

PIPE TECH REVIEW


Pipe Technology NEWS from
TEPPFA

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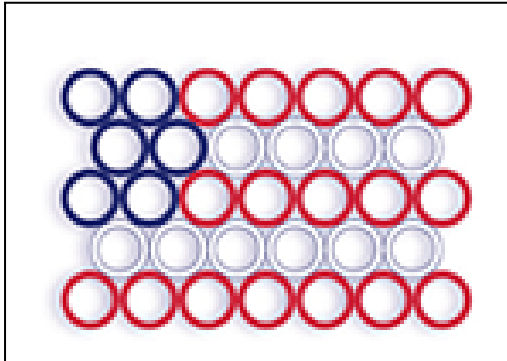
- ▶ Architects
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PLASTICS PIPES XIII


Washington. The latest news from the Plastic Pipes Conference in the US.



"There is now a global swell of opinion that plastic pipe systems have a more sustainable and valuable contribution to make. The technical competence and talent of our industry has never been so evident."
Roger Smith, President of TEPPFA



PLASTICS PIPES XIII



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► CLINICAL SILENCE

Architects are increasingly interested in noise pollution. The inner workings of office soil and waste pipe systems are not exactly preferable to silence. In a hospital, their acoustic properties are therefore a major subject for building design. A recent hospital project extension in The Netherlands illustrates the growing importance of silence"

The Gelre Hospital in the city of Apeldoorn has been created from the fusion of two hospitals. The result is that the Lukas and Juliana Hospital will have to increase its floor space from 30,533 m² to 62,840 m².

The prospect of extending the premises prompted discussions between GTI Utiliteit Oost and Wavin as to the eventual form and design of the new Soil & Waste system.

Criteria for the system were costs and quality improvement alongside a requirement for efficient and innovative design of installation. The firm's AS system was chosen.

The pipe owes its acoustic features to its thick wall and the molecular structure of its material (1.9g/cm³) called Astolan. Complete networks can be designed in the same flexible way as other plastic pipe systems and the noise control is according to DIN 4109.



Wavin AS system



The Gelre Hospital as it will be in 2007

Since its introduction in 1988, the pipe system has been used extensively for a variety of applications such as high-rise apartment blocks, theatres, offices, etc.

From a cost point of view, it is more expensive per metre than cast iron or even other plastic systems but the makers insist that its ease of installation and silent quality of its life-long performance are worthwhile benefits.

Other requirements

Other requirements were also examined for the Gelre hospital project. Chemical resistance, durability and hot and cold-water temperature factors were also taken into consideration.

Architects for the project are Nijst Idema and the spec was prepared and written by the engineering consultants of DEERNS from Rijswijk.

► PIPE FOR WORLD'S LARGEST METHANOL PLANT

At the Washington Pipes Conference, Matthias Haese from Frank GmbH presented an industrial case history for the use of polypropylene pipe in a methanol plant in Trinidad.

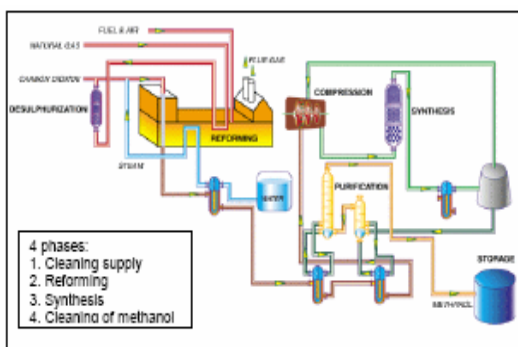
The problem

The clock is ticking away for the construction of a new M5000 methanol plant at an industrial complex in Point Lisas, Trinidad. A feeder pipeline is required to transport waste carbon dioxide. A steel pipeline with the customary protection for internal corrosion could have been used. But the high degree of saturation of CO₂ and low pressure were such that engineers decide to look elsewhere for their pipe material.

The solution

Their answer was found in Austria and comprised the eventual installation of a 3000 meter long buried polypropylene pipeline.

The pipeline components were designed for the worst case scenario in which the carbon dioxide flows through the line with a maximum inner pressure of 1.03 bars and a temperature of 71°C. The solution thus involved the use of a PP-H pipe diameter 1050 x 31.9mm (SDR 33) in 11.8m-length, manufactured according to DIN 8077/ 8078.



