PLASTIC PIPE CONFERENCE

Philadelphia, PA April 16-17, 2019

Presented by the Philadelphia SPE Section

PLASTIC PIPE IN INFRASTRUCTURE AND INDUSTRIAL APPLICATIONS

Technical Program Abstracts

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Tuesday, April 16, 2019

Materials, Testing, New Products
9:00 am

Improved Methods for Determining the Design Basis of Polyethylene Pipeline Materials
Ernest LEVER – Gas Technology Institute - USA

A New Approach for Evaluating Long-Term Performance of Plastic Pipe
Ben JAR – University of Alberta - CANADA

The Application of Material Testing, Material Models and Finite Element Methods in Probabilistic Risk Models for Plastic Piping Systems
Ernest LEVER – Gas Technology Institute - USA

Performing Root Cause Failure Analysis of PE Pipes and Fittings Prevent Their Recurrence
Perry SHETH – National Grid - USA

Practical Aspects of Large Diameter HDPE Pipe Production
Steve SANDSTRUM – Borealis - USA

12:00 Lunch Break

Qualifying a Masterbatch For Use with a Pressure Pipe Resin To Meet PE 4710 Pipe Requirements
Taha ABDULLA and White G. JEE – Sasol Chemicals North America LLC

PA11, a High-Performance Polyamide for Oil and Gas Piping Applications
Patrick DANG – Arkema - FRANCE

Non-Metallic Pipe Solutions for High Temperature High Pressure (HTHP) Applications. Recent Developments in Polyamide 12 UV Resistance for Above Ground and Buried Services along with PEEK Performance Characteristics for HTHP Applications
Akshay PONDA – Evonik Industries – USA

Coffee Break

Shaking Things Up – A New PVC Addresses Ground Shifting
Dave HUGHES – Modernizing Distribution - USA

Enhanced Orientation of PVC Pipe Using Acrylic Processing Aids
Manoj NERKAR – Dow Chemical Company - USA

Use of Fusible C900 PVC Pipe in The Potable Water Industry Alongside Ductile Iron Pipe Systems
Ed LOBELLO – Underground Solutions, Inc. – USA

Ensuring Highest Quality Pipe at Lowest Cost Per Foot by Employing Proven Innovative Technologies
Andrej UNRUH – iNOEX LLC

Networking Reception

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Wednesday, April 17, 2019

Case Studies and Histories
9:00 am

Be In The Know on Quality Pipe
Sarah PATTERSON – Plastics Pipe Institute - USA

Emergency Sewer Force Main Rehabilitation in Valley Forge National Historic Park
Jeremy BALKE – United Pipeline Systems - USA

Ductility and Durability of HDPE Pipe - A Directional Boring Case Study
Dustin LANGSTON – WL Plastics - USA

High Density Polyethylene (HDPE): An Overview of the First Ever ASME BPVC Section III, Class 3 Nuclear Piping Installation
Shane SCHUESSLER – ISCO Industries - USA

Heat Fusion Joining Procedure Qualification for Natural Gas Utilities with Polyethylene Distribution Systems
Bryan HAUGER– Bryan Hauger Consulting - USA

12:00 Lunch Break

The Three P's of High Temperature Plastic Pipe
Steve SANDSTRUM – Borealis - USA

The Use of Pe-Xa Coils in Hot and Cold Water and Condensate Systems
Kevin PRICE – PEX Industrial - CANADA

Cavitation Damage in High-Rise Piping Applications
Jim PASCHAL – Aquatherm – USA

Coffee Break

Large Diameter Pe-Xa Pipe and Its Use in Industrial Processing and Mining
Aviv SCHEINMAN – PEX Industrial - CANADA

Pipe Welding Techniques: A Closer Look at PVDF Pipe for Demanding Applications
Averie PALOVCAK– Arkema Inc. – USA

Usage of 1 Inch to 160-Inch GRP-RTR-RPM-GRE Piping Systems in Under Ground, Above Ground, On Ground, Under Sea and Jacking Applications for Pressure Classes from Gravity up to 3000 psi
Sadath KAHN– Infrastructure Engineering and Construction Company – SAUDI ARABIA

Adjournment

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Improved Methods for Determining the Design Basis of Polyethylene Pipeline Materials

Ernest Lever
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Plastic pipe installed into an infrastructure system responds to loads imparted to the pipe by undergoing constant creep. The rate at which the pipe creeps is a function of the molecular architecture of the plastic material, the rate of loading, temperature and time. In polyethylene pipe there are two modes of failure associated with this creep mechanism:

