AMPP Nonmetallics Conference 2023
September 4-6, 2023
Oman Convention and Exhibition Centre
Muscat, Oman

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Fiber Glass Systems
An Insight into Nonmetallic Materials Excellence & Advancement in PDO
Presented by Zaher Al Hajri, Head Materials & Corrosion Engineering, Petroleum Development Oman

In this presentation, PDO shares its +30 years of knowledge and experience in leveraging the use of non-metallic solutions as well as its latest advancement and deployment across the company fields. In addition, it will discuss what is required for a successful application of nonmetallic materials from PDO prospective, highlights the opportunities and challenges and areas of expansion in the use of nonmetallic material solutions.

About the Speaker
Zaher Al Hajri is Head Materials and Corrosion with PDO Function responsible for leading Material, Corrosion Engineering Discipline Team that provide specialised consultancy in areas related to materials and corrosion engineering like material selection, metallic and non-metallic materials, coating, cathodic protection, vendors approvals, welding and non-destructive examination. In addition, he has direct responsibility to develop in house material and corrosion expertise as well as develop fit for purpose standards and deploy, test and assess new materials, technologies, process and tools that add value to PDO.

Zaher received his bachelor’s degree in Mechanical Engineering from the Sultan Qaboos University. Prior to his current post he was the lead material and corrosion engineer for PDO small-to-large projects portfolio with direct responsibility to ensuring deliverables meet technical requirements, quality assurance, schedule and cost requirements.
## Schedule at a glance

### Day 1 (Monday, September 4)

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<tr>
<td>9:00 a.m.</td>
<td>Registration opens</td>
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<tr>
<td>10:00 a.m. – 12:00 p.m.</td>
<td>Pre-Conference Workshops 1 and 2</td>
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<tr>
<td>12:00 a.m. – 5:00 p.m.</td>
<td>Exhibitor Move In</td>
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<tr>
<td>1:30 – 3:30 p.m.</td>
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<td>6:30 p.m. Onwards</td>
<td>Opening Reception and Exhibit Opening</td>
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### Day 2 (Tuesday, September 5)

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<tr>
<td>7:30 a.m.</td>
<td>Registration opens</td>
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<tr>
<td>8:30 – 9:30 a.m.</td>
<td>Opening and Keynote Presentation</td>
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<td>9:30 a.m. – 4:30 p.m.</td>
<td>Exhibition Hours</td>
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<tr>
<td>9:50 – 11:55 a.m.</td>
<td>Environmental Degradation of Nonmetallics: Mechanisms &amp; Durability Track</td>
</tr>
<tr>
<td>1:15 – 4:25 p.m.</td>
<td>Advancement in the Materials and Use of Nonmetallic in High-Pressure and High-Temperature Applications Track</td>
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### Day 3 (Wednesday, September 6)

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<tr>
<td>7:30 a.m.</td>
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<td>8:30 a.m. – 3:30 p.m.</td>
<td>Exhibition Hours</td>
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<tr>
<td>8:30 a.m. – 12:05 p.m.</td>
<td>Integrity Management and Remaining Life Assessment of Nonmetallic Materials Track</td>
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<tr>
<td>1:15 – 4:00 p.m.</td>
<td>Inspection, NDT and Repair on Nonmetallic Materials Track</td>
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<tr>
<td>3:30 – 5:30 p.m.</td>
<td>Exhibitor Move-out</td>
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Thank You To Our Technical Committee:

Abderrazak Traidia, Saudi Aramco
Abdulelah Mehlisi, Oil Sustainability Program
Mohammed Al-Abri, Sultan Qaboos University
Prakash Kumar, CPI
Rama Ramanahalli, Petroleum Development Oman
Yahyah Al-Bulushi, OQ
## MONDAY, September 4

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<tr>
<td>9:00 a.m.</td>
<td>Registration</td>
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| 10:00 a.m. – 12:00 p.m. | **Composite Repairs for Piping and Other Structures**  
Presented by Shaun Ahern, Carbontech Middle East  
Meeting Rooms 10 & 11  
**Elastomer, Thermoplastic and TCP Qualification Programmes at a Material Level**  
Presented by Glyn Morgan, Element Materials Technology  
Meeting Rooms 13 & 14 |
| 1:00 – 3:00 p.m.   | **Introduction into Composites and Resolving Reliability Issues**  
Presented by Michael Yee, RT Consults  
Meeting Rooms 10 & 11  
**Challenges during GRE Piping Qualification & Construction**  
Presented by Fahad Rashid Al Matroushi, Imran Al Kharusi, and Ramachandrappa Ramanahalli, PDO  
Meeting Rooms 13 & 14 |
| 6:30 p.m. Onwards  | Conference Opening Reception and Exhibit Opening  
Junior Ballroom |

## TUESDAY, September 5

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<tr>
<td>8:30 - 8:45 a.m.</td>
<td>Opening and Welcome Remarks</td>
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<tr>
<td>8:45 - 9:30 a.m.</td>
<td>Keynote Presentation</td>
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<tr>
<td>9:30 - 9:50 a.m.</td>
<td>Visit to Exhibition and Morning Break</td>
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| **Environmental Degradation of Nonmetallics: Mechanisms & Durability Session**  
9:50 - 10:15 a.m. | **The Vital Role of Nonmetallics in the Global Energy Transition**  
Presented by Lauren Lopez, NOV Fiber Glass Systems |
| 10:15 - 10:40 a.m. | **Advancement in Material Characterization at Realistic In-Situ Conditions for Composite Line Pipe Applications**  
Presented by Ahmed Hammami, Shawcor |
| 10:40 - 11:05 a.m. | **Learning from the Effects of Carbon Dioxide on RTP and GRE Materials in the Pursuit of Hydrogen**  
Presented by Glyn Morgan, Element Materials Technology |
| 11:05 - 11:30 a.m. | **Unleashing Sustainable Potential: Pioneering GRE Solutions for Hydrogen, CO2, and Ultra-Pure Water Applications**  
Presented by Uday Shankar Uthaman, Future Pipe Industries |
| 11:30 - 11:55 a.m. | **Experimental Evaluation of Polycarbonate as a Potential Front-Sheet in PV Applications**  
Presented by Anas Bintin, Saudi Aramco |
## Conference Schedule