Production of methanol



Polypropylene pipes d. 1050 mm/SDR33 in Trinidad

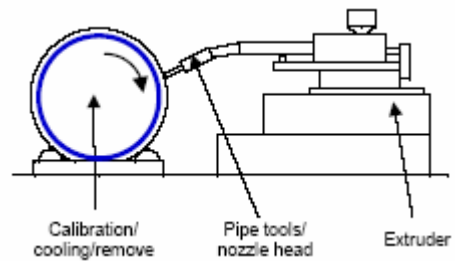
With so many existing underground pipes in the petrochemical plants in Point Lisas, a lot of direction changes were required. To facilitate the network, 36 segmented bends of polypropylene pipe d 1050 x 31.9 mm (angle: 41°, 45°, 60°, 68° and 90°) were prefabricated in the FRANK-workshop and delivered to the construction site in Trinidad.

The segments were butt-welded, in various ways according to the requirements of the customer who demanded that the radii be as big as possible to minimize leakage of pressure. According to DVS guideline 2205 – part 1, the long-term welding factor of polypropylene (e.g. PP-H pipes) for heating element butt-welding was at least 0.8. Reduced-T pieces were also manufactured (see photo below) for the connection of the second ammonia plant and the introduction of additional CO₂-waste gas in the carbon dioxide line.



Polypropylene reduced T-piece diameter 1050/900 mm in SDR 33

Also interesting to note that a stub flange, machined from a polypropylene bar with an additional steel backing ring (including anti-corrosion protection) was connected factory-installed with the reduced branch (d 900 mm) by heating element butt-welding. The connection of this branch to the main line (d 1050mm), has been completed via extrusion welding, according to DVS guideline 2207. The reducing coefficient ($f_s=0,6$) resulted from a required increase in the wall thickness in the area of the branch. This has been done through winding up additional polypropylene in the spiral pipe production (see diagram opposite).



Production of spiral pipes according to DIN 16961I

In this way, wall thickness was increased by 30 mm thus ensuring that the pressure resistance in the area of connection was guaranteed as per customer requirements.

The result

The new pipeline has good thermal and chemical resistance. Furthermore, it was completed in time to meet the project deadline of connecting the M5000 methanol plant to the ammonia factories located in the neighbourhood.

The carbon dioxide is fed into the CO₂-transport-line at almost 42°C and cools down upon arrival in the M5000 methanol plant. Due to temperature fluctuations the operators of the plant expect that condensed water will be created in the pipe. 18 condensation pots were therefore built along the line.

The pipe's lightweight meant that transport was relatively easy. Good welding techniques also meant that installation was straightforward. This was all the more important given that a large part of the buried pipeline runs close to previously existing methanol and gas pipeline. Polypropylene offered the possibility of easy direction changes and its low weight of 97.6 kg/m made for handling benefits not associated with traditional materials.

These were integrated into the main line at regular intervals and consist of a welded end cap d 315 mm that is brought in the main line via heating element socket welding.

The condensed water that accumulates here is drained away through two polypropylene lines d 40mm with connected ball valves type 21 into an installed concrete shaft. All the maintenance staff of the Point Lisas industrial complex have to do is to empty the condensed water from the carbon dioxide line at regular intervals in a controlled way.



Condensation pots from injection moulded fittings (PP-R)



Installation of the PP pipeline d 1050 mm

► GOOD CONFERENCE

The organisation of the Washington Plastic Pipes Conference can be pleased with their efforts. The statistics speak for themselves. 435 delegates participated from over 30 countries to witness the presentation of over 90 technical papers. A summary of these technical papers appears at the end of this issue.

Ocean is a universal sewer – says Cousteau

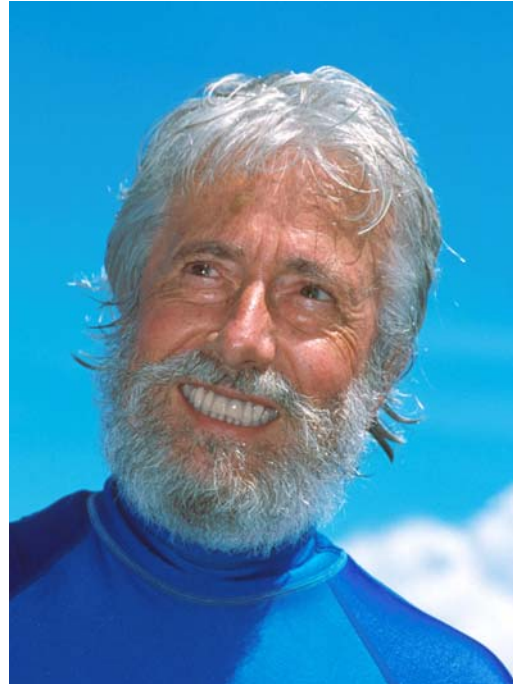
“A staggering 2.45 billion gallons of treated water is lost every day in the US from corroded or damaged pipes. This loss of good clean water, if available in Africa would save thousands of lives a day.” Jean-Michel Cousteau, told the conference.