- Ductile rupture
- Slow Crack Growth

The design basis of a polyethylene material is determined by determining the stress that will cause a pipe to fail by ductile rupture at a specified time under static loading and a constant specified temperature. Under ASTM standards the design basis is arrived at by fitting a linear regression model to test data at the desired operational temperature. This model is used to calculate the stress that will cause ductile rupture of 100,000 hours. The mean (expected value) of the model is used. The regression model is validated by testing at higher temperatures to a minimum time determined by shifting the design basis stress and time to the higher temperature using Popelar shift factors. Under ISO standards a full rate process regression model is fit to test data generated at multiple temperatures and the stress that will cause ductile rupture at a specified temperature in 50 years is calculated. The lower prediction value of the model at a 97.5% single sided confidence level is used.

One would expect the rate process model approach to be coherent with shift factors arrived at through determining the activation energy associated with the creep process (Popelar shift factors are a variant of thee shift factors). However, the mathematical form of the regression models specified in the ISO approach force incoherence between the two approaches. This paper describes how to bring empirically measured shift factors into coherence with a rate process methodology. The resulting models are very useful in arriving at performance envelopes of polyethylene resins over a wide range of temperatures, potentially removing the artificial temperature restrictions on applications. Each application temperature can have the allowable stress levels calculated from the coherent regression model describing material creep behavior across a wide range of temperatures. The method could also be useful in accelerating the resin approval process through use of the independently determined shift factors together with test data generated at multiple temperatures.

A New Approach for Evaluating Long-Term Performance of Plastic Pipe

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A new approach has been developed to predict failure time of polyethylene (PE) pipe under creep loading using short-term tests. Currently, tests adopted in the new approach are used to determine critical stress for the ductile-brittle (DB) transition and to construct the master curve of applied stress versus time under creep loading. Based on studies we have conducted so far, the critical stress for DB transition can be determined in one week and the master curve of stress versus failure in about one month. For comparison, standard tests for the similar purpose, such as ASTM D2837, take more than one year to complete, but may not detect the DB transition. This paper presents the new approach using coupon specimens from PE pipes. The main test used in the new approach is named “multi-relaxation test” which is to subject single specimen to multiple relaxation stages at various deformation levels. Data analysis follows the procedure originally suggested by Hong et al. [1], to determine the critical stress and deformation levels for the DB transition. Wide-angle X-ray scattering has been used to verify the change of crystalline structure in PE when the specimen is subjected to the critical deformation level. Another test used in the new approach is creep test at elevated temperatures, to confirm the DB transition determined from the multi-relaxation test, and to construct the master curve of stress versus failure time which includes the stress and time for the DB transition. We believe that the new test approach can benefit plastic pipe industry in product evaluation and quality control, and even to provide reference at an early stage of new material development.

1. K. Hong, A. Rastogi, G. Strobl, A Model Treating Tensile Deformation of Semicrystalline Polymers: Quasi- Static Stress-Strain Relationship and Viscous Stress Determined for a Sample of Polyethylene, *Macromolecules* 37 (2004) *,* 10165-10173

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The Application of Material Testing, Material Models and Finite Element Methods in Probabilistic Risk Models for Plastic Piping Systems

Ernest Lever
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Plastic pipe installed into an infrastructure system responds to loads imparted to the pipe by undergoing constant creep. The rate at which the pipe creeps is a function of the molecular architecture of the plastic material, the rate of loading, temperature and time. In polyethylene pipe there are two modes of failure associated with this creep mechanism:

- Ductile rupture
- Slow Crack Growth

Both these failure modes can be accurately modeled using a rate process model that describes the time to failure of the pipe as a function of temperature and stress. Separate models are needed for each of the two failure modes. Typically, the stress input into the models is pipe hoop stress. However, hoop stress is never an accurate measure of localized stress due to stress risers acting on the pipe and there are large uncertainties in calculations based on hoop stress. These uncertainties can be addressed by using finite element and other methods to determine stress intensification factors associated with typical piping components. It is possible to derive parametric expressions that capture the resulting stress intensification factors due to different configurations of the categories of piping components, as laid geometry of the pipe and the rate of loading. The true stress in a component is then calculated by linear multiplication of the nominal hoop stress by the stress intensification factor. This basic methodology is very amenable to being inserted into probabilistic models that predict expected lifetime, with credible bounds, of plastic pipelines under a wide variety of service and installation conditions. These probabilistic models are very useful in assessing the risk associated with plastic pipelines in that they allow comprehensive scenario analyses that can be used to evaluate different mitigation strategies. This paper will present several use cases of the approach described above as applied to actual risk evaluation projects in polyethylene gas distribution systems.

