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Collecting and Managing Pipeline Information for Compliance and System Integrity.

John Linehan, GISP

ABSTRACT

Enbridge Energy is going through an evolution in the methods used to collect and report information for pipeline compliance and system integrity. This evolution is steering the company to use data models and off-the-shelf GIS tools to query, manage, and store the increasing volumes of required data.

This paper will discuss the approach Enbridge Energy is adopting to collect the necessary information such as using sub-meter GPS, calibrated smart pigging, and aerial interpretation. The goal is to economically gather, model, and process data for reporting items such as Integrity Management Plans, DOT class, High Consequence Areas, centerline location, and for maintenance budgeting in a timely and efficient manner.

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Necessity

The purpose of any pipeline integrity program is to insure that the pipeline operates in a safe and reliable manner. The integrity program is based on observing and testing the pipeline system to discover and mediate areas of concern. While prudent for operators to employ an integrity program for the continued economic operation of their pipeline, several federal and state agencies are also dictating a program be in place.

Beginning with the Natural Gas and Pipeline Safety Act of 1968 and the Hazardous Liquid Pipeline Safety Act of 1979, operators were required to enact specific public safety measures for their pipelines. The Pipeline Safety Improvement Act of 2002 expanded integrity requirements to include defining and monitoring High Consequence Areas (HCA's). Federal regulation 49 CFR 192 Subpart O defines the integrity management requirements and the creation of a Baseline Assessment Plan (BAP) to assess the integrity of at least 50% of an operator's pipelines by December 2007 and all pipelines by 2012.

The core of an integrity program is comprised of several items of data including the physical characteristics, the surrounding environment, and repair and maintenance work performed on the pipeline. The American Society of Mechanical Engineers (ASME) manual B31.8S 2001, describes the methods and data items necessary to create and maintain an integrity program for gas pipelines. There are 22 listed root causes that represent threats to a pipeline. Each threat covers specific areas of the pipeline such as corrosion, external damage, and manufacture failure. To support the evaluation of each of these threats, the operator must collect and process hundreds of data elements such as pipeline diameter, age, operating pressure, centerline position, and HCA locations. Management and reporting of this information is best accomplished using a Geospatial Information System (GIS). The need for processing this information in a timely and efficient manner is the basis for an accurate and functioning integrity program.

Tradition

Pipeline companies generally function in two groups, the office and the field. Field operations concern themselves with the physical operation of the pipeline including repairs, construction, and testing. Office operations are concerned with filing regulatory reports, accounting, and product sales. Unfortunately, what happens in one group is seldom reported to the other.

Traditionally, the field offices operate and maintain the pipeline and by default they have a core integrity program in action. However, this plan is generally reactive in nature suggesting that problems are mediated when discovered. Documents and reports that result are generally stored as hardcopy in the field office, commonly in the operator's desk drawer. After a time, these documents are placed in boxes and moved out of the building and generally forgotten. What is pertinent is often only stored in the operator's bio-database or head. Collecting and moving this information to the master database supporting the integrity management program is a priority.

The corporate office is generally not much better in data management than the field offices. The problem is data silos. Each corporate group, such as sales, safety, operations, or regulatory, for example, has their own methods and data storage files. Intercommunication between these groups is a common problem for an overall integrity management plan. Often the data is stored in local proprietary databases that are not readily accessible by other users outside the department. Creating pathways for the master integrity database to communicate with these small datasets is essential.

Aspiration

A successful integrity system is dynamic, manageable, and ever-green. It should be comprehensive, containing or accessing all of the essential data to create and manage pipeline integrity in a centralized location. A change control process should be enacted to assure the quality of data used in the evaluations. The system will allow users to create custom reports or to generate pre-designed reports and maps as needed. Finally, an integrity management system should have a comprehensive documentation and archival process.

Attaining the integrity management system will require cooperative effort between several groups including field operations, GIS, integrity auditing, compliance and central office management. Field data collection procedures should be well defined and implement the use of forms or templates that include items that are essential for integrity. Once collected, the process for forwarding the information to the integrity database must be outlined and followed. The core data should be centralized and organized using a robust model designed for pipeline integrity management. Associated data, from groups such as corrosion, operations, and measurement should be kept within their respective department databases for maintenance, but contain links into the core integrity database for processing.

