The State of the National Pipeline Infrastructure

A Preliminary Report

Comment [PWB1]: The report only has one trend chart. At a minimum the preliminary report needs to show trends for material and capital expenditures.

Comment [PWB2]: An executive summary is needed

Over the past 70 years, a nationwide system of gathering and transmission pipelines has been constructed to transport almost 100 percent of the natural gas and about 66 percent of the ton-miles of oil and refined petroleum products consumed in the United States. The majority of these hazardous liquid and gas products are transported via large diameter steel transmission pipelines. Approximately 294,000 miles of onshore gas transmission pipelines and 164,000 miles of onshore hazardous liquid pipelines move natural gas, crude oil, and petroleum products throughout the U.S. every day. These pipelines transport commodities from producers, refiners, and processors to industrial and commercial end users, as well as to terminals and distribution companies.

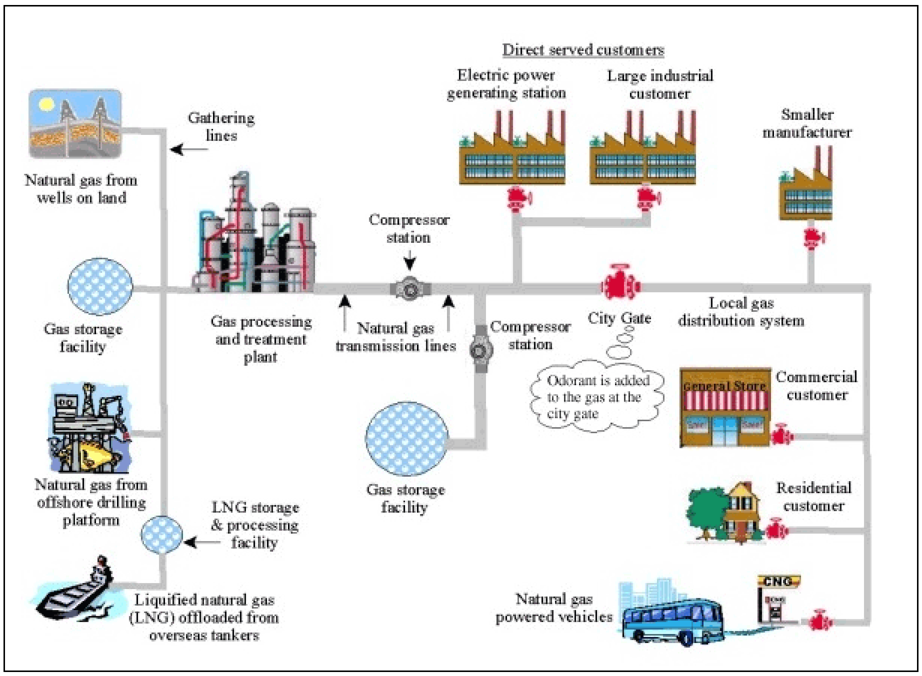


Figure 1: Natural Gas Pipeline Systems: From the Wellhead to the Consumer[i]

Augmenting this network of cross-country pipelines is a gas distribution network which transports gas more locally. Gas distribution lines have delivered gas locally for almost 200 years. There are over 2 million miles of distribution pipelines in service. Distribution pipeline systems exist in restricted geographical areas that are predominantly urban/suburban, because the purpose of these pipelines is to deliver natural gas to end users – residential, commercial, industrial, institutional, and electric generation customers. Distribution pipelines are generally small in diameter (as small as 5/8 ½ inch), and are constructed of several kinds of materials including a significant percentage of plastic pipe.

These pipelines are operated by many thousands of companies, large and small, ranging from giant multi-national corporations to small local gas companies.

Pipeline Risks

Risks to the public from hazardous liquid and gas transmission pipelines result from the potential for an unintentional release of products transported through the pipelines. Releases of products carried by these pipelines can impact surrounding populations, property, and the environment, and may result in injuries or fatalities as well as property and environmental damage.

