Corrosion Control in the Oil and Gas Industry

Sankara Papavinasam

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Corrosion Control in the Oil and Gas Industry, Sankara Papavinasam, Elsevier, 2013, 0123973066, 9780123973061, 1020 pages. The effect of corrosion in the oil industry leads to the failure of parts. This failure results in shutting down the plant to clean the facility. The annual cost of corrosion to the oil and gas industry in the United States alone is estimated at $27 billion (According to NACE International)Ð²Ð‚â€•leading some to estimate the global annual cost to the oil and gas industry as exceeding $60 billion. In addition, corrosion commonly causes serious environmental problems, such as spills and releases. An essential resource for all those who are involved in the corrosion management of oil and gas infrastructure, Corrosion Control in the Oil and Gas Industry provides engineers and designers with the tools and methods to design and implement comprehensive corrosion-management programs for oil and gas infrastructures. The book addresses all segments of the industry, including production, transmission, storage, refining and distribution. Selects cost-effective methods to control corrosionQuantitatively measures and estimates corrosion ratesTreats oil and gas infrastructures as systems in order to avoid the impacts that changes to one segment if a corrosion management program may have on othersProvides a gateway to more than 1,000 industry best practices and international standards.

Corrosion under oil films with special reference to the cause and prevention of the after-corrosion of firearms, Wilbert James Huff, 1922, , 26 pages. .

Fluid Dynamics of Oil Production , Bakytzhan Zhumagulov, Valentin Monakhov, Sep 13, 2013, Mathematics, 280 pages. Fluid Dynamics of Oil Production is the perfect guide for understanding and building more accurate oil production models. It is dedicated to the theoretical and numerical study ....

Subsea Pipeline Engineering , Andrew Clennel Palmer, Roger A. King, 2004, Science, 570 pages. Authored by two of the world's most respected authorities in subsea pipeline engineering, this definitive reference book covers the entire spectrum of subjects in the ....

Ecosystem Services Global Issues, Local Practices, Sander Jacobs, Nicolas Dendoncker, Hans Keune, Oct 11, 2013, Nature, 456 pages. Ecosystem Services: Global Issues, Local Practices covers scientific input, socioeconomic considerations, and governance issues on ecosystem services. This book provides hands ....

Corrosion and water technology for petroleum producers , Loyd W. Jones, 1988, Science, 202 pages. .

A History of Modern Immunology The Path Toward Understanding, Zoltan A. Nagy, Oct 11, 2013, Medical, 356 pages. A History of Modern Immunology: A Path Toward Understanding describes, analyzes, and conceptualizes several seminal events and discoveries in immunology in the last third of ....

Coal and Coalbed Gas Fueling the Future, Romeo M. Flores, Dec 5, 2013, Science, 720 pages. Bridging the gap in expertise between coal and coalbed gas, subfields in which opportunities for cross training have been nonexistent, Coal and Coalbed Gas sets the standard ....

Natural Gas Hydrates in Flow Assurance , Carolyn Ann Koh, Amadeu Sum, Oct 12, 2010, Science, 224 pages. With millions of kilometres of onshore and offshore oil and gas pipelines in service around the world, pipelines are the lifeÐ²Ð‚â„¢s blood of the world. Notorious for disrupting ....

Advanced Well Completion Engineering , Wan Renpu, Aug 23, 2011, Science, 736 pages. Once a natural gas or oil well is drilled, and it has been verified that commercially viable, it must be "completed" to allow for the flow of petroleum or natural gas out of ....

Advanced Water Injection for Low Permeability Reservoirs Theory and Practice, Ran Xinquan, Mar 29, 2013, Science, 264 pages. Concise and readable, Water Injection For Low Permeability Reservoirs provides operators with the proper workflow systems and engineering techniques for designing, planning and ....

Techniques for corrosion monitoring , Southwest Research Institute, Institute of Materials, Minerals, and Mining, Feb 1, 2008, , 691 pages. Corrosion monitoring techniques play a key role in efforts to combat corrosion, which can have major economic and safety implications. This important book starts with a review ....

Catalytic RNA , , Dec 24, 2013, Medical, 248 pages. This special volume of Progress in Molecular Biology and Translational Science focuses on catalytic RNA. Written by experts in the field, the reviews cover a range of topics ....

Corrosion Inspection and Monitoring , Pierre R. Roberge, Feb 9, 2007, Science, 368 pages. The comprehensive reference on modern techniques and methods for monitoring and inspecting corrosion Strategic corrosion inspection and monitoring can improve asset management ....