The President of the Ocean Futures Society and son of the famous oceanographer went on: “It has been 61 years since my father literally pushed me overboard to show me the wonders of the ocean. For me, the pure source of an ocean is on top of a mountain. Everything is connected but how come we are running out of water? Because of mismanagement and not understanding how water works. The ocean has now become a universal sewer - out of place and out of mind! And yet water is our life support system.”

What can I do?

“One way to change this situation is through education, education, education.” Cousteau has a foundation that promotes awareness of global water issues especially for a young audience.

“Later in life, our many disciples become local cheer leaders and even activists in the endless struggle for what should be our birthright: pure drinking water. But there is a need for individuals to change the way they think about water. The community and business have also a role to play. We have to ask ourselves: What is it I can do that I haven't already done.”



Jean-Michel Cousteau

Bob Walker, another conference organisation explained: “Every year, three million people die through water scarcity and related disease. By spending an additional \$11.5 billion on the water infrastructure we could eliminate this tragic loss.”

Mains breaks

“We average 600 mains breaks every year in the US. The cost of such a breach may well amount to over \$100,000. The problem is worldwide and effects rich and poor countries alike. Members of our industry and of industry in general have a responsibility to act as stewards by advocating the use of sustainable plastic pipes.”

The Conference was the first plastic pipes event of the series to be held in the Americas and the delegate breakdown reflected a strong European participation.

The regional split was: North America (52%), Europe (32%), Asia (13%), Latin America (3%).

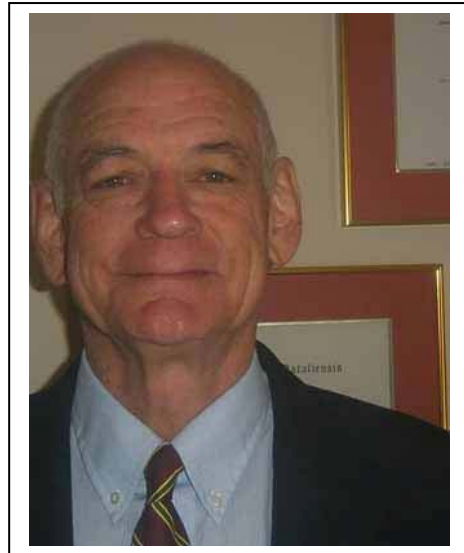
Dr. David Walton, vice chairman of the organising committee explains: "Conference participation reflected a good geographic spread with a good representation from our European colleagues. This truly international forum has served more than ever as a technical exchange of quality ideas, facts, trends and information critical to the plastics pipes industry."

► ENERGY COMPARISONS

Environmental considerations have clearly entered the industry technical agenda. Mike Osry's paper entitled 'The energy crisis – designing with material and energy efficient PVC and HDPE piping systems' was a case in hand. His comparisons of the amount of energy required to manufacture plastic sewer and pressure pipes with those of ductile iron are clearly seminal.

Less energy

He says: "It may be considered that plastics pipes use more natural resources in the form of fossil fuels than traditional pipe materials. In fact, as most electrical or heat energy required for the production of the basic raw



Mike Osry

materials comes from oil or coal, the reverse is true. It takes less energy to produce plastics materials for pipes than it does to make steel, copper, ductile iron or aluminium pipes - these metal products are very energy intensive, as is zinc, used as galvanizing to provide corrosion resistance to steel and ductile iron pipes."

PRESSURE PIPES

The energy used in the manufacture of various pipes is shown in Table I.

Table I. Energy Values for PVC and HDPE (250mm PN16) and Ductile Iron Pressure Pipes.