### Wednesday, September 6

**Junior Ballroom**

### Integrity Management and Remaining Life Assessment of Nonmetallic Materials Session

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<tr>
<th>Time</th>
<th>Presentation</th>
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| 8:30 - 8:55 a.m.| Development of Testing Facility to Investigate GRE Pipes Behavior in Harsh Environment  
|                 | Presented by Abdulaziz Alsakiti, Petroleum Development Oman                   |
| 8:55 - 9:20 a.m.| Annulus Testing as the Integrity Management Method for Steel-Reinforced Thermoplastic Pipe  
|                 | Presented by Jonathan Guerrero, FlexSteel Pipe                                |
| 9:20 - 9:45 a.m.| GRE Sand Erosion Study                                                        
|                 | Presented by Imran Al Kharusi, Petroleum Development Oman                     |
| 9:45 - 10:00 a.m.| Visit to Exhibition and Morning Break                                        |

### Advancement in the Materials and Use of Nonmetallic in High-Pressure and High-Temperature Applications Session

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<tr>
<td>11:55 - 1:15 p.m.</td>
<td>Prayer Time, Lunch Break and Visit to Exhibition</td>
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| 1:15 - 1:40 p.m.   | Advancements in Metal-Organic Frameworks (MOFs) for Gas Storage, Separation, and Catalytic Applications  
|                  | Presented by Hussein Hassan, Sultan Qaboos University                         |
| 1:40 - 2:05 p.m.   | Novel Thermoplastic Lining Technologies for Downhole Tubing                  
|                  | Presented by Jeff Schell, USTS                                               |
| 2:05 - 2:30 p.m.   | Using Flexible Steel Pipe for Supercritical Carbon Dioxide Transportation  
|                  | Presented by Jonathan Guerrero, FlexSteel Pipe                               |
| 2:30 - 2:55 p.m.   | Polytetrafluoroethylene (PTFE) Application at QCPF                           
|                  | Presented by Abdulrahman Alame, Saudi Aramco                                 |
| 2:55 - 3:10 p.m.   | Visit to Exhibition and Afternoon Break                                       |
| 3:10 - 3:35 p.m.   | Performance of High Temperature Severe Environment Oil Flow Lines after One Year of Service  
|                  | Presented by John Wright, Specialty RTP                                      |
| 3:35 - 4:00 p.m.   | Development & Implementation of High Pressure Large Diameter RTR Pipe Systems for Oil & Gas Transmission Pipelines  
|                  | Presented by Alwin Fahrer, NOV Fiber Glass Systems                           |
| 4:00 - 4:25 p.m.   | The Adoption of Non-Metallic GRE Tubulars in Critical High-Pressure Oil & Gas Applications  
<p>|                  | Presented by Ghassan Zein and Ralph El-mir, Future Pipe Industries           |</p>
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<thead>
<tr>
<th>Time</th>
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<tr>
<td>10:00 - 10:25 a.m.</td>
<td>Failure Analysis of an Underground Reinforced Thermosetting Resin (RTR) Pipe from Firewater Network of a Gas Plant&lt;br&gt;Presentation by Nayef Alanazi, Saudi Aramco</td>
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<tr>
<td>10:25 - 10:50 a.m.</td>
<td><strong>Integrity Management of the Polyethylene Lined CS</strong>&lt;br&gt;Presentation by Yousuf Al Busaidi, Petroleum Development Oman</td>
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<tr>
<td>10:50 - 11:15 a.m.</td>
<td><strong>LLRTP Applications and Challenges in Oil and Gas industry</strong>&lt;br&gt;Presentation by Hilal Alshuhumi, Petroleum Development Oman</td>
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<tr>
<td>11:15 - 11:40 a.m.</td>
<td><strong>Evaluation of the Remaining Potential of Multilayer Composite Tubular Structures Damaged in Fatigue</strong>&lt;br&gt;Presentation by Ghouaoula Abd El Hamid, CHLEF University</td>
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<tr>
<td>11:40 - 12:05 p.m.</td>
<td><strong>Nonmetals Sustainability – Journey, Impact and Futuristic Strategy</strong>&lt;br&gt;Presentation by Saud Abudaly, Saudi Aramco</td>
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<tr>
<td>12:05 - 1:15 p.m.</td>
<td><strong>Prayer Time, Lunch Break and Visit to Exhibition</strong></td>
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<td></td>
<td><strong>Inspection, NDT and Repair on Nonmetallic Materials Session</strong></td>
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<tr>
<td>1:15 - 1:40 p.m.</td>
<td><strong>Nonmetallic Construction Issues and Case Studies</strong>&lt;br&gt;Presentation by Michael Yee, RTConsults PLLC</td>
</tr>
<tr>
<td>1:40 - 2:05 p.m.</td>
<td><strong>Life Extension Inspection for GRE Pipes</strong>&lt;br&gt;Presentation by Said Ali, Composite Pipes Industry LLC</td>
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<tr>
<td>2:05 - 2:30 p.m.</td>
<td><strong>Digital, Sustainable and Offsite Innovations with Plastic Piping Systems for Greener, Longer Living Assets</strong>&lt;br&gt;Presentation by Riccardo Barbone, Oman Allam, and Mark Jarrett, Georg Fischer</td>
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<tr>
<td>2:30 - 2:45 p.m.</td>
<td><strong>Visit to Exhibition and Afternoon Break</strong></td>
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<tr>
<td>2:45 - 3:10 p.m.</td>
<td><strong>Reinforced Thermosetting Resin Pipes (RTRP) Failures &amp; Quality Control Measures Adopted during Construction of the Largest LNGI Facility in Kuwait</strong>&lt;br&gt;Presentation by Faisal Al-Refai, Kuwait Integrated Petroleum Industries Company</td>
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<tr>
<td>3:10 - 3:35 p.m.</td>
<td><strong>Review and Application of Advanced Technologies for Corrosion Monitoring of Pipelines External and Internal Corrosion under Nonmetallic Repairs</strong>&lt;br&gt;Presentation by Rashed Alhajri, Aramco Services Co.</td>
</tr>
<tr>
<td>3:35 - 4:00 p.m.</td>
<td><strong>The Vital Role of Quality in Non-metallics Materials</strong>&lt;br&gt;Presentation by Yusra Al Sawai, Petroleum Development Oman</td>
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Stronger For Longer: Your FRP Partners

For over 25 years, CPI is reliably producing and installing composite pipes for the oil and gas sector, industrial plants, and utility purposes. Now we are developing extension life studies to enhance sustainability and maximize reliability.
**Workshop 1**

**Composite Repairs for Piping and Other Structures**

*Presented by Shaun Ahern, Managing Director for Carbontech Middle East*

**About the Speaker**

Shaun Ahern is the Managing Director for Carbontech Middle East. He is also a qualified composite repair systems supervisor and instructor having experience on many different systems.

