Observations on the Application of Smart Pigging on Transmission Pipelines

A Focus on OPS's Inline Inspection Public Meeting of 8/11/05

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"Clear Knowledge in the Over Information Age"

This report is developed from information clearly in the public domain. The views expressed in this document represent the observations and opinions of the author.

Executive Summary

Smart pigs, also known as inline inspection ("ILI") tools or intelligent pigs, are electronic devices designed to flow on the inside of a transmission pipeline, usually while the line is in service, to inspect a pipeline for various types of anomalies that can increase the risks of pipeline failure.[1] This paper comments on observations pertaining to the Office of Pipeline Safety's ("OPS") public meeting of August 11, 2005 in Houston, Texas.[2] Approximately 400 industry, pigging vendors, and regulatory representatives attended this meeting, dramatically underscoring the gravity of this important subject. This author concurs with the public meeting announcement and fully supports and is committed to assisting OPS's effort, and many in the industry, to advance the prudent application of ILI in gas and liquid transmission pipeline systems. OPS has a long history of encouraging technical development to improve pipeline safety.

Smart pigging has taken on an even more critical role with the promulgation of integrity management rulemaking in the last several years.[3] In some situations pigging is not the best or preferred inspection method for various reasons, especially if the technology is misapplied, oversold, or the pigging process and information mishandled. It is extremely important to recognize those situations where smart pigging technologies have not advanced sufficiently, or where the pigging process is incomplete such that it interferes with inspection quality. In such misapplications, ILI may not be effective or warranted. It is crucial to properly communicate to the industry and the public the appropriate limits of this important technology, especially those tools still in development.

This white paper briefly describes various smart pig technologies, outlines several new industry standards (including the just released API 1163),[4] that should advance the proper utilization of smart pigs, comments on the 8/11/05 public meeting, and identifies areas where further pigging research, development, and advancement are necessary. Smart pigging, when properly applied, can serve as a superior inspection tool for many risks of concern over other integrity inspection methods. A proper smart pigging program can play a vital role in integrity management ("IM"). This author advises that OPS "stay the course" in ILI efforts, but continue its oversight of the inspection repairs and IM process to assure continual improvement. It is expected that the new standards discussed in this report will play a significant role in this continual improvement. An Advisory Bulletin alerting industry, regulators, and the public on the new standards, and OPS's critical observations and expectations on the ILI process, should be issued.

Smart Pig Types – A Brief Overview

Smart pigs are a combination of sophisticated electronic devices utilizing various technologies and include signal sources, sensors to detect various anomalies, onboard computer(s) to gather and collect data, and power sources to drive all the electronics. Together this equipment mounted on a pig sled can

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[1] An anomaly is an imperfection in the pipe wall or weld. All pipelines have anomalies and most anomalies are non-problematic (e.g. many anomalies will not grow or go to failure over time). One objective of integrity management is to specifically identify/control anomalies that can possibly fail.
[2] Office of Pipeline Safety meeting announcement web site, http://primis.phmsa.dot.gov/meetings/, "Public Meeting on Operator Use of Inline Inspection Devices, August 11, 2005.
[3] 49CFR192 Subpart O for gas transmission, and 49CFR195.452 for liquid pipelines.
[4] API 1163, "In-line Inspection Systems Qualification Standard," First Edition, August 2005, issued August 5, 2005.

easily exceed several tons in weight, especially those tools for larger diameter pipelines. The term "smart pig" is utilized to differentiate the tools containing sophisticated electronics from more conventional pigs such as cleaning (i.e. poly, brush, bullet, etc.), gauging, or batch pigs that are simple mechanical devices run in pipelines for various purposes. To get an appreciation of the complexity of smart pigs, the following pig vendor web sites have excellent pictures of various pigs:

http://www.roseninspection.net
http://www.gepower.com/prod_serv/serv/pipeline/en/index.htm
http://www.tuboscope-pipeline.com

Depending on their specific technology, smart pig devices are utilized to identify certain imperfections in the pipeline that might lead to future failure, either leak or rupture. OPS initiated the 8/11/05 public meeting raising questions about the use of ILI, after observing pipeline failures in systems where smart pigging had been performed. This paper presents observations and perspectives from the point of view of Accufacts Inc., who was commissioned by the Pipeline Safety Trust to attend that meeting. We clearly support OPS's efforts to expand and clarify the proper selection and use of inline inspection devices where appropriate, as continual guidance efforts are needed in this area. Many pipeline companies are well versed and experienced in the proper application and limits of various smart pig tools, while other pipeline companies are not. The public meeting was needed to raise the bar on understanding the use of this important inspection method. Frequently ILI can prove superior over many other inspection methods, provided the right ILI tool and pigging processes are utilized, and the pipeline operator clearly understands the limits of these tools.