Description	Units	Plastic Pipe Materials					K9 Ductile Iron		
		PVC-U	PVC-M	PVC-O	PE 80	PE 100	200mm	250mm	'Hybrid'
Product Information									
Mass/meter	kg/m	17.04	12.23	8.34	19.71	16.34	37.00	48.00	41.0
Primary Energy	MJ/m	1 391	998	681	1 922	1 594	1 546	2 006	1 718
Conversion Energy	MJ/m	18.8	15.0	15.8	29.8	29.0	Incl. above	Incl. above	Incl. above
Embodied Energy	MJ/kg	82.70	82.83	83.49	99.01	99.28	41.80	41.80	41.80
	MJ/m	1 409	1 013	696	1 951	1 623	1 546	2 006	1 718
Embodied Energy for 10km pipe	toe	337	242	166	466	680	369	466	410
	Barrels oil	2 356	1 683	1 164	3 262	4 759	2 585	3 354	2 872

Pipe Standards. PVC-U: ISO 4422, PVC-M: SANS 966-2, PVC-O : SANS 1808-85 and ISO/DIS 16422, HDPE : ISO 4427, Ductile Iron : EN 545.

Table II. Energy Values for 160mm PVC (SN8) and Ductile Iron Sewer and Drainage Pipes.

Description	Units	Sewer and Drainage Pipes				
		Solid Wall	DWP	Multilayer		Ductile Iron
				Scrap Core	Virgin Core	
Raw Material						
Mass/meter	kg/m	3.52	1.88	3.10	2.80	17.50
Primary Energy	MJ/m	286.82	153.41	70.81	228.48	731.50
Conversion Energy	MJ/m	3.80	2.71	3.57	3.23	Incl. above
Embodied energy	MJ/kg	82.68	83.04	82.75	82.75	41.80
	MJ/m	290.62	156.12	74.38	231.74	731.50
Embodied energy for 10km pipe	toe	69	37	18	55	175
	Barrels oil	486	261	124	387	1 223

Pipe Standards. Solid wall: SANS 791, Structured wall: SANS 1601, Ductile iron locally made.

He concludes: "The 'new' generation PVC and HDPE materials, PVC-O, PVC-M and PE 100, have proven themselves in service and continue to demonstrate cost effectiveness and energy efficiency."

"It has been shown that the 50 year safety factor depends on pipe material properties and that a high safety factor does not mean that the pipe is safer to use or more reliable. The many benefits associated with their use, including long-term performance, ease of handling and installation, improved flow and reduced pumping power consumption, as well as significant energy conservation and benefits to the environment, are some of the advantages in using these modern generation pipe materials."

► SUSTAINABLE PE

Although very difficult to mention all the good presentations, that of Andre Scheelen was noteworthy. His paper co-written with Paul Rugraff, also from INEOS was entitled *Polyethylene Pipes, the Natural Choice for Sustainable Development*.

It has to be said that many of his comments could be applied to plastic pipes in general. He is clearly making a case for PE pipes.

"Sustainable development is a widely used terminology which brings together two concepts: 'satisfaction of present needs' and 'possible satisfaction of future needs'. He said.

"Life cycle analysis for PE pipes are available regarding the energy content of the pipes and their aptitude for energy recovery , the main points being

that the PE industry converts less than 1% of oil production, can give it back to the energy market at the end of its life cycle and the available energy is still 30% higher than the equivalent weight of the best coal."

Need

His explanation of need was expressed in global terms:

1.1 billion people in the world who do not have access to an adequate supply of drinking water and 2.6 billion without access to basic sanitation.

1.6 million of 3.1 million who died from malaria and diarrhoea could be saved by providing safe access to drinking water, sanitation and hygiene.

"The need for water per person is from two to four litres per day. But it takes 2000 to 5000 litres to produce one person's daily food." Andre explained. "Agriculture represents 70% of the fresh water human consumption in developed countries and up to 95% in developing countries. In many place, 30% – 40% or more of distributed water goes unaccounted for due to leakages or illegal connections."

The future is also less hopeful. "Today, half the world's population lives in urban areas while in 2030, this ratio will be 2/3. This will require an improved infrastructure."

Satisfaction

His solution is PE pipes – pipes that can be produced in diameters from a few millimetres to two metres for sea outfall

or desalination plants. "Furthermore, PE networks are easy to install. There is a low coefficient of PE, long lengths decrease the number of connections."

