Background

The Boilers and Pressure Vessels (BPV) Act, prior to its integration into the Technical Standards and Safety Act, 2000 required internal and external inspections of low pressure boilers once every two years. The specific requirements to carry out internal and external inspections were replaced with a general requirement to carry out periodic inspections under section 10 of the Ontario Regulation 220/01 (Boilers and Pressure Vessels).

Section 10 of the above stated regulation refers to the Code Adoption Document for the frequency of periodic inspections for various types of boilers and pressure vessel equipment. However, no specific requirement exists for the need for and the frequency of internal inspections of boilers. As a result, Technical Standards and Safety Authority (TSSA) and some stakeholders within the insurance industry have used their judgment to carry out internal inspections on an as needed basis.

At the April 29, 2010 BPV Advisory Council Meeting, Council members voted on their top three safety issues for the Council and TSSA to address over the next three years, one of which involved the possible specification of the frequency of internal inspections. Anecdotal evidence of the observations of increasing non compliance amongst some stakeholders within the insurance industry contributed to this perceived safety priority.

This document is meant to guide TSSA and the council to establish the need for further study into this issue prior to making any decisions with respect to internal inspections. The Public Safety Risk Management (PSRM) department was tasked to facilitate internal discussions on this topic. Upon deliberations among TSSA experts and a major insurance provider, the PSRM team identified two possible approaches for the scope of this project. This document lays out the potential scope for the two approaches and the methodology that would be adopted to make a risk informed decision.

Key components of this document include:

- review of information available to TSSA and other external sources including incidents;
- other International standards and best practices;
- expert opinion from a major insurance provider; and
- framework for risk assessment and next steps.

While not within the immediate purview of the council's recommendation, this project is also being considered under a broad TSSA strategic initiative associated with risk informed decision making of aging devices.

Scope

To determine the risks associated with internal failures of boilers (high and low pressure), and determine mitigation solutions (including establishing service lives, need for internal inspections etc.), if risks are unacceptable. Specifically, the objective of this exercise is to determine the need for and the frequency of internal inspections of boilers (high and low pressure), based on internal failures detectable by internal inspections.

In this context, the need for internal inspections may be determined based on the risks posed by this subset of internal failures or may be considered irrelevant. The frequency of internal inspections may be based on the age of boilers. Service life may influence the frequency of internal inspections and therefore may need to be considered within the assessment. Additionally, this scope is dependent on a consistent understanding of the scope of internal inspections.

Currently Available Information

TSSA Information on Incidents and Observed Deficiencies

As part of the preliminary research conducted on internal tank failures, data housed in various TSSA information systems as well as paper records were consulted. The following sources were deemed potentially useful:

1. TSSA information database with respect to periodic inspections; and
2. incident information as reported to and investigated by TSSA.

Information Database Findings

Periodic inspection data was extracted for the measured period of May 1, 2003 – June 30, 2009 inclusive. Also, data showing the inspection orders issued during the same measured period was also extracted.

Upon analysis of these two data sets, it was determined that five inspection orders were issued related to internal inspections. The Internal Inspection Checklist contains the five questions shown below:

Internal Inspection

Are all accessible vessel Internals free from defects?:	○ Pass	○ Fail
Are PV Thickness measurements or other NDE required?:	○ Pass	○ Fail
Is pressure test of the vessel required at this inspection?:	○ Pass	◉ Fail
Is an engineers evaluation and written report required?:	○ Pass	○ Fail
Is a reduction in PV maximum allowable pressure required?:	○ Pass	○ Fail

Incident Information Findings

In all, there were nine occurrences that were reported to TSSA.

Upon analysis, it was determined that there is no evidence to suggest that these occurrences were related to internal failures of boilers.

National Board Statistics on Incidents and Deficiencies

The PSRM department also reviewed and analyzed incident information reported by the National Board of Boiler and Pressure Vessel Inspectors from 1992 to 2001.

This section presents a statistical analysis of the incident data for the above mentioned period as published by the National Board in their summer bulletin of 2002. The average fatality and injury rates associated with BPV are 13 and 72 per year, respectively. All incident reports were compiled from data submitted by National Board jurisdictional authorities and insurance agencies that either provide or do not provide inspection services.

By assuming these incidents as random events and using an average fatality rate of 13 per year, it can be predicted that at the most there is a 95% chance of observing 19 fatalities at the national level due to the failure of boilers and pressure vessels in a given year. Similarly, using an average injury rate of 72 injuries per year, it can be predicted that at the most there is a 95% chance of observing 86 injuries at the national level due to the failure of boilers and pressure vessels in a given year.

