FILLING INTEGRITY MANAGEMENT GAPS:

**Internal Inspection Technologies**

With events of the past few years, it has become clear that a more thorough understanding of the composition, features, and condition of both distribution and transmission assets is required.

In response, GTI recently launched an Internal Inspection Optimization Program, a new effort designed to facilitate the development and implementation of internal inspection technologies to meet regulatory requirements. Beginning with the creation of an R&D roadmap sponsored by Operations Technology Development (OTD) and Pacific Gas and Electric Company (PG&E), the program will provide the industry with new tools and solutions for integrity management.

"At GTI, we're helping the industry identify new data and technical capabilities that operators will need to improve the accuracy of their integrity inspections," says Daniel Ersoy, GTI R&D Executive Director.

**New Directions for Internal Inspection R&D**

In 2012, a team of researchers led by Ersoy kicked off the first phase of GTI’s new Internal Inspection Optimization initiative with the development of an R&D roadmap designed to guide the direction of...
Field Data Collection  

continued from front page

future internal inspection technology projects. After an exhaustive search of published industry literature, in-line inspection (ILI) vendor surveys, and subject matter expert interviews, a comprehensive set of data on the capabilities of current sensors and platforms was compiled. To understand the technology landscape, GTI identified all of the base elements of the 21 standard pipeline threats that need to be measured. The ability of currently available sensors to measure these base elements was then cross-linked to the available sensors and platforms to identify technology gaps.

The gap analysis was then prioritized and used to create an R&D roadmap to guide future research activities. The recommendations from the roadmap include:

> Incorporate material characterization tools onto in-line platforms to validate incomplete or missing records.

> Continue developing and implementing unpiggable pipe inspection platforms that overcome barriers such as low flow, dead legs, small or variable diameters, bends, plug and other valves, and additional reduced-diameter features.

> Continue development and validation of electromagnetic acoustic transducer (EMAT) tools for improved wall loss and crack detection including tools for small diameter and unpiggable pipe.

> Increase the accuracy and precision of magnetic flux leakage (MFL) sensor technology.

> Develop an internal inspection platform that can transport guided wave ultrasonic testing (GWUT) sensors for improved characterization of planar defects.

> Continue the development, testing, and validation of acoustic resonance technology (ART) for detecting and characterizing volumetric defects that cannot be addressed with MFL.

> Develop inspection and assessment tools that could serve as alternatives to hydrotesting.

> Develop tools that can provide improved strain characterization of dents and deformations for pipelines.

> Develop a sensor that can detect geomechanical strains that are difficult to detect with existing ILI tools in a single run.

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emerging regulations. In this issue of Gas Operations News, you’ll learn about the internal inspection technologies we’re working on, as well as new platforms for inspecting unpiggable pipelines. We’re also working to validate technologies that can serve as alternatives to hydrotesting, a new method for determining pipe yield strength that can be accomplished using small pipe samples, and a host of new tools for assessing and tracking threats to pipelines.

Our dedicated team is building, organizing, and maintaining applications that combine sound science with applied models to drive informed decision making. Our focus is on better integration of field data and risk assessment methods to provide optimal results. In addition, GTI is working with key stakeholders in helping to support integration of these results into industry guidelines, standards, and regulations.

We are very cognizant of the importance of coordinating efforts with industry associations to make sure there are no overlaps in efforts and to ensure that solution development is as efficient as possible. By consolidating projects and activities, all the industry’s knowledge and expertise is brought to the table to provide the most comprehensive solutions.

One key example of this is GTI’s Inspection Technology Strategy Tool, which combines the datasets and information being developed by GTI, Interstate Natural Gas Association of America (INGAA), Pipeline Research Council International (PRCI), and Operations Technology Development (OTD) into a software tool/relational database. (See page 3 to learn more.)

More information about the industry associations and their initiatives is available online at prci.org, ingaa.org, and otd-co.org.

Edward B. Johnston  
Vice President, Research and Development
Inspection Technology Strategy Tool: Serving Dual Purposes

“Moving forward with our industry partners, we will now be able to make informed decisions about where R&D efforts should be focused,” says Ersoy. A New Strategy and Selection Tool

With a new R&D roadmap developed and priorities set, the GTI team looked at ways in which they could integrate data from their own research with that of other industry organizations to create a tool to further develop the roadmap (see sidebar). The result will be a new software tool designed to assist the pipeline industry in developing a strategy for selecting and expanding the capabilities of inspection technologies.

