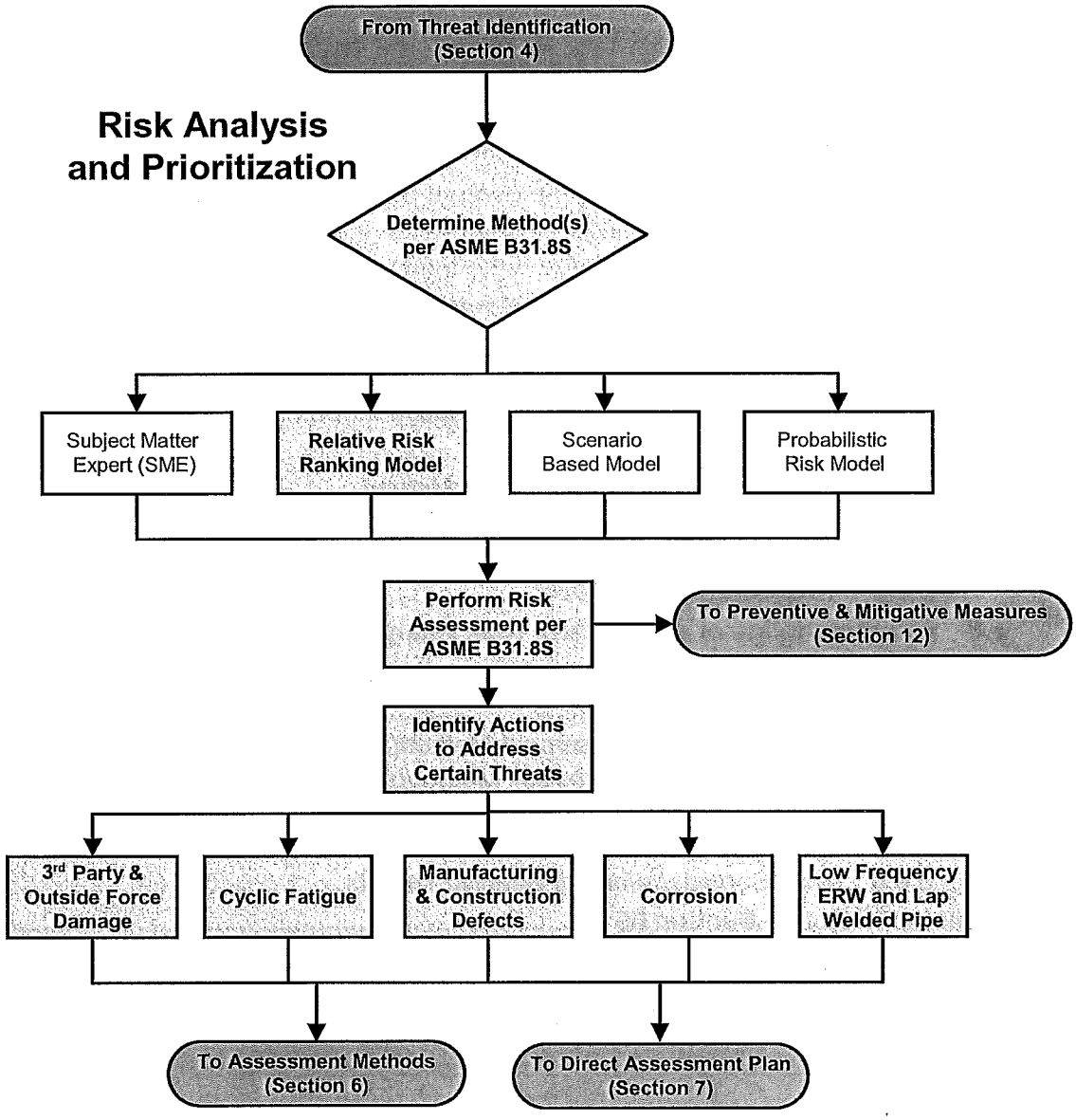
5 RISK ANALYSIS & PRIORITIZATION

5.1 OVERVIEW



Source: OPS Website

Note: Questar has elected to utilize the "Relative Risk Ranking Model" approach (shaded above) as its base method, as further discussed below. Other methods (not shaded) may also be used to supplement this approach.

