging elevators, TSSA has put in place a



requirement that all single speed elevators need to be updated to include a closed loop braking system. The completion dates for this work have been staggered between 2018 and 2021 with those devices presenting the highest risk being addressed first. Efforts to address the hazards associated with elevators with single bottom hydraulic cylinders are nearing completion. Retrofit of these elevators was to have been completed by May 1, 2015. Most recently, the TSSA has issued a Director's Order to address the hazards associated with short apron plates. Affected elevators are to be retrofitted no later than June 30, 2016.

Recognizing that over 25% of all elevator occurrences involve doors closing, the TSSA continues to work on the American Society of Mechanical Engineers (ASME) Door Protection Task Group, which is made up of various industry stakeholders. The goal is to enhance door protection by more effectively detecting passengers approaching well in advance of the closing doors and prevent door strikes while at the same time addressing elevator traffic demands by avoiding unintended detection of persons who are just walking past the elevator entrance.

A recent fatality in Ontario occurred as a result of a self-rescue attempt by several trapped passengers. With the elevator stopped above floor level and with the car and hall doors open, a space exists between the elevator car floor and the hall floor. This space below the car floor was partially protected by a short apron plate. A fall hazard existed due to the gap between the lower edge of the apron plate and the hall floor, and during egress one of the occupants fell into this gap. The original elevator installation (~1966 code) had no requirement for a long apron. In 1981 when the longer apron requirement came into force this building was of an occupancy that did not require the apron to be lengthened. The occupancy type of this building changed in 1987 but the apron was not lengthened as required. TSSA issued a Director's Safety Order (260/14) to address the exposure to a fall hazard as well as prevent the possibility of self rescue by restricting egress from a car not at or near the floor for older elevators located in high risk locations including apartments, condominiums and educational institutions.

A risk assessment conducted by TSSA in partnership with stakeholders indicated that the primary risk with aging elevators was with single speed devices. These devices typically do not have an emergency brake and experience problems with leveling accurately. Analysis of inspection and incident data determined that there was an unacceptable public risk of injury from single speed devices that will occur in 2020.

TSSA, through a new director's order (267/14) created a new alteration requirement that focuses on the leveling aspects on single speed devices. This new alteration requirement offers an economical method to address the leveling risk. It is estimated that 1,100 devices are affected by this order. The compliance for these devices will be phased in over a five-year period ending in 2022.



III.5 Escalators and Moving Walks

TSSA regulates approximately 2,200 escalators and moving walks in Ontario to ensure all devices conform to the Act and applicable regulations, codes and standards. TSSA reviews and registers escalators and moving walks, issues licences, conducts inspections and performs incident investigations.

III.5.1 Risk Assessment

Based on actual injuries and fatalities over the past seven years, the average rate of injury and fatality is approximately 30 injuries/million people/year and 0.01 fatalities/million people/year respectively. Using TSSA's approach for integrating fatalities and injuries this corresponds to an eight-year average injury burden of approximately 0.03 fatality equivalents/million people/year, representing a decrease from last year. Based on 2,200 escalators and moving walks in the province, this translates to an observed injury burden of 1.78×10^{-4} fatality-equivalents/device/year.

Based on all occurrences over the past eight years, TSSA's predictive model [2] estimates the risk of injury or fatality to Ontarians riding escalators and moving walks to be approximately 0.08^{12} fatality-equivalents/million people/year, as indicated in Table EM-1 below. Based on 2,200 escalators and moving walks in the province, this translates to a device risk of 4.52×10^{-4} fatality-equivalents/device/year. Figure EM-1 illustrates these historical observations graphically.

Table EM-1: State of safety measures for escalators and moving walks for the period 2008 – 2015.

Measure	Fiscal Year							
	2008	2009	2010	2011	2012	2013	2014	2015
Occurrences	538	531	504	512	519	518	637	579
Fatalities	0	0	1	0	0	0	0	0
Permanent Injuries	8	1	4	2	4	3	3	7
Non-Permanent Injuries	406	390	343	360	358	384	435	375
Risk of Injury or Fatality (FE/mpy)	Not Available			0.05	0.08	0.07	0.05	0.08
Observed Injury Burden (FE/mpy)	0.03	0.03	0.14	0.00	0.01	0.01	0.00	0.02

There are no observable trends in the number of occurrences, fatalities or injuries over the last eight years. The annual occurrence rate and the number of non-permanent injuries per year have increased over the past three years. In particular, the annual occurrence rate has increased by 4% and the number of non-permanent injuries per year have increased by 2% from the 2013 fiscal year. These increases are primarily due to improved reporting practices. Additionally, these increased contribute to a 47% increase in the risk of injury or fatality as of the 2015 fiscal year when compared to the 2014 fiscal year. Figure EM-2 graphically illustrates the risk of injury or fatality as of the 2015 by causal category. Figure EM-3 illustrates the top issues related to escalators and moving walks shown by their causal pathway.

¹² Represents expected estimate of a simulated distribution; 5th and 95th percentiles are 0.01 and 0.21 fatality-equivalents per million people per year respectively.



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Figure EM-1: State of safety across escalators and moving walks over the last eight years.

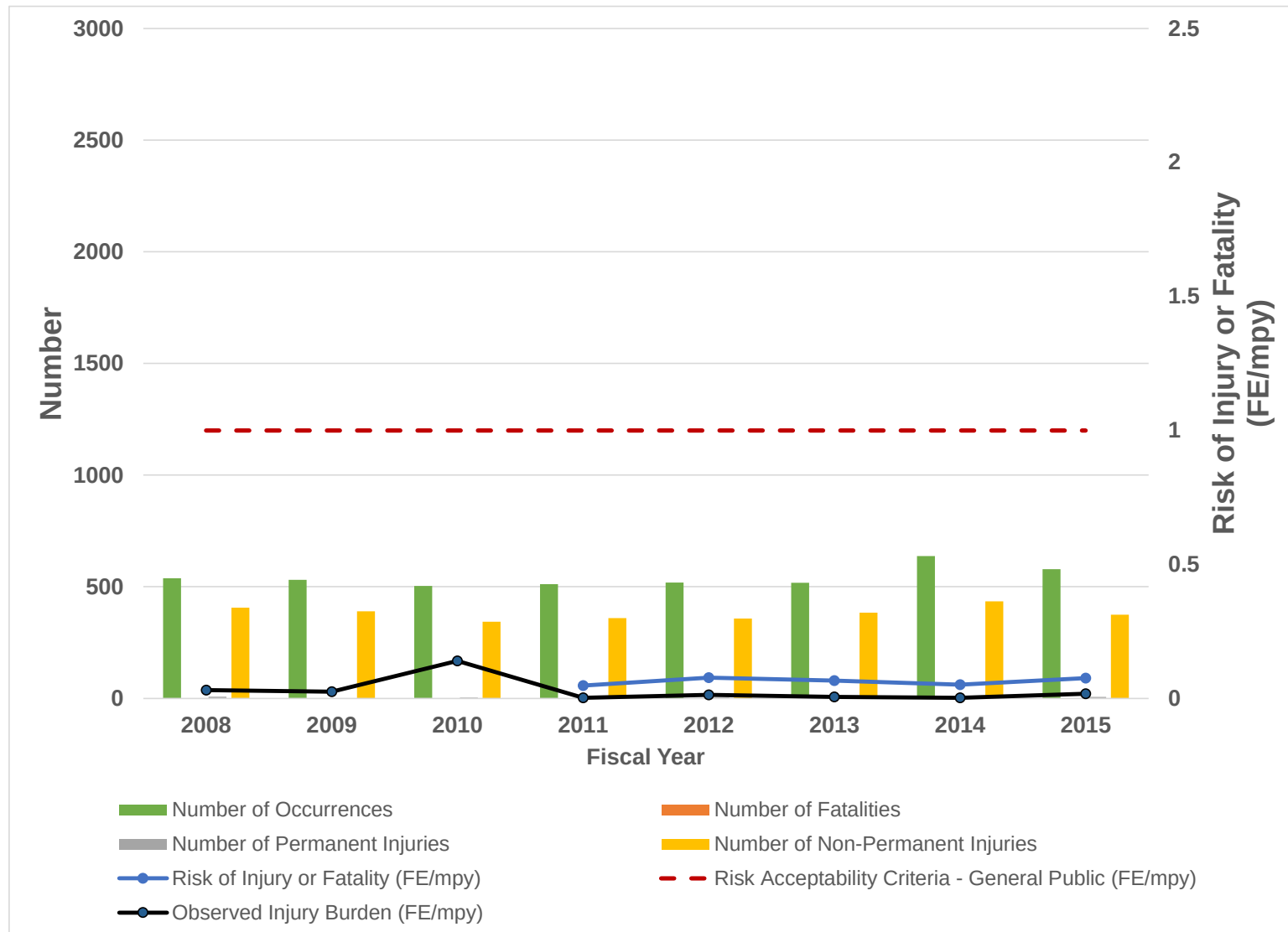
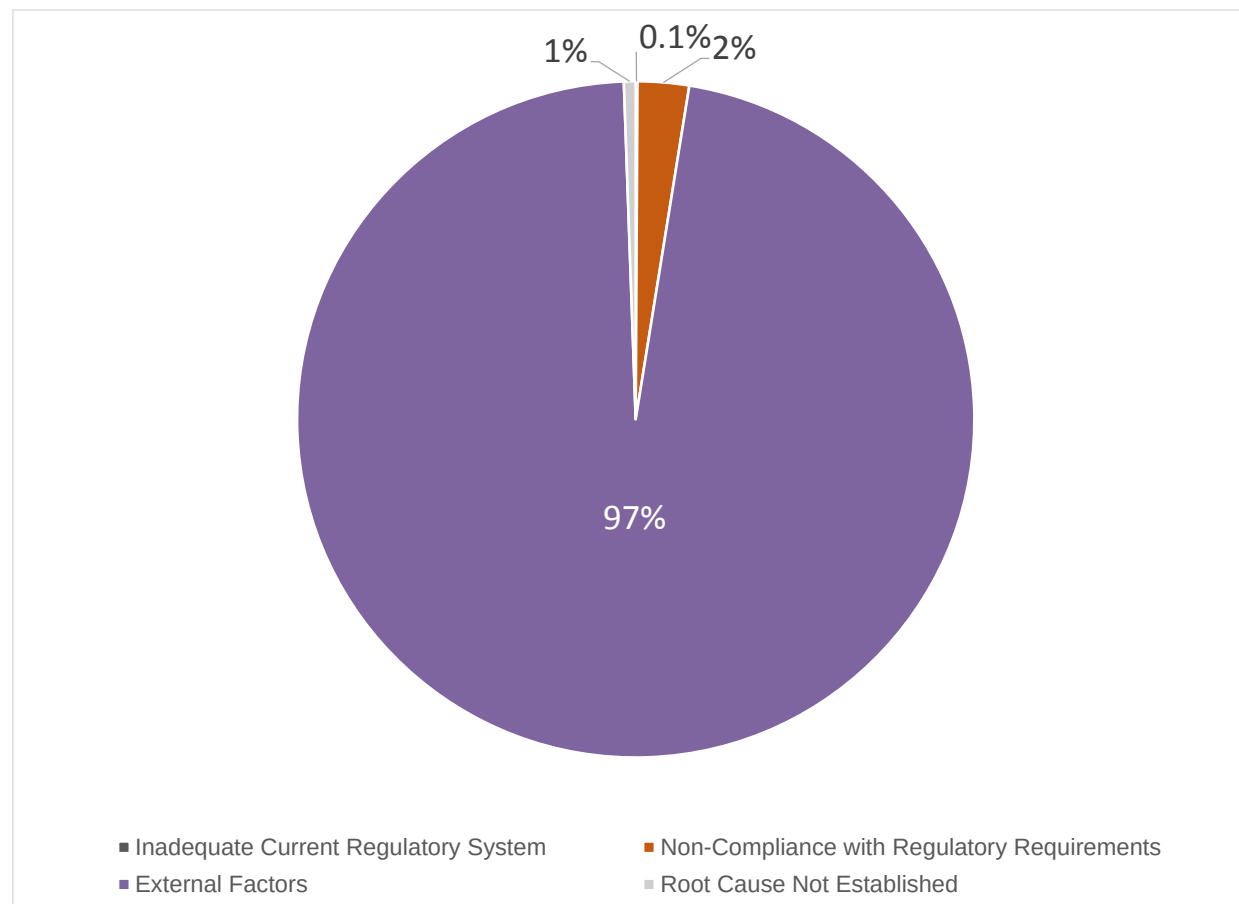




Figure EM-2: Risk of Injury or Fatality in escalators and moving walks by cause (based on period ending 2015).



RISKS BY CAUSAL CATEGORY

Potential Gaps in Regulatory System

- No new safety issues

Non-Compliance

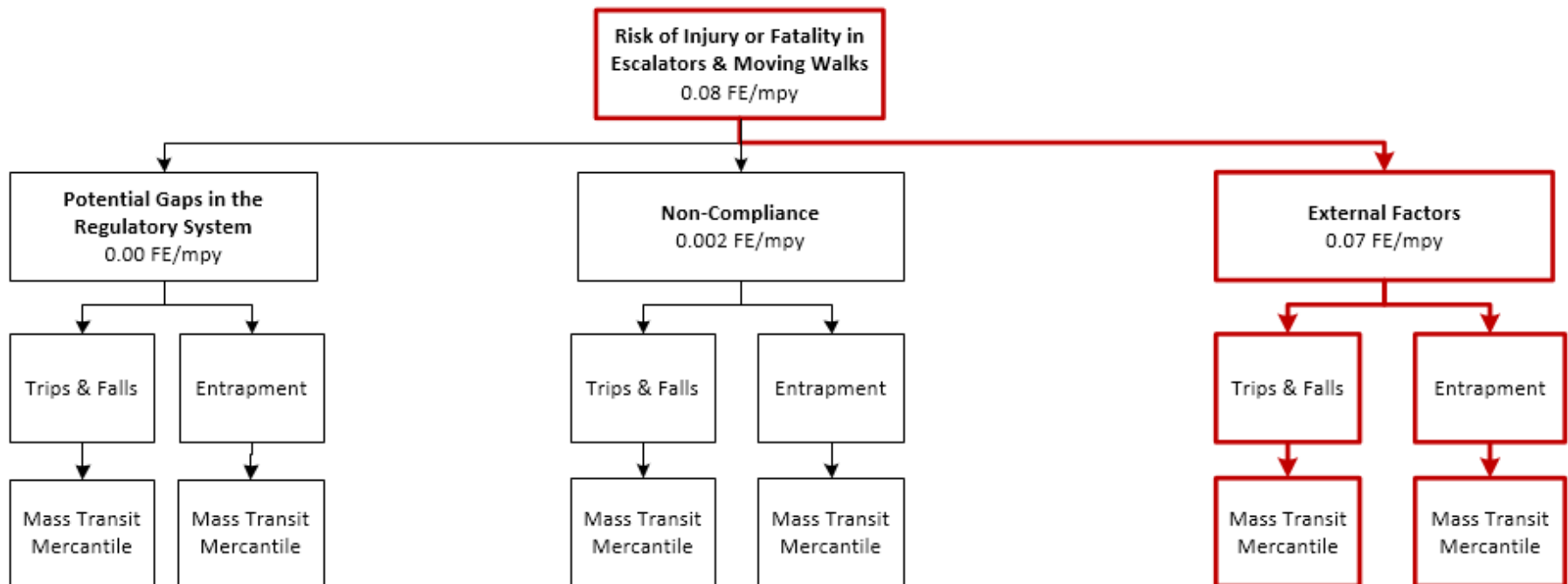
- Occurrences ↓ 20% per year
- Top Issues: entrapment, trips & falls
- Top Locations: mercantile, mass transit

External Factors

- Occurrences ↑ 3% per year
- Caused by user behaviour
- Top Issues: trips & falls, entrapment
- Top Locations: mass transit, mercantile



Figure EM-3: Causal Path of escalators and moving walks safety issues.





Risk of Injury or Fatality due to External Factors

Approximately 97% of the risk caused over the past eight years is due to external factors. There is an increasing trend in the number of occurrences of 3% per year. 96% of all escalator occurrences were due to user behaviour.

Mass transit occurrences account for 54% of all external factor related occurrences and 53% of escalator risk in this category. Occurrences at mercantile locations account for 38% of all external factor occurrences and 38% of escalator risk in this category.

Trips and falls account for 64% of all escalator occurrences and 81% of escalator risk in this category. Entrapment occurrences account for 7% of all escalator occurrences and 5% of escalator risk in this category. Examples include entrapment of footwear and clothing, as well as body parts in handrails.

Risk of Injury or Fatality due to Non-Compliance with Regulatory Requirements

Approximately 2% of the risk caused over the past eight years is due to non-compliance with regulatory requirements. There is a decreasing trend in the number of occurrences of 20% per year.

63% of occurrences in this category took place in mercantile locations, followed by 27% of occurrences in mass transit locations. These occurrences and associated injuries each account for 1% of overall escalator risk.

Occurrences in this category which took place due to entrapment represent 16% of all non-compliance related escalator occurrences, followed by trip and fall occurrences representing 10% of all non-compliance related occurrences.

Risk of Injury or Fatality due to Potential Gaps in Regulatory System

Less than 1% of the risk caused over the past eight years is due to potential gaps in the regulatory system. There is no demonstrable trend in the number of occurrences and injuries. There have been no occurrences related to this causal category in the 2015 fiscal year. There were no new safety issues or requiring further actions by the safety program.

III.5.2 Risk Management – Message from Roger Neate, Statutory Director of EM Safety Program

Managing Risks due to External Factors

Since user behaviour continues to be the dominant root cause of escalator incidents, TSSA has a number of public engagement initiatives aimed at curbing unsafe behaviour on escalators and moving walks.

These initiatives focus on digital and print media campaigns targeted at high risk users in addition to signage in the vicinity of escalators and moving walks where the number of occurrences is high. Based on website statistics and the receptiveness of the audiences which received the printed materials, these initiatives appear to be effective. In addition to these program, research in the form of surveys and interviews is used to refine campaigns for 2015/2016. Please see Appendix D for more details.

Managing Risks due to Non-Compliance with Regulatory Requirements

TSSA conducts periodic inspections of all escalators and moving walks using a risk-based approach to oversee and manage the state of compliance across approximately 2,200 escalators and moving walks in the province of Ontario. TSSA deals with non-compliances by requiring the owner/operator to address observed failures within an appropriate timeframe through the issuance of inspection orders. This periodic inspection process contributes to the preventative management of risk associated with escalators and moving walks, as evidenced by the decreasing trend in the number of occurrences due to non-compliant escalators and moving walks.

As indicated in Table EM-2, periodic inspections conducted over the past five years have yielded a compliance rate of 12%. There is a decreasing trend in the compliance rate of 3% per year.



Table EM-2: State of compliance for escalators and moving walks as of 2015.

Compliance Measure	Measured Over a Five-Year Period
5-Year Compliance Rate	12%
Compliance Rate Trend (Annual)	-3%
Compliance Rate Prediction Interval - Lower Bound	2%
Compliance Rate Prediction Interval - Upper Bound	34%

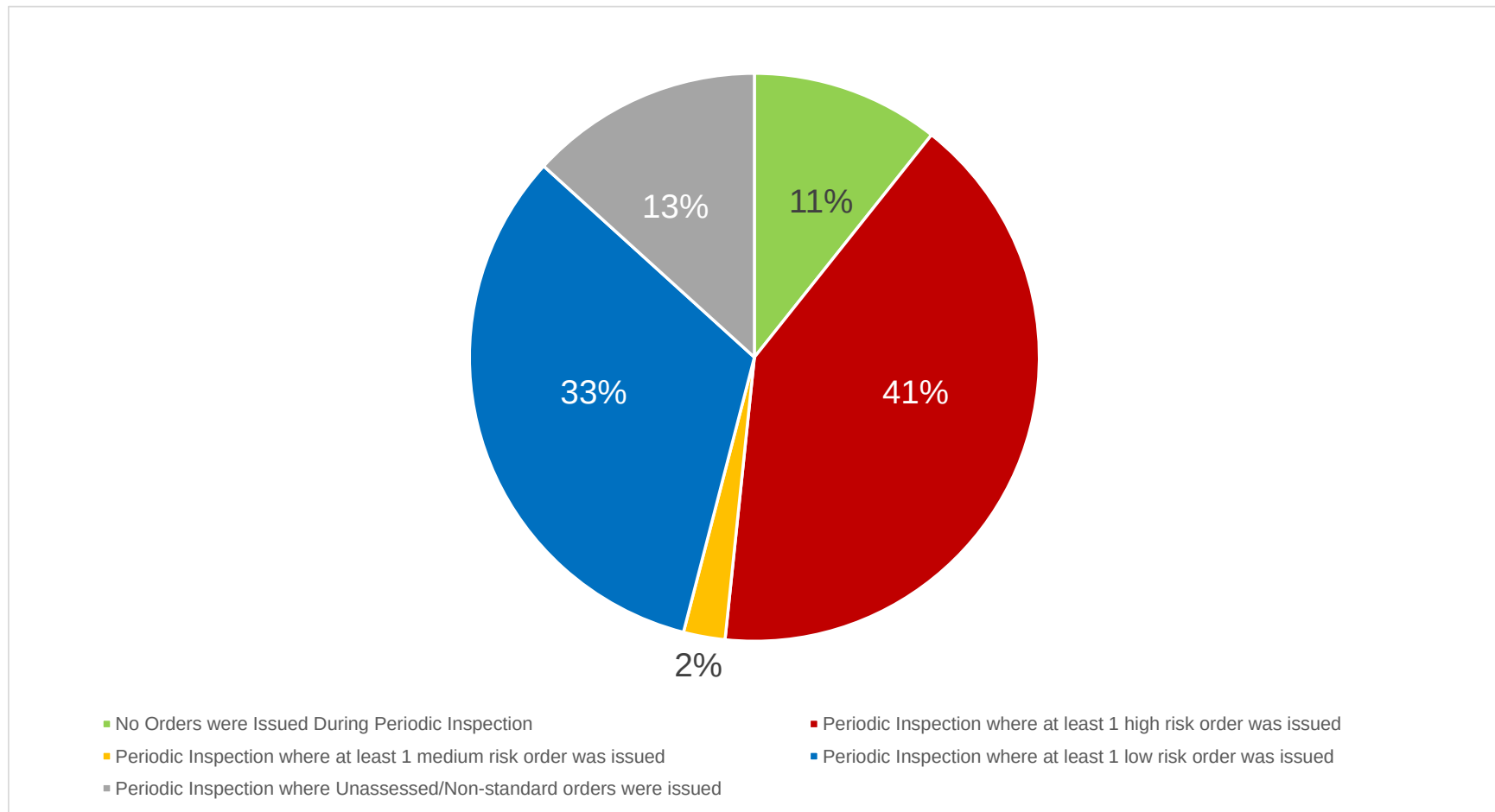
Periodic inspections conducted at office locations also indicate a decreasing trend in compliance of 3% per year. Decreasing trends in compliance have been generally been observed across all other building types.

Assessment of Periodic Inspection Outcomes (December 2, 2013 – April 30, 2015)

Over the above indicated period, 974 periodic inspections have been conducted, of which 11% were fully compliant. Additionally, 4,490 orders have been issued through these inspections. As indicated graphically in Figure EM-4, 41% of these inspections resulted in at least one high risk order being issued. Additionally, 33% of these inspections resulted in low risk orders being issued. For additional details, please refer to Appendix F.



Figure EM-4: Distribution of periodic inspections conducted on escalators and moving walks (December 2, 2013 – April 30, 2015).





As indicated in Table EM-3, 14% of orders issued during this time period were deemed as high risk. The top three non-compliances related to repairing or replacing damaged skirt panels, machine space lighting requirements and material requirements for the exposed surface of skirt panels.

Table EM-3: Distribution of orders issued through periodic inspections conducted on escalators and moving walks (December 2, 2013 – April 30, 2015).