From the author's perspective, smart pig tools fall into four basic general categories or types: 1) general metal loss, such as corrosion or gouge detection,[5] 2) dimensional information tools intended to determine roundness or cross section of the pipe, 3) pipeline position or mapping tools, and 4) specialty pigs, designed to address certain specialized risks of concern or threats on transmission pipelines.

Four Basic ILI Types

- **General Metal Loss**
- **Dimensional**
- **Mapping**
- **Specialty**

General Metal Loss Smart Pigs

General metal loss is usually associated with general corrosion that occurs in the parent metal of the pipe wall. As a result, the corrosion rates tend to be slower (relatively speaking). Pitting corrosion is a special form of general corrosion where the corrosion rates have been accelerated and focused in a specific location of the pipe wall for various reasons. Smart pig tools have improved considerably in the area of general corrosion determination over the past 30 plus years

[5] Gouge is defined here to mean a loss of pipeline wall from an external mechanical source that results in sharp edged grooving or a valley in the pipe wall. Gouge is a different risk of concern than gouge within a dent.

and fall into basically two different technical approaches: conventional magnetic flux leakage ("MFL") or conventional ultrasonic (called compression wave).[6] By conventional, I mean that the tool uses technology with the signal forces aligned with the flow of the pipeline (along the axis of the pipe) for MFL, and directly (radially) into the pipe wall for ultrasonic sound waves. While not making light of the many technical challenges that had to be overcome, these orientations were the easiest to develop and met many of the pipeline operator's needs of the time. General metal loss tools over the years have advanced because of improvements in specific technology such as probe resolution and number (a byproduct of electronic miniaturization), advances in computer power, and power storage improvements. Given the preponderance and significant role of general metal loss pigs in the industry, I need to spend a little time describing their approach.

Conventional magnetic flux leakage ("MFL") pigs utilize powerful magnets on the pig to impart a magnetic flux in the pipe steel along the flow axis of the pipeline. A change in magnetic flux (the leakage) in pipe steel occurs where metal is missing in the pipe wall and this flux change is measured and recorded by instruments on the pig. After the pig has been run and the data retrieved, the flux leakage signals are interpreted via various proprietary software algorithms, experienced personnel, and extensive comparison database files to properly decipher these signal measurements. There are several different resolution versions of MFL now offered as the number and sensitivity of the measurement probes is increased to improve resolution.

Conventional compression wave ultrasonic technology directs high frequency sound waves from probes located on the pig radially into the pipe wall and measures the delay in the return reflected signal to identify metal loss (a process analogous to radar). The data gathered during a pig run are also analyzed, but ultrasonic incorporates more direct measurement and tends to be less prone to misinterpretation as the measurement process is not as "algorithmic" or prone to mistranslation as MFL. Software, however, is often also utilized to assist in the presentation of very large volumes of data received for ultrasonic measurements.

The latest generation of general metal loss ILI tools of the higher resolution variety can be highly reliable in distinguishing between external and internal general corrosion loss, and very effective at properly sizing such anomalies, provided other pigging processes are implemented and followed. Accurate sizing determination is important in formulating possible time to failure estimates as well as calculating allowable safe operating pressures. Conventional ultrasonic smart pigs require a liquid couplant between the sonic probe and the pipe wall to assure contact and communication of the sound waves. As a result, ultrasonic pigs have historically had limited application in gas transmission pipelines unless a liquid medium or other ultrasonic pig approach is utilized. Using water in a gas pipeline to run a pig defeats a major advantage of smart pigging, as the pipeline has to be shut down. There are special ultrasonic pigs now developed for application in gas pipelines that place the sonic probes within liquid wheels on the pig that contact the pipe, avoiding the need to fill the pipeline with water. Magnetic flux pigs can be used in either liquid or gas pipelines as contact with the pipe wall is not required with this technology.

