Session Descriptions

#6 **Tackling Competency in Mechanical Integrity**

This is a high level presentation whose results can be applied to all sectors of the oil and gas industry, not only integrity. The presentation sets forth how to determine the various competencies needed and then establishing the criteria for each skill set identified. The presentation then goes on to explain how to set up the necessary metrics by which to measure individuals' compliance to the applicable criteria.

#8 **Is RBI for You?**

With the increase cost of operating and taking shutdowns, many operators are using a technique to optimize their Mechanical Integrity programs. The approach is Risk based and is called Risk Based Inspection, RBI for short. This is a discussion about the core elements of a RBI program and what it takes to establish and sustain an effective and successful program.

#10 **What Makes a Good Inspector Great?**

To help prevent the Industry incidents and protect the environment and personnel, Inspector training and experience is a very important topic. With many personnel at or near retirement, the knowledge gap and experience is an area where many companies are focusing attention. Without formal programs in place, there comes a burden on the Inspector to begin to self-learn and rely on other resources to help gain knowledge and experience. The one caveat to the Inspector's increase in knowledge is that much is learned on the job and in the field through a series of unique events. In recognition of these gaps and the steep learning curve associated with the Inspection field, it is best served that the Owner-User and Contractor/Supplier of API Inspection services work together to share knowledge and increase the overall effectiveness of the Integrity Programs for Fixed Equipment.

#11 **Mechanical Integrity Program Management - Online Portal Discussion**

The presentation delivers quality management concepts and practices that are newly adopted in the format of an online portal which helped to create an efficient performance monitoring tool for the asset integrity programs and an avenue for the excellence in engineering inspection management at Saudi Aramco.

#12 **Recent PMI Innovations and Your API RP-939C Compliance**

This presentation will highlight recent innovations in HH XRF analysis for In-Service Alloy PMI Testing. XRF analytical field techniques and sample preparation in an industrial setting will be discussed, along with recommendations for effective testing of hot samples and vibrating samples. Attendees will learn techniques for successful in-service testing of Si below 1000 ppm as required by RP-939 C is the major focus.

#13 **Proven Applications for Subsea Vibration Monitoring and Inspection**

Reliable and efficient monitoring is becoming increasingly important as production and processing assets move subsea. A selection of field cases will be shown to illustrate the concept and wide range of applications of the Vibration Monitoring technology.

#15 **A Comprehensive Discussion on Coating Systems for CUI Service**

Corrosion under insulation (CUI) is a serious problem for many owners who have insulated service, where severe corrosion often occurs which can cause plant or process shutdowns, environmental damages and potential injuries to workers. A review of past and current technologies for preventing CUI will be presented. The initial and long term costs, performance characteristics, expected service life as well as ease of application and repair of coatings used under insulation will be discussed. Field and laboratory performance experience obtained from users, third-party laboratories, and vendors of the various coating systems are used for this comparison.

#17 **Challenges Associated with RBI Assessments Of HF Alkylation Facilities**

Some owner/operators have chosen to conduct RBI assessments of HF Alkylation facilities while others have not, preferring alternative approaches to mitigating risk from environmental damage mechanisms. HF Alkylation facilities present particular challenges to RBI assessments due to their unique damage mechanism dependence on operational controls and feed/acid quality, the influence of residual alloying elements on corrosion rates and the batch mode of the HF acid regeneration section of the facility. This presentation describes the RBI facilitation of a new HF Alkylation Facility using commercial RBI software and a subject matter expert (SME) workshop based approach.

#18 **Efficient Implementation of PAUT & TOFD for Weld Inspection**

Several studies and practical trials have shown the value of combining phased array UT (PAUT) and TOFD techniques for the inspection of welded joints. The simultaneous use of these two techniques has a positive impact on the quality and accuracy of the collected data. This paper will show how a recently developed solution allows for efficient, robust and operator-friendly weld inspections using PAUT and TOFD techniques.

#19 **Pipeline Integrity Assessments - The Process and Strategy**

This paper presents the methodology that is adopted for the “integrity assessment” of the onshore and offshore pipelines. The various steps that constitute the process are data collection and review, hoop stress assessment, axial stress assessment, corrosion growth analysis and remnant life prediction of each metal loss anomaly on the pipeline based on relevant codes (ASME B31G and DNV-RP F101). The results of “pipeline integrity assessment” are then used to estimate the time for future inspection and develop a strategy to ensure future integrity of the pipeline.

#21 **Process Safety and the Impact to Your Mechanical Integrity Program**

One of the most significant issues with developing and implementing mechanical integrity programs for Asset Integrity Management (AIM) is lack of adequate process safety information (PSI). This paper describes the relationship between design basis, codes & standards, acceptance criteria and inspection and maintenance priorities to ensure that mechanical integrity programs have a solid foundation. It provides a review of the individual elements of PSI and the importance of each of these elements with conditions that would facilitate the development and implementation of mechanical integrity programs, including a review of recognized and generally accepted good engineering practices.

#22 **How Natural Forces Impact Your Integrity Management Philosophy and Planning**

This presentation provides a brief overview of the history of scour observations; describes the evolution and changes to scour monitoring techniques; and discusses how recent advances in scour monitoring might be employed to provide an "early warning" for pipeline water crossings at risk from flood induced channel scour and how these data can be used to inform or expand integrity management plans.

#23 **A Guide for Successfully Staffing and Executing a Turnaround**

To those in our industry, it's no secret that plant and refinery turnarounds produce complex challenges for all parties involved. From planning to completion, a "successful" turnaround is anything but routine. This presentation will begin by detailing some of the significant issues associated with turnaround staffing and touch on some of the related fundamentals of turnaround execution, including safety, turnaround management and leadership, progress tracking, and communication. This will lay the groundwork for the introduction of mitigation tools and procedures, e.g. manpower selection and screening, that will assist in achievement of a "successful" turnaround.

#24 **The Unit Inspector and the Turnaround Organization - Partnering for Success**

In large part the timely, fixed equipment inspection input into the turnaround plan for a scheduled unit outage is crucial to the success of a facility's turnaround. Accountability for the success of the turnaround, this includes: duration, cost, and safety of all aspects. The presentation centers around the above mentioned three areas, each of the these areas will be broken down, further defined and examples provided in the areas of pressure vessels, piping, exchangers and relief valves in a Power Point format. Barriers to this quest will be identified, challenged and proposed "fixes" presented.

#25 **Utilizing Measured Vibrations in Fatigue Assessments for Upstream Equipment**

The frontier of oil and gas exploration and production goes hand-in-hand with heightened environmental challenges, due to such factors as large waves, strong winds and currents, the presence of ice, high reservoir temperature and pressure, etc. In addition, little data may be available on environmental conditions at the site. As a result there is a higher risk of failure for exploration and production equipment. By employing monitoring methods such as those provided in this presentation, the uncertainties and challenges associated with the frontier of oil and gas exploration and production can be significantly alleviated. The techniques discussed help to ensure safe and efficient operations, even in the most arduous of conditions.

#29 **Guidelines for Routine Visual Inspection by Operations Personnel**

This presentation focuses on the Monthly Examination Checklist utilizing actual field photos to illustrate examples and will also discuss why the visual inspection by Operations personnel is so important.

#31 **Coatings for Heat Exchanger Tubes – Do They Really Work?**

The short answer to the title questions is: "Yes, but it depends." This presentation addresses the ". . . it depends" part. How to properly select a coating material, draft the specification, select the installer, and provide adequate inspection of linings for heat exchanger tubes is no secret. This presentation gives a brief historical background of heat exchanger tube coating and covers each of the above 4 steps, explaining why each is crucial to achieve the intended performance life.

#32 **Calibrating an Ultrasonic Thickness Meter - Some Simple Truths and Things to Avoid**

Current Industry practice reveals that numerous facilities utilize digital type thickness meters for the acquisition of corrosion monitoring thickness data. It has been observed that there are widespread differences in the actual calibration and use of these meters in the field to acquire reliable repeatable data. This presentation seeks to examine the most common methods of field use and calibration techniques to acquire data and to reveal some of the inaccuracies being reported that have gone undetected using actual corroded samples that are both coated and uncoated.

#33 **Source Surveillance - Do We Miss This Portion of Process Safety Management?**

The presentation covers the role of the inspector to implement section 1910.119(j)(6)(i) which reads "In the construction of new plants and equipment, the employer shall assure that equipment as it is fabricated is suitable for the process application for which they will be used." One sentence but to properly implement requires many activities. A detailed thought process and approaches to ensure you are covering these activities will be delivered.

#34 **Mitigation Of Integrity Challenges In Ageing Refineries - A Risk Based Approach**

Ageing Refineries face several operating challenges due to equipment degradation, deficient / obsolete design and/or inadequate control systems jeopardizing productivity and asset integrity. Plant engineers often face the challenges of providing interim solutions, in order to continue operations without sacrificing the integrity of the assets until planned replacements are taken up. These solutions involve risk based approaches, table top discussions, sound engineering judgment, fitness for service assessments, economic and safety considerations and field monitoring. This paper describes two such examples where suggested solutions were implemented and remedial works helped to continue Operation.

#36 **Understanding Acoustic Emissions and Signature Recognition**

In the field of Acoustic Emission (AE) Testing the response of the sensor to the release of energy due to metals deforming in alloy's used in pressure vessel manufacturing with controlled stress when they reach 60% of the yield stress is well documented. This paper offers an explanation of some of the phenomena and to better understand their effect on the AE signature. Both metals and composite materials are discussed.

#37 **Physical Failure Analysis and How We Can Learn From Our Mistakes**

When equipment fails there is an opportunity to learn from those failures. Physical Failure Analysis (PFA) is the key to gain access to those learnings. This presentation will review the fundamentals of Physical Failure Analysis (PFA), provide a cursory review of common damage mechanisms, and present examples of simple failure analysis.

#38 **Fitness for Service Approaches - ASME and API Approaches Compared**

This presentation aims to: provide wall thinning FFS assessment approach for equipment subject to under deposit corrosion. Compare ASME B31G with API 579 analysis results and highlight the main differences with reasons and potential similarities. Provide recommendations to help select a FFS assessment approach.

#40 **How to Deal With Deficiencies in Operating Assets - A Tank Case Study**

Asset integrity programs involve many elements, from equipment design, procurement, and fabrication, to installation, commissioning, operation and shutdown. Effective AI programs also include processes to manage equipment deficiencies when they are identified. A case study involving a production water skim tank will be presented as an example of this deficiency management process, a key component within the mechanical integrity and maintenance elements.

#41 **Non-invasive Heat Exchanger Tube Inspections - Applications and Limitations of Technology**

Pulse reflectometry is a generic method for probing materials and cavities by transmitting a pulse and measuring reflections caused by discontinuities. Two variants of this method used for tube and pipe inspection are Acoustic Pulse Reflectometry (APR), and Guided Waves (GW). We present here a unique implementation employing both methods simultaneously, thus taking advantage of their complementary capabilities. APR detects Inner Diameter (ID) faults such as blockages, through holes and ID wall loss, while GW can detect ID/OD wall loss and cracks.

#42 **Nondestructive Evaluation of Non-Piggable Pipelines in Deepwater - Recent Developments**

With the Sub Sea infrastructure aging and the large number of non-piggable lines a request was made by major oil companies to explore the aspect of inspecting the subsea infrastructure using our Electro Magnetic Acoustic Transducers known as (EMATS). A new technology application was created and will be explained in this presentation.

#43 **Onshore Production Tanks - Risk Assessment and Nondestructive Evaluation Techniques**

Operating a new onshore production asset with more than 1100 carbon steel API 12F production tanks with limited inspection history and several leaks associated with tanks degradation was the situation. It was necessary to develop a tool to prioritize inspection/ replacement activities. This presentation discusses the thought process and what was developed to handle this situation.

#44 **Inspection with Remote Aerial Vehicles, Safety, Operations, and the Positive Impact on the Asset Integrity Field**

What is a sUAV? Description of sUAV and differentiation from “drone”, separating myth from fact concerning small unmanned systems and explaining the roles of Remote Aerial Vehicles for use in Asset Integrity Why use a sUAV? Comparison in effectiveness and cost over a full scale aircraft (helicopter or fixed wing), convenience, safety, operating environment, real-time control of inspection, ability to quickly shift mode of inspection, environmental impact What kind of data can be collected? Various types of imagery and analytical information able to be obtained, with the ability to change operating payloads on the go without extensive downtime What has to be considered? Items to be covered will include- safety (both personnel as well as operational safety), operations (types of operations, capabilities, mission specific needs), logistics, permitting (country/region specific as well as operator specific), permissions (certifications, governmental requirements, ICAO, etc), site personnel, environment, etc. Summary Closing comments concerning the positive aspect of utilizing this remarkable technology to benefit the Asset Integrity field.

#46 **Benefits of ILI Verification**

Pipeline In-Line Inspection (ILI) technology collects and processes a phenomenal amount of information over the length of a pipeline. In-service degradation for upstream pipelines are predominantly at the internal surface. The presence of corrosion by-products and can interfere with the transmission and reception of signals, whether ultrasonic or electro-magnetic. The difference between machined flaw ILI tools calibrations and real-life corrosion flaw morphology responses will be discussed as well as examples of calibration errors and errors in data interpretation.Case studies of ILI data verification through the use of external, advanced automated ultrasonic inspection shall be presented as well as their use for refining the interpretation rules for ILI flaw responses. Validations include excavation of buried lines, removal of concrete weight coat (if subsea) and all surface coatings other than thin, uniform layers of epoxy. Intervention costs of ILI verification are not insignificant, but experience over the past 25 years has proven itself many times over with pipeline and even field lifetimes having been extended significantly.

#47 **A $7MM Success Story: Realizing Value from a World Class Mechanical Integrity Program at Dakota Gas**

Since 2007, Dakota Gasification Co. (DGC) has implemented an APM solution to fit their business needs. By attending this session, managers will learn how choosing an integrated platform for a fixed equipment Mechanical Integrity program at (DGC) allows them to optimize their return on investments. DGC will also share with inspectors how their use of an integrated Mechanical Integrity solution that includes Risk Based Inspection, Thickness Monitoring, Inspection and Recommendation Management together has optimized their maintenance activities. Gain insight on how DGC utilized these tools to drive savings and target areas for improvement,

including identifying $7.3MM in maintenance savings and production availability. Their process of identifying “Bad Actors” and documenting “Equipment Saves” will also be presented.

#48 **Improving Your Compliance with the OSHA PSM Standards**

Manufacturing and storage of highly hazardous substances demands compliance with the OSHA Process Safety Management (PSM) Standard (Sec. 1910.119), requiring facilities to implement processes, procedures and controls to ensure compliance in your industry and region and protect workers and the organization against the risks of catastrophic incidents. The standard requires a detailed mechanical integrity program for all process equipment as well as rigorous requirements for operating procedures, training, compliance audits and process hazards analysis. This session will explain how to improve their regulatory compliance through a fully auditable proactive lifecycle approach, focused on Mechanical Integrity and Process Safety.

#49 **Heat Exchanger Tubing Inspection Analysis Challenges: Capabilities, and Limitations**

This presentation will discuss the most commonly utilized tubing inspection techniques (ECT, RFT, NFT, IRIS) analysis challenges, capabilities, and limitations of each method. The requirement for proper training of data analysts, and proper analysis procedures. The presentation will also touch on new and emerging technologies being utilized to overcome some of the limitations and challenges. The presentation will contain field data, representative pictures of indications, diagrams, and recommended requirements for Heat Exchanger Tubing Data Analysts.