Measure	Measure over Period
Number of Orders Issued	4,490
Percentage of High Risk Orders Issued	14%
Percentage of Medium Risk Orders Issued	2%
Percentage of Low Risk Orders Issued	50%
Percentage of Unassessed Orders	34%

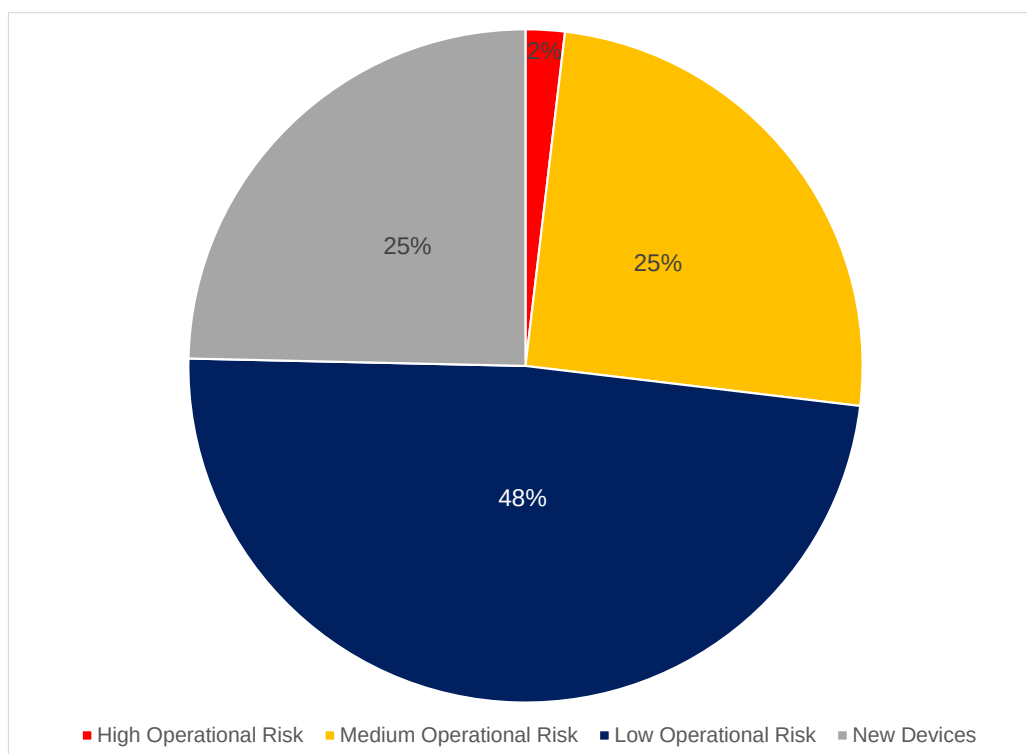
Additionally, 50% of orders issued during this time period were deemed as low risk. The top three non-compliances related to generic compliance requirements, daily stopping distance checks and making step demarcation lights operative.

The TSSA is continuing with its ongoing initiative to review and assess the risk of all orders.

During each inspection where a non-compliance was found, an inspector may choose to issue one or more orders. Inspection data indicate 18% of non-compliant inspections had only one order was issued. Additionally, 40% of non-compliant inspections had five or more orders issued.

Figure EM-5 shows the percentage distribution of the risk profile of escalators and moving walks in the province of Ontario as per TSSA's risk-based scheduling model (RBS2.5) as of July 2015 [6].

Figure EM-5: Distribution of escalators and moving walks in the Province of Ontario (RBS2.5).





As indicated in Figure EM-5, approximately 48% of the active escalators and moving walks in the province, based on their past compliance history, are identified as being low operational risk. 25% of active escalators and moving walks in the province, based on their past compliance history, are identified as being medium operational risk. Finally 2% of active elevators in the province, based on their past compliance history, are identified as being high operational risk.

TSSA continues to evaluate its risk informed inspection scheduling model and, based on recent data on compliance, occurrence history, and the corresponding risk profile of the inventory, is in the process of implementing changes to the frequency of inspections during the current fiscal year. The changes will entail more frequent inspections of high risk escalators and moving walks while incentivizing those escalators and moving walks with high levels of compliance with a lower frequency. The anticipated outcomes of these changes include further decrease in the trends of occurrences due to non-compliances and improvements in the levels of compliance. TSSA will continue to monitor the effectiveness of these changes

While periodic inspections are an important tool to ensure compliance, TSSA expects that the regulated parties are aware of their obligations, informed of their performances and meet regulatory expectations in a timely manner. In this regard, TSSA has proactively begun engaging major contractors by providing them with statistics on non-compliances directly related to their performance and requiring them to provide clear, time-bound strategies for improving compliance levels. TSSA will monitor the effectiveness of these strategies and expects to see a reduction in non-compliances over time. Additionally, TSSA has also introduced a contracting rating system that will be shared with the individual contractors. This strategy is expected to act as an incentive for contractor to exceed expectations and performance levels while providing a clear choice to escalator owners.

Managing Risks due to Potential Gaps in the Regulatory System

No new potential safety issues or gaps requiring action were identified and there are no known safety issues at the present.



III.6 Passenger Ropeways (Ski Lifts)

TSSA regulates chair lifts, bar lifts, outdoor recreational conveyers, rope tows and tube tows, totalling approximately 300 ski lifts in Ontario, to ensure all devices conform to the Act and applicable regulations, codes and standards. TSSA reviews and registers lift designs, conducts inspections, and performs incident investigations. It also licenses lift devices, ensuring they conform to Ontario safety standards. In partnership with the Ontario Snow Resorts Association, TSSA additionally provides public education throughout the province, promoting safer ski lift behaviour.

The trend analysis outlined in this section should consider the predominantly seasonal nature of these devices. The trend analysis confirmed and took into account seasonality while establishing historical patterns of safety and compliance performance.

III.6.1 Risk Assessment

Based on actual injuries and fatalities over the past eight years, the average rate of injury is approximately 6 injuries/million people/year. No fatalities have been reported during this period. Using TSSA's approach to integrating fatalities and injuries, the eight-year average injury burden corresponds to approximately 0.02 fatality equivalents/million people/year. Based on the 300 ski lifts in the province, this translates to an observed injury burden of 8.41×10^{-4} fatality-equivalents/device/year.

Based on all occurrences over the past eight years, TSSA's predictive model [2] estimates the risk of injury or fatality to Ontarians riding ski lifts to be approximately 0.01^{13} fatality-equivalents/ million people/year, as indicated in Table SL-1 below. This estimate assumes that entire population of Ontario (approximately 13 million), would ride a ski lift at least once over the course of a year. A more realistic prediction of risk of injury or fatality may be estimated by obtaining reliable information on ridership. TSSA is working with the ski lift operators to obtain such an estimate. Based on 300 number of ski lifts in the province, this translates to an observed device risk of 5.63×10^{-4} fatality-equivalents/device/year. Figure SL-1 illustrates these historical observations graphically.

Table SL-1: State of safety measures for ski lifts for the period 2008 – 2015.

Measure	Fiscal Year							
	2008	2009	2010	2011	2012	2013	2014	2015
Occurrences	97	100	85	83	130	82	82	60
Fatalities	0	0	0	0	0	0	0	0
Permanent Injuries	6	4	3	1	0	0	3	2
Non-Permanent Injuries	76	82	74	66	115	69	62	47
Risk of Injury or Fatality (FE/mpy)	Not Available			0.04	0.03	0.01	0.01	0.01
Observed Injury Burden (FE/mpy)	0.01	0.00	0.10	0.00	0.00	0.00	0.02	0.00

There are no observable trends in the number of occurrences, fatalities or injuries over the last eight years. The annual occurrence rate, as well as the number of permanent and non-permanent injuries per year have decreased from 2012 by 9%, 15% and 11% respectively. These decreases contribute to a 7% decrease in the risk of injury or fatality as of the 2015 fiscal year when compared to the 2014 fiscal year.

Figure SL-2 graphically illustrates the risk of injury or fatality as of the 2015 by causal category. Figure SL-3 illustrates the top issues related to ski lifts shown by their causal pathway.

¹³ Represents expected estimate of a simulated distribution; 5th and 95th percentiles are 0 and 0.08 fatality-equivalents per million people per year respectively.



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Figure SL-1: State of Safety across ski lifts over the last eight years.

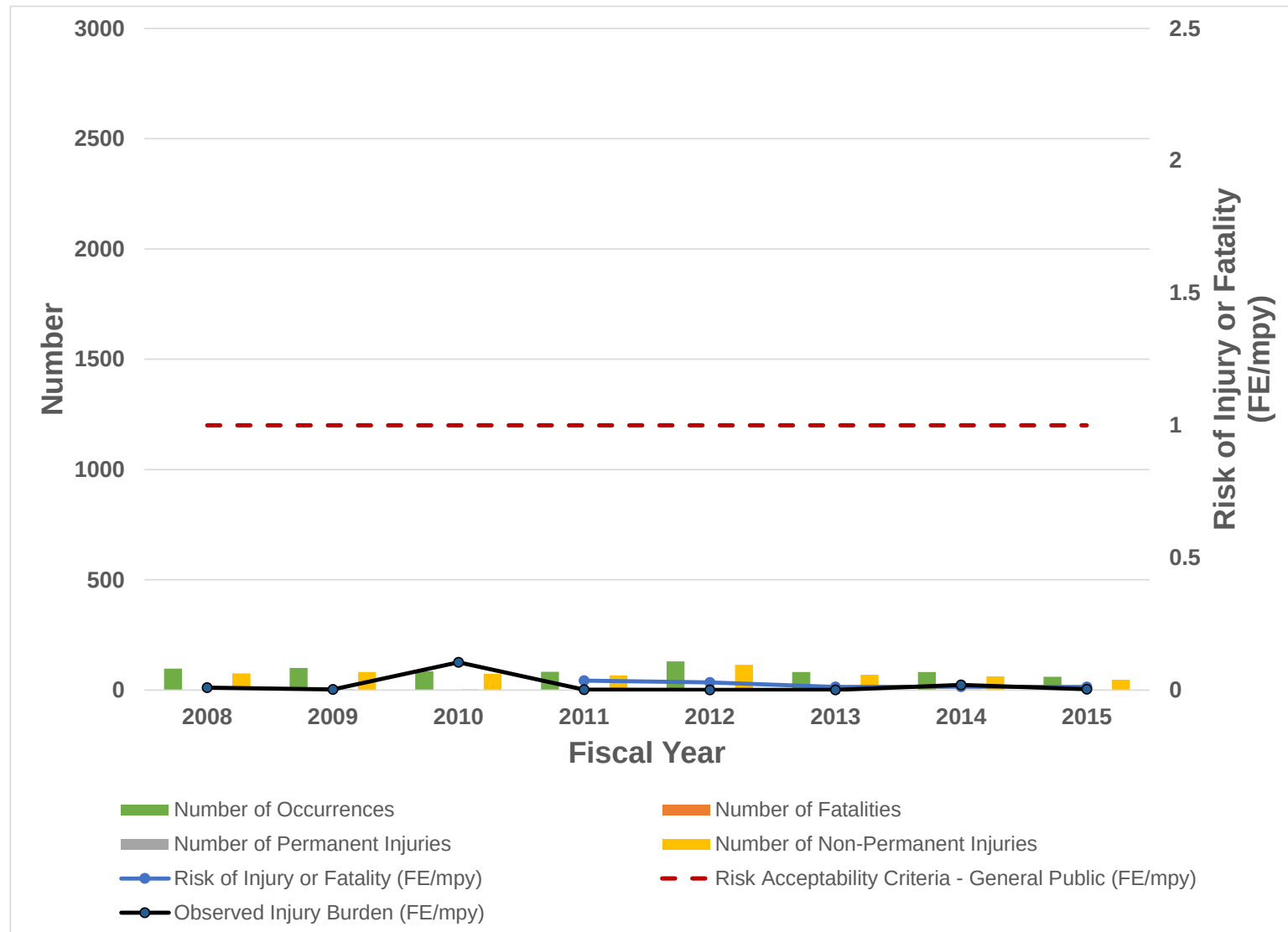
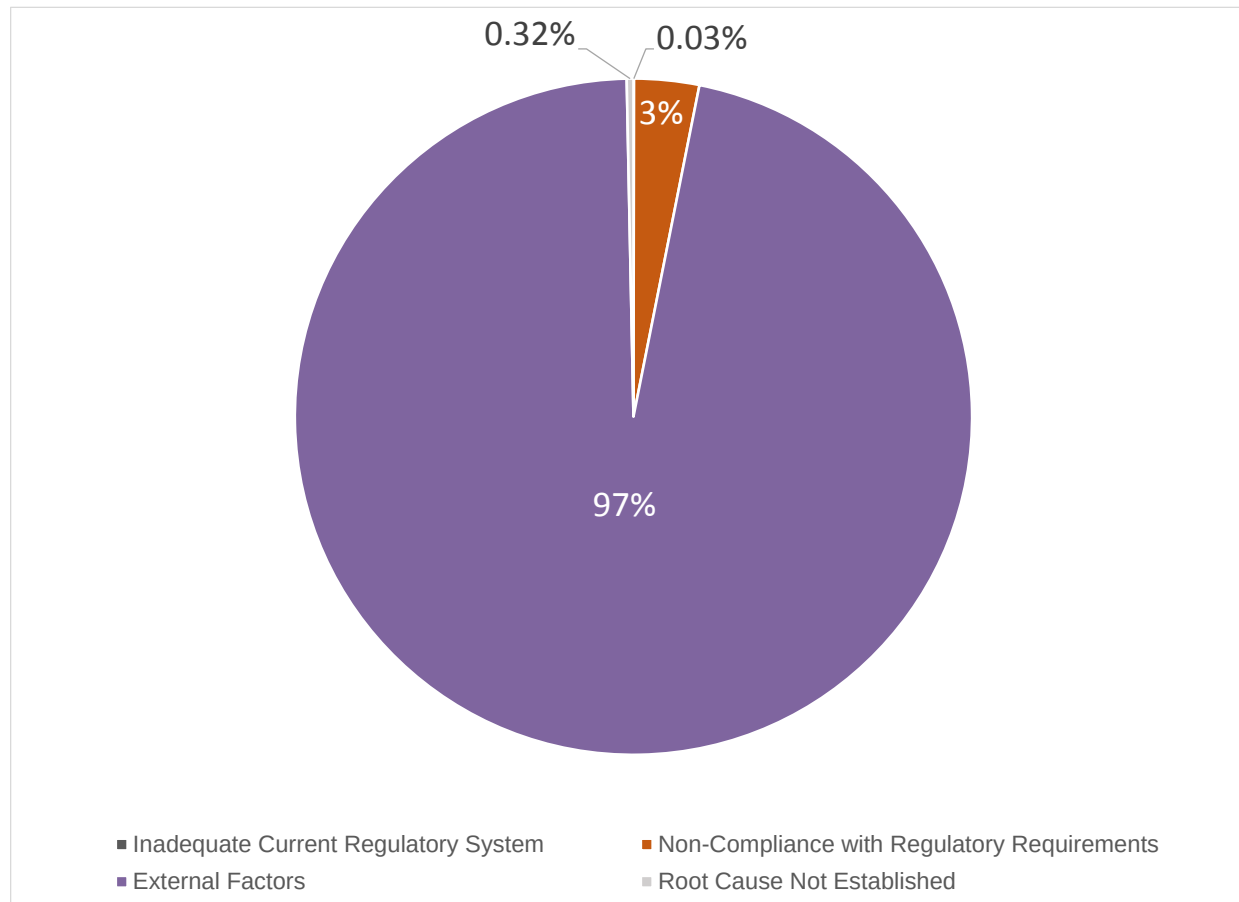




Figure SL-2: Risk of Injury or Fatality in ski lifts by cause (based on period ending 2015).



RISKS BY CAUSAL CATEGORY

Potential Gaps in Regulatory System

- 1 unique design-related occurrence

Non-Compliance

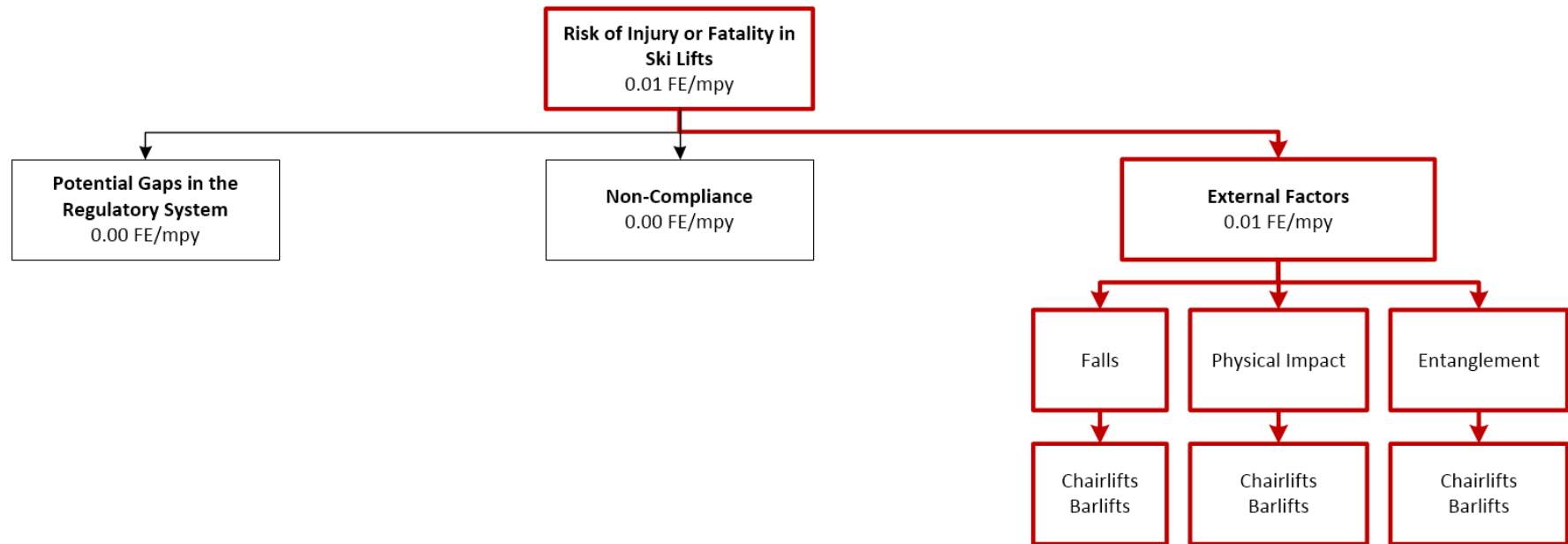
- No new safety issues

External Factors

- Caused by user behaviour
- Top Issues: falls, physical impact, entanglement
- Top Devices: chairlifts, barlifts



Figure SL-3: Causal Pathway of ski lift safety issues.





Risk of Injury or Fatality due to External Factors

Approximately 97% of the risk caused over the past eight years is due to external factors primarily resulting from unsafe user behaviour. There is no observable trends in the number of occurrences or injuries.

Occurrences triggered by unsafe user behaviour on chairlifts account for 72% of all occurrences, and 75% of total ski lift risk. Such occurrences on bar lifts account 21% of all ski lift occurrences and 21% of total ski lift risk.

Since 2009/2010, 46% of occurrences related to external factors resulted in passengers sustaining falls. These occurrences primarily took place during passenger loading and unloading, or when passengers fell from their chairs.

Additionally, 30% of occurrences related to external factors resulted in passengers sustaining physical impacts. These occurrences primarily took place during passenger loading and unloading, or when passengers made contact with T-bars and restraints. Finally 11% of occurrences related to external factors resulted in passengers becoming entangled during loading and/or unloading operations.

Risk of Injury or Fatality due to Non-Compliance with Regulatory System

Approximately 3% of the risk caused over the past eight years is due to non-compliance with regulatory requirements. There is no demonstrable trend in the number of occurrences or injuries. Lack of, or poor maintenance of chair lifts continue to contribute to this source of the risk.

Risk of Injury or Fatality due to Potential Gaps in Regulatory System

One occurrence has been reported to date, which was related to a unique set of circumstances. The device in question is the only one of its kind in the provincial inventory. An adjustment was made immediately to the device to avoid such an incident from recurring in the future. There are currently no new safety issues requiring further action by the safety program.

III.6.2 Risk Management – Message from Roger Neate, Statutory Director of SL Safety Program

Managing Risks due to External Factors

The vast majority of ski incidents continue to be related to user behaviour and further analysis has identified that new or beginner skier and snow boarders are the most at risk group. As such, ski lift user engagement and education is a key risk mitigation strategy. TSSA has completed research focused on the higher risk users and tested engagement strategies to refine its on-site public awareness/education initiatives.

TSSA took the following public engagement initiatives in 2015. TSSA concentrated its engagement strategies on-site to deliver safety messaging as skiers and snow boarders are using the lift devices. RideSmart Safety teams engage users particularly at lifts that are used by new and beginner skiers/snow boarders. TSSA partnerships with Canadian Ski Instructors' Alliance, Association of Day Care Operators, and Chirp (Owl Kids) and ChickaDEE to provide ski lift safety instructions.

TSSA will continue its work with snow resort owners/operators to further enhance the efficiency of its on-site engagement initiatives. Based on feedback from operators and incident data additional attention to unloading issues offers opportunities to further enhance user behaviour. TSSA is also continuing with its strong and effective relationship with CSIA and will explore other options to leverage the *look/Load/Lower Lift/Stand/Leave* messaging through their members and associated on-site ski schools.

Additional details can be found in Appendix D.



Managing Risks due to Non-Compliance in Regulatory System

TSSA conducts periodic inspections of all ski lifts on a historical compliance weighted approach to oversee and manage the state of compliance across approximately 300 ski lifts in the province of Ontario. TSSA deals with non-compliances by requiring the owner/operator to address observed failures within an appropriate timeframe through the issuance of inspection orders. This periodic inspection process contributes to the preventative management of risk associated with ski lifts as evidenced by a decreasing trend in the number of occurrences due to non-compliant ski lifts.

Table SL-2 provides information on key indicators associated with the results of the periodic inspections. The compliance rate measured over the last five years is 44% and does not demonstrate any significant quarterly trend.

Table SL-2: State of compliance for ski lifts as of 2015.

Compliance Measure	Measured Over a Five-Year Period
5-Year Compliance Rate	44%
Compliance Rate Trend (Annual)	No significant quarterly trend
Compliance Rate Prediction Interval - Lower Bound	N/A
Compliance Rate Prediction Interval - Upper Bound	N/A

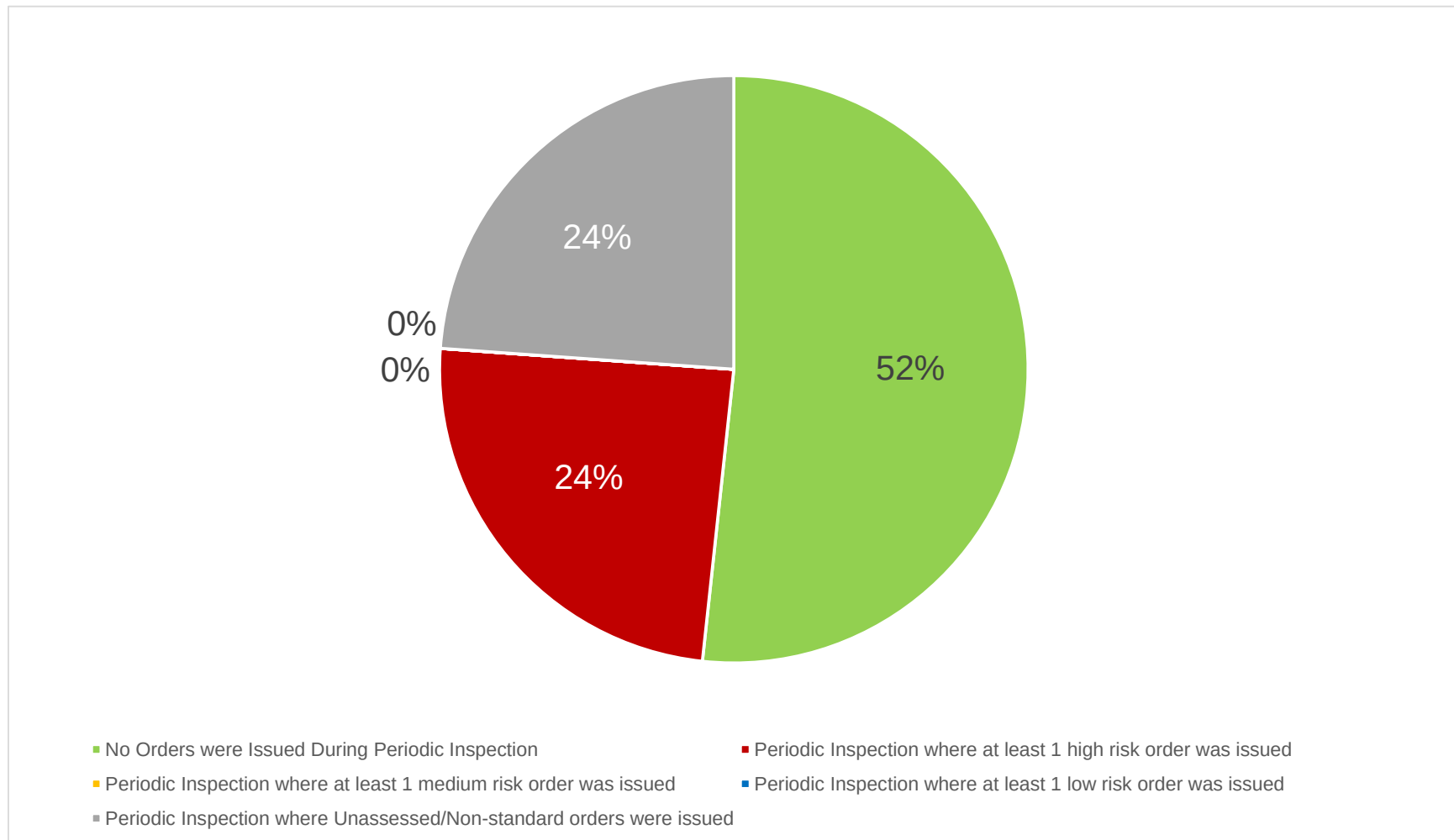
Periodic inspections conducted on chairlifts indicate an increasing trend in compliance of 6% per year. No observable trends in compliance have been observed with other ski lift technologies.