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Dr. Papavinasam is President of CorrMagnet Consulting Inc. He has 20 years of experience in the oil and gas industry. He has led several joint industry projects with more than 50 companies developing new corrosion solutions and insights to manage internal corrosion, microbiologically influenced corrosion, and external corrosion of oil and gas industry. He has published over 100 papers, contributed to 5 book chapters, developed 3 software products, and received 2 patents.

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This 952-page book presents the unique 5-M methodology to help the oil and gas industry to reach this ‘zero failure from corrosion’ goal. The book discusses the characteristics each of the methodology’s five pillars: Modeling, Mitigation, Monitoring, Maintenance, and Management. It describes implementation of the 5-M methodology in various segments of the oil and gas industry including production, transmission, storage, refining, and distribution.

acid alloys anode applied ASM International ASTM biodiesel carbon steel cathodic protection chemical chloride coal tar coating corrosion control corrosion inhibitors corrosion potential corrosion rate cracking crude oil density determine diameter disbondment effect Electrochemical electrode environment epoxy evaluation external Figure galvanic corrosion gas industry Houston hydrocarbons hydrogen increases infrastructure inspection internal corrosion ions ISBN laboratory liquid localized corrosion materials measurement metal surface monitoring N/A N/A NACE International natural gas normally oil and gas oilsands operating conditions oxide oxygen Papavinasam performance Petroleum phase pipe Pipeline Transportation pitting corrosion polyethylene polymeric presents pressure production properties reference electrode refinery Reproduced with permission resistance score soil stainless steel Standard Specification Standard

Test Method Standards providing guidelines stress structure sulfur surface layer susceptible Table techniques transmission pipelines transported typically Valves weld Yes Yes Yes

Oil and gas pipelines play a critical role in delivering the energy resources needed to power communities around the world. In the United States alone, according to the U.S. Department of Transportation (DOT), more than 2.5 million miles of pipelines â€" enough pipeline to circle the earth approximately 100 times â€" deliver oil and gas to homes and businesses.

While pipelines are recognized by government agencies such as the DOT and the National Transportation Safety Board (NTSB) as being one of the safest and most efficient means of transporting these commodities, their use still poses an intrinsic risk due to failures and leaks. Although major pipeline failures occur infrequently, several pipeline incidents in recent years have put the issue of pipeline safety into prominent view. In response, both the Canadian National Energy Board (NEB) and the DOT are implementing measures that promote pipeline safety and security.

To better understand how corrosion can impact the safety and reliability of transmission pipelines, NACE International asked several of its members in the oil and gas industry to comment on the challenges faced by the industry when managing corrosion of pipelines, in particular the pipelines that transport crude oils. This report will be presented in two parts with the second article in April.

Panelists are Jenny Been with TransCanada Pipelines; Oliver Moghissi with DNV; Michael Mosher with Alberta Innovates-Technology Futures; Sankara Papavinasam, FNACE,(1) with CanmetMATERIALS; Trevor Place with Enbridge Pipelines; and Sonja Richter with Ohio University. (See their biographies in the sidebar, â€œMeet the Panelists.â€•)

NACE: The oil industry is facing concerns by the general public that heavy crude oils, particularly diluted bitumen (dilbit), are corrosive and can lead to leaks and oil spills from transmission pipelines. What are the main challenges the industry faces when managing corrosion of pipelines that transport crude oils?

Water carried by heavy crude oils, including dilbit, does not significantly differ in corrosivity from water carried by other crudes. Corrosion in crude oil pipelines is addressed by conventional corrosion control practices and is generally effective. However, pipelines travel over long distances, and what is considered unlikely at one location can become significant when summed over a pipeline infrastructure.

Place: Crude oils, including dilbit, are not corrosive in pipelines. The main technical challenge is that trace water and sediments â€" not the crude oil â€" cause corrosion. The presence of crude oil, including the dilbits we have tested, actually decreases the corrosiveness of the standard brine used in standard testing. Although we know that we have a minimally corrosive system, we think it may be possible to reduce corrosion even further â€" and this possibility is what drives our research and development efforts.

It is challenging to accurately measure very small or very rare things, and the corrosion that occurs in transmission pipelines is typically isolated and progresses rather slowly; this makes it difficult to identify and assess the likelihood of internal corrosion, and also to evaluate the beneficial effects of mitigation activities.

Mosher: One of the main challenges facing the industry with respect to managing corrosion of crude oil transmission pipelines is the difficulty in predicting internal corrosion. Most internal corrosion in crude oil transmission pipelines is caused by the settling of solid particles that can carry water to the pipe surface. Transmission tariffs are set to limit basic sediment and water (BS&W) to <1% (often 0.5%). The solid particles tend to be encapsulated by a layer of water that may concentrate water on the pipe wall surface. This creates the potential for corrosion to occur if the flow conditions of the pipeline system allow for these solids to settle out.