Other benefits are no contamination from the pipe – taste and odour of the water must not be affected! The pipe is also inert to organic bodies and PE does not contain any estrogenic, carcinogenic or endocrine disrupter substances. There is no contamination passing through the pipe. "The only risk is present in heavily contaminated soils where a sufficient gradient of concentration activates diffusion." He points out. "Very few molecules can pass through PE – only non polar, lipophilic and small molecules under liquid form."

"In contaminated soils, most of the contaminants are adsorbed on earth particles, so they are not present under liquid form." For the US with leakage literally running away daily at 22,000 m³ or 6 billion gallons due to corrosion or main breaks, PE pipe was the ideal solution.

Maintenance

The topic of maintenance was also raised. With PE pipes, there was no corrosion or need for cathodic protection. There was also no scaling or need for internal inspection. "In practice, there is nothing to do once the pipeline is installed."



Andre Scheelen

Flexibility

Andre Scheelen quotes the 1995 earthquake in Japan as an example of the product's flexibility. The event caused the failure of 26,459 pipes – none of which were PE.

The list of examples is relevant:

- Sea waves (submarine application)
- Truck load
- Water hammer
- Hit by excavator
- Squeeze off
- Soil movements
- Earthquakes

Energy consumption for the production of PE is also considered. He notes that only 1% of the total oil production is used in the manufacture of polymers and that the production of PE requires:

75 to 90 MJ/Kg PE

Pipe Material	Carbon Steel	PE
Descaling Required	Every month	After 6 months almost no scaling required
# workers	5	2
Time	2-3 hours	20 minutes

Energy consumption comparisons are given (in Kg/oil/equivalent) for the production of 1 Kg.

- Copper: 1
- Steel 5
- HDPE 1.5

The two experts have clearly done their homework. They have calculated that the equivalent energy saved by using plastics versus traditional materials is 70 percent for small water pipes and more than 150 percent for gas pipes.

Furthermore, "Over the whole life cycle," they say, "Our study of pipe applications globally shows that the energy saved by using plastic pipes instead of alternative materials is 32% and emission of GHG (Greenhouse Gas) is reduced by 61%."

► ITALIAN AGENDA

Cino Serrao who looks after public affairs for Borealis in Southern Europe presented an incisive paper on the situation in Italy. With warmer Italian summers and leakage rates up to 42%, pipe replacement has been slow to appear on the agenda.

Even though rehabilitation with plastic pipes have never been so easy and cost effective, government institutions have been reluctant to invest in the present and the future. But Cino informed us that things are changing for the better.

Common platform

A successful attempt has been made to unite all representatives of the complete pipe chain from raw material producers to pipe makers through to utility companies, institutions and consumer groups.

"The seeds for change were sown three years ago at the last pipe conference held in Italy. A small group of interested parties that wanted to promote investment and quality in the infrastructure in Italy came together. From a kick-off workshop seminar we have created waves of involvement and a platform for action." Says Cino.

That platform was absolutely necessary.



Cino Serrao

"The situation before was characterised by problems with underground networks, countless water leakages, rainwater scarcity, changing regulatory environment, focus on price rather than quality, plastic products sold at low added value limiting system investment and hence innovation on the part of pipe makers."

Quality of life

Serrao is confident that all the players are now coming together and collaborating. He quotes Antonio Longo who is former president of the consumer group involved with the change process: "Is cost important? Of course it is, but so is our quality of life which relies on a high quality and effective pipe network"

Four working groups have been set up to look at: Installation Quality and Control, Safeguarding Quality in Operators' Contract, Product Quality & Certification and Longer Term Financial investment

Many proposals, projects and financial resources have been formulated and the plastic pipe industry is studying Italian events closely for best practice.

Next conference

Plastics Pipes XVI will take place at the Budapest Intercontinental Hotel in September/October 2008. Uponor's Jeremy Bowman will chair the event. It will not be a disappointment.

► CONFERENCE PAPERS

1. Polyethylene Pipes, the Natural Choice for Sustainable Development
Andre Scheelen, INEOS Polyolefins

2. Corrosion-Free Solution for Sustainable Water and Wastewater Systems
Bob Walker, Uni-Bell PVC Pipe Association

Applications/Case Studies

3. Replacing London's Victorian Water Mains
Mike Shepherd, Thames Water Utilities

4. Sustainable Municipal Pipes: The Performance of Plastics Pipes in Sewer Systems
Tiem Meijering, TEPPFA

5. Molecularly Oriented PVC Pipe - the North American Experience
John Houle, PW Eagle

6. Central/Eastern Europe (CEE) Experience with Market Development of Plastics Gravity Pipe Networks and Plastics Chambers in Particular
Piotr Falkowski, Wavin Metaplast-Buk