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Performing Root Cause Failure Analysis of PE Pipes and Fittings To Prevent Their Recurrence

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Polyethylene Pipes and fittings are used extensively in operating gas distribution system safely, reliably and economically. By and large, the PE gas distribution network enjoys an excellent performance track record. Most of the infrequent failures have been attributed to the old generation of materials whose properties offered limited resilience against severe environmental and operating conditions. The purpose of this paper is to address the root cause analysis of these infrequent failures, in an effort to prevent their recurrence.

Practical Aspects of Large Diameter HDPE Pipe Production

Steve Sandstrum
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Demand for large diameter high density polyethylene (HDPE) pipe continues to grow both globally and in North America. Today's piping system designers have discovered the advantages of HDPE pipe in an ever-increasing range of applications. The sustained growth in the demand for HDPE pipe has led to continued expansion in the diameter and pressure capability of these tough, durable piping products. As a result, the industry is now offering conventionally extruded HDPE pipe in diameters up through 3500 mm (138 inches) with dimension ratios as low as DR 17 in this size range. This presentation shall discuss the practical aspects and/or challenges of conventional extrusion of HDPE in these diameters and wall thicknesses including resin and processing considerations, equipment requirements, ancillary product needs and various logistic issues. Through this discussion, the attendee will develop an in-depth understanding of the challenges that exist as the HDPE pipe industry advances into these new size ranges.

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Qualifying a Masterbatch For Use with a Pressure Pipe Resin to Meet PE 4710 Pipe Requirements

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High density polyethylene (HDPE) resins or compounds used in the production of various pressure piping system components (solid wall HDPE pipe, fabricated or injection molded fittings, composite pipe, etc.) are required to meet or exceed certain minimum long-term performance requirements as specified in many application standards. HDPE resin producers, pipe manufacturers, and additive/masterbatch producers must adhere to these standards (including but not limited to ASTM, ISO, PPI, NSF, CSA, etc.) in order to participate in the pressure pipe market. In this paper presentation, we take a deep dive into what it takes to qualify masterbatch/additive producers that will be utilized in the production of the pressure piping system components. While there are official standards, published papers and a host of knowledge in understanding HDPE pipe masterbatches, the intention of this document is to specifically outline the step-by-step process of how one could obtain qualification of a masterbatch with a specific HDPE resin for production of HDPE piping system components. This document will address when one begins the process and the tests one conducts during the qualification period. It will also highlight some potential barriers that could render a masterbatch supplier from meeting qualification requirements.

PA11, a High Performance Polyamide For Oil And Gas Piping Applications

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In industrial piping applications, the main plastic materials used are High Density Polyethylene (HDPE), Polypropylene (PP), Polyvinylchloride (PVC) and Chlorinated Polyvinylchloride (C-PVC). But for applications other than potable water, waste water, land drainage, and low-pressure natural gas distribution, there are too many weaknesses to have a safe use. That's the reason why the industry is using technical polymers like polyamides (PA) or polyvinylidene difluoride (PVDF) for their higher thermomechanical properties, and better chemical and permeation resistance to liquid hydrocarbons and gases.

The polyamide or nylon family is wide and the main properties of each product are directly linked to the monomer chain length. From the short chain PA6 to the long chain PA11 and PA12, we will review the main properties that are important for pressure pipe applications in fluids other than water.

A special focus will be made on the use of PA11 as pressure sheath for high pressure flexible pipes used in offshore oil and gas production since the 1970's. The oil and gas industry has developed a lifetime model for the use of PA11 and PA12 in offshore flexible pipes which can also be applied to high pressure natural gas distribution piping systems.

Some differences between PA11 and PA12 will be highlighted, and a comparative in-situ creep study with PE-RT will show why it is important to be cautious when considering the use of materials designed for hot water applications in hot hydrocarbon transportation pipes.

High Performance Polymers: Non-Metallic Pipe Solutions for High Temperature High Pressure (HTHP) Applications. Recent Developments in Polyamide 12 (PA12) UV Resistance for Above Ground and Buried Services Along With PEEK Performance Characteristics for HTHP Applications.