He has 15 years of experience developing composite repair services within the Middle East market as well as a further 15 years working within high temperature processes and oil & gas industries in various operational and project management roles in over 40 countries around the globe.

He has a Diploma in Business Management and an MSc in Project Management from the University of Liverpool.

**Workshop Description**

The purpose of this workshop is to provide an overview of the process of the application of composite repairs to ensure a successful long-term repair. The process of application will be explained in detail and will include:

- Material selection
- Qualification testing
- Design
- Installation
- QA/QC processes
- Operational issues

While expanding on the detail of each of these important aspects of the application of composite repairs reference to the relevant standards, ISO/TS 24817 and ASME PCC-2 Article 4.1 will be made.

As with any repair technique there are limitations in the performance of the chosen solution. These restrictions will be discussed and include:

- Types of defects that can and cannot be repaired, e.g. internal corrosion, external corrosion, through wall defects
- Application conditions, e.g. live repairs, humidity, ambient temperature, surface preparation
- Performance limits, e.g. maximum temperature and pressure
- Compatibility of the repair with the service conditions
- Component types that can and cannot be repaired, e.g. straight pipes, bends, tees, temporary clamps, flanges, tanks and vessels.

The key technology for the successful application of composite repairs is the adhesion of the repair onto the substrate. Particular emphasis will be placed on what variables influence the adhesion of the repair. The main variables are the resin used in the repair, the surface preparation procedure and the substrate material. The effect of these individual variables will be presented and quantified.

Finally a few representative examples of applications will be presented which will highlight the range in pipework, tank and vessel geometries, dimensions and service conditions that can be repaired demonstrating that damaged components can be returned to their original integrity using composite repairs.
Workshop 2
Elastomer, Thermoplastic and TCP Qualification Programmes at a Material Level

Presented by Glyn Morgan, Technical Manager, Energy, in Element Materials Technology

For obvious reasons, non-metallic materials (polymers) need qualifying before being used in critical energy industry applications and components. This ensures that in service the best possible material has been chosen for both short term and long term performance.

The Workshop will explain the polymer qualification process for elastomers and thermoplastics using ISO 23936 as a basis, and discuss the properties necessary for gas decompression resistance and long term chemical ageing effects, how these are monitored and measured and how they influence final product performance.

Also, an overview of the qualification of TCP materials (composites) and products relevant to DNV F119 will be discussed and how these differ from polymers that are not fibre reinforced and the additional understanding this requires and uniqueness they confer.

Samples showing typical materials and failure modes will be available for inspection and handling.

About the Speaker
Glyn has been using and testing non-metallic materials since acquiring a chemistry degree back in the 1980s. Much of this experience has involved determining how well materials will continue to perform in service, whilst operating under a variety of conditions. His interest in permeation started with trying to eliminate moisture entering optical systems and measuring leakage using helium and mass spectrometry. This developed into measuring the passage of liquids and high-pressure gases through elastomers, thermoplastics and composites in the oil and gas and energy industries. He believes that permeation, diffusion and solubility are the cornerstone of understanding many aspects of non-metallic material behaviour whilst in service - such as long-term ageing and chemistry, short-term gas effects like swelling and blistering, and many other physical property changes which impact component life. Recently, hydrogen and carbon dioxide have taken centre stage because of the energy transition and increasing CCUS applications.
**Workshop 3**  
**Introduction into Composites and Resolving Reliability Issues**  
*Presented by Michael Yee, Principal of RT Consults*

**First Part:**  
- How it is made  
- Materials of construction  
- Material selection  
- Examples of composite construction (handouts)

**Second Half:**  
- Reliability issues with composites  
- Industrial and commercial applications  
- Damage mechanisms  
- Troubleshooting root cause analysis (introduction)  
- Q/A session

**About the Speaker**  
Michael Yee is the Principal of RT Consults which is a 3rd-party nonmetallic inspection company for the FRP and nonmetallic coatings industry. He has two offices in Houston Texas USA and in Dubai, UAE. He has over a decade and a half of experience in the nonmetallic industry and is a NACE/AMPP Level III Certified Coating Inspector with a background in chemical engineering and construction management. He is actively involved in ASME RTP committees and the nonmetallic technical committees at AMPP being the chairman for Nonmetallics, corrosion under insulation, thermoplastic, and fireproofing committees. Michael is an avid presenter for several professional organizations over the years who continues to strive for excellence in providing technical services and support for many leading petrochemical companies in the oil and gas sector, chlorine, sulfuric acid, water treatment, and petrochemical industries.
Workshop 4
Challenges during Nonmetallic Qualification & Construction
Presented by Fahad Rashid Al Matroushi, Non-Metallic Quality Lead, PDO; Imran Al Kharusi, QA/QC Engineer, PDO; and Ramachandrappa Ramanahalli, Non-metallic Specialist, PDO

This workshop will highlight the lessons-learned PDO has gathered during the construction of non-metallic for On Plot and Off plot facilities. The workshop will discuss in depth the construction of nonmetallic line pipe, piping, and their accessories items like fittings and flanges. This workshop will cover different types of nonmetallics like GRE, HDPE, and LLRTP, and will highlight construction requirements of each material, challenges faced during construction (e.g. capability, adherence to specifications and procedures, timeline, and inspections), lessons learned, case studies, and more.

PDO specifications and standards based on the preparation of the installation contractors do for most of the projects together with the changes in construction method statements and field working procedures will be addressed in this workshop.

About the Speakers
Fahad Rashid Al Matroushi is a PGDip mechanical engineer with 22 years of experience in field of design, manufacturing and construction of GRE piping and pipelines system.