#50 **Eddy Current Array Probes for Crack Detection and Sizing in Carbon Steel Welds**

The inspection of carbon steel welds for surface cracks remains a significant inspection challenge. Conventional eddy current inspection technique (ECT) represents an opportunity for improved crack detection and measurement over other NDT methods, however using a single coil ECT pencil probe results in protracted inspection times and poor probability of detection. ECT can be negatively impacted by variations of magnetic permeability in carbon steel, sensor lift-off variations and weld geometry. Eddy current array probes (ECA) are a however limited to defect detection only in carbon steels. Recent advances in ECA coil design and multiplexing patterns have contributed to the development of a new generation of ECA probes for carbon steel weld inspection that allows inspections to be carried out quickly with accurate depth of crack sizing without the need to remove protective coatings. Various aspects of the ECA technique are discussed and supported by inspection results obtained from different welded carbon steel specimens.

#51 **High Temperature Sulfidation Corrosion (HTSC) Inspection**

Sulfidation corrosion is of concern in sour oil services starting at temperatures in the 500F (260C) range, and sulfidation corrosion rates are typically uniform and predictable. The 2012 HTSC incident at the Chevron Richmond refinery involved a 52 inch straight section of A53 carbon steel pipe having a low silicon content that was installed decades prior to the failure. Radiometric profiling will be discusses as a faster and safer alternative to ultrasonic testing method for inspecting insulated piping circuits. As the RT profile sees both sides of the pipe at the same time, twice as much pipe is inspected compared to more conventional NDT methods without insulation removal. Simple but effective centering devices are also available to keep the radiation beam oriented correctly through the pipe under test. This presentation will cover the capabilities and limitations of radiometric profiling in identifying HTSC and other anomalies commonly found in refinery piping.

#53 **Integrating ILI and Pipeline Data to Evaluate Asset Preservation Strategies**

PHMSA regulations require that Pipeline Operators use available data sets to continuously review and improve their integrity management programs. While most Operators are accustomed to evaluating multiple successive in-line inspection data sets, other data streams can provide significant insight into the overall “health” of a pipeline.

This integration can identify materials, manufacturers, and other factors which have the potential to substantially reduce the life of the pipeline if left unmitigated. Evaluation of multiple data streams is used to identify areas where preemptive reconditioning can slow pipeline corrosion. It can also be used to identify specific coatings which may have decay rates which are higher than expected and target management strategies which can extend the useful life of the pipeline. This presentation shows how the integration of multiple data sets with successive ILI data identified specific pipe and coatings that were suffering accelerated coating failure and increased corrosion rates.

#54 **NDE of Composite Wrap Repairs Piping & Pipelines**

This presentation will outline the deliverables ro industry group sponsored project to assess the performance capabilities of a range of NDE techniques to examine non destructively the integrity of composite wrap repairs as applied to pipelines and piping. The presentation will discuss ability to assess remaining wall under the wrap repair as well as integrity degradation of the rpairs themselves.Techniques discussed and assessed include Digital Radiography, Long range Ultrasonics, Microwave, Laser Shearography and a range of Electromagnetic techniques. Attendees will depart with ainsight into the expected performance of these techniques.

#55 **Selection of Risk Mitigation Tool for Confirmation of Containment**

Sunoco Pipeline L.P. (Sunoco) has ~5,500 miles of crude oil trunk and gathering lines, and 2,500 miles of pipelines for refined products, crude oil and natural gas liquids. Sunoco follows DOT, API, NACE and in-house pipeline inspection protocols as part of the asset integrity management program using a variety of recommended technologies like smart pigs, hydro-static test, etc. Sunoco aims to meet and exceed current pipeline risk protocols. Within a well maintained pipeline network. MFL inspection in 38 mile section of 10" Orlando-Hudson line revealed many locations with wall loss. Sunoco undertook to deploy a novel in-line smart ball tool to determine if any of these locations were through wall defects. This paper will provide background on the MFL inspection data, employment of in-line free swimming acoustic leak detection tool and subsequent field verification. The application of smart ball tool for confirmation of containment will be discussed in detail in this paper.

#56 **Large Scale Guided Wave Testing (GWT) of Aboveground Tanks for API-653 Engineering Reports**

The long-range propagation of ultrasonic guided waves, or Guided Wave Testing (GWT) is a useful rapid screening tool to detect corrosion, cracks, or other anomalies in structures. GWT is optimal for assessing the condition of pipes, vessels, and plates where ordinary NDT methods are limited, difficult, or expensive to perform. GWT technology is also well suited for rapid, non-intrusive tank inspection. This presentation discusses GWT technology for prioritization and preparation for storage tank inspection including field tests and findings. GWT was applied for inspecting an approximately 30-year old, 35-ft diameter, 36-ft high insulated Evaporator Feed Tank resting on a concrete ring wall. GWT was used along the vertical direction of the tank. The entire tank circumference was scanned by moving the probe vertically upwards from those two probe locations. Several vertical Stress Corrosion Crack (SCC) defects were detected and analysed for fitness-for-service in accordance with API-653. Guided wave testing reduced the time and cost to setup and implement, gathered useful data, and thus enhanced the overall efficiency of the inspection.

#57 **Learning How to Avoid Expensive Shutdowns with Non-intrusive Inspections**

This presentation will cover the following areas: Current Challenges to plant owners /operators for maintaining assets fit for purpose while ensuring maximum availability with reduced turnaround; Traditional Inspection approaches, their advantage and disadvantages; Shutdown challenges and optimization; Codes and industries recognition for on-stream inspection; Selection criteria for On-stream non intrusive inspection; Using RBI for the preparation of Non Intrusive inspection plan; Advancement in inspection technologies; Overview of few advance

inspection techniques application as a non intrusive inspection; and Advantages of non intrusive inspection over traditional offline inspection.

#59 **Equipment Deficiency Reports Toward Manufacturing Process Improvement**

The presentation will provide an overview of the equipment deficiency report (EDR) process. This presentation provides a great opportunity for exploring the benefits of utilizing EDRs in organizations for them to collaboratively work together with their suppliers to improve the manufacturing process. The presentation will start with an overview of the EDR process by defining the EDR, scope and objectives. Then the EDR process cycle will be described starting from initiation to completion of the EDR. Advantages of EDRs will be discussed to show how they can help in improving the manufacturing process. General EDR statistics will be shown for some commodity deficiencies from historical periods. The presentation will conclude with an outline of a real case study where EDRs were used to show how EDRs can contribute toward improvement of manufacturing processes by highlighting challenges. The analysis and root cause will then be discussed. Finally, corrective actions resulting from the EDR case study will be shared.

#60 **IOW – How It Can Help in Failure Prevention. Crude Upgrader Study Case in Latin America**

An IOW program along 18 process units with 165 MBl's per day was developed and implemented. The key to implement IOW was real time identification of process variables, secure boundaries and the setting up into the Process Historian System, Analytic Tool, and MI System as an integrated approach that avoids non-planned shutdowns and optimization of unit availability and production. The program combined appropriate technologies per a degradation mechanism assessment. The Corrosion Engineer could define the parameters, frequency, and places to proceed within the data collection from different sources such as gauges, laboratory analysis and field surveillance. An example case involving sulfidation of a Feed Preheat System with a high corrosion rates will be discussed. Automated alerts from the IOW resulted in actions to adjust process variables, inspection frequency and corrosion control, avoiding a premature failure and its impact (45 MM US).

#61 **Rapid Inspection of Tank And Vessels Using Electromagnetic Acoustic Transducer (EMAT) Angle Beam, for Detection of Corrosion, Hydrogen Damage and Cracking**

Ultrasonic testing using Electromangentic Acoustic Transducer (EMAT) has been around for some time now. For the last 10 years the inspection method has been utilized in oil and gas industry mainly for guidedwaves. With the recent advancement in technology it is now possible to use EMAT systems to excite other types of wave modes including shear vertical and shear horizontal. Using pitch catch method with shear waves, tank floors and vessels can be inspected rapidly to determine discontinuities. Unlike guided waves shear waves are not limited by thickness restrictions. EMAT approach enables operators to rapidly inspect their system with little to no impact to normal operations. The goal of this paper is to explain the rapid alternative inspection method for overall condition of equipment and vessels assessment.

#62 **Inspecting High Consequence Areas of Unpiggable Pipelines**

The integrity management of Gulf of Mexico's unpiggable deep-water pipeline systems is an ongoing industry challenge. There are currently no in-line inspection (ILI) tools capable of inspecting the risers either due to a lack of a launching and receiving facility or limitations in size and wall thickness of the pipelines. Revalidating these systems and establishing their fitness for service using external quantitative inspection techniques is considered an acceptable alternative for high consequence pipe areas. The presence of coating and insulation materials and Vortex Induced Vibration (VIV) suppression devices on the thick-walled risers means that there are extremely limited technologies capable of obtaining satisfactory results. Hence, BP's GOM pipeline integrity team commenced a project to engineer, qualify and construct an external Saturated Low Frequency Eddy Current

(SLOFEC) tool for topside and subsea pipeline/riser systems. A field trial case study from June of 2014 shall be discussed.

#63 **In-Line Inspection Technique Suitable for Lined or Internally Coated Pipelines**

This presentation will cover the inspection of previously "unpiggable pipelines" using Remote Field Technology (RFT). RFT is a non-contact, electromagnetic technique that works through liners, internal coatings, sludge, scale and tubercles. It works well in cement lined, HDPE lined and epoxy coated pipes without damaging the liner. Several new case studies will be presented and the technique explained. Intended target audience is pipeline owners, chief inspectors and asset managers of pipelines. Dave holds four patents to the technology and has led the development of RFT technology for various applications since the mid 1980's.

#64 **Save Time and Cost for Turnarounds Using Phased Array Technology**

All refineries and chemicals plants have regular plant turnarounds and shutdowns for maintenance, inspection and engineering projects which generally involve new pipe fabrication and butt welds that require NDE inspections. Planners and engineers look for ways to improve the schedule and not have radiation boundaries take significant time from the schedule. The purpose of this presentation is to explain how to successfully introduce Ultrasonic Testing Method, Phased Array Technique (PAUT) into a plant turnaround as an alternative to common film Radiographic Testing for the inspection of pipe butt welds.

#65 **Case Study of AC Induced Corrosion on a 24'' Natural Gas Pipeline**

An integrity FFP study was generated as a result of a re-inspection done for a 24 inch diameter Natural Gas pipeline. During this FFP, it was noticed that the MFL re-inspection report has commented that the deepest reported external metal loss feature was not visible in the previous inspection. The result of the direct assessment confirmed that this feature was corrosion in nature and it was concluded that this corrosion occurred due to a problem with CP system, caused by the interaction between buried pipeline and high voltage overhead transmission power lines. AC voltage was measured at the test point was found to be 13Vac. The corrosion was a result of an AC current flowing from the buried pipeline to the surrounding ground via a small coating defect. To ensure the integrity of the pipeline, GASCO connected the pipeline with a bare copper cable / tape via a cathodic isolator.

#67 **Remote Measurement of Stress in Carbon Steel Pipelines**

Monitoring the integrity of buried ageing ferromagnetic pipelines is a significant problem for infrastructure operators. Inspection relies on pig surveys, DCVG, CIPS and contact NDT methods that often require pipes to be uncovered and often at great expense. Recent developments have been made in a remote sensing technique to detect corrosion, metal defects and the effects of ground movement by mapping variations in the earth's magnetic field around pipelines. Magnetostriction is the process by which internal domains inside the structure of ferroelectric materials, such as carbon steel alloys, create magnetic fields when subjected to mechanical stress. Measurement of the remote magnetic field around a pipeline due to magnetostriction allows the measurement of stress and determines the location of defects. This presentation will be of particular interest to all pipeline integrity, inspection management and engineers by specifically offering a solution for those involved with the inspection of unpiggable lines.

#69 **Finding Isolated Corrosion Due to High Residual Elements in HF Alky Units**

Carbon steel piping in HF Alkylation units have been found to develop extensive general and weld root corrosion losses; the losses are associated with high residual elements (such as Cr, Ni and Cu) in the steel. The NDT inspection program described was used to identify and monitor these defective components. Guided wave testing (GWT) was used to identify the location of welds within a piping system. Real-time radiography (RTR) was used to

pin-point, without removing insulation, the locations of some circumferential butt welds requiring computed radiography. Computed radiography (CR) was performed to: Examine transverse joints and suspect welds identified with GWT/UT and quantify erosion/corrosion losses in suspect welds of NPS less than 6. The paper presents GWT and CR graphic information of the examinations. The CR images show weld attack and attack to threaded joints. Photographs of the damage to one of the deficient welds removed from service are shown.

#70 **Supplementing Pipeline System Records Using ILI Survey Data**

In-line inspection (ILI) tools are widely used to provide supplemental data for use in integrity management programs established by oil and gas transmission pipeline operators. Due to several recent incidents and subsequent regulatory initiatives, confirmation of material properties for individual joints has been proposed in an Integrity Verification Process (IVP). In the absence of documentation or records, using ILI data from prior surveys has been identified as a method of identifying joints fabricated using similar material and processes. Attributes may include wall thickness, joint length, seam type, fabrication artifacts (physical and magnetic), bore, base material magnetic response, seam characteristics and magnetic fingerprinting. This technique should translate into significant savings by reducing the number of digs required in a positive material identification (PMI) process. In addition, this method can be used as the basis for providing discrepancy analysis as outlined in API 1163 to confirm accuracy and completeness of existing documentation.

#71 **Corrosion Protection of Oil Storage Tanks Soil Side Bottoms and Roofs**

Corrosion of crude oil storage tanks soil side bottoms and roofs are worldwide problems due to unpredictable environmental conditions. Pitting and crevice corrosion rates can be as high as 3-10 mm/year causing tanks can be taken out of operation for maintenance every 7-10 years. Field trial test results of efficiency corrosion protection solutions for roofs legs implemented on floating roofs of a tank will also be presented. New corrosion protection systems greatly reduce all types of corrosion rates and Volatile Corrosion Inhibitors (VCI) can increase the tank service life approximately 3-5 times. This paper will present the results of case studies of the implemented system installed on new and existing storage tanks, utilizing VCI over an 8 year period for tank roofs and 5 years for soil side bottom and double bottom storage tanks.

#73 **Pipe Support Inspections - Review of Select Codes, Standards and Recommended Practices**

Regular inspections of pipe supports and hangers at refineries, power plants and other industrial sites is often overlooked or ignored. API, ASME and other Codes and Standards have long included recommended or required practices to perform regular monitoring of pipe supports and restraints. Pipe supports and hangers affects the condition of the piping at existing plants as well as new. The condition of these supports and restraints is an external barometer of hidden problems with the piping and attached equipment. Recognizing distress can help prioritize pipe inspections and maintenance. This paper reviews and identifies applicable sections of the various Codes, Standards and Recommended Practices to provide the reader with a source for such information.

#74 **Pressure Relief Valve Inspection, A Neglected Necessity**

This presentation will cover the proper inspection of RV inlet and outlet nozzles immediately at RV removal. The follow up review of RV pre-disassembly pop test, i.e. did it open with in specifications, did it leak prior to lift, if so, how much and at what point. What parts were worn and how were they repaired, what was final test results and finally was the RV installed on clean nozzles and in the right location. And finally a review, prior to start up, as to whether the settings and interval are adequate and changes made if necessary. This presentation will cover suggested testing and handling, Inspector interface in all phases of the PRD testing and repair process. I will cover the code allowable leakage rates for the different classes of PRV's, what a "V" stamp vs a non V stamp repair is.