Akshay Ponda and Doug Weishaar
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The presentation will cover recent developments in PA12 materials which enhances the UV resistance of this material allowing for use in above ground applications such as line pipe, gathering lines, and produced water lines operating at high temperature and pressures. Available data will demonstrate weatherability, Hydrostatic Strength and temperature resistance for suitability for Oil and Gas installations.

Recent development surrounding PEEK material properties will be presented which addresses the need for non-metallic pipe and seal applications where required service temperatures and pressures warrant HTHP solutions.

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Shaking Up the PVC Pipe Industry- iPVC Pipe

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For many water utilities, plastic has proven to be durable and corrosion resistant material for pipe. This presentation looks at a relatively new product that modifies PVC pipe, outlining a variety of tests suggesting an evolution is continuing with PVC.

The first steps in the evolution taking place in the PVC pipe materials is seen in the thinner stronger extruded PVCO pipe. This report provides the latest development in PVC pipe, iPVC (i stands for innovation). This presentation will report on the testing of iPVC pipe for strength, stiffness, impact resistance and durability as well as provide an assessment of pipe performance during installation. The pipe researched demonstrated a pipe that survived 4 million cycles of high surging pressures, 100-pound weights dropped from 12 feet, 1500 psi of applied pressure with only 5% shape change. As part of a Water Research Foundation funded project, American Water has both tested and installed this pipe to evaluate it for long term use.

The presentation will suggest that iPVC provides a new balance between strength, corrosion resistance and ductility that will meet environmental conditions found today and avoids the complications of composite materials. Installation evaluation included placement in streets, cutting, tapping, compatibility with fittings, ease of handling etc.

Additional testing has taken place at Cornell University to simulate stresses on pipe to mimic earthquake stresses including actions like sliding soil, bending, compressing and tensioning pipe. A variety of manufacturers have used these tests to show how resilient their products are under seismic stress and potentially devise more seismic tolerant pipe systems.

This analysis should be instructive to many utilities in non-seismic regions where other causes of shifting soil can occur. Erosion, changes in soil moisture (especially in clay soils) and freeze thaw cycles are examples of movement experienced in many places.

Enhanced Orientation of PVC Pipe Using Acrylic Processing Aids

Manoj Nerkar, John Cornetta, Ted Price, Steve Rapacki, Ian Drake, Ramesh Iyer
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Molecular orientation of PVC pipe via biaxial orientation (in hoop and axial direction) leads to superior mechanical performance in addition to reduced pipe thickness. The present study is focused on the fundamental understanding of pipe orientation. Key mechanical properties of PVC compound as a function of strain rate and temperature are discussed in details. It was demonstrated that the maximum engineering strain of PVC compound can be obtained at 100°C. Furthermore, a lab scale set up was developed to orient pipe and to generate critical data. The set up was used to evaluate lubricity between the expanding pipe and a mandrel. The rate of orientation was simulated using strain rate data generated on a universal tensile machine. The maximum strain was measured at various temperatures and pulling rates. It was observed that as the pulling rate was increased, the maximum strain decreased. However, the strain at higher pulling rates was increased by using acrylic processing aids. Acrylic processing aids can be synthesized to produce high molecular weight polymer chains which function to entangle with shorter chain PVC to modify its rheology. This special acrylic processing aid developed for PVC-O pipes improves melt strength of the compound and provides the right balance of elasticity and viscosity to enable orientation of the pipe over the mandrel without rupture at higher speeds. Mathematical modeling was used to calculate strain during the orientation process. Biaxial orientating was also analyzed to validate improvement in performance as a result of orientation.

Use of Fusible C900 PVC pipe in the Potable Water Industry Alongside Ductile Iron Pipe Systems

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The purpose of this paper is to discuss the use of Fusible C900 PVC in combination with a metallic (ductile iron pipe - DIP) municipal water system. While DIP is commonly used in municipal water and sewer applications, there are challenges related to the use of DIP in trenchless applications. FPVC is a common choice of pipe material in trenchless applications. This paper will discuss advantages of the use of FPVC in trenchless applications in conjunction with DIP. This discussion will include examination of cost, constructability, life cycle, and design.