Imran Al Kharusi is a Senior Non-metallic QA/QC engineer with over 7 years of experience at PDO. Imran has a Bachelor’s degree in Materials Engineering and an MSc in corrosion control engineering from Manchester University.

Rama Ramanahalli is a nonmetallic specialist in PDO with over 20 years of experience in nonmetallics, ensuring that quality products and services are provided to company in design, manufacturing, construction and operational phases.
Munanoor is a plastic pipe manufacturer in Oman with a long history of providing high-quality products, innovative solutions, and dedicated customer service. Established in 1975, Munanoor has grown to become one of the leading companies in the industry.

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Sultanate of Oman
Phone - 00968 24442500
Website - www.munanoor.com
Environmental Degradation of Nonmetallics: Mechanisms & Durability Session

9:50 - 10:15 a.m.
The Vital Role of Nonmetallics in the Global Energy Transition
Presented by Lauren Lopez, NOV Fiber Glass Systems

Countries around the world, including many in the ME, are announcing net-zero goals and incentivizing industry to put carbon management technologies in place while also moving towards renewable energy sources. By the end of the decade, significant infrastructure is planned to be developed via several energy transition sectors.

Typically, we see the use of composites in renewables as structural components, such as wind towers and blades. However, non-metallics have a much bigger role to play in the inner workings of several areas such as CO2 capture and transport, hydrogen infrastructure, geothermal district heating systems, and many more. Additionally, the energy transition is going to place significant strain on steel globally and will have to rely on alternatives. This presentation will demonstrate the vital role fiberglass piping systems, tanks, and composite structures will play in key energy transition areas where corrosion and weight challenge the long-term success of energy transition projects.

10:15 - 10:40 a.m.
Advancement in Material Characterization at Realistic In-Situ Conditions for Composite Line Pipe Applications
Presented by Ahmed Hammami, Shawcor

A novel in-situ punch-shear device has recently been developed to enable testing of polymers while saturated (aged) in fluids at elevated temperatures and pressure conditions typically encountered in oil and gas operations [1]. Conventional testing protocols involve exposing material samples to the desired environment until saturation, then removing the samples from the aging environment for mechanical testing. This practice can generate misleading results, especially for materials for which fluid ingress is rapidly reversible, most notably at elevated temperatures.

The modular and compact in-situ test device, which is an extension of the ASTM D 732 punch-shear method, has been successfully used to establish experimental correlations between the tensile yield strength and modulus properties of compression molded Polyethylene of Raised Temperature (PE-RT) measured at various temperatures via ASTM D732 and ASTM D638 tests under dry conditions. The in-situ device also enabled measurement of shear properties for select compression molded polymer coupons while immersed in fluids of interest at elevated temperature and pressure.

The present work extends the treatment to a suite of five (5) commercially available thermoplastic resins spanning the commodity, engineering, and high-performance polymer grades with varying degrees of hygroscopicity and, in turn, susceptibility to hydrolysis. The objectives of this contribution are three folds, namely: (i) assess effect of sample preparation method (compression molding vs. injection molding vs. extrusion) on measured shear and tensile properties, (ii) compare the experimentally established correlations between shear and tensile tests for the different class of injection molded polymer grades before fluid exposure, (iii) assess reversibility of injection molded polymers tensile and shear properties post 24 hours immersion in water at 95°C.

10:40 - 11:05 a.m.
Learning from the Effects of Carbon Dioxide on RTP and GRE Materials in the Pursuit of Hydrogen
Presented by Glyn Morgan, Element Materials Technology
Carbon dioxide has been associated with hydrocarbon production for decades and its’ potentially damaging effect on non-metallic materials and components well documented, well understood and respected. The advent of CCUS and supercritical carbon dioxide has rightly placed further emphasis on this aspect of non-metallic material performance. A brief summary of examples and photographs of damage mechanisms caused by CO2 in general, and supercritical CO2 in particular, will be given, in particular highlighting the relevance of permeation and diffusion of gases (with values comparing CO2 and CH4) through polymers and how this influences subsequent behaviour; rapid gas decompression damage being the prominent failure mechanism.

This knowledge will then be extended to the hydrogen economy where initial concerns have been raised about the small size of the hydrogen molecule and its’ capacity to cause similar problems to CO2 when being stored and transported in non-metallic systems. Whilst experience and data are still being gathered, some internal R&D results (H2 versus CO2) will be used to focus on permeation characteristics and damage mechanisms, and how diffusion and solubility are indeed key influencers on nonmetallic material performance.

11:05 - 11:30 a.m.
Unleashing Sustainable Potential: Pioneering GRE Solutions for Hydrogen, CO2, and Ultra-Pure Water Applications
Presented by Uday Shankar Uthaman, Future Pipe Industries
For hydrogen transportation, the limitations of steel, including hydrogen embrittlement and permeation, necessitate alternative materials. GRE is specifically tailored to meet the stringent mechanical integrity and permeation management requirements of the hydrogen industry. By leveraging ISO14692 standards and third-party independent testing, the GRE material demonstrates significantly lower permeation levels compared to steel, making it a superior choice for long-term hydrogen infrastructure. Additionally, external impact-resistant coatings and pre-insulation options are available to ensure reliable above-ground service and meet the demands of ammonia transportation. In CO2 applications, GRE composites offer exceptional low-temperature performance and corrosion resistance, mitigating the risks associated with steel pipelines. The filament wound construction eliminates the potential for running fractures, allowing for rapid depressurization in emergency shutdown scenarios. The option for an external impact-resistant coating further enhances the above-ground service capabilities of GRE.

Furthermore, for ultra-pure water applications, GRE ensures the delivery of contamination-free water for electrolysis processes of green hydrogen production. With stringent quality control and independent testing, GRE supports the sustainable operation of Proton Exchange Membrane (PEM) electrolysers, providing a cost-effective and low-carbon solution.