#75 **Considerations for Heavy-Wall Hydrogen Service Pressure Vessel Repair**

The increased demand for clean fuels requires refineries to utilize processing methods such as hydrocracking, which operates at high temperature, high pressure, and high partial pressure of hydrogen. Older hydrocracking reactors typically constructed from 1¼ Cr-0.5Mo or 2¼Cr-1Mo steel have inferior performance compared to newer reactors utilizing alloys such as low alloy Cr-Mo with enhanced vanadium. Because of the severe operating conditions, these older reactors are vulnerable to temper and hydrogen embrittlement, hydrogen attack, and clad disbonding or failure. Repair is often a cheaper alternative than replacement, but history has clearly shown that conventional weld repair practices for these components provide at best only a very temporary life improvement. An Engineered Repair Solution, backed by design analysis and advanced welding technologies is required to provide a desired long term, reliable solution. This presentation will highlight the factors that should be considered for a heavy-wall hydrogen service pressure vessel repair, along with providing case studies as examples.

#77 **NDE for Detection and Evaluation of In-Service Pipeline Damage**

Mechanical damage is the leading cause of pipeline failures. Current non-destructive inspection technologies are successful at finding and characterizing mechanically damaged regions on pipelines, however the affect of the mechanical damage on pipeline integrity still needs to be properly addressed. The residual stresses associated with mechanical damage can be modeled however the variables such as hydrogen accumulation in the damaged region are not accounted for giving an incorrect assessment of the integrity of the pipeline. To determine the actual state or condition of a mechanically damaged pipeline, an electromagnetic system has been developed and is presented here to measure through thickness residual stresses associated with the mechanically damaged region. Quantified residual stress analysis of the mechanical damaged region would provide a means to assess the severity of the damage while reducing the amount of unnecessary removal and repair applications.

#79 **Non-Invasive Monitoring Strategies Using Ultrasonic Guided Waves**

Ultrasonic waves can propagate for long distances with a low loss of intensity in a variety of engineering structures with plate-like or prismatic geometries, because these geometries cause the structures to act as acoustic waveguides. These Ultrasonic Guided Waves (UGWs) can be manipulated to allow rapid structural evaluation that is non-destructive and non-disruptive. Discontinuities in a waveguide's cross-section, such as ancillary structural features or structural flaws, cause ultrasonic guided waves to be partially scattered. Of particular relevance is the ability to detect time dependent changes to a structure's condition through its service life, caused by corrosion, fatigue or SCC. This strategy may be implemented using permanently mounted sensors which are interrogated frequently. These applications include the structural evaluation of oil and gas pipelines, aircraft components, storage tanks, ship hulls and bridges, although many of the developments presented have scope for wider application.

#80 **A New Phased Array Probe Technology Simplifies Recording of DAC/TCG Curves Significantly**

When using phased array angle beam probes defect sizing gets very time consuming. For each incidence angle applied during testing a DAC/TCG curve has to be recorded. By changing the phasing angle important probe parameters such as near field length, delay line length and sensitivity are changed as well, resulting in a change of the DAC/TCG curve. A new probe technology results in a fully modelled rotationally symmetric sound field. The advantage of these probes is that they can be handled mathematically the same as a straight beam shear wave probe with a circular transducer having a delay line of the same material as the test specimen. Two ways to record DAC/TCG curves are presented. In both cases DAC/TCG curves for all angles can be calculated with high precision. The accuracy of this new method will be proven by using the recorded echoes from other angles then comparing these measurement values with the model. By using this approach defect sizing using phased array probes is as

easy as using a single element angle beam probe. This new approach results in high accuracy and a huge productivity gain.

#82 **Low Frequency Electromagnetic Technique for Continuous Inspection of Plant Piping**

Traditional thickness testing is time consuming and does not provide a thorough inspection. The Low Frequency Electromagnetic Technique (LFET) is a method to inspect piping from the outside through the use of contoured scanners fitted to specific pipe diameters. As the scanner is pushed across the pipe, continuous thickness readings are taken. This method provides a quick assessment of the piping. The technology has been used for the inspection of Tank Floors since the early 1990's. This technique is able to be performed online. The presentation will discuss previous inspections performed and the types of defects found including severity and locations. Some of the piping is easily accessible while other locations require scaffolding or a man-lift. The presentation will show how through the use of LFET, a plant can assess the condition of their piping.

#83 **A New Electromagnetic-Based Approach to CUI Inspection**

The lack of a variety of field deployable systems with the ability to detect and/or quantify corrosion under insulation (CUI) is a significant problem for the petrochemical industry. The development of reliable methods to detect this corrosion is difficult because the insulation can be 50 mm or more thick and the outer surface of the insulation has a metallic shield. Data interpretation is also complicated by pipe features and nearby structures. There is typically never a perfect solution for every problem the field situation might present for CUI inspection, therefore it is important to have a variety of solutions available. This presentation outlines the progress to date on the development of an electromagnetic-based system to rapidly detect and quantify CUI. The approach utilizes an innovative and compact excitation method combined with a multi-frequency excitation scheme that can be easily installed and operated. This presentation will summarize our approach, discuss laboratory and field results, and compare the advantages and disadvantages of the overall system.

#85 **A Damage Mechanism Review Methodology for Refinery Process Units**

This presentation outlines a methodology that has been successfully used to systematically identify the most likely active (and potentially active) API 571 Damage Mechanisms that can occur in refinery process units. These methods have been used in preparation for PHA meetings to help identify and mitigate risk and as a roadmap for identifying damage mechanisms as part of the implementation of RBI programs. The method uses a clearly defined process which can be divided into three main parts. The first part utilizes Process Flow Diagrams (PFDs) that have been color-coded to identify 'Systems' of common operating conditions. The second part is a written document summarizing the most important active and potential damage mechanisms in the 'Systems' marked on the PFDs. The third part is a question and answer assessment tool that is used as part of a team meeting to review a list of specific questions that have been developed for each System to identify potential vulnerabilities together with potential action items to mitigate or eliminate risk.

#87 **Improving Piping Inspection with RBI and IOW's**

Risk-Based Inspection (RBI) is an accepted methodology that has been widely used to optimize inspection activities in the industry since the early 1990's. While RBI for pressure vessels and other equipment types has been generally accepted and easily managed, the application to piping systems in a manageable way has been more challenging due to piping complexity. However, API 584, the recommended practice for establishing Integrity Operating Windows (IOW's), has created an opportunity to manage piping and properly integrate inspection activities through RBI approaches. The objective of this presentation is to provide a description of the steps necessary to develop an improved piping inspection program through risk analysis, identifying corrosion loops and circuits, and defining IOWs. Several examples will be included to demonstrate the suggested application of techniques and results.

#88 **The Methodology and Effectiveness of On Stream Inspection Programs (OSI) Relevant to Gas Oil Separation Plants (GOSP) at Saudi Aramco**

Gas Oil Separation Process is a milestone for supplying most of the energy around the world. In Gas Oil Separation Plants (GOSPs), all the natural crude oil from the wells is collected and the natural gases, water and contaminants are separated. The work scope includes the condition monitoring and protection of more than forty five (45) GOSPs and 4500 supply wells and their pipelines. The main objective is to provide the methodology of administering on-stream inspection activities and to evaluate the effectiveness. Most of the common NDT methods are used regularly. In addition to normal inspection activities, need based technical alert surveys, Risk based inspection analysis, special advanced inspection techniques like Advanced UT scan(TOFD), linear accelerator, robotic video crawler, Lixie profiler testing, acoustic emission testing and other advanced inspection techniques managed by inspection department at head office for the entire company facilities are used as best practices and issue/need based to extend the shutdowns/turn around.

#89 **Key Performance Indicator's for Risk Based Inspection Effectiveness**

This presentation will overview the importance of KPI's for Risk Based Inspection effectiveness. The presentation will: Describe the relationship of organizational design to KPI data management and reporting; Describe REAGEP associated with Process Safety Metrics; Describe methods to collect data as part of work execution within multiple organizations to ensure effective communications; Describe 3 metrics to the above facilitates RBI effectiveness. The presentation is applicable to Upstream, Midsteam, Downstream, Petrochmical and Chemicals owner operator who are interested in learning more about the the KPI process and data collection to support KPI execution. The intent is that attendee's sufficient understand the challenges of KPI implementation to improve their performance in implementing KPI 's and using KPI's to drive actions.

#94 **Corrosion Monitoring Equipment**

This presentation is an overview of different corrosion monitoring methods and equipment. This presentation is relevant to the industry as a general refresher course on a wide variety of monitoring equipment and methods. The target audience is new users, people with experience using some of these methods and for general information.

#95 **Injection Quills – Guidelines to Getting the Best Equipment for the Job**

An overview of what needs to be considered when specifying injection quills, as well as different types for different applications. This presentation is relevant to the industry as a general knowledge on specifying and working with injection quills. The target audience is new users, people with experience using some of these methods and for general information.

#96 **Two Case Studies of Failues from Liquid Metal Embrittlement and Corrosion Under Deposits**

Lessons learnt from these two separate incidents of failures with their contributing factors and root cause(s) will be presented. A small fire occurred at the down comer pipe of the double pipe quench exchanger of a cracking furnace in an Ethylene cracker plant. A detailed failure investigation concluded that the down comers had suffered LME caused by melting zinc. Probable areas of external sources of zinc were explored and finally was a surprise to note that poor painting practice on an adjacent pipe was the root cause! The presentation intends to highlight that poor maintenance practices could lead to a process safety incident. In the other case, a horizontal, shell & tube type reboiler in a set of five started developing tube leaks with an increasing trend, predominantly in bottom section. Under-deposit corrosion was identified as the root cause of the failures with several unique contributing factors. The importance of good engineering considerations during design and modifications to achieve reliability in operation will be discussed.

#97 **Do Not Underestimate RBI's Contribution to Process Safety**

The contribution of RBI to Mechanical Integrity and thus to Process safety should not be underestimated. To ensure safe process plant operations and to extend the operating lifetime of ageing equipment safely and cost effectively, it is necessary to implement effective inspection and maintenance strategies. RBI has its roots in PSM and Mechanical Integrity programs and is gradually becoming an accepted good engineering practice for the implementation of inspection and maintenance programs with risk focus. Although RBI is not a substitute for a Process Hazards Analysis (PHA) or a HAZOP study, it complements the PHA by focusing solely on the Mechanical Integrity related degradation mechanisms and risk mitigation through inspection. Using the RBI calculated risk values, a fixed equipment relative risk ranking can be established that strengthens the mechanical integrity program by allowing the operator to: (i) set priorities and focus their attention on the critical areas (ii) justify capital investment for lifetime extension projects (iii) proactively address loss of primary containment and process safety issues. As such, a good RBI program that complements the effective implementation and management of PSM elements can enhance process safety greatly.

#99 **Chevron NDE Performance Demonstration Exams**

This presentation has been delivered at previous API Inspection Summit's however this year it will include updated statistics as well as examples showing the importance of the topic. I have selected Upstream NDE as the 1st category / topic since the examples will be related to upstream activities; however the presentation can / does equally suffice for use in the midstream and downstream sectors. This presentation will cover the following topics: - Poor NDE represents a very significant asset integrity and process safety risk due to missed and/or inaccurately quantified defects. - Due to poor quality of inspections over the years Chevron has developed and deployed globaly a standard industry recognized qualification exam for many NDE methodologies. - The more than 1000 UT qualification exams administered by Chevron in both downstream & upstream have demonstrated an initial pass rate of only approximately 50% however this improves with repeated testing and training.

#101 **Advanced Internal Inspection Alternatives Used to Optimize Effectiveness During Short Duration Turnaround Windows**

As the time allotted for Turnaround windows continues to decrease, alternative inspection techniques need to be utilized to support these demands, but still maintain a high standard and degree of accuracy. We will discuss an innovative technique recently implemented to screen areas of base material for evidence of damage associated with equipment operating in a H2S environment.

#103 **Non-Intrusive Subsea Corrosion and Erosion Monitoring**

Monitoring the wall thickness of subsea pipes and similar structures is becoming increasingly important as more assets are moved subsea and existing installations age. The completely non-intrusive ClampOn Subsea Corrosion-Erosion Monitor (CEM®) utilizes ultrasonic guided waves to monitor thickness change in walls of, for example, pipes and tanks. Being non-intrusive means that the ClampOn Subsea Corrosion-Erosion Monitor can be installed on any pipe section or structure and there is no need for our own spool piece. The system can even be retrofitted with all components installed by diver or ROV, which is good news for brown fields. The technology provides excellent robustness and stability over time. The Subsea CEM® is delivered in several versions, allowing full online integration or stand-alone solutions with data logging, transducers under insulation, ROV retrievable electronics, battery powered operation, wireless communication, retrofit installation and more. ClampOn Subsea CEM® was awarded the 2012 Spotlight on New Technology Award at OTC. The proposed talk discusses the working principle of the Subsea CEM® and its benefits and applications. The discussion is based on a selection of field cases.

#104 **Corrosion problems and Related Challenges in the Inspection of Aboveground Storage Tanks**

Any tank failure could disrupt the production cycle due to the loss of available storage capacity and also lead to

environmental and safety hazards. One of the most common causes of the tank failures is the bottom plate leak, as the bottom plate is the most corrosion prone part in a storage tank. Factors that are responsible for the bottom plate corrosion include soil type, foundation type, soil resistivity, water content in the product, product composition, sludge level in the tank, microbial activities (MIC) etc. Just one or two NDT technique(s) may not provide adequate information on the bottom plate condition. A judicious combination of various techniques is required for the effective assessment of the bottom plate. This presentation discusses KOC's experience about the challenges associated with the bottom plate inspection and about various methodologies for out-of-service as well as in-service inspection for the best possible assessment of bottom plates.

#105 **An In-depth Analysis of Tank Inspection and Maintenance Data To Determine the Best Inspection Interval**

Determining the frequency of out-of-Service inspection of storage tanks and scheduling their outages should be done very judiciously, keeping all the relevant requirements in mind including those of the applicable codes and standards. While on one hand it is important to extract the maximum service life of a storage tank, on the other it is equally vital to maintain its integrity and reliability. At Kuwait Oil Company, an in-depth study was undertaken, in which the relevant engineering / construction data, inspection and maintenance history for all the tanks were collected and systematically analyzed for understanding the safe operating period for the tanks. This presentation includes all the findings of the study and discusses the factors that influence the inspection frequency of the storage tanks. All the analyses were done considering the relevant codes and standards including API-650, API-653 and API-581.

#106 **Inspection Techniques for In-plant Buried Process Piping**

This presentation will summarise available information on inspection techniques for in-plant buried process piping. It is intended for inspection companies and plant operators. A HOIS member's survey carried out in 2013, indicated that buried in-plant piping is mostly carbon steel transmitting hydrocarbons (oil, gas) and water. Diameters were in the range of 2" to 32". Inspection techniques that can be considered for buried in plant piping include: Indirect assessment using above-ground electrical measurements. If piggable, use standard ILI tools or small diameter, snake-like or mini-pig tools. Large stand-off magnetometry including magnetic tomography method (MTM) or stress concentration tomography (SCT). Ground penetrating radar (GPR). Guided Wave Testing. Laser and white light scanning. Pit gauge. Radiography. Electromagnetic measurements. Ultrasonics, e.g. 0° pulse-echo, corrosion mapping, shear wave and wall thickness measurements. The presentation will present a summary of the survey and applicability of the inspection techniques applied to buried lines.

#107 **Finite Element Analysis and Crack-like Flaw Evaluation of High Strength Steel Vessel in Wet H2S Service**

There is an incentive to utilize high strength steels when designing pressure vessels for upstream production sites where size and weight are major considerations. Such steels have high allowable stresses, but may be particularly vulnerable to environmental degradations, e.g. wet H2S cracking. In this case study, the operator of a production facility discovered high levels of chlorides in a stream containing wet H2S. An Engineering Company performed such a study using Finite Element Analysis (FEA) and a fatigue crack-growth study using Fracture Mechanics (FM) methods and quantified the critical crack size and permissible remaining life of the vessels. For comparison, the permissible life in the non-degraded condition was also determined. The results of the degraded case show much smaller critical flaw sizes and vastly shorter permissible lives than those of the non-degraded case, demonstrating the high adverse impact a wet H2S environment can have on operating life of vessels fabricated from high strength steels.