These consequences may result from fires or explosions caused by ignition of the released product, as well as possible toxicity and asphyxiation effects. Some releases can cause environmental damage, impact wildlife, or contaminate drinking water supplies. Releases can have significant economic effects as well, such as business interruptions, damaged infrastructure, or loss of supplies of fuel such as natural gas, gasoline, home heating oil, and even jet fuel supply at airports. [Comments-such as "contaminate drinking water supplies" mix haz. Liquids and natural gas impacts]

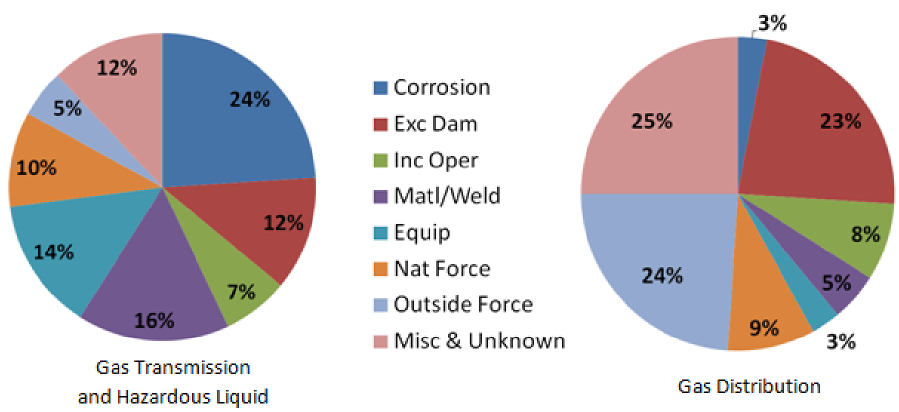
The potential consequences of gas transmission pipeline releases vary primarily due to the characteristics of the surrounding area. Gas transmission pipelines transport natural gas almost exclusively[7]. Natural gas releases pose a primarily acute hazard. If an ignition source exists, a release of gas can result in an immediate fire or explosion near the point of the release. The potential for ignition, however, is reduced over a relatively short period as the gas disperses. If the vapors accumulate inside a building, then the hazard may remain longer. There is also a possibility that the size or movement of the vapor cloud could result in consequences away from the initial point of the release, but because natural gas is lighter than air, this situation occurs rarely. Even so, natural gas has been known to travel underground along migration pathways such as sewer lines, finding an ignition source some distance from the location of the release. Other structures and topographic features in the vicinity of a release can serve as barriers and mitigate the consequences of the release for other nearby areas. And, less acutely, any release of natural gas contributes to the global "greenhouse effect".

Hazardous liquid pipelines transport a greater variety of products (including crude oil, petroleum products, natural gas liquids, anhydrous ammonia, and carbon dioxide), so the risks of hazardous liquid pipeline releases vary both according to the commodity involved as well as due to the characteristics of the surrounding area. Releases of some commodities transported in hazardous liquid pipelines, such as propane, pose primarily an acute hazard of fire or explosion, similar to natural gas. These commodities have a high vapor pressure and are in liquid form while transported under pressure in a pipeline. However, if they are released from the pipeline, they will convert to gas as the pressure is reduced.

Some of these commodities have densities greater than air, so they have a stronger propensity to remain near the ground than natural gas, which disperses more readily.

Releases of other hazardous liquids, such as gasoline and crude oil, have both acute and more long-term potential consequences, as the released product can spread over land and water, flowing into valleys, ravines, and waterways. This can result in harmful consequences to people and to the environment, including human injuries or fatalities from fire or explosion, as well as potential ecological damage and contamination of drinking water supplies occurring some distance from the point of initial release.

