MORE THAN 350 ATTENDEES
FROM 30 COUNTRIES EXPECTED

PLASTIC PIPES CONFERENCE ASSOCIATION

LAS VEGAS PLASTIC PIPES XIX

Conference and Exhibition

LAS VEGAS, NEVADA

Red Rock Resort

September 24–26, 2018

ABSTRACT BOOK

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CONTENTS

Welcome

On behalf of the Plastic Pipes Conference Association (PPCA) and the Organizing Committee (OC), welcome to Plastic Pipes XIX. For this conference, we visit the conference capital of the USA - Las Vegas, Nevada at the lovely Red Rock Resort & Spa, located 25-minutes to the north of the city. The surrounding Red Rock Canyons provide a majestic background for the resort and the downtown Summerlin area.

The excitement for PPXIX is unprecedented. New records were achieved with the exhibition closing 2-months before the conference, having 3 companies on the exhibition wait list and 22 sponsors. This unparalleled interest in PPXIX, indicates the growing use of plastic pipe around the world. Freedonia reports an expected "6.7 percent annual world demand through 2019 to 63.3 billion-feet (19.3 Bn-meters)[1]". Another reports the "global market for plastic pipes is estimated to account for about US $30 billion by the end of 2017 and register a compound annual growth rate (CAGR) of 5.5% during the forecast period (2016–2024) to reach a market value of around US $44 billion by 2024 end[2]." Overall, the news is quite positive for the industry.

The nearly 100 technical papers, representing 20 countries, reflect the breadth of plastic pipe systems and applications. From solid wall pipe to composite structures comprising polyethylene (PE), poly vinyl chloride (PVC), crosslinked PE (PEX), chlorinated PVC (CPVC), polypropylene (PP), oriented PVC (PVC-O) and polyamide (PA); barrier, corrugated, reinforced, spiral wound pipe and others. Further, presentations will detail research and new technologies on equipment, testing, ingredients, chambers, fittings, lifetime, case studies, standards, sustainability as well as research specific to gas and water applications.

The PPXIX exhibition compliments the conference as a key networking forum. The 34-exhibitors are keen to connect, discuss and provide unique solutions. Be prepared to carry discussions forward or start others during the Welcome Reception, Gala Dinner, lunches and coffee breaks to maximize knowledge exchanges and conversations. Every minute of the conference is an opportunity to learn, connect and propel initiatives forward.

A heart-felt thank you to the authors, presenters, PPXIX Organizing Committee members and the conference management services, Evacon Ltd. The success of this conference is because of your hard work, efforts and dedication. Further, special mentions to the many PPXIX sponsors and exhibitors. Your support is truly appreciated. As a non-profit organization, the PPCA conference proceeds supplement the next main PPCA conference as well as two spin-off conferences. Remember to attend the closing ceremony to discover these three future locations.

In closing, I am honored to have filled the PPXIX OC Chair position. This conference is not only the prestigious event in our industry but is also quite important. The PPCA conferences are the forums where we continue to pursue our passions on all aspects related to plastic pipe systems. And although we represent different positions in the value chain and materials or structures, in the end – we are the plastics pipe industry – we are One Voice.

Sincerely,

Sarah Patterson
PPXIX OC Chair
PPI Technical Director

1 https://www.freedoniagroup.com/World-Plastic-Pipe.html

2 https://www.persistencemarketresearch.com/market-research/plastic-pipes-market.asp

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PLASTIC PIPES CONFERENCE ASSOCIATION

10 Homefieldway
EARLS Colne Colchester Essex CO6
2SP, UK
Name of contact person: **Tony Radoszewski,**
Chairman of the Board of Directors
E-mail: tonyr@plasticpipe.org

The Plastic Pipes Conference Association (PPCA) was formed to organize and run the series of Plastic Pipes Conferences on behalf of the international plastics pipes industry. The PPCA Board of Directors include Chairman, Tony Radoszewski (Plastics Pipe Institute, www.plasticpipe.org); Vice Chairman, Adolf Seidl (Inovyn, https://www.inovyn.com); Treasurer, Tony Calton (The European Plastic Pipe and Fittings Association (TEPPFA), www.teppfa.com); Secretariat, Hans Pierik (PE100+ Association, " https://www.pe100plus.com); all are voting members.

In addition, Sarah Patterson (PPXIX Chair) and Zoran Davidovski (PPXIX Co-Chair) serve on the board as non-voting members.

"PPCA is a global association dedicated to the ongoing creation and distribution of technical and application information on plastic pipes systems in order to educate and expand their safe, cost effective and sustainable use."

PLASTICS PIPE INSTITUTE

105 Decker Court, Suite 825, Irving, TX 75062 U.S.A.
Phone: 1-469-499-1044
E-mail: info@plasticpipe.org
www.plasticpipe.org
Contact person: **Tony Radoszewski,** President

The Plastics Pipe Institute Inc. (PPI) is the major trade association in North America representing all segments of the plastics pipe industry. PPI members share a common interest in broadening awareness and creating opportunities that expand market share and extend the use of plastics pipe in all its many applications. As an association, PPI focuses collaborative efforts to accumulate data, concentrate facts and target resources toward advancements in applications and increases in widespread usage. Members include pipe manufacturers, resin and additives suppliers, machinery manufacturers, distributors and testing and standards organizations.

PPI MEMBERS

MANUFACTURING MEMBERS

Additives Plastics Group
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Muehlstein
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NOV Fiber Glass Systems
Nova Chemicals
NUPI Americas
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Oregon Plastic Tubing
Orion Engineered Carbons
Osterman & Company
Pacific Corrugated Pipe
Performance Pipe
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Philmac
Pipeline Plastics, LLC
Plasson USA
Plastics Color Corporation
Policonductos, S.A. DE C.V.
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PolyOne Corp
Press-Seal Corporation
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Southeast Culvert, Inc.
Southwire
Springfield Plastic Inc.
Strongbridge-Tega
TDR
Teel Plastics
Timewell Drainage Products
Trademark Plastics Corporation
Trelleborg AB
Unicor North America
United Poly Systems, LLC
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Uponor Infra Ltd.
Uponor, Inc.
VALTIC SA DE CV
Versaprofiles Products Inc.
Victaulic
Viega LLC
Watts Water Technologies
Widos Welding, LLC
WL Plastics Corp
Wolseley Industrial Group
WRW Westfalische Rohrwerke GmbH
Zurn PEX, Inc.

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Crossroads Engineering Services
CSA Group
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International Code Council
International Ground Source Heat Pump Association
Microbac Laboratories
NSF International
Plastic Pipe Associates-LLC
PSILab, Inc.
TRI Environmental
UL LLC

INDIVIDUAL CONSULTANTS

Abraham Murra Consulting
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Professional Code Consulting, LLC

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THE PE100+ ASSOCIATION

Phone: +31 6 4642 5438
E-mail: contact@pe100plus.com
www.pe100plus.com
Contact person: **Hans Pierik**

Founded in 1999, PE100+ Association is a global industry organization made of several leading PE manufacturers (today 10) whose objective is to promote consistent quality at the highest level in the production and the use of polyethylene for PE100 pipes.

Safety and quality play critical role in pressure pipe applications. PE100+ Association monitors and regularly tests the most critical properties of PE100 member materials against enhanced industry requirements. This way, PE100+ Association is able to issue a "PE100+ Association Quality Materials List" on a regular basis.

PE100+ Association supports the plastic pipe industry by developing tools and sharing technical guidance for pipe design and installation, such as the PE Pipe manual, PACE+ Design tool and No-Dig technical guide for trenchless installation.

PE100+ ASSOCIATION MEMBER COMPANIES

Borealis, Borouge, INEOS O&P, IRPC, LyondellBasell, PetroChina Dushanzi Petrochemical Company, Prime Polymer, SABIC, SCG & Thai Polyethylene, Sinopec, and Tasnee.

TEPPFA – THE EUROPEAN PLASTIC PIPES AND FITTINGS ASSOCIATION

TEPPFA aisbl
Avenue de Cortenbergh 71
B - 1000 Brussels, Belgium
Phone : +32 2 736 2406
E-mail: info@teppfa.eu
www.teppfa.eu
Contact person: **Ludo Debever**

TEPPFA, founded in 1991, is the European Plastic Pipes and Fittings Association, consisting of 15 national associations together with 10 companies manufacturing plastic pipe systems across Europe.

Our mission is to:

- Welcomes European plastic pipe system manufacturers whose products comply with quality and sustainability standards.
- Supports and promotes strong National Associations who in turn strengthen TEPPFA.
- Takes leadership in the public understanding of the benefits of plastic pipe systems.
- Promotes usage of all plastic pipe systems in the building, civils and utility sectors and defends its products when challenged by alternative materials.
- Takes initiatives and coordinates on environmental issues and studies to defend and promote plastic pipe applications .
- Collects and analysis eco and sustainability information on his products in comparison with other materials.
- Complies with the principles and agreements of the Voluntary Commitment as a responsible association within society.

TEPPFA is the voice of the plastic pipes and fittings industry at EU level and actively contributes to the development of European policies.

MEMBERSHIP LIST

NATIONAL ASSOCIATION MEMBERS

ASETUB – Asociación Española de Fabricantes de Tubos y Accesorios Plásticos
Please visit us at: www.asetub.es

BPF – Plastic Pipes Group
Please visit us at:
www.plasticpipesgroup.com

BureauLeiding – Dutch Plastic Pipes Association
Please visit us at: www.bureauleiding.nl

Czech Republic – Czech Republic plastic pipes association
Please visit us at: www.adpp.cz

DPF – Danish Plastics Federation
Please visit us at: www.plast.dk

Essenscia – Belgian Federation for Chemistry and Life Sciences industries
Please visit us at: www.essenscia.be

FCIO – Fachverband der Chemischen Industrie Österreich
Please visit us at: www.fcio.at

FIPIF – Finnish Plastics Industries Federation
Please visit us at : www.plastics.fi/eng/

KRV – Kunstoffrohrverband e.V.- Fachverband der Kunstoffrohr-Industrie
Please visit us at: www.krv.de

MMSZ – MCSSZ – Műanyag – Csőgyártók Szövetsége
Please visit us at: www.appm.hu

PRIK – Polish Association of Pipes and Fittings Producers
Please visit us at: www.prik.pl

STR – Syndicat des Tubes et Raccords
Please visit us at: www.str-pvc.org

Swedish Plastics and Chemical Federation
Please visit us at: www.plastkemiforetagen.se

VKR – Verband Kunststoffrohre und Rohrleitungsteile
Please visit us at: www.vkr.ch

Unionplast/Federazione Gomma Plastica – Pipes Sector Group
Please visit us at: www.federazionegommaplastica.it

COMPANY MEMBERS

Aliaxis
DYKA
Geberit
Georg Fischer Piping Systems
Pipelife International
Polypipe
Radius Systems
Rehau
Tessenderlo Group
Uponor
Wavin

ASSOCIATED MEMBERS

Borealis Group
LyondellBasell
Lubrizol
Molecor
Vynova-Group

SUPPORTING MEMBER

Rollepaal

CHAIR OF THE ORGANIZING COMMITTEE

Sarah Patterson holds a Bachelor of Science degree in Chemical Engineering from Kansas State University. In 2000, she started her career with The Dow Chemical Company as a run-plant engineer in production. In 2006, Sarah transitioned to the Polyethylene Pipe Technical Service and Development Group (TS&D). As a TS&D Research Scientist, her responsibilities included development of technologies and new business developments for non-pressure and pressure pipe applications. In 2013, Sarah became the Technical Director of the Plastics Pipe Institute (PPI) and Chairman of the PPI Hydrostatic Stress Board (PPI HSB). PPI is a major trade association representing all segments of the plastics piping industry.

CO-CHAIR OF THE ORGANIZING COMMITTEE/ TECHNICAL PROGRAM CHAIR

Zoran Davidovski – Pipelife International
Zoran Davidovski is the Vice President for Marketing & Innovation of the Pipelife International in charge of Corporate RD & CSR and member of the Management Committee.
Zoran has a master degree in mechanical engineering from the University of Zagreb, Croatia. He started as an engineer in Jedinstvo, Zagreb in 1989, were he was two years and then moved on to be a consultant for process improvements in Improd Limited and after started his own consultancy company ZIN d.o.o. In 1993, he became the production manager at EATON and later the plant manager of their production facility in Zagreb. In 1998, he became the General manager of the Pipelife factory in Croatia and in 2001 took over his current position.
Zoran has been working in the plastic industry for the last 20 years and represents Pipelife in Teppfa where he is the chairman of WG HSE, and a member of WG Civils, Utilities and Communication. He has been the chairman of the Plastic Pipes conference PPXIV, PPXVI and PPXVIII.
Zoran is from Croatia. He and his wife Bojana have been together for nearly 30 years and have 3 sons and live in Hinterbrühl, Austria.

CO-CHAIR, EXHIBITION

Steve Sandstrum has over 30 years of direct involvement in the global HDPE pipe and resin industry. He is currently Business Development Manager – Pipe, NA for Borealis. Steve's previous professional experience includes private consulting as owner of Sandstrum Consulting Services, LLC and various sales/marketing, technical, product development and management positions with Agru America, Inc., ISCO Industries, McElroy Manufacturing, BP-Solvay Polymers, Solvay Polymers and Phillips Driscopipe.
Steve has served the industry in numerous leadership capacities including PPI Chairman of the Board of Directors and President of the Plastic Pipe and Fitting Association. He has served on the Board of Directors for ASTM International and is currently an officer of ASTM F17 Committee on Plastic Pipes. He is a member of the Hydrostatic Stress Board of PPI, AWWA, AGA-PMC and NSPE. Steve has published numerous papers relating to HDPE and PP pipe, HDPE and PP pipe resins and thermoplastic pipe performance.

ORGANIZING COMMITTEE

MEMBERS

Rainer Grasmuck	**Baerlocher**
Norbert Jansen	**Borealis AG**
Dr. Suleyman Deveci	**Borouge Pte. Ltd.**
Wang Zhanjie	**China Plastics Piping Association** (CPPA)
Mike Plumier	**Crossroads Engineering**
Dane Chang	**The Dow Chemical Company**
Vincent Stone	**The European Council of Vinyl Manufacturers** (ECVM)
Hiroyuki Nishimura	**Kyoto Institute of Technology**
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Randy Knapp	**Plastics Pipe Institute**
Lance MacNevin	**Plastics Pipe Institute**
Hans Pierik	**SABIC**
Jan Venter	**Southern African Plastic Pipe Manufacturers Association** (SAPPMA)
Joel Martell	**Southwest Gas**
Ludo Debever	**The European Plastic Pipes & Fittings Association** (TEPPFA)
Peter Sejersen	**The European Plastic Pipes & Fittings Association** (TEPPFA)
Mark Heathcote	**The Plastics Industry Pipe Association of Australia** (PIPA)
Bruce Hollands	**Uni-Bell PVC Pipe Association**
Haemi Pollett	**Uponor**

EVENT ORGANIZER COMPANY:

EVACON Conference Management and Consulting Ltd.

evaCON CONFERENCE MANAGEMENT AND CONSULTING LTD.

GENERAL INFORMATION

CONFERENCE VENUE

Red Rock Hotel, 11011 West Charleston Blvd. Las Vegas, NV 89135, USA
http://www.redrock.sclv.com
Conveniently located on 70 acres of land at the gateway to Red Rock Canyon and just 10 miles west of the Las Vegas Strip, in downtown Summerlin on Charleston Boulevard Red Rock Casino Resort & Spa is just a 20-minute drive from McCarran International Airport. It is the best location in Las Vegas and right in the heart of the PPXIX conference. Inspired by the natural beauty of the neighboring mountains, Red Rock Casino Resort & Spa pays homage to the elegant mid-century modern resorts that made Las Vegas famous. The design is classic, cool Las Vegas, reinvented for the 21st century.

PAPER PRESENTATIONS

The Conference opens Monday, September 24, 2018 at 9:30 a.m. with an opening ceremony and welcome messages. It will be followed by the technical sessions A and B taking place concurrently on Monday, Tuesday and Wednesday. On Wednesday afternoon the 5-minute poster session and conference closing will take place.
All sessions will take place at the conference level of the Red Rock Hotel.

POSTER PRESENTATIONS

Posters will be displayed in conference level, foyer. The posters should be mounted on the numbered bulletin boards from 2:00 p.m.–7:00 p.m. Sunday 23 and 7:30 a.m.–9:00 a.m. Monday, 24 September 2018. if you need assistance, please contact the registration desk.

INFORMATION BOARD, MESSAGES

There will be a Message Board for official notes of the conference and program next to the Registration and information desk. please, check the board daily and use it for important messages.

CONFERENCE MOBILE APP

The PPXIX conference is supported by the Attendify mobile app. Using the application is free for all registered participants. The content is only accessible by the PPXIX participants. To register in the PPXIX mobile app, follow the below instructions:

1. Download the “Attendify” app from the App Store or Google Play.

2. Open the app and sign-up by tapping the corresponding button at the top or bottom of the page or log in if your profile already exists in the system. To create a new account, it is recommended to use the same email address entered when registering for the PPXIX conference.

3. Search for the event name “Plastic Pipes XIX. Conference” or use the event code provided by the PPXIX management services company, Evacon.

4. To view your personal list of events, view the home screen of the Attendify App under "Your Events" section or open the list of all events, you registered for, from the side menu.

5. On the "event card", the event's date, location, and description are shown. Tap "join" to access the event, see the full, up-to-date information and start interacting with other users.

6. If you received the error message saying "Private Event" when joining, access to it is restricted. In this case, please reach out to Evacon for additional information.

After completing the above registration steps, you are now ready to use the PPXIX mobile app! With the Attendify App, access to all topics and speakers, selections of the sessions are possible. There is even an option to make a personal conference diary!

PPXIX Mobil app users can also connect with the PPXIX sponsors, exhibitors and participants by using the in-app messaging is possible. Furthermore, conference organizers may push important messages to all Attendify users. This could include program changes, reminders on upcoming events and more!

If there are questions at any time, Evacon is ready to assist. Just stop by the conference registration desk to have your questions addressed.

SPEAKERS

All presenter must check day prior to their session to be sure their presentation is uploaded on the room laptop where the presentation will be held. Speakers should check-in with the session moderator prior to the start of the session. Speakers will have a total 20 minutes for presentation and questions. This timing will strictly have adhered to.

EXHIBITS

A technical exhibition will accompany the conference where new developments of product design, manufacture, maintenance, evaluation and testing will be introduced. The exhibition will take place in Charleston Ballroom at the conference level. Coffee breaks and lunches will be served there, and also in the foyer of the Charleston Ballroom.

OPENING HOURS OF THE EXHIBITION

Monday, September 24 - 8:30 a.m.–5:30 p.m.

Tuesday, September 25 - 8:00 a.m.–5:30 p.m.

Wednesday, September 26 - 8:00 a.m.–5:00 p.m.

GENERAL INFORMATION

REGISTRATION AND INFORMATION DESK

All participants must check in at the PPXIX Conference Registration desk to receive their badge and conference materials. Registration desk will be located in the main hall of the Conference level in Red Rock Hotel, 5th Floor and will be open:

Sunday, September 23, 2018 – 2:00 p.m.–7:00 p.m.

Monday, September 24, 2018 – 8:00 a.m.–5:30 p.m.

Tuesday, September 25, 2018 – 8:00 a.m.–5:30 p.m.

Wednesday, September 26, 2018 – 8:00 a.m.–5:00 p.m.

On-site registration and on-site payment will be available on spot.

BADGE

The conference badge entitles you to take part in the scientific programs and social events therefore you are kindly requested to wear your badges throughout the duration of the conference including meal times, welcome reception and the gala dinner as well.

ACCOMPANYING PERSONS

Registered accompanying persons are invited to the Monday evening Welcome Reception and the Tuesday evening Cocktail Reception and Gala Dinner.

COFFEE BREAKS AND LUNCHES

Coffee breaks and lunches will be served at the Conference level in the exhibition area and in the foyer.

INTERNET ACCESS

The internet is free for the participants.

SOCIAL PROGRAMS

WELCOME RECEPTION

On Monday, September 24, 2018 at 7.30 p.m. we will kick off the XIX. Plastic Pipes Conference with a Welcome Reception at the at The Terrace, Omnia Nightclub, Las Vegas. Open to all registered attendees and registered accompanying persons.

Wristbands (not the USB stick) are required. Evacon will distribute to those entering the buses. If you are securing your own transportation, consult Evacon staff at the registration desk. All attendees must be 21+ years of age with proper photo ID. Passports are required for International guests.

Transport will be provided from the conference venue (Red Rock Resort) to the site of the Welcome Reception and then back to Red Rock Resort at 10:00 p.m.
Buses depart at 6:30 p.m. from the Red Rock Resort. The meeting point is the hotel lobby at the main entrance.

Suggested attire: Business casual / cocktail

COCKTAIL RECEPTION / GALA DINNER

On Tuesday, September 25, 2018 Cocktail Reception will take place between 7:00 p.m.–7.45 p.m. in Red Rock Resort Veranda Terrace (conference area). The Gala dinner celebration from 8:00 p.m. will take place at the Summerlin Ballroom of Red Rock hotel. Open to all registered attendees and registered accompanying persons. You must bring your invitation card with you!

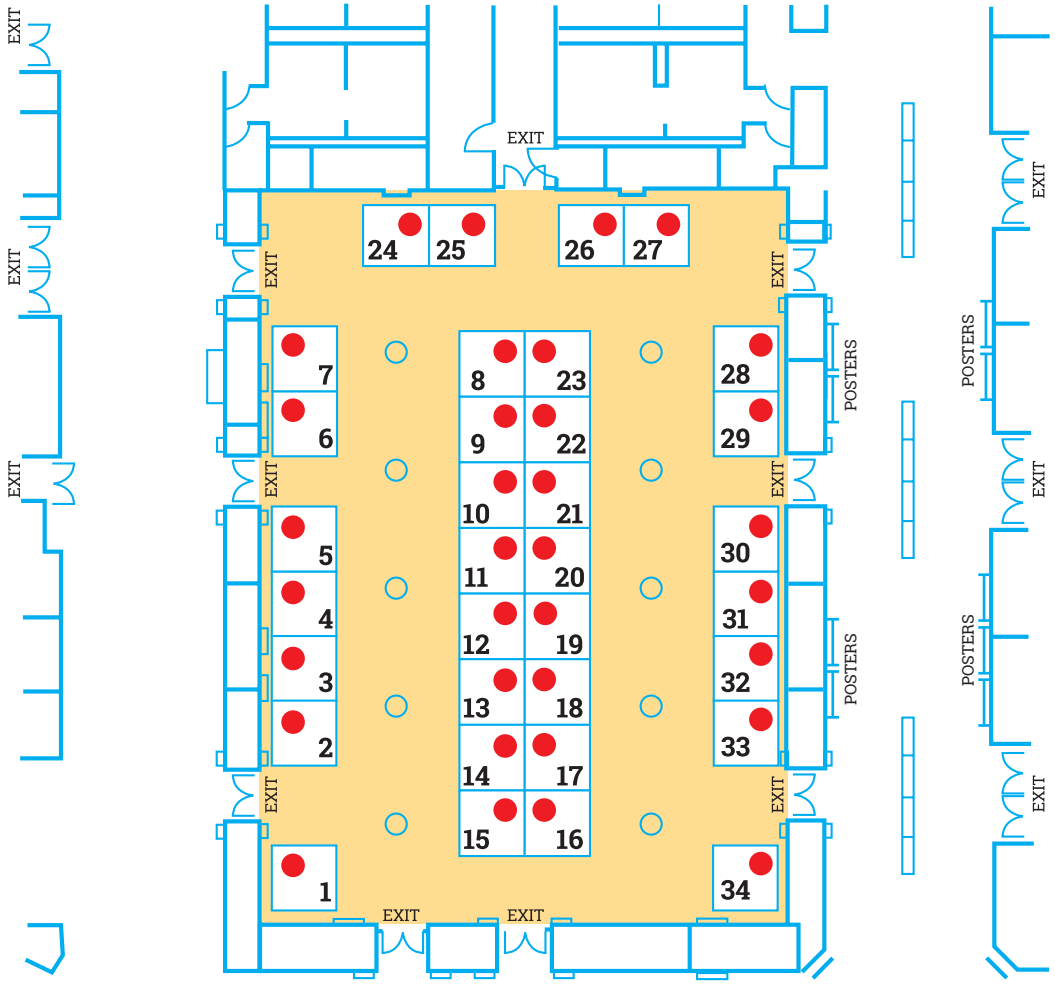
Suggested attire: Business formal / cocktail

MAP OF EXHIBITION

MAP OF EXHIBITORS

Charleston Ballroom

RED ROCK RESORT – LAS VEGAS, NEVADA



Company:	Booth No:
AGRU America, Inc.	26, 27
Alwasail Industrial Company	14
Baerlocher	16
Borealis Borouge	15
Pipe Downstream Extrusion Solutions	31
Corma Inc.	28
Element	2
FB Balzanelli	4
GTI – gastechnology.org	32
INEOS Olefins & Polymers USA	1
Kebeln Plastic Machinery Co., Ltd.	25
Kiwa	29
LyondellBasell	17
M.O.L.	20
NanoXplore	3
NSF International	24
Performance Pipe	6

Company:	Booth No:
Rifeng Enterprise Group Co., Ltd.	18
Rollepaal	23
S&B Technical Products / Hultec	22
Sasol Chemicals North America Llc.	7
SCITEQ	11
Sica America Corp	21
Sikora International Corp	33
Spectrum NDT – System One	12
Starway Piping Technology	9
Taizhou Huangyan Forsee Mould and Plastic Co., Ltd.	13
The Dow Chemical Company	8
Trelleborg Pipe Seals	5
TRI Environmental Inc.	34
UNICOR	10
United Precision Engineering	19
Zhongyun Group	30

PROGRAM

Day 1, Monday 24th

Day	Start	End	Session	A-sessions	B-Sessions
Monday	9:30 am	5:30 pm		DAY1: Conference Opening and Technical Sessions	
Monday	9:30 am	10:35 am	Opening	**OPENING** **Chair:** Sarah Patterson – U.S.A. (Plastics Pipe Institute)	
	9:30 am	9:45 am		– **WELCOME SPEECH FROM CONFERENCE CHAIR** Sarah Patterson – U.S.A. (Plastics Pipe Institute)	
	9:45 am	10:15 am		• ID140 – **DISCOVER: PLASTICS** Zoran Davidovski – Austria (Pipelife International)	
	10:15 am	10:35 am		• ID129 – **CHINA PLASTIC PIPE INDUSTRY – TECHNICAL PROGRESS AND QUALITY IMPROVEMENT** Wang Zhanjie – China (China Plastic Pipe Industry – CPPA)	
Monday	10:35 am	11:20 am		Technical Break	
Monday	11:20 am	12:40 am	1A / 1B	**1A – NEW MATERIALS** **Chair:** Lance MacNevin – U.S.A. (Plastics Pipe Institute)	**1B – CASE STUDY** **Chair:** Bruce Hollands – U.S.A. (Uni-Bell)
	11:20 am	11:40 am		• ID194 – **A NEW FLEXIBLE JOINTING METHOD OF PLASTIC (PE) PIPES** Tianjun Zhang – China (Harbin Starway Piping Technology Co., Ltd)	• ID221 – **UPDATE ON PVC STABILIZATION AND LUBRICATION FOR PIPES– GLOBAL TRENDS AND THEIR IMPLICATIONS ON RECIPE DESIGN** Dane Tallen – United Kingdom (Baerlocher)
	11:40 am	12:00 pm		• ID118 – **PREPARATION AND STUDYING OF TWO-LAYER OXYGEN BARRIER PLASTIC PIPE** Mingyuan Hu – China (Menred Group Co., Ltd.)	• ID225 – **PIPELINE REPLACEMENT IN LAS VEGAS** Greg Kodweis, Roger Jordan, Ryan Benner – U.S.A. (Las Vegas Valley Water District)
	12:00 pm	12:20 pm		• ID216 – **BIOMIMETIC DESIGN CONCEPTS FOR THE PIPE ARCHITECTURE OF TOMORROW** Gerald Pinter – Austria (Montanuniversitaet Leoben)	• ID224 – **MOLECULARLY ORIENTED AWWA C909 PIPE FOR SEISMIC APPLICATIONS** Richard St-Aubin – Canada (IPEX USA LLC.)
	12:20 pm	12:40 pm		• ID122 – **USE OF RISK BASED "FIT FOR PURPOSE" DESIGN FOR SAFE AND STRUCTURALLY RELIABLE PE PRESSURE PIPE LINES** Predrag Micic – Australia (Qenos Pty Ltd.)	• ID113 – **CONSIDERATIONS WHEN RE-STRAINING MOLECULARY ORIENTED PVC PIPE** Keith H. Steinbruck – U.S.A. (SiDE – Steinbridge LLC – S&B / Hultec)
Monday	12:40 am	1:40 pm		Lunch Sponsored by RTP	
Monday	1:40 pm	3:20 pm	2A / 2B	**2A – CASE STUDY** **Chair:** Peter Sejersen – Belgium (TEPPFA)	**2B – TESTING** **Chair:** Suleyman Deveci – U.A.E. (Borouge)
	1:40 pm	2:00 pm		• ID156 – **INNOVATIVE DESIGN OF THE ATLANTA BRAVES BASEBALL FIELD** Jim Goddard – U.S.A. (JimGoddard3, LLC)	• ID147 – **THE EVOLUTION OF ELASTOMERIC JOINTS IN PLASTIC PIPELINE SYSTEMS AND THE USE OF LONG TERM STRESS RELAXATION TESTING TO PREDICT SERVICE LIFE** Julian West – The Netherlands (Trelleborg Pipe Seals)
	2:00 pm	2:20 pm		• ID158 – **POLYETHYLENE PIPELINE PERFORMANCE AGAINST EARTHQUAKE** Hideki Omuro – Japan (Kubota ChemiX Co., Ltd.)	• ID138 – **FATIGUE CRACK GROWTH TESTING IN CHLORINATED WATER AT ELEVATED TEMPERATURES – TEST EQUIPMENT AND DATA REDUCTION** Patrick Bradler – Austria (Johannes Kepler University Linz – Institute of Polymeric Materials and Testing)
	2:20 pm	2:40 pm		• ID200 – **PANORAMIC VIEW OF A WATER MAIN REPLACEMENT PROJECT IN A FIRE-SEISMIC GEOHAZARD ZONE** Krista Moita – U.S.A. (East Bay Municipal Utility District)	• ID136 – **EFFECT OF ECCENTRICITY ON THE MEASUREMENT OF HYDROSTATIC PRESSURE RESISTANCE OF PLASTIC PIPES** Suleyman Deveci – U.A.E. (Borouge Pte Ltd.)
	2:40 pm	3:00 pm		• ID201 – **HDPE PIPE AS A SOLUTION TO UTILITIES OPERATING ON A MANAGE TO FAIL BASIS** Peter Dyke – U.S.A. (Alliance for PE Pipe)	• ID143 – **TESTING PARAMETERS INFLUENCING THE STRAIN HARDENING MODULUS** Ernst van der Stok – The Netherlands (Kiwa Technology)
	3:00 pm	3:20 pm		• ID203 – **POLYOLEFIN PIPES IN MIDDLE EAST – TODAY AND TOMORROW** Mohana Murali Adhyatmabhattar – United Kingdom (ProjAC Land and Marine)	• ID176 – **DEVELOPMENT OF CYCLIC PRESSURE FATIGUE (CPF) TEST METHOD** Ernest Lever – U.S.A. (Gas Technology Institute)

