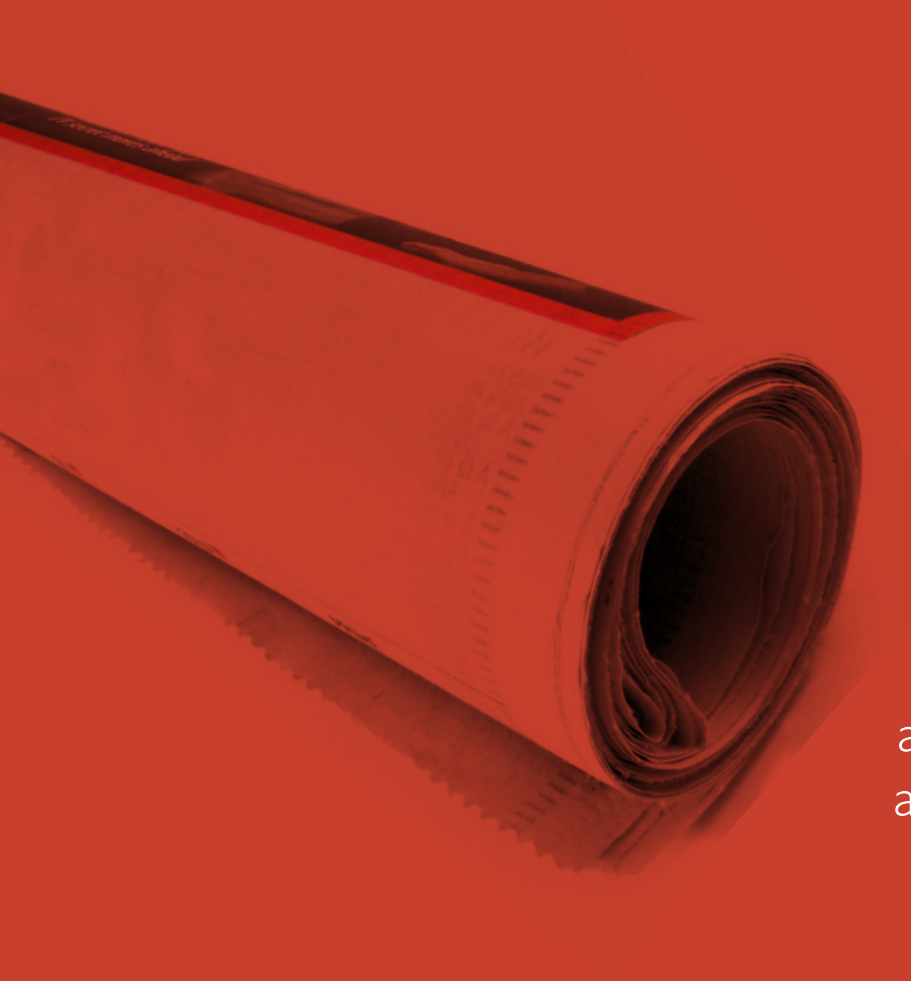

The inside story

James A. Huggins, CRTS, Inc., USA, asks "what is important about internal field joint coating?"

For starters, let's agree to adopt the same vernacular. The oil and gas industry has used the terms 'external pipe coating' and 'internal pipe coating' for years. For the purpose of this article, the author will use internal pipe coating as common.

Internal pipe coatings are not new to the market, companies have been utilising them for decades. Engineers have long developed favourites among the different products. CRTS, Inc. has a unique perspective on coatings because after all the engineering is complete and the pipe has been coated and delivered to a job site, the company is called in to coat the internal field joints.

In the beginning (commodity transport)

Pipeline owners invest hundreds of million of dollars in pipeline asset infrastructure. Those assets need protection from the environment. Companies have been coating the outside of pipes for many decades. Of course, used in conjunction with cathodic protection pipe coating economically extends the useful life of the pipeline for many years. Some regions of the world require cathodic protection and pipeline coatings as matter of public safety law and/or environmental responsibility. What about internal corrosion? Pipeline failures have a finite number of causes (partial list below):

- Microbiologically Induced Corrosion (MIC), i.e., sulfate reducing bacteria (SRBs).
- Wet sour production.
- Wet production high in CO_2.
- Erosion/corrosion.
- Simple passivation layer washing.
- Salt water attack.
- Sewer gas attack.

Not every pipeline is under attack. If your pipeline lasted for 50 years, you don't have a problem. However, everyone knows of at least one pipeline that failed in a few months or a few years and simply thanked God if they were not involved. Neither society nor companies can afford to build pipeline infrastructure that doesn't last its design life. The decision to build a pipeline is made after a careful economic analysis. In any analysis, assumptions are made relative to product demand, pipeline life expectancy, the market value of the flow media (product), pipeline flow capacity, the construction cost, the construction materials cost and finally the operating cost. Engineers are not responsible for the market fluctuations in commodity pricing. However, engineering design can mitigate the risks that a pipeline asset will last its entire design life, maintain full flow capacity and minimise amortised construction and materials cost. Internal coating is a useful tool for extending asset life.

