

Kiefner-NYGAS Risk Assessment Model



New York Gas Group



Kiefner & Associates

The Kiefner-NYGAS risk assessment model is designed to evaluate the relative risk of failure for each pipeline segment in a natural gas transmission system, determine the highest threat of failure on each segment, assess the most appropriate mitigative strategy for each segment by conducting cost/benefit analyses, and assist in prioritizing the order that baseline assessment should follow as well as when reassessment should occur.

~ The Federal Pipeline Safety Rule ~

The US Department of Transportation (DOT) is developing a rule on gas pipeline integrity management. Their objective is to evaluate and address potential threats posed by pipeline segments in areas where the consequences of potential pipeline accidents pose the greatest risk to people and property and to provide additional mitigative measures in those areas. NYGAS believes that a comprehensive risk based approach, such as is found with the Kiefner-NYGAS risk assessment model, can be used effectively to comply with implementing federal regulation and mitigate the potential for failure of LDC natural gas transmission systems.

~ The Model ~

A risk assessment model to assist natural gas LDC operators in evaluating pipeline integrity has been developed by Kiefner and Associates, Inc., of Worthington, Ohio in conjunction with the New York Gas Group¹ (NYGAS). This effort was undertaken with the active participation of the New York State Department of Public Service staff. As a result, a robust model was built from the combined expertise of the three entities: a pipeline integrity specialist, ten gas LDC operators, and a Commission safety staff.

The purpose of the risk assessment model is to assist an operator in determining the relative level of risk involved in operating the various segments of its transmission pipeline system and to help the operator to make sound pipeline integrity decisions regarding operation, maintenance and risk mitigation.

The model is capable of analyzing various scenarios of mitigative actions *specific to each pipeline segment* to reduce risk and bring the segments with “high” risk into a more

¹ NYGAS is the New York State natural gas utility trade association whose 10 members are the largest local gas distribution companies (LDCs) in the state. These ten members are: Central Hudson Gas and Electric Corp., Consolidated Edison Co. of N.Y., Inc., Corning Natural Gas Corp., National Fuel Gas Distribution Corp., New York State Electric and Gas Corp., Niagara Mohawk Power Corp., Orange and Rockland Utilities, Inc., Rochester Gas and Electric Corp., St. Lawrence Gas Company, Inc., and KeySpan Energy Corp.

acceptable risk range. Potential costs associated with each mitigative action are also identified, cost benefits are calculated, and together with other operator knowledge, logical and *specific solutions* for each segment to improve pipeline integrity are established. Mitigative actions include performing in-line inspection, a hydrotest, or direct assessment; recoating a pipeline; replacing a pipeline; increasing pipeline markers; increasing pipeline patrols; installing new anodes and rectifiers; etc.

The first step involved in implementing the model is data gathering and defining pipeline segments. After the operator gathers the data and inputs the appropriate pipeline attributes into the model, the model calculates and specifies the predominant risk to each pipeline segment and determines whether the threat is time dependent (due to internal or external corrosion); static or resident (due to defects introduced during fabrication of the pipe or construction of the line); or random (due to third party damage and outside force). Appropriate mitigative actions can then be identified to reduce the predominant risk. The costs of the mitigative actions are calculated and compared.

~ Basis of the Model ~

The risk assessment model operates in Microsoft ACCESS database, either 97 or 2000 versions. Pipeline data is stored in the database and a risk “algorithm” calculates relative risk for each distinct segment within the system. The algorithm consists of equation sets that address five causes of potential pipeline failure to calculate a “likelihood of failure” for each segment. The five potential causes of pipeline failure (ie, threats to pipeline integrity) addressed by the model are: external corrosion, internal corrosion, mechanical damage from excavating equipment, inherent material or construction defects, and damage from outside forces such as floods, landslides, and subsidence. 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 rankings* of the likelihood of failure rather than the true mathematical probability of failure. Relative rankings of segments are sufficient, however, to inform the pipeline operator with respect to which segments require the most urgent action.