5 RISK ASSESSMENT & PRIORITIZATION §192.917(c)

(Reference: ASME B31.8S Section 5)

In This Section

Note: Refer also to Volume III - "*Report Documenting Questar's Integrity Management Pipeline Risk Assessment Model*," KAI Final Report No. 04-94, Proj. No. 0280-0401.

Referenced Protocols

Operating / Mitigation History

The frequency and consequences of previous events are considered for the pipeline system, as well as other pertinent industry data. Updates are performed based upon the preventive, mitigative, and corrective actions taken.

Predictive Capability

The risk assessment method can help identify integrity threats not previously considered through the integration of data. This integration may also include the trending of various results from inspections, examinations, and evaluations over time to help predict future conditions.

Risk Confidence

Risk data used in the risk assessment method is checked for accuracy as part of the program's quality assurance (see related documentation in Volume IV Subsection 3.9.4 and 3.9.5 of this Manual). When missing or questionable data exists, conservative default values are established until more accurate and reliable data can be obtained.

Documentation

The approach is thoroughly documented (see related documentation in Volume III of this Manual) explaining the technical basis for the method, the procedures used, and the impacts on risk determinations.

"What If" Determinations

The risk model has the capability to perform "what if" determinations to see the potential impacts of assessment action or other preventative and mitigative measures being considered (e.g. modify).

Weighting Factors

A structured set of weighting factors exist to indicate the value of each risk assessment component both failure probability and consequences.

Structure

A structure with the ability to compare and rank the risk assessment results to support the IMP decision process and identify the primary risk drivers with the most influence on results.

Segmentation

A structure exists (based on dynamic segmentation) which provides sufficient resolution of a pipeline segment to adequately analyze the data along the pipeline.

The structure is used to assist in the determination of high risk areas. The ability exists to update segments where risk factors change, such as when preventive and mitigative measures are implemented.

5.6 COMPANY'S RISK ASSESSMENT APPROACH

✓ *Referenced Protocol:* *C.4 Risk Assessment*
C.5 Characteristics of an Effective Risk Assessment Approach

The following describes Questar's objectives in selecting a risk assessment approach. As previously indicated, Questar has elected to utilize a Relative Risk Model as its primary method. The risk model is part of the ESRI technology platform implemented by the company, and uses a customized algorithm developed by Kiefner & Associates (subcontracted as part of the overall ESRI project.).

Note: Refer also to Volume III - "*Report Documenting Questar's Integrity Management Pipeline Risk Assessment Model*," KAI Final Report No. 04-94, Project No. 0280-0401.

5.6.1 Objectives

Questar has determined it will be using a prescriptive based approach, and has established the following objectives. Questar's risk assessment approach is intended to:

- Address the "threats of concern" identified in section 4
- Accommodate the level of available information
- Provide a structured approach
- Thoroughly document and maintain data inputs and attributes
- Provide objective results which are reproducible
- Determine a relative risk score to be used in risk ranking
- Accommodate pipeline segmentation to evaluate the risks
- Consider occurrence of previous events and risk-findings
- Perform "what if" analysis
- Provide a means of feedback and updating to continue to refine and validate the model over time.

These objectives have been considered in the development of Questar's risk assessment method.

5.6.2 Selected Risk Assessment Method(s)

Questar has reviewed the four risk analysis methods described in subsection 5.4 of this document and has selected the Relative Risk Ranking approach as its primary method to analyze and prioritize its (covered) pipeline segments. The risk model is part of the ESRI technology platform implemented by the Company, and uses a

customized algorithm developed by Kiefner & Associates (subcontracted as part of the overall ESRI project.)

> **Note:** Refer also to Volume III - "*Report Documenting Questar's Integrity Management Pipeline Risk Assessment Model*," KAI Final Report No. 04-94, Project No. 0280-0401.

5.6.3 Characteristics of the Risk Method(s)

The purpose of the risk model is to provide a framework for Questar to evaluate and compare the diverse parts the pipeline system on the basis of relative risk. The results of these evaluations can be used to priority rank the covered segments in the baseline assessment plan, evaluate preventive and mitigative measures, and perform continual evaluations and reassessments.