Assessment of Periodic Inspection Outcomes (December 2, 2013 – April 30, 2015)

Over the above indicated period, 176 periodic inspections have been conducted, of which 52% were fully compliant. Additionally, 214 orders have been issued through these inspections. As indicated graphically in Figure SL-4, 24% of these inspections resulted in at least one high risk order being issued. Additionally, 24% of these inspections resulted in unassessed orders being issued. For additional details, please refer to Appendix F.



Figure SL-4: Distribution of periodic inspections conducted on ski lifts (December 2, 2013 – April 30, 2015).





As indicated in Table SL-3, 23% of orders issued during this time period were deemed as high risk. The top three non-compliances related to operational requirements for ground fault protection, sheave assembly alignment and conveyor dimension requirements.

Table SL-3: Distribution of orders issued through periodic inspections conducted on ski lifts (December 2, 2013 – April 30, 2015)

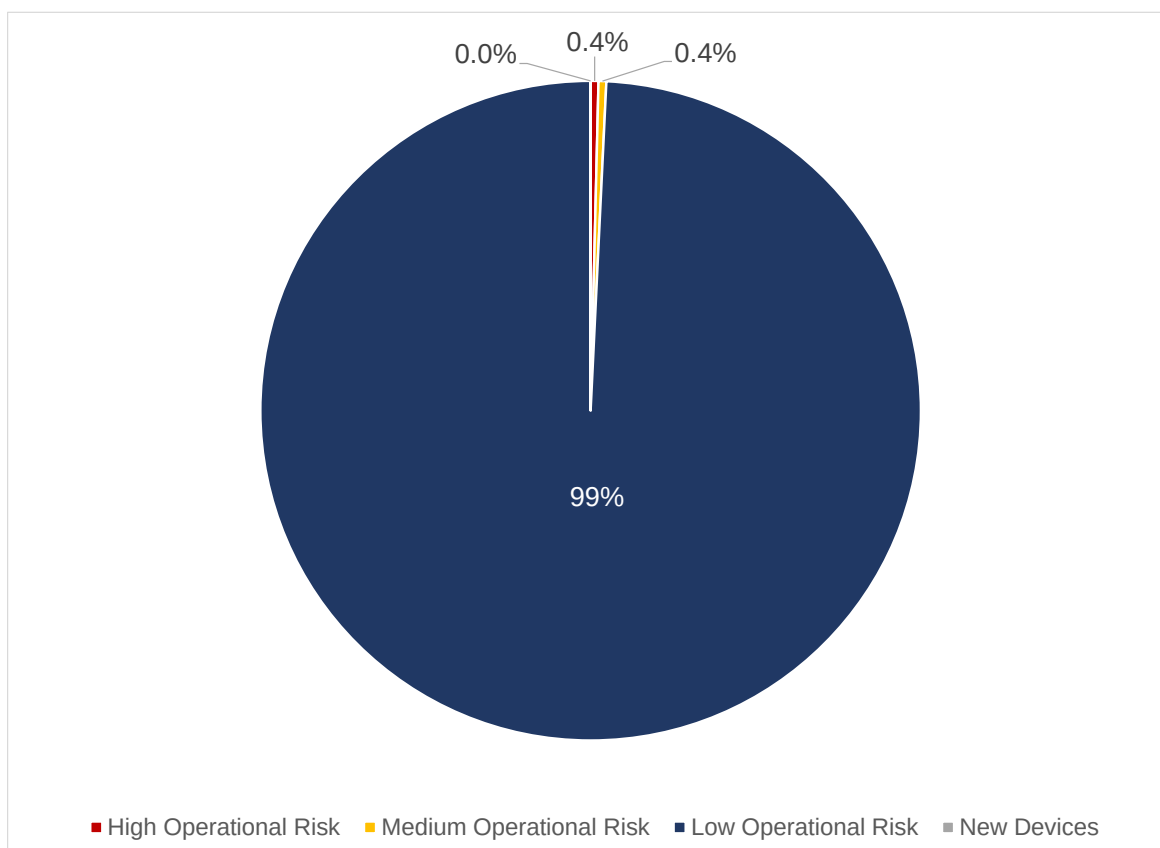
Measure	Measure over Period
Number of Orders Issued	214
Percentage of High Risk Orders Issued	23%
Percentage of Medium Risk Orders Issued	5%
Percentage of Low Risk Orders Issued	8%
Percentage of Unassessed Orders Issued	64%

Additionally, 8% of orders issued during this time period were deemed as low risk. The top three non-compliances related to tower numbering requirements, posting of ropeway occurrence procedures and generic maintenance requirements.

During each inspection where a non-compliance was found, an inspector may choose to issue one or more orders. Inspection data indicate 43% of non-compliant inspections had only one order was issued. Additionally, 13% of non-compliant inspections had five or more orders issued.

Figure SL-5 shows the percentage distribution of the risk profile of ski lifts in the province of Ontario as per TSSA's risk-based scheduling model (RBS2.0) as of October 2014 [6].

Figure SL-5: Distribution of ski lifts in the Province of Ontario (RBS2.0).





As indicated in Figure SL-5, approximately 99% of the active ski lift devices in the province, based on their past compliance history, are identified as being low operational risk. Less than 1% of active ski lifts in the province, based on their past compliance history, are identified as being medium or high operational risk.

Managing Risks due to Potential Gaps in the Regulatory System

No new potential safety issues or gaps requiring action were identified.

III.7 Fuels Safety

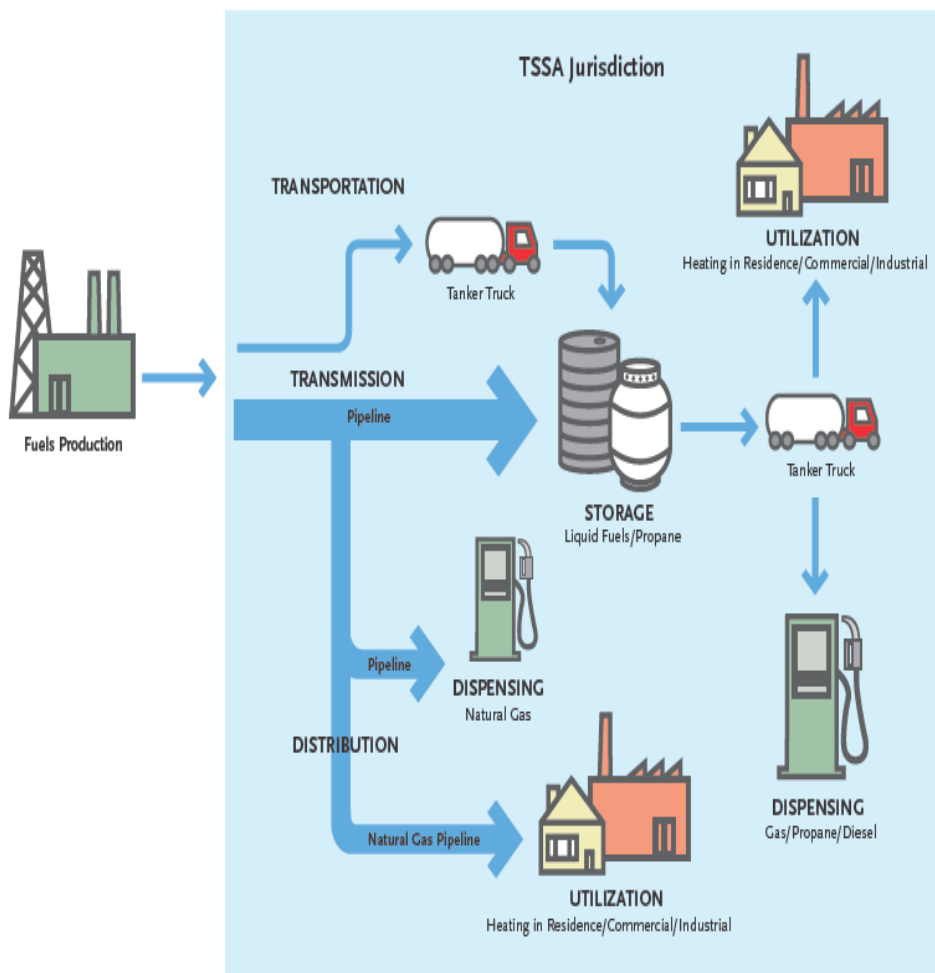
TSSA regulates the transportation, storage, handling and use of fuels to ensure compliance with the Act and applicable regulations, codes and standards. These fuels include: natural gas, propane, butane, hydrogen, digester gas, landfill gas, fuel oil, gasoline and diesel. TSSA licenses fuel facilities, registers contractors and certifies tradespersons who install and service equipment.

Additionally, TSSA reviews and approves facility plans for sites licensed by TSSA, and performs custom equipment approvals and inspection services to ensure fuel is handled and used safely.

The three stages of the fuels life-cycle that fall under TSSA's jurisdiction as illustrated in Figure FS-1 are:

- transmission, distribution and transportation;
- storage and dispensing; and
- utilization (burning).

Figure FS-1: The fuels lifecycle.





III.7.1 Risk Assessment

Based on actual injuries and fatalities over the past eight years, the observed average rate of injury and fatality is approximately 3.8 injuries/million people/year and 0.38 fatalities/million people/year respectively. Using TSSA's approach for integrating injuries and fatalities, these rates approximately correspond to an eight-year average injury burden of 0.37 fatality-equivalents/million people/year.

TSSA's prediction model estimates the risk of injury or fatality to be approximately 1.39¹⁴ fatality-equivalents/million people/year, as indicated in Table FS-1 below. This represents a decrease by 5% from last year. Figure FS-2 illustrates these historical observations graphically.

Table FS-1: State of safety measures for fuels for the period 2008 – 2015.

Measure	Fiscal Year							
	2008	2009	2010	2011	2012	2013	2014	2015
Occurrences	807	711	681	655	412	468	763	475
Fatalities	6	14	1	4	2	4	9	0
Permanent Injuries	12	21	21	8	7	6	10	11
Non-Permanent Injuries	65	65	13	34	48	23	40	15
Risk of Injury or Fatality (FE/mpy)	Not Available			1.49	1.22	1.30	1.47	1.39
Observed Injury Burden (FE/mpy)	0.31	0.95	0.23	0.20	0.17	0.51	0.53	0.07

There is a decreasing trend in the number of occurrences of 6% per year. While there are no demonstrable trends in the number of fatalities or injuries, the number of fatalities, permanent and non-permanent injuries per year have decreased from 2014 by 13%, 1% and 8% respectively. These decreases contribute to a 5% decrease in the risk of injury or fatality as of the 2015 fiscal year when compared to the 2014 fiscal year.

Figure FS-3 graphically illustrates the risk of injury or fatality as of the 2015 by causal category. Figure FS-4 illustrates the top issues related to fuels safety shown by their causal pathway.

¹⁴ Represents expected estimate of a simulated distribution; 5th and 95th percentiles are 0 and 5.2 fatality-equivalents per million people per year respectively.



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Figure FS-2: State of safety across fuels safety over the last eight years.

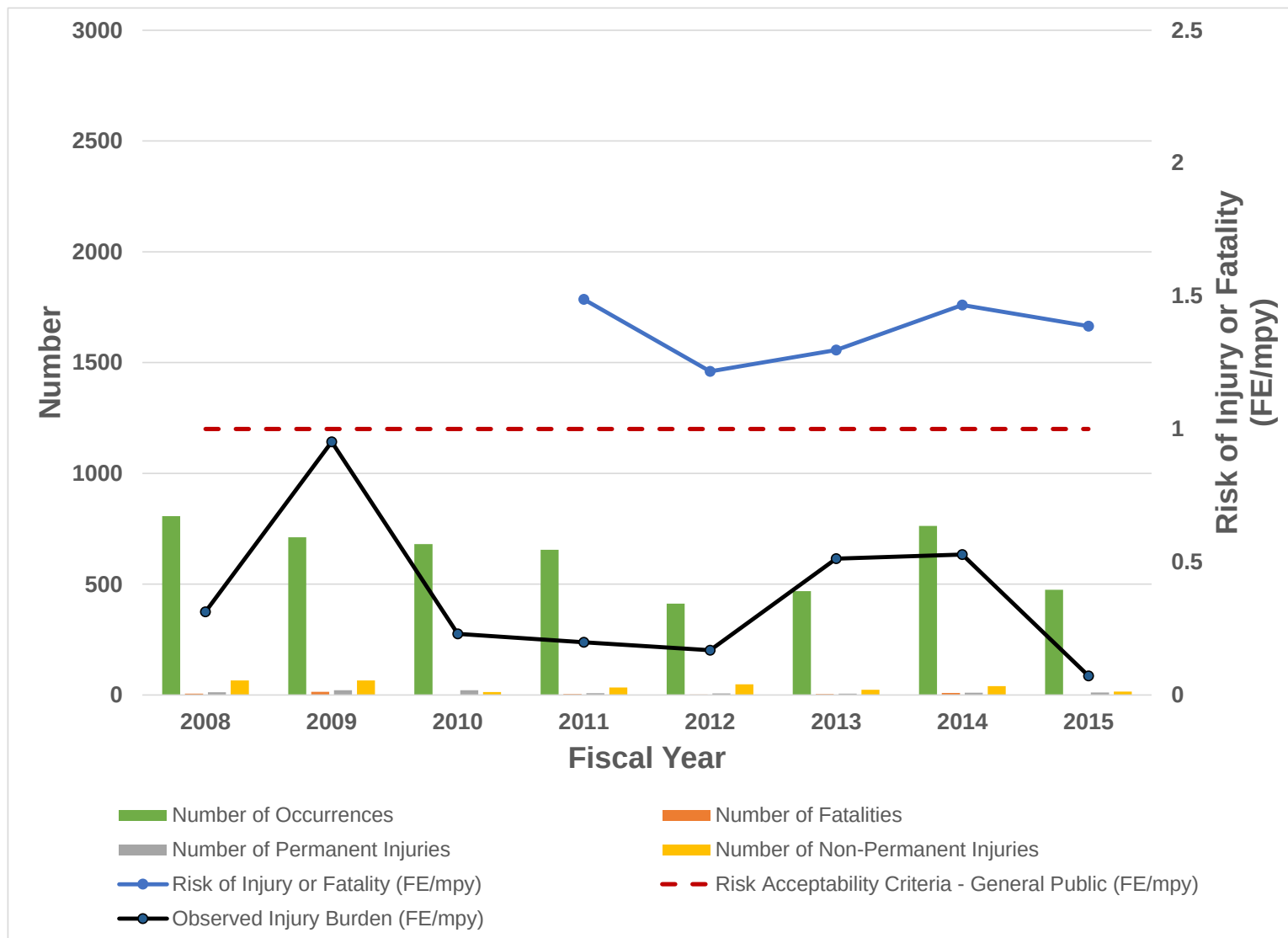
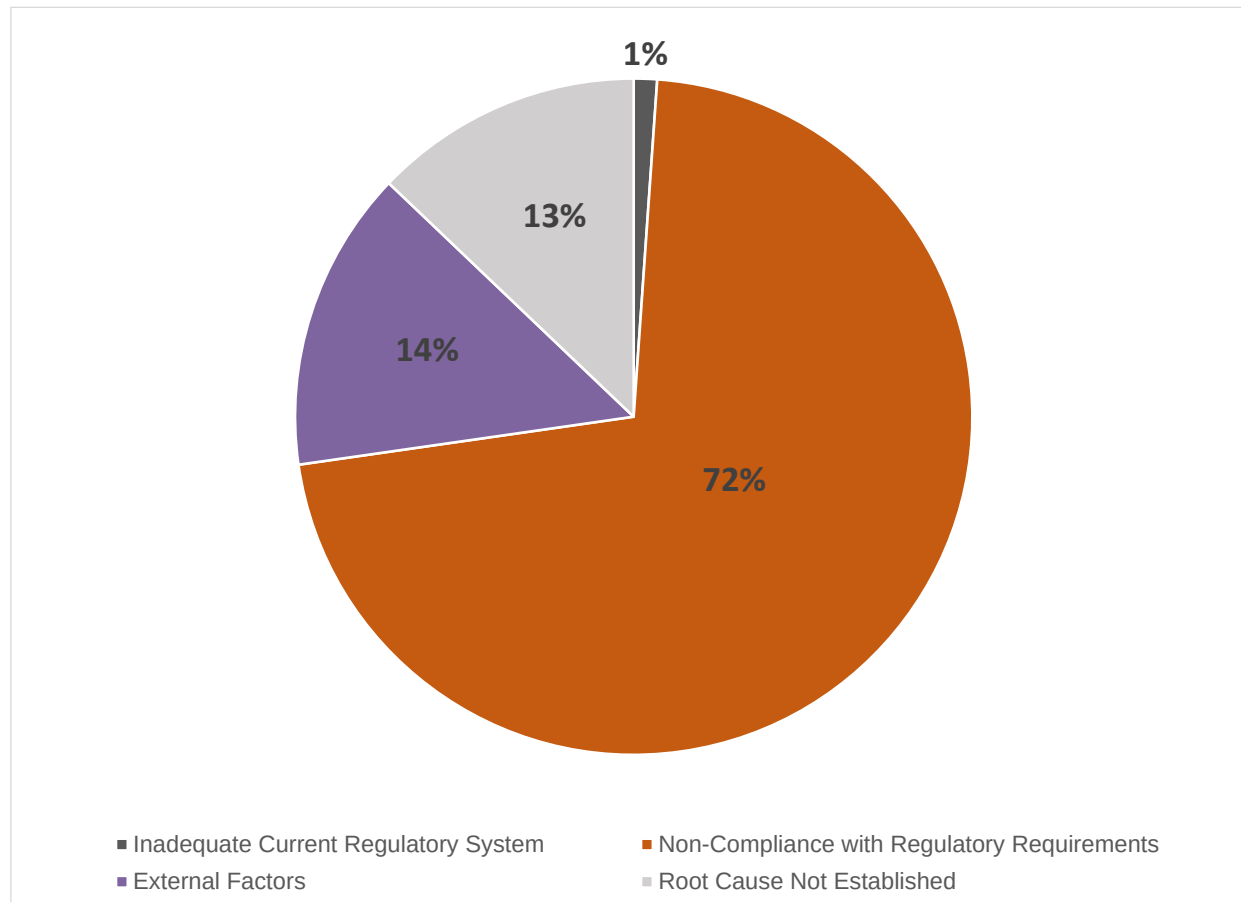




Figure FS-3: Risk of Injury or Fatality in fuels safety by cause (based on period ending 2015).



RISKS BY CAUSAL CATEGORY

Potential Gaps in Regulatory System

- Defective/wearing gas valves on fireplaces
- Aboveground fuel oil residential tank corrosion failures

Non-Compliance

- Occurrences ↓7% per year
- Top locations: private dwellings, commercial establishments, institutions

External Factors

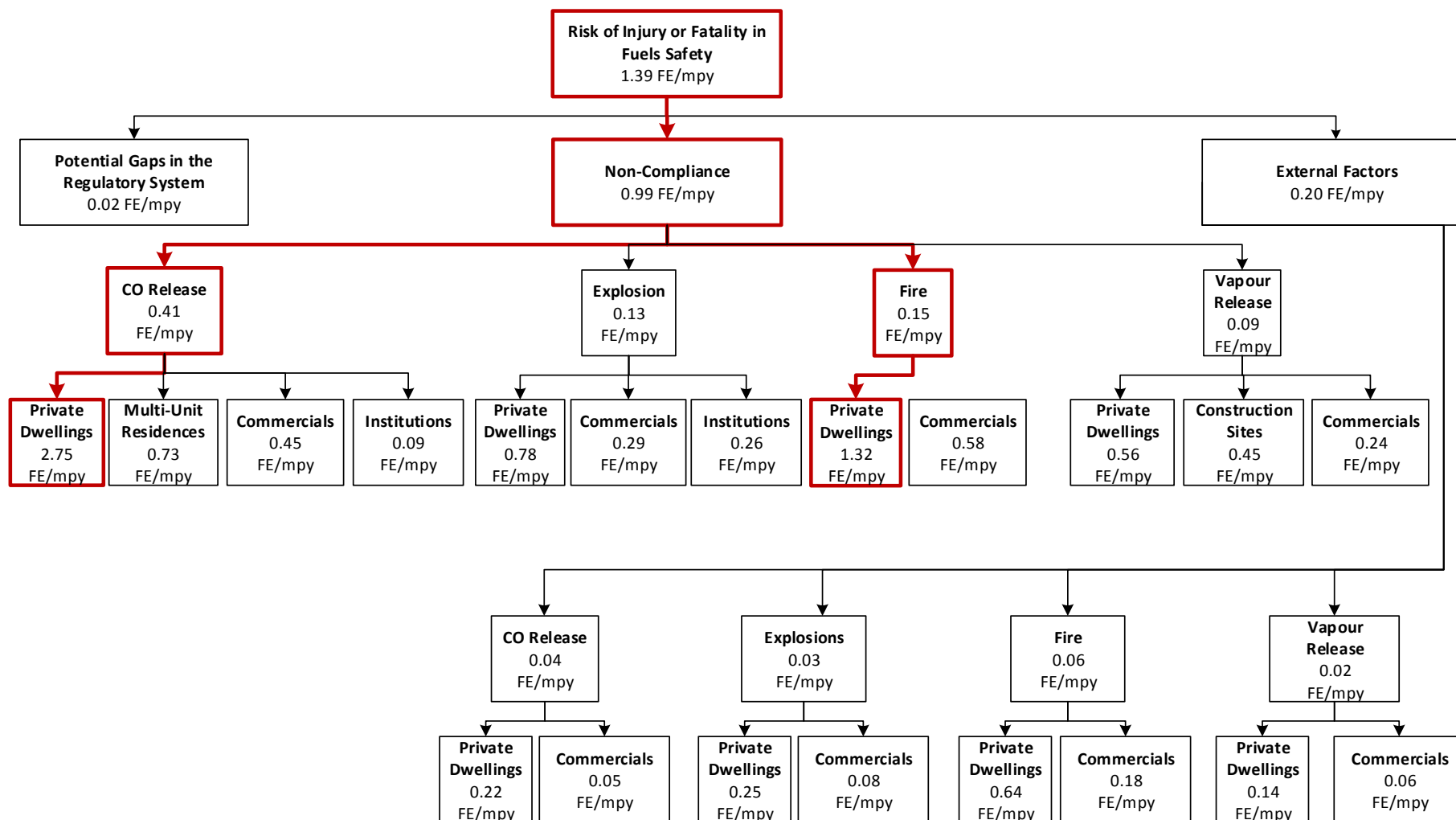
- CO release occurrences from users failing to follow operating procedures



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Figure FS-4: Causal Pathway of fuels safety risks.