It is important to notice that, National Board (2002) presented the raw incident data over the 10-year period, and the fatality and injury data are not standardized by using any population exposure. The injury severity, such as serious or minor injury, was not specified. The above stated fatality and injury rates include all boilers and pressure vessel equipments and they do not exclusively represent the boiler incidents. However, National Board

(2002) also provides the average fatality, injury and accident data over the 10-year period. This data is presented in Table 1.

Table 1: Break down of fatality, injury, and incident attributes by equipment category for the 10-year period.

Attribute	Unfired Pressure Vessels	Power Boilers	Water-Heating Boilers	Steam-Heating Boilers
Fatality	64	44	14	5
Injury	289	250	92	89
Incident	2511	4311	6928	9588

It is interesting to see that for “fatality” and “injury”, “unfired pressure vessels” proved by far to be the most critical, followed by “power boilers”, “water-heating boilers”, and “steam-heating boilers”. However, for incident attribute the above listing is reversed with “steam-heating boiler” contributing to the most incidents, followed by “water-heating boilers”, “power boilers”, and “unfired pressure vessel”.

The major causes of boiler incidents that are identified in the report include low-water condition, operator error or poor maintenance, burner failure etc. The following paragraph is excerpted from the report.

> “LOW-WATER CONDITION and OPERATOR ERROR OR POOR MAINTENANCE have stood atop the list of *boiler* accident causes for all ten years (includes power boilers, steam-heating boilers and water-heating boilers). While LOW-WATER CONDITION has been the predominant cause during this time period, OPERATOR ERROR OR POOR MAINTENANCE has surpassed its causal counterpart just three times: in 1998, 1999 and 2000. (After this three-year hiatus, LOW-WATER CONDITION regained its position as leading cause last year.)"

The report documented that approximately 100,000 boilers and pressure vessel inspection violations were found over a two-year period after the establishment of the National Board Violation Findings program. The report claimed credit for averting a large number of incidents as a result of identifying these violations and correcting them in a timely fashion.

French (1992) tabulated the following top ten causes of fossil fired boilers’ failure:

i) Creep (long-term over heating),
ii) Fatigue (thermal and corrosion)
iii) Ash Corrosion (coal, oil, and refuse)
iv) Hydrogen damage
v) Weld failures
vi) High temperature (short term overheating)
vii) Erosion
viii) Oxygen pitting
ix) Caustic attack
x) Stress corrosion cracking

The condition assessment at optimal intervals through internal inspections can help in identifying some of the above stated failure causes in a timely fashion.

According to NBIC 2007 the maximum period between internal inspections shall not exceed one-half of the estimated remaining service life of the vessel or ten years, whichever is less. Inspection intervals can be revised beyond the maximum period stated above, provided the owner-user has submitted technical justification for revising the inspection interval. The remaining service life estimation typically involves the condition assessment of a device. The code also provides guidelines to assess inspection intervals for pressure-retaining items subject to internal erosion, or corrosion, and a cursory introduction to risk based inspection program.

References

- David N. French, 1992. Metallurgical failures in fossil fired boilers. John Wiley and Sons, Inc. USA.
- National Board, 2002. Ten years of incident reports. Bulletin 57(2).
- National Board Inspection Code (2007)

International knowledge and best practices

AS/NZS 3788:2006 (Australian New Zealand Standard, Pressure equipment, In-service inspection)

This standard specifies minimum requirements for the inspection, repair and alteration of in-service boilers, pressure vessels, piping, safety equipment and associated controls, and gives guidance on the execution of such activities. These inspections include the initial inspection after installation and prior to commissioning. Information is also given to facilitate grounds for agreement between the interested parties in establishing appropriate inspection intervals and procedures for pressure equipment.

The standard recommends the need for carrying out periodic internal and external inspections of boilers and provides guidance on the methods of these inspections. The standard includes risk based approaches for carrying out external and internal inspections.

The American Society of Mechanical Engineers (ASME) Research Report

The ASME has provided guidelines for conducting risk based in-service inspections for boilers, pressure vessels and a wide range of power generating applications.