Progression

There is a story during the great space race with the Soviet Union concerning our NASA scientists. During one of the Apollo-Soyuz joint project meetings, our scientists were proudly showing off their new "Space Pen" which took months to design and thousands of dollars to meet the requirement of building a writing instrument that worked in zero gravity. Chiding the Soviets as to what they came up with, the Soviets simply replied that they used pencils.

Creating a super system that due to its size, budget, and complexity may perform all the desired tasks and store the necessary information could have a downside of alienating its users, who then revert to old methods. The design and construction of a comprehensive integrity management system should include a full study of the current methods and how they may be compiled into the larger project. The evaluation should review field practices on collecting requisite information, the flow of that information to the various groups, and the storage and reporting of the collected and processed information.

Collection

The process of collecting field data is generally fallen into the hands of the field technicians, who have other duties as well as capturing data for a corporate integrity database. Several on-site, field collection methods have been presented by various vendors and corporate staff that include using digital devices, such as laptops, GPS data dictionaries, and PDA's to store information in local mini-databases. These devices seldom stand up to the rigorous field environment and are often rejected by the technicians due to complexity, being cumbersome, or by being responsible for the unit incase of loss or damage. Additionally, these methods require training on using the application, connecting to the central database, and updating the information.

The combination of the traditional field method of using pencil and paper forms combined with the concept of website database updating is a viable solution that has minimal cost and low impact on the field technician's workload. The process involves the field technician collecting the required information on a paper form and handing the forms to a field office worker at the end of the day. The office worker then quality checks the reports and logs the new information into the database using a desktop connected to the corporate database via the web. The office worker is the only person that requires training and becomes the central point of contact for issues concerning quality. To assist in the loading of information into the database, the forms should mimic the field names, table structure, and hierarchy of the database for the specific items collected. Once processed, the worker may file or archive the paper form according to corporate procedures.

Management

The integrity management system is changing constantly because of new additions to the system, enhancements and repairs to existing pipelines, scheduled pipeline testing and assessments, and the encroachment of population into the pipeline corridor. Managing the flux of data is accomplished using data editing tools designed to work with the database structure. Using generic editing tools found in GIS, CAD and database management applications could apply, however attention should be paid to addressing the relationships between tables in the selected model. Vendor tools designed to maintain these relationships while allowing data editing may be costly, but the ease and speed of their use generally offsets that cost.

All changes to information stored in the database should be tracked and documented. This process may be a simple time-stamp applied to any edited feature or attribute that contains the editor's name and time of change. For some items in the database, regulations may dictate that a full change control process be enacted to contain signatures of authorizing parties allowing the change. Quality assurance of the data is another faction of change control that should be managed to include completeness and accuracy of information entered into the database. While tools exist to manage change control and quality assurance, these procedures are best managed using company standard practices.

Storage

Designing the central database is also a concern when building tables to store information. Care must be taken to not overburden the database with information commonly stored in other databases or by storing information that has minimal impact on the integrity evaluation process. The selection of a pipeline integrity database model is prudent in trimming extraneous data and reducing design time and costs. There are several models designed for pipelines as well as several methods and platforms to store the collected information.

A review of the data processing methods should be made to select which elements and methods used to manage the integrity data is most efficient. Selecting and altering an off-the-shelf model is advisable to reduce costs. However, altering the model should be restricted such that the original core structure is not changed. This restriction adds value to the resultant database if the pipeline system is sold to someone who uses a similar model. Additionally, the selection and use of generic, vendor-developed tools to manipulate the data minimizes customization and reduces costs when using the core model design.

Reporting

The core essence of a pipeline integrity management system is to review information concerning the pipeline and calculate a probability of failure of that pipeline. This probability is then weighed against the probability of causing injury or damage to population and environment. Factors used in this calculation include the physical characteristics of the pipeline, the pipeline's operational parameters, the location of nearby HCA's, the location of DOT classified congested areas, and the impact of external forces including weather, soil and third party activity. Other factors such as test results and information collected during pipeline assessments and repairs are also included in the evaluation.