Another subset of general metal loss is metal removal associated with pipe damage that causes gouging of the pipe wall. The major difference associated with gouging forms of metal loss versus corrosion is that gouges tend to be sharp edged while corrosion is usually soft edged (varying metal

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[6] Unfortunately, the author cannot avoid the use of acronyms common in the industry. For quick reference, a list of acronyms utilized in this paper is summarized on the last page of this report.

loss at site). Sharp edges can concentrate stresses and essentially lower the thresholds at which the pipe can fail as compared to corrosion. Depending on gouging alignment and size, there can be a low reliability in the ability to determine the presence of gouges with either magnetic flux leakage or conventional ultrasonic smart pigging tools.[7] Special care must be exercised in the proper selection of pig technology if gouging (i.e. third party damage) is a risk of concern that needs to be investigated on a particular pipeline segment. Pig tolerances play a critical role in their ability to determine gouging. None of the standards are very clear as to which ILI technology is best at determining gouge damage on pipelines. Recognizing that current pig technology concerning gouges is still improving, federal pipeline regulations now require additional actions on certain indicators (i.e. dents on top half of pipe) that might suggest the presence of gouges. We believe these regulatory efforts to be reasonable, but champion continued advancements in ILI to clearly determine gouges.

Dimensional Smart Pigs

The second general type of smart pig is one utilized to determine various types of dimensional information on a pipeline. A dimensional pig tool can be identified as either a caliper or a deformation/geometry ILI tool. Caliper smart pigs are used to determine the internal diameter of the pipeline. Deformation smart pigs are used to determine if the pipe has changed shape, which can be associated with a bend, buckle, wrinkle, ripple, dent, ovality or other conditions that affect the pipe's roundness or symmetric cross section. Geometry tools are essentially deformation tools and the industry has sometimes interchanged the caliper, deformation and geometry nomenclature causing some confusion. Depending of how the specific tools are set up, either technology may determine dents though exact position and size of such anomalies are pig specific, falling usually under the auspices of the more complex deformation/geometric pigs. Until a more consistent nomenclature is incorporated throughout the industry, it is important when discussing dimensional pig tools to clarify what the particular tool was looking for before coming to any specific conclusions about a particular dimensional tool's run or its purpose.

Mapping Smart Pigs

A third type of smart pig tool is the mapping, also sometimes called a geo-positioning or pipeline position, tool. Historically, these ILI tools have utilized inertial sensing, but more recently global positioning system ("GPS") technologies are more likely to be used to develop an approximate pipeline position or an alignment profile (elevation and plan view).[8] Under certain situations these tools may also be utilized to determine load stresses on a pipeline segment. Such loading conditions can occur from pipeline settlement, for example.

Speciality Smart Pigs

The fourth general category of smart pigs is classified as "specialty" tools, smart pigs that have been developed to address unique needs that generally don't occur on all pipelines. Metal loss and

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[7] Gouges aligned along the flow axis of the pipe are the most at-risk to failure because of pressure stress forces on a pipeline. Ironically, this alignment is one of the more difficult to determine with conventional smart pigs.

[8] The author believes quite strongly that such mapping pigs should never be utilized to override the requirement for critical field pipeline locates for certain at-risk excavation activity near a pipeline.

dimensional tools tend to be utilized in most pigable pipelines. The specialty smart pigs, however, have evolved to satisfy certain risks usually, but not always, associated with older pipe manufacturing and coating processes. These risks fall into the anomaly categories of cracking (either weld or stress corrosion cracking which can be either axial or circumferential), selective corrosion (such as v groove), hard spots, lack of weld fusion, and weld related anomalies or inclusions (i.e. hook cracks).