PROGRAM

Day 1, Monday 24th

Day	Start	End	Session	A-sessions	B-Sessions
Monday	3:20 pm	3:50 pm		Coffee Break Sponsored by NSF International	
Monday	3:50 pm	5:30 pm	3A / 3B	**3A – DISINFECTIONS** **Chair:** Douglas Keller – U.S.A. (LyondellBasell)	**3B – GAS** **Chair:** Randy Knapp – U.S.A. (Plastics Pipe Institute)
	3:50 pm	4:10 pm		• ID109 – **LITERATURE REVIEW: EFFECT OF ClO_2 ON AGEING OF POLYMER MATERIALS AND RELATED TEST METHODS** Ernst van der Stok – The Netherlands (Kiwa Technology)	• ID123 – **DEVELOPMENT OF POLYETHYLENE BALL VALVE TO PURSUE ROBUSTNESS** Ryosuke Nagahisa – Japan (Hitachi Metals, Ltd.)
	4:10 pm	4:30 pm		• ID202 – **AGING MECHANISM OF POLYETHYLENE PIPE MATERIAL IN CHLORINE DIOXIDE AND HYPOCHLORITE SOLUTION** Márton Bredács – Austria (Polymer Competence Center Leoben GmbH)	• ID207 – **MODERN PE PIPE ENABLES THE TRANSPORT OF HYDROGEN** Harald Ophoff – The Netherlands (Kiwa Technology)
	4:30 pm	4:50 pm		• ID188 – **CHLORINE DIOXIDE RESISTANT HDPE MECHANISM, ANALYTICAL TOOLS AND SOLUTIONS** Mark Boerakker – The Netherlands (SABIC Technology Center Geleen, The Netherlands)	• ID170 – **DESIGN AND QUALIFICATION OF PA-PERT PIPE FOR OIL AND GAS TRANSPORTATION** Liang Yu – U.S.A. (Polyflow LLC)
	4:50 pm	5:10 pm		• ID152 – **NEW DISCOVERIES IN STABILIZING DRINKING WATER PIPES IN CONTACT WITH CHLORINE DIOXIDE** Jung Du Kim – U.S.A. (Songwon International USA)	• ID190 – **SQUEEZE-OFF AND REROUNDING OF PLASTIC PRESSURE PIPES** Juergen Wuest – Germany (SKZ – German Plastics Center)
	5:10 pm	5:30 pm		• ID148 – **EFFECT OF BETA-NUCLEATION ON AGING AND CRACK GROWTH RESISTANCE OF POLYPROPYLENE EXPOSED TO CHLORINATED WATER** Joerg Fischer – Austria (Johannes Kepler University Linz – Institute of polymeric materials and Testing)	• ID204 – **INVESTIGATION OF THE CREEP FAILURE BEHAVIOR OF POLYAMIDE PIPES** Hiroto Taguchi – Japan (Tokyo Gas Co., Ltd.)
Monday	7:30 pm			Wecome Reception at Omnia – Sponsored by Krauss Maffei Berstorff (Bus transfer from Red Rock Resort at 6.30 pm)	

PROGRAM

Day 2, Tuesday 25th

Day	Start	End	Session	A-sessions	B-Sessions
Tuesday	9:00 am	4:40 pm		DAY2: Technical Sessions	
Tuesday	9:00 am	10:40 am	4A / 4B	**4A – JOINTS** **Chair:** Hiroyuki Nishimura – Japan (Kyoto Institute of Technology)	**4B – LARGE DIAMETER** **Chair:** Norbert Jansen – Germany (Borealis)
	9:00 am	9:20 am		• ID102 – **NEW TESTING METHOD FOR ELECTROFUSION WELDS** Love Pallon – Sweden (Swerea KIMAB)	• ID164 – **PE100-RC IN LARGE DIAMETER SEA OUTFALL APPLICATIONS** Mark Yu – China (Borouge)
	9:20 am	9:40 am		• ID105 – **ACCEPTANCE CRITERIA FOR VOLUME DEFECTS IN WELDED ASSEMBLIES, DETECTED AND SIZED USING THE PHASED ARRAY ULTRASONIC TECHNIQUE** Dominique Gueugnaut – France (GRTgaz)	• ID182 – **PE100 LARGE DIAMETER WATER TRANSMISSION PIPELINES TAKE OFF IN ASIA** Mohamed Al Jaber – U.A.E. (Borouge Pte Ltd.)
	9:40 am	10:00 am		• ID181 – **INCREASING HDPE BUTT FUSION PRODUCTIVITY BY OPTIMIZING THE COOL TIME BASED ON THERMAL MASS CHARACTERISTICS WITHOUT COMPROMISING JOINT STRENGTH** Amanda Hawkins – U.S.A. (McElroy)	• ID197 – **LARGE PRESSURE PIPE SYSTEM – FULLY PE100** Sverre Tragethon – Norway (Hallingplast AS)
	10:00 am	10:20 am		• ID195 – **QUALITY ASSURANCE ON WELDED JOINTS WITH THE MECHANISED LINEAR SHEAR TEST (LST)** Juergen Wuest – Germany (SKZ – Das Kunststoff-Zentrum)	• ID223 – **DEVELOPMENT OF LARGE-DIAMETER CONTINUOUS-FIBERREINFORCED THERMOPLASTIC PIPE** Nian Wu – China (Rongyee Engineering Pipeline Co., Ltd.)
	10:20 am	10:40 am		• ID196 – **INVESTIGATION OF THE FAILURE BEHAVIOR OF POLYETHYLENE ELECTROFUSION SOCKETS** Isabelle Berger – Austria (Polymer Competence Center Leoben GmbH, Austria)	• ID183 – **PERFORMANCE OF LARGE MARINE HDPE PIPES DURING THE SUBMERSION AS BASED ON LABORATORY TESTING** Ilija Radeljic – Norway (Pipelife Norway)
Tuesday	10:40 am	11:10 am		Coffee Break Sponsored by battenfeld-cincinnati	
Tuesday	11:10 am	12:30 pm	5A / 5B	**5A – LIFETIME** **Chair:** Steve Sandstrum – U.S.A. (Borealis Compounds Inc.)	**5B – PROCESSING** **Chair:** Dane Chang – U.S.A. (The Dow Chemical Company)
	11:10 am	11:30 am		• ID111 – **STUDY ON PARAMETERS AFFECTING DURABILITY OF POLYETHYLENE PIPES FOR HOT WATER APPLICATION** Hiroyuki Nishimura – Japan (Kyoto Institute of Technology)	• ID145 – **NEW PROCESS FOR THE HOT FORMING OF THE INTEGRATED SOCKET ON UNDERGROUND DRAINAGE PIPES MADE OF HIGH MODULUS POLYPROPYLENE WITH A COMPACT OR MULTILAYER WALL STRUCTURE** Joe Everett – U.S.A (Sica)
	11:30 am	11:50 am		• ID175 – **UNIMODAL MDPE (PE 2708/PE 80) PIPE MATERIALS SIGNIFICANTLY IMPROVE ABRASION RESISTANCE IN SLURRY FLOW APPLICATIONS** Wes Long, Ashish Sukhadia – U.S.A. (Performance Pipe and Chevron Phillips Chemical Co. Lp)	• ID205 – **INNOVATIVE MILLIMETER WAVES TECHNOLOGY FOR MEASURING DIAMETER, OVALITY, WALL THICKNESS, AND SAGGING OF LARGE PLASTIC PIPES** Christian Schalich – Germany (Sikora)
	11:50 am	12:10 pm		• ID184 – **ASSESSING THE REMAINING SERVICE LIFETIME OF PE PIPES: AN AUSTRALIAN CASE STUDY** Nolene Byrne – Australia (Deakin University)	• ID193 – **C-PVC-O, PUSHING LIMITS BEYOND IN MOLECULAR ORIENTATION** Ignacio Munoz De Juan – Spain (Molecor)
	12:10 pm	12:30 pm		• ID248 – **INCORPORATION OF RECYCLED HDPE TO PE100 RESINS FOR PIPE APPLICATIONS** Carlos Dominguez – Spain (Rey Juan Carlos University – LATEP – GIQA)	• ID167 – **EXTRUSION TECHNOLOGY** Rob Spekreijse – The Netherlands (Rollepaal)
Tuesday	12:30 pm	1:30 pm		Lunch Sponsored by PSILab Testing • Forensics • Consulting	

PROGRAM

Day 2, Tuesday 25th

Day	Start	End	Session	A-sessions	B-Sessions
Tuesday	1:30 pm	3:10 pm	6A / 6B	**6A – PROCESSING** **Chair:** Zoran Davidovski – Austria (Pipelife International)	**6B – SUSTAINABILITY** **Chair:** Michael Plumier – U.S.A. (Crossroads Engineering)
	1:30 pm	1:50 pm		• ID126 – **EXTRUSION OF THICK WALL PIPES USING A NEW BIMODAL PE 4710/PE 100 RESIN** Vivek Rohatgi – U.S.A. (Chevron Phillips Chemical Company)	• ID192 – **SLOW CRACK GROWTH RESISTANCE OF NON-VIRGIN POLYMERS** Andreas Frank – Austria (Polymer Competence Center Leoben GmbH, Austria)
	1:50 pm	2:10 pm		• ID191 – **PERFORMANCE EVALUATION OF COUNTER-ROTATING CONTINUOUS MIXER AND CO-ROTATING TWIN SCREW EXTRUDER FOR HIGH DENSITY POLYETHYLENE** Sayaka Yamada – Japan (Kobe Steel, Ltd – Kobelco)	• ID169 – **CHARACTERIZATION OF POST-USE POLYETHYLENE AND POLYPROPYLENE RECYCLATE BLENDS FOR PIPE APPLICATIONS** Markus Gall – Austria (Johannes Kepler University Linz)
	2:10 pm	2:30 pm		• ID135 – **EFFECT OF CARBON BLACK DISTRIBUTION ON POLYETHYLENE PIPES** Suleyman Deveci – U.A.E. (Borouge Pte Ltd.)	• ID206 – **SUSTAINABLE CONSTRUCTION – ENVIRONMENTAL IMPACT ANALYSIS OF INTEGRATING RECYCLED HDPE INTO CORRUGATED PIPING** Daniel Currence – U.S.A. (Plastics Pipe Institute – PPI)
	2:30 pm	2:50 pm		• ID154 – **PRODUCTION OF POTABLE WATER PIPES FOR CHILE USING THE INLINE EXTRUSION PROCESS** Douglas Keller – U.S.A. (LyondellBasell)	• ID161 – **NEW CROSSLINKED (PEX) PIPES FROM SUSTAINABLE RESOURCES** Jacob John – U.S.A. (Uponor Inc.)
	2:50 pm	3:10 pm		• ID210 – **TAKING POLYETHYLENE (PE) PIPE TO NEW HEIGHTS....AND NEW DIAMETERS!** Norbert Jansen – Germany (Borealis Polymere GmbH)	• ID120 – **PRODUCT ENVIRONMENTAL FOOTPRINT (PEF) METHOD COMPARED WITH ENVIRONMENTAL PRODUCT DECLARATIONS (EPDS)** Ludo Debever – Belgium (TEPPFA)
Tuesday	3:10 pm	3:40 pm		Coffee Break Sponsored by Hamilton Kent – Sealing Your Connection	
Tuesday	3:40 pm	4:40 pm	7A / 7B	**7A – SUSTAINABILITY / RECYCLING** **Chair:** Tony Calton – UK (Plastic Pipes Conference Association)	**7B – COMPOSITES / DESIGN** **Chair:** Haemi Pollett – Canada (Uponor)
	3:40 pm	4:00 pm		• ID179 – **MULTILAYER POLYMER PIPES - POSSIBLE UTILIZATION OF RECYCLED MATERIAL** Pavel Hutar – Czech Republic (Institute of Physics of Materials)	• ID232 – **POLYETHYLENE/ALUMINUM/POLYEHTHYLENE COMPOSITE PIPE FOR FUEL GAS APPLICATION** Baiqian Li – China (Rifeng Enterprise Group Co. Ltd.)
	4:00 pm	4:20 pm		• ID217 – **ENGINEERING AND TESTING REQUIREMENTS FOR INFRASTRUCTURE PIPELINE APPLICATIONS UTILIZING HDPE RECYCLED MATERIALS** John Kurdziel – U.S.A. (Advanced Drainage Systems)	• ID110 – **DEVELOPMENT STATUS AND TECHNICAL REQUIREMENTS OF COMPOSITE INSULATING PLASTIC PIPE** Hu Fa – China (Sinopec Beijing Research Institute of Chemical Industry)
	4:20 pm	4:40 pm		• ID220 – **GUIDELINES FOR CORRUGATED HDPE PIPES MANUFACTURED WITH RECYCLED MATERIALS FOR HIGHWAY CULVERT AND STORM DRAIN APPLICATIONS** Michael Plumier – U.S.A. (Crossroads Engineering Services)	• ID144 – **TRENCHLESS ADVANCEMENTS IN HDD WITH FUSED PVC** Tom Marti – U.S.A. (Underground Solutions, Inc.)
Tuesday	7:00 pm	10:30 pm		Gala Dinner at Veranda Terrace and Summerline Ballrom of Red Rock Resort Sponsored by teppfa – Channelling Performance	

PROGRAM

Day 3, Wednesday 26th

Day	Start	End	Session	A-sessions	B-Sessions
Wednesday	9:00 am	4:00 pm		DAY3: Technical Sessions and 5-Minutes Poster Session and Closing	
Wednesday	9:00 am	10:40 am	8A / 8B	**8A – CASE STUDY INDUSTRIAL** **Chair:** Hans Pierik – Netherlands (SABIC)	**8B – TESTING SCG** **Chair:** Joel Martell – U.S.A. (Southwest Gas)
	9:00 am	9:20 am		• ID133 – **THE WORLD'S FIRST CLASS 3 SAFETY RELATED NUCLEAR PE4710 PIPING PROJECT – 10 YEAR REVIEW** Shane Schuessler – U.S.A. (ISCO Industries)	• ID137 – **SENSITIVITY OF STRAIN HARDENING MODULUS TO MOLECULAR STRUCTURE OF POLYETHYLENE** Suleyman Deveci – U.A.E. (Borouge Pte Ltd.)
	9:20 am	9:40 am		• ID246 – **BIOFILM GROWTH AND THE IMPACT IT HAS ON THE HYDRAULIC CAPACITY OF PIPELINES** Stefanus Johannes Van Vuuren – South Africa (University of Pretoria)	• ID155 – **EFFECT OF CARBON BLACK, COMPOUNDING AND PIPE EXTRUSION ON THE SLOW CRACK GROWTH PENT TEST RESULT** Siddharth Athreya – U.S.A. (The Dow Chemical Company)
	9:40 am	10:00 am		• ID212 – **VARIABILITY AND QUALITY CONTROL FOR PRODUCTION OF CORRUGATED HDPE PIPE MANUFACTURED WITH RECYCLED CONTENT** Crista McNish – U.S.A. (Advanced Drainage Systems, Inc)	• ID160 – **THE INFLUENCE OF MOLECULAR DESIGN VARIABLES OF BIMODAL HDPE ON THE SLOW CRACK GROWTH RESISTANCE MEASURED BY ACCELERATED METHODS** Cliff Mure – U.S.A. (The Dow Chemical Company)
	10:00 am	10:20 am		• ID214 – **HIGH DENSITY POLYETHYLENE (HDPE): AN OVERVIEW OF THE FIRST EVER ASME BPVC SECTION III, CLASS 3 NUCLEAR PIPING INSTALLATION** Shane Schuessler – U.S.A. (ISCO Industries, Inc.)	• ID177 – **EVALUATION AND COMPARISON OF STANDARD AND ACCELERATED SLOW CRACK GROWTH DETERMINATION METHODOLOGIES: EFFECT OF THE COMONOMER TYPE INFLUENCE** Carlos Dominguez – Spain (Rey Juan Carlos University – LATEP – GIQA)
	10:20 am	10:40 am		• ID171 – **NEW HIGH MODULUS POLYPROPYLENE HELPS THE DEVELOPMENT OF LARGE DIAMETER UTILITY TUNNEL** Dongyu Fang – China (Borouge Pte Ltd.)	• ID213 – **DETERMINATION OF THE SLOW CRACK GROWTH RESISTANCE OF PA12 PIPE GRADES** Mario Messiha– Austria (Polymer Competence Center Leoben)
Wednesday	10:40 am	11:10 am		Coffee Break Sponsored by MILACRON®	
Wednesday	11:10 am	12:50 pm	9A / 9B	**9A – STANDARDS** **Chair:** Wang Zhanjie – China (China Plastics Piping Association)	**9B – STRUCTURED PIPES** **Chair:** Vincent Stone – Belgium (European Council of Vinyl Manufacturers)
	11:10 am	11:30 am		• ID142 – **NEW EN STANDARD FOR INFILTRATION UNITS** Peter Verlaan – The Netherlands (Wavin)	• ID163 – **INNOVATIONS IN PRODUCTION OF CORRUGATED PIPES** John Vlachopoulos – Canada (McMaster University)
	11:30 am	11:50 am		• ID119 – **HARMONIZING THE EUROPEAN HYGIENIC REQUIREMENTS** Peter Sejersen – Belgium (TEPPFA)	• ID114 – **HIGH MODULUS PP TANKS DELIVERS PRACTICAL & COST EFFECTIVE SEWAGE TREATMENT TO RURAL INDONESIA** KumHoong Lou – Singapore (Borouge Pte Ltd.)
	11:50 am	12:10 pm		• ID125 – **ACCELERATED PIPE TEST METHODS TO EVALUATE PE 100-RC MATERIALS – POSSIBILITIES FOR ISO STANDARDISATION** Thomas R. Kratochvilla – Austria (TGM, Department of Plastics Technology)	• ID165 – **INTRODUCTION OF LARGE DIA PROFILED PE/PP PIPES FOR INNOVATIVE PIPED DISTRIBUTION NETWORK (PDN) FOR IRRIGATION IN INDIA** C. B. Dandekar – India (Rex Polyextrusion Pvt. Ltd, An Astral Group Company)
	12:10 pm	12:30 pm		• ID112 – **VARIOUS APPROACHES TO THE IMPROVEMENT OF POLYETHYLENE PIPING CONSTRUCTION QUALITY IN OSAKA GAS** Katsutaka Nakagami – Japan (Osaka Gas Co., Ltd.)	• ID215 – **LARGE DIAMETER SPIRAL WOUND PRESSURE PIPES** Bülent Kuzkaya – Germany (KHB GmbH)
	12:30 pm	12:50 pm		• ID121 – **DESIGN OF LARGE DIAMETER BURIED PIPES** Peter Sejersen – Belgium (TEPPFA aisbl)	• ID127 – **STUDY ON THE RESISTANCE TO EXTERNAL PRESSURE TEST METHODS OF PLASTIC INSPECTION CHAMBERS** Zhang Wei – China (China Sinopec Beijing Research Institute of Chemical Industry)

PROGRAM

Day 3, Wednesday 26th

Day	Start	End	Session	A-sessions	B-Sessions
Wednesday	12:50 pm	1:50 pm		Lunch Sponsored by uponor	
Wednesday	1:50 pm	3:30 pm	10A	**10A – CASE STUDY** **Chair:** Forest Hampton – U.S.A. (Lubrizol)	
	1:50 pm	2:10 pm		• ID124 – **A RECENT SURVEY OF WATER MAIN FAILURES IN THE US AND CANADA** Steven Folkman – U.S.A. (Utah State University)	
	2:10 pm	2:30 pm		• ID199 – **THE USE OF TEMPERATURE, LUBRICATION, AND SUPPLIED HYDRAULIC PRESSURE IN THE PRODUCTION OF ORIENTED PVC PIPE** Jie Feng – U.S.A. (The Dow Chemical Company)	
	2:30 pm	2:50 pm		• ID116 – **LONGITUDINAL CRACK IN LARGE PVC-U PRESSURE PIPES. PIPE GELATION INFLUENCE. CASE STUDY III** Joaquin Lahoz Castillo – Spain (CEIS, Centro de Ensayos Innovacio Servicios, S.L)	
	2:50 pm	3:10 pm		• ID159 – **NOVEL STABILIZERS FOR PVC/CPVC PIPE AND FITTINGS** Mario Berna – Italy (Reagens)	
	3:10 pm	3:30 pm		• ID132 – **CPVC APPLICATION IN THE FIRE SPRINKLER SYSTEM IN CHINA** Fu Zhimin – China (Hong Yi Technology Co., Ltd.)	
	3:30 pm	3:50 pm	5-Minute Poster Session	**5-MINUTE POSTER SESSION** **Chair:** Ludo Debever – Belgium (TEPPFA)	
	3:30 pm	3:35 pm		• ID115 – **REHABILITATION OF ABANDONED DN1000MM STEEL PIPE WITH PE100 IN MALAYSIA** KumHoong Lou – Singapore (Borouge Pte Ltd.)	
	3:35 pm	3:40 pm		• ID222 – **FIELD TEST OF GLASS FIBER REINFORCED POLYETHYLENE PIPE SYSTEM AT SOFTEN GROUND** Mitsuaki Tokiyoshi – Japan (High Stiffness Polyethylene Pipes Association)	
	3:40 pm	3:45 pm		• ID128 – **THE TEST METHOD OF METALLIC ELEMENT FOR POLYETHYLENE PLASTIC PIPES OR MATERIALS FOR PIPES AND ITS APPLICATION** Xiaoying Lu – China (Petrochina Petrochemical Research Institute)	
	3:45 pm	3:50 pm		• ID230 – **PRESERVING MARINE ENVIRONMENT FROM HYDROCARBONS CONTAMINATION WITH LEAK-FREE PE100 PIPES USED IN OFF-SHORE OIL WELLS** Farraj Tashman – U.A.E. (Borouge pte. Ltd.)	
10 mins	3:50 pm	4:00 pm	Closing Ceremony (Sarah Patterson)		

AGRU AMERICA INC

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Name of representative on the stand: **Melissa Grace, Joe Farley**

AGRU America, Inc. is part of the worldwide AGRU Group, an Austrian family-owned business since 1948 with production facilities in Austria, the United States, Germany, China and India, and distribution in over 80 countries worldwide. One of AGRU's core competences involves the manufacturing of piping systems made of polyethylene (PE) for the supply of natural gas and potable water. Within the product group AGRULINE®, a complete range of pipes, fittings and valves, as well as the required joining technology are offered.

Product Overview – Large Diameter Piping System
AGRU America offers the most economic solution for high-volume flow applications with its specialized large diameter piping system. These large diameter pipes are manufactured at AGRU's cutting-edge XXL Pipe Production Facility in Charleston, SC and deliver better long-term hydraulic properties and operating expense savings. The pipe is extruded from PE 100 or PE 4710, and offers high resistance to corrosion, wear and tear, and UV radiation. AGRU's large diameter pipes offer fast and efficient installation both on- and offshore.

Large Diameter Pipe – Technical Aspects
Large diameter pipes by AGRU are available in sizes up to OD 3500 mm and 610 m in length. Fittings are also available. Designed for high volume flow applications such as cooling water intakes for power plants, large sewage systems, sea water desalination, or mining jobs, these pipes can tackle a range of applications. The ductility of PE withstands water hammers and pressure surges, where other materials would crack or burst. Large diameter pipes are available in a wide range of SDRs in accordance with recognized ISO or ASTM International pressure rating procedures.
The large diameter piping system is made from tough, durable extruded polyethylene, which never corrodes. This proven maintenance-free design saves operating costs compared to other solutions made from metallics or concrete. Additionally, polyethylene is highly flexible, lightweight, and easily welded. Large Diameter Pipe Benefits include:

- A smooth internal pipe surface reduces biological growth and incrustations
- HDPE is corrosion-resistant, nontoxic, and resistant to chemicals
- Manufactured with high-quality PE to provide high-abrasion resistance
- Long-lasting, retaining long-term hydraulic properties
- Permanent low-head loss, which results in lower pumping costs
- High-fatigue strength with proven resistance to seismic forces (impact and soil settlements)
- Withstands water hammers and pressure surges.

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Name of the SECONDARY contact person: **Mohammed Anwaruddin Zubair**
Name of representative on the stand: **Saleh Abdullah Al Mushekih**

Al Wasail industrial company was founded in 1979 with the capital of 100 Million SAR. The Manufacturing facilities are located in city of Burydah in Kingdom of Saudi Arabia.

Alwasail manufacturers polyethylene pipes, lining and fittings; mainly for irrigation, telecom, drinking water and firefighting networks, gas and oil transport systems. It also produces rubber products and foam through its affiliate company Saudi Rubber Products (SRP).

Alwasail has grown to become one of the Saudi Arabia's largest manufacturers and suppliers of polyethylene products serving infrastructure and irrigation products; it has more than 25 branches covering the Kingdom and the Gulf... It's well known for its quality products and accredited with ISO 9001 standards and follows stringent European and US standards; It is preapproved by major companies like Aramco, Sabic, Maaden and many others...

BAERLOCHER GMBH

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Name of representative on the stand: **Mr. Rainer Grasmück**

The Baerlocher Group of Companies, is a family-owned company, with more than 1,150 employees and 16 production sites around the world. Baerlocher is one of the leading suppliers of additives for the plastics industry with PVC additives at its core and looks back on a history of over 190 years.

Baerlocher is your global partner for all PVC processing with leading edge technology for Solid Calcium Zinc and Calcium Organic stabilizer systems serviced locally from our numerous production sites.

Furthermore, Baerlocher produces stearates as acid scavenger for the production of polyolefins and raw materials for Calcium-based stabilizers. Alongside the products for plastics, Baerlocher supplies creative solutions for the construction and lubricant industries.

Baerlocher´s Technical Service ensures that product development is on track with customer needs. We individually develop tailor-made solutions in our well-equipped technical labs for our customers. Experience and Knowledge are the key factors of our service.

Baerlocher runs R&D laboratories worldwide. Comprehensive production and application knowledge along with the development of new additive systems make Baerlocher stand out as research-oriented enterprise with strong creative potential.

With two production sites, in Dover (OH) and Cincinnati (OH), a state- of- the- art laboratory paired with an extensive technical service, Baerlocher can locally support the customer requirements efficiently. Especially in the United States Baerlocher offers Metal Soaps tailor-made for the PVC pipe industry.

The Baerlocher Group is introducing Baeropol RST (resin stabilization technology), which represents the latest advancement in antioxidant technology. Baeropol T-Blends incorporate both primary antioxidants for long-term stability of the final product, as well as secondary antioxidants for stability of the melt comparable to the primary resin. In addition, they optimize rheology and color stability during multiple passes through the extruder.

“The plastic pipe conference is a fantastic opportunity to capture market trends and to network with the peers of the whole pipe industry,” states Rainer Grasmück, Head of SBU PVC Additives India & Americas at Baerlocher.

BATTENFELD-CINCINNATI USA

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battenfeld-cincinnati is a leading technology equipment manufacturing company for the extruded products of pipe, profile, sheet, pellets.

We offer expert technical solutions for customers in our three business divisions Construction, Infrastructure and Packaging.

Our Construction Division manufactures and offers the leading technology in counter rotating twin screw extruders, tooling, downstream and screws and barrels for the manufacture of PVC Pipe, Foam core PVC Pipe, PVC profiles, fence/deck and rail profiles, foam pvc sheet and siding.

Our Infrastructure Division manufactures and offers the leading technology in single screw extruders, tooling and downstream for the manufacture of smooth wall and corrugated polyethylene pipe, smooth wall corrugated polypropylene pipe, micro-ducts, drip irrigation, multilayer pipe, crosslinked polyethylene pipe and engineered plastic pipe.

Our Packaging Division manufactures and offers the leading technology in single screw extruders, tooling and downstream for the manufacture of thin gage sheet for packaging. Unique solutions for the major materials used for packaging including polypropylene, polystyrene, and polyethylene terephthalate. Inline and off-line sheet downstream systems are available to meet every need. In addition to the sheet extrusion offering we have a line of pelletizing systems for heat sensitive polymers.

We have manufacturing facilities in Germany, Austria, China and United States providing worldwide sales and service.

BOREALIS

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As a trusted and experienced partner with more than 50 years of experience, Borealis and Borouge supply materials for advanced polyolefin pipe systems that help the pipe industry better serve a variety of communities worldwide.

Using the proprietary Borstar® technology as a base, Borealis and Borouge offer polyethylene and polypropylene materials for pipes used in many different industries: water and gas supply, waste water and sewage disposal, plumbing and heating, and oil and gas, including multi-layer steel pipe coating solutions for onshore and offshore oil and gas pipelines.