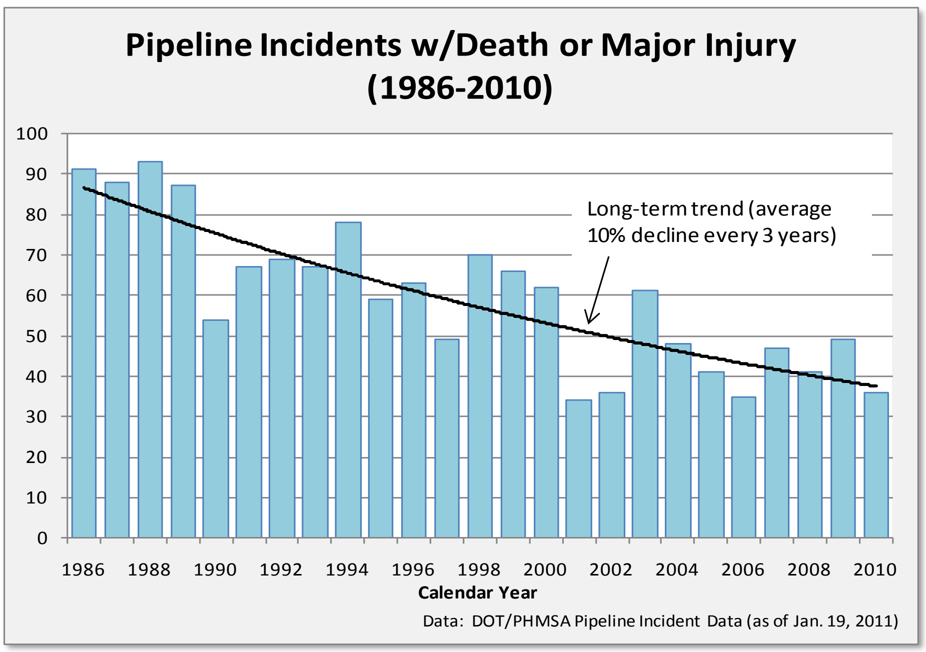
The major causes of pipeline releases also vary based on the type of pipeline involved and the nature of the threats involved. The pie charts below depict the percentages of all causes of significant incidents for the 3-year period from 2008-2010. Corrosion is the leading cause of releases on gas transmission and hazardous liquid pipelines, followed by Material/Weld failures, Equipment failures, and Excavation Damage. For Gas Distribution pipelines, which are concentrated in populated areas where excavation activity is particularly active, Excavation Damage and Other Outside Force Damage are the major causes.



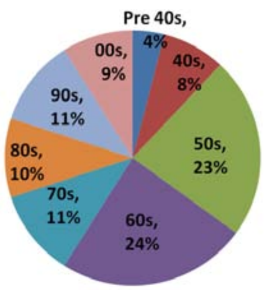
[Should have different pie charts for hazardous liquids and gas transmission lines. Individual factors, such as material/weld/equipment failure are significantly different]

Pipeline Condition

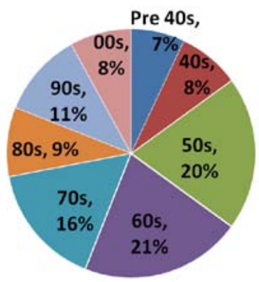
The vast majority of pipelines are in good condition. It is far safer to ship these products through a pipeline than it is to ship it by truck, train, boat, or any other mode of transportation. And the overall trend in pipeline safety has been steadily improving. Pipeline incidents involving human casualties have dropped by more than half over the past 20 years.



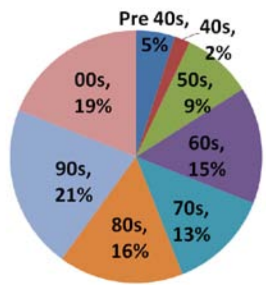
But some of this pipe has been in the ground for a long time. Over 50% of the nation's pipelines were constructed in the 1950's and 1960's during the creation of the interstate pipeline network built in response to the huge demand for energy in the thriving post-World War II economy. And some pipelines were built even earlier. Approximately 3% of our gas distribution mains are made of cast or wrought iron and were built in the first half of the 20th century. Over 12% of the nation’s cross-country gas transmission and hazardous liquid pipelines were built prior to the 1950's. Each of these types of pipelines has its own unique age (and even material) distribution. The following charts depict the percentage of pipelines constructed by decade (50s = 1950’s) for each of the three types of regulated pipelines.



Gas Transmission and Gathering



Hazardous Liquid



Gas Distribution

The first federal pipeline safety regulations were put in place for gas pipelines in 1968 and were based on the standard adopted by most states, ASME B31.8 Gas Transmission & Distribution Piping Systems. And soon thereafter, similar regulations were added covering hazardous liquid pipelines, based on ASME B31.4 Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids. Prior to these rules, operating companies generally used the accepted industry standards for pipe materials, manufacturing, construction, testing, and operation that were considered state-of-the-art at the time of installation. Pipeline materials, corrosion protection methods, and construction technologies and standards changed and by and large improved over time. For example, modern coating materials for steel pipe has greatly improved over those used decades ago, and in the very early decades of construction, no coating was used at all. In addition, pipe welding, inspection and testing techniques have evolved. Many of the welding techniques used earlier have been phased out and replaced by newer, more reliable, and more effective techniques.