The water (an electrolyte) is a necessary component of the corrosion cell. Without it, corrosion will

not occur at appreciable rates within the transmission pipeline. This type of corrosion is typically referred to as underdeposit corrosion and will often manifest as localized pitting. Moreover, pitting corrosion can proceed rapidly or lay dormant for extended periods of time, making this type of corrosion particularly difficult to predict.

Richter: The main challenge is to manage the water that is transported along with the crude oil and is responsible for the corrosion that occurs if it is in contact with the pipeline wall. Crude oils are not corrosive at temperatures encountered in pipelines. It is not until crude oils are heated in refineries that they can become corrosive. The industry severely limits the amount of water allowed into transmission lines to <0.5% by weight.

While this small amount of water (which is heavier than the oil) can easily be kept off the pipeline wall and entrained in the crude oil, it is a challenge for the industry if production (and flow rates) decreases, making it more challenging to keep the water entrained and off the pipeline walls. However, heavier crude oils entrain the water more easily than lighter crude oils, which is beneficial for corrosion protection.

Papavinasam: The main challenge the industry faces is to establish public confidence that the risk due to internal corrosion of oil transmission pipelines is low and that the risk can continue to be managed at the lower level using established engineering practices. Under normal oil transmission pipeline operating conditions, corrosion occurs by an electrochemical mechanism. Crude oil (including dilbit), being a non-conducting electrolyte, does not support corrosion. However, if the crude oil contains water, then corrosion may take place in those locations where water drops out of crude oil and comes in contact with the metallic surface. The bulk crude oil may indirectly affect the corrosion by influencing the locations where water may accumulate and by influencing the corrosivity of water in those locations.

The pipeline operators keep the risk of internal corrosion in oil transmission pipelines at a lower level by limiting the amount of water to <1% BS&W (typically to <0.5%). However, based on some non-scientific reports and extrapolation of corrosive conditions of refineries (operating above 200 oC) to the conditions of oil transmission pipelines (operating typically below 70o C), some members of the public are concerned that crude oils are corrosive.

Place: The primary factor that affects internal corrosion in transmission pipelines is flow rate. Transmission/refinery-ready crude oils (including dilbit) contain very little corrosion-causing water or sediment, but internal corrosion can occur if the flow conditions in the pipeline allow these materials to accumulate and persist on the pipe floor for extended periods of time. No crude oil grades have yet been proven to be more corrosive than others, but there are measurable variations in certain corrosion-related properties of crude oil.

ASTM G2051 is an industry guide for evaluating three important crude oil properties that can have an impact on internal corrosion: these are wettability, emulsion-forming tendency, and effect of crude oil on the corrosiveness of brine. Based on our investigation so far, there does not appear to be any correlation between the crude oil grade and these corrosion-related crude properties. Our tests have shown these properties to vary as much within a crude grade as they do between different crude grades.

Moghissi: Corrosion in crude oil pipelines is often attributed to microbiologically influenced corrosion (MIC). The most significant factor in evaluating the likelihood of MIC is whether water and solids suspended in the oil remain entrained or fall to the bottom of the pipe. The critical velocity for entrainment depends upon physical properties of the oil (e.g., heavy crudes have lower critical velocities) and throughput. With everything else being the same, pipelines with slow flow (below critical velocity) tend to be more susceptible to corrosion than those with high flow (above critical velocity).

Mosher: The primary method of crude oil corrosion within transmission lines is underdeposit corrosion. Particles settling at the bottom of the pipeline establish an environment that can promote

a water-wetted surface. Chemical properties of the settled water and presence/absence of active bacteria could vary between crude oil sources, but (to my knowledge) there is no literature comparing the corrosiveness of waters from different crude oils. However, several papers have been published that show crude oils can inhibit the corrosiveness of water when mixed together.

Settling of solids during the transportation process is largely governed by elevation changes in the pipeline. In areas of overbends or under bends in the pipeline, the fluid dynamics can promote the settling of particles where they would otherwise be carried safely through the pipe. I have seen no evidence â€" scientific or statistical â€" indicating that one type of crude is noticeably more corrosive than another under standard pipeline operating conditions.

Papavinasam: Industry has established that the BS&W of oil transmission pipelines is lower than 1% (typically lower than 0.5%) volume to volume. The result of low amounts of water in oil transmission pipelines is a low probability of internal corrosion. However, locations where water accumulates may be susceptible to corrosion.
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