RE-WRITING STANDARD OPERATING POLICY USING RISK-BASED METHODOLOGIES

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ABSTRACT

In 2002, Union Gas was searching for a rigorous method to establish appropriate standard operating policies (SOPs). These SOPs are the company’s policies for the inspection and maintenance of distribution and transmission systems. The policies were initially developed using intuition, experience and engineering judgment. Union Gas preferred a more sophisticated approach to establish the SOPs to ensure that time and money was being spent wisely, while maintaining the safety and reliability of the distribution and transmission systems. At the same time, several high profile transmission pipeline failures resulted in risk based methodologies being developed for use in assessing and ensuring the integrity of transmission systems and high pressure pipelines. Union Gas undertook to develop and apply risk based methodologies to distribution systems’ operating and maintenance policy development.

The approach used to develop the risk assessment methodology was to combine both quantitative and qualitative risk assessment, as appropriate. A quantitative risk assessment, comparing inspection frequencies and system failure rates, was completed to establish the probability of a system failure. The qualitative risk assessment was developed to establish the consequence of system failure. Several factors were considered including:

- Geography (urban, rural and remote)
- Type of customer (care or detention facility, residential, commercial, etc.)
- Nature of the system
  - Plastic vs. steel
  - Age
  - Size
  - Construction methods
  - Maintenance history
  - Location (wall to wall concrete/pavement vs. rural)

The risk assessments challenged several commonly held beliefs regarding the Company’s SOPs. In many cases, there were changes made to inspection frequencies and gaps in the policies were identified and addressed. The risk based methodologies allowed Union Gas to reduce the overall cost of system inspection and maintenance based on incident avoidance and judicious use of finite resources. Union Gas also increased confidence in our inspection practices in a manner that was appropriate to the risk. Maintenance practices were improved with the addition of critical maintenance timelines. The revised SOPs are defendable to both safety regulators and shareholders alike.
ACKNOWLEDGEMENTS

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1. INTRODUCTION

1.1 Project Motivation

The deregulation of the natural gas industry has resulted in closer scrutiny of operating and maintenance costs by regulators and shareholders alike. At the same time, several high profile transmission pipeline failures resulted in risk based methodologies being developed for use in assessing and ensuring the integrity of transmission systems and high pressure pipelines. In Canada, formal risk based integrity management techniques have typically been applied to pipelines operating at 30% SMYS or more. The risk assessment methodologies for high stress pipelines are well developed and are supported by the safety regulators and Canadian Oil and Gas Pipeline Code.

In assessing the operating and maintenance requirements for distribution systems, Union Gas has historically developed standard operating policies (SOPs) using intuition, experience and engineering judgment. The SOPs are the Company’s policies for the inspection and maintenance of distribution and transmission systems. Examples of policies that exist today include leakage survey and repair, valve survey and maintenance, corrosion survey and maintenance, etc.

In 2002, Union Gas was searching for better ways to establish appropriate SOPs, particularly as they are applied to Distribution systems. A survey of North American Natural Gas utilities suggested that formal risk assessment methodologies are rarely applied to distribution systems. Where these methodologies have been applied, they are generally completed for specific material failures or operating issues.

Union Gas undertook to develop and apply risk based methodologies to distribution system operating and maintenance policy development. The rationale for the development of more sophisticated tools to assess the SOPs included ensuring that time and money were being spent wisely and ensuring for sound decision making in policy development. Union Gas also wanted to demonstrate due diligence in operating and maintaining the distribution system to shareholder and regulators alike.

1.2 Background

1.2.1 Risk Based Analysis

Risk is present in all phases of the pipeline life cycle [1]. The basis of a risk based analysis is to analyze the consequence and probability of a certain event occurring in order to predict the ultimate risk associated with that event. The results of probability and consequence analyses are combined to produce a measure of risk, which can then be expressed as a risk matrix, a sample of which can be seen in Fig. 1. The risk matrix approach produces a relative measure of risk, which is helpful to identify potentially high-risk scenarios. The risk matrix concept is well developed in the industry and is presented in the CSA Oil and Gas Pipeline Systems Code, Z662-03.
The ultimate goal of any operating company is to maintain safe and reliable facilities. Risk management techniques can be used to help achieve this goal. Intuitively, it stands to reason that a company is not at risk if the probability of a hazard developing is non-existent, even if the consequence of that event is great. Similarly, if the probability of a hazard developing is very high, the overall risk is negligible if there is no consequence associated with that development. However, this utopian philosophy does not exist in practice and so therefore a company must determine the risk threshold that they are comfortable with and strive to consistently remain below that level through the application of strategic operating and maintenance practices.