By offering more durable and reliable pipe solutions, Borealis and Borouge's step-change innovations continue to boost the sustainability of pipe networks by making them safer, longer lasting and more efficient, by helping eliminate wastage and loss whilst at the same time offering energy savings. Borealis and Borouge have been a solution provider and one-stop shop for polyolefins in the oil and gas industry providing reliable service and quality from one end of the pipeline to the other. Water and sanitation systems can be made more efficient and reliable by using proprietary Borealis and Borouge materials. Systems made of conventional materials are struggling with water losses up to 30-50%, whereas new PE pipe systems can avoid leakages. Trenchless technology reduces installation costs by up to 60%.

Borealis and Borouge pipe solutions are Enabling life's essentials.

CDS
– CUSTOM DOWNSTREAM SYSTEMS INC.

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For over 20 years Custom Downstream Systems has been a North American leading company in designing and building custom downstream plastic extrusion machinery delivering turnkey systems for most polymer or rubber applications. We also pride ourselves in providing great after sales services.

CDS pipe systems will exceed your expectations as we design and build cost efficient and reliable equipment to your specific requirements. From automation to energy efficiency, we follow the latest technological trends to maximize your production and improve your output.

CORMA INC.

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Corma is a world leader in the design and manufacture of corrugated plastic pipe production systems with over 45 years of experience in the industry.

Our cutting-edge technologies have advanced the corrugated double wall plastic pipe industry. As an innovator, we have hundreds of patents worldwide on our technologies such as the cutting edge large diameter Pulsating Corrugator, Super Coupling, double layer in-line couplings, mold block inserts, compact dies for large diameter pipes, vertical construction, vacuum forming, double wall pipe systems and Super CoolingTM.

Our corrugators can produce small to large diameter corrugated pipes in materials such as PVC, PE, PP and PA. With manufacturing plants and offices around the world, we are able to provide supporting services for our customers in over 100 different countries.

ELEMENT MATERIALS TECHNOLOGY AB

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Element Plastic Pipes in Nyköping, Sweden is an independent testing institute that has been performing pressure tests on plastic pipes since 1973. We perform hydrostatic pressure testing, high flow circulation loop testing, chlorine resistance testing and chlorine dioxide resistance testing and have a capacity of 5,000 pipe samples. Our independent test lab and testing services have a ISO 17025 accreditation to perform standardized- and custom tests.

We primarily serve suppliers of plastic materials, plastic pipe manufacturers and end-users, such as water companies and verification organizations. But we also provide in-house labs with extra testing capacity when needed. Element uses Pipeson software to provide our customers with effective data communication.

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Behind every FB Balzanelli pipe coiler there is a whole knowledge based on a huge R&D, oriented toward the plastic pipes manufacturers growing needs. FB Balzanelli matured a huge experience about coiling typical issues, thanks to the previous 25 years of leadership in the plastic pipes extrusion.

Flexibility, efficiency and innovation are all must for FB Balzanelli Avvolgitori, who manufactures, with great care, 60 automatic coiling machines a year, becoming the Company that deliver the larger number of fully automatic coilers worldwide.

The combination of experience and global reliability allow us to consolidate our leadership in fully automatic highspeed coiling machines for coiling in-line those pipe or hoses produced in short coil lengths.

The field of action, today, is also broadened toward automatic coils handling in different ways, according to customer needs and coil sizes.

Within the last few years a particularly strong interest growth toward our technology, either from Europe and North America, where we are establishing our new premises.

If you know us, please, do not hesitate to keep in touch, if you don't, visit us at www.fb-balzanelli.it

FORSEE MOULD AND PLASTIC CO., LTD.

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Forsee Mould Factory was set up in 1992. In 2000, the company expand rapidly. In 2005, we began exporting and now exportation play a very significant part in our business. Forsee Mould has more than 90 employees. Among staff, we have 12 technicians, and half of them have more than 20-year experience. Besides, about 30 workers have engaged 10 years in mould production. Our annual output of the moulds amounts to 1000 sets of moulds.

GAS TECHNOLOGY INSTITUTE (GTI)

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GTI is a leading research, development, and training organization addressing global energy and environmental challenges to enable a secure, abundant, and clean energy future.
For more than 75 years, GTI has been providing economic value to the natural gas industry and energy markets by developing technology-based solutions for industry, government, and consumers. We focus on expanding the supply of natural gas and renewable energy, ensuring a safe and reliable delivery infrastructure, promoting the efficient use of energy resources, and reducing emissions to the environment.

GTI initiatives lead to emerging technologies across market sectors and services at every phase of the technology development cycle, from concept to commercialization. Our efforts include research and development, program management, technical services, analytical services, consulting, commercialization, and education and training.

GTI's Delivery sector is focused on addressing the strategic concerns of domestic gas storage, transmission, and distribution infrastructure and is working to enhance safety, reliability, efficiency, and environmental stewardship.

Technology and information developments are geared toward improving integrity management, maintaining safety, reducing risk, preventing damage, and enhancing operational efficiency. R&D initiatives make accurate, high-quality data readily accessible for analysis and decision-making. With expertise in using GPS and GIS systems to automate field data collection, GTI has created asset lifecycle tracking, leak surveying, and pinpointing technology.

GTI is working to reduce the cost and improve overall efficiency of construction and maintenance, including next-generation materials such as higher-performance PE pipes and fittings, PA11 and PA12 high-pressure plastics, and composite materials and new tools and techniques for system installations, repairs, and rehabilitation. Researchers are developing improved inspection technologies, reducing third-party damage, and supporting the vision of a smart energy infrastructure with automation and sensor technology.

GTI Testing Laboratories (accredited by the American Association for Laboratory Accreditation in compliance with ISO/IEC 17025) provide chemical research services, materials analysis and characterization, pipe testing, and engineering and failure analysis. Scientists employ environmental forensic tools to address contamination issues and integrate molecular genetics techniques in a comprehensive corrosion testing service.

GTI offers customized and confidential technical consulting and provides knowledge-based services that combine utility expertise with detailed analysis of regulatory, technical, and business issues, and add testing and technical services as needed to deliver comprehensive and credible data.

Standardized training delivered by GTI helps operations and engineering professionals rapidly adapt to change and broaden their skill sets in a range of topics are covered. Industry-driven courses on gas distribution, transmission have been extremely popular and well received. A new Natural Gas Field Skills series of training modules for field workers involved in operations and maintenance is aimed at preparing them for safe, effective on-the-job performance and Operator Qualification assessments.

HAMILTON KENT INC.

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Hamilton Kent is an international, ISO9001-certified manufacturer based in Toronto, Ontario Canada with an additional production facility in Winchester, Tennessee USA. Founded in 1943, we design and produce a broad range of rubber gaskets for a variety of plastic pipe materials and configurations, including corrugated HDPE and PP, and all PVC styles. The company also provides several styles of rubber connectors for plastic pipe to concrete structure connections. Our goal is to partner with pipe producers to design innovative gasket systems that enhance the performance of their products.

HARBIN STARWAY PIPINGTECHNOLOGY CO., LTD.

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Founded in 1993 in China and now wholly owned by Hongkong Starway Holding Co., Ltd, Harbin Starway Piping Technology Co., Ltd has been committed to R&D, design, manufacturing and sales of the machineries for making steel reinforced polyethylene pipe system for over 20 years. Both pipe system and technology & machineries for making the pipes have been patented in China and overseas. Starway's steel reinforced PE pipe system mainly includes three types: (1) small and medium size steel mesh reinforced PE pipes for pressure applications, mainly used for city water supply, city natural gas distribution, crude oil transportation, chemical pipelines, pipelines in mines, pressure drainage and sewers, etc.; (2) full diameter range multiple reinforced PE pipes for pressure applications, mainly used for long distance water-source pipelines, water pipelines for desalination projects and large diameter pressure sewers, etc.; and (3) steel reinforced spirally wound PE pipes for gravity flow applications, mainly used for drainage and sewers. Based on experience and expertise's obtained over the past 20 years, Starway is now the leading expert in the field of composite PE pipe system. Starway is looking forward to building business relationships with intended clients to develop both domestic and overseas markets for the steel reinforced pipe system as well as the technology/machineries for making the pipes. Our clients include, but not limited to, state enterprises, private enterprises, joint-stock companies, investment companies, foreign companies or individual investors, etc. Starway will offer its client with exclusive franchise in certain geographical areas to produce and sell Starway pipe products, provided that Starway's conditions are met.

INEOS OLEFINS & POLYMERS USA

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INEOS Olefins & Polymers USA has been a leading resin supplier to the PE pipe market for over three decades. INEOS is a full-service supplier, providing bimodal/monomodal resins for the PE4710/PE3608 markets, yellow medium density resins for the PE2708 gas markets, and pipe resins for non-pressure pipe markets like conduit, corrugated, and drip irrigation. In total, INEOS USA has one billion pounds per year capacity to service these pipe markets. This includes 500 million lbs/year of bimodal pressure pipe resin TUB121/TUB121GN, manufactured on our new state of the art manufacturing line, to service the PE100 and PE4710 markets, respectively.

Headquartered in Houston and with major manufacturing sites on the gulf and west coasts, INEOS Olefins & Polymers USA is the 4th-largest high-density polyethylene and polypropylene resin supplier in North America. INEOS Olefins & Polymers' mission is to transform hydrocarbon raw materials into the high-quality olefins, high density polyethylene, and polypropylene that its customers have come to count on. We constantly strive to be the best at what we do, consistently delivering strong performance for our stakeholders while building a profitable enterprise for another generation. Our motto is "On time, on target, with service you can count on."

INFORMED INFRASTRUCTURE

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Informed Infrastructure is the construction engineers' source for projects, products, and technology. Informed Infrastructure addresses the markets of water/wastewater, storm water, transportation, energy, structures, erosion control and land development.

Informed Infrastructure delivers actionable information for improving infrastructure via a bimonthly print publication, Professional Development Hours, website, social media syndication, and weekly e-newsletter.

Informed Infrastructure is an objective source directed towards both civil and structural engineers, providing details on topics that affect the industry.

KEBELN PLASTIC MACHINERY CO. LTD

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Kebeln Plastic Machinery Co., Ltd is one of the leading manufacturers of plastic extrusion machines for pipes, profiles, sheets extrusion. It established in 2005. As one of the top China leading manufactures, we supply various kinds of extrusion lines equipped with different capacity from 1KG to 1500KG of extruders with Chinese/English PLC automatic control system according to customers' requirements.

Kebeln is located in Shunde District, Foshan City, Guangdong Province. It covers an area of over 15000 square meters with over 10 million investments of fixed assets and the excellent equipment's. Kebeln is committed to provide the first-class service for the customers from all over the world, and only the superior technology quality and the competitive price. The products from Kebeln are popular in the market. The excellent service of Kebeln obtains the good reputation in extrusion field. Kebeln has been approved by ISO9001: 2000 International Quality Certification.

Kebeln insists on the customer-centric and market-focused policy for providing good product and excellent service.

Since established, Kebeln persists in the principle of "people centering and keep improving" for developing in the international market. The customers of Kebeln are from more than 90 countries all over the world. Kebeln Machinery is the best joint-stock enterprise in the mainland supplying professional technology and extrusion machines, such as PVC, PP-R, PE pipe extrusion machines, PVC cable trunking extrusion line, PVC cable trunking punching machine, and pipe on-line automatic packing machine, PVC/PE corrugated pipe extrusion machine, PVC windows & doors extrusion line etc. Kebeln provides complete extrusion machines with comprehensive service and field support. Kebeln has maximum production flexibility by automation manufacturing equipment's combine with professional personnel training. Kebeln is proud of its product quality, function, price and after-sales service.

Kebeln insists on the customer-centered policy by providing excellent service.
Kebeln carries out the marketing strategy on product brand, quality, price and service.
Providing excellent products with reputed service in the international market.

KIWA

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Kiwa is an independent highly qualified organization having testing and certification as its core activity. Kiwa wants to be a Partner for progress and create trust on the basis of its qualities as a recognized and renowned certification and testing company, relying on testing, inspection, training, technology and data services. The slogan 'Partner for progress' is our way of expressing our desire to develop long-term relationships based on equality and geared to helping you improve your organization, products, services, management systems and personnel. We have even made this motto a part of our corporate style, affirming that it is our objective to help companies and organizations move forward. You have the ambition, we have the expertise to be partners for progress.

Kiwa is globally active in over forty countries with offices, our head office is located in the Netherlands. For plastics pipes and piping systems the leading Kiwa location is in Apeldoorn, the Netherlands.

Kiwa works for clients in the complete chain, from the raw material suppliers up to the pipe producer and installer.

Focus on polymer and elastomeric materials

Kiwa has the expertise and lab facilities to perform full testing works and life time prediction evaluations on both polymer pipe and fitting materials as elastomeric materials. We are able to perform for plastics and elastomeric materials all standardized testing works and further R&D testing works. Kiwa is actively involved in many standardization committees for plastics and elastomeric materials.

Focus on pipes and fittings.

Kiwa has the expertise and lab facilities to perform full testing works for pipes and fittings whether intended for water, gas, sewerage, drainage or else. Whether the material is a PE, PVC, GFR, PA or multilayer pipe, we are known to the products and materials.

Testing activities

Kiwa's testing activities are performed under ISO 17025 accreditation and the reports are recognized all over the world. Long term strength evaluations on materials and pipes can be monitored 24/7 via the Kiwa Online system.

Drinking water and Gas

Additional to all expertise and facilities on materials and testing Kiwa has its origin coming from the water and gas distribution. Kiwa nowadays still has the leading position in the world for drinking water and gas distribution approvals and testing, including hygienic and drinking water aspects.

For more information on certification and testing of materials, pipes, fittings etc, please visit www.kiwa.com or visit our booth nr. 29 at the Plastics Pipes Conference in Las Vegas.

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Around the world, the KraussMaffei Berstorff product brand stands for advanced, future proof extrusion solutions. The company's product spectrum ranges from single extruders with application-specific tooling, to up- and downstream components and fully automated extrusion lines. This product range, plus a customer-specific choice of service modules, guarantees that KraussMaffei Berstorff is a robust system partner for customers such as the bulk chemicals, automotive, construction, packaging and pharmaceuticals industries. KraussMaffei Berstorff, part of the KraussMaffei Group since 2007, was created through a merger of KraussMaffei and Berstorff, an engineering specialist with a long tradition.

Products:
Single and twin-screw extruders, complete extrusion lines for compounding and for the production of pipes, profiles, sheets and physical foaming. Rubber extruders and extrusion lines for technical rubbers and intermediates for the tire production.

LYONDELLBASELL

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LyondellBasell (NYSE: LYB) is one of the largest plastics, chemicals and refining companies in the world. We produce materials and products that are key to advancing solutions to modern challenges like protecting the purity of water supplies through stronger and more versatile pipes.

Our customers have come to rely on us over the past 50 years for:

- Developing innovative products that enhance pipe performance
- Offering a broad product portfolio supporting numerous applications
- Providing dedicated technical support and expertise in Europe, North America and Asia Pacific

Our PE, PP and PB-1 resins – marketed as Hostalen, Lupolen, Moplen, Hifax and Alathon – are utilized in numerous applications, including:

- Water and wastewater piping
- Plumbing and radiant heating
- Gas distribution
- Industrial pipe

With our high-performance resins, our customers are able to develop highly durable, long-lasting pipes that are resistant to high temperatures and disinfectants.

LyondellBasell sells products into approximately 100 countries and is the world's largest licensor of polyolefin technologies. In 2018, we were named to Fortune magazine's list of the „World's Most Admired Companies." More information about our company can be found at www.LyondellBasell.com.

M.O.L. ELASTOMERTECHNIK GERMANY

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M.O.L. ELASTOMERTECHNIK is one of the leading manufacturers of rubber sealing systems and elastomer profiles. As a competent and strong partner of the plastic pipe industry we develop tailored product solutions in the drinking and sewage water pipe sectors. The on-site tool shop provides fast product development and guaranties short delivery times for customized production moulds.

M.O.L. is running 60 injection moulding machines with clamp force from 250 up to 1000 to. Our rubber extrusion lines are producing profiles for a wide range of industrial applications.

The sealing rings made by M.O.L. are produced to the international standard EN 681-1. CE marking is mandatory, third party tests are licensed by MPA Materialprüfungsamt Nordrhein-Westfalen in Dortmund, GERMANY and KIWA KOMO, THE NETHERLANDS. Our quality management system is monitored according to DIN EN ISO 9001:2015. M.O.L. Environmental Management System to ISO 14001:2004 + Cor 1:2009

Facts and Figures:
Production of 2 Mio sealing rings per day
260 employees in Germany
2.000 different extrusion dies in use
750 rubber injection moulding tools in operation
60 injection moulding units, 4 rubber extrusion lines (LCM, UHF)

MCELROY

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McElroy is the leading manufacturer and innovator in the science of joining thermoplastic pipe. The Tulsa, Okla.-based company offers the industry's most complete line of butt, saddle and socket fusion equipment for ½" CTS to 2000mm OD pipe as well as quality assurance accessories that increase productivity and efficiency on the jobsite. For more than 60 years, McElroy has successfully demonstrated a complete dedication to excellence that lies at the heart of the design, engineering and manufacturing of its products. McElroy's commitment to the industry also includes an extensive training program through McElroy University to ensure that operators and inspectors develop best practices in the quality and reliability of fused pipe systems. For additional information, please visit the McElroy website at mcelroy.com.

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Milacron is a supplier of injection, extrusion, blow molding machinery, injection mold hot runner systems, mold components industrial supplies and metal working fluids. Milacron has a global manufacturing footprint with operations in the US, Canada, Europe, India and China. The extrusion business product offerings include technologies used to produce polyolefin and PVC pipes. These technologies include extruders, pipe dies and the integration of downstream equipment for single solution offering.

NANOXPLORE INC.

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Why choose NanoXplore's graphene for your PE pipe?
NanoXplore is the largest North American producer of low cost, high volume industrial graphene powder. NanoXplore's graphene powder is a nanocarbon additive that provides unmatched multifunctional improvements that directly align with the innovation goals of today's PE corrugated pipe manufacturers. In fact, this 2010 Nobel prize-winning material is the only market-ready additive that can provide uncompromised improvements in all major performance metrics including flexural modulus, ultimate strength, oxidation resistance, long term durability, and improved processability. Graphene-enhanced polyethylene provides a unique opportunity to enable manufacturers to reach the next level of long term performance and cost reduction with virgin and recycled resins.
Come and see us at our booth at PPXIX or find us online at www.nanoxplore.ca for more information.

Why NanoXplore?
Thanks to our scalable, proprietary, and environmentally friendly production methods, we are currently building a plant with a capacity of 10,000 tonnes per year to produce high quality, industrial volume graphene powder at a projected cost of US$10/kg. Our powder plant is collocated with a unique compounding facility that produces graphene-enhanced plastic masterbatch pellets.
Established in 2011, the company's headquarters and graphene production facility are in Montreal, Quebec and its plastic production facilities are on Montreal's South Shore and in Vallorbe, Switzerland. NanoXplore brings together a team of seasoned business leaders, scientists, and engineers with carbon chemistry expertise and the industry experience required to develop innovative customer solutions.

NSF INTERNATIONAL

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NSF International (nsf.org) is a global independent organization that writes standards, and tests and certifies products for the water, food, health sciences and consumer goods industries to minimize adverse health effects and protect the environment. Founded in 1944, NSF is committed to protecting human health and safety worldwide. Operating in more than 170 countries, NSF International is a Pan American Health Organization/World Health Organization Collaborating Center on Food Safety, Water Quality and Indoor Environment.

NSF's global water services include testing, certification and auditing for municipal water treatment components and chemicals, plastic piping systems, plumbing fixtures and fittings, point-of-use and point-of-entry water systems and filters.

PERFORMANCE PIPE, A DIVISION OF CHEVRON PHILLIPS CHEMICAL COMPANY LP

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Performance Pipe, a division of Chevron Phillips Chemical Company LP, manufactures polyethylene (PE) piping and fittings for a variety of applications. Chevron Corporation and Phillips 66 each own 50% of Chevron Phillips Chemical. Phillips 66 invented highdensity polyethylene (HDPE) as well as the butt fusion joining process. Phillips 66 first used HDPE pipe in the 1950s to take advantage of the pipe's features and benefits for water, brine, crude oil and gas gathering. With over 60 years of experience in manufacturing quality PE pipe and seven plants across the U.S. utilizing state-of-the-art extrusion technology, Performance Pipe is the leader in PE pressure pipe. Performance Pipe continues to innovate by producing even more advanced thermoplastic pipes to increase the use of nonmetallic pipe solutions.

PE pipe is a frequent choice for transporting slurry solutions. It has proven to have superior wear resistance compared to many other materials. For example, when carrying fine grain slurries, PE pipe has been shown in laboratory tests to be three to five times more wear resistant than steel pipe. Abrasion resistance of plastics is dependent on numerous factors—the nature of the PE, surface roughness, lubricating agents, load, material hardness, and others. Contrary to intuitive belief, PE abrasion resistance does not correlate directly with hardness. Test data will be presented to show that a new unimodal medium-density polyethylene (MDPE) pipe provides at least 30% greater abrasion wear resistance compared to other HDPE pipe, translating to longer service life in these applications.

Performance Pipe will also be showcasing another new polyethylene pipe referred to as PE-RT pipe which now expands PE pipe into oil & gas gathering, produced water, and liner applications requiring corrosion resistance and enhanced liquid hydrocarbon permeation resistance combined with resistance to high temperatures. Performance Pipe's PlatinumStripe® 1800 Series PE-RT pipe has an HDB of 800psi at 180°F (82.2°C). The applications for PlatinumStripe® 1800 Series PE-RT are many and include oil & gas gathering, produced water, lining, mining, pulp and paper, chemical processing, and district energy systems to produce steam, hot water or chilled water from central plants. For district energy, the steam, hot water or chilled water is piped underground to individual buildings for space heating, domestic hot water heating and air conditioning. As a result, individual buildings served by a district energy system do not need their own boilers or furnaces, chillers or air conditioners.

Finally, Performance Pipe will showcase our newest pipe product, PVDF (CH2CF2) pressure pipe, as a newly developed solid-wall thermoplastic corrosion-resistant pipe that can be operated at pressures up to 1050 psig (70 bar) for SDR 7 to convey fluids such as oil, dry or wet gas, hazardous liquids, multiphase fluids, steam, non-potable oilfield water and chemicals, and up to 650 psig (45 bar) for SDR 7 in regulated gas transmission applications. Please visit Performance Pipe, the leader in thermoplastic pressure piping systems, at the Plastics Pipe Conference in Las Vegas, September 2426, Booth #6, or visit our website at www.performancepipe.com.

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PSILab is a state of the art, quality focused, ISO 17025 accredited testing laboratory. Our expertise includes polymeric materials and piping products. We provide physical, mechanical, and hydrostatic testing services as well as consulting, failure analysis, and forensic investigation services. Our clients include resin manufacturers, pipe and fitting manufacturers, engineers and system owners.

PVC4PIPES

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PVC4Pipes is the value chain platform of ECVM* (the European Council of Vinyl Manufacturers) founded to communicate about the use of PVC in pipe systems in the global market. Our members come from all parts of the industry's value chain. PVC4Pipes welcomes companies which produce raw materials – PVC resin and additives – and those which manufacture the wide array of PVC pipes and fittings available in today's market, as well as scientific and testing institutes and promotional associations.

PVC pipe systems are used in a wide range of water applications such as drinking water, sewage and underground drainage, soil and waste, rainwater and hot and cold applications. Other applications include cable protection, industrial uses, fire sprinklers and fittings.

* ECVM (www.pvc.org) is the organization representing the six leading European PVC resin manufac¬turers, accounting for about 75% of the PVC resins produced in Europe. As founding member of VinylPlus® (www.vinylplus.eu), ECVM is committed to promote sustainable development and health, safety and environmental best practices over the PVC life cycle.

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Established in 1996, Rifeng Enterprise Group Co., Ltd. is the technology pioneer and leading enterprise for the research and development, production, promotion and application of China's new plastic pipe, as well as the important facilitator for the upgrading and transformation of China's plumbing system. As the Vice Chairman of the board of directors of the professional committee in China Plastics Processing Industry Association, Rifeng is also the representative for the all-round development of pipe and sanitary wares; Rifeng has been as a member of PPI and ASTM more than 13 years.

With our unanimous effort in innovation, through our professional services and by closely cooperating with our global strategic partners, we, Rifeng, are devoted to providing you with a series of environmentally friendly and reliable indoor climate, plumbing and gas transportations in all building types, from residential house to industrial and commercial building.

Rifeng endeavors to provide our customers with diversity in choices and satisfaction in quality. By integrating our excellent R&D capability and production scale, we are able to provide integrated systems from pipes and fittings to tools and accessories, everything you need is designed, produced and supported by the same company, with over 20 years' experiences in the thermoplastic piping, you can count on Rifeng to deliver quality.

Rifeng multilayer and PEX piping systems obtain more than 60 international certificates including NSF in USA and SKZ in Germany, and other international institutes such as STF, SKZ, AENOR, KIWA.... It enjoys good market in over 100 countries and acquires market recognition worldwide.

ROLLEPAAL

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Rollepaal is a leading manufacturer of pipe extrusion equipment for PVC, PVC-O and PO pipe. Rollepaal serves the global market with facilities in the Netherlands, USA and India and has dedicated agents all over the world.
With over 50 years of experience Rollepaal is able to build high quality equipment for the plastic pipe extrusion market based on leading innovative technology and a clear customer focus.
It is our mission to contribute actively to the success of our customers by offering sustainable cost saving solutions. Our cost saving solutions are innovative and ensure a lasting competitive edge.

Our solutions
Rollepaal provides first class solutions in pipe extrusion in the range from 16 to 1200 mm. Within this range Rollepaal supplies all parts for PVC, PVC-O and PO production lines, both upstream and downstream. These products include extruders, die heads, cooling units, haul offs, cutters and scanners. In addition to this, Rollepaal has extensive captive material handling capacities to complete our market offerings.
Rollepaal collaborates globally with customers, suppliers, universities and technology institutes in order to combine creativity, experience and opportunities.

Innovation
Rollepaal product innovations are brought to maturity in close cooperation with our customers. Our most recent innovations include RBlue technology for producing PVC-O pipe and RMD multilayer die heads for multi viscosity applications.
With these costs saving solutions we connect with the Plastic Pipe Conference in safe, cost effective and sustainable use. We are proud sponsors of the Plastic Pipe Conference and we are looking forward to contribute in promoting plastic pipe systems altogether.

RPflow
Rollepaal is part of RPflow, an internationally active group consisting of four specialist companies operating in different markets. Besides Rollepaal, RPflow consists of the companies Romit, Ramix and Hoppmann. Romit is a full-service supplier of components, subassemblies and complete products for customers in different markets. Ramix Injection Moulds delivers first class solutions for premium pipe fittings and pipe related products, and Hoppmann is a leading international supplier of high-quality automation technology, with centrifugal feeding systems at the heart of every solution.

RTP COMPANY

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Headquartered in Winona, Minnesota, USA, RTP Company is one of the largest global suppliers of carbon black masterbatch for the plastic pipe industry, offering thermoplastic materials for pressure pipe, conduit, and drainage pipe.

RTP Company has more than 20 manufacturing plants in the United States, Europe, and Asia, and sales representatives located throughout the world. Engineers from RTP Company develop customized thermoplastic compounds in over 60 different engineering resin systems for applications requiring color, conductive, elastomeric, flame retardant, high temperature, structural, and wear resistant properties.

For more information, visit www.rtpcompany.com

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World's largest provider of Pipe Sealing Solutions:
Ductile Iron Pipes and Fittings:
Mechanical Joint gasket
Push-on gasket
Tyton gasket
Restraint gasket: Fast-Grip, Field Lok®, Sure Stop, Tyton Sit®, Tyton Sit Plus®
PVC Pipes and Fittings:
Integrated gaskets Rieber System
Non-integrated gasket:
Turner for bi-orientated water pressure pipes
HB-Fix (TPV-PP) for sewage pipes
Restraint Systems: Bulldog™, K2 Viper Lock
Corrugated pipes: F794 – F667 – EN 13476

Specialty products: Railroad boots, Baseball cores, Custom rubber molding

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Sasol is an international integrated chemicals and energy company that leverages technologies and the expertise of our 30,300 people working in 33 countries. We develop and commercialize technologies and build and operate world-scale facilities to produce a range of high-value product stream, including liquid fuels, chemicals and low-carbon electricity. Sasol's operating model is organized into two upstream business units – Sasol Base Chemicals and Sasol Performance Chemicals.

Sasol Base Chemicals is a producer and marketer of a range of commodity chemicals based on the Fischer Tropsch (FT) and natural gas value chains including chemical feedstocks of ethane, ethylene, propylene and ammonia. Final products include explosives, fertilizers, polymers (polyethylene, polypropylene, polyvinylchloride), mining reagents (caustic soda, sodium cyanide), and a range of alcohols, ketones, acrylate monomers, and other oxygenated solvents.

Sasol Performance Chemicals markets a broad portfolio of organic and inorganic commodity and specialty chemicals. Key products include surfactants, surfactant intermediates, fatty alcohols, linear alkyl benzene, short-chain linear alpha olefins, ethylene, mineral oil-based and synthetic paraffin waxes, cresylic acids, high-quality carbon solutions as well as high-purity and ultra-high-purity alumina.

For the plastics piping market, Sasol Chemicals offers its HD4985 BK product formulation, a PPI listed PE4710 compound and a PPI listed PE100 compound for the HDPE piping system producers. Sasol Performance Chemicals offers its paraffin wax functional equivalent ingredients Sasolwax B52, L6600, and L6800 and polyethylene wax functional equivalent ingredient Sasolwax A28 for the PVC piping system producers. For more information about Sasol and its products, please stop by Exhibit Booth #7 at the International Plastics Pipes XIX Conference and Exhibition.

Sasol is listed on the JSE in South Africa and the New York Stock Exchange in the United States.

SCITEQ A/S

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One of the main focal points of the PPXIX conference is development and testing of plastic pipes systems. SCITEQ A/S develop and manufacture test equipment and quality control solutions for plastic pipe manufacturers, test institutes and related industries.