The tool will enable operators to input data about vintage, material properties, and construction techniques for a specific pipe segment in order to identify potential threats and select the most appropriate inspection technology. In addition, the tool will help the industry identify pipe configurations and threats that current technologies cannot address. Based on gaps identified, the industry will be able to quantify the potential market for new inspection technologies and focus R&D efforts on solutions for the highest-priority applications.

“The work that GTI is doing is very impactful and has significant industry sponsorship from operators and important organizations like American Gas Association (AGA), INGAA, PRCI, and OTD,” notes Ersoy. “The inspection technology strategy tool, delivered as a comprehensive relational database, presents extensive data in a simple tool to optimize new technology development. GTI is playing a unique role in connecting the dots and bringing knowledge and a deep understanding of the issues to create a tool that industry can unite around for new technology development.”

Bringing Together Industry Intelligence

The new Inspection Technology Strategy Tool integrates data from some of the industry’s premier integrity management research projects.

<table>
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<tr>
<th>INGAA</th>
<th>PRCI</th>
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<td>Integrity Management Continuous Improvement (IMCI) Action Plan</td>
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- Incident and mill performance data from PHMSA incident reports (1970–2012)
- Updates of historical material information—including dates, mills, grades, seams, and chemistry
- ILI service providers inspection capabilities
- Vintage pipe sample data

Threat Interactions Project
- Tool to model the interactions of various threats to identify high risk pipe segments based on multiple threats

Internal Inspection Optimization Project
- Database of capabilities of currently available inspection technologies

Industry inputs:
- Current sensor and platform capabilities
- Failure frequencies for threats based on pipe data
- Mileage of pipe with specific characteristics

Output:
Strategy and business case defining the need and market for development of new inspection technologies

Operator inputs:
- Pipe vintage
- Material properties
- Construction technique

Output:
Most appropriate inspection technology to address threats for a specific pipe segment

Assisting Individual Operators

Assisting Broader Industry
Hydrotesting: Searching for Alternatives

In its report following the 2010 San Bruno pipeline explosion, the National Transportation Safety Board (NTSB) found pronounced defects in the pipeline. The report stated that, because the pipeline, which had been installed in 1954, had been grandfathered from testing protocols required of newly constructed pipeline, it had not undergone hydrostatic pressure tests that may have revealed the defects.

As a result, the NTSB recommended that the Pipeline and Hazardous Materials Safety Administration (PHMSA) eliminate the grandfather clause and require that “all gas transmission pipelines constructed before 1970 be subject to a hydrostatic pressure test that incorporates a spike test.”

According to PHMSA, 61% of onshore natural gas transmission lines were constructed before 1970. If the grandfather clause were to be eliminated, the industry would be required to hydrotest thousands of miles of pipe.

Pipeline inspection tools that would be accepted by regulators as alternatives to hydrotesting would provide the industry with significant cost savings. Hydrotesting introduces water into the pipeline that, because it can be difficult to remove completely, leads to potential internal corrosion. Hydrotesting may also contribute to the growth of existing cracks while missing sub-critical defects.

GTI’s Hydrotesting Alternatives Program
With funding support from OTD, GTI is in the first phases of a new program designed to identify and validate technologies that are capable of providing an assessment that is at least equivalent—and, at times, superior—to a construction hydrotest.

A team of GTI researchers began by gathering the pipeline data statistics—including mileage, diameter, vintage, seam and girth weld type, construction method, and restrictions to hydrotesting—that would be subject to the new or retroactive hydrotesting requirements. “We have quantified and qualified the type of pipe that could be subject to new regulations, and we are now developing a strategy for selecting assessment techniques that could be validated as acceptable alternatives to hydrotesting,” says Alicia Farag, GTI program manager.