11:30 - 11:55 a.m.
Experimental Evaluation of Polycarbonate as a Potential Front-Sheet in PV Applications
Presented by Anas Bintin, Saudi Aramco
In this work, we examine the performance of polycarbonate (PC) used to replace glass in solar module. An experimental study was done on the strength of adhesion of polycarbonate with alternative commercial photovoltaic encapsulants, and the subsequent degradation of the material in real operating conditions. Degradation was measured through spectral absorption, mechanical strength, and water ingress. 8 transparent PC samples of two commercial grades were lap shear tested for strength of adhesion with EVA, TPU-PVB, and TPU-Ionomer encapsulants before and after UVA and UVB dose of 60 kWh/m2. Accelerated ageing test under 85% Rh and 85oC for a total of 1000 h was carried out in a damp heat chamber to assess the performance of fully encapsulated polycarbonate mini PV modules. Results show a predominant effect of humidity in reducing the age of PC mini modules as moisture gradually seeps into the encapsulation zone and causes delamination. We will also present the field performance of commercially available plastic-based PV module in real operating conditions.
Advancement in the Materials and Use of Nonmetallic in High-Pressure and High-Temperature Applications Session

1:15 - 1:40 p.m.
Advancements in Metal-Organic Frameworks (MOFs) for Gas Storage, Separation, and Catalytic Applications
Presented by Hussein Hassan, Sultan Qaboos University

Metal-Organic Frameworks (MOFs) are highly versatile materials with its unique structure providing exceptional properties such as high surface areas and tunable pore sizes. Extensive research has been dedicated to exploring the potential of MOFs in gas storage, separation, catalysis, and corrosion inhibition, where their exceptional morphology, structure, and porosity enables efficient gas adsorption, selective gas separation, catalytic applications, and fabrication of corrosion inhibitors. MOFs have shown great potential for hydrogen (H2) storage in high-pressure and high-temperature applications. MOFs can be utilized as adsorbents for H2 gas at elevated pressures. This makes MOFs suitable for applications such as onboard storage in hydrogen fuel cell vehicles or stationary storage systems. Further, MOFs can be engineered to exhibit thermal stability and retain their structural integrity. MOFs can be employed as protective coatings in high-pressure and high-temperature environments. The ability of MOFs to selectively adsorb harmful species or gases can contribute to corrosion resistance, thereby enhancing the durability and lifetime of materials exposed to extreme conditions. The use of MOFs-based corrosion inhibitors is widespread in protecting various metals, including steel, copper, aluminum, and magnesium, against aggressive corrosive environments. By leveraging the exceptional properties of MOFs, such as their high surface areas, tunable pore sizes, and customizable functionalities, these materials offer significant advantages for H2 storage and high-pressure and high-temperature applications, including their potential as corrosion inhibitors.

1:40 - 2:05 p.m.
Novel Thermoplastic Lining Technologies for Downhole Tubing
Presented by Jeff Schell, USTS

Thermoplastic liners for flowlines and pipelines have proven to be a cost-effective and reliable solution throughout the MENA region due to their cost-benefit, reliability, and flow improvement. Utilizing a similar concept downhole is a logical next step and has been used globally for decades, but adoption of the technology in MENA has lagged so far. In this paper, the authors will discuss the use of thermoplastic liners to protect a wide range of oilfield tubular ranging from water injection to high-pressure, high-temperature sour gas production.

2:05 - 2:30 p.m.
Using Flexible Steel Pipe for Supercritical Carbon Dioxide Transportation
Presented by Jonathan Guerrero, FlexSteel Pipe

Recent industry focus on environmental conservancy has incentivized operators to consider new carbon capture and storage (CCS) applications. With minimal capital investment and interruption to production, flexible steel line pipe is ideally suited for carbon capture and storage (CCS) applications. Flexible steel line pipe consists of a high-density polyethylene (HDPE) liner and cover that isolate the steel reinforcement from the corrosive elements found in both the environment and conveyed media. Qualification testing on flexible steel pipe has proven compatibility for CO2 service. Flexible steel pipe’s unique product design has allowed operators to employ a dual-containment design while also implementing real-time continuous monitoring on multiple interfaces. With pipe diameters ranging from 2-inch through 10-inch and pressure ratings up to 3,000 psi, flexible steel pipe is ideally suited for service conditions commonly specified to transport CO2 in the supercritical fluid phase.

2:30 - 2:55 p.m.
Polytetrafluoroethylene (PTFE) Application at QCPF
Presented by Abdulrahman Alame, Saudi Aramco

The main objective of this submission is to discuss the application of Polytetrafluoroethylene (PTFE) at Qatif Central Producing Facility (QCPF) on the seal flush piping systems to overcome the unremitting failures occurring on Cu-Ni lines. Seal Flush system was experiencing such failures on internally coated carbon steel and copper nickel (Cu-Ni) since the start-up of the plant due to Microbiologically-Influenced Corrosion (MIC) which resulted in premature failures on mentioned lines. To overcome such failures, a team from different
organization in Saudi Aramco proposed the use of Polytetrafluorethylene (PTFE) material as a liner on carbon steel pipes to prevent MIC from developing. This pilot was installed in 2020 for 36 meters segment with zero reported failures which makes it a very successful trial. Currently, QCPF seal flush piping system is under replacement with PTFE lined carbon steel pipes to achieve the optimum reliability for Seal Flush Water Lines.

3:10 - 3:35 p.m.
Performance of High Temperature Severe Environment Oil Flow Lines after One Year of Service
Presented by John Wright, Specialty RTP
A section of a multi-phase flow line operating at 105°C with 5% H2S, high aromatics, brine, oil and gas was replaced with a high temperature reinforced thermoplastic pipe (RTP). After approximately a year of service samples were removed and tested to evaluate for changes in properties. This paper details the RTP construction, the installation, the operating environment and the testing of samples after a year in service and then compared with unaged samples. The results showed stable properties over time and proposes a pipeline integrity methodology for RTP products. The results show that RTP products can meet the challenging high temperature severe environment applications in the Middle East.

3:35 - 4:00 p.m.
Development & Implementation of High Pressure Large Diameter RTR Pipe Systems for Oil & Gas Transmission Pipelines
Presented by Alwin Fahrer, NOV Fiber Glass Systems
To maintain production levels, oil fields in the ME region increasingly require water injection to maintain pressure in the hydrocarbon reservoirs. The injected water increases the water-cut of the produced fluids, resulting in a very corrosive mixture for metallic piping. For this reason, non-metallic pipe systems have become more widely accepted as an alternative pipe material for transportation of produced fluids and injection water.