With more than 60 years' experience and installations in more than 80 countries SCITEQ A/S is one of the world's leading specialists in test equipment for the extrusion industry. We take huge pride in ensuring not only precise and accurate tests, but also easy handling and intuitive controlling of the equipment, we are therefore introducing our latest software development; providing online monitoring and control of tests with the cloud-based software.

At SCITEQ we develop engineered laboratory testing equipment of the highest standard. We strive to give our customers the tools to produce to the highest standards, while helping them to produce as cost-effectively as possible with Q.C. tools throughout the factory. We supply large-scale laboratory projects as well as single products for the leading producers of pipes and fittings worldwide, technical institutes and raw material suppliers.

SCITEQ is your solution provider. We help our customers find the perfect solution in close dialogue. Our worldwide representatives support our customers locally throughout the process, from the initial analysis of scope, to production, installation, training and after-sales service. Installation and training is always carried out by our SCITEQ staff of skilled technicians and partners.

The key to our success is our flexibility and close dialogue with our customers, whether large or small.

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Sica, is a globally renowned Italian producer of downstream equipment for plastic pipes: haul-offs, saws, belling machines, packaging machines, automation and ancillary equipment. It promotes 200 different machine models, has 25 active patents, sells approximately 500 machines per year, exports 90% of its products all over the world and has a turnover of about 30 million euro. The company is fired by a strong drive to deliver value for customers, employees, shareholders, stakeholders and suppliers, while also pursuing honest business practice that is respectful of people and of the environment. In 2016, our US division, Sica America Corporation, opened an office in Atlanta, Georgia.

SIKORA AG

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SIKORA AG – Technology to Perfection
SIKORA AG is a leading manufacturer and supplier of innovative online measuring, control, inspection, analyzing and sorting technology for the hose, tube, sheet, metal, plastics, wire and cable and optical fiber industries. Worldwide, users of SIKORA measuring devices benefit from an increasing quality, profitability and efficiency of the manufacturing process. Modern Laser, X-ray and millimeter waves technologies measure precisely and reliably product parameters such as diameter, ovality, wall thickness, concentricity and sagging. In addition, SIKORA's product portfolio comprises systems for online inspection and sorting of plastic material as well as offline systems for inspection and analysis of pellets, flakes and films/tapes.

SIKORA is headquartered in Bremen, Germany. Since 1973 the high-quality devices have been developed and manufactured at this site. With regard to service and sales, SIKORA is globally active with offices in Brazil, China, France, India, Italy, Japan, Korea, Malaysia, Mexico, Russia, Turkey, the Ukraine, USA and the United Arab Emirates. In cooperation with more than 30 local representatives worldwide, SIKORA serves all customer demands for optimum quality control and productivity. In addition, international service locations ensure fast and reliable customer support on site.

To meet the high standards and requirements at the manufacturing of large plastic pipes, SIKORA has developed a new technology for online quality control based on millimeter waves. It provides a non-contact, non-destructive, online measurement of inner and outer diameter, ovality, wall thickness and sagging (sagging of the melt during solidification at a too high viscosity) of large plastic pipes during the extrusion process. The innovative millimeter waves technology contributes to the highest product quality, process optimization and cost reduction.

SPECTRUM NDT LTD.

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Spectrum NDT Ltd. ("Spectrum") formed in Canada in 1984, is an established materials evaluation service company. Service offerings are both non-destructive and destructive testing for metallic and non-metallic materials. Testing of non-metallic materials includes a proprietary technology, microwave interferometry, for which Spectrum holds the exclusive rights in Canada.
In early 2011, Spectrum entered into a licensing agreement with Evisive Inc. of Louisiana to become the exclusive provider of Evisive microwave interferometry scanning services, sale of Evisive equipment, and trainer of Evisive users across Canada. The Evisive technology has allowed us to provide testing services on non-metallic materials as well as complementary destructive testing services for both non-metallic and metallic materials.

Spectrum NDT Ltd Services:
ACID Testing
AUT: Automated Ultrasonic Testing
BFW: Butt Fusion Weld Testing (as in polyethylene pipe)
CIT: Computerized Imaging Technology
MIC: Microdur Hardness Testing
LPI: Liquid Penetrant Treating
LM: Laser Mapping
MT: Magnetic Particle Testing,
NDT/NDE: same thing, Non-Destructive Testing, Evaluation, or Examination
Non-Metallic Testing – HDPE: High density polyethylene (BFW – butt fusion weld)
PAUT: Phased Array Ultrasonic
PIG: Pipeline Inspection Gauge
PT: Liquid Penetrant Testing
QA/QC: Quality Assurance/Quality Control
RT: Radiographic Testing
TDVIS/NDE: Visual Testing, Non-Destructive evaluation
TOFD: Time of Flight Diffraction
VT: Visual Testing
UT: Ultrasonic testing
UT – TOFD: Ultrasonic Time of Flight Diffraction
UT-TPA: Ultrasonic Tandem Phased Array
OTHER: Includes PMI – Positive Material Identification and Ferrite Testing

SYSTEM ONE

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Microwave Inspection Technology
Through a partnership agreement with Evisive LLC, System One has the exclusive rights to the EvisiveScanTM technology in the United States*. EvisiveScanTM is a unique, patented, cutting-edge microwave inspection technology that effectively revolutionizes nondestructive testing and examination.
The ASNT handbook recognizes Microwave Inspection Technology for the inspection of non-metallic materials and its unique nature is reinforced by multiple global patents.

Key Features:
• 100% volumetric inspection of wall and joints
• Wall and joint integrity assurance
• Detection and sizing of disbonds, delaminations and damage

System One is a Leader in Microwave Technology Applications
With the advancements in microwave inspection technology over the past 10 years, this new method has gained recognition for its ability to inspect many different "dielectric" materials with broad industry implications. Microwave inspection has shown to be capable of inspecting High Density Polyethylene (HDPE) piping/vessels with superior performance in detection of Windowing and Cold Fusion. Several ASTM standards are in the establishment and approval process.
EvisiveScanTM Inspection Technology is being used on Fiber Reinforced Plastic (FRP), providing first ever volumetric inspection of vessels and piping (including pipe wraps). From thickness measurement to detection of ID pitting/blistering, and delamination, EvisiveScanTM can inspect from the OD of the vessel/pipe with no human entry required.
Electric Power Research Institute (EPRI) is working with microwave technology to identify opportunities for inspection of dielectrics materials in nuclear power plants such as REJ's, HDPE, and Ceramic/Rubber coatings.
ASME HDPE Code Case Committees are working with microwave technology in consideration of the technology's role in butt fusion and electro-fusion weld inspection.

About System One
System One delivers specialized workforce solutions and integrated services. We help clients get work done more efficiently and economically, without compromising quality. For more than 35 years, we've built our reputation on exceptional talent, flexible delivery, and full accountability.
System One has built our services – and our Quality Solutions team – around deep specialization in quality assurance, quality control, NDE, and related services. From program design to large-scale deployment, we help you achieve compliance, improve safety, reduce downtime, and enhance profitability.

THE DOW CHEMICAL COMPANY

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Many pipe purchasers – municipal governments to business to home-owners – are choosing polyethylene (PE) pipe based on the distinct advantages it offers over traditional materials like steel, ductile iron, concrete, clay and PVC. The Dow Chemical Company (Dow) offers an industry-leading portfolio of PE resins for Pipe and Irrigation that provides opportunities for advantaged long-tern performance, efficient processing and installation, and – in many cases – reduced overall costs. With a lineup that features both proven performers and the latest innovations, Dow delivers technologically advanced materials for:

- Natural Gas Distribution Pipe
- Municipal Water Pipe
- Hot & Cold Water Pipe for Plumbing
- Radiant Floor Heating
- Micro Irrigation
- Oil & Gas Gathering Pipe
- Energy Pipe Systems

Dow Pipe and Irrigation solutions, however, go far beyond the manufacture and delivery of quality PE resins. We work closely with customers to develop solid answers to their specific needs. Our dedicated Pipe team offers technical service 24 hours a day, seven days a week. Combined with our global reach and ongoing commitment to R&D and innovation, these features help demonstrate the value Dow can offer as a leading-edge Pipe and Irrigation solutions provider.

About Dow Packaging and Specialty Plastics:
Dow Packaging and Specialty Plastics, a business unit of DowDuPont's Materials Science division, combines core strengths of R&D, worldwide reach, broad product lines and industry expertise to deliver high performing technologies for end use markets in food packaging, personal hygiene, infrastructure, consumer goods and transportation. Dow Packaging and Specialty Plastics is one of the world's largest producers of polyethylene resins, specialty resins and adhesives, and is a leading innovator and collaborator across the value chain on sustainable application development and circular economy life-cycle principals for plastics.

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Trelleborg Pipe Seals is a world leading supplier of a new and rehabilitation sealing solutions for concrete and plastic pipes, manholes and connectors used for water, sewerage and drainage.

Part of the Trelleborg Group, we benefit from over 100 years of experience in engineered polymer solutions that, seal damp and protect critical applications in demanding circumstances.

With our global reach, we deliver continuous innovation, logistics and a sales network spanning over 50 countries in Europe, the Middle East, Africa, North and South America, and Asia Pacific.

We will see you through from the beginning of your project right to the very end with the most advanced polymer technology and engineering expertise. The high-performance level of our seals ensures fulfilment of the highest possible reliability standards. Whether you need an entirely new system or improvements to your existing one, you can choose from a range of market-leading seats and pipe repair solutions that offer:

High quality
Quick and easy installation
Zero leakage

Trelleborg Pipe Seals offer watertight solutions that protect not only your pipe system, but your reputation too.

TRI ENVIRONMENTAL

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TRI/Environmental, Inc. (TRI) is an independent, third party, global materials testing and research company with service centers in the United States, Brazil, Australia, China and India. TRI performs testing services for a wide range of materials including resins, resins formulations, pipe, conduit, geosynthetics, soils, aggregates, rock, metals, concrete, polymers, composites, and many other related materials. TRI also serves as a third-party research, sampling, and manufacturing auditing firm performing quality assurance and material verification in support of critical materials procurement projects. TRI is unaffiliated with any manufacturer or engineering firm, and thus provides non-competitive services to government, regulators, manufacturers, engineering firms, contractors, and installers.

TRI performs routine standardized testing in accordance with ISO, AASHTO, ASTM International, BS, DIN and GRI test methods. These standards are performed to measure mechanical properties such as tensile, modulus, stiffness, puncture resistance, compression strength and resistance, flexibility, stiffness, and strain. The measurement of hydraulic properties includes permeability, permittivity, transmissivity and flow rate, manning's n value, diffusion, permeation, water and gas transmission rates, etc. TRI also performs durability testing including conventional (room temperature) and accelerated deformation studies in response to tensile and compressive loading. The Stepped Isothermal Method (SIM) was developed at TRI and has contributed to more accurate and quicker determinations of compressive and tensile creep strain properties. TRI also performs oxidation, hydrolysis, chemical resistance, UV resistance and extreme temperature resistance studies. In addition to routine index testing in accordance with, TRI also provides standardized interface friction, permeability, creep and stress-rupture, transmissivity, gradient ratio, UV-resistance, chemical resistance, and accelerated time-temperature creep and stress rupture testing.

TRI also performs large-scale testing services to demonstrate empirically a product's in-field performance and provide test data suitable for the calibration of in-situ performance modeling. Large in-situ testing includes trafficking studies to develop a traffic benefit ratio or reduced asphalt layer determination. Testing services include deep burial and large load studies, channel and slope erosion testing, highway edge drain and culvert drainage studies, filtration and scour protection measurements and many other product evaluations.

TRI provides consulting services and forensic investigations when material applications fail or do not perform as designed. TRI engineers and scientists have a wealth of experience over a broad range of disciplines to assist clients in determining the cause of field events and challenges. TRI senior staff provide expert witness testimony when required and benefit from the enormous TRI infrastructure of testing and evaluation abilities to document and demonstrate findings and conclusions.

TRI's personnel are active throughout the world's standards development organizations serving in leadership roles in both ASTM International and the International Standards Organization. TRI shares learned expertise by routinely provide short courses, seminars and tailor-made training services to those learning about materials in general and geosynthetics and geotechnical science in particular. Short courses and seminars include CQA for geosynthetics and compacted clay containment and drainage systems, electrical resistivity testing and leak surveying and slope stability and interface friction testing.

UNICOR GMBH

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ABSTRACTS

DISCOVER: PLASTICS

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A major multinational awareness campaign, championing the suitability of plastic pipe systems for subterranean sewer applications, has been launched to inform and inspire the civil engineering and utilities sectors. Discover: Plastics celebrates the flexibility, longevity and strength of plastic pipes – as well as their ease and speed of installation – drawing on more than 20 years of independent research. Curated by TEPPFA, the European Plastic Pipes and Fittings Association and in partnership with 4 National Associations. Discover: Plastics drives awareness of the natural suitability of plastic pipes for sewer and storm water applications. It also shines a light on real-life case studies from across Europe, showcasing how plastic pipe systems have been successfully deployed in many challenging situations, and are continuing to function decades after their installation. At the center of the campaign is a dedicated knowledge hub – a specialist microsite – which brings together the results of multiple wide-ranging studies into the performance and behavior of plastic pipes when used for sewers.

As second part will show the main barriers and drivers of in-house plastic products. This research was structured as market investigation with interviews and discussions. This paper will deal with the outcome of these interviews, results and conclusions and working out the second phase of the project with outcome to promote it under the discover plastic website.

ID140

CHINA PLASTIC PIPE INDUSTRY – TECHNICAL PROGRESS AND QUALITY IMPROVEMENT

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By virtue of its vast manufacturing industry, China has become a real „world factory". China enjoys this great reputation while at the same time, is a country working to solve a lot of problems and achieve the dream to become the „manufacturing power country". On the microcosm, China's plastic pipe industry still has a very long way to achieve all of their aims. In recent years, China's plastic pipe industry keeps increasing by improving the development model, industrial structure, quality level, comprehensive competitiveness and so on. China became the largest production and application country for plastic pipe. Nowadays, China strives to be the "Strongest" instead of the "Largest". Meanwhile, there are also some barriers to resolve. The two breakthroughs - technological progress and quality improvement — should be grasped firmly.

This paper analyzes the current situation and barriers, as well as propose breakthroughs to achieve the sustainable, stable and healthy development of China's plastic pipe industry, such as technical progress to drive development, quality improvement to promote industry upgrading.

ID129

A NEW FLEXIBLE JOINTING METHOD OF PLASTIC (PE) PIPES

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A new electrofusion PE belt is developed by reinforcing it with various layers of steel mesh. It's of sandwich structure, consisting of steel mesh reinforcement, heating wire and polyethylene. One or more layers of steel mesh is encapsulated in the middle, and heating wire is embedded onto "inner side" of the belt. Just outside the heating wire, a thin film of adhesive resin is applied for purposes of anticorrosion and increasing water-tightness.

This belt is much stronger than PE-only electrofusion belt due to the steel mesh reinforcement, and also flexible due to its thinner wall. PE100 or PE80 can be used to produce the belt.The belt width depends on diameter of pipes to be jointed, ranging from 300 to 500mm, and the diameter range of pipes it can joint is from 315 mm to 2600 mm. The maximum operating pressure for dn 315-1200 mm is 16bar and the maximum operating pressure for dn > 1200 mm is 12.5 bar. Belts for larger diameters and higher pressures can be designed and produced upon customer's special request.

This belt can be used for jointing new pipes as well as for repairs, and it is suitable for both pressure and non-pressure applications. It can also be used to joint pipes to pipe fittings provided the pipe and the pipe fitting to be jointed are equal in outside diameter. The belt work only with pipes with smooth-wall pipe-ends. For profile pipes with corrugations, the pipe ends shall be pre-processed at factory to be smooth so that the pipes can be jointed with the belts.

Pipe jointing with this electrofusion belt is easy and cheap. In on-site jointing operation, steel clamp is used to push the belt onto the outside wall of the pipe end tightly. For local damage to pipes like holes running through pipe wall, "patching" style of repair can be done using this belt.

Short-term hydrostatic tests, burst tests and joint decohesion tests have been done on all diameters. This product has been commercially used in China for a few years. The development/technical details will be presented in the paper.

ID194

UPDATE ON PVC STABILIZATION AND LUBRICATION FOR PIPES- GLOBAL TRENDS AND THEIR IMPLICATIONS ON RECIPE DESIGN

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PVC is a well-established material used worldwide for different applications such as window profiles, technical profiles, cables and sheets. Usage of PVC for pipes covers pressurized potable water applications as well as sewage systems, gas piping systems, gutters and fittings.

An overview of stabilizer systems for PVC pipes had been given at the last Plastics Pipes conference (PPXVII), detailing out which technologies are used around the world. Different technologies of stabilizer have a very varied rheology. The amount of gelation with each stabilizer system needs to be „equalized" by a very different lubrication package. In particular in North America, Sn stabilizers dominate, and it will be shown how to adapt formulations to allow continued usage of Sn formulations which is very different on how to adapt European type Ca/Zn formulations.

This presentation aims to give an update upon technology changes (replacement of Pb by Ca-based stabilizers, situation of Sn stabilizers) trying to work out a perspective for the upcoming years. This update has a particular focus on the lubrication required with the different technologies, and particularly the key considerations when switching between the various technologies.

ID221

PREPARATION AND STUDYING OF TWO-LAYER OXYGEN BARRIER PLASTIC PIPE

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The traditional Ethylene vinyl alcohol copolymer (EVOH) barrier plastic pipe used in internal closed-loop hydronic heating systems is three or five layers, which has complex structure and easy to be separated. Thermotropic Liquid Crystal Polymer (TLCP) is a new type barrier material. The oxygen permeability of TLCP is only one-tenth of EVOH. When EVOH or TLCP is used as barrier layer, the waste can't be recycled because EVOH or TLCP is not compatible with work layer. The thermotropic liquid crystal also has some machining difficulties such as higher processing temperature, smaller melt viscosity and obvious orientation. EVOH/PO(polyolefins) alloy and TLCP/PO alloy can be used as high barrier material layer, which can be extruded with the thermoplastic working layer such as PERT and PB, to form two-layer structure oxygen barrier pipe. Choosing the polyolefins which has the same or similar material with work pipe, so that adhesive layer can be abandon, separating will not be easy and the scrap can be processed directly to the machine. This subject has been preliminarily made EVOH/PERT alloy, EVOH/PP alloy, TLCP/HDPE alloy and TLCP/PP alloy. The oxygen permeability of EVOH/PERT is only ten times of EVOH, and one percent of PERT; The vicat softening temperature can reaches 130.90°C, which has good heat resistance; in addition, it keeps compatible with polyolefins.

ID118

PIPELINE REPLACEMENT IN LAS VEGAS

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The Las Vegas Valley Water District (District) delivers water to approximately 1.4 million residents within the City of Las Vegas and unincorporated Clark County. The District maintains more than 4500 miles of water pipeline ranging from 4-inches to 102-inches in diameter, as well as another 2,000 miles of small-diameter service laterals ranging from one-half inch to 4 inches in diameter. With an average infrastructure age of approximately 22 years, the District's water distribution system is relatively young, with less than six percent non-revenue water losses and a break rate of 1.3 breaks/100 miles. The utility's pipeline network primarily consists of PVC (52 percent) and concrete pipe (36 percent); steel and ductile iron comprise much of the remaining pipe material. The District has embarked on a $600 million dollar, 10-year Capital Improvement Plan (CIP). Two-thirds of the CIP funds are allocated for the repair and replacement of aging infrastructure, including more than $200 million dedicated to replacing aging water pipelines. The District has developed a program to identify and replace aging and failing pipelines utilizing a methodology that focuses on field investigations, break history, material type, and other parameters. The District utilizes a variety of technologies to determine the condition of pipelines. These include acoustic monitoring for leaks, direct assessment of pipelines, and utilizing data captured and compiled in the District's Graphical Information System. District engineers utilize this and other data, such as hydraulics, to determine the likelihood, as well as potential impacts, of failure. An overall risk assessment ranking is then developed for each pipeline to identify and prioritize replacement schedules. This data-based, proactive method allows the District to proactively target its capital investments in the most cost-effective manner possible. This paper will summarize the District's methodology to identify and replace aging pipe with new PVC pipelines.

ID225

BIOMIMETIC DESIGN CONCEPTS FOR THE PIPE ARCHITECTURE OF TOMORROW

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To account for the strains put on materials in load bearing applications, sufficient toughness is a crucial property sought after in all engineering materials. Due to complex conditions in which these materials are intended to be used, homogeneous materials are often not able to provide the required combined properties, such as stiffness, tensile strength and toughness. Often, this lack of performance is partially overcome by reinforcing polymeric materials via organic or inorganic fillers, such as fibres, spheres or platelets. However, reinforcing materials usually leads to embrittlement, which renders the material unusable in applications where toughness is required. Still the question to be solved is to find ways to overcome this predicament. Similar to other fields of science, nature provides blueprints which can be adapted for engineering purposes, like the architecture of deep-sea sponges [1]. Even though these consist of more than 90% brittle bio-glass they exhibit extraordinary toughness values. Studies have shown that this toughness is rooted in a multi-layered architecture, where small and soft protein-layers act as crack arrests in-between brittle layers of glass. This phenomenon can mechanically be described by the use of fracture mechanics methodologies and it is even possible to develop design criteria [2] to optimize and use aforementioned toughening effects in engineering materials. Previous studies on metals [3] and ceramics [4] have already proven the effectiveness of this approach.

Current work aims towards the transfer of these toughening effects also to polymeric structures. Specifically, pipes fit for this design concept because modern extrusion technologies allow for a production of pipes with a very flexible multi-layer architecture. Although the characterization of multi-layered polymer structures which possess, stiff and brittle as well as soft and ductile layers, poses serious challenges, first results on pipes based on pure polypropylene and highly reinforced polypropylene show very promising results. Interface properties, mechanical property mismatch and plastic zone sizes play a key role in the development of optimized structures based on this methodology.

ID216

MOLECULARLY ORIENTED AWWA C909 PIPE FOR SEISMIC APPLICATIONS

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Buried infrastructure is vulnerable to the soil movements caused by seismic events and can fail if properly designed piping materials are not specified. Plastic piping systems have many of the qualities required to withstand seismic events including flexibility and corrosion resistance, however molecularly oriented pipe (PVCO) is particularly well suited for this application due to its higher strength and ease of installation. As a result, and in cooperation with Cornell university a comprehensive research project to evaluate how AWWA C909 PVCO pipe reacts to seismic events, and also to study the performance of an innovative new joining system designed to enhance the seismic performance of the pipeline.

The research included material testing and analysis as well as full scale product tests and culminated in two full scale split basin tests at Cornell's campus in Ithaca, New York. These split basin tests model the effect of liquefying soil on a pipeline and give the best indication of the performance of a pipeline during a seismic event. The work was divided into two distinct phases. The first phase was a complete program to evaluate the properties of standard biaxially-oriented C909 pipe. Biaxially oriented PVC pipe has been stretched both circumferentially and longitudinally and therefore has enhanced properties in both directions – allowing both increased pressure capabilities and improved bending performance over the length of the pipe. These properties were quantified using a variety of tests, including tensile testing of material coupons, bending tests of the pipe itself, and tensile testing of fully restrained joints. unlike most standard tests for pipe, the bending tests and the tensile tests were completed on pressurized pipe in order to better simulate real-world conditions. In addition, having the pipe pressurized during the testing provided a clear end point for each test: the instant that pressure was lost. The first phase of the project culminated in a full scale split basin test.

The second phase of the project began with a review of the results of the first phase, with the objective of modifying the pipe to improve the results even further. Based on these discussions, the joint design was optimized for seismic loads, and the testing from phase one was repeated in exactly the same sequence, again culminating in a full split-basin test. The performance of the modified system was assessed and compared to phase one results. The results of all the testing undertaken in this program will be presented and will show that molecularly oriented PVC pipe is an excellent choice for system designers in seismically active areas. In addition to describing the research, the current state of seismic design standards for buried pipelines will be briefly discussed.

ID224

USE OF RISK BASED "FIT FOR PURPOSE" DESIGN FOR SAFE AND STRUCTURALLY RELIABLE PE PRESSURE PIPE LINES

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The polyethylene pipeline business has been undergoing significant change in recent years. In the not too distant past, lower-performance materials and a lack of understanding of major risks meant that the industry needed prescriptive standards with an emphasis on managing risk with conservative safety factors resulting in thicker wall pipes.

Research and experience has provided a better understanding of the major risks i.e. long-term brittle pipe failures by slow crack growth due to installation damages and in-service defects as well as susceptibility to third party damage. Consequently, management strategies about pipeline "integrity" evolved to using enhanced pipe materials as well as design and operation practices to manage risks that present a major threat to pipeline safety.

Standards and National Codes have evolved to accommodate innovation in materials, pipeline design and monitoring integrity during service life. Many of the current regulations are not prescriptive; they are explicitly goal setting allowing operators of pipelines to base design and operation on "fitness for purpose". Pipeline operators use risk-based design supported by structural reliability methods to design safe and cost-efficient pipelines. This paper outlines how risk based "fit for purpose" design has been used in the Coal Seam Gas extraction industry in Australia.

An example is shown of how the risk control strategy and process for optimization of the design safety factor is relevant to the use of trenchless pipe installation. Specifically, for the cases of plough-in and HDD installation of large bore PE100 pipelines for transport of extracted gas and process formation water. PE100 material with exceptional resistance to slow crack growth has been identified as a physical control to enable cost effective design and manage risk to pipeline integrity due to potential damage during trenchless installation and occurrence of "brittle" failure by slow crack growth in service.

ID122

CONSIDERATIONS WHEN RESTRAINING MOLECULARLY ORIENTED PVC PIPE

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Benefits associated with molecularly oriented PVC pipe (PVC-O) are well established. While reducing raw material by over 45%, pressure rating can be maintained, impact properties are improved, and water transmission cross section is increased.

Restraining PVC-U (unplasticized) pipe joints is well established and known. Restraining PVC-O presents significant challenges, since wall reduction causes dimension ratio to increase and pipe stiffness to decrease when compared to a PVC-U pipe having the same pressure rating. This paper investigates restraining PVC-O pipe joints having the objective to identify potential design considerations.

Among joint configuration alternatives considered in various levels of detail are external (restraining elements bracing both socket and spigot from the outside) or internal (restraining elements inside the socket), restraining elements integrated with the seal or separated from it, continuous or segmented grips, rotating or wedged gripping action, and self-engaging or mechanically engaged mechanisms. Empirical and theoretical methodologies are employed. Empirical data is collected using test protocols comparing behavior of PVC-U and PVC-O pipe assemblies including joint restraint devices. Theoretical methodology includes Finite Element Analysis and mathematical analysis.

The results of the investigation lead to the conclusion that restraining PVC-O pipe requires design considerations unique to PVC-O pipe when comparing to PVC-U pipe. Joint restraint systems originally intended for PVC-U, relying on its relatively large wall thickness and pipe stiffness, will be suboptimal if used to restrain PVC-O joints. Specific joint restraint design approaches and criteria are identified for PVC-O pipe joints.

ID113

INNOVATIVE DESIGN OF THE ATLANTA BRAVES BASEBALL FIELD

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Atlanta Braves Sun Trust Field features an innovative design for the drainage, aeration, and geothermal temperature moderation. The design objectives were removal of rainfall at a high rate, uniform distribution of air through the field profile, and moderate cooling or heating of the root zone of the turf. The system design, small scale tests, and actual performance results for the first year of use are presented. The field profile is discussed, and the low-profile drainage system detailed. This project presents a model for natural turf athletic fields for baseball, football, and soccer venues in moderate climate areas.

The design and performance tests of the research plot are presented, and their influence on the final design outlined. These items include the design for a 12,100 square meter (130,000 square foot) field area of the drainage system and the ultimate field profile.

The project site conditions are outlined. These include the geologic conditions, ground temperature at 3 meters (10 feet) depth, and the typical climate for the location. The construction of the Sun Trust Park field is described, including the geothermal aeration pipe, the drainage system, and the field profile. Performance of the system relative to the rainfall and temperature history through the first season is presented. Through the winter, the primary objective was to keep the turf from freezing. The design assumed a low ambient temperature of -7°C (20°F). Actual low temperature in January of 2018 reached -12°C (11°F). During that period the turf root zone temperature was no lower than 4°C (39°F), with air blown into the field profile from a depth of 3 meters (10 feet).

Applicability to other sports and climates is discussed. Some general recommendations are included.

ID156

THE EVOLUTION OF ELASTOMERIC JOINTS IN PLASTIC PIPELINE SYSTEMS AND THE USE OF LONG TERM STRESS RELAXATION TESTING TO PREDICT SERVICE LIFE

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Until the late 1950s, water and sewerage pipelines used predominantly rigid joints often made from tarred rope and cement mortar. The introduction of 'flexible' elastomeric joints allowed angular deflection, transverse shear load and localized pipe deformation, without leakage or failure of the joint.

The main criteria for the development of such pipe joints are:
• Leak tightness – for both infiltration and exfiltration
• Ease and reliability of jointing on site
• Long-term durability

This paper considers each of the criteria individually and presents a brief history of elastomeric seals in water and sewerage pipeline systems. In particular, it discusses how pipe joint designs, and the materials used, have evolved over recent decades. The paper also considers current elastomeric material standards and how these specifications relate to the long-term durability of the joint.

A pipe joint assembly has to remain watertight throughout its working life. A significant factor in achieving this objective is that the physical characteristics of the installed seal are sustained at accepted levels or that they exceed these.

The contact pressure in a joint decreases over time due to relaxation of the rubber seal. In this time-dependent relaxation process, the rubber relieves part of the imposed compressive stress through the reorientation of polymer chains in the rubber material. This reorientation is non-elastic and results in a permanent reduction in contact pressure.

Using recognized and proven ISO methodology, the relaxation threshold value may be set according to the maximum relaxation level acceptable for the joint design and application. The time taken for the rubber to reach this threshold may also be calculated.

This paper details this method and its typical outcomes, examining the impact on joint design where a >120-year service life is now the norm.