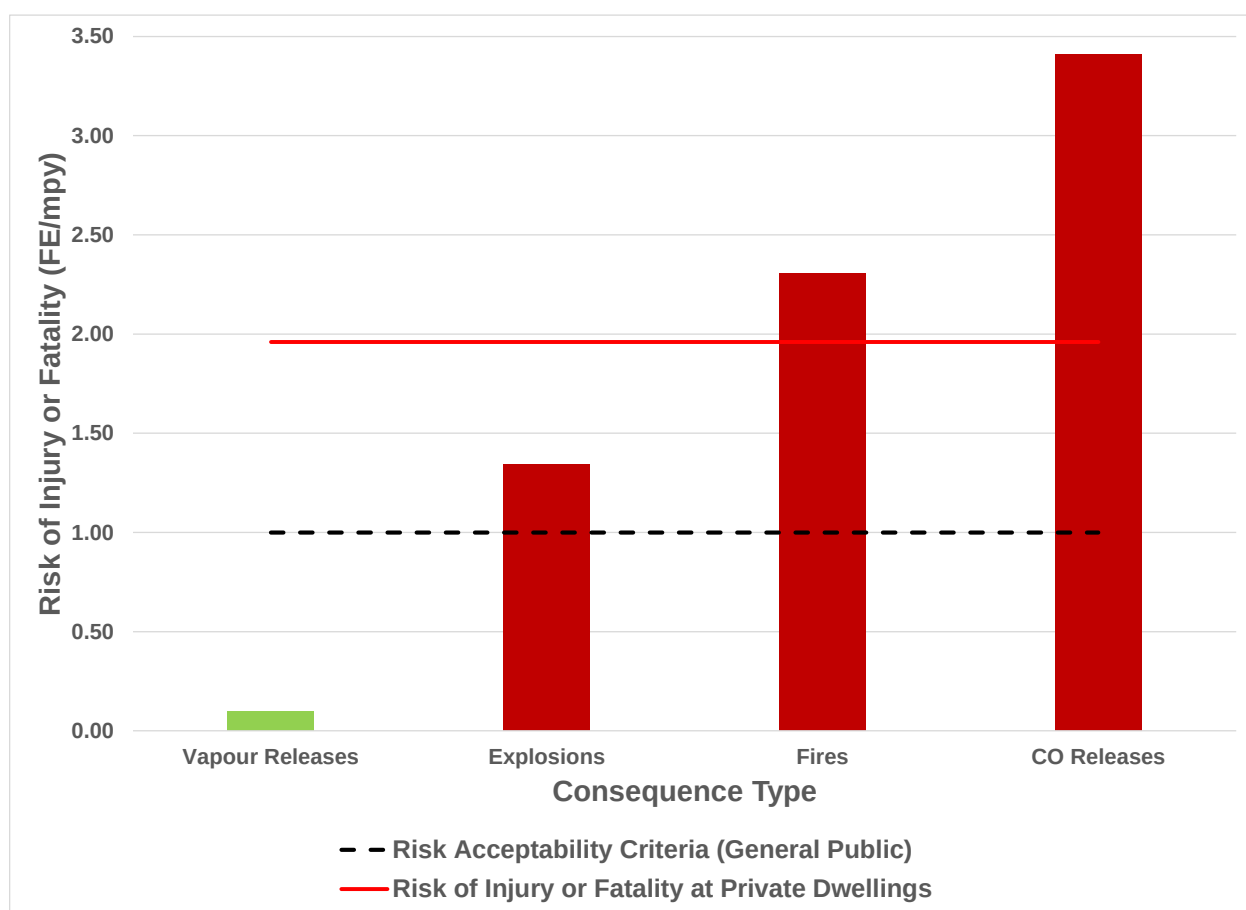
Risk of Injury or Fatality due to Non-Compliance with Regulatory System

72% of the risk of injury or fatality is attributed to non-compliance with the regulatory system. There is a 3% reduction in the risk of injury or fatality from the 2014 fiscal year. Additionally, there is a decreasing trend in the number of occurrences related to non-compliances of 7% per year. These risks include a reduction in the risk due to non-compliance in private dwellings.

Risk of Injury or Fatality at Private Dwellings

Occurrences at private dwellings account for 52% of all fuels safety occurrences and account for 1.96 fatality-equivalents/million people/year. There is a decreasing trend in the number of these occurrences of 4% per year. The risk of injury or fatality in private dwellings has been represented graphically in Figure FS-5.

Figure FS-5: Risk of Injury or Fatality across private dwellings by consequence.



As indicated in Figure FS-5, the largest source of risk at private dwellings continues to be related to carbon monoxide release and accounts for 3.41 fatality-equivalents/million people/year. While this represents a decrease in risk of 2% from 2014, the associated risk continues to be well above the internationally accepted benchmark criteria of 1.00 fatality-equivalent/million people/year (indicated in black). Additionally, CO release occurrences in private dwellings account for 66% of all occurrences involving CO release, and 12% of all fuels safety occurrences over the last eight years.

Occurrences in private dwellings resulting in carbon monoxide release involved furnaces, gas supply and piping, water heaters and boilers.

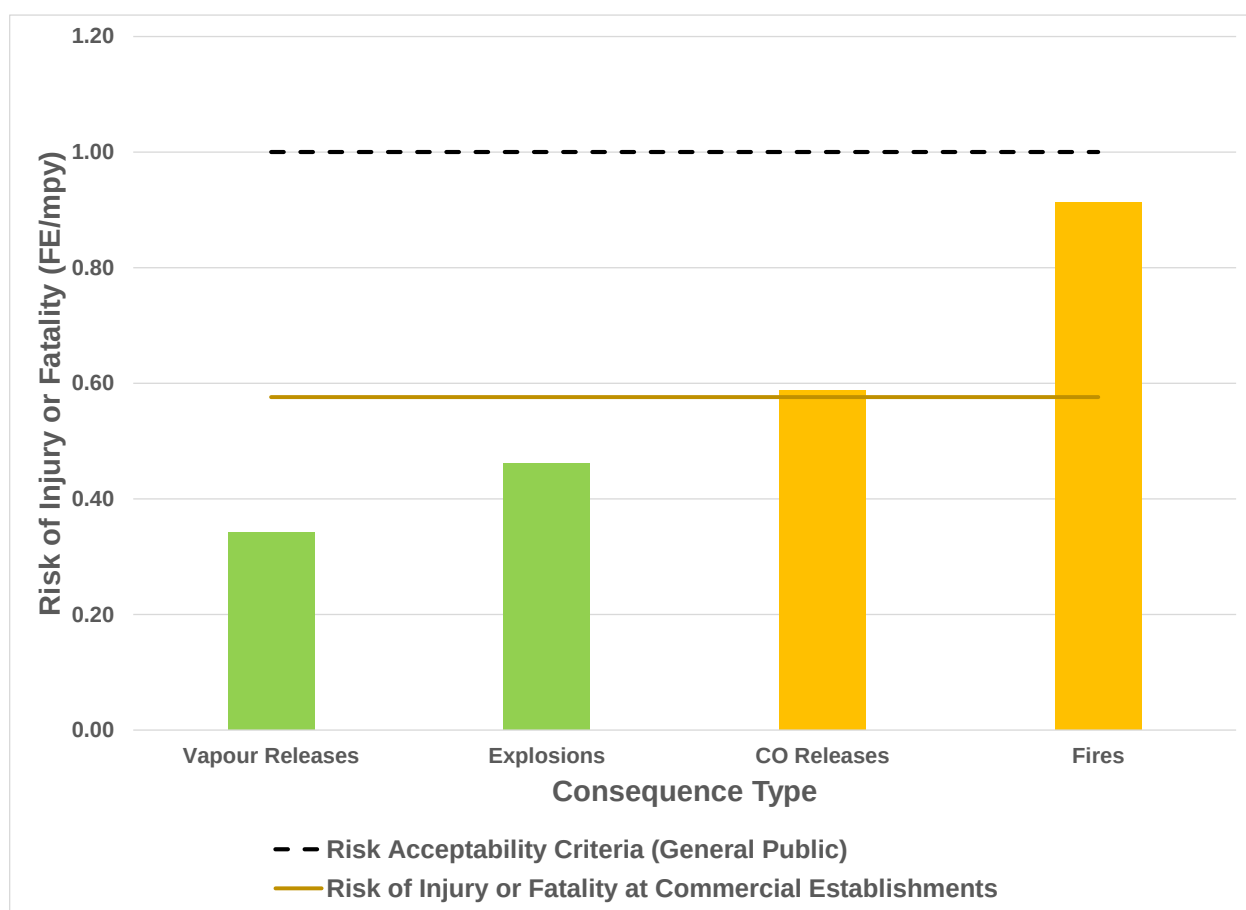


There continue to be reports of incidents and fatalities associated with natural gas-fired natural draft boilers in residences. Occurrences involving these appliances in residences demonstrate an increasing trend at a rate of 11% per year over the last eight years, and represent a risk of injury or fatality of 0.52 fatality-equivalents/million people/year. These occurrences continue to demonstrate deficiencies due to poor installation and inadequate maintenance of boilers.

Risk of Injury or Fatality at Commercial Establishments

The risk of injury or fatality at commercial establishments accounts for 0.58 fatality-equivalents/million people/year, and has decreased by 3% since the last year. There is no observable trend in the number of these occurrences. The risk of injury or fatality in commercial establishments has been represented graphically in Figure FS-6.

Figure FS-6: Risk of Injury or Fatality across commercial establishments by consequence.



Approximately 80% of occurrences that took place at commercial establishments had adequate information on causal details. Based on this available information, 34% of the occurrences were considered to take place upstream of the gas meter (outside the building), and they primarily involved damage to unprotected risers and regulators, as well as gas supply and related piping.

The remaining occurrences took place downstream (typically inside the building involving appliances). From these occurrences, TSSA has identified three issues involving appliances. Firstly, grease fires in restaurants involving stoves and fryers represent a major source of risk involving fires. Secondly, delayed ignitions in ovens, particularly in pizzerias, have resulted in explosions with health impacts. Finally, burners left operating overnight on stoves at restaurants, contributed to vapour release occurrences.

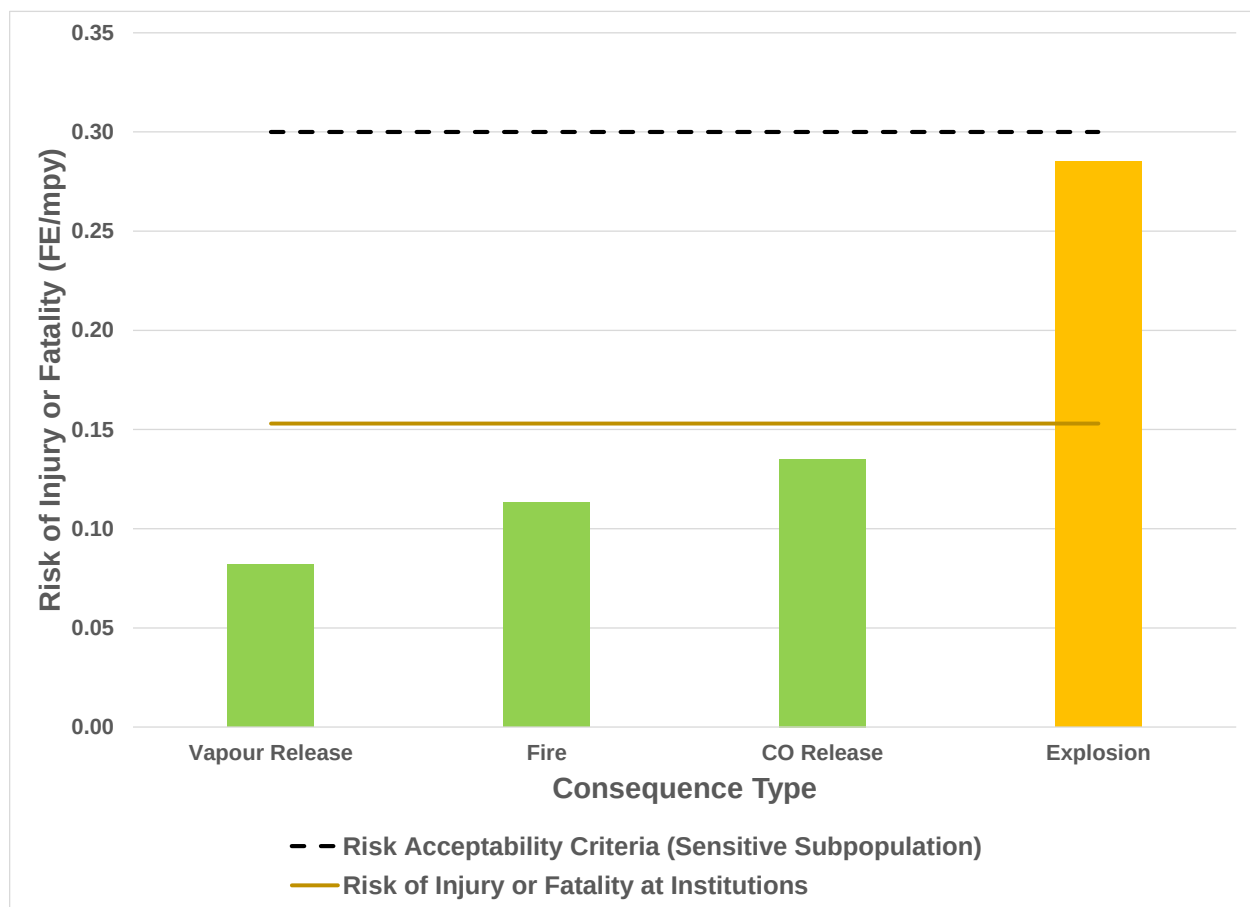


Risk of Injury or Fatality at Institutions with Vulnerable Populations

The risk of injury or fatality at institutions accounts for 0.15 fatality-equivalents/million people/year. This risk, as well as the risk due to non-compliant installation and maintenance practices of heating appliances and associated fuel supply and venting systems at institutions with vulnerable populations (hospitals, schools, nursing homes, etc.), have both decreased by 13% since the last year.

The acceptability threshold at these locations [3] due to the type of occupants is understandably much lower than normal locations [4, 5] of exposure. The risk of injury or fatality at these locations have been illustrated graphically in Figure FS-7.

Figure FS-7: Risk of Injury or Fatality across institutions housing vulnerable populations by consequence.

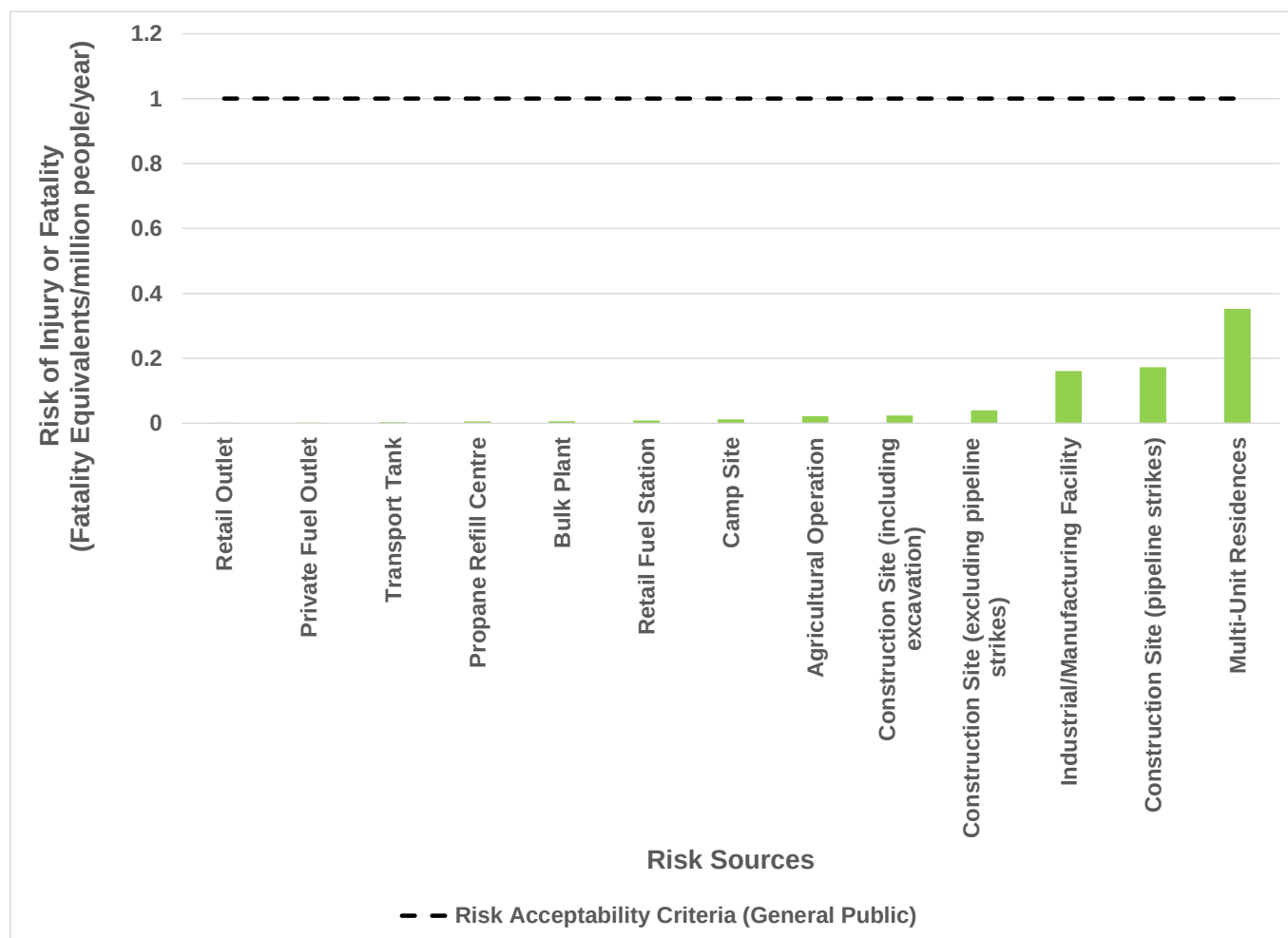




Risk of Injury or Fatality at Other Locations

The risk of injury or fatality relating to TSSA-regulated technologies and sectors including construction sites (i.e., pipeline strikes), multi-unit residences, industrial/manufacturing facilities, agricultural operation, camp sites, licensed fuels storage and dispensing facilities and private fuel outlets fall within acceptable levels. Figure FS-8 shows the levels of risk at these locations.

Figure FS-8: Risk sources with acceptable levels of Risk of Injury or Fatality.



It is important to note that while the overall risk of injury or fatality at multi-unit residences represents 0.35 fatality-equivalents/million people/year, the risk of injury or fatality due to carbon monoxide poisoning at these locations accounts for 0.86 fatality-equivalents/million people/year. This source of risk is currently being addressed through the TSSA's broad strategy of reducing CO-related risks at residences.

Risk of Injury or Fatality due to External Factors

Approximately 14% of the estimated risk is attributed to factors external to the regulatory requirements including owners failing to follow user instructions while operating appliances, such as barbecues, portable heaters at campsites, etc. Other factors including criminal activity and sabotage, also contribute to some of the occurrences, which may have involved TSSA's role as technical support to other regulatory agencies.



Risk of Injury or Fatality due to Potential Gaps in Regulatory System

Approximately 1% of the risk of injury or fatality caused over the past eight years is due to potential gaps in the regulatory system. Known safety issues include defective or wearing gas valves on fireplaces and corrosion-related failures on aboveground fuel oil residential tanks [7, 8], as reported in previous versions of this report.

III.7.2 Risk Management – Message from John Marshall, Statutory Director of Fuels Safety Program

Managing Risks due to Non-Compliance in Regulatory System

Managing Risks due to TSSA Periodically Inspected Technology at Liquid Fuels Licensed Sites

TSSA conducts periodic inspections of liquid fuels storage and dispensing facilities at least once every three years to oversee and manage the state of compliance across approximately 4,300 licensed sites in the province of Ontario.

Assessment of Periodic Inspection Outcomes at Liquid Fuels Sites (May 1, 2010 – April 30, 2015)

As indicated in Table FS-2, the compliance rate at liquid fuels licenced sites is 32% and does not demonstrate a significant trend.

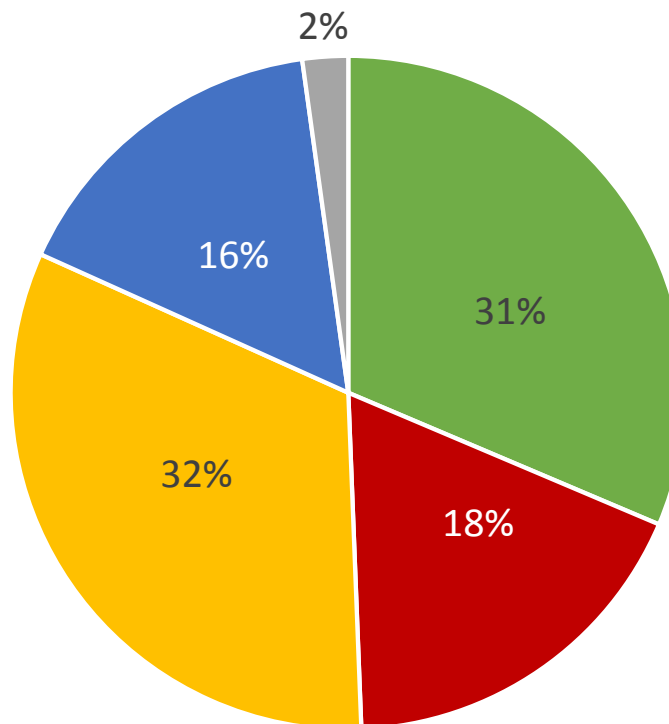
Table FS-2: State of compliance for liquid fuels licenced sites as of 2015.

Compliance Measure	Measured Over a Five-Year Period
5-Year Compliance Rate	32%
Compliance Rate Trend (Annual)	No significant quarterly trend
Compliance Rate Prediction Interval - Lower Bound	13%
Compliance Rate Prediction Interval - Upper Bound	44%

Over the five-year period 31% of periodic inspections conducted were fully compliant. As indicated graphically in Figure FS-9, 18% of these inspections resulted in at least one high risk order being issued. Additionally, 16% of these inspections resulted in at least one low risk order being issued. For additional details, please refer to Appendix F.



Figure FS-9: Distribution of periodic inspections conducted on liquid fuels licenced sites (May 1, 2010 – April 30, 2015).



- No Orders were Issued During Periodic Inspection
- Periodic Inspection where at least 1 high risk order was issued
- Periodic Inspection where at least 1 medium risk order was issued
- Periodic Inspection where at least 1 low risk order was issued
- Periodic Inspection where Unassessed/Non-standard orders were issued



Table FS-3 contains the distribution of orders issued through periodic inspections at liquid fuels sites.

Table FS-3: Distribution of orders issued through periodic inspections conducted on liquid fuels licenced sites (May 1, 2010 – April 30, 2015).

Measure	Measure over Period
Percentage of High Risk Orders Issued	7%
Percentage of Medium Risk Orders Issued	27%
Percentage of Low Risk Orders Issued	55%
Percentage of Unassessed Orders Issued	10%

As indicated in Table FS-3, 7% of orders issued during this time period were deemed as high risk. There is no demonstrable trend in the percentage of high-risk orders issued. Examples of these non-compliances were related to proximity of combustible materials near pumps, requirements for spill containment devices and installation requirements for Stage I vapour recovery equipment.

Additionally, 55% of orders issued during this time period were deemed as low risk. There is an increasing trend in the percentage of low risk orders issued of 1% per year. Examples of these non-compliances related to signage related to portable containers, availability of written spill procedures and requirements pertaining to off-season inspections at marinas.

During each inspection where a non-compliance was found, an inspector may choose to issue one or more orders. Inspection data indicate 17% of non-compliant inspections had only one order issued. Additionally, 37% of non-compliant inspections had five or more orders issued.

Managing Risks due to TSSA Periodically Inspected Technology at Propane Licensed Sites

TSSA conducts periodic inspections of propane facilities to oversee and manage the state of compliance across approximately 1,400 licensed sites in the province of Ontario.

A regulatory change made in 2014 removed annual inspection requirements for these facilities. These facilities are now inspected using a risk informed approach. The TSSA successfully implemented a risk-informed inspection scheduling process for propane storage and dispensing facilities that has received broad stakeholder support and acceptance. This process has helped the TSSA focus its inspection efforts based on risk while providing incentives to industry with better compliance records.

Assessment of Periodic Inspection Outcomes at Propane Licenced Sites (May 1, 2010 – April 30, 2015)

As indicated in Table FS-4, the compliance rate at propane licenced sites is 70% and is demonstrating an increasing trend of 4% per year.