The specific technologies dealing with these various specialized risks tend to fall into transverse flux inspection ("TFI") and shear wave ultrasonic. TFI applies the principles of MFL but realigns the flux along the circumference (the girth) of the pipe, rather than axially down the pipe as in conventional MFL. Shear wave utilizes ultrasonics but instead of sending the sound waves radially into the pipe, sends the signals at an angle into the inner pipe wall. These changes are trying to provide a sharper indication of the much harder to resolve specialty anomalies that tend to be axially oriented and very "tight," such as cracks. While in theory changing the direction of either signal seems simple, their field application is anything but simple. In TFI the permeability changes in the pipe and difficulties in maintaining a constant magnetic flux in the pipe girth direction can interfere with attaining clear results. Also, a whole new set of interpretative algorithms may be required. In the ultrasonic shear wave approach much more data is received and the signal may not be as clear as that for compression wave ultrasonic tools as the cracks can be very narrow. None of these specialized anomalies can be reliably identified by conventional MFL or ultrasonic compression wave approaches.

Special mention should be made of a developing smart pig technology called electromagnetic acoustic transducer, or EMAT. This technology uses electronics to generate ultrasonic waves within the pipe, eliminating the need for a liquid couplant. EMAT can bring the advantages of ultrasonic to gas transmission pipelines. This technical effort is still in the early stages of field application and its use should be considered with sufficient data, such as field verification digs, discussed later.

New Industry Pigging Standards - A Positive and Needed Step

This author fully supports OPS in announcing and holding the public meeting of 8/11/05, a needed benchmark to inform many in the industry. The incidents referenced in the meeting's public announcement come as no surprise based on extensive experience and observations across numerous pipeline operations in North America and elsewhere. While there are many pipeline operators properly applying smart pigging in their operations, there are other companies still developing a learning curve for this important inspection process. Improvements in the rapidly growing ILI process are warranted. To address this challenge, as well as to meet OPS's new pipeline integrity management regulatory demands, a series of industry standards have recently been developed and issued. These standards should significantly advance the reliability, effectiveness, and efficiency of smart pigging inspection in transmission pipelines. These specific standards are:

1. API Standard 1163, "In-line Inspection Systems Qualification Standard," First Edition, August 2005. This overall pigging system umbrella standard governs the other standards to insure a consistent approach in qualifying and applying in-line inspections. Important process steps that all smart pigging programs should include are now defined in this document.

2. NACE International, NACE RP0102, "NACE Standard Recommended Practice In-Line Inspection of Pipelines," dated 2002, provides general guidance in tool selection (for various risks of concern), planning, execution, data, and ILI management

3. American Society for Nondestructive Testing (ANST), "In-Line Inspection Personnel Qualification and Certification," Standard No. ILI-PQ-2005, updated August 18, 2005, focuses minimum qualification and certification requirements for critical personnel analyzing and interpreting smart pig information.

API Standard 1163 ("API 1163") should be considered the master document for anyone wishing to become more familiar with prudent smart pig applications on a pipeline system. While not intending to make light of or belittle very serious efforts involved in developing various pigging standards over the years, this author would recommend that those most interested in pigging start by: 1) obtain a copy of Table 1 in NACE RP 0102-2002 (Types of ILI Tools and Inspection Purposes), 2) gain a very clear understanding of API 1163, 3) read NACE RP0102, and its companion report NACE TR 35000[9] (if additional background is needed), and finally 4) digest ANST ILI-PQ-2005 if your charter includes qualifying/certifying personnel using this method. Of course, additional knowledge of other documents referenced in API 1163 is also warranted as these other documents apply to one's particular pipeline of concern.[10] API 1163 should improve ILI programs where the pipeline operator has determined this inspection method is appropriate for the particular risks of concern on their pipeline. API 1163 is more process and system oriented, clearly defining roles, responsibilities, and ILI performance measures (i.e. understanding pig tolerances and the importance of verifying results). These are critical processes apparently missing in many of the pipeline failures that followed pig runs identified in OPS's announcement of the 8/11/05 public meeting.

Only time will tell if these new core standards have established a sufficient minimum road map to insure the reliable and effective application of smart pigging that fosters the needed confidence in a pipeline's integrity management program. While in certain areas of risk, such as general corrosion, ILI can be a superior method of inspection (identifying very small anomalies, even those not at risk to fail), if a management team fails to use the appropriate processes to analyze, review, verify, integrate and communicate possible issues related to various risks of concern, the best tool will still be ineffective.

