Use of Pressure Activated Sealant Technology to Cure Pipeline Leaks

Technology Status Assessment Report

DE-FC26-03NT41858

Michael A. Romano
Seal-Tite International
500 Deer Cross Drive
Madisonville, Louisiana 70447

October 31, 2003

Use of Pressure Activated Sealant Technology to Cure Pipeline Leaks

Introduction

Pressure activated sealant technology has been successfully and commercially applied in the oil and gas industry on a world-wide basis for over seven years. Over these years the capabilities of this technology has been substantially expanded to be able to cure leaks in a wide variety of equipment in a broad range of conditions, including applications in subsea gathering lines and pipeline applications in South America. This technology is unique in that a pressure drop through a leak site causes the sealant fluid to polymerize into a flexible solid seal only at the leak site. We believe utilization of pressure activated sealants is an attractive alternative to conventional repair methods that require excavation of the pipeline.

Background

According to Department of Transportation's Office of Pipeline Safety there are over 326,000 miles of natural gas transmission pipelines and over 1,923,000 miles of natural gas distribution pipelines presently in the United States. With natural gas consumption projected to increase by 50% over the next seventeen years a major focus will be placed on pipeline integrity management, particularly pipe and joint leak repair systems.

There are two broad methods of repairing pipeline leaks; external and internal. The most common method, external, requires excavation of the leak site, but allows the pipeline to remain in service during repair. With external repair there is an inherent increase in both costs and risks associated with the population and environment.

Internal repair methods typically have the pipeline taken out of service during the repair, but generally have less associated cost and risks than the external repair method.

A review of the current repair technologies follows.

Current Repair Technologies

External Repairs

External repairs have an advantage of restoring pipe strength, but require excavation and cleaning of the external pipe surface. The two oldest methods, spot welding directly onto the external surface of the pipe to build up wall loss, and cutting and removing a damaged pipe section and installing a replacement section, are proven, but time consuming methods that have been replaced by welded full-encirclement split sleeve.

Welded Full-Encirclement Split Sleeve, the most common and simplest method for external repair of gas pipelines, is usually utilized to spot repair welded steel liners. The leak site is excavated and the exterior of the pipe is cleaned. A full-encirclement stainless steel sleeve is positioned around the circumference of the pipe encasing the leak site. The sleeve is then welded longitudinally and at the ends. A similar repair method is the Bolt-On Repair Sleeve. The same procedure is generally followed for excavation and cleaning but then a rubber lined, stainless steel sleeve is bolted in place across the leak site.

Fiber Reinforced Composite Repair, in general, consists of woven fiberglass in an epoxy resin material bonded to the pipe using an adhesive. This method, as an alternative to Welded Full-Encirclement Split Sleeves, has the advantage of eliminating the need for welding but still requires excavation and cleaning.

Internal Repairs

Internal repairs have the advantage of precluding the need to excavate, but are generally used to restore leak tightness and not to restore pipes strength.

Remote/Robotic Welding Repairs, primarily developed for the nuclear power industry, presently exists in varying stages of development from prototypes to field trials to fully operational units. Generally, the units fall under three categories based on locomotive capability; stationary, self-propelled and towed.

Self propelled units on wheels or tracks, receive power and control via umbilical cables, while the power supply for the welding module remains at the entry point. The ability of the units to pull the umbilicals, along with the welding power supply remaining at the point of entry, limits the working range. The working range for the self propelled welding units vary from 135 ft to 500 ft in pipe sizes from 12” to 24”, with one unit, comprised of separate modules connected by flexible coupling, able to service 6” to 40” pipe. All of the self propelled units can transverse 90° bends.

Towed units, which can reach lengths of 1,000 ft in 12” to 18” pipe, are operational in straight pipe only.

Stationary units, for obvious reasons, have a very short working range of only 12 ft.

Fiber Reinforced Composite Repair, as previously described, have two methods that can be utilized for internal repairs; Cured-In-Place Pipe Liners and Fold-And Form Liners.

Cured-in Place Pipe systems consist of a flexible reinforced non woven felt liner with the outermost layer coated with polyethylene and the inside diameter saturated with liquid thermosetting resin. The liner is installed by using water pressure to propel the liner through the pipe and turn it “inside-out” so that the saturated resin side is pressed tightly against the host pipe section to be repaired. Once in place heat is applied to cure the resin. Sections of up to 1,000 ft can be lined depending on diameter and number of bends. While this method is primarily used to restore leak tightness, several companies are working with utilizing glass fibers and braided tubing for restoring pipe strength.

Fold-and-Form Liners involve manufacturing a thermoplastic pipe into a folded "C" shape and then, after pulling into the host pipe via a winch, is expanded with pressure and heat. The liners, which are made from polyethylene or polyethylene reinforced with polyester fiber, achieve a close fit after expansion to restore leak tightness. Due to the pull-in requirements this technology is limited to smaller pipe sizes.