Expert Opinion from Insurers

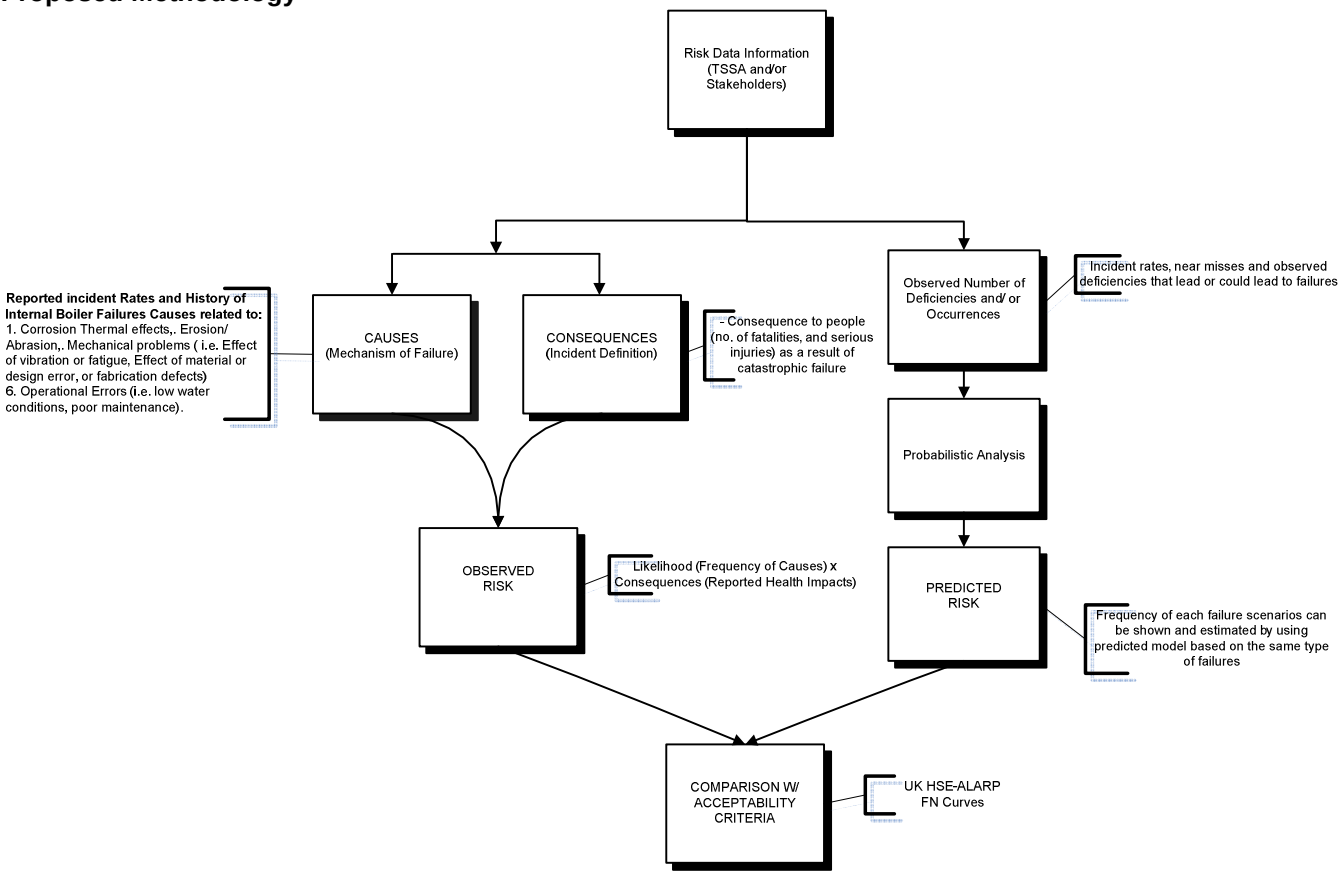
Upon consultation with a major insurance provider, the following information and expert opinion was ascertained:

- A boiler explosion that killed three workers in Massachusetts involved defective welding and corrosion.
- insurance claims pertaining to internal failures are significant and increasing;
- internal inspections not being mandatory are arbitrarily conducted by the insurance industry; their frequency and methods may vary and are inconsistent;
- owners of these boilers tend to select insurance companies on the basis of cost as one of the primary factors; the lack of a mandatory requirement for internal inspections influences this factor and their decision;
- countries like Australia and New Zealand have adopted standards requiring mandatory in-service inspections including internal inspections; and
- details of incidents, results of inspections, insurance claim details over the last 10 years may be available with the insurance industry, however, due to confidentiality reasons, there may be challenges with respect to accessing this information.

Recommendations

If TSSA and the Council agree to proceed with conducting this risk assessment irrespective of the scope, the PSRM department recommends:

Proposed Methodology



Formation of an expert group that involves:

- TSSA expertise (Engineering and Inspection)
- Industry expertise (manufacturers, insurance companies)
- PSRM facilitation
- Exposed population (representation from public, workers, owners).

Additionally, the PSRM department believes that in order to conduct a credible risk assessment, the following pieces of information are essential:

- incidents from other jurisdictions
- insurance company deficiency and incident data
- manufacturers' information on incidents/deficiencies
- manufacture reliability data including failure rates

The detailed methodology time frames and terms of reference for the expert group may be determined upon acceptance of this proposal.