Comment [PB3]: Legislation in 1968 with the first regulations in 1970.

That means that some of our current pipeline infrastructure was built using materials and welding techniques that – though considered acceptable and state-of-the-art at the time - are no longer used today. Recent accidents in San Bruno, California and Allentown, Pennsylvania have raised questions in the public's mind about the safety of older pipelines. PHMSA is taking a hard look at the causes and characteristics of these failures to see how future incidents can be prevented. PHMSA is assessing how to accelerate the replacement of pipe to ensure public safety and the reliability of our critical pipeline system into the future. *[For information pertaining to pipelines in a particular State, see this site’s U.S. map.]*

The Department of Transportation has issued a call for action to identify pipe with the poorest performing characteristics within our nation's pipeline system and to determine the course of action needed regarding the repair, rehabilitation, or replacement of these pipelines. [this macro approach with defining broad categories of "bad pipe" is in conflict with the principals of DIMP and the positions of operators at the Pipeline Safety Forum. DIMP principals require operators to identify the worst pipe for **their individual systems** and take appropriate actions. Industry speakers at the forum consistently said that you can't generalize the worst pipe for each operator; one size fits all approach will not work and the real issue is "fitness for service, not age"]

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The first thing we need to do is take stock of what we have.

This preliminary report serves as an introduction to what we know about our nation's pipeline infrastructure, what we need to know better, and what PHMSA is already doing and planning to do to address pipelines of concern.

Where Should We Be Most Concerned?

Comment [PWB4]: Is "we" regulators, operators, public?

Just because one pipeline is older than another does not necessarily mean that it is has a higher likelihood of leaking or rupturing. Materials, corrosion control methods, manufacturing techniques, joining methods, and design standards evolve. Over time some have proven to be better than others. Through ongoing collection and analysis of performance data, the pipes most susceptible to failure can be categorized and profiled. Addressing the pipe in the worst condition most improves the integrity of the pipeline system and has the greatest potential to reduce the risk to the public.

Each material has advantages and disadvantages in terms of long-term serviceability. For example, cast iron has excellent corrosion resistance but has low beam strength. Steel has great physical strength and is less susceptible to failure due to excavation damage but corrodes. Plastic does not corrode but is more susceptible to excavation damage and requires the use of a tracer wire to locate. Within each material category lie subsets of pipe with different levels of serviceability. They may be distinguished due to method of manufacturing, joining, welding, or ability to be maintained.

Not all pipe has performed well over time. We need to identify and differentiate between those pipes that were made using more problematic materials or practices and those that were constructed with materials and techniques that have proven effective. And we need to identify and differentiate between those pipelines that have been adequately tested, monitored, surveyed, assessed, operated, and maintained, and those that have not been. We need to oversee the replacement of this pipe to ensure that it is being replaced. We need to continue to oversee operators and take interim actions to step up the monitoring of these facilities to reduce the risk of incidents while the pipe is being replaced. We also need to expand funding for research and development of new tools to improve pipeline assessments. We need to ensure through inspections that operators are performing these practices and performing them effectively. [again, broad based assessments. Sounds very heavy handed- operators want, and will do the "right thing" given some rate treatment support]

The percentage of pipe that is or has become unfit for service is small, and the vast majority of pipelines are well built, monitored, inspected, assessed, operated, and maintained. Through integrity management programs, operators have been responsible for identifying which pipes in their system pose the highest risk and determine what preventative and mitigative actions to take. Due to the recent incidents, PHMSA is aggressively moving to identify and expedite the repair, rehabilitation, or replacement of pipe which has not performed well historically.

For example, some older distribution mains and service lines that deliver gas to homes were made of cast iron. There are still about 36,000 miles of cast iron main gas distribution lines in the U.S. Most of this is concentrated in five states - New Jersey, New York, Massachusetts, Pennsylvania, and Michigan; 80% is concentrated in just ten states. Washington, DC has 36% of its distribution mains made out of cast iron. Of these, the small diameter cast iron pipes have low beam strength and are particularly susceptible to stresses from underground disturbances, such as ground settlement, freeze-thaw cycles, soil erosion, undermining due to water main breaks, or nearby excavation activities. Preliminary analyses indicate that Pennsylvania has the highest incident frequency for cast iron incidents, and the highest overall incident rate per mile for states that have any significant amount of cast iron pipe. These same analyses at the national level indicate that the rates of cast iron failures per mile in urban settings are no higher than those in lesser populated areas, suggesting that population-related factors may not be significant.