Ensuring Highest Quality Pipe at Lowest Cost Per Foot

by Employing Proven Innovative Technologies

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Demands for production efficiency and product quality continue to tighten for pipe producers, and process monitoring and control system continue to evolve to give market leaders the tools they need to ensure they achieve the most rigorous quality requirements while at the same minimizing the material usage. Continuous improvements of established technologies as well as game changing new innovations provide viable solutions to help pipe producers attain a competitive advantage in this highly competitive market. This paper will provide an overview of technologies that can help pipe producers ensure dimensional specifications are met using minimal raw materials.

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Be in the Know on Quality Pipe

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With the introduction of modern materials into the North American pressure pipe applications, the plastics industry established a foundation for quality. Over the years, the work developed into a robust “quality infrastructure” that continues contributing to the confidence of plastic pipe systems. While built upon the two “foundational” materials (PVC and PE), today’s quality infrastructure comprises many materials as well as ingredients. The Plastics Pipe Institute’s Hydrostatic Stress Board (PPI HSB) is an element of this quality infrastructure since the early days, originating in 1958. Comprised of nearly 25 industry experts representing the major thermoplastic pipe materials, the PPI HSB continues to apply their knowledge and expertise, in harmony with the plastic pipe industry, to address various critical issues such as the rigorous demonstration of long-term strength. Further, manufacturers and industry organizations actively participate by establishing standards and expectations for quality at all levels. Although Board members skill sets differ, each work in a collaborative manner to contribute to the confidence and reliability of plastic pipe systems.

This presentation shares aspects of the historical foundation and provides an overview of the concert of activities in one of the most sophisticated global quality infrastructures. Manufacturers, installers, specifiers and users need to know, understand and expect active participation. In this way, they also promote the responsible manufacture, installation, design and use of plastic pipes. This in turn, positively impacts the quality of life for current and future generations.

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Emergency Sewer Force Main Rehabilitation in Valley Forge National Historic Park

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Tredyffrin Township faced three catastrophic failures of a 30-inch prestressed concrete cylinder pipe (PCCP), the Wilson Road Sewage Force Main, between 2012 and 2014. The first failure resulted in a wastewater spill to Valley Creek. Second and third failures occurred just 42 days apart in the spring of 2014. Tredyffrin proactively entered into a voluntary consent decree to ensure a solution was reached in a timely manner given the complex stakeholder environment and threat of legal action from environmental groups.

Assessment of the 18,000-ft. force main determined that external corrosion had degraded the strength of the wire inside the 30-inch PCCP, rendering the pipeline unable to handle the system's operating pressure. Working with the engineer CH2M on the project, the method of repair chosen was a thermoplastic close-fit lining system known commercially as Tite Liner®. The system is a high-density polyethylene liner that can provide a fully-structural solution when pulled into place inside the existing pipeline. The Tite Liner® system was engineered and custom made to be slightly larger than the host pipe and installed utilizing a proprietary roller compression system.

United Pipeline Systems’ (United) installation method helped minimize disruption and expand system capacity within the Park’s limited jobsite footprint, while also offering low material costs and long installation sections. The lining portion of the project was completed over 3 months in 31 separate installations – on time and on budget – with zero safety incidents or wetlands impacts. This paper will highlight the rehabilitation method selection, project planning and installation.

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Ductility and Durability of High Density Polyethylene Pipe

Dustin Langston
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In 2015 a ground breaking project was completed by King county Washington to keep contaminated water out of the Puget Sound. The project was a land mark directional drill that anyone would have been proud of. This project was called the Magnolia Wet Weather Facility and its great accomplishment was soon dwarfed by its quick and utter failure.

The original project in 2015 was a horizontal direction drill of 32" FPVC pipe over 3000 feet long at depths greater than 160ft. The pipeline failed within a year of installation and the pipeline quickly clogged with sand and debris through the crack side wall blow out. The city of Seattle scrambler to come up with a fix. They decided to pipe burst the failed FPVC pipe using 30" HDPE pipe. This presentation will go over the design and installation of that pipeline and the reasons why HDPE pipe is the number one pipe for trenchless applications.

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High Density Polyethylene (HDPE): An Overview of the First Ever ASME BPVC Section III, Class 3 Nuclear Piping Installation.

Shane Schuessler
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Buried HDPE piping systems have been installed for decades in critical industrial applications such as cooling water and firewater. This paper will discuss the installation of HDPE piping materials for an ASME Class 3 piping systems at the Emirates Nuclear Energy Corporation's (ENEC) Barakah Nuclear Power Plant near Abu Dhabi, U.A.E.

