Building it right the first time

Cal Chapman, Chapman Engineering Inc., USA, argues that pipeline integrity management, and especially cathodic protection, is sustainability work.

Underground carbon steel pipelines are, and will continue to be, the transportation mode of choice for many crude oil, natural gas, and other petroleum and petrochemical products. Similar underground or submerged metal pipelines are often used, too, for water, wastewater and other liquid or gaseous products. Taking one famous (indeed, iconic) pipeline as a discussion point, the 48 in. nominal diameter (122 cm) crude oil Trans-Alaska pipeline was put into service in August 1977, spanning a total length of 800 miles (1288 km). Now 46 plus years old in terms of active service, the original pipeline design was for 30 years of useful life. It has thus far performed for 50% more years than originally intended. Is this asset being sustained? Is it being operated in a sustainable fashion and, even now, for a long-term service outlook? This certainly seems to be the case.

The cost of corrosion

The pipeline industry over the last 30 years has greatly improved the general principles and practices that encompass asset integrity management. What is the motivation to do so? The first, and obvious motivation, is to avoid the need for complete asset removal and replacement. A study by NACE International (now called 'Association for Material Protection and Performance [AMPP]') released in 2016 described that the annual cost of corrosion damage across the globe was in the range of US$2.7 trillion.[1] This was true even though some industries were using corrosion control measures quite effectively. If, in 2016, the world's gross economic product produced was close to US$90 trillion, one could say that all metal infrastructure would need complete replacement every 30 years without significant asset integrity management practices in place. Proper coatings on metal structures is one obvious protection method, which some industries do very well, and others may not do so effectively.

The cost of operation

A big motivation for asset integrity management is, therefore, to properly maintain the asset, thereby avoiding the much larger costs of failure events, shutdowns, major repairs, or even replacement. Often the operator is looking to manage or reduce costs of operation, even as the asset is put into performance at a higher output, or efficiency, and for longer service life.

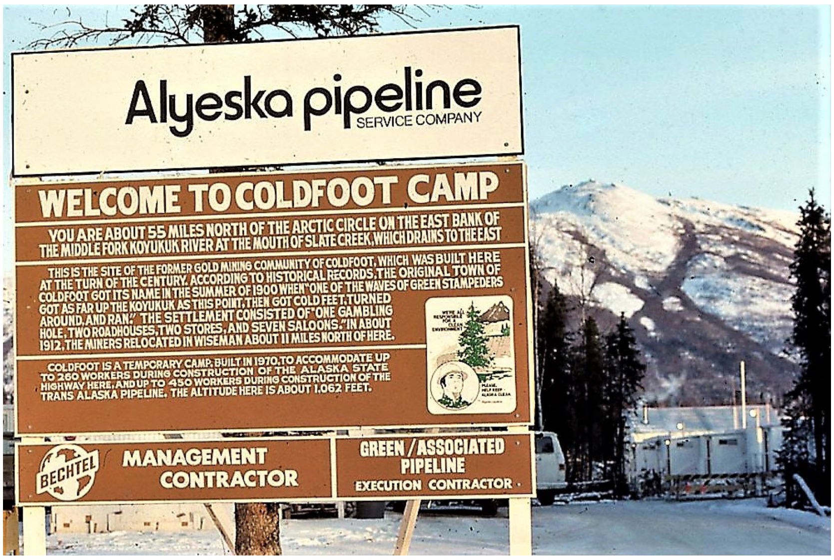

Figure 1. Author's photo at Coldfoot Camp during pipeline construction, March 1976.

Other goals might be to improve safety of an operation, or to gain energy efficiency – and in such ways, reduce operating risk or cost, or both. It has sometimes been government regulation that has brought the operational improvements, risk reductions, and improved safety profiles. Pipeline regulations in the US and other jurisdictions have periodically been expanded and tightened, and frequently in response to high-visibility, high-cost accidents occurring.

The Trans-Alaska pipeline project, first publicly proposed around 1970, did not get US Congressional approval for construction until 1973, and only after a major piece of federal legislation was passed. That legislation laid out requirements for complex environmental studies and plans for mitigation of negative effects to caribou herds, to permafrost soils, and water quality protection, among other requirements. Some risk was related to the many river and stream crossings required along the 798 mile (1285 km) route. Thanks to the driving need for high-quality environmental protection over time, this project's successful execution led to many improvements in pipeline and pump station designs, and in complex construction/installation practices in remote, difficult terrains.

This one amazing pipeline example helps to illustrate several major points. The first is that, once a pipeline is constructed and goes into operation, many parties have an interest in keeping the pipeline operating. The biggest costs are field studies and design, and then the massive capital investment for installation and startup. Once product is flowing, the asset is delivering monetary return on the investment. And because most pipelines serve a long-term purpose, or even get repurposed for a different product after some time goes by, few people want to shut in and abandon the typical large diameter pipeline.