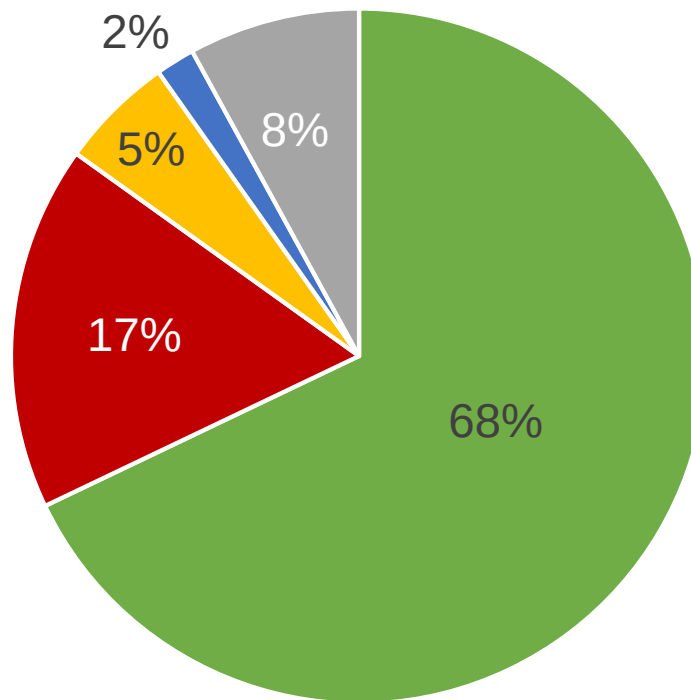
Table FS-4: State of compliance for propane licenced sites as of 2015.

Compliance Measure	Measured Over a Five-Year Period
5-Year Compliance Rate	70%
Compliance Rate Trend (Annual)	4%
Compliance Rate Prediction Interval - Lower Bound	43%
Compliance Rate Prediction Interval - Upper Bound	84%

Over the five-year period, 68% of periodic inspections conducted were fully compliant. As indicated graphically in Figure FS-10, 17% of these inspections resulted in at least one high risk order being issued. Additionally, 2% of these inspections resulted in at least one low risk order being issued. For additional details, please refer to Appendix F.



Figure FS-10: Distribution of periodic inspections conducted on propane licenced sites (May 1, 2010 – April 30, 2015).



- No Orders were Issued During Periodic Inspection
- Periodic Inspection where at least 1 high risk order was issued
- Periodic Inspection where at least 1 medium risk order was issued
- Periodic Inspection where at least 1 low risk order was issued
- Periodic Inspection where Unassessed/Non-standard orders were issued



Table FS-5 contains the distribution of orders issued through periodic inspections at propane sites. 38% of orders issued during this time period were deemed as high risk. There is an increasing trend in the number of orders issued of 3% per year. Examples of these non-compliances were related to cylinder relief valve requirements, cylinder temperature exposure requirements and requirements associated with the protection of tanks.

Additionally, 10% of orders issued during this time period were deemed as low risk. There is an increasing trend in the percentage of low risk orders issued of 3% per year. Examples of these non-compliances were related to location of hydrostatic relief valves, and general signage requirements.

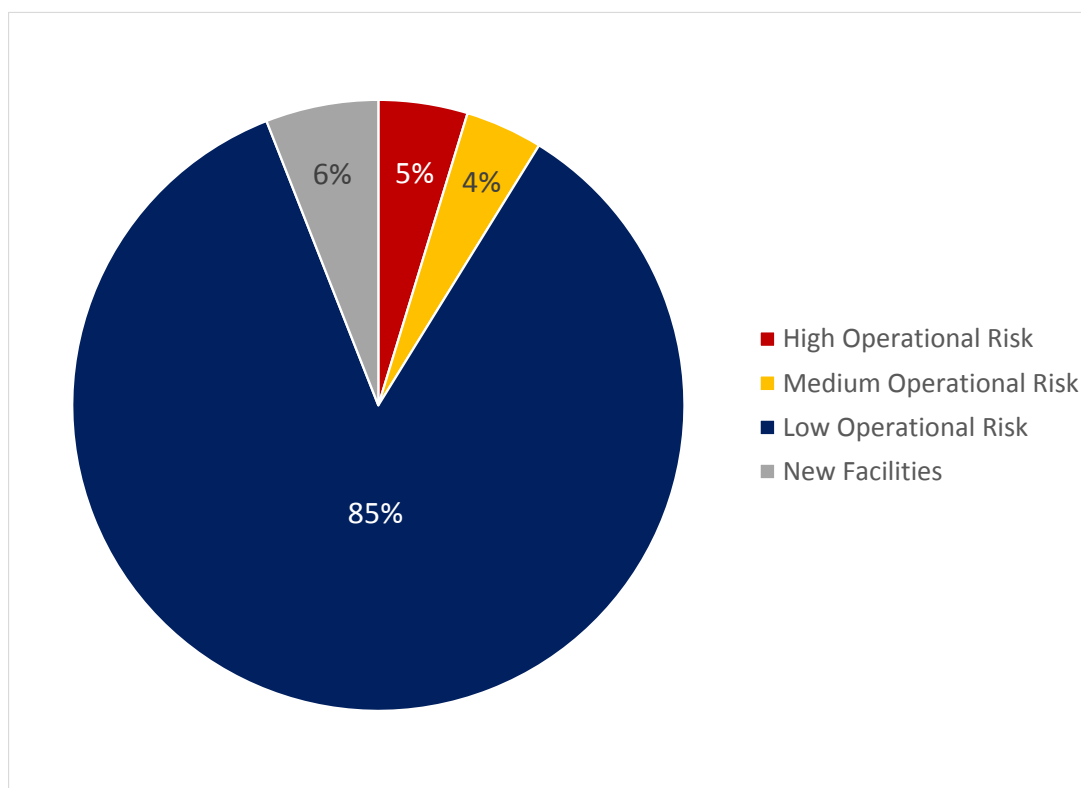
Table FS-5: Distribution of orders issued through periodic inspections conducted on propane licenced sites (May 1, 2010 – April 30, 2015).

Measure	Measure over Period
Percentage of High Risk Orders Issued	38%
Percentage of Medium Risk Orders Issued	24%
Percentage of Low Risk Orders Issued	10%
Percentage of Unassessed Orders Issued	28%

During each inspection where a non-compliance was found, an inspector may choose to issue one or more orders. Inspection data indicate 42% of non-compliant inspections had only one order was issued. Additionally, 13% of non-compliant inspections had five or more orders issued.

Figure FS-11 shows the percentage distribution of the risk profile of propane facilities in the province of Ontario as per TSSA's risk-based scheduling model (RBS2.0) as of November 2014 [6].

Figure FS-11: Distribution of propane facilities in the Province of Ontario (RBS2.0).





Managing Risks at Private and Multi-Residential Dwellings

While these risks have been identified as the result of non-compliances, section 17.(2)(b) of the Act [1] places limitations on TSSA to enter private dwellings, and states that “An inspector shall not, enter any part of premises that are being used as a dwelling, except with the consent of the owner or occupier”. The TSSA’s Research and Education Program has established a multi-stakeholder strategy to build public awareness of these risks and share the responsibilities of mitigating the risks.

Consistent with its proactive preventative strategy philosophy, TSSA’s approach focuses first and foremost on changing the public’s behaviour with respect to how they use and maintain fuel-burning appliances with a particular emphasis on those in private residential dwellings. Adopting the appropriate behaviours would address the hazard by preventing it at the source. Based on comprehensive research and field experience, TSSA has a number of CO engagement strategies that have demonstrated success in terms of increased public awareness, understanding regarding the risks this hazard presents as well as action they can take to mitigate those risks.

Please refer to Appendix D for additional details regarding TSSA’s research and education strategies.

In response to continued reports of incidents and fatalities associated with natural gas-fired natural draft boilers in residences, TSSA issued director’s orders in 2006 and 2009 to address the deficiencies with boilers installation and maintenance, which was incorporated into the Gaseous Fuels Code Adoption Document in November 2012. Over 20% of orders issued were due to a failure to check for carbon monoxide in the flue gas.

Though there is no observable trend in the number of occurrences after Director’s Order FS 156-09 was issued, the annual occurrence rate has steadily increased since the Director’s Order was issued, indicating that this issue continues to remain a significant risk at residences with no formal maintenance program in place. As such, TSSA will consider implementing mandatory maintenance and inspection for residential heating appliances and chimneys.

Managing Risks at Commercial Establishments

While the risk in the commercial sector is tolerable TSSA will work with industry stakeholders to reduce occurrences upstream of the meter and gas supply piping as well as communicating the need for maintenance of commercial appliances such as stoves, fryers and ovens and providing training/awareness to address issues of improper user behaviour.

Managing Risks at Institutions with Vulnerable Populations

Following concerns highlighted during incident investigations, TSSA embarked on a three phase Special Buildings Inspection Pilot (SBIP) in 2014.

TSSA has completed the Phase I SBIP inspections of these facilities and will continue with the communications strategy which will ensure all stakeholders are fully informed of TSSA’s activities in order to establish a no-surprises environment, to share details with the Retirement Home Regulatory Authority, Ontario Retirement Communities Association, institutions, contractors and other stakeholders to promote safety awareness and increase regulatory compliance.

Following the communications phase TSSA will conduct post communication inspections to gauge the success in educating facility operators and driving higher compliance rates in this sector.

Managing Risks due to External Factors

These strategies have been described in the above section regarding managing the risk in private dwellings. In particular, the TSSA has partnered with nine different organisations, such as utility providers, fuel distributors and education centres to reach roughly 3 million Ontarians with print media alone. Additionally, the TSSA has created a reference website to house public information on CO safety in the province of Ontario.



Managing Risks due to Potential Gaps in Regulatory System

As a result of several incidents with direct vent fireplaces TSSA continues to work with the industry to enhance the standards used by manufacturers to increase safety requirements to prevent future incidents and address ageing equipment.

TSSA became aware of many instances of aboveground storage tank failures, with many occurring after a short operating life. Since the failure mode was not immediately evident, TSSA, after industry consultation, issued a Code Adoption (FS-202-12 on November 1, 2012), after extensive industry consultation, for all tanks to be double-bottom or incorporate secondary containment. TSSA will continue to monitor the issuance of this order through inspection activities.

Liquefied natural gas for small plants, refuelling and vehicles is an emerging market with insufficient regulatory requirements. For these instances, TSSA has developed local criteria until such time that code requirements are completed.



III.8 Upholstered and Stuffed Articles

The role of the Upholstered and Stuffed Articles Safety Program is to protect the public from potential hazards associated with the use of unclean or unsafe filling materials in upholstered and stuffed articles in Ontario. In addition to promoting safety, TSSA's aim is to protect consumers against fraud, misrepresentation of filling materials in upholstered and stuffed articles, and to provide a level playing field for the industries.

Under *Ontario Regulation 218/01, Upholstered and Stuffed Articles*, only new clean filling materials are allowed in upholstered and stuffed articles, and all articles are required to be labelled that identify the registration number and indicate all filling materials. Such articles include: toys, sporting goods, pet items, furniture, mattresses/box springs, apparel, bedding items, handbags, luggage and seasonal ornaments. The requirements for new and clean filling materials are enforced through inspections at point-of-sale and the manufacturing level.

The following stakeholders fall under TSSA's jurisdiction:

- retailer;
- manufacturer;
- importer/distributor;
- renovator
- home hobby/craft operator; and
- supplier

III.8.1 Risk Assessment

Occurrences are currently not required to be reported to TSSA under *Ontario Regulation 218/01, Upholstered and Stuffed Articles*. While TSSA does not have any reports of actual health impacts, several instances of near-misses have been reported that are currently under investigation. These near-miss occurrences have the potential to cause health impacts to Ontarians and, the findings of the investigations will be included in future versions of this report.

III.8.2 Risk Management – Message from the Statutory Director, USA Program

Over the past five years, TSSA's Upholstered and Stuffed Articles program has conducted almost 6,000 inspections focusing mainly on retailers as indicated in Table USA-1. Orders related to manufacturers not being registered in Ontario continue to represent the majority of orders issued, due to new products being sold in the marketplace and unfamiliarity with the Regulation. Additionally, measures are taken by TSSA inspectors to educate stakeholders as required on complying with the requirements in the Regulation.



Table USA-1: Inspections by inspection type for the period 2010 – 2015.

Inspection Type	Number of Inspections Conducted	Number of Orders Issued	Number of Orders Resolved
Retailer	3,388	46,965	45,520
Importer/Distributor	778	15,618	15,617
Manufacturer	754	1,115	1,108
Renovator	595	352	347
Seasonal	257	5,999	5,749
Home Hobbyist/Craft	87	49	49
Other	84	4,930	4,930
Supplier	39	2	2
Printer	11	2	2
Total	5,993	75,032	73,324

During the course of the past and current year, TSSA received several reports of near-miss occurrences involving supply of unsafe articles by independent retailers, which had the potential to cause adverse health effects to Ontarians.

One such occurrence resulted from a fire at a mattress factory. Based on information received and preliminary results of a subsequent investigation have revealed that smoke damaged filling materials, polyester fibre rolls from this factory were being sold by a supplier who was located adjacent to this factory. All smoke damaged filling material and finished products which were cross-contaminated were ordered destroyed. Continued sale of these products would have caused severe health effects to Ontarians.

During another inspection conducted at a retailer (liquidator) it was found that soiled decorative pillows were being sold as new. These pillows were not labelled in accordance with the requirements in the legislation. On this instance, approximately 80 contaminated/soiled decorator pillows were ordered destroyed and over 254 orders were issued.

Similarly, another inspection at an independent retailer found toys containing used contaminated materials labelled as new. These toys had labels declaring content as “Recycled Polyester”. However, investigations revealed that the toys had an outer cover made from used wool sweaters. These toys were also ordered to be destroyed.

These and other reported occurrences are currently under further investigation, and once completed will reflect in next year's safety report.

In light of an increase in reported occurrences, a Director's Notice (USA-001-14) was issued that required persons engaged in the manufacture, renovation or sale of upholstered and stuffed articles to;

- a) Immediately notify the director in the event involving the sale, distribution or resale of an upholstered or stuffed article that causes injury or death due to the presence of vermin, disease, contaminated or otherwise unclean filling materials contained in any upholstered or stuffed article sold, renovated or manufactured by them.
- b) Notify the director within 48 hours or as soon as is practicable upon becoming aware of any upholstered or stuffed article which;
 - i. Have second hand material used as stuffing in the manufacture or renovation of the article
 - ii. Have material used as stuffing containing vermin or is unclean
 - iii. Has been in contact with a person suffering a communicable disease



- iv. Contain down or feather products that have not be processed in accordance with the requirements of the regulation.
- v. Has been soiled or is in such condition that it is likely to adversely affect a person's health
- vi. Shows signs of corrosion or other degradation

TSSA will continue to conduct inspections at independent retailers. TSSA will develop a risk-informed approach to inspections based on information collected through incident reporting and inspections to prioritize future inspections. These inspections focus on those retailers that have a known history of selling unsafe articles and demonstrate increasing levels of non-compliance.



References

- [1] Technical Standards and Safety Authority. Technical Standards and Safety Act, 2000. Retrieved on July 29, 2014 from http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_00t16_e.htm
- [2] Arun Veeramany and Srikanth Mangalam. "Application of disability-adjusted life years to predict the burden of injuries and fatalities due to public exposure to engineering technologies." *Population Health Metrics* 12 (2014): 1-9.
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- [4] Jørn Vatn. "A discussion of the acceptable risk problem." *Reliability Engineering & System Safety* 61 (1998): 11-19.
- [5] Terje Aven, "Reliability & Risk Analysis." North Holland, 1992.
- [6] Srikanth Mangalam, Lency Abraham Mulamootil, Arun Veeramany, David Witt, and Rene Karavas. "System and method for inspecting and assessing risk of mechanical equipment and facilities." U.S. Patent No. 13/894,812, May 15, 2013.
- [7] Technical Standards and Safety Authority (2013). "Above Ground Storage Tanks: A Risk Assessment Study," Toronto, ON.
- [8] Technical Standards and Safety Authority. FS-202-12. Amendment to the Fuel Oil Code Adoption Document – Double wall tanks, double bottom tanks and spill containment. Retrieved on July 29, 2014 from <http://www.tssa.org/regulated/fuels/fuelsLegislation.aspx?loc3=act>



Appendix A – Risk of Injury or Fatality Metric

Disability-Adjusted Life-Year (DALY)

The Risk of Injury or Fatality metric is determined using the Disability-Adjusted Life-Years (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 useful life were lost for that year 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:

$$\begin{aligned} & (\text{Short-term Weight} * \text{Short-term Duration}) + \\ & (\text{Fraction Long-term}) * (\text{Long-term Weight} * \text{Long-term Duration}) \end{aligned}$$

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 Study¹⁵. 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 34.87 DALY by using the above equation. In this calculation, the short-term weight of 0.725 and duration of 0 years were used respectively and the fraction long-term and long-term duration parameters were taken to be 1 and 0.725 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.

¹⁵Begg S, Vos T, Barker B, Stevenson C, Stanley L and Lopez A: The burden of disease and injury in Australia 2003. Cat. No. PHE 82. Canberra: AIHW 2007.



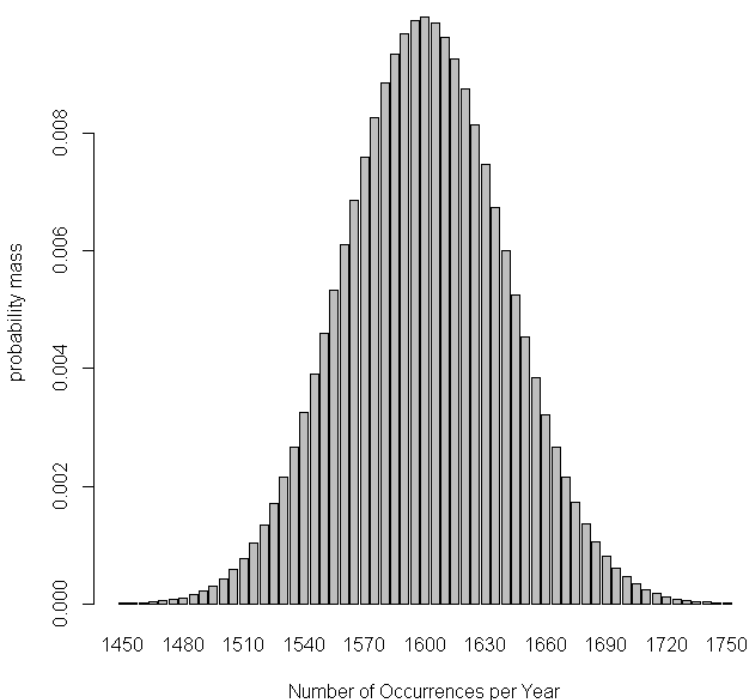
This version of the ASPR includes the observed injury burden expressed using actual DALYs (see below) as well as the risk of injury or fatality. The former is a reflection of the health impact experienced in a given year, while the latter is a prediction of the injury burden expected in the future based on historical data.

Risk of Injury or Fatality

The Risk of Injury or Fatality¹⁶ approach determines predicted injury burden by accounting for historic 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 go unreported to TSSA. The randomness is assumed to follow a Poisson distribution with the observed occurrence rate as the input parameter.

Figure A1: Probability mass distribution of the occurrence rate.



The figure above illustrates the breadth of uncertainty in the occurrence rate when, for example, 1600 occurrences a year are observed on average.

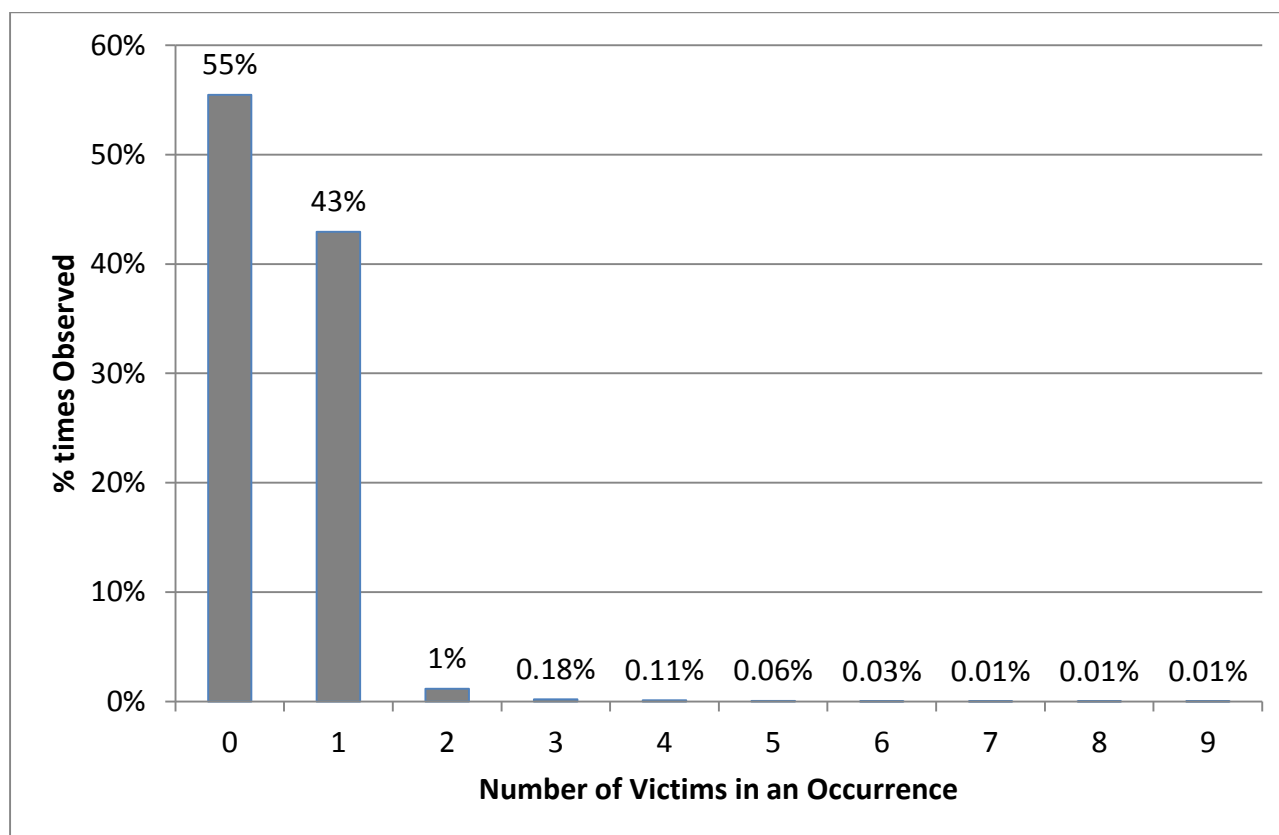
- (b) The number of victims involved in an occurrence is assumed to be a discrete probability distribution based on historic observations. In cases where there is adequate evidence, a categorical distribution is used. An example is the determination of the TSSA composite prediction.

¹⁶ Veeramany, Arun, and Srikanth Mangalam. "Application of disability-adjusted life years to predict the burden of injuries and fatalities due to public exposure to engineering technologies." *Population health metrics* 12.1 (2014): 1-9.



The TSSA Composite Risk of Injury or Fatality assumes that the number of victims per occurrence follows a discrete empirical probability distribution constructed from historical observations instead of the prior (FY12-13) assumption that the number of occurrences is uniformly distributed between zero and the maximum number observed in the past. 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. In the case of granular drill-downs where there is inadequate evidence, the number of occurrences is assumed to be equally likely between zero and the 99.9th percentile of historically observed number of victims. This ensures that unexpected or misreported events occurring as extreme outliers with large impact, are excluded from the analysis.

Figure A2: Frequency of the number of victims in an occurrence.