ID147

POLYETHYLENE PIPELINE PERFORMANCE AGAINST EARTHQUAKE

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In Japan, polyethylene (PE) pipe have been used for a long time, but its usage is limited for water service (low density PE / PE 50) and gas service (medium density PE / PE 80). However, after Hyogoken Nanbu Earthquake in 1995, it started to sell PE pipes for water distribution applications, because no damage on PE pipes at the earthquake was highly evaluated. In addition, long-term durability was also evaluated, and 31,700 km PE pipes for water distribution have been installed until 2015.

The main futures of PE pipe are two points, 1) pipes and fittings using a high-performance polyethylene material „PE 100", 2) pipes and fittings are formed by an integral structural by electro-fusion (EF) joints. The „PE100" material developed in the late 1980s has many advantages for underground pressure pipeline, e.g. flexibility, impact resistance, anti-crack propagation performance and long-term durability. With respect to flexibility, in particular, the tensile yield strain is 8% or more, which is much larger than that of a metal material, and almost no deterioration in strength is caused by tension and compression until yield. In addition, both pipes and fittings can be provided of the same polyethylene material. We think that the characteristics of monolithic pipeline and the flexibility can absorb the ground distortion due to the earthquake.

We have verified the characteristics of PE pipeline from the viewpoint of seismic performance. 1) Basic characteristics (tensile, compression and repeated elongation), 2) Real scale simulated test, 3) Evaluating pipeline after actual earthquake. We measured strain distribution of pipe deformation by actual scale experiment simulating ground crack and unequal settlement. We selected hydrostatic pressure performance for the evaluating pipe and fittings through the real earthquake. As the result, we found that it has high earthquake resistance performance.

Also, we were investigating PE pipeline damages after actual earthquakes, e.g. 2007 Niigata Chuetsu-oki Earthquake, 2011 the Great East Japan Great Earthquake, 2016 Kumamoto earthquake. There is no damage by ground deformation, seismic motions and liquefaction, except for extreme cases like tsunami and ground collapse.

From the above, we can confirm that polyethylene pipe has high earthquake resistance. Furthermore, it has a superiority of long life and economic efficiency.

ID158

FATIGUE CRACK GROWTH TESTING IN CHLORINATED WATER AT ELEVATED TEMPERATURES – TEST EQUIPMENT AND DATA REDUCTION

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To prevent the spread of waterborne diseases, a sufficient water disinfection is essential for meeting hygiene standards for potable and other tap water worldwide. Chlorine, based on chlorine gas (Cl2) or on sodium hypochlorite (NaOCl), is the most widely utilized and the most affordable water disinfectant. Due to the increasing application of polymeric materials in water supply systems, there is a great need for adequate test methods that are capable of determining the crack growth resistance of polymers under superimposed mechanical loading and exposure to chlorine. Hence, a novel test arrangement was designed and implemented on a conventional electro-dynamic test machine that permits for such superimposed mechanical-environmental loading conditions in a cyclic manner. Simultaneously, it allows for the determination of the quasi-automatic determination of the fatigue crack growth kinetics via an optical crack length measurement system. The test device and test arrangement were developed to ensure tests with compact type and cracked round bar specimens. By using sodium hypochlorite in a controlled system under continuous flow, preventing also the faster decrease in reactive chlorine content at elevated temperatures, constant chlorine contents in the range between 0.1 and 10 ppm over the complete testing time are assured. A range of fatigue crack growth results for pipe grades of polyethylene and polypropylene tested at different temperatures and chlorine concentrations will be compared and contrasted to highlight the potential of this novel test procedure in determining especially critical environmental loading conditions.

ID138

PANORAMIC VIEW OF A WATER MAIN REPLACEMENT PROJECT IN A FIRE-SEISMIC GEOHAZARD ZONE

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East Bay Municipal Utility District (District) constructed a multiphase High-Density Polyethylene (HDPE) water main replacement project in a fire-seismic geohazard zone known as Panoramic Hill. The pipeline replacements were part of a $12M water system improvement project for Panoramic Hill, a historic residential neighborhood located in Berkeley and Oakland, California which has narrow, winding roads and only one entrance where traffic is limited to one direction at a time. Given its proximity to open space and challenging access for fire agencies, the neighborhood has an extreme high fire risk. Additionally, the Hayward Fault Zone traverses the lower portion of the neighborhood. To improve the reliability of the area's domestic and emergency water service, the District replaced approximately 7,800 feet of primarily 4-inch unlined cast iron water mains with 2- through 12-inch HDPE pipelines. This paper will discuss the project's planning and design phases, including full-scale HDPE testing to verify the minimum bend radius for installation of electrofusion service saddles. This paper will also detail some construction challenges and how they were addressed.

ID200

EFFECT OF ECCENTRICITY ON THE MEASUREMENT OF HYDROSTATIC PRESSURE RESISTANCE OF PLASTIC PIPES

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Polyolefin pipes are increasingly used as the preferred product to transport water from the source to the service. Potable water networks are pressurized to create the required flow inside the pipe, which creates a circumferential or hoop stress on pipe wall. Therefore, the pipeline has to be designed accordingly to withstand these hoop stresses. This is achieved by the correct selection of material and pipe dimensions. The standard test method for measuring a material's resistance to hoop stress is the hydrostatic pressure test (HPT) performed according to ISO1167; this is applied at 20°C and elevated temperatures and used inconjunction with the ISO9080 testing scheme to fully characterize the material's performance. An important aspect of this method is the accurate measurement of pipe dimensions including(critically) the minimum wall thickness, which is used to calculate the required internal pressure to give a pre-defined hoop stress. The thinnest point in the pipe wall is the location of the highest hoop stress and is the point where the test specimen fails.

Plastic pipes are produced according to given standard dimensions as specified in international standards, e.g. ISO 4427-2, where limits on the outer diameter, wall thickness variation and out-of-roundness are prescribed. Wall thickness of the pipe defines the inner diameter of the pipe and the inner and outer circumferences of the pipe are expected to be concentric or at minimum eccentricity, although there is no specific mention of this in the standards. Therefore, one can produce pipe at a certain eccentricity but still comply with the product standards.

In this study, we have evaluated the effect of eccentricity of 32 and 110 mm diameter SDR11 pipes made from PE100 material on the HPT performance at 20°C and 80°C with the support of heat transfer and thermal analyses. It has been observed that pipe eccentricity has a significant effect in internal pressure testing. The effect of eccentricity is of technical significance even within the limited range of eccentricity allowed by wall thickness variation specified in current pipe standards. Therefore, we suggest a maximum eccentricity level of pipe specimens be introduced in ISO 1167 in order to prevent the misjudgement of material properties from pressure testing.

ID136

HDPE PIPE AS A SOLUTION TO UTILITIES OPERATING ON A MANAGE TO FAIL BASIS

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Many municipalities treat their systems on a manage-to-fail basis. Replacement schedules are drawn out to where failures and leaks continue to steadily increase. Maintenance dollars and repair dollars could be used for capital improvement. Examples of Fraser, MI, the Oroville Dam, Los Angeles, San Antonio Water System, Louisville, KY, and the City of Philadelphia are used as examples to describe this "manage to fail" practice. Attendees will hear first-hand of locations where outdated systems were failing and how HDPE tackled challenges that are far too common in the wastewater and water industries. These cities have adopted HDPE because it respects the water resource and provides a low-cost, long-term solution.

The Oroville Dam failure resulted in the evacuation of 188,000 people and a $850 million fix. The state was warned to go beyond a visual inspection as cracks were visible on the dam. These cracks had been found repeatedly since 2009. This dam was managed to failure.

Fraser, MI bought an interceptor with a known history of failures. In 2016, a sinkhole was formed that collapsed. This failure affected 500,000 residents in 11 communities. The cost of rehab would have been $6 – $8 million but turned out to be a $150 million repair bill.

Ft. Wayne, IN made the decision to rehab with HDPE due to the drastically increasing amount of water main breaks in their system. Since then, they've seen a steady decrease in main breaks. Utilities should aim to be like Ft. Wayne.

Manage to fail is not a sustainable method to manage water infrastructure replacement. This creates a constant state of "playing catch-up" where no real improvements are made to infrastructure and money is wasted. Utilities should invest in cost-effective solutions to break this cycle.

It is important to note that HDPE use has a positive effect on water treatment capacity, lowers electricity cost, and positively affects the social costs of roads that are undermined by water leaks. Through this leak-free and corrosion-resistant system, the surrounding communities and environment will benefit. Water loss has been proven to be significantly reduced and water quality is preserved.

ID201

TESTING PARAMETERS INFLUENCING THE STRAIN HARDENING MODULUS

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The Strain Hardening Test (SHT) is a quick test method to determine the strain hardening modulus, which is a measure for the resistance against Slow Crack Growth (SCG) of polyethylene (PE). It involves performing a simple tensile test at 80°C in accordance with ISO 18488.

Variation in certain test parameters can occur during normal laboratory practices, while not all test parameters are defined in detail in the standard. The effect of this variation on the resulting strain hardening modulus is unknown up to now.

Therefore, the effect of eleven different test parameters on the strain hardening modulus are investigated using Design of Experiments (DoE). This is a statistical method to quickly determine and quantify the effect of multiple test parameters including their interactions, while only a limited amount of tests needs to be performed.

From the statistical analysis it was found that the locations of the markers, the clamping and the alignment of the test specimen have a statistical significant influence on the strain hardening modulus. This shows the importance of proper preparation of the test set-up and could (partly) explain the already small deviations between different laboratories in Round Robins. Also, the test temperature and the cooling speed after annealing are of importance. A change in test temperature of 10°C can result in a ±7 MPa change in strain hardening modulus. This means that the 2°C temperature variation allowed by the standard ISO 18488 could lead to a variation of about 1,4 MPa in the strain hardening modulus.

The statistical analysis also looked for interactions between test parameters, i.e. if they are 'confounded' or not. For instance, it is found that the effect of the temperature on the strain hardening modulus is different for first generation PE than for PE 100RC.

Finally, although the tensile speed is on its own not statistically significant, the tensile speed combined with the test temperature does have a statistical significant influence the strain hardening modulus.

Separately, more research is performed on the difference on testing granulate versus re-granulated pipe. This showed that often, but not always, the strain hardening modulus of re-granulated pipe is lower compared to original granulate.

This paper therefore gives important insights of the various testing parameters influencing the strain hardening modulus.

ID143

POLYOLEFIN PIPES IN THE MIDDLE EAST – TODAY AND TOMORROW

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The Middle Eastern economy has grown multi fold in the last two decades, thanks to their proven natural resources and the vision of regional governments. Future forecasts also indicate considerable further growth owing to diversification and increased government spending on infrastructure and the industrial segment. The expected non-oil GDP growth of around 3.5% is a positive sign for business. Even though PO pipes were introduced in the early 1990s, the real growth started in the early 2000s. failure of conventional materials and ready availability of locally produced raw material, have worked as catalysts for the growth of polyolefin pipe applications, in water & Gas, sewerage & drainage and the industrial & oil and gas sectors.

Consistent efforts to educate the value chain on better understanding the engineering of PO materials have led to improved design practices and specifications more suitable for the Middle East environment. We can therefore expect further market growth in the medium term.

However, with innovation in conventional materials, non-adherence to quality standards and ineffective implementation of quality surveillance systems, we may find further obstacles that hamper the anticipated growth of PO pipes in the region.

In this paper the authors share some of the many challenges they have faced during their involvement in the Middle Eastern PO pipe industry over the last 25 years along with two unique case studies. The continuing misconceptions of designers and system owners are highlighted and identified to improve engineering understanding of plastic pipe systems.

They also give their views on the future of the regional PO pipe industry and the promising developments of new applications in years to come. The recent advances in composites and multilayers have opened new horizons. But, along with our packaging colleagues we also face increased challenges from public perceptions of the 'evil' plastic.

ID203

DEVELOPMENT OF CYCLIC PRESSURE FATIGUE (CPF) TEST METHOD

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The Plastics Pipe Institute Hydrostatic Stress Board (PPI HSB) commissioned the Gas Technology Institute (GTI) to perform Phase II of a research effort to develop a method to accelerate the validation of the Long Term hydrostatic Strength (LTHS) performance of resins using Cyclic Pressure fatigue (CPF) as the accelerating process. Phase I of this effort had shown a strong correlation between the Rate Process Method (RPM) and the CPF method and recommended a second follow on development effort.

The Phase II work has been completed and a final report was submitted to the PPI HSB for review. The research results confirmed the strong correlation between the CPF and RPM methods, but highlighted difficulties in applying the method to Slow Crack Growth evaluation due to mixed mode failures. Detailed analysis of the test method and results supports the assertion that the maximum stress achieved in the stress cycle is the dominant factor accelerating the failure mechanism of the pipe, regardless of whether SCG or mixed-mode fractures are generated. The combination of peak cycle stress and notch-tip stress intensification will determine the exact mix of SCG or ductile tearing at the notch tip.

The CPF method can be used to effectively validate the ductile behavior of resins when used in conjunction with material specific bi-directional shift factors.

Furthermore, the method is very useful in extending the cyclic fatigue resistance testing performed on polyethylene pipes over the past three decades. It was shown that the CPF results can extend the cyclic fatigue resistance evaluation of polyethylene materials to 100 million cycles to failure at 20°C. A method for ranking the relative cyclic fatigue performance of resins was suggested.

This paper will discuss the topics mentioned and provide suggestions for potential applications of the results and follow on work.

ID176

LITERATURE REVIEW: EFFECT OF ClO_2 ON AGEING OF POLYMER MATERIALS AND RELATED TEST METHODS

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Chlorine dioxide (ClO_2) is increasingly used in drinking water applications, because of its high efficiency as disinfectant. It is a strong oxidizing agent capable to disinfect water containing viruses, chlorine-resistant pathogens and Legionella. Due to its strong oxidizing properties ClO_2 is more aggressive towards polyolefins than hypochlorite (ClO-). This has led to premature failure of water pipes, especially at higher service temperatures.

To make polyolefins more resistant to ClO_2 it is imperative that the degradation mechanism is known. Furthermore, these materials need to be tested in a short, but functional manner to verify the materials resistance against the right failure mechanism. Therefore, a literature survey has been performed to define the degradation process and to describe and reflect on the different testing methods stipulated by standards and developed by research institutes.

The polymer degrades via an oxidative mechanism. Several factors influence the degradation and the time to failure of the pipe, such as the water temperature, disinfectant concentration and water pressure. However, the response of material to oxidative degradation and the effect on pipe performance varies with different polyolefins. Moreover, the effect of the stabilizers, their activity, their migration through the polymer and even the effect of the reaction products makes this degradation process very complex. This literature review will give an overview of the proposed mechanisms and mechanisms still under dispute.

For now, piping manufacturers try to expend the time to failure by influencing the polymer resin, additive package and wall thickness. However, the development of new material mixtures and compositions relies on a few general testing standards and testing methods developed by manufacturers and research institutes. Various test set-ups use loops were pipe samples are exposed to hypochlorite or ClO_2, or the loops contain (stressed) rings or other small samples. Other test lack continuous refreshment of the solution and are only based upon immersion. Many parameters can be monitored during the various tests and even more characterization tests are possible afterwards. However, the lack of a fast universally accepted testing method obstructs the development of new piping materials. In this literature review the pros and cons are compared for each test method and a proposal for a future test set-up will be made.

ID109

DEVELOPMENT OF POLYETHYLENE BALL VALVE TO PURSUE ROBUSTNESS

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Polyethylene (PE) has been used as a material of buried pipes for gas because it has excellent durability and flexibility. This performance is also needed in for valves in gas service. This paper shows the design of PE ball valves to achieve robustness and stable performance for leak tightness and operating torque of opening and closing operation in various environments and situations.

The performance of PE ball valves are more influenced by external environments than that of metals valves, so there are some points in considering to design.PE ball valve consists of the body made of PE that has plastic ball between rubber seals. Then PE has higher coefficient of thermal expansion and makes more dimension changes by thermal changes than metals. So, attention is drawn to the coefficient of thermal expansion of plastics in order to stabilize the performance for leak tightness and operating torque. Also, wall thickness of body is thicker than connecting pipe in order to minimize the strain by external force of earthquake.

Furthermore, it is needed to consider complicated disturbance factors in actual environment of usage. For example, under low temperature, friction force between ball and seals may increase because the seal rubbers become harder in addition to increase the compression rate of seals. Also, it is concerned that the gas leakage or the increase of operating torque may occur since dusts in the gas such as impurities of gas, rusts and sands get blocked in the clearance of the body, ball and stem. Traditionally, lubricant between ball and packing are used to reduce the friction force in PE ball valve, but it could become a factor for reducing the durability of product to make dusts easier to deposit. In addition, lubricant becomes more desiccated by operating many times, more operating torque becomes increase although operating torque increase by adhering between ball and seals without operating in the long term.

This report describes the process used to improve the robustness for leak tightness and operating torque by the improvement of assembly accuracy by use of electrofusion connecting to body assembly and change of seal materials. Improvement of assembly accuracy was shown to obtain stabilize performance by stabilizing compression rate of seals. In mind of use in the long term, surface treatment seals were used in order to reduce friction rate. So, it was found that non-lubricant valves can reduce the risk of dusts depositing and operating torque increasing without lubricant and inhibit adhering between ball and seals. Furthermore, valves should demonstrate their robustness by repeated opening and closing operations two hundred times without damage.

ID123

AGING MECHANISM OF POLYETHYLENE PIPE MATERIAL IN CHLORINE DIOXIDE AND HYPOCHLORITE SOLUTION

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Chlorine dioxide (ClO_2) and hypochlorite (HOCl) are the most used oxidizing agents for secondary drinking water disinfection due to their high effectivity against pathogenic microorganisms. Considering the strong oxidative nature of these disinfectants accelerated antioxidant consumption and material degradation can be expected in the affected pipe surface layer. The presence of chlorine-based oxidizing agents will shorten the crack initiation time and lead to premature pipe failure.

To accurately study the effect of ClO_2 and HOCl on polyethylene (PE) pipes materials, during laboratory aging stable exposure parameters are essential to generate reliable and reproducible data. Unfortunately, accelerated experiments with constant concentration are quite challenging in laboratory scale due to the fast reaction with organic and inorganic compounds as well as the considerable thermal decomposition of both disinfectants. To overcome this obstacle an exposure device was developed at PCCL which allows stable and well-controlled aging experiments in ClO2 and HOCl solutions.

The objective of this work is to provide further insight into the relevant degradation process of PE in chlorinated media. Tensile specimens with a thickness of 1 mm were immersed in 100 ppm of HOCl solution at 60°C and in 1 ppm of ClO_2 at 60, 50, and 40°C of exposure temperatures. Samples were periodically removed and tested during the overall five and three months long of aging experiments. Scanning electron microscopy (SEM) images showed different surface structure due to immersion in ClO_2 or HOCl solution. Based on thermal analysis such as Oxidation Onset Temperature (OOT), tensile tests and IR-spectroscopy (FTIR) distinct aging processes were observed for each disinfectant. In case of ClO_2, the results indicate that the oxidizing agent attacks simultaneously the polymer and antioxidant molecules. Exposure to HOCl led to material embrittlement only after the complete loss of active antioxidants. The analyses of the molecular weight distribution also demonstrate the various aging effects of ClO_2 and HOCl solution. Profound knowledge of the dominating aging mechanisms would be highly valuable information to develop PE pipe materials and antioxidant packages with increased performance in the chlorinated water.

ID202

MODERN PE PIPE ENABLES THE TRANSPORT OF HYDROGEN

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At Groningen Seaports hydrogen gas is produced as a by-product at a local chemical site. To stimulate reuse of this kind of energy-rich waste, the hydrogen is used as a fuel for line buses in the northern part of the Netherlands (Groningen).

A special pipeline is used to transport the hydrogen gas from the production facility to the gas filling station, where the buses can take in the hydrogen gas. Important prerequisites for this pipeline are a long-time guarantee on safety, security and cost-efficiently construction and maintenance. Polyethylene with raised crack resistance (PE100 RC) meets these requirements and was chosen as piping material. To overcome the lack in knowledge regarding the material performance in this specific hydrogen environment, a study has been performed before actual construction has begun. This study considered both safety and material aspects as well as maintenance issues. For example, the choice for the mode of installation (open cut or horizontal drilling) of the pipeline and the possible types of maintenance during the operational phase were considered. For the selected PE 100 RC material, a number of important material parameters such as the permeation rate and weldability after prolonged exposure to hydrogen gas have been investigated. The results of the study and additional insights obtained during the pipeline design, preparation and construction will be presented.

In the near future the available volume of hydrogen gas tends to grow. Especially if the surplus of power generated by photo voltaic cells or wind turbines is transformed into hydrogen gas. In that case, not only new applications as mentioned above are relevant, but also the current natural gas network offers new and economically interesting possibilities to store and transport this excess sustainable power in the form of hydrogen gas. However, one drawback might be the volume of hydrogen gas escaping from the oldest natural gas networks as a result of permeation and leakage, if this proves to be much higher than modern PE materials. Therefore, permeation tests of these old (first generation) PE pipes were performed. The results of these tests will also be presented in this paper.

ID207

CHLORINE DIOXIDE RESISTANT HDPE MECHANISM, ANALYTICAL TOOLS AND SOLUTIONS

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HDPE pipes are used for standard pressurized water pipes, offering an excellent solution for safe transport of (drinking) water. The HDPE pipe market is growing globally. Especially in countries that suffer from water scarcity, surface water and water from rivers have to be used for drinking water supply. To guarantee a safe drinking water supply, the water has to be disinfected properly. One of the most efficient disinfecting agents is chlorine dioxide. It has advantages over chlorine, since it does not affect taste or smell of water. The disadvantage of this disinfecting agent is the associated accelerated degradation of polyethylene pipes.

In this paper, work is presented that gains further insight in the mode of failure and the route designed to validate potential solutions is highlighted. The route taken consists of two stages, one small-scale evaluation to perform a screening of potential solutions and a second stage of a long-term evaluation of pipe performance. The small-scale evaluation method was developed after close examination of both pipe and small-scale aged specimen.

ID188

DESIGN AND QUALIFICATION OF PA-PERT PIPE FOR OIL AND GAS TRANSPORTATION

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Following the development of US shale oil and gas production since 2007, the demand for thermoplastic pipes with better corrosion resistance, and lower installation and operation cost than carbon steel pipe, has been growing. Nylon 12 has been qualified for hydrocarbon transportation in offshore flexible pipes and for natural gas distribution pipes. It maintains its mechanical properties well when contacting hydrocarbons, natural gas condensate and refined fuels.

A unique method of co-extruding Nylon 12 and Polyethylene with a tie-bond layer in-between to form a fully bonded tri-layer pipe is developed. This tri-layer PA-PERT pipe has the combined advantages of Nylon 12's resistance to hydrocarbon and the cost-effectiveness of Polyethylene. For low pressure applications (<240 psi), the tri-layer PA-PERT pipe is designed with PE layer wall thickness of DR 9 without any other reinforcement layer. An environmental application factor of 0.5 is not needed because the Nylon 12 inner layer protects the PE structural layer outside. The pipe is coextruded in diameters ranging from 2 inch to 6 inch nominal size. For high pressure applications (300 psi to 2000 psi), this tri-layer PA-PERT pipe can be reinforced with Aramid fiber in the same diameter range. This paper presents the design, manufacture and qualification test of the co-extruded PA-PERT pipe for transportation of crude oil, produced water, brine and natural gases.

ID170

NEW DISCOVERIES IN STABILIZING DRINKING WATER PIPES IN CONTACT WITH CHLORINE DIOXIDE

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Since decades drinking water has been disinfected by municipalities to avoid health hazards and epidemics. Chlorine (usually in the form of hypochlorous acid) is a known disinfectant that allows to avoid the formation of germ or bacteria. Since many years now, some municipalities or hospitals also use chlorine dioxide which is much more efficient and are also helpful in fighting Legionella, Giardia and Cryptosporidium pathogens that are chlorine resistant.

These disinfectants will then be in contact with pipes used for drinking water transportation or sanitary pipes in healthcare centres. Those pipes are usually made of polyethylene. Chlorine disinfectants will contribute to the degradation of the polymer. It is a well-known situation to stabilize polyethylene pipes against hypochlorous acid to prevent degradation and insure required lifetime and existing solutions have proven track-records.

Chlorine dioxide is much more aggressive than hypochlorous acid and leads to premature failure of the polyethylene pipe. This problem is particularly severe in hospital environments where there can be peeks of disinfectants poured into the sanitary pipes. Many studies have been conducted until known to understand the degradation mechanisms. Songwon latest study shows how to significantly improve the stabilization of polyethylene pipes in contact with chlorine dioxide to reach pipes standards.

ID152

SQUEEZE-OFF AND REROUNDING OF PLASTIC PRESSURE PIPES

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The squeezing of plastic pipes is a standard shut-off method and safety measure, which is often used in grid operation. Typical uses are repair, integration, and rerouting measures. Shut-off technologies for plastic piping systems are increasingly becoming important, since in particular gas distribution networks are nowadays mainly designed for plastic piping systems. Due to current material developments, plastic pipes are expected to be used in higher pressure ranges (>10 bar) in the foreseeable future. Therefore, operational shut-off measures such as squeezing become an indispensable instrument for network operation. In a DVGW research project three institutes have investigated the method of squeeze-off with regard to gas tightness, applicability at operating pressures > 1 bar and the effects on the continued operation of the pipelines. Pipes made of polyethylene (PE 80, PE 100, PE 100-RC) in various dimensions and pipes made of materials for higher operating pressures (e. g. PA 12, reinforced thermoplastic pipes) were investigated. With the squeezed off pipes the gas tightness was tested by creeping gas measurements up to an operating pressure of 10 bar. Mechanical investigations, creep rupture pressure tests and microscopic examinations were carried out in order to investigate the influence of squeeze-off and rerounding on the integrity of the pipes. Computer tomographic (CT) images were taken to inspect the pipes for defects in the pipe wall. The results were used to derive recommendations for practical action, which are currently incorporated into the DVGW's rules and regulations.

ID190

EFFECT OF BETA-NUCLEATION ON AGING AND CRACK GROWTH RESISTANCE OF POLYPROPYLENE EXPOSED TO CHLORINATED WATER

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In many world regions, water is polluted with bacteria, viruses and parasites, and disinfection of contaminated water is required as a prevention of waterborne diseases. Chlorine is the most widely utilized and the most affordable water disinfectant, as it is easy to use and highly efficient against different kinds of waterborne pathogens. In this context, it is well known that polyolefins in general exhibit a significant degree of aging when exposed to water disinfectants. However, for the case of polypropylene (PP), little information is available on how the aging behavior and crack growth resistance in chlorinated water environments is affected by the material morphology and micro-structure, in particular the type and degree of semi-crystallinity. Hence, utilizing a novel test device for superimposed mechanical-thermal-environmental fatigue crack growth testing, the aging behavior and crack growth resistance of two commercial PP random copolymer pipe grades was systematically investigated. One of the PP grades was of a conventional alpha-nucleated type (PP-alpha), whereas the other was specifically beta-nucleated (PP-beta). Material exposure and testing was performed at room temperature (reference state) and in the temperature range from 60°C to 95°C, and under environmental conditions of air, deionized water and chlorinated water, the latter containing 0.3 mg/l and 5 mg/l chlorine, respectively. In addition to crack growth experiments, tensile tests and DSC experiments (oxidation temperature) were conducted to elucidate some of the aging and fracture micro-mechanisms. Under all loading conditions, PP-beta turned out to be superior to PP-alpha, and the results of the crack growth performance for both materials are quantitatively compared and interpreted in terms of the material micro-structure and the prevailing aging mechanisms.

ID148

INVESTIGATION OF THE CREEP FAILURE BEHAVIOR OF POLYAMIDE PIPES

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To reduce installation and maintenance costs, plastic pipes should be used more widely under higher pressure. Recently, multi-layer polyethylene pipes and polyamide pipes have been using at pressures above 1.0 MPa as an alternative for steel pipes in several countries. When plastic pipes are under higher pressure, the evaluation of their creep properties is important. however, there are not many studies of creep failure behavior of high strength pipes such as polyamide pipes. The focus was on the long-term durability of polyamide pipes and carried out the hydrostatic test and the Notched Pipe Test (NPT) of polyamide pipes at 80°C.

The appearances of the polyamide pipes fractured in the hydrostatic test were significantly different from those of fractured polyethylene pipes reported in many studies. Besides, from the results of the failure time up to 10000 hours, the unnotched pipes for the hydrostatic test became fractured earlier than the notched pipes for NPT at the same hoop stress. These results suggest that the creep failure behavior of polyamide pipe is different from that of polyethylene pipe.

This study will elucidate the unique creep failure behavior of polyamide pipes in more detail. Since the higher order structural change of pipe material is said to correlate with development of creep failure, the higher order structural change of polyamide during the hydrostatic test and the NPT were observed by using several methods.

ID204

NEW TESTING METHOD FOR ELECTROFUSION WELDS

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The Swedish distribution network is large and valuable. Replacing it would cost 500 billion SEK. Estimates indicate that the needed maintenance exceeds the current investment levels and thus the costs are being postponed for the future. The municipalities estimate that a service lifetime of 150 years for new pipes is necessary to handle the future costs. Because of this situation the demands on new pipelines are high. They should be both cheap to install and also cost little to maintain. Polyethylene (PE) is the most promising, and thus the leading material for new installations. PE offers a flexible, light weight, corrosion resistant and cost-efficient solution with the potential to last more than 150 years. however, a large number of leaks in the joints between large pipes have occurred after only a few years. The problems have mostly happened in cases were the pipes have been joined by electrofusion. One of the actions taken to improve the quality is that the amount of procedure tests on welded PE-pipes has increased. A procedure test is performed before the installation starts and a passed test indicates that products, welders, equipment, and procedure work and quality welds are produced.

Following the increase in numbers of tests, the test methods are being investigated, as it is not uncommon that they produce misleading results. for electrofusion welds the standardized testing methods used today are all based on peeling apart the fitting from the pipe and visually inspecting the fracture surface. A weld is approved if the surface is ductile, and not approved if it is brittle. The most notable disadvantage with this evaluation technique is that the assessment is subjective and the distinction between ductile and brittle is unclear. Another drawback is for example that the fracture often deviates from the weld line and the weld can thus not be evaluated. Therefore, in cooperation with 4S Lednignsnat developed a new testing method for electrofusion welds that offers an easy and objective evaluation of the quality.