The risk model has been specifically designed (customized) for use by Questar, taking into consideration the nature of the pipeline systems it operates, as well as related industry data / experience.

The system data is stored in an APDM database for documentation, with a risk algorithm that calculates the risk for each distinct segment within the pipeline system. The model ranks all segments by relative risk, determines the factors that drive the risk, and can be used to evaluate the effects of risk reduction through preventive and mitigative measures using "what if" analysis. Refer also to related discussion on calculation of risk scores in Section 8.

The risk model uses mathematical equations which utilize the pipeline attributes, environmental factors, and mitigative responses as inputs to calculate the likelihood of failure. The higher the resulting score, the more likely it is that a failure will occur.

Since the format and weighting factors that characterize the equations are based on a combination of expert judgment, experience, and technical knowledge, the model provides relative risk rankings of the likelihood of failure rather than the true mathematical probability of failure.

When the required data is either missing or questionable, Questar typically uses the most conservative value or weighting in the range (minimum to maximum) of values for the parameter. In certain cases, the most conservative values are not thought to be realistic, so moderately conservative values are used instead. As additional data is obtained these default values will be updated to reflect actual data.

The risk model takes into consideration both probability of failure and consequences. The model uses mathematical equations to represent the degree of exposure of people and property to the potentially damaging effects of a pipeline failure. The consequence equations also address the impact of loss of service, an important risk factor considering that Questar provides (primary) heating fuel to hundreds of thousands of customers, and serves as gas supply to power generation and other important industrial and commercial customers. The risk of failure from any

particular threat is assumed to be the probability of failure from the threat, times the conceivable consequences of the failure. The total risk of failure for a segment is calculated as the sum of the risks for each threat.

Questar may use the Subject Matter Expert (SME) approach for risk assessment to address any new or other threats not specifically addressed by the relative risk model.

5.6.4 Prioritization

The total risk for each segment is a relative number. The higher the number, the higher the relative risk. This relative risk score assists in the decision making process by allowing the covered segments to be ranked according to relative risk and ultimately developing a prioritized list of covered segments.

Through the use of "what if" analysis, Questar can determine the impacts of assessments or preventive and mitigative measures in terms of relative risk. Since the model considers the benefits of these risk reduction actions, various scenarios can be examined to determine the various degrees of risk reduction achievable. These "what if" analysis should be tempered with subjective evaluation by qualified IM personnel.

Upon completion of an integrity assessment or implementation of a mitigative action, Questar will update the appropriate risk parameters in the risk model and can recalculate risk scores to reflect the new information obtained on the affected covered segments. As discussed in subsection 1.14, risk analysis is periodically (at least annually) updated.

Once the risk reduction actions have been implemented, Questar can use the model to re-rank the covered segments based upon the resulting relative risk. As discussed in subsection 1.14, the BAP is periodically (at least annually) revised and updated as needed.

Questar also captures other changes that could impact the integrity (risk scoring) of the pipeline system through routine operations, integrity assessments, and the Management of Change process (see Section 14.)

5.6.5 Validation of the Risk Method(s)

✓ ***Referenced Protocol:*** ***C.6 Validation of the Risk Assessment***

To ensure the successful use of the selected risk assessment method, Questar will provide adequate data sets, use defined and structured algorithms, and work to assure the algorithms are properly tuned and validated. The ability to correctly identify the most critical segments depends on the validity and completeness of the system data, and the extent to which the algorithms reflect the true effects of the controlling factors.

The model and its algorithms have been reviewed and tested by Kiefner & Associates, Inc., MJ Harden, and Questar to provide a typical and representative model. Additional fine tuning will occur over time as more and improved data becomes available, experience with the model grows, and industry experience suggests new or varying risk factors.

Note: Refer to ESRI project documentation in Volume IV Subsection 3.9 regarding testing of the risk model.