Global nuclear power plants have relied on buried metallic piping systems since the first commercial plants built in the 1950's. Corrosion, leaks, and expensive replacement has been the eminent path for many of these metallic piping systems. In the late 2000's, several nuclear power plant owners decided to alter the buried pipe paradigm by considering plastic pipe to reduce piping material and installation costs while ensuring safety and performance for the operating life of the plants. Since the HDPE piping systems would be installed in nuclear safety-related systems, the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC) formed committees to develop rules for installing high-density polyethylene (HDPE) pipe in ASME BPVC Section III (new build) and Section XI (repair/replacement) Class 3 piping systems.

Three nuclear power plants have used HDPE in ASME Class 3 piping systems where the most recent project took place at the Emirates Nuclear Energy Corporation's Barakah Nuclear Power Plant located in the United Arab Emirates. This paper will provide an overview of the procurement requirements and installation for this project's Essential Service Water Discharge system consisting of 21,000 feet of 36-inch HDPE pipe.

The paper will conclude with a brief synopsis of the evolution of HDPE pipe within the ASME Boiler & Pressure Vessel Code, which now provides nuclear power plant owners around the world with a clear path to installing safety-related HDPE piping systems.

Heat Fusion Joining Procedure Qualification for Natural Gas Utilities with Polyethylene Distribution Systems

Bryan Hauger
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Natural gas distribution companies are required to comply with many sections of Federal Law relating to construction of plastic piping systems including the use of qualified joining procedures. If a distribution operation intends to change their joining procedure, 49 CFR 192.283 requires that they make specimen joints according to their procedures and subject those joints to testing in order to qualify their procedure. The testing requirements are described in detail in the federal code using regulatory language. However, the requirements include many references to ASTM test methods which may be unfamiliar to operators. This presentation intends to present the same testing requirements in a format that is more easily understood. The testing requirements for several different types of fittings will be discussed including socket joining, butt fusion joining, conventional saddle joining, electrofusion saddle joining and electrofusion joining using couplers. Photographic examples will be used illustrate the testing procedures to assist the audience in understanding this important topic.

The Three P's of High Temperature Plastic Pipe

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This discussion provides a basic overview of the three "P's" of high temperature plastic pipe, PEX (cross-linked PE), PE-RT (polyethylene raised temperature) and PP-RCT (polypropylene random copolymer with modified crystallinity and raised temperature resistance). While each of these piping materials and its role in expanding the operational window for thermoplastic piping systems will be explored, particular focus will be given the evolutionary trend that is occurring in the transition from PP-R to PP-RCT. The fundamental material properties and performance capabilities of PP-RCT (the most recent entrant into the higher temperature plastic piping arena) will be presented. This presentation should provide a clear indication of how these materials complement each other and how together they can be effectively utilized to meet the growing demand for thermoplastic piping in higher temperature applications.

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The Use of Pe-Xa Coils in Hot and Cold Water and Condensate Systems

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With increasing attention to the reliability of piping systems, especially where the number of connections is high, the option of long length coils is appealing to more and more owners and contractors, as it reduces the risk of fitting failure and the time of installation. With coils of pipes up to 10 inches diameter at 600 ft., it is an option to consider when distances are involved or running a line through a high-risk area. The option to quickly insulate a coiled pipe brings another level of system improvement for system owners.

Cavitation Damage to Polypropylene Piping in a High-Rise Piping Applications

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This paper discusses cavitation damage that is sometimes encountered in piping systems installed in high-rise commercial buildings. While cavitation is readily encountered and understood in pump impellers, the mechanisms which can lead to cavitation in high-rise piping are less well understood. The conditions for cavitation to occur in these systems, including surge pressures, high temperatures, and entrapped air, and how these conditions can be inadvertently created in the system are described. A computation fluid dynamics (CFD) model was created to confirm the initial conditions, and subsequent benefits of slight changes in system operation and maintenance to reduce the likelihood of cavitation.

While cavitation damage itself is not normally sufficient to cause pipe failure, the damage zone can greatly affect the pipe material locally, making it more susceptible to localized corrosion for metal pipe, and oxidative degradation for plastic piping.

A case study will be presented where cavitation damage was found to initiate cracks and promote local oxidative degradation of polypropylene piping used in a chlorinated hot water distribution system. In this case, the system had been operating for approximately 5 years. Most of the piping did not exhibit any mechanical damage or oxidative degradation, but specific portions showed severe cavitation wear, crack initiation, subsequent oxidative degradation and final through-wall cracking.