7. Sustainable Sewage Management Through High Quality Piping Systems Made of HDPE - 16 Years of Experience in the City of Goettingen, Germany
Manfred Fiedler, City of Goettingen Germany

8. Case Study of the Largest PE100 Pipeline Project in North America
Dane Chang, The Dow Chemical Company

Developments in new materials

9. High Performance PE100 Resin with Extraordinary Resistance to Slow Crack Growth
Tetsuya Yoshikiyo, Japan Polyethylene Corporation

10. Choosing PVC Resins for Formulation Properties
Zena Sin-Nga Ng, Ipex, Inc.

11. Innovative PE100 Material Improves the Quality and Productivity of Injection Moulded Fittings
James McGoldrick, Borealis Group

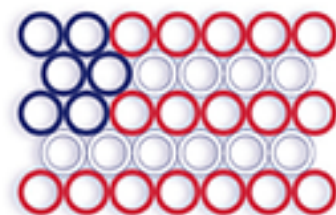
12. Taking Slow Crack Growth - Rapid Crack Propagation Balance of Bimodal PE 100 Resins to the Next Level
Sebastian Joseph, Lyondell Chemical Company

13. Introduction of New Materials "High-flow" PE 100 Grade
Yoshiyuki Hirase, Prime Polymer Co., LTD.

14. An Evaluation of Polyamide 12 for High Pressure Natural Gas Distribution Applications
Richard Wolf, Polymer Processing Solutions, Inc.

Installation

15 Horizontal Directional Drilling of PE Pipe: An Advanced Technology
Larry Petroff, Performance Pipe Div of Chevron Phillips Chemical CO



16. Solutions to Installation Difficulties with PE Pipelines
Steve Mackellar, Bodycote PDL

17. Viability of High Density Polyethylene Pipe for Trenchless Installations
Samuel T. Ariaratnam, Arizona State University

18. A novel Qualification Concept for Lifetime & Safety Assessment of PE Pressure Pipes for Arbitrary Installation Conditions
Reinhold Lang, University of Leoben, Austria

19. A Novel Approach to PE Pipe Insertion Using Four-Lobe Vacuum Collapse
Trevor Stafford, PLASTICPIPES

20. Repair and Remediation Technologies for Damaged PE Pipes
Hitesh Patadia, Gas Technology Institute

Lifetime and durability of systems

21. A Vision Becomes True: 50 years of Pipes Made from High Density Polyethylene
Ulrich Schulte, Basell Polyolefine GmbH

22. Evaluate the Long-Term Stress Crack Resistance of Corrugated HDPE Pipes
Grace Hsuan, Civil, Architectural & Environmental Engineering, Drexel

23. Effect of Processing on the Lifetime of Pipe HDPE Grade
Pavel Sindelar, Polymer Institute Brno, LTD

24. Durability Testing for 100 year Lifetime for Buried Non-pressure Plastic Pipes
Kristian Thornblom, SP Swedish National Testing & Research Institute

25. Performance of Scratched HDPE Pressure Pipe
Jimmy Zhou, The Dow Chemical Company

26. Practical Use & Performance Testing of Light Weight Thermoplastics Pipes
Peter Chapman, Vinindex Pty Ltd.

The World

27. Promoting Investment & Quality in the Local Infrastructures in Italy
Cino Serrao, Borealis Group

28. Introducing PE100 for Medium Pressure Gas Networks in South America – Quality and Value from a Leading Material
Andre Scheelen, INEOS Polyolefins

29. The Energy Crisis - Designing with Material and Energy Efficient PVC and HDPE Piping Systems
M.A. Osry and Anton Tjabring, DPI Plastics (Pty) Ltd.