Specific Observations on the 8/11/05 Meeting

Given the length constraints for this paper, it is impossible to comment on all of the nineteen or so presentations at the very full 8/11/05 one-day public meeting. This author must focus on several critical key observations. All slide presentations and transcripts of the day's meeting can be found at OPS's web site: http://ops.dot.gov/new/New_2005/ILIPublicMeetingAgenda_file.htm

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[9] A referenced earlier technical report, NACE TR 35000, "In-Line Nondestructive Inspection of Pipelines," dated December 2000, provides addition background on ILI technologies and assisted in the development of the final NACE RP0102 Standard.

[10] Specific sections of ASME B31.4-2002, "Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids," and API 1160, "Managing System Integrity for Hazardous Pipelines-2001," for liquid pipelines and ASME B31.8, "2004 - Gas Transmission and Distribution Piping Systems," and ASME B31.8S, "Managing System Integrity of Gas Piplines-2004," for gas transmission pipelines.

ILI Process Improvements are Warranted

While OPS called the meeting to elicit questions about their observations related to pipeline failures after smart pig inspections, I do not see any attempt on OPS's part to eliminate or otherwise seriously change the important role that smart pigging can play in an integrity management program. Some in the day's meeting have suggested that OPS may be rethinking the use of smart pigging as a bona fide pipeline inspection method in integrity management. It is this author's opinion that OPS is raising the important observation that there appears to be some process "growing problems" in smart pigging applications, suggesting areas for tweaking and improvement. This should come as no surprise given the complexities associated with rapidly developing and implementing prudent smart pigging programs.

The industry needs to continue evolutionary steps, especially in the specialized pig arena that is pushing developing ILI technology. OPS can and should play an important role in providing guidance as necessary to assure smart pigging lives up to its promise, which should be achievable. Those familiar with the many decades of pigging development understand that while technology theoretically can advance quickly, its field application usually takes a little longer because of various unforeseen complications or surprises. A classic example is the development of the smart pigging tools to determine general corrosion metal loss. Earlier models were not as sensitive or reliable compared to the higher resolution tools of today. In many companies, smart pig inspection has fully evolved, but this achievement did not develop overnight. Growing pains are part of this process and the industry and OPS appear to be taking steps to advance this effort.

API 1163 appears to be a positive step in addressing many of the shortcomings in smart pigging that less experienced companies may not yet understand. Several of the day's presenters identified critical steps or processes that a pigging system needs to incorporate and these are summarized in the following highlighted text box (they are captured in API 1163, though using slightly different terminology in some areas).

Critical ILI Process Steps

- *Identify Risk of Concern on Segment*
- *Choose the Right ILI Tool*
- *Use the Appropriate Tool – Appropriately*
- *Receive & Validate ILI Data*
- *Integrate the ILI Data with the System Data*
- *Feedback and Continual Improvement*

Know Your Pipeline Threats and Use ILI Where Appropriate

Risks of concern are the various 22 categories of threats that can cause anomalies possibly resulting in pipeline failure (summarized in the text box below). These categories are listed in further detail in ASME B31.8S, section 2.2 and were developed by PIRC.[11] The catch-all "unknown" threat should represent a much smaller percentage of reported failures than those

[11] Pipeline Research Committee International, Inc., 1600 Wilson Blvd., Arlington, VA 22209.

reported for past pipeline events, given the additional detail of the remaining 21 threats. I have removed the classification categories of “time dependent,” “stable”, and “time independent” utilized in B31.8S. While it is generally true that many of these threats will fall into the classifications listed in the supplemental standard, there are certain pipeline operational or process changes that can cause threats to shift from one classification category to another.[12] A prudent pipeline operator, if their pipeline is at risk to these possible shifts, will proactively incorporate this dynamic into their inspection and IM program. Given the improvements that are outlined in API 1163, I support OPS incorporating the suggestions made in the public meeting to issue an Advisory Bulletin concerning the use of ILI methods in transmission pipeline integrity management programs. Advisory Bulletins are an efficient and effective mechanism for OPS to quickly and prudently get the word out to industry, regulators, and the public on high profile issues or subjects.