Over the 3 to 4 decades, the operating envelop for non-metallic pipe systems has increasingly expanded in terms of diameter, pressure, and temperature. This presentation will describe the historical developments that have allowed the application envelop of RTR to expand to its current version, and where this envelop is going to be expanded to within the next 3 to 5 years. An overview of the qualification test program that has been completed to support this expansion will be discussed, and new application areas for this technology will be highlighted.

4:00 - 4:25 p.m.
The Adoption of Non-Metallic GRE Tubulars in Critical High-Pressure Oil & Gas Applications
Presented by Ghassan Zein and Ralph El-mir, Future Pipe Industries
10”, 12” and 14” GRE pipes and fittings were qualified by FPI for up to 1,300 psi and 95°C hydrocarbon application. Threaded & Coupled joint was used for this application. The joint was designed to seal without any rubber O-ring. The utilized thread is custom and conforming to the requirements of API 5B. Additionally, 6” and 8” GRE pipes and fittings were qualified for up to 2,000 psi 65°C gas application. Integral joint was used for this application. The joint was designed to seal with a self-curing thread sealant.

Pipes and fittings were tested, and the performance was proven conforming to the requirements of API SPEC 15HR. After the successful qualifications of pipes and fittings, 37 km of 10”, 189 km of 12” and 140 km of 14”, all with API 15 HR monogram, were supplied for an operator in the GCC. Additionally, 6 km of 6” and 23 km of 8” were supplied for an operator in Egypt.
Duqm Hongtong Piping LLC (DHTP), was established in Aug 2019 located in The Special Economic Zone at Duqm (SEZAD). built over an area of 60,000 sqm capable of producing of 4” and 6” of Long Length Reinforced Thermopolyethylene Pipes (LLRTP) 
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Technical Session Descriptions

WEDNESDAY, September 6

Integrity Management and Remaining Life Assessment of Nonmetallic Materials Session

8:30 - 8:55 a.m.
Development of Testing Facility to Investigate GRE Pipes Behavior in Harsh Environment
Presented by Abdulaziz Alsakiti, Petroleum Development Oman

An in-house testing facility under controlled conditions has been developed in order to perform integrity design verifications for the GRE pipes that used in oil and gas lines in PDO according to the ASTM and ISO Standards. The aim of these inspection activities is to find an improved method of predicting the failure behavior of Glass Reinforced Epoxy (GRE) pipe-work and to ensure all components are working in a safe condition. Approaches in technical inspection turn to cost-effective and much reliable strategies such as inspections based on the level of the risk of the components. This as well helps to increase the safety of the processing unit, reduce the costs, and improve environmental protection.

8:55 - 9:20 a.m.
Annulus Testing as the Integrity Management Method for Steel-Reinforced Thermoplastic Pipe
Presented by Jonathan Guerrero, FlexSteel Pipe

Flexible steel pipe products have a built-in “annulus” space between the liner and the shield. This inherent feature fundamentally allows for controlled emission management. The presence of the annulus also offers a unique opportunity for pneumatic confirmation of the integrity of the pipe shield. This test may be completed post-construction prior to commissioning and can also be repeated at scheduled intervals during the pipeline operation. While such testing is well-known in the offshore pipeline industry, it has not been widely used in composite onshore pipeline applications. This presentation discusses the successful implementation of annulus testing for onshore pipelines constructed from flexible steel pipe. The presentation details the testing method, recent case studies, and the benefits of annulus testing for operators’ Integrity Management and Monitoring programs.

9:20 - 9:45 a.m.
GRE Sand Erosion Study
Presented by Imran Al Kharusi, Petroleum Development Oman

PDO have started the use of Glass reinforced Pipes in the 1980s in a wide range of applications. Over time GRE was found to be one of the best materials in the Oil production industry. PDO have utilized GRE material, in flowlines/ pipeline and station interconnecting lines. One of the challenges faced with GRE lines is the presence of sand in the produced fluid. The models and available literature are very limited with limited data points. A number of lines in PDO network were found to transport fluids with sand contents of more than 50 g/ m³. As a results of this, a study was initiated to investigate the effect of sand on GRE pipes.

In this study, A GRE flow loop was used to determine the effect of sand on The GRE a pipes. Three sand concentration with different sizes were tested for a 500 hours duration. The test was conducted on three phases with different sand contents at 5 m/s where each run was conducted for 500hours. After each run the pipes were cut, visually inspected and then inspected using optical microscope. The test was conducted at 100, 500 and 5000 g/m³ concentration at a velocity of 5m/s. The sand sizes were distributed between 300 - 1mm. The 100 & 500 g/m³ GRE spools did not show signs of erosion while the 5000 g/m³ sample showed a number of striation on the elbow and tee sections. Based on this testing the Sand envelope was expanded to 100 g/m³. This gave more confidence on the integrity of the existing lines operating within these envelopes.

10:00 - 10:25 a.m.
Failure Analysis of an Underground Reinforced Thermosetting Resin (RTR) Pipe from Firewater Network of a Gas Plant
Presented by Nayef Alanazi, Saudi Aramco

In Most of the oil & gas plants the firewater ring main is constructed out of Reinforced Thermoplastic Resin (RTR) for the buried sections, and constructed in carbon steel for the above ground sections. An underground fiberglass reinforced thermosetting resin (RTR) piping system used for firewater network experienced few failures after around 7 years of service at several locations. This work encompasses a pipe material failure analysis study to investigate the root cause of the failures. The analysis was conducted through
a series of analytical and mechanical methodologies starting with visual inspection, and followed by ignition loss, DSC, TGA, FT-IR spectroscopy, axial tensile testing, and SEM. Results revealed the presence of microdefects within the fiberglass/resin matrix, as well as unfilled gaps between fiber structures suggesting an uneven distribution of resin. These findings suggest possible reduction in the mechanical, physical, and chemical properties of the pipe, leading to its overall performance degradation over time which eventually resulted in its final failure.

10:25 - 10:50 a.m.
**Integrity Management of the Polyethylene Lined CS**
*Presented by Yousuf Al Busaidi, Petroleum Development Oman*
Polyethylene allows the gas to permeate into the annulus, so ideally fluid moves from high pressure region to low pressure region. Hence, the pressure will start building up in the annulus until it gets equilibrium with the operating pressure if the gas not vented, and the permeation rate varies from one gas to another depending on different factors such as GLR, and temperature.