Expandable Metal Patch has been successfully used in the oil and gas industry for several years and with modification can be applied to gas pipelines. A fixed sized metal liner is deployed via coiled tubing with expandable metal seals at the top and bottom of the assembly. The metal seals are energized and expanded hydraulically via a hydraulic setting tool. The setting tool is pulled from the pipeline along with the coiled tubing after the setting process is completed. The Expandable Metal Patch is presently available for sizes up to 9-5/8" with a minimum burst pressure rating of 3,560 psi. The disadvantage of this method is the necessity of coiled tubing deployment. Although vibration tool technology enhances the ability of the coiled tubing to reach extended lengths, the working range may still be inadequate for many of the applications. Another disadvantage of this method is the size reduction through the patch. Generally, the patch will reduce the pipe internal diameter by 1".

Internal Repair Sleeve is basically a combination of fiber reinforced composite repair and expandable liner patch repair. It consists of a stainless steel sleeve surrounded by an outer sleeve of felt liner that is saturated with liquid resin immediately prior to installation. The sleeve can be deployed on coiled tubing, carried by robots or pulled by cable. Once in place an inflatable bladder expands the sleeve out to the host pipe internal diameter. Locking barbs on the exterior wall of the sleeve lock the sleeve in place while the resin cures. At present, this system is available in sizes from 4" to 54". Typically, the sleeve will reduce the pipe internal diameter by approximately 1-1/2".

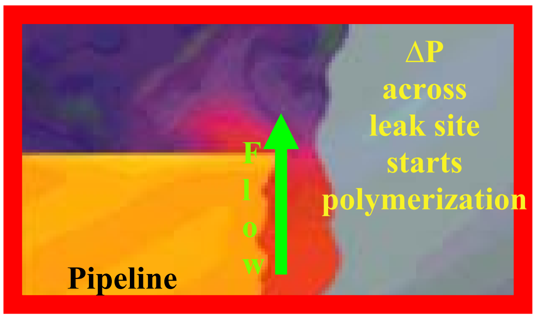
Project Technology Development

Pressure Activated Sealant Technology

The overall objective of this project is to develop new, efficient and cost effective methods of internally curing pipeline leaks by expanding the application for the technology of pressure activated sealants, and ultimately to enhance natural gas delivery reliability and reduce environmental impact of natural gas leaks.

Pressure activated sealant reaction is analogous to blood coagulating at a cut. The sealant will remain fluid in the pipeline until released through a leak site. Only at the point of differential pressure, through the leak site, will the sealant reaction occur to bridge the leak. The remainder of the sealant will remain fluid and can be left in the system or flushed out.

The basic formula of the sealant consists of monomers, polymers and polymerizing chemicals, with customization to the particular conditions of the application. This allows the injection pressure to be regulated so that the proper pressure differential at the leak site can be created to initiate the sealant reaction. During this initial reaction the monomers and polymers in the formula are cross-linked by the polymerizing chemicals. As the reaction proceeds, the polymerized sealant plates out on the edges of the leak site and, simultaneously, links across the leak site to seal the leak. As the seal builds across the leak site, the leak is cured, just like blood coagulating across a cut. The resulting seal is a flexible bond, or skin, across the leak.



1. Fluid escaping through leak site

2. Sealant bridging across leak site

3. Leak sealed

The likelihood of pressure activated sealants providing a long-term seal is dependent on the severity of the original leak and the stress placed on the seal after the treatment. On moderate leaks, the sealant, once cured for two weeks, has the same longevity as an 80 durometer elastomer in the same service. For leaks within their capabilities, pressure activated sealants are very cost-effective compared to the alternatives.

The methods of delivering the sealant are very flexible. In pipelines it is expected that the sealant will be delivered between isolating media such as foam pigs or a family of smart pigs. Because the sealant never hardens except in the presence of a differential pressure, concerns about the time to deliver the sealant and pipeline temperature have been eliminated. If the sealant can be delivered to the leak site and a differential pressure created through the leak, there is a high probability of sealing the leak.

The benefits realized by development of this technology include:

- Repair of inaccessible pipeline leaks
- Repair of pipeline leaks without a need to excavate
- Significant reduction in pipeline downtime
- Elimination of environmental problems caused by pipeline leakage and excavation
- Significant reduction in the cost of pipeline leak repairs

Comparison of Pipeline Sealing Methods

Repair Method	Advantages	Disadvantages
External	Restores Pipe Strength In-Service Pipeline Repair No Pipe ID Reduction	Excavation Risks & Costs
Remote/Robotic Welding	Internal, No Excavation No Pipe ID Reduction Can Restore Pipe Strength	Short Working Ranges &/or Unable to Transverse Bends Out-of-Service Repair
Fiber Reinforced Composite	Internal, No Excavation No Welding	Short Repair Sections Reduced Host Pipe ID Low Pressure Rating Out-of-Service Repair Time Consuming
Expandable Metal Patch	Internal, No Excavation No Welding High Pressure Rating	Reduced Host Pipe ID Coiled Tubing Deployed Limited Working Range Short Repair Sections Out-of-Service Repair
Internal Repair Sleeve	Internal, No Excavation No Welding	Reduced Host Pipe ID Low Pressure Rating Out-of-Service Repair Time Consuming
Pressure Activated Sealant	Internal, No Excavation No Welding Unlimited Working Range High Pressure Rating No Pipe ID Reduction Short Job Duration	Dependent on leak size /rate Out-of-Service Repair

In conclusion, if the project is successful, it appears that pressure activated sealant technology will provide a cost effective alternative to existing pipeline repair technology.