~ Total Risk ~

$$\textit{Total Risk} = \textit{Likelihood of Failure} \times \textit{Consequence of Failure}$$

Risk associated with a pipeline failure depends not only on the “likelihood of failure” but on the “consequences of failure” as well. Consequences of a failure include the likelihood of fatalities and/or injuries, property damage, and loss of service to customers. The model uses mathematic equations to represent the degree 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 to customers. The risk of failure from any particular cause is assumed to be the “likelihood of failure” from that cause times the conceivable “consequences of a failure”. Since the consequences can be expected to vary according to the mode of failure, that is whether the failure is a leak (a small release), a puncture (a moderate size release), or a rupture (a large release), one calculates with this model the risk of failure from each cause as the likelihood of a leak times consequences of a leak plus the likelihood of a puncture times the consequences of a puncture plus the likelihood

of a rupture times the consequences of a rupture. The total risk of failure for a segment is calculated as the sum of the risks of failure for each cause of failure.

~ Data Implementation ~

While the model is user friendly, a person with an engineering or operations background with pipeline integrity knowledge and experience would be well equipped to run the model. When the program is started, the first of fourteen windows, the “Pipeline” window, appears. The remaining windows, which can be viewed in any order by placing the cursor on the appropriate “folder” tab, are External Corrosion, Internal Corrosion, U. Slope, Flood, Earthquake, Subsidence, ROW, ROW 2, ROW 3, ROW 4, Losses, Reports and Risk. A brief description of each of the input windows follows. (The Reports and Risk windows are described separately.) Note that for each input window, various pieces of pipeline data are solicited, some are objective physical values and others are indirect values where pull down menus are featured.

Window 1 – Pipeline: The Pipeline screen contains the following input boxes: Outside Diameter of Pipe, Wall Thickness, SMYS (specified minimum yield strength), Max Operating Pressure, Hydrostatic Test Pressure, Year of Last Hydrostatic Test, Year Line Installed, Length of Segment, Type of Seam, Girth Weld Quality, External Loads, Are Couplings Used?, Are There Old Any Suspect Repairs?, ATRM, and Depth of Burial.

Window 2 - External Corrosion: The External Corrosion screen contains the following input boxes: Year of last In-Line Inspection for Metal Loss, Year of Last Direct Assessment, Hydrostatic Test Pressure for Retest, Coating Type, Coating Condition, Casing Factor, Soil Type, Soil Characteristics, Current Cathodic Protection Effectiveness, Past Cathodic Protection Effectiveness, ME (mitigation of external corrosion by direct assessment), and Leak History for External Corrosion.

Window 3 - Internal Corrosion: The Internal Corrosion screen contains the following input boxes: The Pipeline Segment Has an Internal Lining Applied; Water Is Present in the Pipeline Segment; Bacteria Are Present in the Pipeline Segment; Monitoring for Internal Corrosion is Done; Segment Is Within 10-mile Downstream of a Source of Contaminants; Glycol Injection; Flow Velocity Factor; Leak History for Internal Corrosion; three “characterization” boxes one to characterize Inhibitor use, another to characterize Biocide use, and a third to characterize Gas Corrosivity “MI” (mitigation of internal corrosion by direct assessment); and finally Year of last direct assessment for internal corrosion.

Window 4 - U. Slope: The U. Slope screen allows the user to enter slope and soil parameters that can be used to assess the likelihood of a circumferential rupture as the result of a landslide. The inputs on this screen are Angle, Soil Characteristics, Direction of Movement, and Mitigation Factors.

Window 5 - Flood: The Flood screen allows the user to enter parameters that reflect the likelihood of a circumferential rupture at a water crossing. The inputs on this screen are Type of Crossing, Buoyancy Effects, Tidal Effects, Current Effects, and Scour.

Window 6 – Earthquake: The Earthquake screen allows the user to enter data that represents the likelihood of a circumferential rupture from an earthquake. The inputs on this screen include percentage of pipeline in Earthquake Zones 1-4 as defined by the Uniform Building Code, Fault Crossings, and Earthquake Mitigation.

Window 7 – Subsidence: The Subsidence screen allows the entry of data to be used in estimating the risk of a circumferential rupture from subsidence. The inputs are Soil Friction Factor and Mitigation Factor.

Windows 8 – ROW: The ROW screen is the first of four ROW screens that allow the entry of data relevant to estimating the likelihood of a mechanical damage incident. It contains three input boxes titled Right of Way, Excavation, and One Call Quality.