Fluctuation or a sudden drop on the operating pressure will end up having a higher pressure on the annulus than the liner, consequently, liner will collapse and fail if the deferential pressure exceeds the collapse pressure capability. Also, frequent fluctuation on the operating pressure might cause to have a fatigue failure due to cyclic load on the liner as most of the PE liner in PDO are designed to be expanded (loose) fit.

10:50 - 11:15 a.m.
**LLRTP Applications and Challenges in Oil and Gas industry**
*Presented by Hilal Alshuhumi, Petroleum Development Oman*
Background. LLRTP was first installed in PDO in the early 2000s. With over 20 years of experience, PDO has managed the application of LLRTP across its fields through top of the class design, installation, and operation. Today, PDO uses LLRTP in applications ranging from water, hydrocarbons to sweet and sour severe services. LLRTP is a material that has proven its performance in PDO fields to be a reliable technology ensuring faster installation, reduction in life cycle cost, and enhancing project delivery.

Application envelope. Currently PDO uses LLRTP for various ranges of applications. The design envelope includes limitations such as the following:
- Highest qualified pressure: 150 Bar
- Highest qualified temperature: 85 C
- Approved Gas to Liquid ration: 300
- Highest OD: 6”
- Approved safe H2S Limit: 1000 ppm
- Approved partial pressure CO2: 10 bar

Qualifications. All approved LLRTP products have undergone a rigorous testing regime to ensure asset integrity and safety requirements are met. Tests done include but not limited to the following: STHP, 1000 Hrs, tensile strength test, Vacuum test, Hydrocarbon Permeation test, Elevated Temp End fitting test, and Collapse test.

Challenges and failures. During the 20 years experience with LLRTP, lots of challenges have raised with dealing with this materials. PDO has managed each and every challenge with different engineering solutions taking into the consideration the available tools and resources in the market. Some of the challenges faced includes the following:

1. Buried Vs not buried. Many operators across the globe, have used LLRTP on above ground condition. However, PDO have learnt from the past that the safest way to install LLRTP is to bury it underground.
2. Permeation. PDO have learned over the past decades, the liner material used in LLRTP affects the permeation rates of gases accordingly. Things that also affects permeation rate include the following: temperature, pressure, reinforcing material, and gas content.
3. CO2 transport. With the increase of CO2 capture projects across the world and in PDO, LLRTP has been identified as a potential pipeline material to transport CO2. The qualification and approval of such service is under question, and requires further study, which is currently ongoing in the company.

11:15 - 11:40 a.m.
Evaluation of the Remaining Potential of Multilayer Composite Tubular Structures Damaged in Fatigue
Presented by Ghouaoula Abd El Hamid, CHLEF University
The objective is to develop an analytical model that predicts the lifetime of multilayer tubular, these structures are made with long fibers glass and epoxy matrix. The model developed simulated the mechanical response of a cylindrical composite structure under different types of loading, pure internal pressure, tension and fatigue cyclic. Tests are done out on composite tubes, these tubes contains six layers with an angle of orientation equal to 55 °. Two types of loading in tension and in cyclic traction. The tensile tests allow us to estimate the stress rupture. The cyclic reaction test allows us to estimate the remaining potential.

11:40 - 12:05 p.m.
Nonmetallics Sustainability – Journey, Impact and Futuristic Strategy
Presented by Saud Abudaly, Saudi Aramco
The seawater treatment system's nonmetallic journey spanned a variety of equipment, diversity of nonmetallic types, and massive scale of deployment. For more nascent technologies, it implemented the first corporate deployments, leading to standard changes. The plant has also been a pioneer in innovation, with filed patents and uniquely designed engineering solutions. It expanded the pressure envelope of nonmetallic RTP material to 3,000 psi in two unique cases, marking corporate and global firsts. The plant also implemented nonmetallic HDPE lining for a 42” pipeline, the largest such deployment in the Middle East. Moreover, the plant implemented the company’s first nonmetallic Air Distribution System, as well as an unprecedented nonmetallic tank marked as the largest in-plant construction of an FRP tank. This selected list of corporate and regional firsts is only an example of markers in the journey. The nonmetallic journey has had significant benefits in operating and capital cost, asset integrity and longevity.

1:15 - 1:40 p.m.
Nonmetallic Construction Issues and Case Studies
Presented by Michael Yee, RTConsults PLLC
Nonmetallic materials use in industrial plants pertaining to piping and tanks can perform well in a corrosive environment with proper oversight. The design, fabrication, inspection, and maintenance of nonmetallic construction are important key requirements. Furthermore, the qualification of materials and testing is necessary to complement the specification and material selection for optimum performance. In addition, the paper will go into case studies and lessons learned from successful projects covering the importance of inspection and quality assurance for reliable service life.

1:40 - 2:05 p.m.
Life Extension Inspection for GRE Pipes
Presented by Said Ali, Composite Pipes Industry LLC
The literature will start with presenting the advantages of using Pipelines in transportation, then the advantages parts will be linked with the concept of (PIM) Pipe Integrity Management by showing how the correct PIM will lead to the mentioned advantages. After that a brief comparison will be made between the PIM of metallic and non-metallic pipes. Next will identify specifically about PIM for non-metallic. And will introduce this part from GRE Manufacturer perspective. Showing how the right quality for GRE pipe will help the PIM cycle with the End User. Later, will move to the life extension inspection. By referring to SP-2468 this part will be mentioned. And as a practical example a Case Study of a life extension inspection of 16” GRE pipe will be presented.
2:05 - 2:30 p.m.
Digital, Sustainable and Offsite Innovations with Plastic Piping Systems for Greener, Longer Living Assets
Presented by Riccardo Barbone, Omar Allam, and Mark Jarrett, Georg Fisher
As the use of nonmetallic materials, particularly High-Density Polyethylene (HDPE), gains prominence in the oil and gas, petrochemical, and other industries, the need for effective inspection, Non-Destructive Testing (NDT), and repair strategies becomes paramount. This abstract aims to showcase Georg Fischer (GF) Piping Systems’ pioneering role in industrial piping systems and their innovative NDT and repair technologies.