Analyzing a Standard Operating Practice using a risk based approach involves a series of steps, as shown in Figure 2. It is crucial to identify the scope of the analysis as it will drive the type and extent of data that must be collected in order to complete the study. The risk based methodologies that were employed by Union Gas included qualitative and, where possible, quantitative assessments.

The quantitative assessment was completed by primarily consulting historical data. Surveys of internal subject matter experts, surveys of other companies and the review of research documents all helped to provide the qualitative background that fed into the analysis. Applicable Code documents were also referenced to ensure that all practices meet, at a very minimum, the requirements specified therein.

Figure 1 – Sample Risk Matrix [1]
The final step before implementation of a Standard Operating Policy at Union Gas is an approval process that involves the participation of both management and field personnel. This inclusive approval process ensures that the policy changes make sense from both operational and business perspectives.

1.2.2 Standard Operating Practices at Union Gas

Currently Union Gas has a number of Standard Operating Practices, including, but not limited to:

- Valve Inspection and Maintenance SOP
- Leakage Survey SOP
- Corrosion Control SOP
- Odourization SOP

Each of the policies are structured to define the required inspection frequencies as well as the maintenance guidelines if a failure is detected. The timelines for inspection and maintenance will typically vary according to how a given item or situation is categorized. For example, the valve maintenance SOP defines the frequency with which valves are to be inspected and, if a problem is detected, how quickly that problem must be addressed. The timelines required for those activities vary depending on the classification of the valve, or in the case of Union Gas, whether the valve is classified as emergency, convenience or load shedding valve.
2. METHODOLOGY

2.1 Analyzing Practices Using a Risk Based Approach

As previously mentioned, the two main components of an SOP are inspection frequency and repair timelines. Inspection frequencies are determined by taking into consideration the risk associated with failure of the system in question. The consequence of a failure is derived from a qualitative analysis that aims to determine the impact, both from a safety and business perspective, of that failure occurring. The probability of a failure is extrapolated from historical data. Once the consequence and probability are defined for each SOP classification, the data is plotted on a risk matrix.

The ultimate goal is to bring the risk for each category covered by the SOP as close to the company’s risk threshold as is practicable. The consequence of a given event is typically not easily influenced and therefore, the risk can only be influenced by altering the probability of that event taking place. Inspection frequency was determined to greatly affect the probability of a failure. For categories that produce an unacceptably high risk, inspection frequency must be increased to reduce the risk and conversely, consideration could be given to decreasing the inspection frequency for categories that produce an exceedingly low risk. At Union Gas, it was found that for each of the SOPs that were analyzed, there were opportunities to reduce certain inspection frequencies while at the same time it was apparent that certain categories required a more frequent inspection.

Once a failure is detected, the consequence ranking of that particular category is used to determine the speed with which the failure must be addressed. Probability is now removed from the equation and the response time is a function of consequence alone. For example, if a minor leak is detected on a small-diameter, low pressure main in a rural location, the problem is not as consequential and therefore does not require the same attention as a leak on a large high pressure main in an urban setting.

2.2 Completing the Review

Before any conclusions are made and a new SOP is written, it is important to review the changes with field operating personnel to ensure that all of the items make sense from a practical perspective. While it is important to solicit informal input from others throughout the review process, a formal review performed by a cross section of operating personnel prior to roll out and implementation can be held to identify possible concerns.

2.3 Case Study – Valve Inspection and Maintenance SOP

In order to further explain the methodology that was employed by Union Gas, the following is a summary of the analysis that was completed on our Valve Inspection and Maintenance Standard Operating Practice.

Prior to the review, the policy defined two categories of valves. The first were emergency valves, which included:
- Station inlet, outlet and bypass valves
- Load shedding valves, used for large isolate areas in the event of a major incident
- Service valves on services that are 4” or greater
- Service valves on services to public buildings
- Service valves on services that do not have any other outside shut-off (no meter stop outside)
- Transmission line valves
- Other valves so designated by local operating groups
These “emergency” valves were inspected on an annual basis (as per code requirements) and if the inspection revealed a problem they were to be repaired “as soon as possible”.

The second category was convenience valves and these included all other active valves in the system. Convenience valves were inspected on a five year rotation and if a problem was detected, it was to be rectified within one year.

In order to define the scope of the analysis, the policy was reviewed, and in doing so, several questions became apparent:
1. Should all emergency valves be inspected with the same frequency or are some more critical than others?
2. Should all convenience valves be inspected with the same frequency or should we have multiple categories of convenience valves? (i.e. based on pressure, size, location, number of customers that the valve controls)
3. How do we monitor compliance for repairing an emergency valve “as soon as possible”?
4. What does Union Gas define as a public building, and do all public buildings require emergency valves?
5. Are all of the convenience valves that we are inspecting required?