#108 **Pre-Turnaround Inspections Can Lead to Reduced T/A Work Scope and Improved Equipment Integrity**

Pre-turnaround planning starts more than one year in advance of oil-out. Normally, these plans result in an intensive inspection effort during the shutdown period, putting serious time constraints on the inspection organization to complete the required physical work and obtain quality results. Many inspection activities can be accomplished in the months preceding oil-out, greatly reducing the inspection workload during the shutdown. Advanced inspection techniques may allow critical inspection activities to be conducted without the need for extensive scaffolding or having to open equipment. These Pre-T/A inspections can provide better definition of the equipment and piping condition and provide needed information for Risk-Based Work Selection for the T/A. Early decisions on work selection will lead to reduced work scope and improved equipment integrity.

#109 **Correlation of Corrosion Rates with Acoustic Emission Activity of a Carbon Steel Plate**

The AE method can be used for on-line monitoring to periodically detect corrosion growth during the active corrosion stage or off-line for detection of active corrosion at a specific time. Although the signals from the corrosion process are low in amplitude compared to other damaging emission mechanisms such as crack growth, they still may be detected depending on the background noise conditions. In the present work different corrosion rates of a carbon steel plate in a 3.5% NaCl solution were studied under controlled conditions. A combination of electrochemical tests such as Potentiostatic and Polarization Resistance experiments were carried out to observe and analyze the change in corrosion rate simultaneously with AE tests. Comparison of corrosion rates and the AE hit rate calculated from both electrochemical and AE tests was carried out. Preliminary results show some degree of correlation between the different corrosion rates associated with different AE hit rate activity taking place during the corrosion process.

#110 **Optimizing Tank Inspection Intervals Through the Use of On-Stream Inspections and RBI**

Optimizing the time interval between internal inspections of an above ground storage tank is a key element of a tank management program. A benefit of the RBI approach is that it can utilize qualitative information as well as quantitative data when making an assessment. Much of the qualitative information can be acquired with the tank in service. With recent on-stream inspections, a more accurate summary about the condition of the tank is possible as opposed to relaying on data that may be several years old. On stream inspections that can be performed are typically separated into two classes – conventional, in-service inspections as defined in API 653 Appendix C 1.1 and those using advanced NDE techniques. With these advanced NDE techniques, an on stream assessment of the tank floor for active corrosion is possible, pitting and grooving in the annular ring can be evaluated and preferential corrosion on the tank shell can be assessed to name a few.

#113 **Field Trial Test Results for Eddy Current Inspection of Twisted Tube Heat Exchangers**

Twisted tubes are free of baffles or supports, which allow them to have the highest heat transfer coefficient of all tubular heat exchangers (up to 40% higher). Twisted tubes come in a variety of sizes and material types such as stainless, titanium, brass, monel, carbon steel, duplex, and nickel. Because of their unique design and shape inspection of these tubes is a new challenge. There are some existing applications such as long range guided wave ultrasonic and acoustic eye. However, these applications have shown limited success so far. This presentation is a case study of test results performed at a Marathon GBR turnaround with the collaboration of Eddyfi and a new technology (Twisted Probe) that will have the capability of detecting, sizing and characterizing defects both internally and externally for the inspection of twisted tubes. Also, review of field data collection (titanium twisted tubes) will be presented to show the inspection speed, durability, detection capabilities, etc.

#114 **Assessing the Mechanical Integrity and Need for Jurisdictional Compliance for Relocating a 50 Year Old Ammonia Converter**

Relocation of certain types of equipment and even an entire process plant is sometimes the economic choice

instead of building a new plant. However, when relocating process plants the jurisdictional requirements of the new geographical area are sometimes overlooked. Furthermore, the process of dismantling an entire plant and relocating it to a new site requires a careful plan and due diligence. This presentation is a road map to mechanical integrity assessment, verification of the code, standard, and jurisdictional compliance, and a cost effective process for such relocations. The presentation concentrates on both the technical and economical aspects of relocating an entire 50 year old ammonia plant.

#116 **Subsea CT (Computed Tomography) Technology for Pipeline Integrity and Flow Assurance Visualisation**

A new non-intrusive external inspection technology for ultra-deep water subsea pipeline inspection/NDE applications, specifically to measure both integrity and flow assurance issues within piggable and unpiggable coated pipelines has been developed. A development project for a new tool that can produce extremely high-resolution pipeline tomography images has recently been completed, resulting in an inspection tool that can externally inspect the condition of subsea unpiggable and piggable coated pipelines. Real time communications allow instant assessment of pipeline conditions. Different versions are available based on pipe diameter, and all are fully marinized and pressure rated to 10000' water depth. The presentation will give examples of recent inspection projects, and a description of cutting edge technology that finally fulfils the long waited dream of having technology to help solve some of the most intriguing subsea pipeline integrity challenges.

#117 **Eddy Current As Alternative to Penetrant for Weld Inspection**

Weld inspection of critical components in petro-chemical facilities is traditionally performed with liquid penetrant or magnetic particle techniques. For specific applications, eddy current offers an alternative with several advantages including: No need for pre-inspection coating removal and post-inspection recoating; No disposal of chemicals; Digital documentation of the scanned area; Improved probability-of-detection In addition, new eddy current solutions offer on-device guided application workflows to aid the inspector in performing their work. This presentation will review several typical applications of eddy current weld inspection including automatic gain compensation for varying coating thicknesses.

#118 **Reboiler Exchanger Heater Fire Tube Failures (A case study and lessons learned)**

Newly constructed and installed reboiler exchangers were placed into service at Stabilization plant facilities in the South Texas Eagle Ford Area. After only several months of service some of the fire tubes had begun to fail in-service. Upon examination it was determined that the fire tubes had several design and fabrication flaws that combined with operating parameters and constraints had caused the failures. Based on several examinations and investigation of these fire tubes it was determined that all the installed reboiler exchanges would eventually fail and all in similar locations. Several design reviews and enhanced inspection techniques were used for temporary repair options and long term repairs/solutions. This presentation will explain the importance of engineering and design reviews along with establishing proper quality assurance programs applying proper nondestructive testing techniques.

#120 **The Importance of Surface Cleanliness for NDE Reliability**

Discover how surface preparation for inspection plays a vital role in achieving reliable NDE performance. Selecting the proper surface preparation for the scope of inspection is essential to maximize probability of achieving "highly effective inspection". Selecting an improper cleaning method may lead to poor inspection performance and potentially creating operational havoc. Optimizing surface preparation in conjunction with prescribing the correct NDE for the type of anomalies anticipated is "best in class practice" in equipment reliability assurance circles. It is equally important to understanding the impact surface preparation may have on long term reliability of equipment. Understanding proper surface preparation is essential to owner operators and NDE practitioners alike.

#121 **3D Laser Scanning to Solve Real World Integrity Problems**

The main objectives of the presentation will be to provide a general overview of how the 3D Laser Scanning Technology works; discuss potential applications of how it can be used as an inspection technique; and describe three case studies in which 3D laser scanning was used to solve real world integrity problems. A brief summary of laser scanning applied to storage tanks as an inspection technique is outlined. 3D laser scanning offers a new approach in which an entire storage tank or vessel can be modeled in a fraction of the time of traditional methods. After the data is exported into a modeling software, a model of a perfect tank is then made and the scanned tank can be fit to that model to classify all bulges and dents. We can then set API 653 tolerances to determine if dents/bulges are within acceptable limits. This technology can save a great deal of time and resources during inspection while having greatly improved the accuracy of traditional measurement techniques.

#122 **Real Time Situational Awareness and the Turnaround Inspection Work Process**

This presentation will cover the latest technologies available for making turnarounds as effective and efficient as possible. Use cases will cover the inspection work execution process including automation of the turnaround work order generation and closure process. In addition, a greatly improved work package management process will be covered. The presenter will show how real time situational awareness can be accomplished and a closed loop communications framework established across platforms and departments/people. The workforce competency issue will be tackled as part of the solution. Actual case studies will be presented.

#123 **PSM Reality - AIM Moving to Virtual Technology**

3D Imaging and spherical photography are moving Asset Integrity Management programs from P&ID environments to a virtual world. Rather than utilizing paper files or electronic folders on a server, users can virtually immerse themselves within the plant conditions by employing the use of spherical photography. From their office or from mobile vantage points, users can "virtually move" to a location where the photography was acquired and view their sites as if they were standing there. With spherical photography allowing for a nearly complete view from the camera positions, users can interact and retrieve data sets related to MI platforms, including specification sheets, equipment photographs, equipment plate photographs, equipment information and folders containing previous inspection report information.

#124 **Pipeline Facility Integrity Management Programs**

Pipeline operators are being subject to greater scrutiny relating to the integrity of equipment in their facilities as well as pipelines. Facility Integrity Management is the program or system used by an operating company to ensure its assets are able to perform as intended without causing harm to people, the environment, or the company's reputation. This presentation discusses the key elements in a facility integrity management program (FIMP). These elements include: data gathering; threat, operational hazard, and consequence identification; risk assessment; integrity-related activities and responses; performance management, communications; management of change; quality control; and design assurance. Facilities are subject to both condition-based and event-based threats. Once these threats have been identified, a risk assessment is used to determine the need to perform integrity-related activities such as inspection, testing and monitoring.

#125 **A Methodology to Prioritize the Inspection of Dead-Legs in Deepwater Systems Using CFD and Corrosion Models**

One important concern in the integrity management of subsea systems is the internal corrosion damage of dead-legs in manifolds and other equipment where corrosion inhibitors might not properly protect bare carbon steels. Subsea application of NDT to evaluate remaining wall thickness is complex and expensive and sometimes impossible; therefore, it is important to assess the probability of having internal corrosion before committing resources to its inspection. The objective of this presentation is to show that Computational Fluid Dynamics (CFD)

together with commercially available corrosion modeling software can be used to not only to predict the conditions of a fluid existing within a dead leg in a deep water subsea manifold, but also can be used to estimate the corrosion rates and enable the selection of sound engineering solutions that can be used to increase the lifetime of an the equipment. A case study and the results from the modeling as well as the engineering solutions will be presented.

#126 **Spaced Interval Direct Contact Pipeline Survey**

Historically, a few methods have been used to survey submarine pipelines for cathodic protection (CP) performance. The most notable of these is the "three electrode method", which is still in use. Such techniques are costly and difficult, requiring the remotely operated vehicle (ROV) operator to painstakingly move at a low rate of speed with high accuracy. Due to the consistent electrolyte encountered offshore, close interval surveys collect superfluous data that are open to subjective interpretation. Only contact based pipe-to-electrolyte measurements are capable of providing CP performance directly. This presentation proposes an alternative to the traditional close interval methodology by introducing a suite of simple-but-effective retrofit test points and ROV-operated tools that allow superior, direct measurements to be made and analyzed while allowing the ROV to travel the pipeline at approximately 8 times previously allowed speeds, which reduces cost and complexity while improving the reliability of the survey.

#128 **Fired Heater Tube Reliability: Deciding to Inspect or Replace**

A case history of a fired heater assessment is used to illustrate an alternative approach to quantify some of the uncertainty associated with fired heater tube remaining life estimates (e.g. temperature history, tube wall thickness, existing creep damage, etc.) which complicate decisions regarding tube replacement or inspection. While it is well understood that fired heater tubes are susceptible to creep and corrosion damage due to high operating temperatures, it can be challenging to estimate fired heater remaining life and a bigger challenge to quantify the margin of error associated with typical analyses. In order to determine conservative estimates of remaining life, it is not unusual for some companies to use overly conservative input parameters (e.g. minimum measured thicknesses, maximum temperatures and pressures, etc.). This often results in a "worst case scenario" or "pass/fail" answer, but it does not necessarily provide any insight into the effect of uncertainty. In this presentation, an alternative method which has been utilized by E2G to perform heater tube evaluations is demonstrated. This procedure allows one to determine the probability of tubes failing by a specified time. The methodology utilizes a statistical characterization of the uncertainty associated with the primary input parameters. Although the methodology relies on what is known as a Monte Carlo Simulation and utilizes the API 579 Part 10 Omega creep procedures, this presentation will be of a practical nature illustrating how this methodology can be used to aid in decision making prior to turnarounds.

#129 **The Future of NDE Personnel Qualification & Certification**

There is a shortage of qualified NDE technicians in the industry. This shortage has led some NDE service providers to issue NDE certifications to personnel who are not qualified to perform, evaluate and report test results. To solve this problem, industry is requiring third party certification of NDE technicians to increase confidence that test methods are performed properly. Canada implemented CGSB 48.9712 NDT Certification and Europe has created EN ISO 9712. ASNT created the ACCP, but nothing much has changed within the US until now. Europe doesn't accept CGASB, Canada doesn't accept EN ISO 9712 and the ACCP is not accepted by either party. So where does this leave industry for technician qualification and certification? That is the output of this presentation.

#131 **Fitness For Service Assessment of Alcohol Storage Tank Based on API Standards (Case Study)**

Based on Bureau Veritas' experience in inspection and consultancy services in the industry, most of them with API standards, decided to develop a paper combining four API standards most common for inspections and storage

tanks. API has developed several worldwide industry standards used to assess various types of pressure vessels, storage tanks and piping (API 650/620/653/570). Each of these four standards will be used in the assessment of two aboveground storage tanks that once stored ethanol and will now hold denatured alcohol. The objective of this presentation is to show how the combined use of these standards are used in order to assess the fitness for service of these storage tanks.

#132 **Supplier Technical Assessment – The Evolution of Vendor Surveillance**

Equipment failures in process plants and its related transportation systems (i.e. pipelines); still happen despite manufacturer's quality management systems are in place. The accidental leakage of hydrocarbons or chemicals may cause owners/operators millions of dollars in direct losses, In addition, consequent litigations and reputational damage will increase significantly the overall financial losses. Investigations reveal that equipment not built to design specifications is main causes of some accidents. The use of inadequate materials is one of the most frequent causes. The lack of material traceability made investigations difficult or even impossible tasks. Three decades ago the Supplier Chain Management (SCM) concept was introduced by the International Organization for Standardization (ISO) 9000 standard series. Since then this concept has been broadly utilized by many industries as a tool to significantly reduce and ultimately eliminate disastrous equipment failures due to equipment quality. An important aspect of the SCM concept is the so-called Supplier Technical Assessment (STA). The STA not only assesses manufacturer's quality management systems but also assesses its technical capabilities. Execution of STAs requires technical personnel with the knowledge of the quality management system, manufacturing processes, and products application. Inspectors often have those qualifications. The aim is to ensure the supplier is capable of consistently provide quality products to buyer's expectations. The assessment findings and recommendations will guide inspectors to focus on those areas with findings from the assessments such as machining processes. While the benefits of STA are recognized, there are some challenges. In this globalized world, suppliers are often located around the globe. This may require significant investment due to logistics. Buyers need to decide between preventive investments against potential corrective costs later due to equipment failure

#134 **Risk Based Inspection Ten Years Later: Case History of Alkylation Plant**

This presentation describes API RP 581 Risk-Based Inspection as applied to an Alkylation Process Unit. The RBI analysis was completed with a semi-quantitative study and the results show damage mechanisms, probability of failure, consequence of failure, risk and inspection plans. However, during the operation of the plant, changes in process conditions caused changes in damage mechanisms, leading to the repair and replacement of assets and which impacted the RBI analysis. Over time, the RBI analysis evolved from semi-quantitative to quantitative and integrity operating windows (IOWs) were applied to the process to establish conditions indicating hazards. This presentation will describe the analysis and development of the RBI program in an alkylation process plant with 10 years of changes.