The team will then select those existing and emerging inspection technologies they believe are the best candidates to serve as alternatives to hydrotests and conduct validation studies as needed. “Our focus will be on those technologies that can assess welds and manufacturing defects that would have failed a construction hydrotest,” Farag says. “Technologies such as EMAT (electromagnetic acoustic transducer) and ART (acoustic resonance technology) are particularly promising. We will work with the appropriate stakeholders to generate a technically sound basis for regulatory acceptance of these assessment techniques to provide operators with an alternative to hydrotesting.”

“There is no safety justification for the grandfather clause exempting pre-1970 pipelines from the requirement for post-construction hydrostatic pressure testing.”
—NTSB report

Photos on this page provided courtesy of Gas Transmission Systems, Inc.
A New Method for Determining Yield Strength

Over the years, operators have been required to establish and maintain MAOP records. Recent high-profile incidents and NTSB comments have placed a new focus on data and establishing MAOP. As a result, operators are now required to provide traceable and verifiable yield strength records. In most cases, operators will be able to uncover these records through exhaustive searches. When records cannot be found, many operators will need to test pipe segments to determine yield strength properties. **Current practices for determining yield strength of in-service pipe require the use of large coupons—procedures in which the line must be taken out of service or bypassed.**

Developing New Methods

In a project sponsored by OTD, GTI researchers have developed a new method for determining pipe yield strength that will enable operators to extract and test small pipe samples without taking the line out of service. **By using standard hot tapping equipment, extracted coupons can now be used in place of full-size samples.**

“We tested and compared the smaller, full-wall specimen cut out from a hot tap coupon with full-sized samples,” says Alicia Farag, GTI program manager. The testing program, conducted on more than 40 real-world pipe samples, validated the new sample size. “The mini specimens were actually found to be superior to the full-sized samples in several respects.”

In fact, the smaller samples provided the following benefits:

- **Always conservative**—on average, the small samples produce a -8.5% lower (conservative) value for yield strength when compared with the full-test method.
- **More robust**—allows four samples to be removed from each hot tap coupon for testing rather than using one full-size sample, which also allows application of a standard deviation and confidence calculation.
- **Simple and more repeatable**—no need to flatten the specimen and extensometers and standard grips can be used for testing.
- **Less intrusive**—uses small-diameter coupon removal with weld-on fitting instead of full-size cutouts.

Recently, one operator was granted the first special permit from PHMSA—and approval from its state regulator—to use the new small sample yield strength testing technique. “GTI is available to support the special permit process, including providing technical documentation and presentations to support the acceptance of this new technique,” says Farag.

GTI is now working to help operators improve sampling methods by using statistical sampling and field verification instead of prescriptive intervals. In order to develop the new method, GTI researchers started by developing a series of synthetic pipeline segments that could serve as a comprehensive set of pipeline populations for yield strength sampling and analysis.

Multiple pipeline segment categories were established and used to generate thousands of randomly generated segments. These segments were then used in sampling experiments using three methods:

- sampling and yield strength calculation according to currently approved federal codes
- advanced nonparametric statistical methods with random sampling
- advanced probabilistic techniques using adaptive sampling.

“Using this method, operators will be able to classify pipeline segment properties with a high confidence level, determine the likelihood of a ‘weakest link’ section, and determine geographic segregation of properties within their system,” says Dan Ersoy, GTI R&D Executive Director. “If the data allows, operators may be able to increase the MAOP of pipe segments or reclassify pipe from transmission to distribution based on new yield strength properties using the new techniques developed in this program.”
While improvements have been made in the safety of regulated pipelines over the last decade, there continues to be a need for more data and new tools for predicting asset performance, calculating system risk, and mitigating threats. “The industry needs more research on potential threats and probabilistic models that use currently available data to develop tools,” says Eddie Johnston, Vice President, Research and Development at GTI.

To that end, GTI is developing a host of new applications that combine sound science with applied models. Multiple teams are focusing on integrating field data and risk assessment methods for better results. Working with key industry stakeholders, they are aiming to turn the results of their various projects into industry guidelines and standards.

Various studies, methodologies, data collection and modeling, and intensive literature reviews serve as the foundation for development of these advanced modeling and analysis tools. GTI is taking the results of this background work to develop a comprehensive view and using it to create tools, such as calculators, that make it easy for operators to manipulate the data and turn the information into actionable items.