30. Development of a Whole Life Costing Model for Large Diameter Water Mains
David Walton, Borealis AB

31. Plastic Pipes Play a Major Role in Rehabilitating the Water and Sewerage Systems in Bydgoszcz, Poland
Anna Wroblewska, Wavin Poland

Recycling and environment

31. Plastics Pipes and Drinking Water Quality
Tiem Meijering, TEPPFA

32. Kinetic Modeling of the Ageing of Polyethylene Pipes for the Transport of Water Containing Disinfectants
Ludmila Audouin, ENSAM

33. Collection and Recycling of Plastics Pipes in the Demolition and Construction Waste Stream
Alan Whittle, Iplex Pipelines Australia Pty Limited

34. PVC Pipe and Fitting Recycling in Action
C. Fisher, Uni-Bell PVC Pipe Association

35. New Test Method to Determine the Effect of Recycled Materials on Corrugated HDPE Pipe Performance as Projected by the Rate Process Method
Gene Palermo, Palermo Plastics Pipe Consulting

Plastic pipe design

36. Stability of Deeply Buried PVC Sewers Under Vertical Risers
Ian Moore, GeoEngineering Centre at Queen's –RMC, Queen's University

37. Study of the Use of Rocker Pipes to Allow for Differential Ground Movement in Pipelines
Professor D.C. Wijeyesekera, University of East London

38. Buried Plastics Chambers: Performance
Frans Alferink
Wavin Overseas B.V.

39. The Reclamation E' Table, 25 Years Later
Amster Howard, Consultant

40. Transport Properties of Gas Mixtures through Polyethylene
Marie-Helene Klopffer, Institut Francais du Petrole

41. Usage of HDPE in Bridge Construction – A Corrosion Protection System for Steel Tendons Under Extreme Loading
Hermann Weiher, Technical University Munich, Department of Concrete Structures

Material Science SCG

42. Development of Notched Ring Test for Measuring Slow Crack Growth in Plastics Pipes and Fittings
Sunwoong Choi, Hannam University

43. Predicting Slow Crack Resistance Growth in Polyethylene Resins from Detailed Polymer Microstructure Obtained by SEC-FTIR
Paul DesLauriers, Chevron Phillips Chemical Company, LP

44. Research of PE Pipe's SCG Characterization Under Varying Temperature Conditions
Naoto Tominaga, Pipeline Technology Center, Tokyo-Gas Co. LTD.

45. Accelerated Method to Determine or Predict Failure in Polyethylenes
Carlos R. Corleto, Total Petrochemicals USA, Inc.

46. Development of an Accelerated Slow Crack Growth (SCG) Test Method for Polyethylene (PE) Pipe and Correlation with Hydrostatic Stress Rupture Test Method ASTM D 1598
Stephen Boros, Plastics Pipe Institute, Inc.

47. High Melt Strength PE100 Pipe Resin
William J. Michie, The Dow Chemical Company

Industrial

48. Use of a DN 1050 mm PP Pipe in a Methanol Plant in Trinidad
Matthias Haese, FRANK GmbH

49. Large Diameter Profile Wall Pressure Pipe
Gerry Groen, KWH Pipe (Canada)

50. PE-RT, A New Class of Polyethylene for Industrial Pipes
Detlef Schramm, The Dow Chemical Company

51. New Realm of Possibilities for PEX Pipes
Yosi Bar, Golan Plastics Products

52. Using the CRS Concept for Plastic Pipe Design Applications
Gene Palermo, Palermo Plastics Pipe Consulting

Material Science RCP

53. Establishing the Correlation Between S4 & Full Scale Rapid Crack Propagation Testing for Polyamide-11 (PA-11) Pipe
Jim Mason, Arkema, Inc.

54. S4 Critical Pressure and Critical Temperature: A New 4-Laboratory Round Robin
Pamela Maeger, Chevron Phillips Chemical Company, LP

55. Rapid Crack Propagation (RCP) Failures in HDPE Pipes: Structure-Property Investigations
Rajendra Krishnaswamy, Chevron Phillips Chemical Company, LP

56. False Arrest in Small Scale Steady State (S4) Rapid Crack Propagation (RCP) Testing
Ken Oliphant, Jana Laboratories

57. Rapid Crack Propagation in Loosely Fitted PE Liner Pipe
Patrick Leever, Imperial College London

Joining I

58. Comparison of Long-Term and Short-Term Tests for Electrofusion joints in PE Pipes
Mike Troughton, TWI Ltd.

59. The Inspection of Cold Welds in Electrofusion Joints
Colin Bird, TWI Ltd.

60. Fusing at Higher Interfacial Pressures
Ted Striplin, McElroy Manufacturing, Inc

61. Containing Thrust Forces in Municipal Pipelines: An Integral Joint restraint System for PVC Pressure Pipes
Shah Rahman, S&B Technical Products/Hultec

62. Plastic Pipes for High Pressure Applications: Jointing Technique for New Pipe Design & Materials
Robert Eckert, FRIATEC AG

63. Non-Destructive Ultrasonic Inspection to Detect Flaws in Plastic Pipe Walls & Joints – Correlation with Lab Testing
Frans Scholten, Kiwa Gastec Technology

Hot water

64. Flexible, Pre-Insulated Polymer District Heating Pipes: A Service Lifetime Study
Dr. Alexander Graf von Bassewitz, Rehau AG & Co.