#137 **Can Tomography Provide Minimum Wall Thickness Readings in Subsea Applications?**

The presentation discribes the latest developments in using non-intrusive corrosion-erosion monitoring w/tomography for subsea and topside installations. Today, subsea production templates, flow jumpers, manifolds and flow lines can only be inspected using pre-installed corrosion/erosion sensors or an ROV. Current pre-installed sensor systems for monitoring pipeline integrity have proven to be of limited value to the operators, and ROV-operated sensors provide unreliable readings and are costly to operate. A major challenge is that "hot-spots", i.e. areas particularly susceptible to erosion/corrosion, are often only detected after the template and pipes have been in operation for some time. Accordingly, the ability to retrofit a corrosion-erosion monitor (CEM) on identified hot spots subsea is crucial. This technique has been in development over many years for measuring changes in pipe wall thickness over a pre-determined pipe area using a limited number of transducers. The instrument is an online, real-time path based thickness assessment tool that deploys a set of transducers over a pipe area, and utilizes a

dispersion based principle to assess wall thickness loss. The technique uses ultrasonic guided waves, called Lamb waves, to perform its measurements, covering a larger area of the pipe surface than any other spot measurement systems with a comparable number of transducers.

#138 **ASME Section IX. Reviewing Welding Documents 101**

Reviewing Welding Documents 101 will simplify the basics of how to approach the review of welding documents as the WPS, PQR, and WPQ. The Presentation will give the attendee some method of quickly and simply determining the correctness of the documents as it refers to the particular welding project. Welding documents are completed for project work as well as repairs to assure the quality of work achieved is of the anticipated quality and is properly documented. The main objective is to point out essential variables and their respective places in the documents and where non-essential variables are called out and how they should appear in the documents. Welder Qualification will be discussed in regards to the PQR and the differences in what may be seen on the PQR. It will point out essential and non-essential variables for the Welder Qualification and clarify the need to separate the PQR from the WPQ for review utilizing table out of the ASME Section IX Code.

#139 **Integrity Management of Arctic Exploration and Production Facilities**

Asset integrity management is the systematic and coordinated preservation of the performance of an asset, and it is essential to ensure production. This talk presents operators and anyone with responsibility for asset integrity with a picture of how Oceaneering AI has performed asset integrity management for the arctic Norwegian continental shelf. Arctic environments carry inherent dangers and increased risk. Some of the dangers are of the arctic kind; ice, snow, cold, polar storms and long dark winters. The risks are further increased by reduced access and unusual operating conditions and again increased due to the fact that building for arctic operations carries additional expenses. In short, the arctic operations on the Norwegian continental shelf have to handle asset integrity right to ensure satisfactory availability and performance. The session aims at describing how asset integrity is managed in the arctic and what additional considerations have to be taken into account for arctic assets. Oceaneering AI has performed inspection planning, spare parts management, maintenance planning and management for arctic assets, and we will show methods and share experiences from this. When starting out in the arctic, Oceaneering AI had extensive experience from the sub-arctic regions of the Norwegian continental shelf, and we will look at the methods used in sub-arctic, and how these methods were applied to the arctic assets. Finally we will look at some examples and experiences from asset management in the arctic, and some possible improvements for future assets and operations.

#140 **Utitlizing Risk Based Inspection on Subsea Assets**

Presentation describes a Risk Based Inspection methodology to provide subsea operators with tools for managing the Technical Integrity of their subsea assets. Subsea operation is an expanding and challenging field and the inaccessibility of the subsea asset during everyday operation calls for a systematic approach to manage the Technical Integrity. Every operating asset and its equipment and pipelines represents a risk and controlling that risk is of high importance to secure a safe and profitable operation. The RBI process is used to identify the threats that the subsea asset faces throughout the lifetime and by developing strategies and plans to handling these threats and control the risk. Process specialists identify the critical equipment and the failure mechanisms for each equipment group. The Possibility of Failure (PoF) and Consequence of Failure (CoF), for each failure mechanism applicable for each equipment type, is reviewed. The resulting Risk Scores forms the basis for the Risk Based Inspection Plan. The inspection results help the subsea operator manage the risk by applying the remedial actions required to maintain the Technical integrity of the asset.

#141 **A Methodology to Develop Coating and Insulation Maintenance Plans for Offshore Structures**

Corrosion and poorly prioritized maintenance costs the industry billions every year. The session describes a

software tool, SOLV, for planning condition based maintenance of any coating or insulation, including passive fire protection and pipe and cable penetrations. SOLV has been used for over 15 years and has been employed on more than 70 installations worldwide. The session describes what SOLV is, how it is implemented and how it produces the results.

#143 **Manage CUI programs through a Cloud-Based Mobile Solution**

With the release of API RP 583, many companies are evaluating their current and on going CUI – Corrosion under insulation programs. PK Technology has analyzed and evaluated many programs that operate outside and within company's Risk Based Inspection programs. This presentation will demonstrate how to create and manage all of the processes of a Corrosion Under Insulation program; from baseline walkthrough, 3rd party non destructive surveys, to the repair of the pipe and equipment after the insulation is removed using a mobile inspection and management solution. This allows owner-users to manage risks and budgets at a much more efficient pace, and keep documentation of the whole process.

#146 **Online Realtime Corrosion Monitoring of Subsea Pipelines with Permanently Installed Ultrasonic Sensor Arrays**

Permanently mounted ultrasound probes is used for highly sensitive wall thickness monitoring of subsea pipelines, being able to detect wall thickness changes down to the micrometer range. Online and real time corrosion and erosion monitoring enables pipeline operators to adjust inhibitor programs, perform drying or do other corrective actions to stay within allowed corrosion rates. A new ultrasonic monitoring tool has been developed, designed to be mounted on subsea pipelines prior to the installation of the pipeline on the seabed. The instrumentation is protected from sea water, giving long lifetime (30 years) and highly stable and reliable performance. Test and lab data will be presented, qualifying the tool for pressures down to 200 bar, and temperatures up to 90°C, and demonstrating that the system can detect corrosion on uneven/pitted surfaces.

#147 **Development of a Proactive Comprehensive Asset Integrity Program during Construction**

Mississippi Power Company constructed an Integrated Gasification Combined Cycle plant in Kemper County Mississippi. The facility developed a proactive plan to be fully OSHA 1910.119(j) Mechanical Integrity, compliant at plant startup. Mistras Group was chosen as the consultant to assist in development and implementation of the proactive program.This presentation will follow the proactive approach to development of the comprehensive, compliant Asset Integrity Program. Elements include: ·process safety information data collection and confirmation ·development of the Asset Integrity Policy and Procedures Manual ·engineering assessment of the process for potential damage/corrosion · systemization and circuitization of process equipment based on damage/corrosion assessment ·3D design model for development of inspection isometrics · development of inspection and test plans, ITPM's · data population into the IDMS · baseline data collection · preparation and planning for evergreen utilization of the Asset Integrity Program for the life of the facility.

#151 **Tramp Amines: Sources, Detection, Mitigation, Monitoring**

With the surge of light tight oil (shale oil) processing comes the expanded use of H2S scavengers that can result in the reduction of equipment reliability to the point of loss of containment. There are several early warning signs to look for and several mitigating options. In addition, there are some key areas for increase inspection. This presentation will discuss the sources, detection and mitigating options including areas where additional inspection is warranted.

#152 **Fabulous Facts about Protecting your Passivation Layer**

A fundamental understanding of the process/operating conditions and resulting damage mechanisms are required in order to understand the cause and effects of maintaining metal passivation. Some metals form a protective

passivation layer, essentially a layer of metal at the surface only a few atoms deep, and how tightly that layer binds to the underlying metal determines whether the metal corrodes. Process/operating conditions can either promote the stability of this protective layer or promote removal of this layer, and therefore are a cause of deterioration. Corrosion attack occurs at the surface of the metal, hence any modification of the surface or its environment can change the rate of reaction. This presentation will address common refinery conditions that inadvertently remove the protective passivizing layer and cause excessive corrosion.

#155 **UPDATE on API RP 970 A Corrosion Control System**

A new RP is being developed. This new PP is currently being called a Corrosion Control System or commonly referred to as a Corrosion Control Document (CCD). CCD's are generally understood to summarize the materials of construction, the operating conditions, and Integrity Windows and appropriate inspection and maintenance strategies are developed. However, there is currently no consensus on the methodology or work process to develop a CCD, so there is a wide variation in the format, content, and level of detail included in these types of reports. We continue to relearn lessons learned years ago, a central corrosion document to keep efforts in one place.

#157 **Large Standoff Magnetometry For Buried Piping & Pipelines - An Industry Study**

A number of above-the-pipe integrity assessment techniques generically classified as Large Standoff Magnetometry are coming to market. The ability to determine integrity of buried piping and pipelines without the need to excavate or insert device into the line is valuable. This presentation will describe the aggregated results of some 60 plus field trials of various variants of the technology and its reliability as a buried piping or pipeline integrity assessment technique. The success, failures, operating envelope of the technologies as well as the path forward for the approach will be discussed.

#158 **As-Built 3D Modelling for Plant Piping Inspection Program**

In order to improve efficiency, accuracy, and content of inspection isometric drawings, NCRA utilized an "as built" 3D model program representing the existing process units at their McPherson, KS refinery. The 3D model is created by laser scanning entire process units which captures the existing geometry of the structure, piping, equipment and all other components within the plant. Intelligence is applied to the modeled assets from data obtained from Piping and Instrumentation Diagrams (P&IDs). Piping inspection isometric drawings are created in the 3D model program by isolating desired piping systems and are realistic representations of actual field conditions. Key information such as Operating Conditions, API classification, Corrosion Monitoring Locations, etc. are identified for each system. Drawings are printed as plan and isometric views, and bundled with P&IDs as inspection packets for the field inspection crew.

#163 **When to Perform On-Stream Inspections in Lieu of Internal Inspections - A Proven Approach**

API 510 6.5.2 – On-stream inspection is analyzed as it relates to plant pressure vessels whose current risk falls below the facilitie's acceptable risk threshold. If there is no risk to mitigate by inspection, when is it appropriate to perform on-stream inspections in lieu of internal inspections? The effectiveness of the external NDE technique(s) defined in the Inspection and Test Plan (ITP) have to be adequate for the expected damage mechanism(s) identified in the Corrosion Control Documents (CCD). Consequence driven risk assessments present an often overlooked opportunity to perform an on-stream inspection in lieu of an internal inspection. The best candidate pressure vessels for performing an on-stream inspection in lieu of an internal inspection is discussed as to their risk characteristics and susceptible damage mechanisms.

#164 **Case Study: Assessment and Remediation of a Local Thin Area**

A major refinery client detected a leak in a contactor tower and performed an immediate patch with composite

materials. Subsequently, the facility performed thickness grid measurements and contacted Stress Engineering for an expedited Fitness For Service (FFS) assessment. This presentation will explore the project workflow, steps that the client and the consultant took to both ensure rapid success and minimize unit down-time. This presentation will discuss getting proper inspection technique on-task from the beginning of the problem, how having an engineer engaged immediately improves speedy project flow, and how clear communications within the project team keeps decision makers informed in a timely manner. This presentation will also detail the remediation steps performed, and how the Level 3 analysis guided plate and weld sizing decisions. Significant benefit was derived from having access to a site metallurgist for corrosion, cracking, and weldability questions that arose throughout the course of the work.

#166 **1.25Cr Reformer Reactor Flange Brittle Fracture: Lessons Learned**

This presentation will highlight a recent failure on an older 1.25 Cr Reformer Reactor flange that failed from brittle fracture. This failure is unusual in that the Industry focus for controlling brittle fracture caused by temper embrittlement has been focused more on 2.25 Cr materials. The presentation will include a basic summary on principals of brittle fracture and explore the key elements contributing to this failure, including; 1. A severe loss of ductility from in-service temper embrittlement of the 1.25 Cr material, supported by multiple charpy impact strength test; 2. Observance of multiple pre-existing crack like flaws emanating from damaged sustained during torch cutting bolts during Turnarounds (from the physical failure analysis), and; 3. A high applied stress at the zone of fracture resulting from the flange design and bolting load, supported by a finite element analysis. Specific applications to the Refining Industry will also be discussed on establishing acceptable Minimum Pressurization Temperatures (MPT's)

#167 **The Dilemma of Field Applied Pipeline Coatings: Proven Solutions**

Coating inspection of a field applied, surface preparation tolerant, pipeline coating is often made easier since the requirements for a successful application are less demanding. The flexibility of a coating system's capabilities for usage in an outdoor environment can be an important factor in making a selection of corrosion protective coatings. Many pipeline coating failure investigations have determined that improper application of a coating system in the field are mainly attributable to improper pipe surface preparation. Wax tape coatings applied to protect pipelines in the field from external corrosion are often thought of as a solution that removes the variable of strict weather and other environmental constraints to obtain a successful application.

#168 **Mechanical Evaluation of Liquid Full Relief Case**

The inclusion of static head in the design of pressure vessels is not a new concept. However, it is one area that has been misinterpreted in many cases. Many older vessels currently operating in refineries and petrochemical plants were not originally designed with any static head considerations. In the case of process towers systems, the pressure and loading effects of static head can be significant and must be considered in vessel design. Additionally, as relief system studies are revised and updated, new potential scenarios for vessels operating with high liquid levels are discovered. This presentation will specifically address screening criteria used to mechanically evaluate an existing pressure vessel for a liquid full pressure relief scenario. Required documentation, mechanical and operating information requirements, and conservative assumptions for loadings will be detailed. While the results of the analysis will not allow continued liquid full operation, a short-term maximum operating level, limiting component(s), and maximum allowance working pressure can be determined.

#170 **Acid Gas Preheater Furnace Tube Failures: Case Study**

Acid gas preheaters of SRUs (sulfur recovery unit) have experienced failures of the stainless steel tubes in the furnace. The acid gas preheater heats acid gas before admitting it to the reaction furnace for further processing. The acid gas preheater furnace is a natural draft, direct fired, radiant heater with four horizontal mounted burners;

two on each end with one mounted above the other. The furnace tubes are an austenitic stainless steel, ASTM A213 Grade 321 and experienced cracking in the U-section of the tubes. This presentation, shares the root cause of the failure of stainless steel furnace tubes, discussesd mitigation methods and disseminates lessons learned.

#171 **Optimising Terminal Pipe Inspection**

Storage facility inspection programmes should not only cover the storage tanks but also the many metres of connection piping and feed lines from loading facilities. Historically, inspection of these pipe runs were carried out under the API 570 Piping Inspection Code. Whilst API 570 will ensure safe operation within terminals, API 570 is primarily aimed at petrochemical facilities to cover pipe that can operate at high temperatures, high pressures, and be subject to aggressive internal processes. API recognised this and released a new standard, API 2611, in 2011 for inspection of terminal pipe work operating up to maximum 300 psi at ambient temperature. The accuracy of data gathered from inspections is critical to the assessment of pipe condition and life expectancy. Using a range of different techniques can significantly improve the quality of this data, and this presentation outlines a suite of techniques (e.g MFL screening, Guided Wave and Ultrasonic thickness mapping) to achieve the desired result.

#172 **Continuous Monitoring of Corrosion Using Single-Element Dry-Coupled Ultrasonic Sensors**

Integrity management of a facility is a challenge for owners and the availability of continuous data of asset condition can be part of the solution. A proposed technology using high temperature, piezoceramic ultrasonic sensors sprayed on a foil layer and directly clamped to the outside surface of a pipe, should allow for continuous monitoring of an asset's remaining wall thickness. In this presentation, a case study to validate the technology against field conditions is offered and the corresponding results are discussed.