Some types of older ductile iron, most of which was not cathodically protected, may pose a greater risk of failure than cast iron. Fortunately there is relatively little pipe of this material left.

Copper service lines were installed most prevalently during the 1970's. The service piping was connected using brass or steel fittings. The dissimilar materials in the presence of moisture experienced galvanic corrosion. These services experienced a higher than average leak rate.

During the 1970s and 1980s some operators installed pipelines with material manufactured from coiled steel tubing. The pipe was made from malleable steel with an X-Tru (extruded polyethylene) coating. The pipeline was joined with compression couplings and is susceptible to corrosion.

There is also some steel pipe still in service that was constructed before the requirement to provide a protective coating to inhibit corrosion on the outside of the pipe. These "bare" steel pipelines are also of concern. But we also know that some of the older ways that were used to coat pipe have problems. In fact, some preliminary analyses have shown that certain older coating methods can be worse than having no coating at all.

Some of the older types of plastic pipe also need to be examined more closely. The National Transportation Safety Board (NTSB) has reported that plastic pipe installed in natural gas distribution systems from the 1960's through the early 1980's may be vulnerable to brittle-like cracking resulting in gas leakage and potential hazards to the public. Hundreds of thousands of miles of plastic pipe have been installed, with a significant amount installed prior to the mid-1980's.

Comment [PWB5]: The plastic of concern was very specific types of plastic during certain years. This report should reference the PPDC which has looked at plastic pipe performance extensively.

It's not just the material the pipe was made of that can raise concerns. There are also pipes still in use that were built using older methods, including out-dated welding and joining techniques. PHMSA has issued multiple advisories to owners and operators of gas pipelines to consider the potential failure modes for mechanical fittings used for joining and pressure sealing two pipes together. Failures can occur when there is inadequate restraint for the potential stresses on the two pipes, either when the fittings are incorrectly installed or supported or when the coupling components such as elastomers degrade over time. These fittings were and continue to be manufactured in both steel and plastic.

Operators were required as of January 1, ~~2010~~2011 to collect and report to PHMSA information, beginning March 15, 2012, about mechanical fitting failures which result in a hazardous leak. PHMSA needs to collect this additional information to determine if there are any trends or concerns regarding mechanical fitting failures in the industry.

An older welding type of concern is called low frequency electric resistance welding (ERW). In 1970, this welding technique was generally discontinued in transportation pipelines, and later regulations required additional testing and inspection of this specific pipe. But there are still over 50,000 miles of this type of pre-1970 pipe in the ground.

PHMSA does not have the data to determine exactly how many pipeline accidents have been associated with each of these types of materials, manufacturing, welding, or joining practices. But it seems very prudent to assume that materials and practices that the industry has abandoned years ago due to concerns over reliability would be of serious concern and the focal point of any rehabilitation and replacement program. [Broad, generalization]

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But we need to expand our knowledge of these pipes which may no longer be fit for continued service as well as those manufactured or installed using legacy practices to better understand the risks they impose and what is the best way to reduce those risks.

How Are We Improving Our Knowledge?

Comment [PWB6]: Define "we"

Requirements for pipeline operators to publicly report the types of materials in their pipelines, and their history of incidents for different types of pipes, have evolved considerably over the years. Unfortunately, it has only been recently that much of this data has been reported and collected, and there are currently gaps in our understanding of how "risky" some of this pipe really is. We are working to fill these gaps and increase our knowledge and understanding of these threats and how best to reduce them.

PHMSA has made significant changes to industry reporting requirements. While accident reporting forms have been revised and improved several times over the past decades, a major revision intended to significantly improve PHMSA's analytical capabilities has recently been implemented beginning in January of 2010. And, following on this effort, PHMSA has also completed a major revision of all of their infrastructure reporting forms – again for improved analytical capabilities - with the changes taking effect beginning January of 2011.

The recent distribution integrity management rule will require distribution operators to categorize by material the number of hazardous leaks either eliminated or repaired. With this data, they will be able to monitor the amount and ratio of pipe made from materials such as cast iron, bare steel, plastic pipe, etc. These data monitoring will help operators get a much better picture of the aging infrastructure, but it is just getting started.