Questar Gas will validate the results of the risk analysis to assure that the methods used have produced results that make sense and are consistent with our own and industry's experience as required by ASME B31.8S – 2001 Section 5.12. Following each risk analysis and ranking for the BAP (Section 8), the **Integrity Engineer** M3, will schedule a review of the analysis results with the **Supervisor of Integrity Management** M2, the **Manager of Operations Services** M1, and other SME's as required to determine the reasonableness of the risk results and ranking of covered segments. If the results are found to be unreasonable when compared to the SME's experience, the risk data will be reviewed and adjusted and a new analysis performed until reasonable results are obtained. All risk validation review meetings and adjustments to the risk model and/or risk data will be documented by the **Integrity Engineer** M3.

The **Integrity Engineer** M3 will also continue to review data and forms generated during field inspections, examinations and evaluations to determine if the methods used by Questar Gas are correctly characterizing risk. As these forms are generated and are routed to be entered into the APDM database (See Volume IV Figure 4.1-1), the **Project Coordinator – Transmission Mapping** F3 will flag those forms and risk related data that are significantly different than data previously captured or that are grossly inconsistent with the risk characterization in the risk model. Attention should be paid to any potential inconsistencies between field inspection/evaluation findings and risk-model scores, particularly for high risk or low risk scenarios. For example, a finding of extensive external corrosion in the field when the risk model indicates a low-risk for external corrosion would be flagged for review. These forms will be routed to the **Integrity Engineer** M3 for review and for consideration of potential updates to the risk model. This will be a continuous process to improve the accuracy and reasonableness of the risk model. The risk model shall be updated when deemed necessary by the **Integrity Engineer** M3.

Industry incident and accident statistics will also be considered to determine the various causes of pipeline failures. The **Integrity Engineer** M3 will review the risk model prior to each risk update and will make adjustments if deemed necessary to account for new trends in industry pipeline failure causes. Also, Questar Gas may review the overall risk model algorithms with industry experts such as Kiefner Associates to determine if any adjustments need to be made to account for any industry trends or changes that they may have witnessed during their industry consulting activities.

5.6.6 Risk Considerations of Specific Threats

The relative risk model is capable of addressing all of the potential threat categories from Section 4. Questar has incorporated risk parameters and algorithms into its customized model encompassing all nine of the threat categories from ASME B31.8S. The nine threats categories are: External Corrosion, Internal Corrosion, Stress-Corrosion Cracking, Manufacturing Defects, Construction Defects, Equipment Failure, Third-Party Damage, Incorrect Operations, and Weather-Related and Outside Forces.

REVISION HISTORY – SECTION 05
RISK ASSESSMENT & PRIORITIZATION

REVISION DATE	AUTHORIZATION FORM	AUTHOR	SIGNIFICANT (Yes/No)	SUMMARY or REMARKS**
12/17/04	**QRS IMP-05-A**	NGA / R. Jorgensen	N/A	Initial adoption of section
3/9/05	**QGC IMP-05-A1**	R. Jorgensen/ Rick Ferlin	No	Formatting corrections; non-substantive edits.
2/27/06	**QGC IMP-05-B**	M. Warner	No	Annual QA Review updates

5.1.1 Purpose

This Section describes available risk assessment (risk analysis) approaches under the rule and the method selected by Questar to satisfy these requirements. It also describes how all identified "threats of concern" from Section 4 will be used in the risk assessment process.

The risk assessment process is used to prioritize the covered segments for use in the Baseline Assessment (Section 8), the evaluation of Preventive and Mitigative Measures (Section 12), and the Continual Assessments (Section 13) in the future.

5.1.2 Responsibility

The **Supervisor of Integrity Management** M2, working in conjunction with the **Integrity Engineer** M3 has overall responsibility for the performance of these procedures and for any modifications to this Section.

5.2 DEFINITIONS

The following defined terms have been used in this Section.

Covered Segment

A Covered Segment means a segment of gas transmission pipeline located in a high consequence area (HCA).

Risk

Risk is a measure of potential loss in terms of both the incident probability (likelihood) of occurrence and the magnitude of the consequences.

Risk Assessment

Risk Assessment is a systematic process in which potential hazards from facility operation are identified, and the likelihood and consequences of potential adverse events are estimated. Risk assessments can have varying scopes, and be performed at varying level of detail depending on the operator's objectives.