#173 **Extending Boiler Life: A Case Study in Inspection and Life Assessment Strategy**

Water tube type boilers are an integral and complex system for electric generation, pump/compressor driver and process heating. Tube leakage is the most common issue for asset integrity. Additionally, asset aging due to continuous exposure at high temperature will restrict the life cycle. The presented case is valid for boilers in operation for more than 30 years. A comprehensive inspection program and remaining life assessment were conducted to assure all boilers (in the study) are still safe for continued service. The inspection program and remaining life assessment conducted as part of life extension program will be discussed.

#174 **Corrosion Resistant Alloy (CRA) Clad Pressure Vessel: A Case Study in Inspection**

Corrosion Resistant Alloy (CRA) clad pressure vessels are used in various parts of the petroleum and chemical industries. In particular, Alloy 625 cladding of carbon steel is a preferred material solution as barrier protection for pressure vessels in handling fluids with CO2, H2S, chlorides, etc. For fabrication, most vessel manufacturers will specify Alloy 625 strip cladding overlay using and electroslag Strip Clad Welding (ESCW) technique primarily due to the benefits of lower dilution rates and higher productivity. For the case study presentation, a relatively new inlet separator - a carbon steel pressure vessel with Alloy 625 ESCW overlay - was opened for internal inspection with the sole objective of assessing the condition of the vessel internals. During the inspection, a chance but critical finding was found concerning a localized failure of the clad overlay compounded with a loss of wall thickness of the parent carbon steel pressure boundary. An in depth multi-disciplinary analysis was undertaken to investigate the causes of the unexpected failure including a review of the operating conditions and an audit of the vessel manufacturing and inspection records. This presentation describes the failure and its contributory factors as well as the issues with a clad weld overlay inspection program. The presentation will discuss the strategies for integrity assurance with regards to specification, execution, interpretation, acceptance criteria, limitations in current inspection techniques and review of records. Additionally, suggestions will be made to improve the existing

inspection programs for such vessels and to explore the opportunities to update industry standards to provide more stringent inspection requirements for clad weld overlay pressure vessels.

#176 **Corrosion Imaging through Insulation**

After six years of development with funding from the U.S. Department of Transportation, Chevron, and other oil majors, JENTEK's magnetoresistive (MR)‑MWM®‑Array low frequency eddy current technology has successfully completed several performance trials. These trials have included performance validation tests conducted at the PRCI Technology Deployment Center in Houston, TX, as well as field trials at several operating facilities of oil majors. Currently, several service companies are using the system in preliminary field services. This paper describes use of the MR-MWM®-Array system for the detection of internal and external corrosion through insulation and weather jacketing. Also to be discussed are the advantages of the technology and its relation to inspection for internal and external corrosion.

#180 **Asset Integrity Management of a Seawater Strainer for a Fresh Water vs. Seawater Plate Heat Exchanger**

Closed fresh cooling water system are utilized to cool multi-component refrigerant gases and other fluids. In some cases, the fresh cooling water is cooled via a Fresh Water vs. Seawater Plate Heat Exchanger. A primary issue for the seawater supply header is foreign materials and impurities which should be addressed by an upstream strainer vessel. Carried-over impurities, such as seashells, may contribute to the failure of the strainer. The scope of this presentation shares technical information in relation to the reliability, integrity, inspection, maintenance and operability of a seawater strainer. The presentation will discuss a preventive maintenance plan, an equipment operating strategy, cost optimization for inspection/repair, failure analysis of seawater strainer vessels, corrosion prevention program, and applicability of a risk-based inspection (RBI) review.

#181 **WeldCRO – A Fully Quantitative Cost-Risk Optimization Process-software for P91 Piping Lifetime Management**

The demand of improving plant thermal efficiency requires the development of the creep strength enhanced ferritic steels, such as P91. However, like all dispersion strengthened low alloy ferritic steels, P91 suffers substantial strength reductions in the welded condition due to elevated temperature. TWI, utilizing a limit-state equation to estimate P91 weldments remaining life in conjuction with a risk-based management (RBM) approach, has developed a cost-risk optimization software tool: WeldCRO. The software is a fully quantitative A-to-Z risk-based lifetime management system for P91 pipework, which includes calculating the remaining life and risk level, providing a cost-risk optimization assessment, and offering a Probability of Detection (POD) calculator, sensitivity analysis of risk factors and automatic meshing design. In this presentation, the cost-risk optimization algorithm behind WeldCRO and the functions of WeldCRO will be discussed.

#183 **Supplementing Intrusive Inspections with Non-Intrusive Inspection Technologies for Pressure Vessels**

Currently, for most industries pressure vessels have been required to undergo periodic internal inspections to ensure mechanical integrity and continued safe operation. Equipment owners pay a heavy price to shut vessels down in order to facilitate internal inspections. However, the introduction of advanced non-destructive, non-intrusive inspection technologies can minimize, if not replace, the need for intrusive inspections. Compared with traditional intrusive internal inspection, non-intrusive inspection is relatively new and there are a wide variety of inspection techniques available. This presentation reviews the key non-destructive inspection technologies and the assessment techniques currently used in the oil and gas industry to determine the type of degradation mechanisms present. In addition, the presentation will provide several case studies in which the non-intrusive inspections were employed on an offshore platform, involving the inspection of pressure vessels, and evaluating the results against the traditional intrusive inspection. The presentation will provide conclusive evidence

suggesting that the introduction of non-intrusive inspections can increase the intervals between intrusive inspections.

#184 **Continuous Monitoring of Critical Welds**

Critical welds often pose difficulty in performing the necessary inspections and/or the subsequent inspections on a frequency that complies with the risk-based reliability models. Many variables challenge a successful weld inspection and continuous monitoring provides a cost effective solution to some of these challenges. This paper presents three challenges that continuous monitoring can cost effectively overcome: remote access, surface preparation and under insulation. A solution described in the presentation concerns the permanently mounted placement of a series of Surface Eddy Current Coils over or adjacent to the critical weld. A small microprocessor continuously energizing the coils and recording data can be connected within a short proximity and data can be stored locally to a removable flash drive, hardwired to a network, or transmitted wirelessly. This solution provides the owner-operator with the ability to set up a proactive program with inspection frequencies that meet the risk-based analysis inspection requirement.

#185 **Root Cause Analysis of a Pipeline Loss of Primary Containment Event**

An onshore sweet gas asset experienced an Loss of Primary Containment (LOPC) event in their buried multiphase pipeline. A Root Cause Analysis (RCA) was performed and concluded that the event was caused by under-deposit corrosion. Based on the findings, several options of inspection and repair were evaluated. The presentation will provide the information behind the LOPC and will share the key learnings from the event in order to improve pipeline integrity knowledge within the industry.

#186 **How Can An IOW Program Increase Risk-Based Inspection Effectiveness?**

A failure of a critical asset typically has a significant impact on the safety, health, environment or the reputation and profitability of the business. Integrity Operating Windows (IOWs) are established limits for key process variables that are known to affect the integrity of the equipment if the process operation deviates from the established limits. Short term focus on reducing asset management costs often result in higher risk and long term loss of value to the organization. RBI (risk based inspection) utilizes process conditions and past inspection results at a snapshot in time to recommend inspection strategies for the future which can cover the span of the equipment's remaining life. However, on a day to day level, changes that occur in process conditions (excursions and upsets) are not fed back into the risk and criticality calculation. Such changes to operating conditions and process excursions often affect key process variables that lead to new damage mechanisms being introduced or accelerate existing damage mechanisms. The resulting increase in risk goes unaccounted for a significant amount of time and in some cases leads to "unexpected incidents". A well established IOW program is designed to provide real time notification of an increased risk to the integrity of an asset so that identified actions can be taken by the operators and/or plant managers proactively in a timely manner. Incorporating an IOW program alongside an RBI program can significantly increase the effectiveness of both programs and provide early and proactive recognition of equipment risks due to process changes, especially for aging equipment.

#187 **PMI - An Expensive Lesson**

Positive Material Identification, (PMI) for existing piping systems and for new construction is, and has been an industry challenge. What defines a good PMI program for both new and retro? Can your company pass a compliance audit if a compliance officer from OSHA arrived and wanted to know the exact chemical composition of any single component in a piping syetem chosen from a P&ID or an isometric drawing? This presentation provides a first hand account of what can happen when a properly documented PMI program is not in place. It is based on an actual event that occurred due to a sulfidation incident. Further, the presentation will address the PMI completed after the event, how the results were documented and the required follow up to the findings. And, the

lessons learned at "retro" PMI attempt will be discussed as well as some of the pitfalls and challenges of a PMI program, including the amount of support and cost that is required to have a successful program.

#191 **Integrity Assessment of Duplex Stainless Steel Fittings in an Operating Gas Plant**

An alert from Petroleum Safety Authority (PSA Norway) and Health and Safety Executive (HSE) warned that approximately 10-20% of each production batch within a production period of duplex stainless steel (DSS) material was defective. This resulted from an improper heat treatment in the manufacturer's furnace, which can result in the development of intermetallic phases in the DSS. Significant presence of intermetallic phases in DSS are considered a safety risk because they can lead to reduced pitting corrosion resistance and low material toughness/strength with risk ofa brittle fracture failure. Considering the safety risk as well as the cost and schedule constraints, an in-situ ferrite count and metallography examination were considered as the most optimal alternative to assess the DSS materials. The results provided assurance that the fittings were fit for purpose and presented no risk of brittle fracture failure. The objective of this paper is to present the management of the asset integrity risk through innovative inspection and robust engineering applications thereby preventing loss of life, loss of the assets, and loss of production downtime.

#192 **Development of a Next-Generation System for Ultrasonic Wall Thickness Monitoring Using Digital Communications Bus Protocol**

Installed sensor systems are becoming more commonly used and accepted as a method to improve data integrity and increase productivity for Oil & Gas asset inspections especially with underground, insulated, offshore and other hard-to-access thickness monitoring locations (TMLs). Example applications where installed sensor technologies have been deployed successfully include: crude overhead lines, sour water service, offshore risers for sand monitoring and midstream buried pipelines. Many additional applications of these systems are anticipated to augment static thickness monitoring, improve the accuracy of thickness data/trending and reduce pressure-boundary penetration of conventional corrosion probes while allowing both remote and real-time monitoring where desirable. This paper / presentation will review the development of a new multi-drop, digital communications protocol and ultrasonic transducer system network which enables dozens to hundreds of TMLs to be accurately monitored from a single location. Data capture paradigms will be discussed including wired access with data logging, automated data logging with wireless backhaul and mesh wireless. The benefits of cloud based software for data reporting and analysis will also be presented.

#193 **Unexpected Brittle Fracture of a Heat Exchanger Channel**

This presentation will discuss the failure analysis of an incident in a hydrocracker hot vapor trim cooler (heat exchanger). After an unexpectedly cold night, the channel failed suddenly while in service along the length of the weld on the channel body. There were no injuries or fatalities associated with the failure. The subsequent failure investigation and the results will be discussed in relation to the operating conditions, the environmental conditions, and the materials of construction.

#194 **A New Tool for Determining the Corrosion Depth on a Curved Section**

One of common problems found in gas processing and petrochemical plant is corrosion under insulation (CUI) in process pressure equipment. It is a challenge for to assess the equipment condition where CUI is found in curved sections. This is primarily due to the limitation of current metal loss measurement tools because no tools currently are built to specifically measure metal loss on curved section. To overcome this obstacle, a special tool was developed to measure the depth of metal loss on curved sections. The tool is equipped with flexible reference plates which can be adjusted and locked to match the corroded sections curvature and a vise for mounting a caliper. The presentation will describe the new tool, share the results of testing performed by measuring curved

sections having metal loss using the new tool, and compare the results with values obtained from existing tools. The presentation will also share the plans of how to construct the new tool.

#197 **Practical Guidance in Welding of Duplex and Super Duplex Stainless Steels**

Welding duplex and super duplex stainless steels is similar to welding austenitic stainless steels; however, critical steps must be taken to achieve both the corrosion resistance and mechanical properties required. When maximum results are necessary, such as in corrosive service applications, selecting the proper base material and weld filler metal alone will not guarantee success. Attention to welding process(es), welder techniques, bead shape, preheat/interpass temperatures, heat input on a per bead basis, and corrosion sample preparation are all essential to achieving satisfactory and repeatable results. Practical guidance for developing welding procedures and production welding to ensure optimum results are maintained and repeatable will be discussed.

#198 **MIC Assessment Model for Oil and Gas Production Systems**

An empirical microbiologically influenced corrosion (MIC) assessment model has been developed for production systems. The model is based on both microbial science and oil and gas production field experience. The model is designed to enhanced delineation of MIC likelihood for production equipment, include a MIC risk assessment capability, incorporation recent field experience, and include data input from recently developed bio-monitoring technologies. The primary input parameters are divided into two groups: prediction parameters and monitoring parameters. These two types of parameters are used in the model in different mathematical operations. The MIC likelihood for a system is output in the form of an index using semi-quantitative likelihood ranking (low, medium, high, extreme). Based on the combination of MIC likelihood and consequence of failure for the equipment, the MIC risk assessment supports recommendation of surveillance and mitigation actions for engineers in both design and operating scenarios. This presentation describes the MIC risk assessment model.

#200 **Storage Tanks: A Guide for RBI, FFS, IOWs, and Incident Investigations**

Concerning storage tanks, this presentation will present information to be used as a guide to implement Risk Based Inspection methodology, Fitness for Service methods, Integrity Operating Windows, and Incident Investigations based upon API RP 581, API RP 584, API RP 579 and API RP 585. This guide should be useful for inspectors and will include the key factors to optimize inspection plannning. The presentation will provide practical examples concerning the use of API 653 inspection intervals in combination with an RBI practice. An example of FFS, where inspection results find indications, will be provided to enable decisions making. And also based on inspection results, IOWs can be established for condition limits, as required. And finally, the incident investigation portion will provide a simple process for storage tanks. The presentation should provide practical guidelines for these areas based on published API documents, summarizing the requirements and providing technical applications.

#201 **Comprehensive Inspection Programs to Sustain an Aging LNG Plant Integrity**

Badak LNG operates 8 process trains to produce LNG with total capacity of 22.5 MTPA operating more than 35 years. To support LNG production, maintaining integrity of stationary equipment units is one of the key success factors in LNG production sustainability. There are a great number of stationary equipment units in Badak LNG Plant, i.e. 21 boilers, 6 LNG Tanks, 4 LPG Tanks, pressure vessels, heat exchangers, pipings, pipe lines, flares, pressure relief valves, etc with total units more than 25,000 equipment items. This presentation will provide an overview of all inspection programs, including our inspection philosophy, interval, method and scope. Our RBI program is continuously re-assessed based on the previous inspection results. Based on historical data, corrosion in acid gas removal units and CUI are the main equipment risks observed during 3 decades of Badak LNG operation.

#202 **Use of Geospatial Mapping and Production Data to Evaluate Integrity Risk to Pipeline Gathering Systems**

Onshore pipeline gathering systems have historically received less attention in integrity management systems due to their unregulated nature. Increasing focus on these unregulated gathering systems by PHMSA and State regulatory bodies have increased the need to become more proactive in assessing risks as opposed to reactively responding to threats. The expansion of gathering systems in the new shale plays have many states proposing new initiatives and regulations that potentially will impact the unregulated status of these pipelines based on new risk appraisals. The use of Geographical Information Systems (GIS) combined with pipeline attribute databases (PODS) and linked to production data have the ability to provide a predictive tool that identifies line segments that are at a higher risk in near real time. This presentation shows the potential of linking the various data together to better manage the integrity of gathering systems by focusing on at-risk areas through targeted abatement efforts to decrease the potential for failures.