A Pipeline Safety Executive Forum scheduled for April 18 will provide a valuable opportunity to discuss these issues and better identify the gaps in our knowledge that need to be filled.

What Are We Doing Right Now to Protect Against These Problems?

We don't know everything, but we know a lot. And both Federal and State regulators already have aggressive inspection and enforcement programs to identify pipeline risks and segments of pipe with elevated levels of concern, and to force industry to make the necessary repairs or replacements. [!!!!]

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Many States have mandated pipeline replacement programs for some of these types of older pipes. Some states have incentivized operators to replace cast iron pipe by providing operators with rate relief to accelerate replacement. But some of these replacement programs in the bigger states are not scheduled for completion for many decades. Pennsylvania's replacement program is scheduled to be completed a century from now.

DOT's Pipeline and Hazardous Materials Safety Administration (PHMSA) has also taken a variety of actions to alert the industry to these problems and work toward solutions.

PHMSA has issued a series of Advisory Bulletins to operators on various issues related to materials, fittings, manufacturing, welding, and joining, including:

PHMSA-2010-0078 Pipeline Safety: Girth Weld Quality Issues Due to Improper Transitioning, Misalignment, and Welding Practices of Large Diameter Line Pipe

PHMSA-2009-0158;Weldable Compression Coupling Installation

PHMSA-2009-0148; Pipeline Safety: Potential Low and Variable Yield and Tensile Strength and Chemical Composition Properties in High Strength Line Pipe.

ADB-08-02 - 73 FR 11695 Issues Related to Mechanical Couplings Used in Natural Gas Distribution Systems

ADB-07-02 - 72 FR 51301 Updated Notification of the Susceptibility to Premature Brittle-like Cracking of Older Plastic Pipe

ADB-02-07 - 67 FR 72027 Notification of the Susceptibility to Premature Brittle-Like Cracking of Older Plastic Pipe; Notice; correction

ADB-02-07 - 67 FR 70806 Notification of the Susceptibility to Premature Brittle-Like Cracking of Older Plastic Pipe

ADB-99-02 Potential failures due to cracking of plastic pipe in natural gas systems

ADB-99-01 Potential failures due to cracking of plastic pipe manufactured by Century Utility Products, Inc.

ALN-92-02 Addresses concerns arising from Allentown, P A, explosion

ALN-91-02 NTSB recently issued recommendation P-91-12 related to the August 1990 explosion and fire in Allentown, PA, caused by a crack in a 4-inch cast iron gas main.

ALN-89-02 Results of OPS-conducted investigation of the San Bernardino, CA, 05/12/89 train derailment; each gas/liquid operator should test check valves.

ALN-88-01 Recent findings relative to factors contributing to operational failures of pipelines constructed with ERW prior to 1970

ALN-87-01 Incident involving the fillet welding of a full encirclement repair sleeve on a 14" API 5LX-52 pipeline; King of Prussia, PA 10/07/86 pipeline failure

ADB-86-02 Piping, Mechanical Coupling

PHMSA has also held a series of public workshops to improve our understanding of these problems and devise practical solutions, including:

04/28/2010 Workshop on Guidelines for Integrity Assessment of Cased Pipe

04/20/2010 Distribution Construction Workshop

04/23/2009 New Pipeline Construction Workshop

03/26/2009 Workshop on Internal Corrosion in Hazardous Liquid Pipelines

10/22/2008 Anomaly Assessment and Repair Workshop

07/15/2008 Cased Pipeline Integrity Assessment Workshop

11/04/2003 OPS/NACE/Industry Direct Assessment Workshop

Additionally, PHMSA's Training and Qualifications team participates in ongoing communications with operators about new regulations and pertinent industry issues such as advisory bulletins at Regulations and Code Compliance State Seminars.

PHMSA has not just advised and consulted with industry on these problems, it has mandated strict new requirements. PHMSA has issued new regulations over the last decade to all pipeline operators that require detailed risk analyses and accurate assessments of the physical integrity of their pipelines.