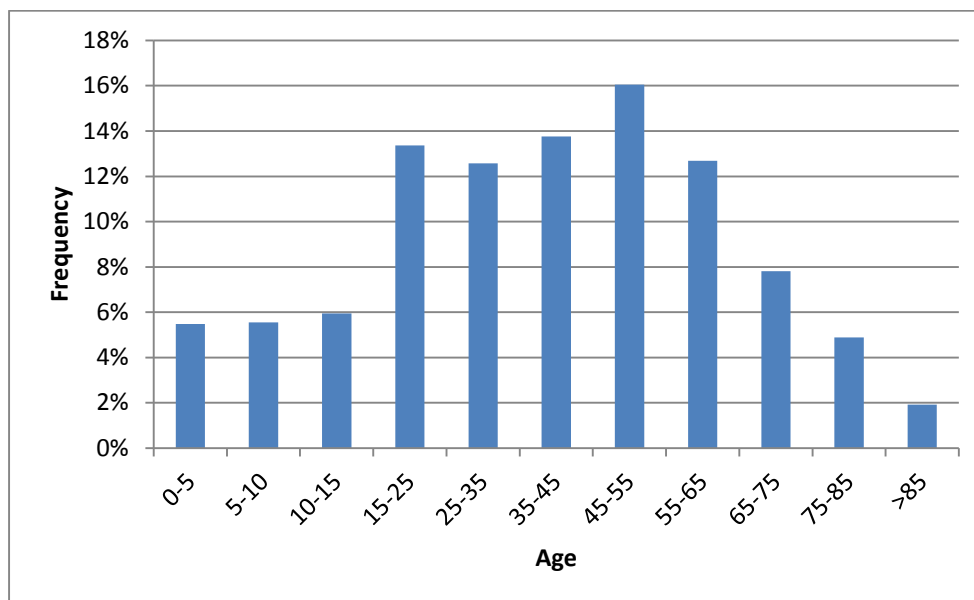


The above figure illustrates the victim count distribution for a typical composite TSSA State of Safety prediction. The example shows that there are no victims involved in 55% of the cases, one victim involved in 43% of the occurrences and as high as nine victims in less than 1% of the occurrences.

- (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 the most recent age-based population census estimates from Statistics Canada.



Figure A3: Age distribution for predicted risk simulation.

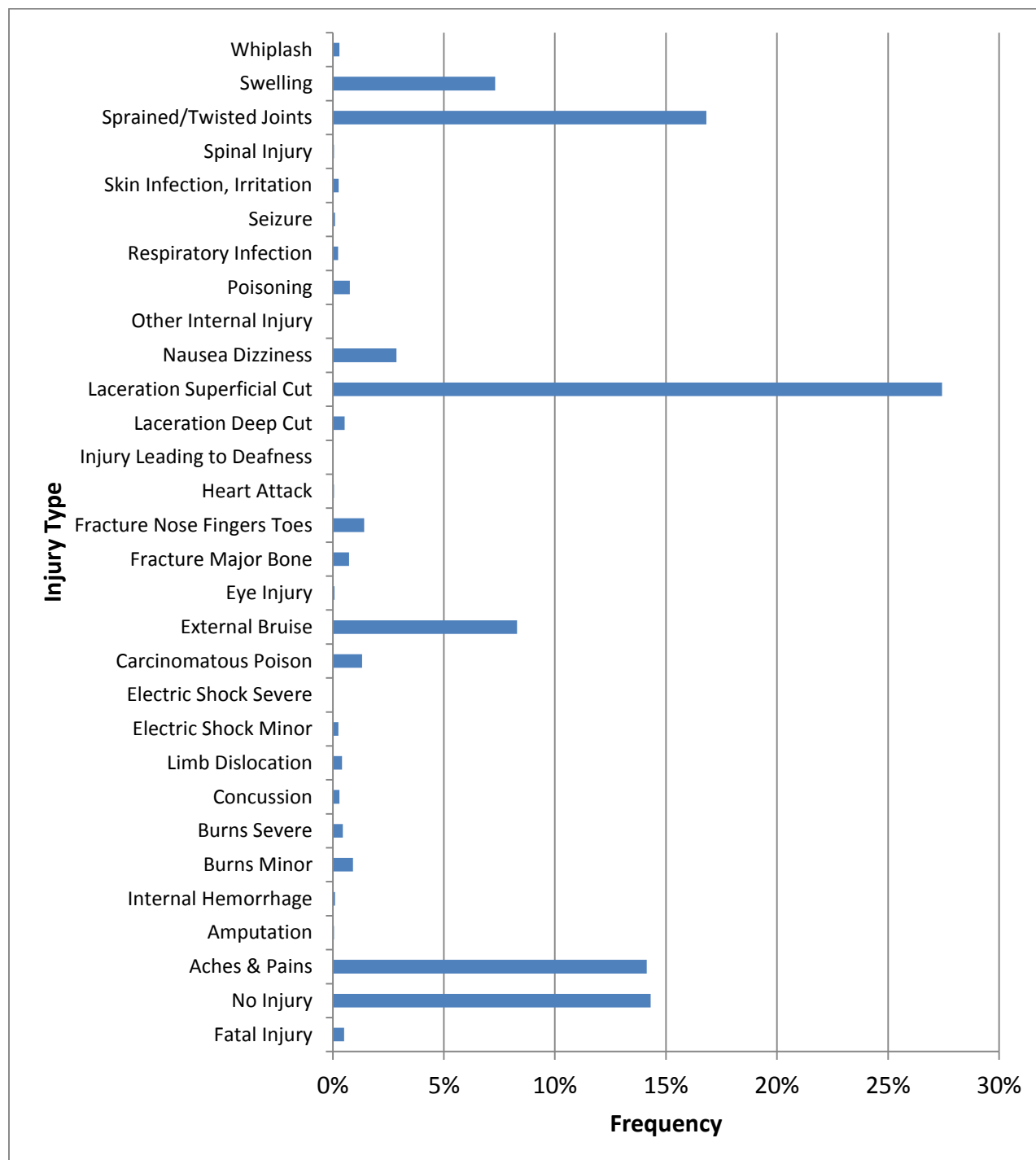


Ontarians aged 15-65 constitute about 70% of the population as seen in the above chart and are more likely to be victims of an occurrence than otherwise.

- (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.

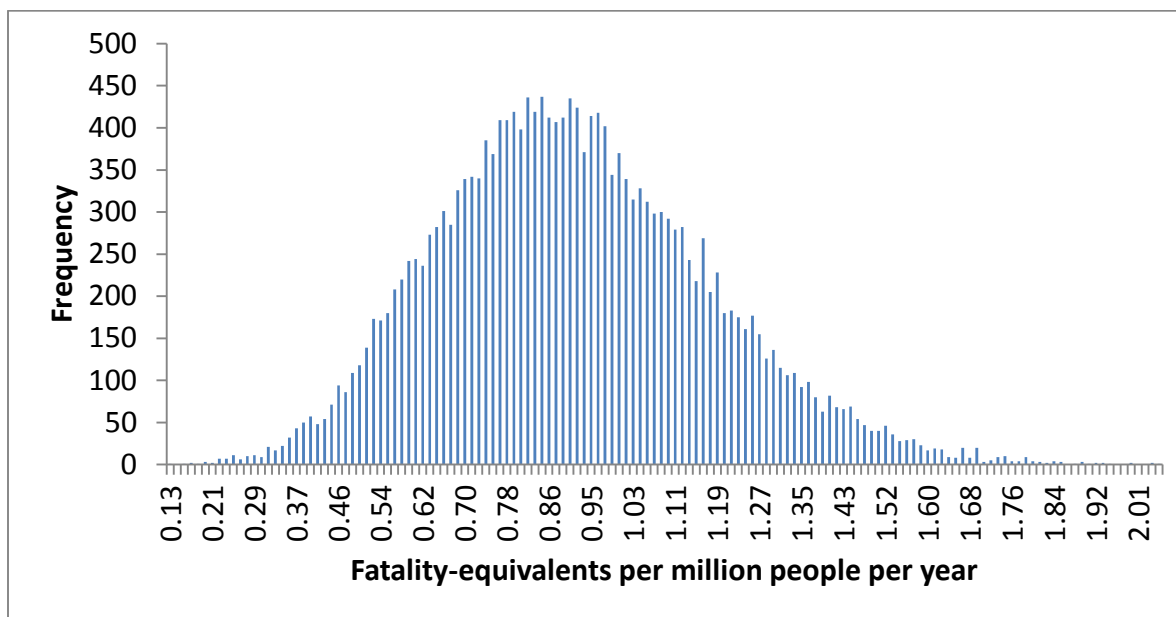


Figure A4: Injury distribution for the composite risk of injury or fatality.



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 the above figure. The distribution is for illustrative purposes only and varies depending on the regulated sector under study.

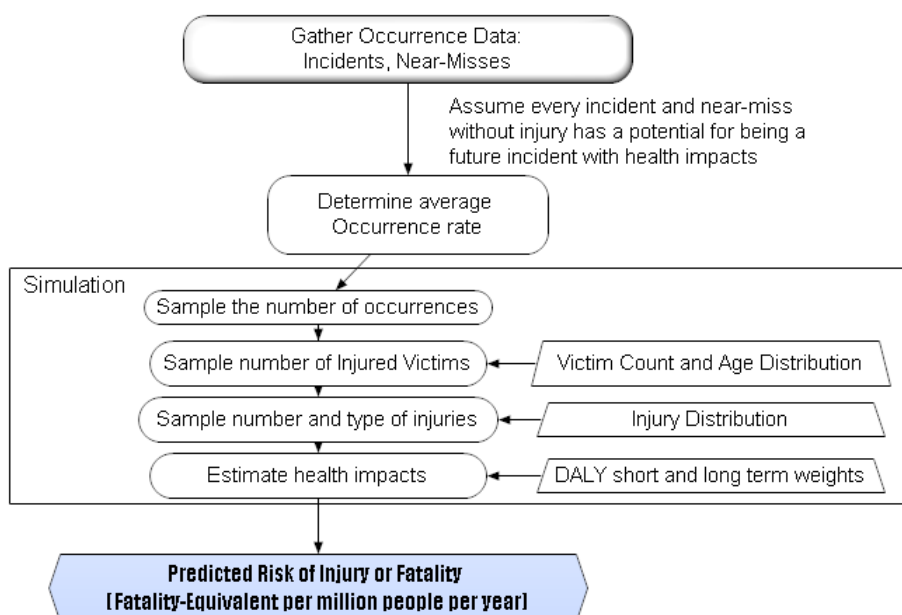
Figure A5: Risk of injury or fatality distribution.



The end result of a risk simulation is a frequency distribution of predicted health impacts as exemplified in the above figure. The mean value, fifth and 95th percentiles of the distribution are used for reporting purposes in the report. In the above figure, the respective estimates are 0.51, 0.91 and 1.37 fatality-equivalents/million/year. Note that the risk of injury or fatality is expected to be somewhat larger than the corresponding observed risk. This is 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.

The procedure followed to determine the anticipated health impacts is shown in the flowchart below.

Figure A6: Flowchart to predict future health impacts.





Appendix B – High Profile Root Cause Analysis

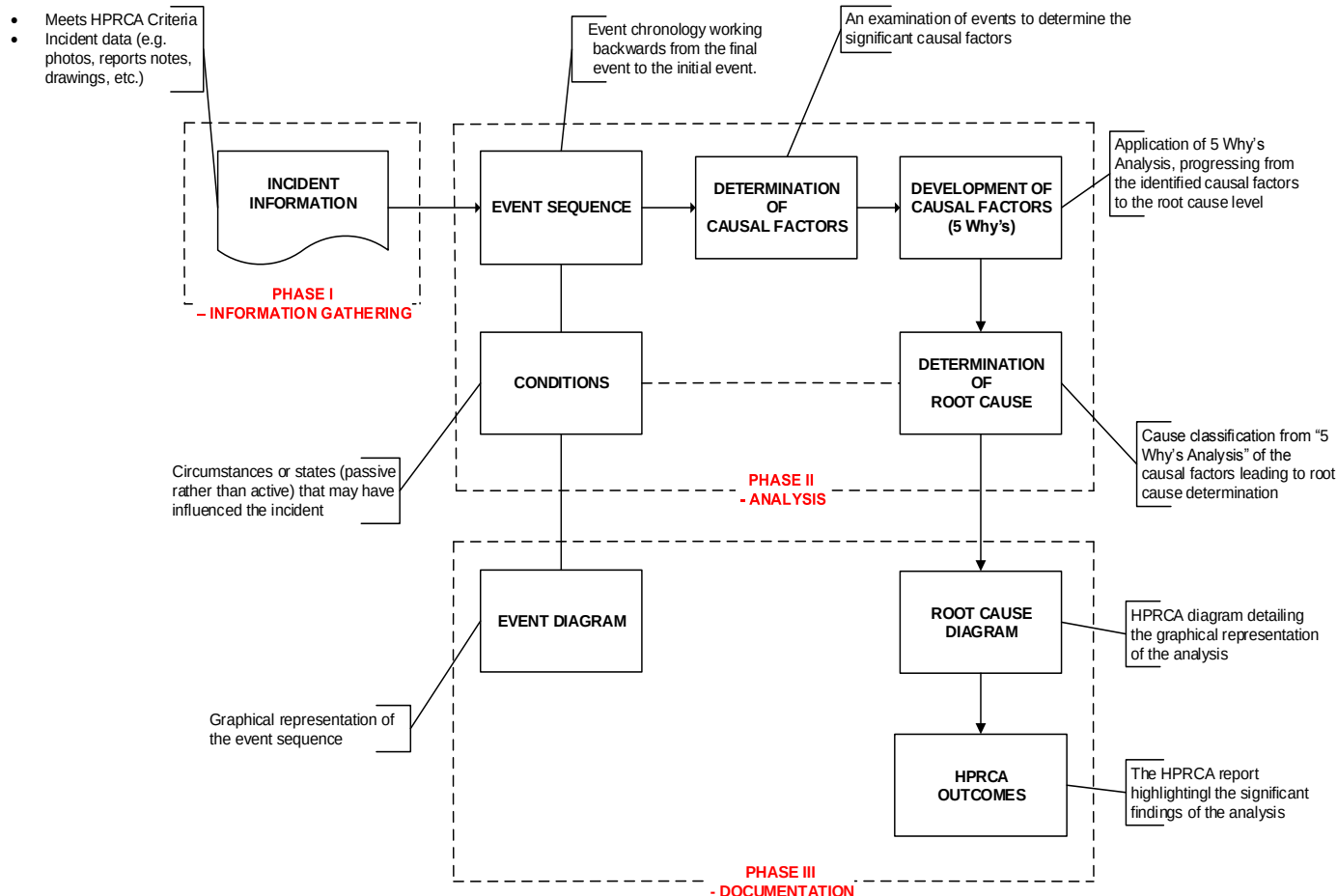
***“A director shall order such investigation as he or she considers necessary
on being notified of an accident or incident,
Technical Standard and Safety Act 2000 (the Act), c. 16, s. 25.”***

Introduction

Technical Standard and Safety Authority (TSSA) administers this requirement in accordance with its risk informed incident management policy and the associated Incident Management System (IMS) that facilitates a decision making process applicable through the life cycle of an occurrence (incident or near-miss). The IMS 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 (IMIS).

A key aspect of the IMS 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. Inspections due to the nature of most occurrences, tend to be completed by inspectors' basic analysis 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, the 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 criteria of the high profile. This formal approach, *High Profile Root Cause Analysis* (HPRCA), 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 1). 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.

Figure B1: High profile root cause analysis flowchart.



The ultimate objective of the HPRCA process is to determine all causal factors and not to identify blame. An additional benefit of the HPRCA 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 a HPRCA, 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 non-compliance and the root cause could not be determined by the inspector alone; and/or
3. Where the inspector and/or those involved in the occurrence inspection believes that there is a 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.)

The HPRCA Process

The HPRCA 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 HPRCA is conducted in three phases:

- (a) Incident information Documentation;
- (b) Root Cause Analysis; and
- (c) Report Preparation.

- (a) Incident Information Documentation— TSSA inspectors are trained to and following 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 2 -4 below:

Figure B2: Relevant conditions (at the time of the occurrence).

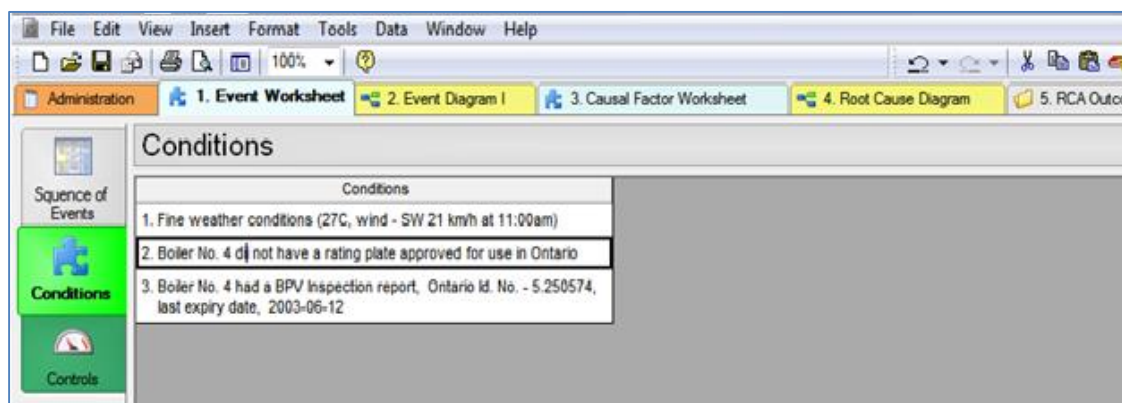


Figure B3: Incident information – data collection.

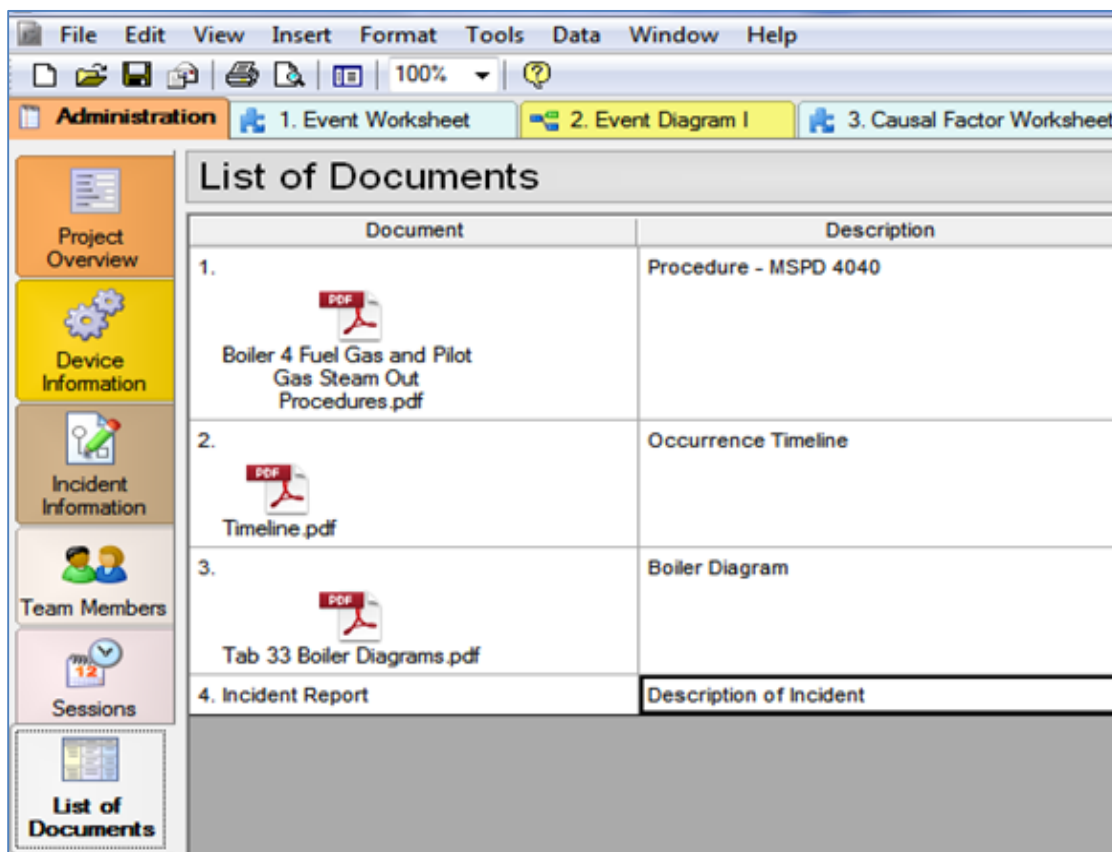
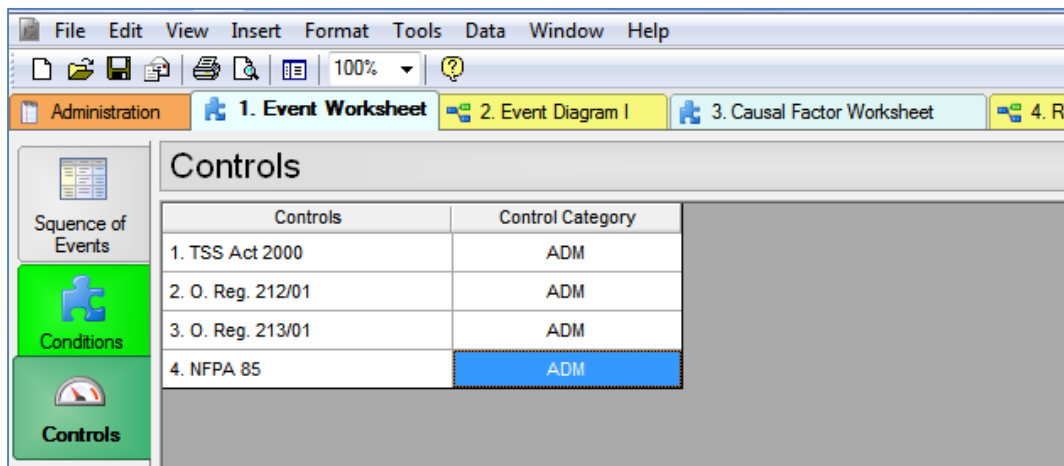


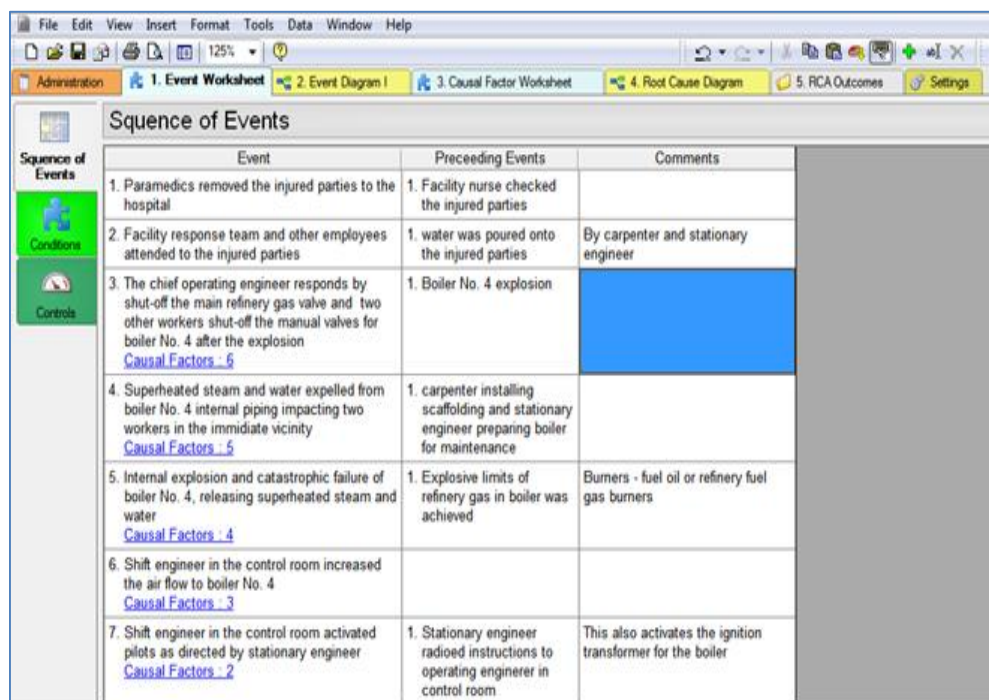
Figure B4: Relevant controls (regulatory or other controls).



Controls	Control Category
1. TSS Act 2000	ADM
2. O. Reg. 212/01	ADM
3. O. Reg. 213/01	ADM
4. NFPA 85	ADM

- (b) 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 (i.e. in a chronological order) of events by working backwards and using a combination of events capable of leading to the final event (see Figures 5 and 6). The analysis of each upstream event identified or in sequence with combinations of events/conditions, (e.g. single or in series/parallel configurations) capable of causing the final event. The determination and evaluation of identified causal factors by application of the “5 Whys Principle?” (see Figure 7 - e.g. asking why or how this could happen?) until associated causes can be determined. This procedure is followed for each causal factor chain identified until the 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 occurrences.

Figure B5: Sequence of events (chronological order).