The 22 Risks of Concern (Pipeline Integrity Threats)

External Corrosion	Wrinkle Bend or Buckle	Previously Damaged Pipe
Internal Corrosion	Strpd Thrds/Bkn Pipe/Coup. Fail	Vandalism
Stress Corrosion Cracking	Gasket O-Ring Failure	Incorrect Oper. Procedure
Defective Pipe Seam	Control/Relief Equip Malfunction	Cold Weather
Defective Pipe	Seal/Pump Packing Failure	Lightning
Defective Pipe Girth Weld	Miscellaneous	Heavy Rains or Floods
Defective Fabrication Weld	Damage Inflicted by 1st. 2nd, or 3rd Parties	Earth Movement
		Unknown

Many of the day’s presenters are advising OPS to stay the course on smart pigging efforts and to allow the new standards to take effect throughout the industry. It is clear that pipeline operators with many years of experience through more than one cycle of inspection (especially in the area of general corrosion), are having real demonstrated success in preventing failures. Unfortunately, there is also a wide spectrum of companies that are just entering the ILI process for the first time, or that are running certain types of specialized pigs for the first time. For those just entering the learning curve, the potential to misapply ILI can be high. The new standards should help to quickly advance the proper and prudent application of ILI.

API and AOPL point to their trending plots, suggesting that smart pigging is having a marked impact on their liquid pipeline failure trends based on data for the years 1999 through 2003. I concur with many of these comments, but strongly suggest that OPS continue to monitor and publicly report on pipeline failures and inspection processes utilized, as a few early years don’t necessarily guarantee that the threats are under control. None of the reported data on first pass inspections under IM regulation have been passed on to the public for their review, either for liquid or gas transmission pipelines. For example, generic information about inspection findings reported to OPS (i.e. immediate repair by threat) should be issued to allow anomaly threats to be better understood by the industry and the public.

[12] For example, the operator who is contemplating a significant increase in operating pressure from past operation, can change a “stable” anomaly to a “time dependent” anomaly.

Trust the Course Outlined in API 1163, but Verify the Processes in Each Pipeline Operation

It is very crucial to recognize that ILI tools are important for integrity management, but running the pig is just part of a much larger overall integrity management effort using ILI. This message was also delivered several times by various parties throughout the meeting. In the recent Corrective Action Order issued by OPS to Kinder Morgan, particular attention was highlighted by OPS about the importance that certain information pass among company personnel, especially those functions integrating/evaluating the system integrity data.[13] It is very clear that OPS and many in the industry recognize the significance of integrating and communicating such important information amongst the key personnel in a company. I would expect any Advisory Bulletin to address the new pipeline recommended practices and standards, clarify the proper use of the appropriate smart pig tool for the risks of concern, and acknowledge that the inspection method needs to be properly integrated into a well defined IM program as outlined in current pipeline regulation. While I can appreciate the commercial sensitivities of pig vendors, the Advisory Bulletin might also incorporate OPS's observations as to which pig technology appears to be more effective at determining gouging, given that this information is not very clear in any industry standard.

The Power of Field Verifications

The true statement was mentioned several times in the public meeting that API 1163 does not require mandatory field verification (sometime called calibration) digs of smart pig runs. There appears to be enough process checks in the standard, however, to provide adequate guidance on the importance of verifying the pig vendor's claimed tolerance standards for cited anomalies. In all fairness, for those rerunning pigs, new field verification digs may be somewhat onerous as the pipeline can usually calibrate confidence in tolerance for a particular pig against field verifications utilized from previous pig runs. For those operators utilizing ILI for the first time, or running pigs that are "pushing" developing technology (such as some of the specialty pigs), failure to utilize field verification digs could be most unwise. Pipeline regulation is very clear: the responsibility for the pipeline integrity rests with the pipeline operator. One of the day's panel members wisely said "a pipeline operator cannot contract out their pipeline integrity management program." One other point concerning field verification digs, as any junior engineer who has taken a usually required basic statistics course knows, one or even two field digs is insufficient to develop a verification plot or "unity graph."[14] Conversely, one doesn't need hundreds of field digs on one pipeline to confirm the tolerance claims of a pig tool. A prudent operator should budget accordingly for field verification as needed in their IM program using ILI.