In order to answer these questions, it was important to understand the probability of the valves in our system failing along with the consequence of a valve failure in an emergency situation. The probability was determined by reviewing the entire maintenance history for over 1,200 valves (which was a statistically valid sampling of valves in our system) and determining the failure rates and mechanisms. The consequence was defined by qualitatively assessing what would happen if each of the different valves failed in an emergency situation.

3.0 RESULTS AND DISCUSSION

3.1 Case Study – Valve Inspection and Maintenance SOP

When the analysis was completed, two risk graphs were produced, see Figures 3 & 4. As previously mentioned, the risk assessment determined consequence through qualitative analysis. In order to develop the risk matrices, the qualitative results had to be converted to numerical values. This was accomplished by relatively ranking the consequences on a scale of one to five. In order to better align the probability and consequence values, the quantitative probability values were also ranked on a one to five scale. Figures 3 and 4 graphically demonstrate the relative levels of risk that were associated with the Company’s existing practices for each valve category (emergency and convenience valves).
Figure 3 – Risk matrix for emergency valves

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<td>Assembly Building Valves</td>
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<tr>
<td>Care or Detention Buildings</td>
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<tr>
<td>Load Shedding Valves</td>
<td>(4.1)</td>
<td>(4.2)</td>
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Studying Figure 3, it is evident that valves installed on services to assembly buildings are well below the acceptable risk threshold, which is shown as a red line. The reason for this ranking is as follows:

- From a probability perspective, we were inspecting our assembly building valves on an annual basis and as a result, the failure rate that we observed from the historical data was quite low.
- The consequence of an assembly building valve failing was also determined to be quite low. Typically, by the time that a Union Gas representative was able to respond to a problem at an assembly building (for instance, a theatre), the building would be evacuated and hence the safety concern would be greatly reduced.

The net result of these observations was a reduction in the inspection frequency of valves installed at assembly buildings.

Referring again to Figure 3, notice that the risk level for a valve at a care or detention centre was inline with the acceptable risk threshold. Because the inhabitants of a care or detention centre typically have significant limitations with regards to their ability to evacuate a building, the consequence of a failure at such a location is far greater than that for an assembly building. In that instance, because the building will not likely be evacuated by the time Union Gas arrives on site, immediate control of the situation is necessary and therefore the reliability of that valve would be very important. Therefore, we continued to inspect care or detention centre valves on an annual basis.

The final type of valve that is represented on Figure 3 is the load shedding valve. These valves are required to control large isolation areas, affecting thousands of customers. Load shedding valves are not operated often, however, they are critical in times of emergency and so the reliability of the valves is crucial. The historical failure rates of these valves was relatively low with our existing practices, however, due to their critical nature, it was desired to further reduce the probability of failure. For that reason, we now inspect load shedding valves twice per year and one inspection is completed in the winter months to ensure that snow/ice has not hampered the accessibility of the valve.
Figure 4 shows the relative risk values for convenience valves. For the purpose of the risk assessment, the convenience valve category was further broken down by valve size. The possibility of including several additional sub-categories, such as pressure, location, valve type, etc. was considered, however, upon review, size was the factor that most affected the probability and consequence values. It was also a priority to keep the SOPs relatively simple for ease of implementation, so sub-categorization was kept to a minimum. From a probability perspective, our data showed that the failure rate of a valve that was NPS 2 or less was significantly less than that of a valve larger than NPS 2. From a consequence perspective, larger lines typically feed a greater number of customers and therefore the failure of a large valve results in the requirement for a larger isolation area to gain control of the system. A valve failure on a small-diameter main can usually be rectified by pinching off the line which is not an option on a larger steel main. For that reason, the inspection frequency was increased for convenience valves larger than NPS 2; inspections are now performed every 2 years, as opposed to the existing practice of every 5 years. For valves sized NPS 2 and smaller, the proposed inspection frequency was set at a 10 year interval, as this seemed acceptable from a 'risk' perspective. However, during the policy review process, it was determined that the likelihood and complexity of valve maintenance would be greatly increased if the inspection frequency was extended to ten years and so a compromise was struck between risk and operational requirements and the inspection frequency was maintained at the existing frequency level of every five years.