GF has developed cutting-edge solutions that leverage Artificial Intelligence (AI) and automated assessments to enhance the inspection and maintenance of HDPE piping systems. By utilizing advanced algorithms and machine learning techniques, GF’s NDT innovation streamlines the assessment process, enabling accurate and efficient identification of potential issues such as corrosion, leaks, and structural weaknesses.

Additionally, GF offers real-life solutions for piping asset management and repair, providing EPCs (Engineering, Procurement, and Construction), construction contractors, and pipeline owners with comprehensive tools to achieve best-in-class performance for Design, Build, Operate, and Maintain (DBOM) cycles. These solutions encompass state-of-the-art repair technologies, including composite repair systems and advanced adhesives, ensuring the integrity and longevity of HDPE piping systems.

By presenting GF’s NDT innovation and repair solutions at the AMPP Nonmetallics Conference 2023, this abstract aims to contribute to the ongoing dialogue on nonmetallic advancements and best practices, fostering a collaborative environment for the sustainable implementation of nonmetallic materials in combating corrosion and achieving operational excellence in various industries.

2:45 - 3:10 p.m.
Reinforced Thermosetting Resin Pipes (RTRP) Failures & Quality Control Measures Adopted during Construction of the Largest LNGi Facility in Kuwait
Presented by Faisal Al-Refai, Kuwait Integrated Petroleum Industries Company
Due to increasing energy demand and need for clean energy, Kuwait embarked on constructing one of the world’s largest LNG storage & regasification projects. Different forms of Glass Fiber Reinforced composite piping and tanks were used in the construction of the LNGi facility. These include Glass Reinforced Epoxy (GRE) for all underground firewater network and Glass fiber Reinforced Vinyl ester GRV for chemical storage tanks and process lines such as seawater and chemical dosing lines.

Throughout the construction phase of the project many issues were faced pertaining to poor lamination work at site, poor storage and handling practices, defective original material as well as revised vendor installation procedures. These incidents were resolved through rigorous field testing and vendor visits to approve new revised procedures, in addition to design modifications to mitigate stress on the subject lines.

This paper, presents the isolated and common cases of failure, recounting the troubleshooting practices followed and the verified remedial actions. Much of these cases, lessons learned, and quality control measures provide valuable tools to users of this type of piping material in the oil & gas industry. This paper also sheds lights on the shortcomings of RTRP, that are usually trumped by operational benefits.

Key Words: Reinforced Thermosetting Resin Pipes (RTRP), Glass fiber Reinforced Epoxy (GRE), Glass fiber Reinforced Vinyl ester (GRV), Ethylene Chlorotrifluoroethylene (ECTFE), Project Management Team (PMT), Engineering, Procurement, and Construction (EPC), Project Management Consultant (PMC)
3:10 - 3:35 p.m.

Review and Application of Advanced Technologies for Corrosion Monitoring of Pipelines External and Internal Corrosion under Nonmetallic Repairs

Presented by Rashed Alhajri, Aramco Services Co.

Composite nonmetallic repairs have been applied to pipelines and piping systems for structural reinforcement after external corrosion. Such repairs may consist of glass or carbon fibers embedded in a matrix of epoxy. Typically, these repairs are hand applied using either wet lay-up systems or prefabricated rolls of composite sleeve. In some applications, pipeline continued corrosion growth under composite repairs were reported using Inline Inspection (ILI) which raises a concern about the integrity of the metallic piping under composite repairs. When continued corrosion is detected by ILI, a difficulty is typically faced due to the inability to measure pipeline remaining thickness under such repairs. To resolve this challenge, this paper will discuss multiple inspection and corrosion monitoring techniques for metal loss under composite repairs and inspection of composite repairs against disbonding and delamination. To measure the pipeline wall thickness due to internal corrosion, one or more of the three (3) Nondestructive Testing (NDT) technologies: Dynamic Response Spectroscopy (DRS), Multi-skip Ultrasonic (MS-UT) and digital radiography were evaluated and found capable. To monitor for external corrosion, a scheduled visual inspection of the composite repair would be the first inspection step. If the composite repair appears to be intact then the visual inspection would suffice and the repair should be acceptable to its design life. If the original defect is external corrosion and a scheduled visual inspection of the composite repair shows damage to the composite repair, then inspection to assess the integrity of the substrate must be done before permanently fixing the composite repair. For this scenario, digital radiography or MS-UT are recommended to assess the condition of the substrate.

3:35 - 4:00 p.m.

The Vital Role of Quality in Non-metallics Materials

Presented by Yusra Al Sawayi, Petroleum Development Oman

In today’s industry, the use of non-metallic materials, such as High-Density Polyethylene (HDPE), Glass Reinforced Epoxy (GRE), and Long Length Reinforced Thermoplastic (LLRTP), has gained significant momentum due to their inherent benefits. However, ensuring the quality and reliability of these materials throughout their lifecycle presents unique challenges. These abstract highlights the critical role played by quality personnel in PDO to assure the integrity and performance of non-metallic materials.

Quality role begins with the thorough qualification of vendors through comprehensive audits and rigorous qualification testing. The role of quality continues in manufacturing and installation phases, by developing comprehensive inspection and testing plans for each material, where quality intervention levels are implemented.

PDO Quality team ensured strict controls when it comes to non-metallic materials storage, preservation, handling, and transportation, ensuring their integrity remains uncompromised.

Recognizing the significance of skilled labor, we as quality team prioritize comprehensive training for the installation crew, ensuring they possess the necessary expertise to handle non-metallic materials safely and effectively. Moreover, to ensure the competence of construction team supervisors, inspectors, and jointers, the quality team conduct rigorous technical assessments.

Our commitment to quality extends beyond initial implementation. We provide ongoing repair support for operations, minimizing downtime and enhancing overall asset performance. Furthermore, in my presentation I will showcase a compelling case study where quality played a key role in resolving a critical issue. Through failures analysis, we effectively identify the root causes of material failures and implement corrective actions based on the findings. This case study serves as evidence to the proactive and problem-solving nature of our maintained quality assurance practices. In conclusion, this abstract emphasizes the essential nature of quality assurance in ensuring the optimal performance and longevity of non-metallic materials. Our comprehensive approach, vendor audits, testing plans, documentation standardization, technical assessments, process validation, training, failures analysis, and corrective actions, establishes a robust framework that guarantees the quality and reliability of HDPE, GRE, and LLRTP.
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