Internal pipe coating benefits

- Reduce steel required replacing corrosion wall thickness allowance with a coating system. Internal coating reduces the surface area subjected to corrosion pitting from infinite to only those locations where the coating gets damaged and doesn't get repaired. It is now technically possible to install a zero defect internal coating.
- Improve the flow efficiency increasing volume or reducing power consumption. Easier flow has a direct savings in horsepower and energy required to push product to market.

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- Maintain product purity. Especially important to some industries, potable water and jet fuel, for example.
- Protect pipe for long-term storage. Many projects face unforeseen delays bringing into question, how will the pipe tolerate the environmental exposure for an indefinite period of time.
- Substantially reduce the incident rate and therefore the cost of catastrophic failure resulting in personal injuries, environmental damage and cleanup, lost production revenue and the negative public relations/corporate image damage. In court, to state that this pipeline was designed and constructed with the latest technological innovations will surely have risk mitigation value.
- Reduce operating and maintenance costs. Internal coating will delay the first leak and ultimately reduce the overall number of repairs performed on the pipeline during its service life.
- Additional protection for High Consequence Areas (HCAs).

Figure 1. Inspection machine.

Figure 2. Pipeline corrosion pitting.

Use of internal coatings is on the rise around the world. All pipeline flow is headed to market somewhere and when the production doesn't get to market, your company doesn't get paid. Whether its oil, gas or water, these commodities are found in lesser volumes by an increasingly thirsty marketplace. The product value increases with scarcity and demand. What percentage of a scarce resource is acceptable as lost in transit.

Pipe coaters

To satisfy the pipeline market demand, professional pipe coating companies have invested tens of millions of dollars to build pipe coating infrastructure. They might be considered service companies by some but they are really manufacturing companies. Applying a coating to the inside or outside of a steel pipe does not constitute a simple service. It is effectively taking two separate items (bare steel pipe and pipe coating) and joining them in an irreversible way to make a new third product (coated pipe). You would never substitute coated pipe for bare if the bare pipe was sufficient. Many companies have invested in both external and internal pipe coating facilities. There are internal coating plants that specialise in Fusion Bonded Epoxy, pre-mix liquid epoxies, novalacs, phenolics and plural component 100% solids liquids (epoxies and polyurethanes). Some have pre-heat and cure ovens; others also coat the external pipe surface with many different products. Over the past twenty years, the internal lining market has shifted away from high VOC materials and their associated environmental restrictions. FBE and plural component 100% solids liquid materials are in a perfect place to respond to the growing demand.

The market for internal coatings

There are many good coating products and the plant facilities to apply them are scattered around the world. Given adequate lead time, engineers and project planners can choose the pipe mill they want to buy their pipe from and then select the most appropriate coating plant to utilise. Some pipe manufacturing facilities use the presence of coating facilities to market their steel and add value to their product stream. Others ignore the market and simply sell their steel pipe and let the customer figure out where and how to get it protected (coated). Either way, the overall project cost can be most efficiently managed by selecting the pipe mill and pipe coater as far in advance of the actual order release date as possible.

The pipe may be purchased and free issued to the contractor, or added to the construction contract. Either way can work, but all quality measures must be in place for each step of the process. The steel pipe should be accepted to

specification before the pipe coater starts his work. Then, the pipe coating should be 100% inspected before it is handed over to the shipping agent. Upon arrival at site, the pipe should be inspected again for shipping damage and coating damage. It might make sense to add this scope to the construction company's contract so they will know the condition of the pipe when they accepted possession of it. They will also be responsible for damage during local transportation, stringing and laying operations.

The internal field joint coating process

During the pipe laying process, strings of pipe 40 to 60 joints long (1600 to 2400 ft/480 to 720 m) are pre-cleaned and welded. The pipes should be capped and kept clean during the transportation process and on the right of way. If dust and debris get in the pipe, it should be swabbed out before pre-cleaning and welding. The internal field joint coating will be addressed in stages. For example, on day one, the first crew will load the cleaning machine into the pipe string and move along cleaning and vacuuming at each weld joint. When the string one is complete, they will move to string two. It is best for this process to follow with in a few days to a week of the welding process. Later on day one, the coating crew will load into string one and apply coating to each bare, freshly cleaned weld joint area.