Probabilistic modeling will lead to an enhanced level of safety in the operation of natural gas transmission infrastructure. For operators, a standardized methodology to identify, rank, mitigate, and continually track threat interactions will demonstrate a focus on continuous improvement to the pipeline integrity process.

Following is a brief summary of some of those projects, which are designed to increase the industry’s understanding of failure mechanisms and consequences in pipelines.

**Leak Rupture Boundary Calculator**

The leak rupture boundary modeling tool, developed with funding from OTD, is helping operators understand how a pipeline could fail based on material properties and defect size. The new calculator tool with predictive capabilities will enable operators to model potential consequences and implement appropriate preventive measures.

**Threat Interaction Calculator**

While Subpart O regulations and support standards provide guidance for assessing threats, there is only limited knowledge about the interactions of various threats to segments of pipe. Current models only look at single combinations of threats. There is a need for a more in-depth look at various combinations of threats and interactions that can lead to the conditions for failure of a pipeline segment.

GTI has developed a method for computing the risk associated with a set of 21 identified superimposed threats from a catalog of threats in ASME B31.8S, as well as a process for addressing unknown threats. The goal is to develop a program that will facilitate the integration of risk management systems currently in use—such as Excel spreadsheets, fault-tree analysis, and customized programs—into the new system so operators will not need to replace or perform new data mining.

In January, GTI led a webinar demonstration of the new software tools for representatives from project sponsors, including OTD, Pacific Gas and Electric Company (PG&E), and the INGAA Foundation.

“Because the underlying methodology is complex, we’ve developed operating guidelines to help operators integrate the methodology and tool into their integrity management programs,” says Andy Hammerschmidt, GTI R&D Director.

**AC Corrosion Calculator**

AC-induced corrosion is not encountered as commonly as traditional, chemically based external corrosion. But, when it does occur, it happens more quickly—leaving little room for error. In order to reduce the risk of these sudden pipeline failures, it is critical for operators to have the ability to predict AC corrosion rates.

Yet, current guidance is confusing and contradictory and current models and software are not intuitive and are often difficult to use. There is a need for clear and consistent guidelines on the current density required for AC corrosion, particularly in the “unpredictable” zone.

GTI is working to develop a user-friendly software tool—a probabilistic model and calculator—that has the ability to adjust inputs and mitigation techniques. Operators will be able to use the software to predict the effect of various mitigations or changes in environmental factors.
on existing lines. The tool could also be used in the preconstruction stage to optimize proposed designs for new lines.

“The new tool will help operators identify those pipe segments that require additional preventive and mitigative measures,” says GTI’s Principal Investigator on the project, Dr. Zhongquan Zhou, P.E. “The information about AC corrosion rates will enable them to target validation digs and other assessments toward pipe segments with the greatest risk.” The team expects to complete work in the first quarter of 2014.

**Crack Growth Calculator**

New NTSB recommendations and federal and state regulations will likely require increased hydrotesting and spike testing on vintage pipes. Because the industry is concerned about the fact that hydrotesting itself can lead to increased crack growth, there is a need for a model that can help operators predict the effect of pressure-based testing on crack growth rates.

Recently, GTI launched a new project, sponsored by OTD, designed to develop a model that correlates pressurization to crack growth rates for transmission line piping, including crack initiation and arrest. The outcome of the project will be a calculator that will enable operators to use historical pressurization records to identify high-risk pipe segments and predict the impact of planned hydrotesting and spike testing.

“With this new solution, operators can help reduce systemic risk associated with vintage transmission pipeline materials,” says Kristine Wiley, a senior scientist at GTI. “They will be able to target their inspections to include those vintage pipe segments that are at the greatest risk of propagating cracks.”

The GTI team is currently developing the predictive model using small pipe samples, with plans to validate the model with full-size specimens. “A second phase has been proposed to PHMSA which will analyze the effects that excessive cathodic protection levels have on crack growth rates,” Wiley says.