Risk Management

Risk Management is an overall program consisting of: identifying potential threats to an area or equipment; assessing the risk associated with those threats in terms of incident likelihood and consequences; mitigating risk by reducing the likelihood, the consequences, or both; and measuring the risk reduction results achieved.

Consequence

A Consequence is the impact that a pipeline failure could have on the public, employees, property and the environment

Risk Variable

A Risk Variable is a root cause, contributing cause, or influence of each failure and consequence type.

Attribute

An Attribute is a quality or characteristic which is inherent to the pipeline system or the risk analysis process.

Risk Score

A Risk Score is the relative risk or ranking result, which has been determined from implementing the selected risk analysis method.

Subject Matter Expert

A Subject Matter Expert (SME) is an individual that has expertise in a specific area of operations or engineering.

5.3 RISK ANALYSIS

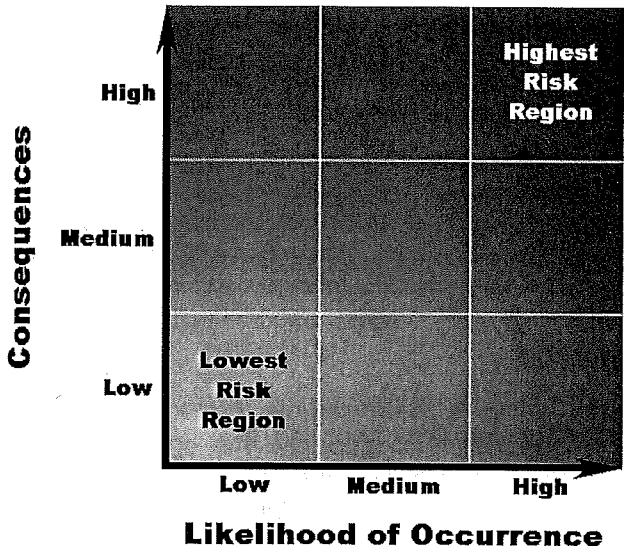
Risk can be characterized as the product of two primary components, the "likelihood" that an adverse event will occur, and the resulting "consequence" if it does. This basic concept can also be reflected in the expression below [Ref: B31.8S Section 5.2].

For a Single Threat $\quad Risk_i = P_i \times C_i$

For a Covered Segment $\quad Risk = \sum_{i=1}^{9} (P_1 \times C_1) + (P_2 \times C_2) \ldots . (P_9 \times C_9)$

where:

P = likelihood of failure
C = Consequence of failure
1 to *9* = failure threat category (prescriptive method)



5.3.1 How the Risk Analysis is Used

Information from the risk assessment process is used in the following key sections of this IM document to prioritize covered segments.

- Section 8: Baseline Assessment Plan
- Section 12: Preventative and Mitigative Measures
- Section 13: Continual Evaluation and Reassessments

5.3.2 Prescriptive vs. Performance Based

The risk assessment and prioritization portion of the IMP can be performed using either a prescriptive based or a performance based approach.

Note: Questar has selected the prescriptive approach which is the basis of this Manual.

Prescriptive Approach [The basis of this IM Document]

A risk analysis performed using a prescriptive based approach is based upon the nine threat "categories" listed in Section 4 which are used to prioritize the covered pipeline segments. The data sets specified in Appendix A of B31.8S are used to perform the prescriptive based risk analysis.

A prescriptive based risk analysis can not be used to increase the prescriptive re-inspection intervals [Ref: Section 13]. The following four risk analysis methods are allowable when a prescriptive based approach is used with the prescriptive re-inspection intervals.

- Subject Matter Experts (SME) Method

- Relative Risk Assessment Model **
- Scenario Based Model
- Probabilistic Model

Note:** Questar has elected to utilize a "Relative Risk Assessment Model" as its primary method for risk assessment. Refer also to Volume III of the Manual for more detailed information on the risk model. Other risk methods may be used as well.