The procedure for the new full Length Tensile Test (FLTT) is to take samples from the welded joint and pull them apart using a fixture designed to reduce the risk of deviating fractures. The sample is pulled apart perpendicular to the weld and the resulting force-elongation curves can then be used to calculate the fracture energy of the weld. The initial study of the fracture energy correlated very well to the ductility of the weld. With a quantified parameter as a criterion for approval the assessment is significantly simplified and no longer subjective and dependent on who conducts the test.

ID102

PE100-RC IN LARGE DIAMETER SEA OUTFALL APPLICATIONS

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Under the Chinese government's expansive "One Belt, One Road" initiative -a development strategy and framework to enhance economic cooperation and trade between China and countries around Asia, the Middle East, Africa and Europe, China's largest PE spiral wound pipe convertor Nachuan was awarded to produce sea outfall pipes for discharging cooling water for the Lanao Kauswagan power station in the Northern Mindanao region of the Philippines. Since the cooling water discharge was a very key safety feature for the power plant, the specification for the spiral wound pipes were determined to be a pipe diameter up to 2.8m with ring stiffness of SN8 and SN12.5. PE100-RC material was selected for the project due to its excellent balance of superior bi-modal stress crack resistance and consistent high stiffness modulus. In this paper, the authors describe material selection, the profile design, production trial, pipe jointing and on-site installation for the spiral wounded pipe. It is shown that a 10% in material saving from the use of PE100-RC material as compared to standard PE material, with no change in the targeted ring stiffness. In addition to contributing to a significant reduction in overall production costs, the material savings also enable the finished product to be lighter and hence, easier to transport and install.

ID164

ACCEPTANCE CRITERIA FOR VOLUME DEFECTS IN WELDED ASSEMBLIES, DETECTED AND SIZED USING THE PHASED ARRAY ULTRASONIC TECHNIQUE

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Phased Array Ultrasonic Technique (PAUT) is currently recognized as the reference technique for non-destructive evaluation of electro welded assemblies. Therefore, over the past five years, CRIGEN has managed a research program comprising various test campaigns both on assemblies recovered from the field and on lab specimens. The primary aim of these campaigns was to evaluate the accuracy of the technique, on the one hand in terms of the detectability of defects mainly located at the pipe-fitting interface and, on the other hand, in terms of the sizing of detected defects. Moreover, an attempt was made to correlate the proportion and distribution of surface defects with the results of peel decohesion tests; but the low sensitivity of these mechanical tests made it difficult to establish a reliable link between the energy required for decohesion and the distribution and proportion of the surface defects. Now the implementation of acceptance criteria for defects – either surfacic or volumic - in welded assemblies requires the establishment of strong correlations between PAUT data and mechanical tests capable of representing long-term performances. But to date, an extremely limited number of relevant studies have been published in this field and the subject is still a matter of debate, as seen during the NDT workshop of the Plastic Pipes XVIII. Consequently, CRIGEN has launched a new campaign in 2016 focused on the volume defects, with the two-fold aim of confirming the accuracy of PAUT for the detection and sizing of volume-type defects implanted in a pipe- saddle electro welded assembly on the one hand and evaluating the harmfulness of volume defects on the mechanical resistance of assemblies through hydrostatic pressure testing on the other hand. For this purpose, four pit-shaped defects were hot-machined in the heating area of a 63 mm saddle at three different locations (outer, middle and inner crown). For a given configuration, the defects had four different heights in the saddle body. PAUT examination during the welding cycle allowed evaluating the changes in height of the defects. X-ray tomography analysis was used to complete the PAUT evaluation and to evaluate the final shape of the implanted defects. Hydrostatic pressure testing was then applied to the welded assemblies up to failure, with regard to the NF EN standard requirements. Finally peel tests were carried out in order to confirm the crack paths. This study reveals the good reliability level of PAUT in detecting and sizing the volume defects in the saddles on the one hand, and the fair correlation existing between PAUT and X-Ray Tomography as a complementary technique on the other hand. The hydrostatic pressure tests do not reveal any detrimental influence of the defects on the mechanical resistance of the welded assemblies in these laboratory conditions.

ID105

PE100 LARGE DIAMETER WATER TRANSMISSION PIPELINES TAKE OFF IN ASIA

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Since they came in to common use in the 1960's the maximum diameter of solid wall polyethylene pipe systems has gradually increased due to improvements in material technology and pipe extrusion machinery. PE100 pipes are now produced in sizes of up to 2500 mm OD, but until recently the use of sizes above 630 mm OD has been limited to industrial and specialized applications such as cooling water pipework, seawater intakes and outfalls.

However, the increasing number of large diameter PE pipe extrusion lines across Asia and the development of extra low sag PE100 grades has both lowered costs and provided water utilities across the region with access large diameter PE pipelines. This together with a better appreciation of the low whole life cost benefits of PE pipe systems has led to a greater adoption of PE for water transmission pipelines for sizes above 630 mm OD.

The paper will discuss the above points in general along with examining in detail two recent large diameter water transmission projects that have been undertaken in the United Arab Emirates and Pakistan. These 1200mm and 1400mm OD projects, with a combined length of over 110 km and have been laid in challenging environments, both in terms of terrain and climate. Both were also designed using a range of pipe SDRs to meet operational pressures whilst minimizing material use and hence cost. The paper will look at the designs in detail along with discussing lessons learnt from each project.

ID182

INCREASING HDPE BUTT FUSION PRODUCTIVITY BY OPTIMIZING THE COOL TIME BASED ON THERMAL MASS CHARACTERISTICS WITHOUT COMPROMISING JOINT STRENGTH

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High density Polyethylene pipes are used in various industries due to its superior chemical compatibility, pressure capability, and flexibility. For the material to perform at the optimal design criteria, the fusion must be performed to allow for the polycrystalline structures to properly form as to achieve appropriate mechanical, chemical, and structural performance. A slower cooling rate at higher temperatures could cause the joint to be at an unacceptably high temperature during removal from the pipe fusion machine which induces yielding stresses on the joint. Standards related to the fusion procedures of this material specify that the ambient conditions should be considered during fusing but do not recognize, in detail, the influence of ambient temperature. This work reviews the increased or decreased cooling rates at higher and lower than normal ambient conditions as well as correlates cooling rates with the short and long term mechanical properties of the PE 4710 material. This work also explores the effects of diameter and wall thickness on the cooling rates as well. The trend shows that the cooling rate of a high-density polyethylene pipe is affected by the ambient temperature by up to 9 seconds per degree Fahrenheit ambient temperature.

ID181

LARGE PRESSURE PIPE SYSTEM – FULLY PE100

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Global mega trends push for investments in sewage treatment capacity & efficiency. A trend is to go for central regional treatment sites, typically remotely located from dense populated cities. This calls for high capacity pressure sewage transmission pipelines. Reliable operation is of course of paramount importance for the circular urban society.

Sweden's currently biggest infrastructure project is a green field project for new regional sewage treatment centre and transmission pipeline. Initially project faced a challenge; how to combine big diameter pipeline with varying topographic and ground conditions, on tight budget? GRP was first considered but was dropped in favour of PE100.

PE100 flexibility and weldability made the difference. Notable is that also selection of ancillary equipment typically produced from stainless steel etc., were here replaced with components machines out from PE100 solid hollow bars and finally welded. This concept was enabled by involving an extended team of expertise. Altogether this new smart concept made the final choice easy for the project team.

Two parallel 1000mm SDR17 PE100 pipelines, >500 welds, PE100 stub ends, electrofusion couplers, degassers, etc. All PE100 and 100% welded.

Key learning; success calls for co-operation between different providers. PE100 proved being the choice for big diameter piping and tailored solutions.

ID197

QUALITY ASSURANCE ON WELDED JOINTS WITH THE MECHANISED LINEAR SHEAR TEST (LST)

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Testing the quality of welded joints in plastic pipe systems is of essential importance, especially in the field of water and gas supply. Currently used test methods for characterizing the mechanical properties of electrofusion and heating tool socket welded joints are mainly manual test methods which do not produce a mechanical characteristic value, e. g. the torsion shear test or radial peeling test. The assessment of the welding zone is done with the naked eye of the operator. Furthermore, these test methods can unintentionally be influenced by the operator.

In cooperation with WIDOS GmbH SKZ developed a testing apparatus for determining the mechanical properties of electrofusion and heating tool socket welded joints with the mechanized linear shear test (LST). Parallel prepared samples from the welding zone are loaded with a linear shear force in the test application. Two hydraulic clamping devices fix the sample. One clamping device fixes the pipe section of the sample and the other one fixes the fitting/coupler section of the sample. An electronic powered linear device moves the upper clamping device and shears the sample. The LST-apparatus allows the recording of the force as a function of the extension/shear length.

The LST has proven to be a reproducible test procedure for the assessment of electrofusion and heating tool socket welded joints. It is very suitable for detecting defects in electrofusion and heating tool socket welded joints. In addition to frequent and obviously incorrect preparations it was possible to detect defects which with the manual radial peeling and torsion shear tests could not be recognized at all, like e. g. contaminations of the welding surface or incorrect welding parameters. Due to its reliability the LST allows the optimization of welding parameters and further developments (e. g. testing of glued connections).

ID195

DEVELOPMENT OF LARGE-DIAMETER CONTINUOUS-FIBERREINFORCED THERMOPLASTIC PIPE

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The market of water-delivering pipes-large-calibre (>1000mm), medium and low pressure (0.4—1.6MPa) is very attractive. Glass-Fibre-enhanced PE composite pipe (CGF-PE) has significant technical and economic advantages such as high stability and reliability, high pressure-bearing capacity, convenient and secure socket connection, low production cost.

This article introduces the Manufacturing process of CGF-PE pipe through its structural design, strength calculation, connection technique, manufactural technique and production equipment. A special device for pre-fusion of multi-layer fiberglass tape and on-line fine-processing of socket joints, which is also presented in our patent application, is designed to greatly improves the production efficiency, ensure the consistence of pipe wall performance and secure the socket connection. Because of difficulties to evaluate long-term strength value of composite pipes (MRS) and calculate universal representative value, our emphasis is on testing basic design value of long-term hydrostatic pressure and taking it as a measure of testing the long-term strength and running a simulation test of CGF-PE pipes. As a result, an ideal solution for the long-term application of composite pipes is also explored.

ID223

INVESTIGATION OF THE FAILURE BEHAVIOR OF POLYETHYLENE ELECTROFUSION SOCKETS

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Electrofusion-sockets (E-sockets) constitute a well-established and practically proven technology for the joining of polyethylene (PE) pressure pipes. As for the pipes, the potential lifetime of such welding connections is highly depending of the resistance of the E sockets against slow crack growth (SCG). Based on laboratory tests it is known that brittle cracks typically initiate in the cold zone between the pipe and the socket and finally lead to brittle failure of the pipe connection.

Within the presented paper a study of the brittle failure behavior of E sockets is presented. Internal pipe pressure tests on E sockets made of two different PE pipe grades, in two different dimensions and provided from two different suppliers were conducted under higher pressure to create brittle failure. A first test run focused on the development of failure curves in order to interpret the failure behavior of the different dimensions and suppliers. The results show, that the only influence is given by the used material where E socket materials with a higher SCG resistance in short term tests also show longer failure times in the pressure tests. In order to investigate the characteristics of crack initiation and crack propagation, in a second test run the pressure tests were stopped after different times but before failure. After testing all E socket samples were systematically analyzed optically with light and scanning electron microscopy to investigate the characteristics of crack initiation and SCG.

Parallel to the pressure testing, for one of the investigated PE grades a fracture mechanical material law for SCG was determined. Furthermore, a model for the stress intensity factor characteristics in E-sockets was developed by finite element methods (FEM). To increase the reliability of the FEM-model, the experimental findings from the optical analysis of the failed E sockets were considered. The generated results demonstrate that with the fracture mechanics approach a reliable prediction of minimum lifetimes of E sockets is possible

ID196

PERFORMANCE OF LARGE MARINE HDPE PIPES DURING THE SUBMERSION AS BASED ON LABORATORY TESTING

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Solid wall HDPE pipes have been used for marine applications in Europe since the 1960-ties. The sizes of solid wall PE marine pipes have been steadily increasing over the years and the maximum size today is OD2500 mm.

Large marine HDPE pipes are usually of SDR-class 26 or 30 and design inputs may differ. Since large diameter HDPE pipes have relatively high SDR ratings, it will in principle be the risk of buckling failures at installation which will set the design limitations. S-bend submersions of large diameter HDPE pipes are critical and thus require detailed studies to ensure a safe installation.

Several factors are crucial for the optimum choice of marine HDPE pipe and these include: pipe SDR, type of HDPE raw material, ballast blocks setup and internal pressure. The stiffening effect of the ballast blocks during the bending is of special interest since most of the existing data is based on the research done in 1930ies on metallic pipes.

A test rig for bending of HDPE pipes was therefore developed with the goal to simulate the bending of the pipes and extract data related to different pipe setups in a smaller scale. The test setup can include various combinations of the above-mentioned factors and tests can be performed on many different combinations. The results can then be scaled up to simulate performance of large diameter HDPE pipes.

Obtained test results gave a better understanding of the failure mechanisms as well as pipe behavior under different setups. Data obtained was: stress and strain in the pipe, creep modulus, out-of-roundness at bending, speed of failure, buckling radius at bending, influence of SDR-ratio, stiffening effect of ballast blocks and others.

The conclusions based on the obtained test data are presented in this paper.

The value of this testing is of particular importance to the marine contractors since design limits of the pipe are better known and uncertainties are reduced, which could result in a better optimization of their processes and cost savings.

Test data can also be used in detailed analysis of the pipe in various FEA programs to quickly simulate many possible options with greater precision and thus increasing the overall safety.

Designers can also use test data to evaluate what pipe is most suitable for their project and to make informed decisions on pipe material selection.

ID183

STUDY ON PARAMETERS AFFECTING DURABILITY OF POLYETHYLENE PIPES FOR HOT WATER APPLICATION

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Hot water distribution pipes connecting a gas cogeneration system with the water heater and terminal appliances are expected to high durability at present. There are mainly two lines for the hot water distribution system. A single pipe is used for water and hot water supply, and a double pipe for circulation of hot water is used for such as central heating, floor heating, and bath water heating.

The hot water circulation test with partial replacement of fresh water which is reflected to the actual operating condition is a useful test method. The hot water circulation test using metal ion containing aqueous solution for central heating is also suitable as the accelerated evaluation test for polyethylene pipes. The pressurized hot water circulation test using chlorine aqueous solution for water and hot water supply is the accelerated evaluation test. It was clarified that parameters such as temperature, pressure, and concentration of aqueous solution of copper ion and/or chlorine ion affected durability of polyethylene pipes for hot water application.

Various additives such as two kinds of polysilane and a nucleating agent as well as antioxidants were mixed to prevent the thermal degradation of polyethylene pipes at the elevated temperature. As a test results, the time to failure of polyethylene pipes mixed two kinds of polysilane was longer than that of a polyethylene pipe without additives. The time to failure of polyethylene pipes mixed a nucleating agent was similar to that of a polyethylene pipe without additives. According to precise observation at the failure part, it was found that there was a small degraded colored layer at the inner surface of polyethylene pipes mixed two kinds of polysilane compared with polyethylene pipes without additives. In addition, it was found that the generation and the growth of degraded colored layer and small cracks was delayed due to diffusion of polysilane to the inner surface and to protection of adhesion of metal oxides such as copper oxide and iron oxide at the inner surface.

ID111

NEW PROCESS FOR THE HOT FORMING OF THE INTEGRATED SOCKET ON UNDERGROUND DRAINAGE PIPES MADE OF HIGH MODULUS POLYPROPYLENE WITH A COMPACT OR MULTILAYER WALL STRUCTURE

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In the underground drainage pipe sector, the integrated socket technique is used widely with solid or multi-layer wall PVC-U pipes. By contrast, this joint type is rarely used in PP and HDPE pipes, despite its recognized advantages. The main reason is the difficulty of designing a process for hot-forming the socket that can also be implemented industrially in extrusion lines.

Nevertheless, the use of PP high modulus, i.e. PP-HM, underground drainage pipes is becoming increasingly widespread, while improvements in material formulations typical of multi-layer wall structures mean that this technique is ideal for producing pipes with a ring stiffness up to SN16, with 500 mm and greater diameters. For these types of pipes, the ability to hot-form integrated socket with a reliable, repeatable process that is compatible with extrusion lines capacities is fundamentally important to ensuring that these pipe systems have efficacy levels that can only be achieved via the use of integrated sockets, as is already the case for corresponding PVC-U pipes.

During the socketing process, many physical phenomena that affect the pipe must be managed: thermal state of the pipe end to be socketed, plastic deformation of the socket shape, calibration of the socket's internal dimensions with respect to variations in the extruded pipe's dimensions and stability of the socket's shape and dimensions over time. The socketing processes for producing PVC-U pipes are not applicable to PP and HDPE pipes, since the physical behaviors of the latter are radically different from those of PVC-U pipes.

As noted in this study, a new thermoforming process has been developed recently for socketing large diameter and thickness underground drainage PP and HDPE pipes with solid or multi-layer structure walls.

ID145

UNIMODAL MDPE (PE 2708/PE 80) PIPE MATERIALS SIGNIFICANTLY IMPROVE ABRASION RESISTANCE IN SLURRY FLOW APPLICATIONS

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SUMMARY
Polyethylene (PE) pipe is a frequent choice for transporting slurry solutions. It has proven to have superior wear resistance to many different materials. For example, when carrying fine grain slurries, polyethylene pipe has been shown in laboratory tests to be three to five times more wear resistant than steel pipes[1]. Abrasion resistance of plastics is dependent on numerous factors – the nature of the plastic, surface roughness, lubricating agents, load, material hardness, and others. Contrary to intuitive belief, abrasion resistance of plastics does not correlate directly with hardness. Test data will be presented to show that unimodal medium-density (MDPE) pipe provides at least 30% greater abrasion wear resistance compared to other high-density (HDPE) pipes tested, translating to longer service life in these applications.

BACKGROUND
Slurry particles wear down pipes through impingement. When particles bounce off or slide along the inner surface of pipe, the particles start mechanically eroding the pipe. Surry abrasion can occur through mechanical erosion, chemical effects of slurry, and through additional synergistic affects between the two. There are three proven ways of quantifying or measuring slurry abrasivity and slurry abrasion resistance and how these components contribute to the overall slurry abrasion of a material. These are the Miller Number, the Gold Number, and the Slurry Abrasion Response (SAR) Number.

RESULTS
Testing was performed to measure the resistance to wear due to slurry abrasion of three different types of polyethylene pipes at both ambient temperature (73°F) and at elevated temperature (140°F). The testing was conducted per ASTM G-75 Standard Test Method for Determination of Slurry Abrasivity (Miller Number) and Slurry Abrasion Response of Materials (SAR Number). Test data will be presented to show that unimodal MDPE pipe provides at least 30% greater abrasion wear resistance compared to other PE pipes tested. The data also suggests even greater abrasion wear resistance at elevated temperatures. In summary, the unimodal MDPE pipe is expected to perform very well in slurry flow applications and is indicated to be a better choice than other polyethylene pipe materials due to its better resistance to abrasion.

ID175

INNOVATIVE MILLIMETER WAVES TECHNOLOGY FOR MEASURING DIAMETER, OVALITY, WALL THICKNESS, AND SAGGING OF LARGE PLASTIC PIPES

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Technical innovation at the manufacturing of plastic pipes with diameters from 90 to 3,200 mm and large wall thicknesses lead to impressive progress in product quality and reduction of material costs. Norms precisely define the minimum and maximum permissible diameter and wall thicknesses of a specific pipe dimension and require repeatable processes. To meet these standards and growing demands in the pipe extrusion requires the use of innovative measuring and control systems already in the production process.

This paper introduces a new technology based on millimeter waves. It provides a non-contact, non-destructive, online measurement of inner and outer diameter, ovality, wall thicknesses and sagging (sagging of the melt during solidification at a too high viscosity) of large plastic pipes during the extrusion process.

The measurement via millimeter waves technology is based on the FMCW (Frequency Modulated Continuous Waves) runtime method. One or two constantly rotating transceivers continuously send and receive frequency modulated millimeter waves thus ensuring the complete recording of the wall thickness over 360 degrees of the entire pipe circumference. From the runtime difference the inner and outer diameter, ovality, wall thickness and sagging is defined. The measuring principle does not require any coupling media and is not influenced by temperature or the plastic material. There is no need for calibration.

In the paper we will at first outline the reasons for the development of the system with regards to the demands of the market. We will introduce the new technology as well as the functional principle, technical features and advantages of the millimeter waves technology for the user compared to other available measuring methods. The technology presented leads to repeatable and optimized production processes, increased product quality and cost savings for higher efficiency during pipe extrusion.

ID205

ASSESSING THE REMAINING SERVICE LIFETIME OF PE PIPES: AN AUSTRALIAN CASE STUDY

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Polyethylene (PE) pipes have been used in gas distribution networks worldwide for nearly half a century including in Australia. Over the years several different grades of PE have been used, resulting in a mix of types in service; these include a vintage high-density grade used extensively in parts of Australia, a medium density grade more commonly used in Britain and currently a bimodal high-density PE grade termed PE100 being used for new installations. A key question facing pipeline assets owners and operators is understanding the remaining lifetime of in service pipes across these different grades. A new test method, the notched cyclic load test, was developed to determine the slow crack growth performance of pipe samples retrieved from different locations in Australia and with different service histories. The test method utilizes cyclic loading applied to a rectangular test specimen with a side notch. A key benefit is that samples can be sectioned directly from the pipe wall. This test was combined with oxygen induction measurements to show that the samples have a consistent trend between time to failure under cyclic loading and resistance to oxidation. Both service location and service age of the pipe were found to be relevant variables. The findings here are likely to reflect the situation in pipe service life and pipe degradation worldwide.

ID184

C-PVC-O, PUSHING LIMITS BEYOND IN MOLECULAR ORIENTATION

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Thanks to the developments reached during the last years, PVC-O technology is ready to provide the market with the best solutions for water transportation, enlarging the product range in this material. PVC-O pipes have the same limitation regarding temperature as PVC-U pipes have. The allowable operating pressure (PFA) for temperatures of the fluid to be transported above 25º C shall be calculated by applying a supplementary derating factor fT to the nominal pressure (PN).

By applying Molecular Orientation principles to C PVC, we want to achieve a product with all the advantages that traditional PVC-O pipes have increasing, at the same time, the resistance to high temperatures that PVC-O pipes have presented till now.

Molecular Orientation technology has been adapted to the product specifications and changes in its design have been implemented; work in the formula of the chlorinated poly (vinyl chloride) was also required to be able to apply Molecular Orientation to this kind of pipes. The first samples of C PVC-O manufactured pipes have been under test and preliminary results have been obtained. This paper is about the technological adaptation requirements due to high temperatures and about the tests results for the characterization of this new material; also, about an overview of the potential of this new material in different scenarios.

The company commitment to R&D and the continuous innovation program allows us to introduce for the first-time oriented chlorinated poly (vinyl chloride) (C PVC-O).

ID193

INCORPORATION OF RECYCLED HDPE TO PE100 RESINS FOR PIPE APPLICATIONS

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In recent years, due to the growing global concern for waste generation and the consequent environmental impact, the search for sustainable and clean products and services has increased. This has resulted in the development of a new concept of economy, referred to as "circular economy", where the value of products, materials and resources is maintained in the system as long as possible.

As part of this model, the utilization of recycled plastics has been proposed. High-density polyethylene (HDPE) is one of the most widely used plastic in the manufacture of non-pressure and pressure pipes. Depending on the structural requirements and loading conditions of polyethylene pipes, recycled HDPE can be introduced blended with a HDPE virgin resin that enhances the final properties of the recycled resin. In this way, new applications to post-use HDPE are provided, obtaining a long-term performance product, which contribute to the standards pursued by the circular economy.

The potential of using recycled HDPE from various sources and with different properties in the manufacture of polyethylene pipes has been evaluated in this work. Blends have been prepared containing up to 50 wt % of recycled HDPE, using a PE100 virgin resin for the remaining portion. All blends were characterized in terms of molecular and mechanical properties. Besides, two important mechanical properties in the development of polyethylene pipes, the Slow Crack Growth (SCG) and the Rapid Crack Propagation (RCP) resistance, have been investigated. SCG resistance is measured through the Pennsylvania Edge-Notch test (PENT test – ASTM F1473) while RCP resistance can be evaluated with the Plane Stress Impact Energy (PSIE) in thin Charpy impact specimens (ASTM F2231) due to the good agreement with the typical S4 test (ISO 13477).

ID248

EXTRUSION TECHNOLOGY

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Big Data in Pipe extrusion
In the market of PVC-O now the use big data and industry 4.0 is a common next step. The next step in the rest extrusion industry is complete pipe extrusion factories changing to this level. It is not only automating the process as much as possible, it is also listening to the customer and helping the customer controlling the process of extrusion nowadays with lower technological know-how on the work floor.

Cost price of pipe production
What is influencing the cost price of pipe production. By collecting a lot of data and a transparent overview of all information in a pipe producing factory, this presentation gives a clear view how to lower the cost price on an extrusion line. This is not only technology but also production technology, habits etc.etc.

Quality Control and Cost control
Cost control is major issue in pipe production. With Big data, the combination of Cost Control and Quality Control gives a clear view how to manage this. The next steps are coming, the first pipe producing factories have telephones to control the production by using APP's. What will happen in the nearby future? This presentation explains what are the next steps in the nearby future in pipe extrusion, independent from material. For different materials to extrude, highlights are given.

ID167

EXTRUSION OF THICK WALL PIPES USING A NEW BIMODAL PE 4710/PE 100 RESIN

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Use of large diameter, thick wall polyethylene (PE) pipes is on the rise globally due to the growth in municipal and industrial water applications. Extrusion of large diameter and especially thick wall pipes (>2-inch wall) presents a challenge to holding the dimensions within the stringent dimensional specifications required by the standards. This is due to the sag (slump) caused by insufficient resin melt strength as the pipe exits the die and travels through the vacuum and the cooling tanks. Careful design of the polymer structure is required to overcome this melt strength limitation, while maintaining the high physical properties required for PE4710/PE100 rated pipes. For commercial pipe production, selection of the right resin and optimal processing conditions (cooling profiles in particular) are both therefore required to minimize sag without introducing excessive residual stresses in the pipe wall. In this work, extrusion of 24-inch DR 7.3 pipes using a new bimodal, high density polyethylene (HDPE), PE4710/PE100 rated resin with excellent sag resistance will be discussed. Cooling analysis was done using chill WARE software utilizing the thermo-physical properties of the resin. Simulation results and comparison with measured process temperature data will be presented. The influence of the cooling process on the predicted residual stresses and resistance to sag are determined. Analysis of pipe quality will also be discussed, along with key observations and conclusions.

ID126

SLOW CRACK GROWTH RESISTANCE OF NON-VIRGIN POLYMERS

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For economic and ecological reasons, the use of non-virgin polymeric materials for structural applications becomes more and more important. The dominating polymers for manufacturing of piping systems are polyethylene (PE), polypropylene (PP) and polyvinylchloride (PVC). Especially in the field of non-pressure applications, during the past years the international piping industry has put additional attention to an in-creased use of non-virgin reprocessed or recycled materials. For non-pressure pipes a minimum lifetime of 100 years will be required in future. Resistance against slow crack growth (SCG) is known as the most critical failure mechanism for long term pressure pipes. Compared to virgin materials, in non-virgin materials different effects are responsible for reduced SCG resistance such as impurities, polymer inhomogeneity or material degradation. Hence, a detailed knowledge about the SCG resistance of the used material is of essential importance for lifetime assessment. The current paper investigates the SCG resistance of different non-virgin PE, PP and PVC grades with the Cracked Round Bar (CRB) Test according ISO 18489. It is demonstrated that the SCG resistance is clearly lower than compared to virgin materials. These results are accompanied by optical fracture surface analysis in order to identify polymeric and inorganic impurities as two of the main reasons for decreased SCG resistance. To investigate effects of polymeric impurities in more detail, in a second step laboratory material were designed by a well-defined mixing of a PE-HD and a PP pipe grade in nine different ratios. The data show that already a very low amount of PE in PP and vice versa reduces the SCG resistance significantly. The current paper demonstrates that the CRB Test is a quick and sensitive method for the characterization of the SCG resistance not only for PE but also for PP and PVC. Moreover, it shows that already a small amount of a polymeric impurity has a big impact on the long-term relevant resistance against SCG.

ID192

PERFORMANCE EVALUATION OF COUNTER-ROTATING CONTINUOUS MIXER AND CO-ROTATING TWIN SCREW EXTRUDER FOR HIGH DENSITY POLYETHYLENE

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Bi-modal high-density polyethylene (HDPE) has become more popular in recent years, because it achieves both easier processability and higher mechanical strength. The easier processability is brought from low molecular weight component and the higher mechanical strength is brought from high molecular weight component in the bi-modal HDPE. On the other hand, it is difficult to disperse clusters of high molecular weight component (gels) by fluid of low molecular weight component. When the gels are not dispersed well, it causes problems in products such as fish eyes in films and white spots in pipes. Therefore, technique to disperse gels is very important. In this study, we investigated dispersive mixing performance of counter-rotating twin screw continuous mixer LCM-H and co-rotating twin screw extruder KTX by experiments and simulations. Furthermore, we developed new mixer LCM-IM (LCM-Intensive Mixing) to improve the performance.

In the mixing experiments, LCM-100 whose barrel diameter was around 100mm with gear pump and KTX-30 whose barrel diameter was around 30mm were used. Bi-modal HDPE for pipe grade with carbon black was used as an experimental material and mixed under various conditions. The mixed samples were evaluated by white spot area rate (WSA, %) which is one of the typical index for evaluating state of white spots in mixed samples for black pipe. The WSA was obtained by observation of sliced samples using reflected light optical microscopy with image analyses. The WSA against specific energy input (SEI, kWh/kg) for each mixing condition was organized. From the results, it is found that LCM dispersed gels better than KTX under same SEI.