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<th><strong>Modeling and analysis tool</strong></th>
<th><strong>Will help operators...</strong></th>
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<tr>
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<td>Complete, further refinements to continue through early 2013</td>
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<td>&gt; Implement preventive measures</td>
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<td>&gt; Calculate the risk associated with various sets of threats in ASME 831.8S-2010</td>
<td>Demo completed; operating guidelines in development</td>
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<td>&gt; Integrate data from other risk management systems they are currently using</td>
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<tr>
<td>AC corrosion calculator</td>
<td>&gt; Predict AC corrosion rates of various mitigations or changes in environmental factors on existing lines</td>
<td>Completed Q1 2014</td>
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<td>&gt; Optimize proposed designs for new lines in the preconstruction stage</td>
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<tr>
<td>Crack growth calculator</td>
<td>&gt; Use historical pressurization records to identify high-risk pipe segments and predict the impact of hydrotesting and spike testing</td>
<td>Currently developing the predictive model with plans to propose follow-up work with PHMSA</td>
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<td>&gt; Select optimal operating pressures</td>
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NEW PRODUCT INTRODUCED TO MARKET

**Acoustic Pipe Locator (APL)**

A new pipe location technology developed by GTI, with funding support from OTD, is expected to save the industry millions of dollars by helping to reduce the potential for damage to unlocated buried pipes and the resulting incidents that can cause customer outages.

Now available from Sensit Technologies, the ULTRA-TRAC® APL is a handheld acoustic locator to detect and locate both metallic and nonmetallic buried gas and sewer pipes. It can be universally applied for use in most soils and ground coverings such as grass, asphalt, concrete, and dirt.

For more information about the technology, contact Dr. Kiran Kothari, GTI Program Manager. The ULTRA-TRAC APL is commercially available for $15,000 from Sensit, and can be ordered at www.gasleaksensors.com/products/ultra-tracacoustic-pipe-locator.
What About Unpiggable Pipelines?

While the majority of natural gas pipelines in the U.S. can be inspected using standard in-line inspection (ILI) tools, a large portion are classified as unpiggable. Challenges presented by these difficult-to-pig pipelines include internal obstacles, insufficient flow, and changes in diameter.

The industry is seeking ways in which operators can inspect these inaccessible systems without interrupting operations. To support this industry goal, GTI is developing and supporting the implementation of new inspection tools for unpiggable pipe.

Live, Tethered MFL Inspections

High-resolution MFL technology has been used to detect, locate, and characterize metal loss in long-distance natural gas pipelines since the 1970s—and it is still considered to be the most advanced and reliable internal inspection technology for this application.

However, the ability to use MFL tools to inspect short, unpiggable pipe segments under live conditions has not been possible. “The need is particularly urgent for cased and uncased pipelines under railroads, highways, and smaller river crossings,” says Kiran Kothari, Institute Engineer, Infrastructure Sector. “But, until now, it’s been very expensive and challenging to inspect these lines.”

Since early 2000, GTI and industry partners have been working on a solution that enables the application of this technology for inspection of short pipeline segments. The solution uses a tethered inspection system with a special fitting that enables it to enter the pipe and move bi-directionally inside the pipeline. Above the ground, field crews control a hydraulic system that pushes the MFL inspection system through the pipeline via coiled tubing, while the MFL sensor uses a patented technique to reduce drag.

The system makes it possible for inspections to be conducted in live operating conditions, providing real-time data about pipe flaws. “The first iteration of the solution has been successfully tested at several companies,” Kothari says. It is designed for use in 4-inch diameter pipelines operating at less than 60 psi and enables inspection of about 1,500 feet from each side of the entry.

OTD is now sponsoring the development of a 12-inch tethered MFL inspection tool for higher pressures.

Unpiggable Inspection Platform for Multiple Sensors

GTI has partnered with Subsea Integrity to transfer pipe crawler technology developed for the off-shore industry to the on-shore natural gas industry for unpiggable pipe. The technology is a platform using brush-drive motors to transport one or more sensors for inspecting long sections of pipe. The current version of the tool can travel distances of up to one mile from a single excavation for 10” and 12” pipe with an MFL sensor. On-going developments will increase the diameter range, sensors and travelling distance.

GTI is supporting field trials for the pipe crawler tool in 2013 with OTD companies.

“This technology shows great promise for overcoming many of the issues associated with the inspection of unpiggable pipelines. We are excited to be partners with Subsea Integrity and we look forward to supporting implementation and further development with new sensors,” says Farag.