Performance Based Approach

A risk analysis performed using a performance based approach uses the 21 "individual" threats listed in Section 4 to prioritize the covered pipeline segments. This method will typically require a broader and more complex range of data than those specified in Appendix A of B31.8S. The risk assessment approach must be able to address this expanded data set. This approach may also be used to establish and technically justify re-inspection intervals.

5.4 RISK ANALYSIS METHODS

The following four risk assessment methods are appropriate when a prescriptive based approach is used with the prescriptive re-inspection intervals.

Under the rule, each operator is responsible for selecting an appropriate risk analysis method(s) which meets the needs of the operator's integrity management program. More than one risk assessment method may be used throughout the pipeline system.

Any risk assessment method considered should include the following key features.

- Ability to match the assessment method to the level of information available
- Ability to thoroughly document data inputs
- Ability to provide a means of "what if" analysis
- Ability to validate risk assessment results

The risk assessment methods discussed in this section all have the following common components which can:

- Identify potential events of conditions that could impact system integrity
- Evaluate the likelihood of failure and the resulting consequences
- Allow risk ranking and identification of specific threats that drive risk
- Lead to the identification of preventive and mitigative options
- Provide a data feedback mechanism
- Provide structure and continuous updating for reassessments of risk

5.4.1 Subject Matter Experts (SME) Method

Note: Questar is not presently using the SME method for risk assessment of pipeline segments. The SME method may be used in the future as a supplemental method.

The Subject Matter Expert Method utilizes the extensive experience and institutional knowledge of the operating company's personnel, contractors, and/or consultants. This knowledge and experience is then combined with information from relevant technical industry publications.

This approach can be combined with a simple relative risk matrix to determine a relative value. SME's are used to analyze each pipeline segment, and to assign a relative likelihood and consequence to determine a relative risk value for each of the 9 threat categories.

These values are then aggregated to determine a total risk score for the segment. The risk scores from each segment are then used to prioritize all covered segments on the pipeline system.

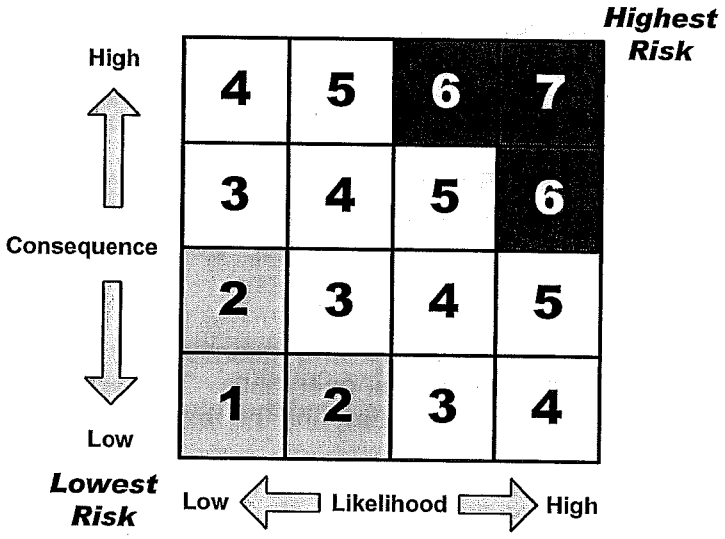


Figure 5-2: Simple Relative Risk Matrix

For a Single Threat $\quad Risk_i = P_i \times C_i$

For a Covered Segment $\quad Risk = \sum_{i=1}^{9} (P_1 \times C_1) + (P_2 \times C_2) \ldots . (P_9 \times C_9)$

where:

P = likelihood of failure
C = Consequence of failure
$_1$ to $_9$ = failure threat category (prescriptive method)

An organized, structured, and thoroughly documented process is important to assure a consistent analysis that is reproducible.

Some Operators may consider this method when there are relatively few pipeline segments to consider.

Advantages

The SME approach can be implemented rather easily without an extensive infrastructure for risk analysis.

Disadvantages

The SME approach can be labor intensive for key personnel since they tend to be the most knowledgeable on the pipeline system. The method also introduces subjectivity, which will require a structured and well-documented process to ensure reproducibility.