Event	Preceding Events	Comments
1. Paramedics removed the injured parties to the hospital	1. Facility nurse checked the injured parties	
2. Facility response team and other employees attended to the injured parties	1. water was poured onto the injured parties	By carpenter and stationary engineer
3. The chief operating engineer responds by shut-off the main refinery gas valve and two other workers shut-off the manual valves for boiler No. 4 after the explosion Causal Factors - 6	1. Boiler No. 4 explosion	
4. Superheated steam and water expelled from boiler No. 4 internal piping impacting two workers in the immediate vicinity Causal Factors - 5	1. carpenter installing scaffolding and stationary engineer preparing boiler for maintenance	
5. Internal explosion and catastrophic failure of boiler No. 4, releasing superheated steam and water Causal Factors - 4	1. Explosive limits of refinery gas in boiler was achieved	Burners - fuel oil or refinery fuel gas burners
6. Shift engineer in the control room increased the air flow to boiler No. 4 Causal Factors - 3		
7. Shift engineer in the control room activated pilots as directed by stationary engineer Causal Factors - 2	1. Stationary engineer radioed instructions to operating engineer in control room	This also activates the ignition transformer for the boiler



Figure B6: Sequence of events – event diagram.

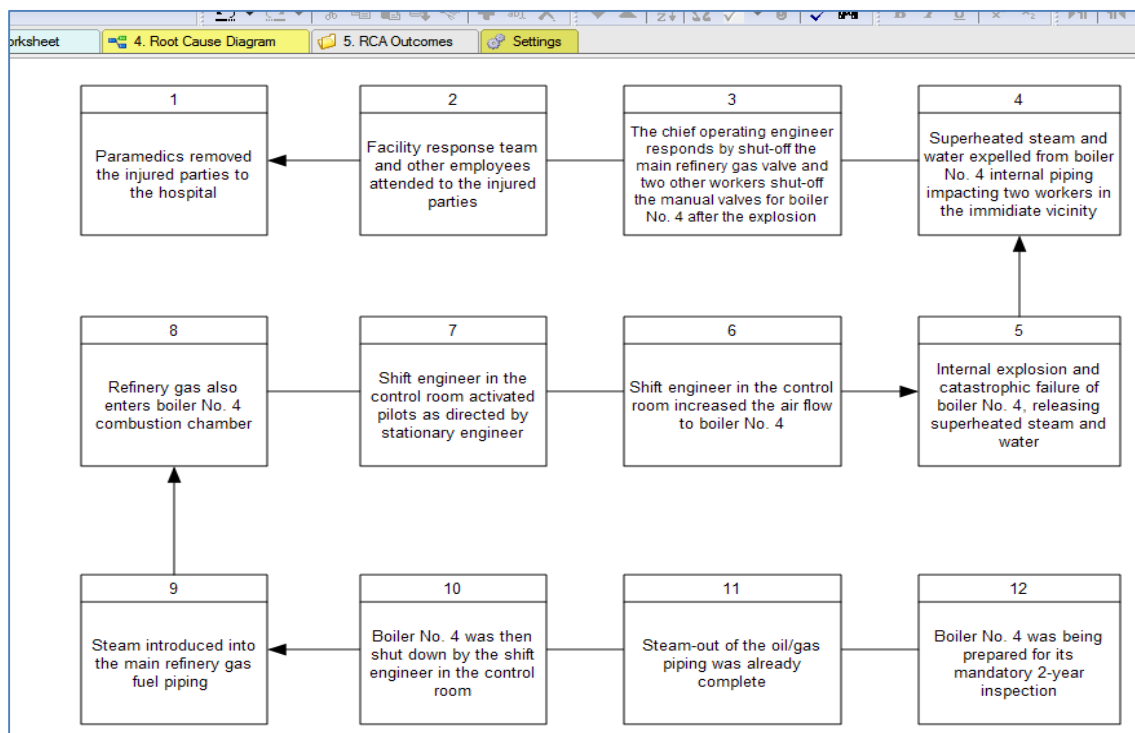


Figure B7: Analysis of causal factors - 5 Why's Approach.

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	Comment
1. Steam introduced into the main refinery gas fuel piping Sequence 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 procedure (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 Outcome 1	ROOT CAUSE	The stationary engineer was trained and qualified (see training records) Other valves had Lock and Tag the keys were left the lock found)
2. Shift engineer in the control room activated pilots as directed by stationary engineer Sequence 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 HPRCA process involves preparing a report that documents the findings, provides conclusions and recommendations. The tool itself is capable of summarizing the entire exercise including, all administrative details and the documentation of evidence, analysis deliberations, graphical representation of all causal findings in the process (see Figures 8, 9 and 10). A summary report is developed when all phases are completed by the HPRCA facilitator and submitted to the program Statutory Director including relevant recommendations and conclusions.

Figure B8: HPRCA diagram.

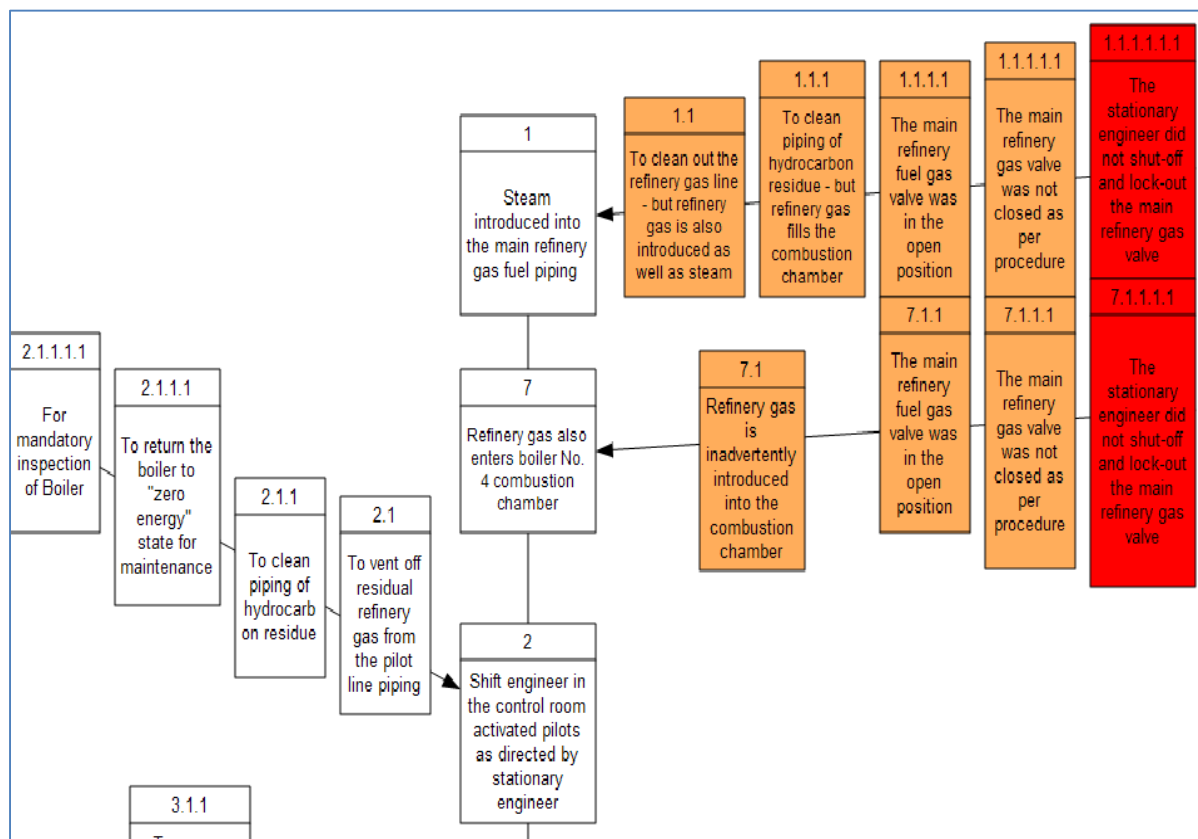
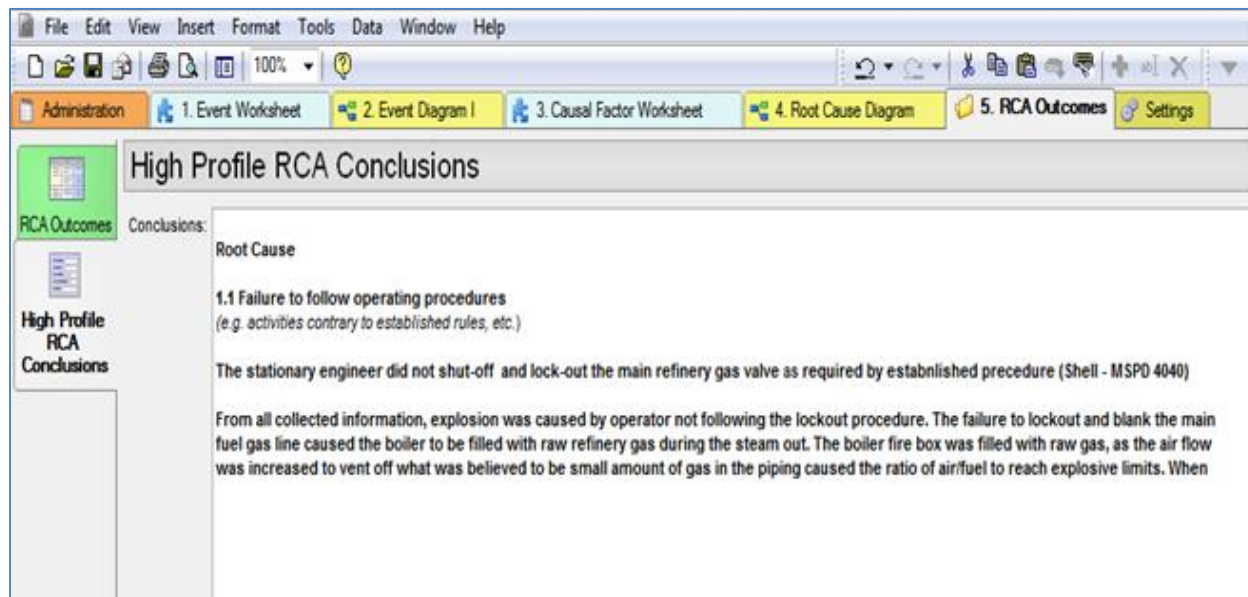




Figure B9: HPRCA outcomes.

RCA Outcomes		
RCA Outcomes	Cause Category	Violations
1. The stationary engineer did not shut-off and lock-out the main refinery gas valve Causal Factors - 5. Why this happened?: 1.1.1.1.1	ROOT CAUSE	1. TSSA Act Section 41. Every person who employs a person to carry out any activity referred to in subsection (1) shall take every precaution that is reasonable in the circumstances to ensure that the person's employees comply with the Act and this Regulation. Note: The stationary engineer did not comply with procedure MSPD 4040: Failure to verify blank is in place of block valve #1. It was confirmed that the main gas valve was not blanked as per procedure and was left in the open position allowing raw refinery fuel gas to enter the combustion chamber the entire duration of the steam out process. 2. ONTARIO REGULATION 212/01. (GASEOUS FUELS) 11 (1). Every person who operates, installs, removes, repairs, alters or services appliances or works shall instruct the person's employees to comply with the Act and this Regulation. Note: The stationary engineer began the shutdown of #4 Boiler without following Procedure MSPD 4040. 3. ONTARIO REGULATION 212/01. (GASEOUS FUELS) 11 (2). Every person who employs a person to carry out any activity referred to in subsection (1) shall take every precaution that is reasonable in the circumstances to ensure that the person's employees comply with the Act and this Regulation. Note: Procedure MSPD 4040 continued with critical lockout and blanking of gas valve # not performed nor verified. 4. ONTARIO REGULATION 212/01. (GASEOUS FUELS) 3 (1). Every person engaged in an activity, use of equipment, process or procedure to which the Act and this Regulation apply shall comply with the Act and this Regulation. Note: The stationary engineer began the shutdown of #4 Boiler without following Procedure MSPD 4040. 5. Ontario Regulation 212/01. (GASEOUS FUELS) 3 (2). For the purposes of subsection (1), the reference to an activity, use of equipment, process or procedure includes, but is not limited to, design, installation, alteration, repair, service, removal, purging, activation, storing, handling, modifying and using. Note: During the entire purging process the boiler filled with raw refinery fuel gas as main gas valve was not blanked as per procedure MSPD 4040 and was left in open position.
2. The pilot ignition transformer was activated igniting the refinery gas/air mixture in the combustion chamber Causal Factors - 1. Why this happened?: 4.1	DIRECT CAUSE	1. 1. Ontario Regulation 212/01. (GASEOUS FUELS) 3 (2). For the purposes of subsection (1), the reference to an activity, use of equipment, process or procedure includes, but is not limited to, design, installation, alteration, repair, service, removal, purging, activation, storing, handling, modifying and using. Note: As procedure MSPD 4040 was not followed. The boiler was filled with raw fuel gas. Stationary engineer contacted the control room manned by operator Ian Snedden and asked for the pilot lines to be opened. Operator Snedden complied by activating the pilots. The pilot solenoid valves as well as the ignition transformers energized. The fuel gas/air mixture was within the explosive limits and the ignition transformers provided the spark that resulted in the explosion.
3. To clean out the refinery gas line - but refinery gas is also introduced as well as steam Causal Factors - 1. Why this happened?: 1.1	CONTRIBUTING CAUSE	1. 1. Ontario Regulation 212/01. (GASEOUS FUELS) 3 (2). For the purposes of subsection (1), the reference to an activity, use of equipment, process or procedure includes, but is not limited to, design, installation, alteration, repair, service, removal, purging, activation, storing, handling, modifying and using. Note: At approx. 1015 hrs. The steam out procedure MSPD 4040 began. Failure to verify main gas valve was closed and blanked resulted in raw fuel gas to enter the combustion chamber the duration of the steam out.

Figure B10. HPRCA conclusions.



The HPRCA Team - Roles and responsibilities

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

- **Facilitator**
The Public Safety Risk Management (PSRM) team at TSSA provides facilitation for the HPRCA 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 HPRCA management. The facilitator develops the summary report with the significant findings of the HPRCA for reporting purposes.
- **Safety Program Experts**
The safety program provides the resources required (i.e. HPRCA team – engineers, inspectors, etc.) for the execution of the HPRCA 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 HPRCA 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.



HPRCA – Examples at TSSA

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

1. Elevator (HPRCA 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 11) was issued on April 15, 2015 to address this issue.

Figure B11. 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:

- it does not extend less than the full width of the widest hoistway door opening;
- 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 (HPRCA Criteria - Where regulatory non-compliance and the root cause could not be determined by the inspector alone)

An elderly man entered the 5th 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 undertakes to perform work. This included non-compliance 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

(HPRCA Criteria - Where the inspector and/or those involved in the occurrence inspection believes that there is a potential for re-occurrence in the future involving similar equipment/circumstances)

Customer at a petrol station refueling a car and 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 was incurred by the customer but the car was burnt out 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 nozzles failures as a component of the fuel dispensing system.



Appendix C – 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.

Inadequate Current 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 C1: Causes contained in the Inadequate Current 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.

Non-compliance 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 C2: Causes contained in the Non-compliance 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 C3: 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 environment conditions. • Utilities disruption or failure. • External incidents. • Sabotage, terrorism, vandalism or theft. • Non-compliance with non-TSSA regulations.
Human Factors	Refers to the use of regulated technology by a user in a manner that the TSSA cannot reasonably know or anticipate and may result in occurrence.	• Special conditions. • Failure to follow user instructions. • Deliberate intent or sabotage.

Appendix D – TSSA’s User Behaviour Strategy

Early in its administration of its delegated responsibilities, TSSA, as an outcome based organization, identified human behaviour as the dominant root cause of incidents in four key sectors – amusement devices, fuels, ski lifts and elevators/escalators. While not mandated to do so, TSSA, essentially since its inception, developed a series of tailored public education/engagement initiatives for these four sectors. Over time, the initiatives and tactics have been modified as new insights and information became available.

In the early stages of public education/engagement initiatives, performance was measured using activity driven metrics. While refinements continued to improve and enhance TSSA’s public education/engagement initiatives, it became evident that achieving additional reduced health impacts would require an informed approach. As a result, TSSA adopted a multi-pronged public education/user behaviour strategy. In 2010, the organization, as part of its strategic planning process, identified that further advances in modifying public/user safety behaviour would be among the key prerequisites for achieving its re-stated corporate vision - *to be a valued advocate and recognized authority in public safety*.

Multi-pronged Strategy

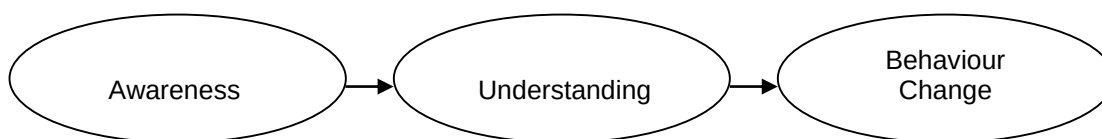
Recognizing the strategic importance of modifying public/user safety behaviour, TSSA uses a multi- dimension public education/user behaviour approach with three key objectives:

- continue to deliver existing public education/engagement initiatives;
- enhance existing initiatives based on sound research (qualitative and quantitative), input from other players in the safety system (e.g., owners/operations, other safety regulators, etc.) and incorporating insights gained through the assessment/evaluation of ongoing programs (i.e., performance measurement); and
- design and implement foundational user behaviour research focused on developing a comprehensive understanding of the ‘how’ and ‘why’ Ontarians make decisions that put them at risk, particularly within the sectors TSSA regulates.

This approach has ensured that TSSA continues to deliver public education programs in tandem with developing a more fundamental understanding of how to more effectively assist the public in managing its safety risk responsibilities. The approach is perhaps best summarized as a parallel strategy incorporating pure and applied research, using the results from both to better define further research plans, as well as ongoing delivery of public engagement and education initiatives.

To illustrate, “pure” research regarding risk perception and risk communication that influences the users across all four sectors provides insights that apply generally, regardless of the specific activities in which the public engages. The “applied” research addresses the need to tailor public engagement initiatives to address unique characteristics; for example, differing key audiences and position on the behaviour change continuum (see Figure 1), associated with each of the four sectors. By developing and conducting each of these research strategies at the same time, the results and insights gained for each serve to inform the other.

Figure D1: The Behaviour Change Continuum.



As a result, TSSA’s behavioural modification strategy has two interrelated components – research and ongoing delivery of public education/engagement initiatives. Naturally, there is a strong inter-relationship among these two as each serves to inform the other.



The basic premise underlying the strategy is what can be described as the behaviour change continuum. Research and field experience has provided strong evidence that changing public safety behaviours is essentially a sequential three step process. One of the key elements in achieving the desired outcome is to first identify where the public rests on this change continuum. This is important as the strategies for engaging key audiences will be very much shaped according to their location on change continuum. Along with this “mapping process” it is important to define, to the extent possible, the risk profile(s) of the target audience. TSSA has, over a number of years, been working in parallel on these two critical success factors and has been applying the knowledge gained to better inform continuing research, as well as to refine and/or redesign its public safety engagement initiatives.

As a result, TSSA developed and applies metrics that indicate if key audiences are moving along the behaviour change continuum – this provides confidence that the ultimate metric – improved health outcomes – can be achieved. For example, through increasing awareness and enhancing understanding, the probability that people will alter their behaviour is much higher.

Reflecting the progress achieved, TSSA’s overall approach to user behaviour and its role in mitigating safety risks focuses on three interrelated steps that reflect fundamental elements of behavioural change. The three steps are:

1. **Research and Development** – this step involves gaining key insights regarding current risk perception, communication and decision making particularly among high risk audiences. This understanding is essential to developing and testing effective engagement strategies (e.g. messaging, delivery tactics and assessment tools). Based on the enhanced awareness and understanding of the target groups strategies can then be developed and pilot tested in the field, which in turn provides critical feedback to inform refined public engagement strategies.
2. **Execution** – as the pilot strategies mature and results become more consistent, larger scale execution of the initiatives are conducted. The larger scale implementation allows for further refinements that increase efficiencies and the effectiveness of the strategies.
3. **Leveraging/Partnerships** – TSSA strategic approach to user behaviour continues to be based on the premise that achieving enhanced safety outcome is a shared responsibility. As strategies mature through the step process, the focus becomes more concentrated on leveraging TSSA success through the participation/ partnership of key stakeholders.

At present, TSSA public awareness and user behaviour initiatives span all three of the three steps outlined above. Several of the carbon monoxide initiatives are at a stage where there is an increasing focus on leveraging/partnership while elevators/escalators efforts focus more on research and development. Ski lift and amusement devices public education initiatives are mostly at the execution and partnership steps. It is important to note that while the degree of ongoing research and testing declines as progress is achieved in applying the results, there continues to be a limited investment across the more mature sectors reflecting the changing environment surrounding public perceptions of and decisions regarding risks associated with TSSA’s regulated sectors. In fact, all four sectors where user behaviour is the dominant root cause have individual initiatives at all three steps in the process.

Fuel Safety

TSSA regulates the transportation, storage, handling and use of fuels as to ensure conformance with the *TSS Act, 2000* and its applicable regulations, codes and standards. These fuels include natural gas, propane, butane, hydrogen, digester gas, landfill gas, fuel oil, gasoline and diesel. TSSA licenses fuel facilities, registers contractors and certifies tradespersons who install and service equipment. Additionally, TSSA reviews and approves facility plans for sites licensed by TSSA, and performs custom equipment approvals and inspection services to ensure fuel is handled and used safely. The three stages of the fuels life cycle that fall under TSSA’s jurisdiction are:

- transmission, distribution and transportation;
- storage and dispensing; and
- utilization (burning)

The utilization of fuels continues to account for the vast majority of fuel related incidents. It is important to note that this aspect of fuels life cycle is also the one where users or the public are most involved as they use fuels for



a wide variety of activities including for example: residential heating, food preparation, water heaters and recreational activities. Further analysis of the data indicates that carbon monoxide (CO) incidents make up the largest proportion of these utilization incidents and identifies non-compliance with regulations as the most prevalent root cause. Specifically, owners of fuel-burning appliances, including the public, are failing to ensure that certified technicians complete proper maintenance of the appliance in accordance with manufacturer's specifications. This responsibility is clearly stated in the applicable provincial fuel regulations. However, TSSA has no legal authority to enter and inspect private dwellings as Section 17 of the *TSS Act, 2000* specifically prohibits TSSA from entering without warrant or consent. As a result, TSSA must rely on alternate initiatives, such as public education to address this safety risk. In Ontario, the vast majority (over 65% over the past eight years) of all CO incidents occur in private dwellings.

Consistent with its proactive preventative strategy philosophy, TSSA's approach focuses first and foremost on changing the public's behaviour with respect to how they use and maintain fuel-burning appliances with a particular emphasis on those in private residential dwellings. Adopting the appropriate behaviours would address the hazard by preventing it at the source. Based on comprehensive research and field experience, TSSA has a number of CO engagement strategies that have demonstrated success in terms of increased public awareness, understanding regarding the risks this hazard presents as well as action they can take to mitigate those risks.

Carbon Monoxide Public Engagement Initiatives and Results: 2015

- Seasonal Safety Handbooks – Three direct mail campaigns were completed – AutumnWatch, WinterWise and for the first time SpringSafe. The handbooks contain a variety of safety topics however fuels safety messaging is the most dominant, as it occupies approximately 65% of the copy. Assessments of the campaigns found that on average over 20% of individuals recalled receiving the booklets (note - recall rates of approximately 2-2.5% are the generally accepted marketing industry standard for successful direct mail initiatives) representing over a 7% increase from the 2013/2014 results. Similar to previous results, over 50% felt more or much more informed after reading the materials, and on average more than 20% were now more likely to take additional actions to address the CO hazard in their home (approximately 65% purchasing and installing CO alarm(s) and over 20% obtaining an inspection by certified fuels technicians). The enhanced performance reflects the refinement of messaging and refreshing of the design of the materials. In total, these initiatives reached 1.3 million households across Ontario.
- Community Blitz Campaigns – Five community blitz campaigns were completed. Refinement of messaging based on additional research conducted during the fiscal year, resulted in higher average recall rates in 2015 (34%) compared to 2014 (30%). In total, the campaigns reached 600,000 households across Ontario.
- Office of the Ontario Fire Marshal (OFM) – TSSA continued to work in partnership with the OFM. Two major new initiatives were completed.
 - TSSA worked with the OFM in the design and implementation of public education workshops across all five of the OFM's regions. TSSA's user behaviour research and its application for designing and successfully conducting public education strategies was the featured case study in sessions conducted by TSSA. Workshops were held in Chatham, Kingston, Toronto, Sudbury and Thunder Bay. Over 120 fire prevention and public education officers from 79 fire and emergency services departments participated in the workshops. Over 90 percent rated the workshops as well as the CO sessions as very good or excellent.
 - TSSA worked closely with the OFM to create a series of CO public education materials for use by fire services across Ontario. OFM adopted TSSA's developed, tested and executed CO public education campaign materials, refining some to reflect OFM's role and responsibilities. OFM co-branded the materials that feature TSSA's COSafety.ca as the reference website for public information on CO.
- Industry partnerships:
 - Kitchener Utilities - TSSA completed two new activities with Kitchener Utilities (KU). The first was a newly designed CO information piece that was delivered to over 95,000 KU customers in their monthly bills. All development and implementation costs were assumed by KU. TSSA's CO messaging was used throughout and most notably, the first call to action cited was the importance of homeowners' obtaining an annual inspection of all fuel-burning appliances. COSafety.ca was promoted as the reference website for public information on CO. The second activity was a short targeted CO video that was co-produced and posted on both KU's and TSSA's websites as well as shared through various social media platforms.