Window 9 - ROW 2: The format of the ROW 2 screen closely resembles that of the ROW screen, and like the ROW screen, it allows the entry of data relevant to estimating the likelihood of failure from mechanical damage. The ROW2 screen contains two boxes, one titled Operators Maps and the other, Operator Response.

Window 10 - ROW 3: ROW 3 is the third of the four screens that allow the entry of data relevant to the likelihood of failure from mechanical damage. The ROW3 screen contains two boxes, one titled Features of Locator and one titled Patrolling Policy.

Window 11 - ROW 4: ROW 4 is the last of four screens that allow the entry of data relevant to the likelihood of failure from mechanical damage. The ROW 4 screen contains inputs for Public Education Policy, Marking, and Digging Policy.

Window 12 - Losses: The Losses screen represents consequences of incidents. On this screen the user enters data for Percentage in Class 1 Location, Percentage in Class 2 Location, Percentage in Class 3 Location, and Percentage in Class 4 Location. The Next series of boxes includes Migration Factor, Shut Off Factor, Detection Factor, and Loss of Service.

~ Evaluating the Results of the Model ~

Window 13 - Reports: These reports represent the most important output of the model, namely, the identification of the highest risk portions of the system and benefits of carrying out certain improvements or preventative or remedial measures. The probabilities and risk of failure for all segments in the database are calculated and shown in reports for each mode of failure: Material Flaw, External Corrosion, Internal Corrosion, Outside Forces, and Mechanical Damage. The Overall Risk report displays a summary of the risks from all causes and the total risk for each segment. The Cost Benefit Analysis report displays comparisons of segments and their associated scenarios, if any were entered. With these results the user can examine the change in risk that results from expenditure of money either on integrity assessment and remediation or on selective or complete refurbishment. Further, these data show the costs of the improvements and the cost/benefit ratio.

Window 14 - Risk: The Risk window provides the user with a summary of the input factors and the probabilities and risks associated with a particular segment or scenario. This screen is useful primarily as a diagnostic tool for checking input data.

~ In Conclusion ~

The model is extremely comprehensive; it accounts for all of the pipeline threats as identified by the federal regulators as part of the US DOT's Pipeline Safety Integrity Initiative. NYGAS members believe it to be an extremely powerful tool that will help operators to evaluate the risk of failure of each pipeline segment in a natural gas transmission system, determine the highest threat of failure on each segment, develop the most appropriate mitigative strategy for each segment by conducting cost/benefit analyses, and identify the order that baseline assessment should follow as well as when reassessment should occur. It will enable operators to respond to the impending regulation in an organized and cost-effective manner.

The NYGAS members have been exercising and testing the model as it has evolved. With use, its effectiveness will become better known, and it should be changed in appropriate ways if faults in it are revealed. As is the case with all models, the more extensively they are used, the better they become. By testing the model as we have done, we believe we have arrived at a truly representative pipeline integrity model.

~ Model Cost ~

The base cost for the model is \$ 12,000.00; annual licensing fee is \$1500 to cover 30 hours of telephone/e-mail support and software upgrades. Included in the base cost are the following: (1) Users' Guide that explains all features of the model step by step and includes a sample base case and several scenarios derived from the base case to illustrate the use of the cost/benefit features; (2) comprehensive final report written by Kiefner & Associates for NYGAS that includes, discussion of pipeline threats, and the rational, equations developed, and explanation of all factors that underlie the equations for all algorithms for each category of risk; (3) designation of a company representative to join a users' group to share ideas and information. The group could help each other with questions and answers, identify bugs and circulate suggestions for improvements to the model. Meetings could be scheduled if needed to work on major issues/enhancements.

For an additional charge, the user can choose to enter into an on-site or off-site training program. These programs are to be developed depending upon level of interest.

~ Contacts ~

For additional information regarding the model or if you have questions regarding purchasing the model please contact: Dr. John Kiefner, Kiefner & Associates, 614-888-8220, jkiefner@kiefner.com, or Debra DiMeo, New York Gas Group, 212-354-4790 x 216, ddimeo@optonline.net.