5.4.2 Relative Risk Ranking Model

Note: Questar has elected to utilize a "Relative Risk Ranking Model" as its primary method for risk assessment. Refer also to Volume III of the Manual for more detailed information on the risk model. Other risk methods may be used as well.

The Relative Risk Ranking Model builds on pipeline specific experience and significant data to develop the risk models. These models use algorithms to address known threats on the pipeline system which have historically impacted pipeline operations.

This type of model identifies and quantitatively weights the major threats and consequences relevant to past operations. The weightings are based upon a range of values (minimum to maximum) and the relative importance of each item.

The approach is considered a relative risk model since the results are compared with other results from the same model. The value generated is a unitless number, which can provide a relative comparison to other results from the same model to produce a relative risk ranking. The generated values are only meaningful relative to each other.

The model uses these algorithms to objectively quantify major threats and consequences on the pipeline system.

Operators of medium to larger transmission systems may consider this method when many pipeline segments must be considered, and there is a need for extensive "what if" analysis.

As indicated, Questar has elected to utilize a relative risk model as its primary method. The risk model is part of the ESRI technology platform implemented by the

Company. The risk model is more fully delineated in Volume III of this Manual; refer to Volume III for additional explanation of the Questar risk model.

Advantages

A properly tuned Relative Risk Ranking Model tends to be more objective than the SME Method. The model is also well suited for extensive "what if" analysis to determine the impacts of preventive and mitigative measures.

Disadvantages

The Relative Risk Ranking Model is more difficult to implement than the SME method and will require more pipeline specific system data.

5.4.3 Scenario Based Model

Note: Questar is not presently using Scenario Based Models for risk assessment.

The Scenario Based Model generates a description of a hypothetical event or a series of events, which leads to a determined level of risk. This type of model includes the generation of both the likelihood and the consequences of such events based upon input from SME's and system data. This method usually includes the construction of event trees, decision trees, and fault trees from which appropriate risk values can be determined.

Under this method the "most probable" or "most severe" pipeline scenarios are typically envisioned. The resulting damages are then estimated, and preventive and mitigative measures are considered.

Operators of smaller transmission systems may consider this method when there are relatively few pipeline segments to consider, and if the operator has extensive experience utilizing event trees, decision trees, and fault trees. This will typically not be the best choice for most operators.

Advantages

The scenario-based approach typically utilizes event trees, decision trees, and fault trees for those operators with extensive experience with these tools.

Disadvantages

This approach is scenario-based and is dependent upon the operator selecting each appropriate failure mode for every threat combination. Although a very structured method within each scenario selected, it can be subjective based on the scenarios selected by the operator. This method can also produce a large quantity of scenarios that may be difficult to successfully manage, update, and perform "what if" analysis.

5.4.4 Probabilistic Risk Model

Note: Questar is not presently using Probabilistic Risk Models for risk assessment.

The Probabilistic Risk Model is the most complex and demanding of the four methods mentioned with respect to data requirements. Models are constructed to describe the probability of specific events leading to failure. The probabilities of the event occurring are based upon available operating experience and system data.

The results of the Probabilistic Risk Model are provided in a format that is compared to acceptable risk probabilities that have been established by the operator. The results are typically expressed as a probability of the event occurring (e.g. = $1x10^{-6}$)

Advantages

The Probabilistic Risk Model expresses the results in terms of probabilities which may be desired by some operators (e.g. probability of the event occurring = $1x10^{-6}$).

Disadvantages

The Probabilistic Risk Model can be difficult to implement, and is very data intensive.

5.5 CHARACTERISTICS OF AN EFFECTIVE RISK ANALYSIS

Several general characteristics exist that will contribute to the overall effectiveness of any risk assessment approach. These characteristics were considered during the selection of a risk assessment approach. These characteristics include:

Attributes

Specific attributes which are used to assist in defining the logic and structure of the risk assessment method which assure a complete, accurate, and objective analysis of the risk.

Resources

Sufficient time, personnel, and funding have been allocated to implement the selected (Relative Risk Ranking) risk assessment method.

Note: Questar committed approximately $2,000,000 in capital funds to develop and implement the new ESRI integrity support technology and relative risk model.