Opportunities for Further ILI Advancement

OPS's efforts to foster continued development of smart pigging technology should be supported. As mentioned previously, such support is especially important for the specialized pigs addressing certain risks of concern discussed earlier. EMAT has been in research for several years and gas transmission pipeline operators are looking forward to the day that this technology reaches widespread industry acceptance. There are, however, several anomaly risks of concern that merit special mention due to

[13] OPS Corrective Action Order to Kinder Morgan, OPS File # CPF No.5-2005-5025H, dated August 24, 2005.
[14] Ibid, 1163 Appendix E, page 33.

their more widespread potential and yet to be reliable available technology. These risks of concern receive special mention because of their nature, possibly resulting in rupture with a very high degree of unpredictability. Their time to failure cannot currently be reliably determined.

Dents with Stress Concentrators

Dents with stress concentrators are dents that occur in pipeline for various reasons and contain either a corrosion site, crack, or gouge within the dent. This anomaly type is not permitted under either liquid (AMSE B31.4) or gas (ASME B31.8/B31.8S) transmission pipeline codes as failure predictions are highly unreliable. Research efforts are underway to advance specialized ILI technology that might confidently determine this anomaly.[15] Pigs can be utilized to determine dents but requiring that all dents be field examined to confirm stress concentrators is extreme and unwarranted. Many dents do not contain stress concentrators and pipelines can tolerate a considerable amount of deformation in the pipe as long as there is no stress concentrator within the dent, or the dent is not on a weld.

Stress Corrosion Cracking (SCC)

While SCC has been getting more public attention lately,[16] this insidious form of corrosion attack has been well known within the industry for many decades. SCC occurs when three specific factors come into play. One of the primary factors triggering attention is disbonded coating (of the non conductive type). In many cases this insidious corrosion may not be observed by the naked eye, requiring instead, special forms of field detection to identify. While shearwave ultrasonic technology has been available for liquid pipelines looking for SCC, gas transmission pipelines have not been able to make general use of shearwave technology because of the need for a liquid couplant between the probe and the pipe wall. There are other operation problems controlling pig speed in gas pipelines in hilly areas that also hamper the use of ultrasonic inspection for SCC. As mentioned earlier, some advances in shear wave pigging design utilizing liquid filled wheels have been applied to gas transmission pipelines. Success has been mixed. This is not just a gas transmission or North American risk of concern. Continued development of pig tools to reliably determine this unique form of corrosion attack is justified.

Selective Seam Corrosion (SSC)

SSC is a specialized form of corrosion associated with older pipelines (commonly referenced by the general nomenclature pre-1970 ERW or FW pipe) that may not have incorporated heat-treating processes that are now standard in modern pipe steel manufacture. As a result, this older pipe may be especially susceptible to an aggressive selective corrosion attack that results in a v-groove being formed along the pipe weld bond line running axially down the pipe. This selective type of corrosion usually manifests itself as a pipeline rupture. Time to failure is not as predictable as general corrosion phenomena. Disbonded coating associated with older pipe also encourages this form of attack for pipe prone to this risk.

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[15] Crouch A. E., and Chell G.G., "New NDE Technology Detects, Characterizes Dent, Gouge Defects," Oil & Gas Journal, August 4, 2003.

[16] OPS Advisory Bulletin ADB-03-5 "Pipeline Safety: Stress Corrosion Cracking (SSC) Threat to Gas and Hazardous Liquid Pipelines," dated 2003.

The Holy Grail Of Pigging

The Holy Grail for smart pig vendors is development of a pig that can find all at-risk anomalies on a pipeline. To paraphrase the Lord of the Rings, think of this as the one pig that can find them all! Currently there is no pig that can accomplish this feat. The pig vendor that comes up with this equipment, while still being able to run inside a pipeline, is going to be minting money. The point worth noting here is very seldom does a pipeline operator run just one type of smart pig as most pipelines have more risks of concern than any one pig can currently determine. It is a rare pipeline IM program that only needs to run one type of ILI tool. Usually, several different types of smart pigs are run at various times to give the pipeline operator full confidence that the risks of concern for a particular pipeline or pipeline segment are being properly evaluated.