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Large Diameter Pe-Xa and their use in Industrial Processing and Mining

Aviv Scheinman
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In Mineral Processing and industrial processing in general, expensive metallic alloys dominate the piping material selection – this is especially true when elevated temperature are involved.

There are some reasons for this discrimination:

1. Historical Use of alloys is a common practice and a safer choice of materials (the Devil You know).
2. Available pipe material that can handle operation conditions and pipe sizing and the historical track record
3. Bad experience with plastics that resulted in unpredicted critical failure leading to production downtime or even safety considerations
4. A misunderstanding of plastics in general and how design differs from steel

For the last 34 years, Pe-Xa pipe material is being used in processes of continuous temperatures of over 230f, replacing a variety of alloys in high chloride elevated temperatures environment.

In this presentation, we intend to showcase studies and explore the added value to Industries in transitioning to plastics in general and Pe-Xa specifically, and address the knowledge gap the exists in this segment.

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Pipe Welding Techniques: A Closer Look at PVDF Pipe for Demanding Applications

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Since its commercialization in the late 1950s, PVDF has been used across a variety of industries such as chemical processing, semiconductor, pharmaceutical, oil and gas, food and beverage, and water treatment amongst others. As a member of the fluoropolymer family, PVDF has a reputation for success in demanding environments. The strongest of all of the fluoropolymers, PVDF also has a UL® RTI rating of 150°C. Combined with its excellent mechanical properties and elevated temperature performance, PVDF also has robust chemical resistance, excellent barrier/permeation properties, while being easily processable and weldable. Since PVDF is used in many different industries and application, this fluoropolymer is compliant with most industry standards.

This paper will demonstrate the use of PVDF piping in a variety of applications by highlighting the innate material properties and examining case histories. Furthermore, there will be a heavy focus on joining and welding methods including the following: bead/crevice free, mechanical, electrofusion, sanitary, threading, butt fusion, socket fusion, and flanging. Each of these joining methods have an important role in maintaining the integrity of the piping system and ensuring the critical fluids are contained properly and efficiently. Discussing the preferred welding method depending on the industry and containment media will also be a topic of this paper.

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PLASTIC PIPE IN INFRASTRUCTURE AND INDUSTRIAL APPLICATIONS

Usage of 1 to 160-inch GRP-RTR-RPM-GRE Piping Systems in Under Ground, Above Ground, On Ground, Under Sea and Jacking Applications for Pressure Classes from Gravity up to 3000 PSI

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Glass Reinforced Plastics, commonly known by various standards, as Fiber Reinforced Plastics (FRP), GRP, Glass Fiber Reinforced Plastic (GFRP), Reinforced Plastic Mortar Pipe (RPMP) or Reinforced Thermoset Resin Plastic (RTRP) is an amalgamation of resin, glass fiber, manufactured using appropriate additives and treatment methods. It is a composite engineering material uniquely capable of meeting a wide variety of specific processes and end product requirements of various applications of fluid transport requirements. It has a combinations of properties generally not found in any other traditional or conventional material, these include exceptionally high strength to weight ratio (have low thicknesses and high mechanical properties-with stands high pressures), superior corrosion resistance (no scaling and no buildup), maintenance free, higher hydraulic efficiency (smaller sizes), light weight (lower transportation and installation costs), higher resistance to surge pressure (more safer under worst conditions due to its low modulus of elasticity), best joining systems, excellent work-ability and design flexibility's. Thus allowing GRP piping to be used for high pressures and in very tough and rough conditions.

Considering the necessity, which arises due to corrosive soils called 'sabkha' and corrosive environments prevailing in Middle East, because of its proximity to Arabian Sea and Red Sea Gulfs coupled with arid regions, the traditional material resulted in faster degradations and this lead to increasing usage of non metallics. Boom in Oil and Gas also accelerated the use of Non Metallics in this part of the world since seventies.

This paper discuss various usage of GRP piping systems for Water, Chemical, Oil and Gas Industries from inception. GRP piping systems were structurally employed in *Above Ground, On Ground, Under Ground, Jacking, above the sea, In the Sea, On the Sea Bed and Under the Sea Bed.* Based on the need, the largest diameter evolved is of 4000 mm (160 Inch) diameter and maximum possible pressure reached for nonmetallic GRP piping system is 3000 Psi (200 Bars). These applications will be summarized with different prevailing standards used will also be discussed in this paper.