Keeping pipelines healthy

How are pipelines kept healthy over time? Some methods are used to protect the insides of pipes from corrosion, from getting filled up with gunk or water dropout in the wrong places, etc. To control external corrosion, good coatings must first be installed with the asset. Then, cathodic protection must be applied effectively, so that any poorly coated locations, or spots where coating was scraped away or otherwise damaged, are adequately protected against aggressive external corrosion. External corrosion control is virtually always said to be good coatings, first, and complemented by good cathodic protection. Any other approach is doomed to be too expensive to achieve when it's complex, or too risky when it is 'skimpy'.

Cathodic protection

Cathodic protection systems, for longer and larger diameter pipelines, are almost always of the impressed-current type. These typically use an AC power supply that feeds a transforming rectifier (most often called just a 'rectifier'). The rectifier converts AC power to DC power, and then pushes positive DC current to a set of anodes. The negative DC output of the rectifier is connected to the metal structure needing protection. Current flow from the anodes, which themselves corrode over time, travels through soils and water (whether moisture in soils and geology, or even through water bodies) to come onto the structure needing protection. This delivery of current to exposed metal in soil/electrolyte contact either greatly diminishes or even eliminates external corrosion reactions.

Because cathodic protection system anodes are always consuming with time and current production, they must be replaced periodically. Proper design and construction of each new or replacement anode bed is critical to ensuring that the high-value structure is continually protected from external corrosion damage. In this way, the timely replacing of cathodic protection system anode beds, and maybe other components, is how below-grade, very valuable metal structures are sustained for long service lives, at lower maintenance costs, and hopefully avoiding expensive failures, shutdowns, and repairs, or major asset replacements.

A word of caution: not all cathodic protection designers and construction companies are alike. Our experiences of the last 20 years, if not longer, show that pipeline owners and operators should purchase such services and systems with more requirements than just 'low bid wins'. It is fairly simple to go and take measurements on a newly installed cathodic protection system and see if the anode bed is going to last the required 15 or 20 years of expected life. In many cases, we assess recent cathodic protection installations, and have to tell the owner: "This may give you five years. Three-quarters of your investment got thrown away." Our recommendation is to get a strong design firm involved at the front end, one that produces good design and specification documents; in some cases, the pipeline operating companies have this kind of strength under their own roof. With that set of documents, they should then require contractors to provide a bid package that includes qualifications and experience for key contractor field and management personnel; satisfied/happy business references related to prior work; and then the project pricing. A choice of contractor can then be made by combining strength of experience and qualifications, testimony from satisfied customers, and the pricing. Low-bid-only choices

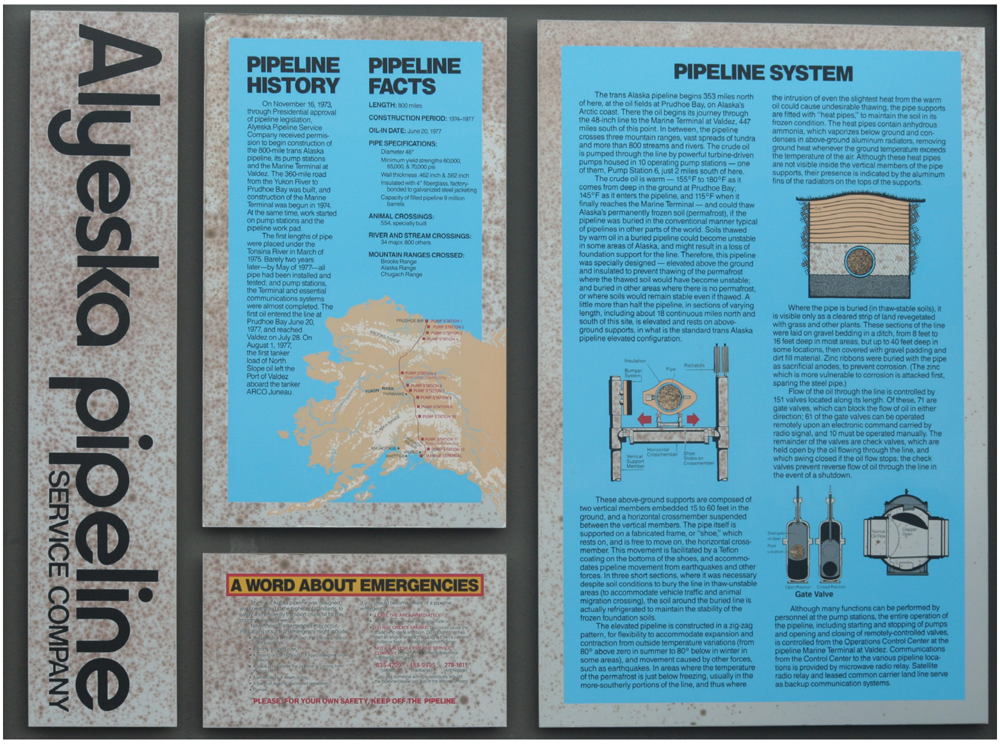

Figure 2. **Author's photo of public storyboard at Yukon River crossing, Trans Alaska pipeline route, July 2012.**