65. Copolymerized Silane PEX Technology – A New Innovation for Producing PEX Pipes
Tom Venator, Borealis Compounds, LLC

66. Evaluation Methods for Cross linked Polyethylene Pipes for Hot Water Supply & Space Heating Systems
Hiroyuki Nishimura, Energy Technology Laboratories, Osaka Gas Co., Ltd.

67. 30 Years of Pressure Testing on PEXa Pipes
Hansjorg Nitz, Basell Polyolefine GmbH

68. CPVC/Metal/CPVC Composite Piping Systems
Robert Frimel, Noveon, Inc.

69. PP-RCT: A New Material Class for Plumbing & Heating Applications
Reinhold Gard, Borealis Group

Joining II

70. A Photoelastic Study of Strains in PVC Pipe Bells Encountered During a Variety of Assembly Scenarios
Dennis Shumard, North American Pipe Corporation

71. PVC Pipe Jointing: The Rieber System in North America
Shah Rahman, S&B Technical Products/Hultec

72. Analytical Testing of Advanced Butt Fusion Technology for HDPE Pipe
Steve Sandstrum, ISCO Industries, LLC

73. Evaluation of Polyethylene Welders
Phillipe Vanspeybroeck, BECETEL vzw

74. Optimisation of Butt Fusion Welding (and Testing) of Thick Walled PE100 Pipe
David Lowe, Bodycote Pipeline Developments

Additives

75. Organic Pigments for Weatherable Polyethylene
Roger Reinicker, Ciba Specialty Chemicals Corp.

76. Development of a Validation Method for the Use of Miner's Rule in Predicting the Oxidative Resistance of Polyolefins
Jim Paschal, J. Hassinen — Bodycote Polymer

77. Inorganic Impact Modifier and Processing Aid for PVC Pipes
Gerd Schmaucks, Elkem AS, Materials

78. The Use of Talc in Polyolefins Pipes Reinforcement
Jerome Crepin-Leblond, Luzenac Europe

79. DSC-Gelation Measurement: Influence of the PVC Pipe Formulation on the Result
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80. Specifying PE by Material Performance
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81. Second Generation Skinned Pipes with Enhanced Fracture Resistance
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82. Renovation of a 2.4 KM Stretch of 2.5 MPa Gas Pipeline Using Compact Pipe Technology
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83. An Examination of the Relative Impact of Common Potable Water Disinfectants (Chlorine, Chloramines and Chlorine Dioxide) on Plastic Piping System Components
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84. UKWIR National Mains Failure Database
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85. Socket Forming Process for Polyethylene Pipes for Conveying Pressurised Water
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86. Fabrication & Evaluation of Polyethylene Based Composite Gas Pipes
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87. Long-Term Hydrostatic Resistance of Multi-layer Pipes
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88. Analysis of the Fracture Behavior of Multi-Layer Pipes
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89. Development of the Innovative Technology for Aged House Pipes Using Double-Layered Corrugated Plastic Pipe
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90. Multilayer Pipes with Integrated Leakage Monitoring for Trenchless Technologies
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91. PE 4710: What's in a Name?
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92. Effect of Elevated Temperature on Stress-Rupture Testing of Low Inherent Viscosity PVC Resin
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93. A Complete Set of Specifications for All Kinds of Plastics Pipeline Materials Used in Gas Distribution Systems
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94. Environmental Effects & Economic Consequences of the Operation of Sewer Systems
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95. Analysis of Ductile and Brittle Failures from Creep Rupture Testing of High-Density Polyethylene (HDPE) Pipes
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96. Innovative Methodology for Fitting Lifetime Prediction and Process Control by Correlating Rate Process Method Analysis of Molded Fittings with Notch Ring Test Data
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97. Development of Large Diameter Multi-Pipe Bundles for Long Distance No-Dig Installations
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98. Gas Pipework Installation in Buildings: New Plastics or Traditional Copper?
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99. An Effective Barrier Pipe System for Contaminated Land
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