Furthermore, we also performed numerical analyses around molten mixing zones to interpret the results of the experiments. In order to express partially filled fluid flow in the mixers, we employed our original flow simulation based on mesh-free method. Average residence time and stress of polymer in mixing zones were focused on to explain the results of experiments and we proposed that only residence time in which fluid get stress over threshold value is effective (effective residence time) for the gel dispersion. It was showed that effective residence time explain the results of experiments well. It was also found that LCM-IM has larger effective residence time than LCM-H.

As a conclusion, the gel dispersive mixing performances of mixers have become clear by experiences and we found that effective residence time is important factor to evaluate gel dispersive mixing.

ID191

CHARACTERIZATION OF POST-USE POLYETHYLENE AND POLYPROPYLENE RECYCLATE BLENDS FOR PIPE APPLICATIONS

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Despite recent efforts in promoting the utilization of recycled polymeric materials for more diverse and more advanced applications, there are still significant knowledge gaps with regards to the applicability of certain recycle types for specific "re-use" purposes. When it comes to pipe applications, for instance, a considerable body of work exists on recycled polyvinylchloride (rPVC), however, systematic investigations of mechanically recycled polyethylene (rPE) and polypropylene (rPP) for structural performance applications such as pipes are still rare. Especially studies of the resistance against slow crack growth, which is a highly relevant failure mechanism of pressurized plastic pipes, are lacking for rPE and rPP. This is particularly true for blends of rPE and rPP, which are of high practical relevance not at least due to cost advantages over mono-fraction recyclates.

In the present work two rPE and two rPP grades originating from post-use sources such as bottle caps, extrusion blow molded objects and injection molded items were analyzed together with six PE-PP recyclate blends produced from these four base recyclates. The recyclate blends differed in the rPE-to-rPP-ratio and the amount of calcium carbonate additive used in the recyclate compounding and blending step. Composition and molecular characteristics of both post-use base recyclates and recyclate blends were investigated using Fourier-transform infrared (FTIR) spectroscopy, differential scanning calorimetry (DSC) and thermo-gravimetric analysis (TGA). A subsequent mechanical characterization based on concepts of linear-elastic fracture mechanics (LEFM) was performed using compact-type (CT) specimens to determine the crack growth resistance of the various recyclate materials under cyclic loads. Small amounts of legacy substances were detected in both rPE and rPP. In terms of crack growth resistance, clear rankings of the materials were derived, with the recyclate blends being inferior to the neat rPE or rPP materials.

ID169

EFFECT OF CARBON BLACK DISTRIBUTION ON POLYETHYLENE PIPES

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Carbon black (CB) has been used as a perfect and the cheapest solution to prevent photo degradation of polyethylene against UV light exposure. Effect of carbon black on the mechanical properties of polyethylene was studied extensively, but only on well dispersed and distributed carbon black polyethylene composites. In this article, we have investigated the effect of carbon black distribution on tensile properties of high density polyethylene in the form of plastic pipes used for water distribution networks. Polyethylene pipes with similar carbon black concentrations but different levels of carbon black distributions were produced by industrial scale compounding and extrusion equipment. Tensile specimens were prepared directly from pipe and butt fusion welded samples and elongated to fracture. Carbon black distribution of bulk samples and fracture surfaces were investigated with stereo and scanning electron microscopy. It is found that tensile properties, fracture surfaces and fracture modes are significantly different on these pipes depending on carbon black distribution.

ID135

SUSTAINABLE CONSTRUCTION – ENVIRONMENTAL IMPACT ANALYSIS OF INTEGRATING RECYCLED HDPE INTO CORRUGATED PIPING

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In 2014, the Plastics Pipe Institute (PPI) commissioned Franklin Associates to evaluate environmental impacts associated with the production and use of several types of corrugated municipal pipes for use in the following applications: water main, force main sewer, and storm water drainage. Expanding on the baseline impacts of storm drainage established by this cradle-to grave life cycle assessment (LCA) for virgin feedstock, corrugated HDPE manufactured with recycled resins was added to compare the impacts of virgin to recycled feedstock for storm drainage applications. As HDPE is a thermoplastic, when heated, its polymer chains disentangle allowing for reprocessing indefinitely until the polymer material loses its structure integrity. North American standard specification bodies, such as ASTM and AASHTO, are actively considering the expansion of existing virgin resin corrugated HDPE pipe standards to include recycled resins. It's currently estimated that nearly a billion pounds of recycled resins are being incorporated into corrugated HDPE pipe. New standards allowing use of recycled HDPE drainage pipe within the public right-of-way are expected to increase these quantities. This shift in recycling presents an opportunity for design engineers and public utility agencies who are seeking to reduce their overall environmental footprint associated with their storm drainage project.

Improving the baseline: Incorporating recycled HDPE into the mix
Criteria for evaluating PCR use in corrugated HDPE drainage pipe:
1) functional unit – Identical performance characteristics over the 75-year life-span of the installed pipe.
2) Materials used – Selected blend mixes to optimize performance in terms of its mechanical properties and durability
3) Recycled Content – The ratio of virgin HDPE to PCR HDPE (0%, 25%, 50%)
4) Ease of Adoption – Polymer blends do not require any equipment modifications to the standard extrusion process
5) Extrusion process line rates – energy consumption of different recycled content ratios
6) Potential for Recyclability
7) Recycling and Recovery Processes

Environmental Impact Results Summary
Reducing the use of virgin HDPE as feedstock, and, supplementing the blends with PCR HDPE results in significant decreases in the overall environmental impacts realized over the life time of the piping system.

ID206

PRODUCTION OF POTABLE WATER PIPES FOR CHILE USING THE INLINE EXTRUSION PROCESS

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A successful cooperation between Centro de EStudios de MEdición y Certificación de calidad (CESMEC), pipe producers and LyondellBasell has resulted in an allowance within Chile for the use of natural resin plus black masterbatch for the inline extrusion production of potable water pipes. Inline extrusion involves the blending of natural (unpigmented) pellets and black masterbatch pellets, at a specified ratio, where the processing occurs in the extruder producing the pipe. In a 2011 meeting between CESMEC and seven pipe producers in Chile, it was communicated that the inline extrusion process would be allowed if test data confirmed that pipe made from this process met the requirements of the Chilean normative NCh398/1. CESMEC also stated that their policy is to allow customers to compete on equal terms. This paper discusses the cooperation between the regulator, pipe producers and a resin supplier to manufacture inline extruded pipe and demonstrate the ability of two different formulations of natural resin plus black masterbatch to meet the material and pipe properties of NCh398/1. Data demonstrating performance of the inline extrusion produced pipes will be provided as well as a comparison of acceptable and unacceptable methods for blending the natural and black masterbatch pellets prior to inline extrusion production of pipes.

ID154

NEW CROSSLINKED (PEX) PIPES FROM SUSTAINABLE RESOURCES

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Evolution of new technologies demand the use of sustainable resources across various platforms. Bioplastics and sustainable polymers have entered the plastic industry; however, the growth is less than 10% of the total plastic market. Crosslinked polyethylene (PEX) tubing continue to gain popularity in plumbing and indoor climate applications around the globe. An approach to increase the sustainability of PEX tubing is to produce them using high density polyethylene derived from sustainable resources. Here, a method for producing a high strength, flexible PEX tubing from such a material will be discussed.

In this study, PEX pipe produced using high density polyethylene derived from sustainable resources will be discussed. The new resin characteristics will be compared to other similar resins derived from petroleum resources. Observed difference in crosslink density was found to correlate with the difference in structure between the resins tested.

Production of bio based PEX tubing was investigated via several twin-screw extruder technologies. Short term testing's performed on the new pipes indicates that the pipes produced meet or exceed the requirements set by the vigorous industrial standards described in ASTM and ISO, such as excessive hot/cold pressure requirements, and environmental stress crack growth resistance (ESCR) tests. Sustainable PEX pipe performance comparison against pipe produced from petroleum derived resources is included in this evaluation. The pipes produced are flexible, easy to install, sustainable, and meet the codes and standard requirements for installation in new energy.

ID161

TAKING POLYETHYLENE (PE) PIPE TO NEW HEIGHTS... AND NEW DIAMETERS!

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Demand for polyethylene (PE) pipe continues to grow on a global basis. The performance properties of this tough, durable piping material are widely recognized by the engineering and design community on a worldwide scale and the range of applications expand. The evolutionary trend in PE piping systems has been very well documented through major advancements in resin technology, pipe extrusion capability, joining mechanisms and installation techniques. With each advance in these critical areas, the breadth of applications for PE piping systems has continued to grow.

The most recent step in the continuing evolution of PE piping systems is the introduction of extremely large diameter (< 3500 mm) conventionally extruded solid wall PE pipe, believed to be limited to 2500 mm currently and wall thicknesses that were once thought infeasible.

This paper will summarize the success and many of the innovations that were required to advance PE pipe production to this latest level. Without advancements in feedstock resin capability and extrusion technology, conventional extrusion of PE pipe in this size range would be problematic. It goes without saying, that extremely large diameter PE pipe requires extremely large diameter fittings and a means of joining those components. Furthermore, those large PE pipes requires a mind-set change on delivery to the job site. This paper will conclude with an overview of some of the applications for which these new extremely large PE pipe systems are preferred as compared to metallic, concrete or even more exotic piping materials. From an understanding of the factors that have contributed to the introduction of these extremely large diameter PE pipe systems, we believe the evolutionary trend for PE will be sustained well into the future.

ID210

PRODUCT ENVIRONMENTAL FOOTPRINT (PEF) METHOD COMPARED WITH ENVIRONMENTAL PRODUCT DECLARATIONS (EPDS)

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The European Commission decided in 2013 to launch a new initiative on how to assess the environmental footprint of products (PEF) and organizations (OEF). Unlike the existing ISO and EN Standards the intension of the commission was to develop a tool which can be used at all kind of products and organizations. A three-year pilot phase has now ended, and we are in a transmission phase lasting till 2020. In the transition phase the experience collected in the pilots will be used for a broader roll out.

The PEF method is seen as a game changer: First of all, there is an environmental benchmark, "the European Representative Product" for each category to which the environmental performance is measured against. Secondly the commission is aiming for a communication not only for B3B business but also for B2C. This aim is very ambiguous and will require a complete new set of communication vehicle which still under discussion and development. The European Commission is for time being still in the process of deciding possible usage of the PEF tool and options discussed are among other as a mandatory tool, a voluntary tool, but mandatory for communication, a tool for eco-labelling or an instrument for Green Public Procurement. TEPPFA has many years of experience in LCA studies assessing the environmental footprint and has during the last 6 years more than 20 EPD's according to EN15804 has been issued. In parallel also as a number of comparative EPD's in which the environmental performance of traditional materials like concrete, copper and ductile iron are compared to plastic pipe systems has been published. For that reason, TEPPFA was selected to lead one of the PEF pilot project: "Hot and Cold-Water supply system".

The PEF method is in many ways different to the currently accepted LCA and EPD's described in various ISO and EN standards: The number of impact categories to report are higher, calculation methods are changed and last but not least: A "PEF compliant dataset" is being provided from the Commission in order to secure that all secondary data are coming from the same source. To understand how the introduction of the PEF system impacts the environmental performance of the plastic pipe systems and how it alters the comparisons to traditional materials TEPPFA has in parallel with the PEF pilot project performed a number of comparisons. These studies have given useful insight in the consequences of the implementation of the PEF method.

ID120

MULTILAYER POLYMER PIPES – POSSIBLE UTILIZATION OF RECYCLED MATERIAL

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Recycling of polymer material used for pipes has become an important issue for pipe community lately. According to Calton 2016 (Plastic Pipes XVIII) TEPPFA has made a commitment to use a quarter of million tons of recycled material a year by 2020. EU initiatives will force larger and larger amounts of virgin material to be replaced by recycled material. At the moment, part of recycled pipe material is used for non-pipe applications and part for non-pressure applications. According to current regulations, recycling is not allowed at all for pressure piping systems.

One way of making the application of recycled material possible also for pressure piping systems is to use it in multilayer pipe systems. Co-extruded multilayer pipes (with the inner layer made of recycled material) can have very similar durability as conventional pipes. This article investigates possible multilayer pipe design including the numerical lifetime prediction of the multilayer system. It is reasonable to assume, that the failure of the recycled pipe material will happen in similar manner as in the virgin materials – the slow crack growth mechanism will be the most important. Therefore, previously established methodology can be used to calculate the lifetime. This methodology follows assumptions published in (Hutar 2011, Hutar 2013). Long term material properties (kinetics of slow crack propagation) are estimated from the results of CRB tests. Using numerical simulations based on finite element method, lifetime of the multilayer pipe is predicted. The obtained lifetime is compared with lifetime of the single and multilayer (co-extruded) pipes. The utilization of recycled material in different layers is discussed and optimized multilayer pipe design combining virgin and recycled material is recommended.

ID179

POLYETHYLENE/ALUMINUM/POLYEHTHYLENE COMPOSITE PIPE FOR FUEL GAS APPLICATION

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Traditional metal pipes (e.g. galvanized pipe) have been used for indoor gas conveyance. However, it has the inherent defects of easy corrosion, excessive joints and complicated installation process. Polyethylene/Aluminum/Polyethylene (PAP) composite pipe has the advantages of corrosion resistance, limited joints and convenient installation procedure. PAP pipe in fuel gas conveyance area has been used for over 20 years. It has excellent performance in indoor gas application. Later, a unique method was designed to apply the PAP pipe in outdoor gas conveyance with the appearance of outdoor gas meter setting, which involves the addition of PVC casing pipe as a protection technique to prevent the aging of PAP pipe. The method allows the PAP pipe to be installed along the outer wall of building and get into user's home directly after the connection with outdoor gas meter without having any joints in the middle. Since 1996, the number of users has increased gradually, and it achieves millions level globally today, including Europe, Asia, Oceania, South America and Africa. Issues with quality and performance of using the PAP pipe have not been observed in fuel gas conveyance indoor and outdoor in the past 20 years. In order to promote and increase awareness of this technique in China, we had participated in the development of relevant standard specification, such as national standard (GB50028-2006), industry standard (CJJ94-2009) and association standard (CECS264-2009).

ID232

ENGINEERING AND TESTING REQUIREMENTS FOR INFRASTRUCTURE PIPELINE APPLICATIONS UTILIZING HDPE RECYCLED MATERIALS

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Contrary to most adopted perceptions on the use of recycled HDPE materials in pipe, it is not necessarily the high-end applications – such as sanitary sewers, storm sewers and highway culverts – that require the most engineering scrutiny. Pipes for these applications are typically placed in extremely well-monitored installations with excellent backfill, which results in relatively low stresses on the pipe wall. Land drainage applications, on the other hand, are often placed in poor soils with little or no field inspection. Although this may not be of much concern in a farm field with shallow installation of 100-mm (4-inch) pipe, it is quite a different situation with agricultural trunk lines that can include up to 1500-mm (60-inch) and are often installed in the same manner and with the same backfill materials as small-diameter farm field drainage pipe. The pipe wall stresses in these applications can greatly exceed those in sanitary and storm sewer applications. Since high tensile stresses in the pipe wall can lead to stress cracking in corrugated HDPE pipes, it is important to design the pipes with materials that are resistant to slow crack growth initiation and propagation, both for pipes manufactured with virgin and recycled materials. This paper examines the types and magnitude of stresses associated with various installations and loading conditions and provides recommendations for material performance properties for these pipes, both regards to mechanical properties as well as stress crack resistance. Minimum performance requirements for the un-notched constant ligament stress (UCLS) test are provided for pipes manufactured with recycled materials based on the desired service life and service conditions for the pipes. It also offers suggestions for the required testing protocols to achieve and validate these materials.

ID217

DEVELOPMENT STATUS AND TECHNICAL REQUIREMENTS OF COMPOSITE INSULATING PLASTIC PIPE

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In order to mitigate climate change, recent trends in building design include a low-carbon emission approach, coupled with energy-saving initiatives. For the plastic pipe industry, it is imperative to improve the heat transfer efficiency of the pipe network. Composite insulated plastic pipe has the advantage of corrosion resistance, low thermal conductivity and reliable connections. The application of composite insulated plastic plays an important role in the new and existing heating pipe networks, chemical transport, apartments and central air conditioning.

There are many types of composite insulated plastic pipes. Various plastic pipes are employed e.g., the carrier pipe could be PE-RT, PP-R, PEX-b or PVC. According to the different structure, it can be divided into the traditional three-layer composite structure and the new fiber reinforced flexible composite structure. According to the different forms of bonding, there are bonded pipe systems and non-bonded pipe systems.

This paper expounds the development status of composite insulated pipe in the heating and chemical fields from the aspects of materials, structure and application. Combined with the relevant standards and technical requirements, the performance advantages and the key evaluation methods such as thermal conductivity, axial shear strength and compression strength of composite insulated pipes are discussed.

ID110

GUIDELINES FOR CORRUGATED HDPE PIPES MANUFACTURED WITH RECYCLED MATERIALS FOR HIGHWAY CULVERT AND STORM DRAIN APPLICATIONS

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In 2017, new recommendations were proposed for the American Association of State Highway and Transportation Officials (AASHTO) M 294 standard specification for corrugated polyethylene pipes regarding the incorporation of post-consumer and post-industrial recycled materials into the specification. These recommendations were based on the research and conclusions from two National Cooperative highway Research Program (NCHRP) projects: Project 4-32, "Performance of Corrugated Pipe Manufactured with Recycled Polyethylene Content", published as NCHRP Report 696; and 4-39, "Field Performance of Corrugated HDPE Pipes Manufactured with Recycled Materials", published as NCHRP Report 870. Additionally, the service life prediction model developed on the performance of corrugated HDPE pipes manufactured with post-consumer recycled materials was used to establish minimum criteria for the stress crack resistance properties of pipes manufactured with recycled materials. This model was specifically developed for commuter railroad applications.

This paper will provide a summary of the recommended proposed changes to AASHTO M 294 to incorporate the use of recycled materials into the specification, along with the basis for the proposed revisions. The proposed revisions include new requirements for the stress crack resistance of pipes containing recycled materials, including the development of a new test method; a minimum elongation at break requirement when tested in accordance to ASTM D 638; and an OIT requirement when tested in accordance to ASTM D 3895 to ensure proper stabilization to prevent Stage III failures.

The research projects that provided the basis for these changes spanned 11 years and were budgeted for $950,000, making this the most robust body of research on recycled materials for pipe applications published to date. Over 1000 different tests were conducted on 28 different recycled materials and 75 different blends of virgin and recycled materials. 24 full-scale pipes were evaluated, and the service life prediction model was validated on several full-scale pipes in both the field and laboratory. If adopted, the recommended changes to AASHTO M 294 will result in the incorporation of more sustainable materials into our drainage infrastructure and will have a lasting positive impact on our society.

ID220

TRENCHLESS ADVANCEMENTS IN HDD WITH FUSED PVC

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Large diameter(>300mm) and long lengths (>1KM) have long been the domain of steel pipe in Horizontal Directional Drilling (HDD) applications. Fused PVC has pushed plastic pipes into this size and length by completing multiple pull-ins of lengths of 2.1 M (7020') in horizontal directional drill applications. These lengths have been achieved through meticulous planning testing, and execution. These have been accomplished in diameters of 812mm (32") and 435 mm (17.4"). The planning covered fusing layout, and pipe handling with slip lining into a casing, floating over water, and elevating aerially over protected forests to reach the insertion point

Particular attention is focused on the hard testing done in advance of these record HDD lengths. The pre-installation test approach included the pull heads, the fused PVC pipe and the fusion joint. The testing was done at full scale.

Along with the planning and testing, two projects will be discussed demonstrating the execution of 2.1 KM plastic pipe HDD's.

ID144

THE WORLD'S FIRST CLASS 3 SAFETY RELATED NUCLEAR PE4710 PIPING PROJECT – 10 YEAR REVIEW

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In 2008, through a well-collaborative effort with a number of industry experts from several key companies (a resin supplier, a pipe manufacturer, a pipe fittings manufacturer, a consultant, an engineering contractor and a primary construction contractor), the world's first PE4710 piping project for Class 3 safety related nuclear plant Essential Service Water system was approved by Nuclear Regulatory Commission and successfully completed at AmerenUE's 1,200-megawatt Callaway Nuclear Power Plant in Fulton, Missouri. Approximately 2,000 feet of 36-inch PE4710 pipe (with 4-inch wall thickness) were installed underground at the site in accordance with ASME Code Case N-755. A number of special PE4710 joint fittings at both 45-degree and 22.5-degree angles, were successfully fused to the main pipe components. The two trains in parallel have been in operation without major issues since then.

This paper provides details of this historic project including: background, design requirement, ASME Code Case N-755 development, qualification/manufacture/handling of PE4710 pipe & fittings, installation, timeline and, most importantly, review of AmerenUE's operational experiences with this PE4710 ESW system during the last 10 years. The Pros and Cons including comparison with the traditional ESW carbon steel pipe are discussed.

ID133

SENSITIVITY OF STRAIN HARDENING MODULUS TO MOLECULAR STRUCTURE OF POLYETHYLENE

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Strain hardening modulus has been published as a standard test method (ISO 18488) to differentiate slow crack growth (SCG) resistance of PE100 and PE100RC materials. SCG is a time-dependent brittle-type failure that polyethylene pipes show when under low stress levels. The polyethylene's molecular weight (and its distribution), crystallinity, co-monomer type, concentration (and its distribution), tie molecules and entanglement density are parameters that are known to affect the SCG of polyethylene. The concept of the strain hardening modulus (Gp) proposed by Haward is based on the entanglement density of a polymer structure. Several research groups have investigated how strain hardening modulus was affected by polymer structure. Most of these studies were based on polyethylene samples with a limited range of molecular parameters. In this study, we prepared a range of polyethylene samples of controlled molecular weights, viscosities and strain hardening moduli that are distributed between lowest and highest values with controlled increments. Findings of this study will help scientist and engineers to understand better the response of strain hardening modulus to molecular properties of pipe grade polyethylene materials.

ID137

BIOFILM GROWTH AND THE IMPACT IT HAS ON THE HYDRAULIC CAPACITY OF PIPELINES

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Research was conducted to investigate the hydraulic capacity of aging pipelines and to relate the reduction in hydraulic capacity to the major contributing factors.

The findings of pipe reviews conducted during the research, highlights the following actions which should be considered during the hydraulic design of pipelines:

- Review and incorporate available recorded hydraulic performance data of pipelines in the region in the design of new infrastructure;
- Include the secondary energy loss associated with the dimensional details of the couplings in the calculation of the energy loss in the pipeline;
- Use the proposed BRM (biofilm resistance model) to calculate a representative roughness for biofouled pipelines;
- Implement the proposed procedure to determine the remaining useful life of pipelines to be able to prioritize the upgrading or replacement of system components; and
- Provide monitoring points for the initial, continuous or intermittent hydraulic assessment of the pipeline.

ID246

EFFECT OF CARBON BLACK, COMPOUNDING AND PIPE EXTRUSION ON THE SLOW CRACK GROWTH PENT TEST RESULT

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The Pennsylvania Notch Test (PENT) is recognized by the North America pipe industry as one of the key methods to measure the Slow Crack Growth resistance of polyethylene resins used in pipe applications. ASTM F1473 specifies that samples can be prepared from either pellets or fabricated pipes. however, there is limited data quantifying the effect of the different sample preparation methods and effects of carbon black on the PENT results.

This study investigates the sensitivity of the PENT result on the following: Black pipe extruded using (inline compound pipe) blending of natural resin and carbon black master batch (inline compound pipe), and black pipe extruded using pre-compounded black resin (Pipe BK). for all the pipe samples evaluated, pipes were extruded at both high and low shear rates. All tests have been done using the same lot of HDPE natural resin. virgin natural resin which had not undergone any additional processing was used in this study. The compounded black material was prepared using a twin-screw extruder. Pipes made with high/low shear rates were extruded using a standard groove-fed pipe extrusion line. All pipe specimens were prepared by compression molding pieces cut from the extruded pipes. All PENT specimens were prepared as per ASTM F1473. To reduce experimental variability, all tests were conducted in the same pipe lab environment and the specimens prepared and put on test by the same operator.

Results show that the method of incorporating the carbon black doesn't have measurable difference on the Slow Crack Growth performance of the pipe based on the PENT failure times.

The effects of heating cycles, S&P blending vs. pre-compounded resins and high/low shear pipe extrusion conditions are also discussed. Recommendations on improvement of test specimen preparation and test procedure to reduce result variation are also made.

ID155

VARIABILITY AND QUALITY CONTROL FOR PRODUCTION OF CORRUGATED HDPE PIPE MANUFACTURED WITH RECYCLED CONTENT

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The worldwide usage of high density polyethylene (HDPE) is estimated above 51 million metric tons this year with usage expected to continue to rise over the next several years. North America continues to have a significant share of HDPE volume with usage coming in various product forms, most commonly as consumer packaging and containers with relatively short-term use. With the number of short-term use products being disposed of by both consumers and industry, there is significant potential to recycle the HDPE material and repurpose the material for use as other products. One such use is production of gravity-flow drainage pipe. When repurposed for use as drainage pipe, the HDPE material that may otherwise have been disposed of in a landfill after short-term use, is used for applications that are generally designed with an installed service life of 50 and more years.

A primary focus of ensuring high performance of recycled-content HDPE drainage pipe is development of test methods and minimum test requirements that accurately quantify the quality of the resin being used for pipe production. This initiative has been underway in both ASTM and AASHTO associations through many years of research leading up to today, where performance-based product standards are being evaluated and implemented that allow the use of recycled-content pipe products. The next logical step in the implementation of product specifications is the development of quality control measures that ensure an inherently variable stream of HDPE source materials and blends are tested at a frequency that adequately characterizes the performance of the material as a finished pipe product.

This paper presents findings from extensive testing performed on various recycled HDPE resins at different stages of processing to evaluate: (1) the variability expected from a source resin (e.g. post-consumer materials from bulk recycling, post-industrial waste stream), (2) variability when blending different types of HDPE (e.g. high molecular weight resin, wide spec resin), (3) variability through processing (e.g. pelletizing), and (4) variability within the final pipe product. By quantifying the variability of each phase in the handling and manufacturing process, manufacturers can implement best practices and inspectors/specifiers can set minimum test frequencies to ensure consistent, quality pipe is produced to meet performance requirements specified in ASTM and AASHTO recycled HDPE pipe product standards.

ID212

THE INFLUENCE OF MOLECULAR DESIGN VARIABLES OF BIMODAL HDPE ON THE SLOW CRACK GROWTH RESISTANCE MEASURED BY ACCELERATED METHODS

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New generations of PE100 pressure pipe materials exhibit a superior balance of mechanical properties. The slow crack growth performance of these materials measured by traditional tests such as PENT and FNCT exceeds one year. These high-performance materials deliver significant advantages to the end uses, especially to challenging installation techniques such as horizontal directional drilling which may cause damage to the pipes during installation. However, these exceptional material properties present some challenges for the raw material suppliers during product development. First, the product development cycle for new polymer structures becomes very long since the evaluation of SCGR performance may take one year or longer. Additionally, quality control of the materials cannot be conducted with traditional methods.

The pipe industry is developing and implementing new test methods for the characterization of SCGR performance. These new techniques include the strain hardening modulus (SH), accelerated FNCT (ACT), cracked round bar (CRB), and the point loading test (PLT). Although these tests significantly reduce the time-to-failure of the improved HDPE resins, the mechanisms of polymer deformation may be different. These differences must be considered when establishing correlations (or lack thereof) between results from different tests and their ability to rank resins consistently. This paper presents preliminary results from PENT, ACT, SHM, PLT, and CRB of various resins and discusses relationships between time-to-failures, molecular design and deformation mechanisms.

ID160

HIGH DENSITY POLYETHYLENE (HDPE): AN OVERVIEW OF THE FIRST EVER ASME BPVC SECTION III, CLASS 3 NUCLEAR PIPING INSTALLATION

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Buried high-density polyethylene (HDPE) piping systems have been installed for decades in critical industrial applications such as cooling water and firewater. This paper will discuss the advancements of HDPE piping systems for use in American Society of Mechanical Engineers (ASME) Class 3 piping systems at nuclear power plants. The discussion will also include references from the nuclear new build use of HDPE pipe 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 as an alternative to metallic piping systems. Their goal was to reduce piping material and installation costs while ensuring safety and performance for the operating life of the plants. To ensure the use of HDPE pipe was fit for nuclear systems, the ASME Boiler and Pressure Vessel Code (BPVC) formed committees to develop rules for designing, procuring and installing high-density polyethylene pipe in ASME BPVC Section III (new build) and Section XI (repair/replacement) 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 code requirements and installation for this project's Essential Service Water Discharge system consisting of 21,000 feet of 36-inch HDPE pipe. Discussion topics include:

1. ASME BPVC definitions and considerations
2. Design and installation challenges
3. Fusion joint welding highlighting the joint integrity validation methods used specific to the project including ultrasonic non-destructive examination.

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

ID214

EVALUATION AND COMPARISON OF STANDARD AND ACCELERATED SLOW CRACK GROWTH DETERMINATION METHODOLOGIES: EFFECT OF THE COMONOMER TYPE INFLUENCE

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Slow Crack Growth (SCG) resistance is one of the most critical long-term mechanical properties that must be controlled and evaluated for determining the final performance of the polyethylene (PE) pipe. The main reason for this assertion lies in the fact that SCG is the only failure mechanism that normally appears in current pipe networks. Last generation of bimodal and multimodal polyethylene resins with very high resistance to SCG has been developed during last years. Standard methodologies for SCG evaluation like Pennsylvania Notch Tensile (PENT) Test (ISO 16241 – ASTM F1473) or Full Notch Creep Test (FNCT) (ISO 16770) have become insufficient due to the long time needed (more than one year) with the consequent unwanted thermal ageing-effects.

During last years, different accelerated and short-time methodologies have been developed for SCG determination on compression molded plaques being the most promising and used: Strain Hardening (SH) determination (ISO 18488), Cracked Round Bar (CRB) Test (ISO 18489) and Accelerated Creep Test (ACT) (Analogous to ISO 16770).