#203 **Elevated Success with Industrial Rope Access**

Rope access has proven itself to be a safe and cost-saving method of performing inspection and maintenance activities at elevated and inaccessible heights. Despite the benefits, successfully implementing rope access within any large facility is an exercise in change management. The presenters will share the basic building blocks of their successful collaboration implementing rope access including assessing potential opportunities, educating stakeholders, delivering, and measuring results. The presenters will include a brief overview and introduction to Industrial Rope Access and the key safety components. Rope access has improved the inspection team's completion rate of difficult access inspections which ties directly to safety and reliability. The presenters will share some of the common challenges and pitfalls while illuminating some of the opportunities which have driven successful results.

#204 **Real-Time Active Pipeline Integrity Detection (RAPID) System for Corrosion Detection, Localization and Quantification**

In order to ensure the continued operation of pipeline and piping systems, operators must invest in regular inspection of their systems by a variety of methods, including visual inspection, inline inspection (ILI), and traditional non-destructive evaluation (NDE) techniques. This results in intermittent inspection of the piping and increased operating costs. Alternately, by utilizing Structural Health Monitoring (SHM) systems, operators can monitor pipelines and piping on a continuous, rather than intermittent basis and drive toward more cost effective Condition-Based Maintenance (CBM) of their systems. Real-Time Active Pipeline Integrity Detection (RAPID) system allows for the detection, localization and quantification of corrosion in steel piping. The basis of this system is ultrasonic guided-wave-based detection technology, which first detects the defect and subsequently calculates damage location and surface area. This presentation will provide information on the fundamentals and working principles of the system and discuss validation work performed in partnership with Chevron.

#206 **Strategic Planning for Inspection of Fired Heaters in a Turnaround**

This presentation is focused on the necessary steps and suggested organization to increase the probability of a successful single or multi-heater inspection in a turnaround. It will cover: accumulating data on the heater(s) before the turnaround, determining expectations for heater(s) inspection, assessing vendors, estimating cleaning and inspection time frames, assessing challenges for the inspection team, setting up an effective communication structure for the turnaround, understanding the inspection process and data analysis, and participation in the closeout meeting, final reporting, and prove ups. A case study of a multi-heater inspection at Blanchard Refining will be presented.

#207 **Use of Integrity Monitoring Systems in Refineries (A Case Study)**

This presentation will present case studies of permanently installed integrity monitoring systems in refineries. Fixed UT sensors that deliver their wall thickness measurements wirelessly afford previously unobtainable quality and frequency of data directly to the desk of those who need it. The presentation explains various examples of how this data has been used to improve refinery profitability. Some high level trends observed in the deployment of these monitoring systems in around 50 refineries worldwide will be presented. Modern monitoring systems can deliver an up-to-date picture of the asset integrity, redefining integrity operating windows and informing a large range of asset management decisions. The examples presented here include better shut down planning and associated increase in plant availability. An example is presented of a controlled increase in feedstock TAN, whilst monitoring in real time for increased corrosion rates in high risk areas of the crude and vacuum distillation units.

#208 **Development of a Minimum Intervention Strategy for Inspection**

As part of the Prelude project Shell has developed a strategy to minimize the effect on planned downtime for the inspection of pressure equipment. The strategy consists of the review of the effectiveness and efficiency of the Risk Based Inspection analysis, the effect of an implemented Corrosion Management Framework and correct data management. The remaining inspection scope is divided into intrusive and non-intrusive parts where the objective is to maximize the use of non-intrusive inspection and on-line monitoring (applying advanced NDE). For optimization of the intrusive part Shell has joined the Petrobot project for the development of robots for on-line inspection of tanks and pressure vessels. The presentation will include examples of the application of the various elements. The implementation of the strategy has resulted in the increased uptime for offshore installations in the UK. The effect of applying the strategy on a Floating LNG facility will be presented.

#209 **Fitness-for-Service Methodology as part of Asset Integrity Management for the ECOPETROL (Results and lessons learned)**

Since the refinery of Barrancabermeja of Ecopetrol is more than 60 years old, the implementation of a fitness-for-service methodology according to API-579 takes an important role in the strategy for the asset integrity management. In just a year, after doing more than 80 assessments, the results have had a huge impact, where more of the 60% percent of the pressure vessels have been defined with a remaining life higher than 20 years, and other 20% of the equipment can be repaired. The company has implemented new strategies for a successful inspection according to API 510 and also providing different alternatives for the maintenance according to ASME PCC-2-2011 The presentation will show the success that has achieved with the implementation of the fitness-for-service analysis in the asset integrity management system for the refinery.

#210 **A Better Way to Manage Your Mechanical Integrity Department**

This presentation will describe an innovative model that brings a holistic approach to mechanical integrity departments industry-wide. This approach will not only increase the effectiveness, but also the efficiency, of the average MI department. It will explain how a single source can provide not only inspection and testing services, but also corrosion experience, IDMS/RBI/CMMS software management, and other maintenance analyses while also managing the entirety of those services. The oversight of this single source by facility personnel is condensed into update meetings that use an innovative reporting system that provide up-to-the-minute information on plant risk, inspection costs, and other KPI's in real-time via a custom dashboard. The presentation will also outline how facilities can be provided with extensive industry experience on aspects like asset integrity, corrosion, inspection techniques and management without increasing current workforce.

#221 **Defining Integrity Operating Windows in Fired Furnace Tubes**

Fired furnaces in the petrochemical and refining industry are critical pieces of equipment that can have a major impact on process unit safety, reliability, and economics. There are several factors playing key roles in the life span

of fired furnace tubes, and one of the most important is establishing reliable operating limits to avoid damage mechanisms of greatest concern (creep, corrosion, embrittlement, stress corrosion cracking, carburization, etc.). Since all these mechanisms are related to fired heater tubes skin temperatures, it is important to define limits for this key operating parameter. This presentation will describe how API RP 584 can be used to establish integrity operating windows (IOW's) for furnace heater tubes by establishing reliable operating skin temperature limits; case studies in the most common refining units will be presented to show and describe how handling this critical parameter could allow reliable operation of fired heaters. Remaining life and fitness-for-service assessment will be discussed as a critical step in the definition of IOW's in furnace heater tubes.

#222 **Managing Mechanical Integrity of Cyclones and Cyclone Systems in FCC Units**

FCC reactor, regenerator, and third stage separator systems are fabricated with complex internals including cyclone systems. The process conditions in this equipment include elevated temperatures, high velocities, and applied loads on internal supports, making the equipment used in the fabrication of cyclone systems susceptible to several degradation mechanisms including erosion, carburization, sigma phase formation, creep, etc. Hence condition assessment, remaining life estimation, repair and replacement decision are always a challenge. This presentation will describe some of mechanisms of greatest concern in FCC Unit cyclone systems and will provide some guidelines for managing the mechanical integrity of in-service cyclone systems. It will include discussion on inspection techniques, sample removal, metallurgical and mechanical assessment and testing of samples, maintenance, repair, and replacement of components of cyclone systems.

#224 **Managing your PSM data to Support Operations - Preparing for an OSHA Audit**

There are many benefits to properly managing your Process Safety Information, that go far beyond being prepared for an OSHA Audit. Having all of the elements of PSM readily available, not only allows quick answers to audits, but it allows facilities to more efficiently perform repairs, update facilities, etc. The objective of the presentation is to provide an overview of methods for collecting, organizing, and accessing all relevant PSM information. It will review data collection options such as mobile devices, connectivity differences, and data organization. The presentation will also provide insight into making data more 'audit proof' by use of electronic methods of organizing and linking of information beginning with the field data collection process. The overall objective of the presentation is to provide insight into how to efficiently evaluate your resulting PSI system to understand if you are prepared for any need for operations, repairs, process updates, or audits.

#225 **Sand Erosion Monitoring to Safely Maximize Production Rate of Offshore Gas Platforms**

This presentation will focus on monitoring sand erosion in order to maximize production on offshore gas platforms using a non-intrusive ultrasonic technology that continually measures pipe wall thickness and reports erosion rates to integrity personnel, offshore or onshore, in real time. While water and salt corrode from the outside, pipe integrity is being eroded from the inside of gas platforms because of sand. Internal erosion is difficult to detect, measure and mitigate. A system comprising of wall thickness measurement sensors that deliver their measurements wirelessly is being used on offshore gas platforms, both manned and unmanned, to measure the piping integrity in real time. The operators of the unmanned offshore gas platform example presented were able to safely increase the gas production rate by 12%, resulting in a fast payback period for the battery operated wireless integrity monitoring system.

#226 **Failure Analysis on Cracked Outlet Nozzle Welds on a Vertical Finned Tube Economizer**

The economizer is a vertical finned hairpin tube design which utilizes combustion flue gases to heat up regeneration gas in 2 coils. Numerous cracks were observed on the welded regions of a pair of outlet nozzle-economizer baseplate attachment welds and their reinforcement pad welds after five (5) years in operation. The findings indicated that the root cause of failure was attributed to a combination of poor engineering design and

poor welding of the nozzle attachment welds. Longitudinal sectioning of the nozzle, flange and baseplate revealed incomplete joint penetration, crevices and exposed poorly profiled weld roots led to a combination of damage mechanisms. The design crevices and exposed welds at the bottom of the plenum chamber, where the nozzles were welded, acted as sites for acid concentration making the welds susceptible to pitting corrosion, intergranular corrosion and SCC. The presentation will reveal the solutions to the combination of design and fabrication problems.

#227 **Materials Selection Options in Oil Refinery Equipment with a Focus on Cost**

Materials selection has become a key factor in the design and repair of pressurized equipment for oil refineries. The costs associated with material upgrades can be substantial. In addition, a material upgrade may bring new problems with different corrosion mechanisms. This presentation will focus on the costs of material choices available for refinery equipment and piping. These costs will be discussed in terms of multipliers over carbon steel. Options such as clad plate vs. solid alloy plate, seamless tubing vs. ERW tubing, and alloy upgrades vs. increased corrosion allowance will be evaluated. The target audience for this presentation will be refinery unit inspectors or engineers.

#228 **A Juror's Perspective: How Negligence Leads to a Wrongful Death Lawsuit**

Regardless of how much effort your company puts into doing the right thing in performing their daily work routines, the chance of future losses from a negligence lawsuit can increase because of the documentation they do or do not have. The information presented is from the Jury Foreman in a lawsuit that was based on documenting deficiencies and corrective actions. The intent of this information is to inform inspection and maintenance personnel regarding the importance of proper documentation. The inspector’s objective is to provide clear, definitive description of the deficiency and the maintenance personnel's requirement is to clearly document the corrective action. The presentation will focus on an example of a wrongful death lawsuit that was directly attributed to a documented deficiency that had no proof of correction.

#229 **Efficient Location Based Inspection and Management**

This presentation will focus on the importance of properly located inspection data, how location based data is used in the MI data management process, and the potential benefits of recent developments to support location based inspection data. The process used for associating the field data to the maps or drawings and then linking them to the data repository is critical. The presentation will discuss the types of located data, various locating methods, and approaches to linking the various related locations and data. A properly designed and implemented approach to location based inspection data can reduce cost, improve accuracy, and better support other aspects of a mechanical integrity program. Methods of locating test locations vary from visual representations to target tags, to GPS, and other specialized approaches. Of great interest is recent developments in digital linking and tagging, and systems and equipment that make improvements in the overall program possible.

#230 **The Transitioning Role of a Process Unit Inspector**

Today, new NDE technology has caused additional demands on inspectors to keep up with the fast pace of R&D of new technologies. In the past 40 years, inspection has gone from being mostly discovery work (what has happened) to being primarily projected/predicted work (what will happen). Leaks, fires and spills are no longer acceptable in the eyes of the public or to regulatory agencies. As a result, inspections have shifted from a reactive approach to a proactive approach. In today’s operating environment, it is not enough to base future inspection plans solely on prior recorded/known history of equipment condition. Now, a fundamental understanding of the process/operating conditions and resulting damage mechanisms is required in order to establish and maintain an inspection program that yields the highest probability of detecting potential damage. Inspection plans must be dynamic and account for changing process conditions and current equipment condition

#231 **The Unit Inspector Transforms into a Mechanical Integrity Compliance Officer (MICO)**

Today's inspectors have gained much respect for their abilities and knowledge as regulatory agencies lean more on Mechanical Integrity during Industry audits. The role of an API Inspector is rapidly changing. Necessary skills for success have changed as technology, standardization and regulations have become part of our way of life. API Inspectors have transitioned over the last 40 years from an employee that was simply capturing and recording data for minimally worded handwritten reports, into a technical analyst role that is now responsible for managing and maintaining complex data bases compiled of data to project what may happen in the future. The inspector is responsible for achieving an overall goal of safety, environmental protection, mechanical integrity (MI) and efficient production.

#232 **The Many Parts of Injection Points**

Who at your facility "owns" injection point hardware? Typically, injection point hardware falls into the "Gray Zone". Gray Zone equipment is that equipment that falls between functional disciplines, so there is not always a responsible person or functional discipline to ensure it is inspected and maintained in an appropriate manner. As a result, this kind of equipment sometimes fails, which can lead to an unscheduled outage, or (worse) a safety incident, as the injection point hardware is usually installed to inject a chemical that mitigates corrosion or cracking, etc.

#234 **Back to Basics with Naphthenic Acid**

As stated in API-581, "While various papers have been presented on naphthenic acid corrosion, no widely accepted correlations have yet been developed between corrosion rate and the various factors influencing it." As a result, there are a lot of misperceptions for both prediction and prevention of this specific corrosion mechanism. Increasing demand on the oil market has raised interest in oils with high naphthenic acid concentrations. These so called "opportunity crudes" are also referred to as "lower quality" corrosive crudes due to their acid content. As a result, refinery Inspectors have to adopt special strategy for monitoring the mitigating efforts of acidic crude oil corrosivity and monitoring where the effects are going to cause corrosion. This presentation will address the known facts for naphthenic acid. It will cover the effect of naphthenic acid concentration, the combined effects with sulfur, temperature, metallurgy and more.

#235 **Unusual Corrosion Mechanism in a Shale Gas Well**

Well corrosion in shale gas fields can be unusual compared to that seen in conventional production. in this case well casing corrosion in a Haynesville field well was unusually low considering the CO2 and H2S partial pressures present. An analysis of the well caliper data combined with corrosion monitoring, advanced corrosion models and well fluid sampling was able to confirm the corrosion was limited by factors other than CO2 partial pressure, resulting in far less corrosion than anticipated. This presentation will discuss the factors restricting corrosion and the methods used to investigate and model the corrosion.

#236 **Heat Exchanger Cleaning Technology for Improved Eddy Current and Remote Field Inspection Results**

The fouling of heat exchangers has a negative impact on heat transfer and production capacity and also may restrict the effectiveness or accuracy of Eddy Current and Remote Field Inspections. The probability of success in cleaning the heat exchanger is dependent on the selection of the appropriate cleaning technology under the specific fouling conditions. Effective cleaning is essential, as after the cleaning of the heat exchangers Eddy Current or Remote Field Inspection is performed to assess the condition of the tubing. In many instances the cleaning of the heat exchanger tubes is performed inadequately and the inspection results are compromised. This presentation covers various heat exchanger cleaning technologies and inspection techniques that have been proven to facilitate accurate results, minimizing risk. The practical application of effective cleaning and inspection technology is discussed, results are demonstrated.

#237 **Failure Analysis on Cracking in SS Integrally Reinforced Nozzles on a Suction Separator for a CO2 Compressor**

Cracking was observed on three austenitic stainless steel integrally reinforced forged nozzles to hemispherical head attachment welds from a fourth stage suction separator. What was peculiar was that three other nozzles of the same size were welded to the 22 mm thk head, but suffered no cracking whatsoever and welded at the same elevation as the other nozzles which failed. Investigations revealed that the three nozzle welds which were which were cracked were integrally reinforced forgings while the others were not. Metallurgical and hardness tests revealed the forgings were sensitized and exhibited a hardness 60 BHN more than the wrought nozzles. There is a debate as to whether the mode of failure could be HIC or SCC or a combination. Let's debate the topic and the similarities between the two damage mechanisms and how they can each manifest themselves differently.