There are several vendors that have tools that will evaluate a pipeline's risk and then generate the information necessary to support an integrity management system. A key factor in the selection of these tools is the ability to translate information from the integrity database to the vendor's tool for processing. Selecting tools that require intermediate databases may lead to version confusion and could have difficulties in translating the results back into the master database. The tools should allow the user to set defaults to override any missing information which could yield false rankings of risk.

For the tools to work accurately, it is essential for the integrity database to contain all pertinent data or to have realistic default values to obtain a true risk ranking.

Attainment

In late 2004, Enbridge Energy's southern division embarked on creating a comprehensive integrity management system for its natural gas pipelines. Prior to the project start, the integrity responsibilities were divided into autonomous groups based in the field offices. Creating a centralized integrity program and generating a comprehensive baseline assessment plan required the diverse field processes be unified and managed in the corporate office in Houston.

Following an internal best practice audit, the project kicked off with the assistance of GE/MJ Harden. The initial system was developed on a modified APDM version 2 model supported by an ArcGIS Editor desktop augmented with GE's PipeView tool. The database was installed using ArcSDE on a Microsoft SQL platform. Initial risk rankings and HCA determinations were defined using Bass Trigon tools from AmerInnovations.

The initial process defined a primitive baseline assessment plan indicating the top 50% of pipelines on which to focus further development. This development included refining the pipeline centerline location using as-build sheets, field notes, and construction files. Attribute data collection centered on the line pressure and diameter to capture an initial Potential Impact Radius (PIR).

Processing the initial top 50% of the pipelines also yielded shortcomings in the model and the collected data. The model was easily altered; however, the absence of attribute data was a major concern. The construction alignment sheets did not have many of the elements used in an assessment, such as wall thickness or current MAOP. This information was stored as hardcopy in the pipeline segment's job book which resided in the field office. A review of the field office job books also revealed that many of the documents were originals and did not have archived copies. Enbridge resolved this issue by contracting a service to scan all documents to an Adobe PDF format and then archiving the originals offsite. The scans were cataloged using the line name and accounting AFE number. GIS technicians read through the documents to find and enter the missing attribute data. Once completed, the scans were associated to their respective line segment and stored as external documents in the model.

Another aspect of integrity determination is the location and identification of HCA sites and structures along the pipeline corridor. This issue has been resolved using software and technical help from Petris Technology. Petris supplied custom aerial imagery for digitization of structures and then calculated DOT class zones and HCA zones using their suite of tools. The results were directly ported into the database to support system risk ranking.

The overall discovery during the construction phase is that one must pay detailed attention to the methods the database information is updated, utilized, and reported by vendor tools. Selecting tools or support from a vendor that does not fully interact with the database model leads to conversion and translation errors. Additionally, attribute information must be documented to store the source and quality of the data. Discovery of new information on a segment may conflict with information from another source. Having detailed documentation and metadata alleviates this issue.

Posterity

Enbridge Energy has fully embraced the GIS as the core for evaluating and managing integrity data and for creating accurate baseline assessment plans to comply with regulations. Enbridge has a fully loaded ArcGIS Pipeline Data Model version 4 database in test with a scheduled mid-summer production date. The APDM 4 model will be supported using the full suite of ArcGIS 9.2 desktop and ArcServer technology along with editing tools from GE. HCA and DOT determinations are based on results from the Petris tools which feed into the risk ranking tools from Dynamic Risk Assessment. Future plans for the system include assessment and maintenance scheduling, system modeling, and support for associated groups such as Tax, Regulatory Affairs, Measurement, and Construction Engineering.

John Linehan, GISP
Sr. Technical Data Specialist
Compliance and System Integrity
Enbridge Energy Company, Inc
1100 Louisiana, #3300
Houston, TX 77002
(713) 353-6384
John.linehan@enbridge.com

John Linehan
Introductory Bio Statement

John has multiple degrees in geology and geography and had 10 years experience as a petroleum explorationist before moving into pipelines. He has worked over 20 years in pipeline GIS and has served on several advisory boards including the NPMS database design team. He is a past president of the ESRI Pipeline Users Group and has published several articles in ESRI books and magazines concerning GIS applications for pipeline operations. He is a 30 year, active member of the American Association of Petroleum Geologists and was granted GISP certification in April, 2004.