Once inspection frequency was determined, repair timelines had to be established. As previously mentioned, repair timelines are a function of consequence alone and therefore the probability of a failure is no longer relevant. The most critical valves in our system, emergency valves, are repaired “as soon as possible”, not exceeding 6 weeks. Convenience valves larger than NPS 2 must be repaired within 6 months and convenience valves NPS 2 and smaller must be repaired within a year.
Union Gas was able to combine the roll-out of the changes to the valve inspection and maintenance SOP with a new valve installation policy. The combined roll-out created a better understanding and awareness with the operating personnel. Union Gas was also able to deactivate some small-diameter valves (2" and less) that were not required according to the new valve installation policy. Similarly, in situations where our existing systems did not have a sufficient number of valves according to the new policy, plans were made to install new valves.

3.2 Project Results

The results that were presented in section 3.1 for the Valve Inspection and Maintenance SOP are a good representation of those found for the other SOPs that were reviewed using the risk-based approach. Risk matrices were developed for each policy, and based on the resulting relative risk profiles, maintenance activities were adjusted to bring each activity in line with the Company’s risk threshold.

Union Gas is now confident that the policies that are in place will ensure the continued operation of a safe and reliable distribution system. The risk associated with common negative events has been determined and risk that those events will occur is being managed to a level that is acceptable to the Company, regulators and shareholders alike.

3.3 Subsidiary Benefits

Along with the development of a Standard Operating Policy that is within acceptable risk limits for Union Gas, the review and subsequent roll-out of SOPs has provided some subsidiary benefits.

3.3.1 Increased awareness and understanding through rollout

The change of any Standard Operating Policy necessitates a communication and roll-out plan to ensure that all field personnel are cognizant of the changes and understand them. This provides an opportunity to present the methodology that led to the changes being made in order to increase acceptance of the changes in the field.

3.3.2 Development of a management system

Any management system is based around the concepts of plan, do, check and act. Reviewing the operating and maintenance policies helps to ensure that the right activities are being planned to enable a reduction in the risk of undesirable events occurring. The method used to implement and roll-out the new policies can help to ensure that the required activities are physically being performed in the field. During the roll-out of the revised SOP’s, the importance of completing all SOP work within the specified timeframes was stressed to field personnel. The inclusion of field personnel in the final review helps to ensure that they take ownership of the process and ‘buy in’ to the results. The efficacy of any policy can only be determined if there are measurable results and a system in place that can track progress. At Union Gas, the SOPs were re-written to include definite timelines for inspection and maintenance activities. In order to track that the work is being done within the allowable timelines, changes to IT systems were required, as will be discussed in Section 3.3.3. In order to ensure that action is taken when SOP timelines are not being met, a non-compliance process was also initiated. For each instance of non-compliance with an SOP, field personnel must document the non-compliance and the reason for its occurrence. This in turn, is sent to the engineering group who review the issue, and help to develop a contingency plan. Each instance of SOP non-compliance must be approved at the Director level. This close scrutiny of instances of SOP non-compliance helps to identify systemic issues, and can lead to further review of the policies.
3.3.3 Improved data collection and IT systems

Changes to any SOP can necessitate changes to supporting IT systems. Due to the fact that SOP inspection and completion work orders are often generated electronically, revised inspection timeframes necessitate IT changes. This often provides an opportunity to ensure that the IT systems have the capability to collect meaningful data that will be useful for further policy reviews. It is desirable that the IT systems:

- Provide data in an easy to collect and usable format for future SOP reviews. An important final step in the SOP review will be to revisit the changes that were made and ensure that they produced the risk reduction that was predicted. Having historical data that is easy to access will be a vital cog in this step.
- Provide reporting so that management personnel can monitor the progress of SOP’s and ensure everything is being completed within the specified timeframes.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The goal of this project was to apply risk based methodologies to distribution systems’ operating and maintenance policy development.

Upon reviewing the results that were presented in Section 3, it can be concluded that:

1. Risk based methodologies can successfully be employed to aid in policy development.
2. A structured review of operating policy can bring about subsidiary benefits including increased awareness of the policies in the field, improved data collection systems and the development of the elements required for a management system.

4.2 Recommendations

There were several assumptions that were made when performing the risk assessments that led to the SOP policy changes. Because the assessments included qualitative analyses, there is subjectivity inherent in the risk rankings that were developed. In order to ensure that the assumptions that were made are reasonable, the analysis should be repeated using data collected since the policy implementation. These results could then be compared with the original data to see if risk has indeed been in line with expectations.
5. REFERENCES


6. LIST OF FIGURES

Figure 1 – Sample Risk Matrix
Figure 2 - Process flow for the risk-based SOP review
Figure 3 - Risk matrix for emergency valves
Figure 4 – Risk matrix for convenience valves