Figure 3. **Author's photo of Trans Alaska pipeline ar Yukon River crossing, July 2012.**

can be dangerous. One of the quotes we frequently use is, "How much does it cost to do the job right the second time?"

One judgment asset owners are likely making, and then revisiting over time, is: "How long should we maintain this asset? Is there another way it can benefit us, and/or the general public, compared to what it is now doing?" The North Slope of Alaska and the shallow continental shelf of the Arctic Ocean are known to host large reserves of natural gas, as well as remaining crude oil reserves. Methane hydride formations contain yet more natural gas that may become a usable resource in the future. It is in the pipeline owner/operator's interest to take good care of the Trans-Alaska pipeline for decades to come, based on what we know at present. And cathodic protection systems plus related surveys are critical sustainability practices to use in this process of maintaining the asset. The Trans-Alaska pipeline project was originally estimated, in 1974, to be a US$3 billion project to complete. By the time it was commissioned and began moving crude oil, total costs were said by some to be closer to US$10 billion.

What would it cost today to build, or rebuild, the pipeline? To even think about calculating the number is mind-boggling, never mind what the regulatory requirements might be. To maintain it and keep using it is downright affordable, by comparison, as long as it has usefulness!

Postscript

I was fortunate enough to drive trucks on the Trans-Alaska Pipeline project, as a member of the Teamsters Union at the time. From August 1975 to April 1977, minus a couple of winter breaks, I lived along stretches of the pipeline from Old Man Camp to Dietrich Camp (all north of the Yukon River), and then up to Pump Station #2. I drove the Haul Road and put loads down along the pipeline right-of-way from the Yukon River to about 30 miles south of Prudhoe Bay. In December 1975, I worked one day at -52˚F, along the Middle Fork Koyukuk River (photo, p.15). After my last layoff, I went to university, and chose mechanical engineering as my degree plan, partly because I had been eyewitness to so much incredible engineering and construction process work, in one of the most beautiful, yet harshest parts of the world.

Another interesting point: I learned trucking, heavy equipment, a little about pipeline welding, pipeline bedding and backfilling, and so many other things from older, very experienced workers! I did not hang out with any engineers, surveyors, or geologists, though I saw them at dinner on many nights in the camps. I learned from technicians, labourers, operators, oilers, welders, welders' helpers, and even post office clerks! Maybe that's why I know to rely today on great technicians and helpers out in the field. Without them, I can't be a good engineer.

Finally, I was able to take my family to Alaska in the summer of 2012, and drove them up the Dalton Highway (what I knew years ago as the pipeline 'Haul Road') to the Arctic Circle. They got a tiny taste of what I was doing many years before, and gained some appreciation for this incredible Trans-Alaska pipeline structure.

References

1. NACE 2016 IMPACT Study, Cost of Corrosion.

Further reading

https://ascelibrary.org/doi/abs/10.1061/40621%28254%2910
https://ascelibrary.org/doi/10.1061/40621%28254%2911

Chapman Engineering

CORPORATE OFFICE:
213 Commerce Ave Boerne,
Texas 78006

Company Profile

Chapman Engineering, Inc., a Texas USA corporation founded in 1989, offers corrosion control and engineering, environmental engineering, subsurface environmental assessment and corrective action, ground-water availability studies, and specialty construction and survey related to corrosion control. Starting in underground fuel storage tank (UST) release detection and cathodic protection of steel USTs, Chapman Engineering has worked in the corrosion protection marketplace since the mid-1990s. It designs, constructs and manages cathodic protection systems for water, sewer and
electrical utilities and infrastructure, oil and gas production and transportation systems, and refining/petrochemical complexes.
The firm's multifaceted engineering team has over three decades of experience in corrosion control design, installation of cathodic protection (CP), coating quality and AC power interaction evaluations with pipelines, and review of existing asset integrity, as well as CP system commissioning,
testing and optimizing across the industries. Our team has a proven track record of effectively mitigating the corrosion risk for steel, ductile iron, concrete pressure pipe, storage tanks, and other metal assets across North America.