#239 **Key Elements in an Excellent Injection & Mix Point Integrity Program**

Refinery injection and mix points are prone to accelerated corrosion and demand robust systems to properly design, manage and inspect. This presentation will discuss key elements of a strong injection and mix point program detailing data requirements, quill design, Von Karman calculations and inspection requirements. Importance and appropriate timing of engineering review for new injection and mix point systems will be emphasized along with use of MOC's to trigger additional review. Several MOC trigger questions will be shared to highlight the need for organizational awareness and impact of potential changes to injection and mix points. Three recent examples of localized loss in hydroprocessing units will be discussed highlighting the benefits of the required API 570 inspections.

#242 **UT Camera For In-Service Inspection: Making NDT Inspectors More Productive**

A big challenge is to provide industry with a cost efficient, easy to use inspection tool that produces high quality data resulting in earlier defect detection while increasing productivity. Industry employs a wide variety of NDT techniques, but there is still a need for a simpler, real time diagnostic tool for in-service inspection. The complexities of advanced techniques have resulted in a shortage of qualified technicians who can quickly and accurately detect subsurface defects over large areas. Traditional and modern ultrasonic testing methods can be tedious, time-consuming, difficult and expensive. This presentation will report on recent results utilizing a real time portable imaging device to find internal damage. We will describe results showing how much faster and easier corrosion testing, crack detection, and other defects can be over conventional UT methods. These and other results will be reported with high resolution images and quantitative data.

#244 **Sharpening Capabilities for Pipeline Leak Detection and Prevention**

This presentation will discuss the challanges and an integrated technology approach to overcome the challanges on pipeline leak detection and prevention. Major threats to pipeline integrity will be presented, and emerging technologies that can help manage the associated risks will be discussed. Focus will be on such key technologies/needs as free swimming UT pigs for inspection of difficult to pig pipelines, EMAT Lamb Wave, Digital Radiography and Large standoff Magnetometry for nonintrusive inspection of unpiggable pipelines, Guided Wave Tomography and Wireless Sensing Network for corrosion monitoring, and Fiber Optics for detection of third party intrusion and leaks. Current activities on the maturation and depolyment of the technologies will be reviewed, learnings will be shared, and plans for further work will be discussed.

#245 **Using RBI for Tank Bottom Corrosion Rate Modeling**

A methodology for using tank bottom corrosion rates to generate distributions and simulations for leakage will be applied using the general concepts of API 580 and API 581. Real data from corrosion of tank bottoms over large areas of the continent illustrate that time is an important covariate for pitting rates. This presentation will show how to model corrosion rates using regression methods and will apply the corrosion rate distribution properties to

likelihood of hole through. Moreover, a hole growth model is developed and illustrated to estimate quantities of leaked oil and the problems of how to assess the volume of spillage will be illustrated. Costs are applied and the risks are computed.

#247 **Remaining Life Assessment of Coker Furnace Tubes Using Omega Methodology**

Based on the results of an intelligent pigging inspection of fired heater coils in a coker heater, samples were removed from the most damaged radiant tubes and a remnant life assessment was performed using the Omega methodology outlined in the API 579/ASME FFS-1 Fitness-for-Service standard. Tubes in coker heaters are known to suffer from not only creep, but also wall thinning due to corrosion. Laboratory-based destructive testing, including dimensional analysis and metallurgical examination, accurately determined creep strain and metal loss due to corrosion. The destructive testing assessment results provided confidence in the remnant life calculation. The cyclic nature of tube metal temperature variations in coking furnaces were taken into consideration to determine the remaining life of the radiant tubes, as well as the effect of these variations in future operating conditions. This analysis provided information to set integrity operating windows for the coker heater.

#249 **Aboveground Storage Tank and Pipeline Integrity Testing Using Tracer Gas Leak Detection**

The objective of this presentation is to introduce the technology of Tracer Gas leak detection and leak location, how it works, where it works, as well as the benefits and limitations of the technology. The presentation will address the current forms of tank and pipeline leak detection, namely Acoustic Testing, Pressure Decay, Internal/External Inspection and Tracer Gas testing. Pipeline Terminals, DOT Breakout Facilities and Storage markets have seen an increased focus on integrity assessment and with that, leak detection systems have become an important part of those assessments. Leak detection methods typically do not provide the usual data points such as wall thickness, remaining life and corrosion rates found in the overall integrity plan and process. Tracer Gas inspections focus on buried pipelines that remain in-service during inspection. Data generated from such inspection summarizes pipeline integrity as well as locating leaks if present.

#250 **Lessons Learned from Failures and LOPC Incidents Involving Pressure Vessels and Piping**

The three unique case histories presented include: 1) High-temperature metal degradation and failure of a nine-story tall coke gasifier that was modified resulting in cracking of gasifier internals, bulging and stress rupture of the thick vessel shell, and escape of hot syngas that resulted in an external fire. 2) Rupture of a sulfur storage tank roof that had a flammable mixture, and 3) High-energy reaction of a zirconium nitric acid condenser. Lessons learned from these three investigations will be discussed.

#252 **Selection of Mobile Data Collection and Data Management Tools in Oil and Gas Inspection**

Used properly, mobile devices can be a big benefit to efficiency of the inspection process; however, if used incorrectly or without proper implementation they can hinder the effectiveness of the process that is currently in place. Many things must be considered while selecting a mobile inspection solution. These considerations include: hardware, security, platform, usability, and flexibility. A key point that should be observed in the selection process is the service provider of the mobile solution, and what services are provided. While selecting this provider, how do they help with the implementation and assist in the change of culture, while making it a smooth transition into the mobile world. Other issues covered include: How does your company currently achieve these results? What works? What doesn't? Where is data lost? Do you have accurate KPI's established? How do you track them? Is your inspection data consistent? Is your inspection data accurate? Is your current system efficient?

#253 **Do Sweat the Small Stuff & Big Things Won't Happen - Preventing Small Bore Piping Failures**

The purpose of this presentation is to alert the industry to the significance of treating small bore piping (SBP) similar to other piping systems as part of an overall piping integrity program. Emphasis on SBP integrity is

warranted based on industry data collected over the last 3 years and is currently being regarded as a priority opportunity for the industry to improve it's mechanical integrity performance. Data has been collected in the API/AFPM Advancing Process Safety program showing that 45% of the reported refinery events were related to piping with about 50% of those events being due to MI failures. The API/AFPM Events Sharing database reveals that 42% of the piping events involved piping or tubing of 2 inches or less. The API/AFPM Site Assessment program points to plentiful "opportunities for improvement" in piping MI programs. As a result, both API 570 and API RP 574 will be improved to provide more guidance on SBP inspection.

#254 **The Corrosion Challenges with Processing Sour Canadian Heavy Crudes**

In today's refining world, processing Canadian Heavy Crude Oil is becoming a more a needed option. With the construction of more pipelines and with the increase of pipeline capacity, one common option is for companies to look at heavy Canadian high TAN and high sulfur crudes as a way to meet the refinery throughput objectives. These companies are no longer just in the northern trier of the USA but with the possible completion of the "Keystone" pipeline, southern refining locations will have access to more heavy Canadian High TAN, High Sulfur crudes This presentation will deal with some of the challenges of processing heavy Canadian crudes such as: single and two stage desalting, solids in Canadian crude, stream TAN's, corrosion control methods. There will be discussion on processing heavy Canadian crudes in detail and understanding the 2nd and 3rd order effects of the Canadian heavy crudes.

#256 **Bridging the Asset Integrity Gap for Upstream Assets**

Due in part to a few high profile incidents in the upstream oil and gas industry, many companies have developed an increased appreciation of the importance of a comprehensive asset integrity management program for upstream assets. Although the downstream sector has some great examples of mature asset integrity programs (AIP), these programs were developed over many years and may not be completely suited to upstream assets. Creating an asset integrity program in a location with very little AIP framework presents special challenges to even the most experienced asset integrity specialist. This presentation will first focus on the necessary steps to assess the state of a facility's asset integrity and then discuss considerations for how to set up the necessary framework to rapidly build and sustain a functioning asset integrity program.

#257 **Inspection Effectiveness and Your Mechanical Integrity Program**

As corporations make their push to improve mechanical integrity programs and strive fewer releases, more emphasis is being placed on inspection and the effectiveness of these inspections. However, inspection plans are too often inadequate e.g. point ultrasonic thickness (UT) measurement being used to monitor localized corrosion. In order to create a robust inspection plan, inspection effectiveness tables could be adopted and utilized in everyday practice for each damage mechanism that considers the following: Type of damage; Degree of localization; Predictability of the corrosion; NDE techniques; Probability of detection; and Sizing accuracy In order to show how to apply these elements in creating an inspection effectiveness table, an example of a vessel subject to corrosion will be reviewed.

#259 **Experience with Acoustic Emission Testing on Offshore Structures**

Several joint development projects (JDPs) were conducted to study the feasibility of acoustic emission testing (AET) technology as a screening tool for inspection planning on marine/offshore structures. Specifically, in-service AET data were collected for a tanker and from container ships during voyages. The AE source identification techniques used to locate the AE activity locations and identify the different nonconformity mechanisms will be discussed. Additionally, laboratory AET data were collected during a full-size mooring chain fatigue test and the AE signatures corresponding to the crack propagation were identified. Based on the experience gained during these projects, a

standard AET procedure is proposed as: 1) test plan, 2) AET system installation and checks, 3) data acquisition and analysis, 4) reporting documentation, and 5) follow-up inspection.

#260 **Corrosion Monitoring Using Ultrasonic Guided Wave Methods**

During the last two decade rapid progress has been made in the development of guided wave testing (GWT) methods mostly for the routine NDE of piping. The GWT method has been used to rapidly screen operational piping for damage, mostly corrosion so that more quantitative methods could be used to accurately size the damage. This presentation will focus on corrosion monitoring methods and the application of permanently installed guided wave sensors for this purpose. Many hundreds of these sensors are in-situ or are currently being installed. Results will be presented from numerous sensors on operational piping where in-service corrosion damage is the major threat. Finally conclusions of the benefits and limitations of the technology will be discussed highlighting were developments should be focused from an users point of view.

#261 **Practical Solutions for Challenging Pipeline Inspections**

Pipeline inspection using In-Line Inspection (ILI) tools has become the standard for pipelines that are considered piggable. However, many of the world's pipelines that are equally important from an integrity standpoint were never designed to be pigged, the so-called unpiggable pipelines. Typical challenges for unpiggable pipelines involve access (no pig traps installed), operating conditions, unknown cleanliness as well as the pipeline geometry. This presentation will discuss how to approach the required wide range of tools as well as the continued development of ILI solutions for challenging pipelines based on a tool box approach using case studies. Also the deployment of new solutions will be discussed including a testing and validation process. Examples include self-propelled solutions that can be combined with bi-directional MFL or UT ILI tools as well as robotic solutions that deploy existing measurement technology in a new way.

#262 **Continuous Thickness Monitoring of Subsea and Buried Pipelines Using Wireless Technology**

There are many techniques for inspecting and monitoring the condition of aged, damaged, and deteriorated subsea pipelines. The scope of this presentation is to present a wireless pipeline monitoring system that uses ultrasonic thickness (UT) sensors to measure pipeline internal corrosion. This presemtatopm will also report on early trials and deployments with operators in the North Sea and assess the long term benefits of retrofit, wireless integrity management tools.

#287 **Vertical Can Pump Case Failure - Are You at Risk?**

This presentation will review a Vertical Pump Can Failure and the significant findings that can be reviewed and applied at your site.

#288 **New ASME Section V Requirements for NDE Personnel - What This Means for You**

This presentation will cover the new requirements in the ASME Sec V Code in regards to NDE personnel qualifications. It will highlight the differences in the ASME and ASNT documents and what this will mean for industry and your work site.

#290 **Phased Array Testing of Welds From Only one Side - Optimize Your Results**

Welds connecting pipes to flanges and pipes to elbows, more often than not, suffer from severe restrictions in terms of accessibility to scan the weld from both sides. A justifiable concern exists that many single sided weld inspections miss reportable defects. This presentation addresses the issues and goes through ways of optimising defect detection capability, characterisation and sizing. The presentation proves though results found by modelling and subsequent practical trials that rejectable defects are being missed by PAUT in one sided access situations. Advice and a solution to this problem is given in the presentation.

#291 **Successful Intelligent Pigging Inspection of a Refinery's Aging Crude Supply Lines - A Case Study**
This presentation will discuss how one Owner/User decided to use In-line Inspection (ILI) technology to inspect their Crude Feed Lines to their refinery. This was a much more comprehensive inspection than what had previously been performed with isolated digs and Direct Assessment with Visual and spot UT. A case history will be reviewed.

#300 **Engineering Technology for Better Data Analysis Using Robotics and Wireless Data Access**
This presentation will highlight the integration of innovative technologies with traditional workflow process models to streamline and enhance shut down/turnaround planning and work execution while reducing risk (increasing safety) and OpEx costs.

This case study involved a multitude of inspection and maintenance related activities using advanced technologies in mobile, wireless and data acquisition and followed traditional "best practice's" pre turnaround inspection and planning workflow processes. The results demonstrate an effectively engineered, efficient, risk reducing method of maintenance practices and regulatory inspection. Additionally, having used owner generated forms, all data collected was reviewed, approved and "pushed" into the owner data repository, in a closed-loop communication process, wirelessly (in a context the owner helped design and understood) in real time. The process was fully intuitive to the client and the results immediately valuable.

#301 **Integrity Management and Inspection of Subsea Blowout Preventers**
The design and integrity management programs for subsea equipment have become a critical subsea operations factor after the Macondo Gulf of Mexico leak crisis. Of particular interest owner-operators and regulatory agencies are the regulation, design and maintenance of subsea blow out preventers. This presentation will overview recent changes in blow out preventer design, operation and integrity management, the application of codes and standards including API-579 Fitness for Service, API6A/6AB, and ASME codes, material qualification and acceptance criteria, qualification and validation testing (including 1st article) and inspection.

#302 **Using Limit Analysis in FFS of Pressure Vessels And Structures**
With advances in computational techniques, limit analysis methods are gaining more acceptance by engineers for checking the structural integrity of pressure vessels and structures. Limit load or limit state analyses size vessel or structural components using both elastic-plastic material properties and non-linear geometric behavior.

The lower bound limit value is found by increasing the load until the forces can no longer be calculated. The techniques are recognized by the ASME Boiler & Pressure Vessel Code in Divisions 2 and 3 and by API-579/ASME FFS-1. Case studies are presented considering pressure, gravity, and wind loads.

We present how limit analyses were used to check the structural integrity of four cases including a corroded tower subjected to wind loads, sizing pressure relief valves based on the capacity of a pressure vessel, design of a subsea vessel, and resistance to buckling of a dented flowline.

#303 **Corrosion Monitoring Using Ultrasonic Guided Wave Methods**
During the last two decade rapid progress has been made in the development of guided wave testing (GWT) methods mostly for the routine NDE of piping. The GWT method has been used to rapidly screen operational piping for damage, mostly corrosion so that more quantitative methods could be used to accurately size the damage. This presentation will focus on corrosion monitoring methods and the application of permanently installed guided wave sensors for this purpose. Many hundreds of these sensors are in-situ or are currently being installed. Results will be presented from numerous sensors on operational piping where in-service corrosion damage is the major threat. Finally conclusions of the benefits and limitations of the technology will be discussed highlighting were developments should be focused from an users point of view.