In the present work, all these methodologies have been deeply evaluated and compared with the standard FNCT and PENT tests. Moreover, the important effect of the comonomer type influence on the test results has been analyzed using Ziegler-Natta and Chromium commercial resins that use 1-butene and 1-hexene comonomer respectively. Finally, taking into account that this topic is under standardization discussion, a different SH critical value for PE100RC materials as function of the comonomer type used has been proposed.

ID177

NEW HIGH MODULUS POLYPROPYLENE HELPS THE DEVELOPMENT OF LARGE DIAMETER UTILITY TUNNEL

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Plastic pipes have been developed for large diameter applications. Traditionally, we believe plastic pipes are used to transport liquid or gas medium. However, plastic pipes can be applied in more applications. In the present paper we introduced how high modulus polypropylene helps an innovative design of utility tunnel up to 4000mm in diameter.

China has started its investment in utility tunnel in its new yearly development plan. The ambition of China is to build 2000km of utility tunnel each year in the coming years. The reason for China to push this application is fast urbanization. Many cities grow into concrete monsters and get more crowded, so underground pipelines have to be well planned to have easy access to installation and maintenance. Therefore, utility tunnel concept is introduced but starting with concrete utility tunnel. Some concrete utility tunnel projects have been carried out in some large and small cities. However, all the current utility tunnel concept is still based on design using concrete. Even though concrete shows advantages in stiffness and fire retardancy, its disadvantages, such as poor performance in earthquake, corrosion and less flexibility in design, are still big concerns.

High modulus polypropylene shows high modulus but still maintain reasonable flexibility so that tunnel and surrounding soil could form an integrated system, which means no force is applied on the wall of tunnel. Reasonable flexibility could thus enhance the safety of tunnel in addition to its good impact performance. At the same time, high modulus polypropylene utility tunnel is easy to be installed, no corrosion and easy to connect branch tunnels. However, to meet the requirements and functions of utility tunnel, other innovative design has to be integrated, including fire retardancy, inspection and internal structural design. In the present article, how to use high modulus polypropylene to design utility tunnel (including main structure design and interior design) was discussed and comparison to concrete utility tunnel was made. The production of the high modulus polypropylene utility tunnel was also discussed. In the meantime, a pilot project of high modulus polypropylene utility tunnel up to 4000mm was introduced.

ID171

DETERMINATION OF THE SLOW CRACK GROWTH RESISTANCE OF PA12 PIPE GRADES

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Since about ten years polyamide 12 (PA12) has successfully been used as material for SDR 11 gas piping systems up to 18 bars. While such pipes made of modern polyethylene (PE) like PE100 and PE100 RC can be operated up to maximum pressures of 10 bar, with this comparably high-pressure range PA12 has become an attractive alternative to steel pipes. Recent material developments are focusing on a fundamental understanding of failure mechanism to achieve further increase of the operating pressure for such pipes. Previous studies as well as practical experience have confirmed that beside the higher strength PA12 pipe grades also show an excellent resistance against relevant pipe failure mechanisms such as slow crack growth (SCG) as well as against any third-party attack or against external surface damages. For PE pipe grades these failure mechanisms have been investigated since many decades and are therefore well understood. Today several modern and time optimized SCG tests methods like the Strain Hardening (SH) Test (ISO 18488) and the Cyclic Cracked Round Bar (CRB) Test (ISO 18489) are available for a reliable material characterization. For PA12 a comparable comprehensive knowledge does not exist. In general, it is known that PA12 also fails by quasi-brittle crack propagation. However, established test methods which are optimized for PE cannot be directly taken for material characterization as the general applicability, suitable testing parameters and the sensitivity for a correct interpretation of the relevant long-term failure mechanisms has not been sufficiently investigated yet.

The current paper presents the analysis of four different PA12 materials with varying macromolecular structure ending up in a long chained PA12 especially designed for pressure pipe applications. On the one hand the experimental focus was put on molecular properties such as molecular weight or intrinsic viscosity as well as rheological investigations with plate-plate rheometer. On the other hand, a special focus was put to examine the applicability of the CRB-Test in order to evaluate the SCG resistance of the materials. The results will demonstrate the dependency between the molecular weight and the sensitivity of the SCG resistance based on the mentioned modern test method.

ID213

NEW EN STANDARD FOR INFILTRATION UNITS

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Three standards, developed by TC155 WG26, are going for CEN Enquiry at the moment. The combination of these standards gives the minimal requirement and an unified way of testing for boxes used in underground infiltration, attenuation and storage systems according the most recent insights by experts all over Europe.

The short-term test standard describes a test where one infiltration unit will be pressed between two stiff plates till failure in about 10 minutes.

- This test assures a proper quality control with the advantage that the results between different series can be compared easily.
- Test institutes, laboratories and the industry can adopt these test for unified process control. The long-term test standard describes a test procedure and calculation method to determine the maximum load under which a unit will last for at least 50 year.
- The big advantages for designers and customers is that the value of the maximum load becomes comparable between different designs and materials.
- The method of testing is well defined.
- The test provides a sound statistical approach. Companies producing and selling these products get clear guidelines. The product standard defines and specifies the minimum requirements for these boxes.
- The materials which can be used (PP or PVC) are well defined, including non-virgin and mineral modified materials.
- The minimum requirements for materials are always set in relation to the properties of the materials used and tested for long term.
- The combination of requirements on the material, mechanical, and physical characteristics are thought to give reliable and durable products and decrease the risks of premature failures.

ID142

INNOVATIONS IN PRODUCTION OF CORRUGATED PIPES

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Double walled corrugated plastic pipe with integral bells (sockets) is produced on the basis of established technology in several extrusion plants around the world. Air pressure and vacuum is applied for forming the corrugations of the outer layer, while carefully controlled pressure ensures the smoothness of the inner layer. For forming the socket, the outer layer is pushed against the mold wall by air pressure and it is aided by external vacuum, while the inner layer under the influence of internal pressure bonds to the outer layer. Sealing rings at the couplings make such pipes watertight, however, at each connection of two pipe sections there is a gap. For large diameter pipes, the gap size can range from several millimeters at installation time, to several centimeters after soil shifting. The gaps result in significant interruptions in the smoothness of the inner layer. Computer flow simulations show the existence of trapped vortices in the gaps. These are known as Moffatt eddies and they have received considerable attention in the fluid mechanics literature. Water recirculates in the vortex regions without being able to escape into the mainstream. Contaminants accumulate, and weeds start growing with significant reduction in water carrying capacity. Also, these regions are likely to have reduced environmental stress cracking resistance (ESCR) due to high concentration of detergents, organic acids and other substances. To eliminate such problems, a new stepped spigot technology has been developed. This involves extrusion of double wall pipe and forming of corrugations with internal overpressure assisted by external vacuum. This novel design necessitates also the reshaping of one or more of the outer layer corrugations and the sectionally programmed enlargement of the inner layer diameter. With this technology a stepped spigot is formed after cutting-off a transition pipe section. Due to the differential corrugation size and the programmed inner layer diameter, the rate of melt extrusion, pressure and temperature (of both the polymer melt and the blowing air) must be very precisely monitored and controlled. Another innovation involves a significant departure from the conventional corrugator technology of a continuous chain of mold blocks mounted vertically to vacuum form continuously the extruded pipe. A pulsating corrugator was developed which works as follows: As the mold blocks travel downstream along the molding track, at a specific point the pair of mold blocks closest to the extruder quickly opens, returns towards the extruder and closes over the last formed profile. Two other pairs of mold blocks continue at production speed holding and cooling the pipe. As the first mold block has closed the second mold block will open, return and close, followed by the third and so forth. The pulsating corrugator is a space efficient system particularly well suited for large diameters.

ID163

HARMONIZING THE EUROPEAN HYGIENIC REQUIREMENTS

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European standardization of plastic pipe systems has been on the agenda since the eighties and almost all applications are now described in common European standards. An important expectance however is the hygienic requirements of pipes for drinking water: The European Drinking Water Directive states in article 10 that "Member States shall ensure that substances and materials in contact with drinking water shall not endanger human health" and this sentence allows each member state to set individual requirements and test methods. The industry is therefore challenged by a system which makes trade across boarders difficult and expensive.

In 2001, The European Commission issued a mandate (M/136) to EU standardization bodies (CEN/CENELEC), to provide European standards for construction products in contact with drinking. Despite all the efforts, the Commission decided to withdraw this mandate in 2015, for the reason that it was impossible to elaborate complete standards on construction products in contact with drinking water, as of the absence of relevant regulatory guidance.

The treaty of Lisbon in 2007 declared the free movement of goods within the European Union to be a top priority and France, Netherlands, the United Kingdom and Germany agreed to pursue a common approach for testing and assessing of products in contact with drinking water on a voluntary basis. This program is generally known as "the Four Member States (4MS) Initiative".

To support the 4MS initiative an alliance of European associations representing the industries which manufacture and supply products that are used in drinking water applications was establish. The members of the initiative called „European Drinking Water ", include representatives from the pipe-, pump-, valve-, tap-, fitting-, seal-, meter-, water heater-, water treatment- and catering equipment-industry, i.e. the entire industry supply chain ranging from the raw materials suppliers to water distribution.

It is a high priority area for the manufacturer of plastic pipes and The European Plastic Pipe and Fitting Association (TEPPFA) is therefore deeply involved in the project.

This presentation explains the long and winding road towards a European harmonization of hygienic requirements for plastic pipes.

ID119

HIGH MODULUS PP TANKS DELIVERS PRACTICAL & COST EFFECTIVE SEWAGE TREATMENT TO RURAL INDONESIA

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As a consequence of the lack of treatment facilities in many developing countries, sewerage is discharged directly to the surrounding, polluting local water sources. Pathogens render the water unsafe for cooking or drinking. Prohibitive cost, challenging ground conditions and lack of reliable maintenance are some reasons making centralized treatment systems unpractical. Making matters worse, these low-income communities sometimes spend a large part of their income to buy bottled drinking water for their daily use because they have no other options.

This paper discusses how a practical and cost-effective solution based on nutrient harvesting can be used to sufficiently clean the sewerage discharged by each household in a wet tropical climate such that they do not contaminate the ground water. With pilot trials set up in the Indonesian island of Bintan, this system consists of: a robust and leak proof septic tanks made from high modulus PP-B, simple piping network and a wastewater garden planted with specially selected plants. The tanks unique design also helps to mitigate the upwards thrust during flooding when it rains heavily.

With additional funding from the Dutch government, research teams from the Eindhoven University of Technology, National University of Singapore and Universitas Gadjah Mada will further investigate the water quality and efficiency of different variants of these systems to allow for future upscaling.

ID114

ACCELERATED PIPE TEST METHODS TO EVALUATE PE 100-RC MATERIALS – POSSIBILITIES FOR ISO STANDARDISATION

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In the last years effort has been made to develop and standardize new accelerated test methods to evaluate PE 100-RC materials on short times on form of test bars. The two most important developments, the cracked round bar test (CRB test) and the strain hardening test (SH test) were published as final ISO standardized in the year 2015 in ISO 18489 and ISO 18488.

For a complete evaluation of a PE pipe material also test methods with specimens in form of pipes are required. In the last years the notch pipe test according ISO 13479 and the point load test, which is still under development as an ISO/PWI 22102 in ISO/TC 138/SC 5/WG 20, have been used to evaluate the SCG behavior of such materials in form of pipes.

In this presentation the actual status of the PLT development will be shown as well as the development of an accelerated notch pipe test (ANPT), which has been reported first in 2008 [1]. Notch pipe testing according ISO 13479 is as worldwide well-known method which is used in many product standards to evaluate the SCG behavior of specimens in form of pipes with outer notches, tested in water with internal pressure. With modern PE 100 and PE 100-RC materials failure times can raise up to 50.000 h, which is far above a useful test time for a short term SCG test method. The accelerated notch pipes test (ANTP) is done exactly according ISO 13479 with the only difference that instead of water as outer media a wetting agent solution is used like in the well-known Full notch creep test (FNCT) according ISO 16770. The experiences done in the last ten years with this novel test method are shown, which result in brittle failures bellow 500 h for all PE 100-RC types available on the market. This modification of the test method, which correlates to the NPT in water and results in short brittle failure times are shown and can be considered to be implemented in a revision of ISO 13479.

ID125

INTRODUCTION OF LARGE DIA PROFILED PE/PP PIPES FOR INNOVATIVE PIPED DISTRIBUTION NETWORK (PDN) FOR IRRIGATION IN INDIA

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Irrigation is the largest consumer of water in INDIA. However, the water distribution efficiency in irrigation is very low in the country. The open canal system requires large area and consequently involves land acquisition issues, evaporation losses and seepage problems. This has led to the use of underground piped network replacing the open canal system in most parts of the country, while reducing the water loss. Many of the states have adopted the conscious policy decision in this regard by way of issuing guidelines to undertake the Piped Distribution Network.

For piped irrigation number of options suggested by Central Water Commission, Government of India like Mild Steel PE Coated Pipe, Prestressed Concrete Pipe etc. The Spirally Wound Profiled PE / PP Pipe from diameter 300 mm to 2500 mm is a most suited and liked option by the user bodies due to many advantages over the other conventional system. Selection of right diameter, suitable pressure class and the ring stiffness and the surge analysis has been left to the consultants and designing fraternity.

The typical layout of the Piped Distribution Network consists rising main which requires pressure sustaining 8 to 10 bar pressures with diameter from 800 to 2000 mm, sub minor pipes or gravity mains sustaining 4 to 6 Bar pressures with diameter from 500 to 800 mm and the distributaries with diameter 110 to 300 mm with no pressure. Considering requirement of pressure, diameters and ring stiffness, installation ease etc., spiral wound PE / PP is a most suited option found by the user department for the applications other than high pressure rising main.

ID165

VARIOUS APPROACHES TO THE IMPROVEMENT OF POLYETHYLENE PIPING CONSTRUCTION QUALITY IN OSAKA GAS

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Although the study of medium-density polyethylene pipes in Japan started in 1970s behind other countries because of the high frequency of earthquakes and the high density of underground facilities, the Japanese Industrial Standard (JIS) for medium density polyethylene pipes was established in 1979. The number of quality assessment tests in Japan was more than other countries because gas pipes needs to withstand several earthquakes and third-party construction damages.

After establishing the JIS for medium-density polyethylene pipes, many Japanese gas companies adopted the use of polyethylene piping for low pressure, and have laid pipes approximately 101,500km which occupies 39% of the gas distribution pipes in Japan and continue to covert old steel and cast-iron pipes into polyethylene pipes. (Osaka Gas has distributed gas to 7,300,000 customers and has laid polyethylene pipes 18,500km which occupies 30% of the gas distribution pipes in Osaka Gas).

To ensure the continued use of polyethylene piping infinitely withstanding the future earthquakes, without the need for replacement, in the process of developing quality assurance systems. For example, random examinations Nondestructive Inspection were carried out by using ultrasonic waves and periodic traceability analysis using the EF controller function for confirming fusion quality of the laid polyethylene pipes. If there was rejectable quality, it would re-examine the other polyethylene pipes, and reflect the results of it on the order quantity to our contractors.

In addition, improvements have been making in tools for polyethylene pipes like scraper for the purpose of not depending on the person. And moreover, the specifications and the process were drafted for polyethylene piping constructions and educate our contractors based on them on a regular basis. This paper introduces the various approaches to manage the quality of polyethylene pipes and the quality performance of polyethylene pipes against the past earthquakes, the Greatest East Japan Earthquake in 2011 and Kumamoto Earthquake in 2016, in comparison with other kinds of pipes.

Finally, this paper introduces the limiting use of polyethylene for middle pressure by insertion method in our company. In Japan the third-party construction around the high density of underground facilities often breaks gas pipes and it has a high possibility to cause human suffering since the density of building is higher than other countries. From this, gas companies in Japan have more responsibility for gas accident rather than other countries, so that they did not use polyethylene for middle or high pressure. But, our company started the limiting use of polyethylene for middle pressure by insertion method, polyethylene pipes are insert in the laid steel or cast-iron pipes used for protection, in terms of cost-cutting and workability.

ID112

LARGE DIAMETER SPIRAL WOUND PRESSURE PIPES

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In the last decades the bigger sizes of polyethylene pressure pipes are continuously increasing. Axial extruded pressure pipes are worldwide available according to technical requirement ISO 4427 until OD 2500 mm. With the helical extrusion process, it's today possible to produce polyethylene pressure pipes according to DIN 16961 with the technical requirements of ISO 4427.

As a matter of fact, the worldwide pipe market requires plastic pressure pipes for much bigger diameters than only OD 2500 mm, which has developed the helical extrusion process for larger diameter pipes into a standardized production level.

Polyethylene pressure pipes until ID 5000 in tailormade pressure classes can be manufactured by the todays developed spiral technology. The pipe wall structure is helical extruded, and each layer is homogenously melted to guarantee the required mechanical and physical properties of the large diameter polyethylene pressure pipe.

The internal resistance against constant internal water pressure was determined at constant temperature bath and at prescribed duration and conditions according ISO 4427. Helical extruded pipes fulfill the requirements of ISO 4427 and other pressure pipe standards regarding hydrostatic pressure load at 20° and at 80°C.

The presentation will show the differences and benefits of the production procedures, under consideration of technical and commercial aspects. It will be shown by reference projects, new pipe standards, creep rupture curves and other quality- reports, that spiral wound pipes are not only competitive, but also the only solution for really large dimensions.

ID215

DESIGN OF LARGE DIAMETER BURIED PIPES

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In the late nineties TEPPFA carried out a study of the behavior of buried thermoplastics pipes. The project had input and participants from both the plastic pipe industry as well as from external organizations. Six external leading experts in the field of pipeline design, not necessarily plastics pipes design, have been involved as consultants in the project. The experimental work included a number of less ideal installation circumstances, in order to fully understand the where the border line of safe installations is.

A report that summarized the experimental work carried out was issued including an analysis of the pipe soil interaction process as it was monitored during the study. Next to that a simple design graph explaining the short and long-term deflection as a function of the pipe stiffness class and the quality of the installation. The results have been presented at the Plastic Pipe Conference as well as it is being used in standardization work, e.g. in developing CEN TS 15223, "validated design parameters of buried thermoplastics piping systems".

Although the physical rules stay the same the world has changed. The need for water tight solutions in large diameter sewer pipes has given plastic pipe solutions a significant increase in market share in Europe, very well supported by the introduction of the EN 13476 standard which describes a number of different ways to design and produce a structures wall pipe. TEPPfA has therefore decided to extend that Buried Pipe Study by adding field test and measurements of large diameter structured wall pipes in order to enhance the scope.

A test field in Denmark has been executed and SN2 and SN4 PE pipes according to EN13476 has been installed under "Good", "Moderate" and "Poor" conditions. The soil used has been poorly grated sand and silt mixture which allows the poor installation. The deflection has been measured after assembly but before backfilling and then again after backfilling and completion of the installation. Measurement has been repeated after 10 weeks. It is planned to continue measuring according the results observed. An older test installation in Finland on the property of Uponor in Vaasa has been included in the project. This test installation is affected by severe traffic load.

ID121

STUDY ON THE RESISTANCE TO EXTERNAL PRESSURE TEST METHODS OF PLASTIC INSPECTION CHAMBERS

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Plastic inspection chamber is one of the rapidly developing products in the field of drainage in China in recent years. At present, plastic inspection chamber is mainly made of PP, PE, PVC and so on. The manufacturing technologies include injection molding, rotational moulding, winding process, mechanical assembly and others. Plastic inspection chambers have developed very fast in the past ten years and there are nearly two hundred manufacturing enterprises in China till now. Plastic inspection chamber is an important component which is convenient for regularly inspecting, cleaning, dredging underground pipe systems, and will be affected by many factors such as backfills, underwater and surface load. In the practical use, the design, departments, the construction organizations and users have different focus on the pressure condition of plastic inspection chambers, so there is a big difference for the recommended test methods for their long-term performance and therefore different standards and specifications co-exist in China. In these conditions, we should figure out the differences and connections of different test methods, which will have important guiding significance on the formulation of relevant standards, product selection and engineering construction.

The evaluation methods of the long-term performance of plastic inspection chambers are mainly categorized into two types: laboratory evaluation and underground test. We established the following test methods according to the stress conditions: structural integrity test, long-term axial loading test (in conditions with and without sand backfills respectively), actual underground engineering test, etc. This paper selects municipal injection inspection chambers (L-1000) (which are the more representative products in China) as the study object. It firstly analyzes the structure of plastic inspection chambers, and studies their long-term stress conditions, and then explains the tests on them by using the different methods above and finally draws corresponding conclusions.

This paper compares the advantages and disadvantages of several evaluation method and provides suggestions for the structural design, construction backfilling and standard setting of plastic inspection chambers in China.

ID127

A RECENT SURVEY OF WATER MAIN FAILURES IN THE US AND CANADA

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During 2017, Utah State University conducted a survey of utilities across the US and Canada to obtain data on water main failures of municipal and private water supply systems. In 2012, a very similar survey was conducted by Utah State University and presented in the 2012 Plastic Pipes Conference in Barcelona. The 2012 survey showed that PVC had the lowest break rate when compared with asbestos cement, concrete, ductile iron, cast iron, and steel pipe materials. After six years, it was time to complete a similar survey that could examine any changes and current trends with respect to water main break rates. The latest survey had a greater participation rate than the 2012 survey and is believed to be the most comprehensive water main break survey ever completed in the US. The results of the latest survey again demonstrate that the break rate for PVC pipe remains the lowest break rate material when compared with asbestos cement, concrete, ductile iron, cast iron, and steel pipe materials. The latest survey also shows that break rates of cast iron and asbestos cement pipes have significantly increased, and utilities should increase replacement rates of those materials. A number of other results are discussed including typical operational parameters of utilities, installation techniques, soil corrosivity effects, material inventory data, and other items that will be of interest to manufacturers, designers, and water utilities.

ID124

THE USE OF TEMPERATURE, LUBRICATION, AND SUPPLIED HYDRAULIC PRESSURE IN THE PRODUCTION OF ORIENTED PVC PIPE

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Oriented PVC (PVCO) is stronger but also much lighter than conventional PVC pipe. To study the manufacturing process, a combination of tensile tests, simulated orientation, tribology, and finite element analysis were used to assess the effects of temperature, lubrication, and supplied hydraulic pressure. The stretching process must take place near 100°C to maximize the PVC compound's strain limit and minimize the stretching force. Lubrication in the form of water, silicone, or potentially other common lubricants, must be present to maintain a low coefficient of friction, which would otherwise increase with strain rate. Even with these two factors under control, the orientation process can still be difficult, so the addition of as little as 69kPa to the inside of the pipe can be utilized to complete the orientation process. Practically speaking, these three design parameters point to the use of boiling water in the orientation process because it is a lubricant at 100°C that can supply hydraulic pressure.

ID199

LONGITUDINAL CRACK IN LARGE PVC-U PRESSURE PIPES. PIPE GELATION INFLUENCE CASE STUDY III

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Irrigation networks in Spain extensively use plastic pressure pipes systems. Some recent failures focus the attention on Rapid Crack Propagation phenomena. Larger high-pressure PVC-u pipes are involved in most incidences detected. The level of gelation of those pipes were measured per EN-ISO 1452-2 test methods DCM, DSC and Tensile. Influence of poor gelation on longitudinal cracks was clearly evidenced in Part I (Proceedings 18th Plastic Pipes Conference, 2016, Berlin). Now relationships between poor gelation and pressure test failures has been evaluated in this study.

ID116

NOVEL STABILIZERS FOR PVC/CPVC PIPE AND FITTINGS

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PVC pipes and fittings are currently manufactured using a wide range of stabilizer systems whilst CPVC is currently manufactured using Tin stabilizers. The aim of this paper is to present a new type of heat stabilizer (booster) to be used in combination with Tin stabilizer; surprisingly this product offers synergistic effect with organotin stabilizers improving heat stability, it increases the softening point and allows a reduction of the formulation cost. The product can be also used as a building block in Calcium Organic Stabilizers for PVC and CPVC application; it improves the long-term heat stability and permits to achieve the most demanding technical requirements for injection molding of PVC and CPVC fittings. The new substance is based on a non-toxic sodium salt of a carboxylic acid and complies with the most relevant regulation for food contact application.

ID159

CPVC APPLICATION IN THE FIRE SPRINKLER SYSTEM IN CHINA

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This paper mainly introduces the advantages and difference on performance between CPVC and steel pipes, the course that China fire accepts the CPVC applied in fire sprinkler system.
This paper introduces the course that China establish the national design code, installation and checking code, national testing code on CPVC applied in fire sprinkler system, the content and progress of the national code that drafted on manufacturing CPVC products for fire sprinkler system.
Briefly introduction for the current situation of the enterprises who manufacture CPVC resin for fire CPVC products in China and oversea market

In this paper, it is introduced that one kind of fire CPVC products which meet China fire requirement. The capacity for fire CPVC products, the products range, the current situation of other Chinese manufacturer for fire CPVC and case study, this paper also analyzes the market prospect for CPVC fire products and investigate the market volume.

ID132

REHABILITATION OF ABANDONED DN1000MM STEEL PIPE WITH PE100 IN MALAYSIA

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The KESAS Highway is a 34km long expressway linking the town of Pandamaran in the state of Selangor with Sri Petaling in the federal territory of Kuala Lumpur. The expressway in Pandamaran, being adjacent to Port Klang which is also the 12th busiest container port in the world, naturally sees extremely heavy traffic from container trucks round the clock. The state water utility company, SYABAS, operated a DN-1000mm cement-lined mild steel water pipeline that crossed under this highway near Port Klang. This pipeline played a critical role in serving the coastal community of Pulau Indah adjacent to the port.

The pipeline crossing is situated in an area that was previously reclaimed land and due to this fact combined with the extremely heavy traffic and constant traffic loads, the steel pipe had sunk by a further 6m into the ground from its original position after barely a decade in operation. The force of this steel pipe caused the internal and external cement lining to come off. Because of its coastal location, this pipeline suffered heavy corrosion. No long-term solution could be found despite numerous repairs and the leaks got worst along this pipeline. It became so severe that this pipeline had to be temporarily abandoned.

Fortunately, this was solved by a PE100 system through insertion into the steel pipeline. This presentation describes the challenges and lessons learned in completing the project and how the versatile PE100 system allowed the water utility to restore service to support the increased demands from the community of Pulau Indah.

ID115

FIELD TEST OF GLASS FIBER REINFORCED POLYETHYLENE PIPE SYSTEM AT SOFTEN GROUND

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Glass fiber reinforced polyethylene pipes and fittings are controlled for bending characteristics (Strength and Stiffness) for vertical and axial directions of pipe by spiral cross winding method. Generally, to use this method, it takes much stronger for vertical strength than axials cause of extruded direction, besides it's more stable of ovality for large diameter pipes. It is expected to use pressure pipes for large diameter pipeline with thermoplastic welding method easier. These pipes and joints can be made from 200 mm to 3000 mm inside diameter by electrofusion or butt welding joint.

Here is shown the experience of field test for soften ground located in Hokkaido, Japan used 600mm DN/ID (SIDR35), total length is 33mm with electrofusion and butt welding joint. These pipes and joints indicate to keep the shape of pipe by the cross section against to adjust for axial followed behavior on the soften ground.

ID222

THE TEST METHOD OF METALLIC ELEMENT FOR POLYETHYLENE PLASTIC PIPES OR MATERIALS FOR PIPES AND ITS APPLICATION

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As the polyethylene pipes widely used in the natural gas fields, water supply fields, the demand for piping material has been always increasing in recent years in China. However, recycled or used piping materials were used to manufacture the pipes which should be produced using new piping materials in pipe industries. Because of the great difference in physical performances between new and recycled or used piping materials, the pipes made from the recycled materials will be a great security hazard in practical application. It is necessary to develop methods for identification of new and recycled materials used in PE pipe. In this paper the test method of metallic element for plastic pipes or materials was introduced. The comparative analysis of metal element content between the new piping material and the recycled or used piping material was carried out. The results show that the recycled PE material or pipes can be identified by determination of metal elements content. Moreover, mixing experiments with different content of typical recycled materials were carried out. The mechanical performances, antioxidant performances, metal contents and rheological behaviors of these mixtures were examined in detail. The results showed that the content of iron and calcium could be used to distinguish whether recycled material is mixed in pipes or raw materials effectively.

ID128

PRESERVING MARINE ENVIRONMENT FROM HYDROCARBONS CONTAMINATION WITH LEAK-FREE PE100 PIPES USED IN OFF-SHORE OIL WELLS

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In late 2011, ADNOC Offshore of UAE (known at that time as Zakum Development Co. – ZADCO) decided to replace its increasingly leaking 4.5-kilometer subsea carbon steel pipe with a temporary 560mm SDR 7.27 PE100 pipe serving its world-scale offshore site at Zirku Island in Abu Dhabi. The line is used to re-inject produced water effluent into the bottom of a dedicated 7,000 ft. deep well, after separation from crude oil. The quality of the re-injected water is strictly monitored after treatment with demulsifies to reduce hydrocarbon contents to the acceptable industry level of 500 – 1,000 ppm. However, increasing leaks from the corroded carbon steel pipe is imposing a continuous risk of contaminating the marine environment with hydrocarbons. This threat was resolved with replacing carbon steel pipe with leak-tight PE100 pipeline system.

After 5 years of continuous operation of the PE100 pipeline at 24 bars (350 psi) and 32° C (90° F) without any leakage, a pipe spool was sampled to assess and quantify degradation in properties of the PE100 material / pipe caused by the subsea environment on the outer surface as well as the re-injected water environment on the internal surface in order to estimate the remaining life of the pipeline. In addition, two butt-fused joints were assessed and permeation of hydrocarbons across the pipe wall was evaluated. The results were benchmarked with similar assessment conducted on a reference pipe spool kept for this purpose. The design lifetime of the PE100 pipe was revised with boundary conditions in light of the findings. This paper will discuss how PE100 pipeline system helped in protecting the marine environment from hydrocarbon contamination by continuous operation without leakage compared to the replaced carbon steel pipe. This paper will also discuss the different tests conducted as well as interpretation of the results.

ID230

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