A publication and review of the repaired anomalies identified by threat category for the "first cycle" of new required integrity inspections for both liquid and gas transmission pipelines should clearly demonstrate the importance and value of smart pigging to avoid pipeline failure. There are many pipeline companies that understand that a pig run is only one part, and usually not the largest part, of their IM budget. There are companies, however, who also don't appreciate this point and need to modify their budgets accordingly. This is not a problem reserved just for small pipeline operators as changes in the ownership of pipelines can cause confusion in an IM program as institutional databases become lost or confused. Running the pig is the easy part of an integrity management program utilizing this inspection tool.

I am often asked why I don't support 100 percent inspection of all pipelines at this time. Critical to my support of the current regulatory approach focusing mainly on High Consequence Areas ("HCAs"),[17] is the need to improve or advance the various inspection methods, their respective tools, and their processes. The author is not attempting to place a lower value on life or the environment in non-HCAs. It is important to realize the need to improve and evolve inspection methods and not fall into the illusion that the technology or the IM process is foolproof. Poor application of even the best inspection methods will not compensate for imprudent management or poor risk assessment approaches on pipelines, for example. New regulations set baseline inspection and re-inspection intervals for pipelines in HCAs.[18] All too frequently the pigs aren't smart enough for various operating reasons, or the operator is running the wrong pig for their operation. It makes more sense to improve the overall ILI process to insure quality results from proper inspection tool choices and proper management processes, especially as the technology advances. This is particularly important for the types of pigs dealing with the highly specialized pigging threats mentioned previously, where technology has not necessarily been completely developed or sufficiently field tested across many pipelines. Advancing the quality of inspections establishes a high confidence in the pipeline's integrity. Demanding more inspections that are of a poorer quality creates the illusion of safety in pipeline integrity, a situation this author believes needs to be avoided. Illusionary and misplaced overconfidence in the integrity of a pipeline, especially as demands on existing infrastructure push for higher throughputs, carry consequences that are all too predictable.

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[17] HCAs are defined in federal pipeline safety regulation and are different for gas and liquid transmission pipelines.

[18] Current law requires that gas transmission pipelines operating in HCAs be re-inspected at least every 7 years after a baseline assessment (Pipeline Safety Improvement Act of 2002 sec14(c)(3)(B)), and liquid transmission pipelines that could affect HCAs undergo "continual integrity assessment" as defined in 49CFR195.452(j), after their baseline assessment.

Historically, operators were required to inspect their pipelines only once, at time of construction, and some pipelines were grandfathered and exempt from performing even this test. Prior to new regulation, many operators inspected their pipelines under their own internal IM program. All too many operators, however, did not. The critical pipeline infrastructure is now moving to comply with new federal IM inspection regulations that have established new baseline inspections for pipeline sections operating in HCAs. In addition, re-inspection intervals, as previously mentioned, are now required. As various inspection methods permitted under these regulations are further defined and advanced, additional confidence in these alternatives should be gained. For many types of the 22 pipeline risk threats listed earlier, ILI can be the superior method for determining anomalies. The use of superior inspection methods may suggest that current re-inspection periods may be punitive, unnecessary, or unwarranted for certain anomalies. I must strongly emphasize that for an informed discussion to occur on this matter, it is imperative in any re-inspection timing discussions, to clearly communicate and reach an understanding on which anomaly threats the ILI method is best, and why. OPS's public meeting of 8/11/05 was appropriate and an Advisory Bulletin on this issue is justified to insure all get this important message, not just the many responsible pipeline operators that attended the public meeting.

List of Acronyms

ANST- American Society for Nondestructive Testing
AOPL- Association of Oil Pipe Lines
API- American Petroleum Institute
ASME- American Society of Mechanical Engineers
EMAT- Electromagnetic Acoustic Transducer
GPS-Global Positioning System
HCA- High Consequence Area
ILI- Inline Inspection
IM-Integrity Management
MFL-Magnetic Flux Leakage
NACE- National Association of Corrosion Engineers
OPS- Office of Pipeline Safety
SCC-Stress Corrosion Cracking
SSC-Selective Seam Corrosion
TFI- Transverse Flux Inspection