For Fusion Bonded Epoxy, (FBE), the process will start with induction heating the weld joint area. As soon as the pipe is up to temperature, the coating robot will be moved into place for the coating application. If the coating is a liquid product, the robot will simply move into place and start the coating cycle. All robotic machine functions are Programmable Logic Controller (PLC) operated and address each weld identically. The operators responsibility is to line up on the weld, activate the machine, observe its function and perform periodic maintenance. The actual robotic function is consistent, every weld, all day long in any weather. When the cleaning crew has finished string number two and moves to string number three, the coating crew moves from string number one to string number two. In most cases, string number one is ready to be inspected with in 24 hours of coating application. FBE can be inspected as soon as it cools down, perhaps 30 minutes later. Many of the new generation plural component liquids are hard to the touch within hours.

After inspection, a video and written record of the results is created. Coating thickness and holidays are reported and repairs are made if necessary.

After several strings of pipe are completed, they need to be joined together (the tie-in). The tie-in welding crew and the tie-in coating crew saddle up and start working their way down the right of way together. This is the only part of the process where the two teams (welders and coaters) work closely together and must wait on each other for the next weld to be addressed. The same process can be used for complex pipe sections where the first weld must be coated before the welding crew can address weld two.

Inspection

Customers have always wanted verification that their internal field joint was actually coated! Originally, a video camcorder was launched into the pipe strings on a robotic crawler. That is it simply travelled from one end of the string to the other looking for coating at 40 ft intervals. Then, in 1995, CRTS developed real-time video feedback. This allowed each internal robotic operation to be viewed as it happened, a significant operational improvement!

The real-time video was seen by engineers as an improvement but what they really wanted was a qualitative/quantitative inspection, such as high voltage holiday test or actual in-situ thickness readings, with specific criteria about how many pass/fail points given a population of inspection data. It has been known for years that such a device would be a tremendous development but there were never any resources to fund the development of such a machine.

Finally, in early 2004, CRTS funded a development programme out of cash flow. Two years and tens of thousands of dollars later, we had a working model. Within another year, it was patented and deployed for field trials. The additional development of the line travel inspection robot will enable us to make a last pass holiday inspection run and verify the in-situ quality of the internal pipe coating. The company recently bid a project where this capacity is a project design requirement not just a process improvement. The theory is sound that if the internal lining can be inspected immediately before the pipe is buried, then it will have the highest quality possible with no defects (or damage) left unaddressed.

Coating products

The internal field joint coating process was originally designed around FBE. For decades, that's all we applied. Then customers started asking for special liquid products to be applied. Originally, a phenolic resin with high Volatile Organic Compound (VOC) was required for a corrosive application on the North Slope of Alaska in the ARCO days. The first liquid spray robot was developed in 1991. By 1993, another application arose for a two part liquid epoxy for a potable water line in the UK. CRTS modified the original liquid coater and addressed this as well. The company always tried to bring customers back to FBE because of historical familiarity. By 1998, the company developed the first plural component 100% solids liquid epoxy robotic applicator with a 2:1 Mix ratio for use in a refinery. Since then, robots have been modified to address ratios of 1:1, 3:1, and 4.5:1. Most recently, CRTS developed a variable ratio plural component robot that can handle anything up to 7.5:1.

The internal field joint coating market is ~30% FBE and ~70% Liquid product. Another recent development is an 8-10 in. tie-in style robot. This means that the crawler, battery cart, cleaner, vacuum and coater are all together and can address a continuous stream of welds, like those found in an offshore water injection system. This machine happens to be for a client in the Middle East and can apply a variety of liquid coating products. Corrosion engineers have access to many excellent coating materials, each with specific application benefits and costs. Our goal is to solve the customer's

problem and apply what he/she wants in the environment he needs it applied.

There are alternative products and alternative vendors. Alternative piping systems such as PVC (Poly Vinyl Chloride), PE (Polyethylene), GRF (Glass reinforced Fibre) and others should be studied. All of these options should be technically and economically evaluated to fit into your project. In fact, man-entry has been used since the beginning of internal pipe coatings for large diameter pipe (36 in. and larger). However, man-entry is rife with technical shortcomings such as contamination, slow production rates and most importantly risk to human life. Internal field joint coating with robots is the only completely safe method of productively laying an internally coated pipeline. Furthermore, it is the only practical solution to pipe diameters less than 24 in.

Conclusion

There is no such thing as one answer to all problems. CRTS believes that if the project involves more than a few dozen internal field joints, we become economically competitive and at several hundred welds you will find few technical and commercial equals. Every solution needs to be technically and economically vetted. Continuous process improvement and cost containment may be rote catch phrases but will be words to live by in the 21st century. Stay ahead or fall behind, there is no middle ground in the pipeline business.

In summary, CRTS has a dedicated multinational workforce striving to deliver a unique service to a global customer base, in all kinds of harsh environments with zero defects. WP