The boom in U.S. shale plays and Canadian oil sands has provided North America with a huge new source of petrochemical and energy-generation feedstock. For the most part, the results of this “shale boom” have been quite positive.

But the sudden abundance of oil and natural gas is putting pressure on North America’s existing pipeline infrastructure, which simply cannot cope with this additional demand. This pressure is compounded by the fact that most of this new oil and gas production is happening in regions not currently served by the existing pipeline infrastructure (Figure 1).

Before the Marcellus boom, for example, Pennsylvania and West Virginia relied largely on natural gas from the western and southwestern U.S. In recent years, however, increased local production has resulted in a supply of gas that is more than sufficient to meet current local demand, with plenty left over to ship to other U.S. states and to Canada. Similarly, the recent oil boom in Canada has resulted in the need to ship large amounts of Canadian oil south to the vast refinery complexes along the Gulf Coast.

As a result of the increase in demand for North American oil and gas shipping, once-uncommon flow reversals and the reuse of existing pipeline assets have become fairly routine for operators, with large incentives being quoted, such as $10-15 million in additional earnings for just one pipeline reversal — Tesoro Logistics LP.

In recent years, for example, gas capacity shipped in pipelines has risen significantly along with the growth in shale production (Figure 2).

Minimizing Failure

One of the most important aspects of pipeline reversals is risk assessment. Many of the pipelines undergoing reversals are older and were manufactured using outdated processes, materials or design elements that aren’t acceptable by today’s standards. Operators need to perform thorough assessments to determine how risks can change when an older pipeline is reversed or repurposed.

Due to a couple of well-publicized reversal failures, the public is all too aware of what can potentially go wrong with a pipeline reversal. In March 2013, a pipeline leaked about 200,000 barrels of oil near Mayflower, AR. In September 2013, a 20-year-old pipeline spilled over 800,000 gallons of oil in Tioga, ND. These failures often overshadow the many successful pipeline reversals over the years. Unfortunately, success stories rarely make headlines. But the truth is that, when completed carefully and after a thorough risk assessment, pipeline reversals can be safe and effective.

Longhorn Reversal, 2001

The original Longhorn Pipeline System — comprised of 18-inch and 20-inch pipelines — was built to ship crude oil from Crane to Baytown, TX in 1949 and 1950. In 1998, the line was converted to refined products service with the addition of pumps, terminals and new pipeline segments to transport product from Houston to Odessa and El Paso.

To manage and reduce risks, Longhorn Partners Pipeline went above and beyond
imported oil from the United Kingdom, West Africa and the Middle East. Now that western Canadian oil is cheaper than the imports, Line 9 will be reversed again.

What’s also interesting about this reversal is the amount of public communication involved in the project that Enbridge made information available to the general public. Available information includes a website (http://www.enbridge.com/line9), as well as a brochure detailing the how, when and why of the reversal.

Of course, these are just a few examples of recent projects. Figure 3 shows the reversed and repurposed pipeline has been steadily increasing since the late 1990s.

**What Do Regulators Think?**

In an effort to establish best practices and safeguard against failures on reversed and repurposed pipelines, regulatory organizations worldwide are beginning to release standards and recommendations. In the U.S., the Pipeline and Hazardous Materials Safety Administration (PHMSA) has issued guidance on pipeline flow reversals, product changes and conversion, alerting U.S.-based operators to review their existing integrity management programs, risk-management processes and integrity issues. PHMSA suggested some pipelines are not prescriptive, except when the cost to make these changes exceeds $10 million, PHMSA strongly encouraged operators to submit a comprehensive written plan before beginning a conversion or reversal. PHMSA also advised operators to review their existing integrity plans and be prepared to demonstrate how any additional or increased risks are mitigated.

In addition to issuing new guidance, PHMSA suggested some operators would also apply to those types of projects.

**Good Practice**

Despite a few well-publicized failures, there have been many successful pipeline reversals and conversions, and organizations worldwide are compiling guidelines for safety and best practices. What are the lessons learned? What approaches and practices can help ensure the safe completion of such projects?