In 2002, PHMSA required all operators of hazardous liquid transmission pipelines to perform detailed assessments of the integrity of their pipelines that passed through or could affect "High Consequence Areas". These are areas near populations or environmentally sensitive areas. This new rule required operators to inspect their systems using either pressure testing their systems to a level well above the allowed operating pressure, performing in-line (inside the pipe) inspections using instruments ("smart pigs") that can detect very small defects in the pipe, or through a process called "direct assessment" which looks for situations where the pipe may not have been adequately protected against corrosion.

Requirements for these "integrity management programs" were expanded to include natural gas transmission pipelines in the ~~2005~~2003 regulation. Since initiation of these programs, thousands of defects have been discovered and repaired.

In 2009, these integrity management requirements were extended to include local gas distribution pipelines, and ~~the rule becomes effective~~natural gas distribution operators will implement their DIMP Programs in August of this year. On older gas distribution systems, the appropriate risk mitigation measures may include pipe repair, rehabilitation, or replacement.

While great progress has been made over the last decade, we are still concerned with the underlying risk assessments used by the operators to identify threats, assess their importance, and identify effective remedies. We are planning a broad-based workshop in August to discuss these issues, share experiences, and improve our knowledge. This workshop may lead to new or more stringent requirements for assessing and reducing pipeline risks.

PHMSA has approximately forty members on twenty-seven committees involved with the development and maintenance of various standards related to pipelines and pipeline safety. Active committee membership provides PHMSA a means to mitigate risks of undesirable changes to standards (requirements in conflict with the regulations or those not in the best interest of public safety) and to leverage committees to produce new, improved provisions in the standards.

The upcoming Pipeline Safety Executive Forum will also help us identify actions that Federal and State regulators and the pipeline industry can take to drive more aggressive actions. Following this Executive Forum, DOT plans to issue additional Advisory Bulletins to pipeline operators that focus on accelerating their repair, rehabilitation, and replacement programs. DOT will also conduct training of State and Federal inspectors on these new advisories.

What Are the Challenges We Face? [This section is much more balanced]

It's not possible, or even prudent, to simply dictate that all pipelines of a certain type or age be replaced by a certain date.

First of all, there is the problem of supply disruption. Replacing, rehabilitating, or repairing pipe requires that the existing system be at least partially shut down and alternative routings be provided. This has to be done with a carefully thought out plan and schedule that does not result in unacceptable or widespread disruptions of energy supply.

It is also not easy to replace pipe in heavily urbanized areas. Sometimes roads need to be dug up. There are also other utility lines like telephone, cable, or water that have to be worked around safely. The local permitting process must look at all these things before local officials can permit a pipe to be dug up and replaced. This process can require large lead times.

There are also challenges associated with the differences in the operating environment in the various cities and states. PHMSA's data shows that some states have weather issues associated with frost heave, and that others have earth movement issues or landslides. There is not a one-size-fits -all plan that can be imposed across the country.

PHMSA has not issued guidance or promulgated regulations covering the rehabilitation of pipelines. The industry has implemented rehabilitation methodologies but needs further guidance on the efficacy of these methods. PHMSA may need to modify the reporting of rehabilitated types to be able to monitor if pipe is being reconditioned to a satisfactory condition.

While the requirement for operators to report mechanical fitting failures is a large step forward in identifying integrity issues, operators and regulators hold a great deal of institutional knowledge. Throughout the years, research organizations, private laboratories, and trade associations have published papers and delivered presentations describing problems as they arise and the root cause is identified. Most of these papers are not readily accessible. Through the distribution integrity management program, operators are seeking to learn more about potential risks to their system.

The owners of these pipelines are mainly corporations or public utilities. The rates they are allowed to charge their customers for the gas or oil delivered are based on the costs they incur, including the costs of repairing, rehabilitating, or replacing pipelines. It has been estimated that these costs could exceed billions of dollars nationwide. If pipeline owners are not allowed to pass a significant portion of these costs through to the customer, they may not be aggressive in taking these actions. If they are allowed, the cost of energy transportation to the public and industry will increase. Public utility commissions have the authority for setting and approving rates for intrastate transportation in each state and the Federal Energy Regulatory Commission has authority for setting and approving rates for interstate transportation. PHMSA does not have the authority for approving rate relief for repairing, rehabilitating, or replacing pipelines, so must remain cognizant of these other factors when charting a course of action.

While these are indeed significant challenges, they are not insurmountable, and they can be managed. DOT's Call to Action is a major effort that will greatly accelerate our efforts to understand and manage these challenges.