- Enbridge Gas Distribution Inc. – Enbridge featured TSSA's CO safety messaging in an article in their April customer newsletter. The article reinforced the need for annual inspections and CO alarms, specifically the new regulatory requirement that came into full effective for individual residences April 15, 2015. The newsletter is distributed to over 2 million Enbridge customers. Once again, TSSA's COSafety.ca was promoted as the reference website for public information on CO safety.
- EnerCare (formerly Direct Energy) – TSSA's CO Safety Kit was a featured item in Direct Energy's media kit which was distributed to over 50 prominent media outlets immediately prior to the first CO Safety Awareness week (established by the new CO legislation enacted in October, 2014).
- Other partnerships:
 - Kingston Fire and Rescue (KFR) – joint CO and fire safety campaign in the City of Kingston. Kingston was included as one of the communities in TSSA's autumn 2014 CO community blitz campaign. Working with the Fire Chief, a door-to-door campaign was developed and conducted by KFR in two communities within Kingston. Fire crew delivered safety messaging and left an information card that was consistent with TSSA's campaign materials and CO messaging. Using TSSA's standard performance assessment methodology (quantitative post campaign survey), it was determined that the co-campaigns improved the recall of both initiatives. The information card was designed to allow any fire department to use it and co-brand (i.e. insert department logo and contact information).
 - Ontario Fire Marshal's Public Fire Safety Council – continued as a member of the Council's Board of Directors and a Council member. TSSA provides 350,000 seasonal safety handbooks (250,000 AutumnWatch and 100,000 SummerSmart) that the Council includes in public education kits used by fire departments across the province. As one of the lead partners in the Council's Swing into Summer Safety campaign CO messaging is now included in the Blue Jay player cards. Over 120,000 decks of cards, produced in partnership with the Toronto Blue Jays, are distributed by fire departments as part of their public education campaign running from June through September.
 - Liquor Control Board of Ontario (LCBO) – expanded the partnership from two seasonal pamphlets, distributed in over 640 store outlets, to four (spring and winter editions added in 2015). Similar to the seasonal safety handbooks, the pamphlets are not exclusively fuels and or CO related however, a significant proportion of the copy does concentrate on relevant fuel safety topics.
 - Chirp (Owl Kids) and ChickaDEE - These two print magazines are specifically targeted to younger audiences that include several of TSSA's high risk groups. The publications have a long and successful history of providing educational and entertaining articles, activities and other engaging materials. In 2015, TSSA placed its CO safety activity sheet in both magazines. The creative approach for TSSA's materials is very much aligned with the publications' tone and look. These placements reached almost 1.2 million readers.

2015-2016 Planned Initiatives

TSSA will continue to execute a number of CO initiatives in 2015/2016 building on and incorporating insights gained from its research and field experience. TSSA will continue to execute its Seasonal Safety Handbook, CO community blitz campaigns and assertive partnership strategy in fiscal year 2015/2016. Additional efforts will be directed to assisting other stakeholders to mature their performance metrics in alignment with those developed by and being used by TSSA. This will assist in assessing and improving partnership/joint initiatives.

Ski Lifts

TSSA Passenger Ropeways (Ski Lifts) Safety Program regulates chair lifts, bar lifts, outdoor recreational conveyors, rope tows and tube tows to ensure all devices conform to the *Technical Standards and Safety Act, 2000* and applicable regulations codes and standards. TSSA reviews designs and registers lift designs, licenses lift devices, conducts inspections, performs incident investigations and delivers public awareness campaigns to address user behaviour, as it constitutes the dominant root cause of all incidents on ski lifts in Ontario.

As indicated, the vast majority of ski incidents continue to be related to user behaviour and further analysis has identified that new or beginner skier and snow boarders are the most at risk group. As reported in the 2015 Annual State of Public Safety Report, 97% of the risks on ski lifts is related to user behaviour, especially during loading and unloading operations. As such, ski lift user engagement and education is a key risk mitigation



strategy. TSSA has completed research focused on the higher risk users and tested engagement strategies to refine its on-site public awareness/education initiatives.

Ski Lift Public Engagement Initiatives: 2014/2015

- On-site Public Education – the most successful time and/or place to engage and influence behavioural decisions is immediately before such decisions or actions are taken. Therefore, TSSA has concentrated its engagement strategies on-site to deliver safety messaging as skiers and snow boarders are using the lift devices. RideSmart Safety teams engage riders particularly at lifts that are used by new and beginner skiers/snow boarders. The focus of the messaging is *Look, Load and Lower* – specifically look back for the lift, load promptly and safely and then lower the safety bar. Incident reports clearly demonstrate that not properly executing these three actions are the dominant cause of incidents during loading. Similarly, at the top of the lift the messaging focuses on the most common errors namely *Lift, Stand and Leave*. Users are reminded to lift the safety bar when instructed (usually by prominent signage), stand and prepare to leave the lift and then quickly move out of the landing area. By condensing the messaging into two groups of three clear actions the RideSmart Teams can deliver those messages in an effective and efficient manner. By using observational assessment methods and with feedback from site operators this approach has consistently achieved increases in proper lift behaviour. During the most recent 2015 ski lift initiative safety messages were delivered to over 51,000 new and beginner skiers/snow boarders at 13 different snow resorts – an increased total number of interactions with the target audience by 29% (2015 vs 2014) with no budget increase by leveraging year over year learning and enhanced resort operator/staff relationships. TSSA and its external service provider ensured that a customized schedule was developed in collaboration with resort contacts. Observational data at the bottom of the hill continues to demonstrate an approximate 5-7% improvement in safety behaviour amongst those that interact with the RideSmart team. Campaign dashboard results:
 - Events: 75
 - Interactions completed: 51,208
 - Observations completed: 1,856
 - Resorts participating: 13
- Partnerships:
 - CSIA – maintained partnership to assist in facilitating on-site public education program through resort ski and snowboard schools. Instructors are certified by CSIA and are encouraged by them to work with TSSA to deliver enhanced ski lift safety messaging during lessons. TSSA in cooperation with CSIA awards one instructor who has demonstrated an enhanced commitment to and delivery of ski lift safety messaging throughout the ski season.
 - Association of Day Care Operators (ADCO) – expanded the existing partnership with ADCO (originally focused on escalator safety) to include ski lifts. The ski lift specific activity and information sheet was created based on the well-received escalator sheet. As with the other activity sheets, it was endorsed by ADCO who provide access to all their members. Over 30,000 activity sheets provided to members to use with children in their day care facilities. Leveraging the ADCO endorsement, TSSA has expanded the day care program to include an additional 3,000 registered day care operators. The endorsement of ADCO provides critically important credibility for TSSA's safety initiatives. ADCO and other operators are extremely sensitive to who and what materials are used in their facilities. The ADCO partnership helps to ensure that an additional 225,000 activity sheets were positively received by non-member day care operators.
 - Schools Program – Based on success of the ADCO initiatives, TSSA now provides over 5,000 public and Catholic elementary schools with a package of its CO activity sheets for use with Kindergarten and grade one students. Additional copies were provided. In addition, TSSA distributes a package of the activity sheet to Montessori schools across the province.
 - Chirp (Owl Kids) and ChickaDEE - These two print magazines are specifically targeted to younger audiences that include several of TSSA's high risk groups. The publications have a long and successful history of providing educational and entertaining articles, activities and other engaging materials. In 2015, TSSA placed its ski lift safety activity sheet in both magazines. The creative approach for TSSA's materials is very much aligned with the publications' tone and look. These placements reached almost 1.2 million readers.



2015-2016 Planned Initiatives

TSSA will continue its work with snow resort owners/operators to further enhance the efficiency of its on-site engagement initiatives. Based on feedback from operators and incident data additional attention to unloading issues offers opportunities to further enhance user behaviour. To assist, TSSA, during the 2015 season, increased its observational data collection by 23% at the top and bottom of the lifts (74% and 26% respectively) and is working with industry to explore options for tailoring engagement strategies. TSSA is also continuing with its strong and effective relationship with CSIA and will explore other options to leverage the *Look/Load/Lower Lift/Stand/Leave* messaging through their members and associated on-site ski schools.

Elevators/Escalators

TSSA's Elevating Devices (ED) Safety Program regulates elevating devices in Ontario as to ensure all devices conform to the *Technical Standards and Safety Act, 2000* and applicable regulations, codes and standards. TSSA reviews and registers elevating devices, issues licences, conducts inspections, performs incident investigations and delivers public awareness programs as user behaviour continues to be the dominant root cause of incidents related to these devices.

As indicated, the vast majority of elevating device incidents continue to be related to user behaviour and further analysis has identified that older and younger users are at a higher risk of being involved in such incidents. As reported in the 2015 Annual State of Public Safety Report, more than 80% of the risks on elevators and over 95% risks on escalators are related to user behaviour. Further, recent trends have shown that the risk is increasing for elevators and again mostly related to user behaviour. User engagement and education are the key risk mitigation strategies to address these results. TSSA enhanced its research and engagement initiatives in 2015 with a particular focus on elevators.

Elevator/Escalator Public Engagement Initiatives and Results: 2015

Digital Campaign – As noted through TSSA's various research initiatives, including those related to CO, dedicated websites is one of the preferred methods for learning more about a particular safety related topic/issue. As such, in 2014, TSSA created a dedicated elevator safety micro website, elevatorsafetyontario.ca, that:

- focuses on three main locations (residential, commercial and institutional buildings) where user behaviour is the dominant root cause of elevator incidents
- reinforces proper behaviours
- is mobile compatible

Shortly after the launch of the website, a digital campaign utilizing four diverse tactics was executed with the overall objective of driving website traffic to the site. These tactics included a:

- Facebook Ad Campaign
- Facebook Remarketing Campaign
- Display & Mobile Campaign
- Google Remarketing Campaign

Overall, most platforms performed above industry standards and achieved the objective of driving traffic and visitors from priority markets to the site to learn about elevator safety. Overall website statistics suggests that the campaign was crucial in creating awareness for this new site.

Commercial Properties – TSSA continues to maintain partnerships with three large commercial property management firms – Oxford, Brookfield and Cadillac-Fairview. The focus on the partnerships is to provide safety messaging in their commercial properties (i.e. office towers, retail malls etc). Such signage reaches millions of elevator and escalator riders throughout the year on a cyclical basis. As the messages are delivered adjacent to the devices the probability of influencing safety behaviour immediately when riders are using elevators/escalators is enhanced.



- Toronto Transit Commission (TTC) – TSSA has had a long-term partnership with the TTC – *Move with the Grooves* campaign – focused on escalator safety behaviours. The program materials (in-station and in-car posters) continue to be used by the TTC in a cyclical fashion.
- Association of Day Care Operators of Ontario (ADCO) – Recognizing that younger riders (escalators and elevators) are among the higher risk groups, TSSA has maintained a multi-year partnership with ADCO to reach out to this key audience. ADCO has over 450 members across Ontario and has endorsed TSSA's escalator and newly created elevator activity sheets for use in their member's locations. Over 30,000 of each of the escalator and elevator activity sheets have been distributed to ADCO members on an annual basis for the past four years. Very positive feedback has been received from the Association as well as individual members. Their continued desire to extend the partnership demonstrates a strong commitment to working with TSSA to deliver fun and important age-appropriate safety messages to day care attendees. Leveraging the ADCO endorsement, TSSA has expanded the day care program to include an additional 3,000 registered day care operators. The endorsement of ADCO provides critically important credibility for TSSA's safety initiatives. ADCO and other operators are extremely sensitive to who and what materials are used in their facilities. The ADCO partnership helps to ensure that an additional 225,000 activity sheets were positively received by non-member day care operators.
- School Program – In addition to leveraging the ADCO endorsement with non-ADCO members, TSSA has incorporated this successful relationship with Ontario elementary schools. Activity packages were sent to over 5,000 school principals across Ontario encouraging their use in the JK-grade 1 classes. The combination of TSSA's not-for-profit status and equally important the longer-term partnership with ADCO greatly assisted in addressing the concerns teachers and principals have regarding external classroom materials. TSSA received several requests for additional copies including from schools that planned to distribute to all students. Additional copies were provided. In addition, TSSA distributes a package of the activity sheet to Montessori schools across the province. This clearly indicates that the approach offers many additional opportunities for all of TSSA public education programs.
- Older Adults' Program – As older adults constitute another high risk group, TSSA has been exploring avenues to reach this audience with key safety messages. An advertisement promoting escalator/escalator rider safety tips was published in the Senior's Health Section of *Fifty-Five Plus* (Jan-Feb 2015 edition) – reaching over 387,500 seniors in print and an additional 15,000 unique on-line visitors
- Chirp (Owl Kids) and ChickaDEE - These two print magazines are specifically targeted to younger audiences that include several of TSSA's high risk groups. The publications have a long and successful history of providing educational and entertaining articles, activities and other engaging materials. In 2014/2015, TSSA placed both its existing escalator safety activity sheet and the new elevator activity sheet – co-branded in association with ADCO - in both magazines. The creative approach for TSSA's materials is very much aligned with the publications' tone and look. These placements reached almost 1.2 million readers.
- User Behaviour Research – In 2014 TSSA completed qualitative research that enhanced its understanding and knowledge of risk perceptions and actions of high-risk elevator users. Initial insights reveal that users:
 - perceive very little risk associated with elevating devices
 - do not believe that their actions can further reduce the risks associated with elevating devices
 - are aware, for the most part, of proper safety behaviours when using elevating devices
 - identify three factors leading to improper user behaviour:
 - i. distraction
 - ii. complacency
 - iii. inconvenience

2015/2016 Planned Initiatives

TSSA will continue to execute its elevating device initiatives, and to the extent possible considering resources available, will seek opportunities to expand where appropriate these programs. Considering that elevator occurrences continue to be largely driven by user behaviour at residential, commercial and institutional buildings TSSA will be designing, implementing and evaluating four elevator public engagement campaigns (two residential, one commercial and one institutional).

Based on learnings from the 2014-2015 initiatives, TSSA will conduct a refined digital campaign focused on driving target audiences to elevatorsafetyontario.ca. This approach recognizes that a multi-dimensional strategy



using a variety of platforms offers additional means to reduce public safety risks associated with elevating device user behaviour.

TSSA will explore opportunities to further enhance its public engagement initiatives, for example:

- working with building management partners to enhance on site delivery of elevator/escalator safety messages and exploring options to add additional management firms
- identifying opportunities for additional public education partnerships associated with the high risk locations
- maintaining its school/daycare engagement activities delivering key elevator and escalator safety messages to potential high-risk users
- continuing its seniors outreach initiative, and like all other programs will be refined as insights are gained through qualitative and quantitative research.

In addition to enhancing its public engagement initiatives, TSSA will also explore opportunities through research to further enhance its public engagement initiatives. The research and related findings will be essential for designing the four elevator public education engagement strategies scheduled to be completed in 2015/2016.

Amusement Devices

TSSA's Amusement Device Safety (AD) program regulates amusement rides in Ontario as to ensure all amusement devices conform to the *Technical Standards and Safety Act, 2000* and applicable regulations, codes and standards. TSSA reviews and registers rides, issues permits for each ride in the current operating season, licenses operators, conducts inspections and incident investigations, and delivers public awareness campaigns throughout the province.

Amusement devices under TSSA's jurisdiction include roller coasters, Ferris wheels, merry-go-rounds (and other circular motion rides) water slides, flume rides, dry slides, go-karts, bumper carts, inflatables (inflatable bouncers), bungee devices, bungee assisted bounces, zip lines (track and cable rides) and other generic spinning and whirling rides.

Approximately 95% of the estimated risk on amusement devices is related to user behaviour. Water slides account for approximately 30% of all amusement device occurrences and 60% of all health impacts. To assist in mitigating these risks, TSSA continues its multi-year public engagement strategies focusing on water slides users and specifically the most at risk users – 10-14 year old riders. Based on enhanced positive results over the past two years, TSSA continues to refine and deliver its positive behaviour reward campaigns at a number of major water parks across Ontario. Based on on-site observational data, this approach achieves positive behavioural change with 10-20% improvements. Building on the success of TSSA's on-site public education strategies, a new initiative, the Safety Ambassador program, was piloted with two water parks. This initiative involves incorporating TSSA engagement strategy into training for water park staff. The goal is to equip park staff with additional engagement techniques that will assist them in delivering positive safety messaging to slide users at their locations.

Water Park Public Engagement Initiatives and Results: 2015

Three initiatives were conducted between June-September 2014.

1. Onsite Public Education Campaign – TSSA continued to deliver its successful on-site water park public safety campaign. Seven operators partnered with TSSA to deliver key safety messaging to the high risk users – 10-14 year olds. Two new locations (Canada's Wonderland and Great Wolf Lodge) joined the program this year increasing the number of major facilities from five to seven. Over 100,000 high-risk users were engaged through TSSA's proven on-site program. Observation data confirmed that TSSA's approach is influencing rider and is decreasing the rate of improper user behaviour – over 20% of those engaged discontinue behaviours that lead to incidents at water parks.
2. Safety Ambassador Program – building on the success of the Safety Ambassador pilot in 2013, TSSA secured the participation of four water park operators in 2014 summer season – doubling the amount of water parks (from two) that participated in the initial pilot in 2013. The program is based on training park staff to



incorporate TSSA's positive reinforcement strategy to promote enhanced safety behaviours. Over 550 park staff were trained and incorporated TSSA's approach into their daily activities at their facilities. Feedback from staff and park management has been very positive as they see a direct correlation between improved behaviour and TSSA's engagement strategy.

3. Summer Camp Program – While the on-site and Safety Ambassador programs are producing positive results, TSSA continues to pursue innovative approaches to further improve user behaviour. A summer day camp pilot was designed and implemented to engage the high-risk group with a variety of safety messages with a particular emphasis on water slides. Four interactive activities were developed to engage children attending summer day camps. In addition to water parks, elevator/escalators and carbon monoxide learning activities were developed and tested. The pilot was well received in four different camp locations and feedback from “day campers”, staff and management has been very positive. This approach offers opportunities to seek partners to expand the program.

Additionally, TSSA placed its Amusement Device – Waterslide Safety – children's activity sheet in Both the Chirp (Owl Kids) and ChickaDEE publications. These two print magazines are specifically targeted to younger audiences that include several of TSSA's high risk groups. The publications have a long and successful history of providing educational and entertaining articles, activities and other engaging materials. The creative approach for TSSA's materials is very much aligned with the publications' tone and look. These placements reached almost 1.2 million readers.

2015-2016 Planned Initiatives

TSSA will continue to executive its on-site programs at major water parks and, to the extent possible considering resources available, will seek opportunities to extend the reach of this successful public education strategy. As with previous years, the on-site programs continue to be refined in consultation with industry partners to reflect the individual characteristics and operating practices at each location. TSSA will also pursue, again in consultation with the water park operators, further refinements to its Safety Ambassador program and seek additional industry participants. TSSA is also continuing to explore other engagement opportunities specifically related to the most at risk group (10-14 year old water park users) as its recognizes that a multi-dimensional strategy using a variety of platforms offers additional means to reduce public safety risks associated with user behaviour at water parks.



Appendix E – Statistical Methods

The statistical analysis of the time-series data in this report includes:

- graphical data analysis;
- construction of prediction intervals; and
- trend tests.

Time-series plots are used to present the data graphically, which provide insight into the data for the analysts and readership. In this year's ASPR, these plots have been used to show how health impact and occurrence data have changed over time.

A prediction interval is an estimate of an interval into which a new observation will fall, with a certain probability, given what has already been observed. In this report, the prediction interval covers between the 5 and 95 percentiles of the measured data. Observations for those indicators lying outside the prediction intervals are made with a 95% confidence level. Prediction intervals allow indicators to be checked on a quarterly basis, verifying if they fit the behaviour of historical observations.

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 “by-eye” conclusions 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 ASPR does not include the p-value explicitly, but it is used as a step in the trend analysis.

The Mann-Kendall test 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.

There are many instances where seasonality is the source of variation in the response variable. As such, this report uses Kruskal-Wallis statistics for testing seasonality in the time series; which done using the Minitab 16[®] 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 plotting purposes. As such, it may be the case that a trend is reported as statistically significant, but is not obvious to the reader from the plot of the data and vice-versa.



Appendix F – Risk Informed Inspection Order Management

1.0 Introduction

Section 17 of the Technical Standards and Safety 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 associated regulations.

During an inspection, section 21 of the Act requires inspectors to issue inspection orders against non-compliances that are observed. The Act also requires inspectors to specify the time period in which the non-compliance should be addressed. This “Time to Comply” (TTC) is an essential component of the inspection process.

Consistent with 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).
- 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. Currently, inspectors from only 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. Inspectors from other programs continue to rely on pre-existing tools including manual entry processes while TSSA is working towards creating new and enhanced tools. For the purposes of analysis and reporting, TSSA is currently interim equivalent approaches to characterize documented inspection orders including the use of actual time to compliances issued by inspectors.

2.0 Elements of Standardized Inspection Orders

2.1 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 F1.

Table F1: 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.

2.2 Risk Characterization – Determination of Time to Compliance

Risk Assessment

Once there is an established list of orders available for an inspector, the next step to assess how much risk each order carries to determine the TTC 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 time-to-compliance is a three step process. In the first step, frequency and severity of possible consequences (occurrences) if an inspector observed non-compliance 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 time-to-compliance 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 and shown in Figure 1 below, guides the expert panel in determining the possible outcome(s) of non-compliance, 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.

Figure F1: TTC tool depicting failure scenarios.

The screenshot shows the 'TTC Tool' interface. At the top, there's a title bar 'TTC Tool : Database (PS\Standard Orders Risk Characterization\SOWA\Development notes)\TTC Tool.accdb (Access 2007)'. Below it is a ribbon with tabs: FILE, HOME, CREATE, EXTERNAL DATA, DATABASE TOOLS, HELPS, and TABLE. The 'TABLE' tab is active, showing a list of tables: All Access..., Standard Orders, and Failure Scenarios. The 'Failure Scenarios' table is selected, and its data is displayed in a table with columns: ID, Failure Scenario, and Click to Add. The table contains 16 rows of failure scenarios, starting with ID 291 'Elevator moves with doors open' and ending with ID 306 'Unauthorised access'.

ID	Failure Scenario	Click to Add
291	Elevator moves with doors open	
292	Limb and/or clothing caught between doors	
293	Door strength inadequate	
294	Governor does not operate	
295	Slip/trip/fall	
296	Leveling	
297	Inadequate/no light	
298	Limb and/or body part caught in escalator component	
299	Step and combplate interaction	
300	Improper escalator stop	
301	Improper escalator start up	
302	Person loses balance and experiences impact	
303	Undesired movement of component/device	
304	Failure/breakage of component	
305	Contact with or between various components	
306	Unauthorised access	



This process is vetted with external stakeholders and experts as appropriate and relevant. The conceptual approach has also been presented at several conference and is patent pending the US and Canada.

Orders with no conceivable health impacts are deemed to be “Administrative” orders with a risk score of zero.

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 time to compliance (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 time to compliance is made available for implementation and use including for analysis purposes using risk bins and referred to throughout this report. Table F2 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 F2: 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

As mentioned earlier, TSSA will continue to implement this process electronically as part of a major strategic information system upgrade initiative. In the interim, TSSA has developed an equivalent approach to determine the risk scores for issued inspection orders using a combination of fuzzy logic searches for clause IDs and inspector issued time to compliances. This interim approach helps TSSA for analysis, reporting and inspection scheduling purposes.