**Most successful case studies share a few common elements:**

- **Threat assessment:** A valuable way to assess all the risks – and how they would change under the new operating conditions – is to conduct a thorough threat assessment and develop a mitigation strategy.
- **Documentation review:** Gathering documentation sounds relatively easy, but the paperwork for older pipeline
offers some advantages over air or product based pressure tests. Though hydrotesting in the 1960s as a direct response to failures resulting from air- or product-based records are often lost or destroyed. Material records seem to be the most valuable, as they provide information about pressure testing. If no documentation is available, it's now possible to conduct in-situ positive material identification (PMI) without expensive laboratory testing.

**Inspection**: Once threats have been assessed, it's important to determine the criticality of the defects that may exist. Inline inspection is by far the best practice, with technology such as the multiple dataset (MDS) inspection platform able to detect and characterize most anomalies.

**Communication**: Keeping all stakeholders informed becomes an absolute imperative. Enbridge's Line 9 reversal is a good example of how social media can be used to communicate project benefits and confront issues.

**Lateral and Connections**: The majority of guidance and case studies relate to the main transmission pipeline. But it's important to remember the connections that may not suit the new service. In this case, reconnections may be necessary. Hot tapping and bypass can ensure that this can happen without disruption to customer connections.

**Preparation is Key**

Probably the most important element in pipeline reversals and conversions is proper preparation, including testing and inspections that can help determine whether the pipeline is fit for the job. There are several inspection and testing methods available; each can help provide a more complete picture of the pipeline.

**Hydrostatic Testing**: Hydrotesting was introduced over 60 years ago. It was developed as a direct response to failures in the 1960s resulting from air- or product-based pressure tests. Though hydrotesting offers some advantages over air or product testing, this method has several drawbacks. While hydrotesting is considered to be the final test for the strength of a pipeline that may be undergoing a reversal or conversion, it is disruptive and does not offer a full picture of potential issues. Hydrotesting really only gives an assurance of integrity on the day testing is conducted. Defects that are close to failure may not be detected during testing, meaning that they will remain unaddressed until they fail at some point in the future.

**Inline Inspection (ILI)**: This is an extremely valuable tool in proving pipeline integrity. There are many tools available for the assessment of a variety of defects, and as computers, storage, and batteries have improved, these tools have only gotten better. Today, MDS tools (Figure 4) can help operators address multiple threats at one time. Running these tools is becoming common practice for integrity management and is almost a requirement for line reversals or conversions.

**Positive Material Identification**: Paper-based records for older pipelines are often misplaced, lost or destroyed. What may seem disastrous becomes manageable thanks to new methods that use a combination of in-situ strength and chemical-composition tests to determine a pipeline's material properties. These methods can be linked to sensors on ILI tools using a low field magnetic array to determine material changes.

**Leak Detection**: Leak detection becomes more important when pipelines change service, especially when the line is carrying new product. Historically, most leaks have been detected by the general public, but there are now more sophisticated solutions available that use fiber optics or airborne survey equipment to detect leaks before they become public incidents. Until recently, many operators looked at leak detection as a last barrier of defense. After recent failures, though, there has been a push for zero loss, which means moving to safety standards more focused on personal safety and much more importantly in the oil and gas arena – process safety. Hence, detection and mitigation are preferred.

**Emergency Preparedness**: Though every step can, and should, be taken to mitigate all threats, there are some situations that just cannot be foreseen (so-called “acts of God”). To guard against the unexpected, emergency-response plans and equipment need to be well-thought-out. For example, one major finding from a recent incident in the Gulf of Mexico was that the emergency-response plan was inadequate and crisis-management training was lacking. In all cases, ensure that every threat is considered in advance. Do not rely on one barrier to prepare for the worst.

**Key to Safe Reversals**

It is not uncommon to find 60-year-old pipelines operating in excellent condition – as long as they have been maintained, inspected and repaired as required.

Materials, welding, construction, operations, maintenance and emergency-preparedness knowledge have all improved in the half-century since many of these lines were installed. But if we continue to make improvements and leverage new and better materials and technology, there is no reason that these pipelines can’t last another 50 years in their converted form.

**Author**: Mike Kirkwood, Ph.D., has more than 25 years of experience in the nuclear, power generation, water, and oil and gas industries. He is a SME in all forms of structural integrity, specializing in pressurized pipelines, and is the author of numerous papers on pipeline integrity, risk, inspection, and repair and rehabilitation.