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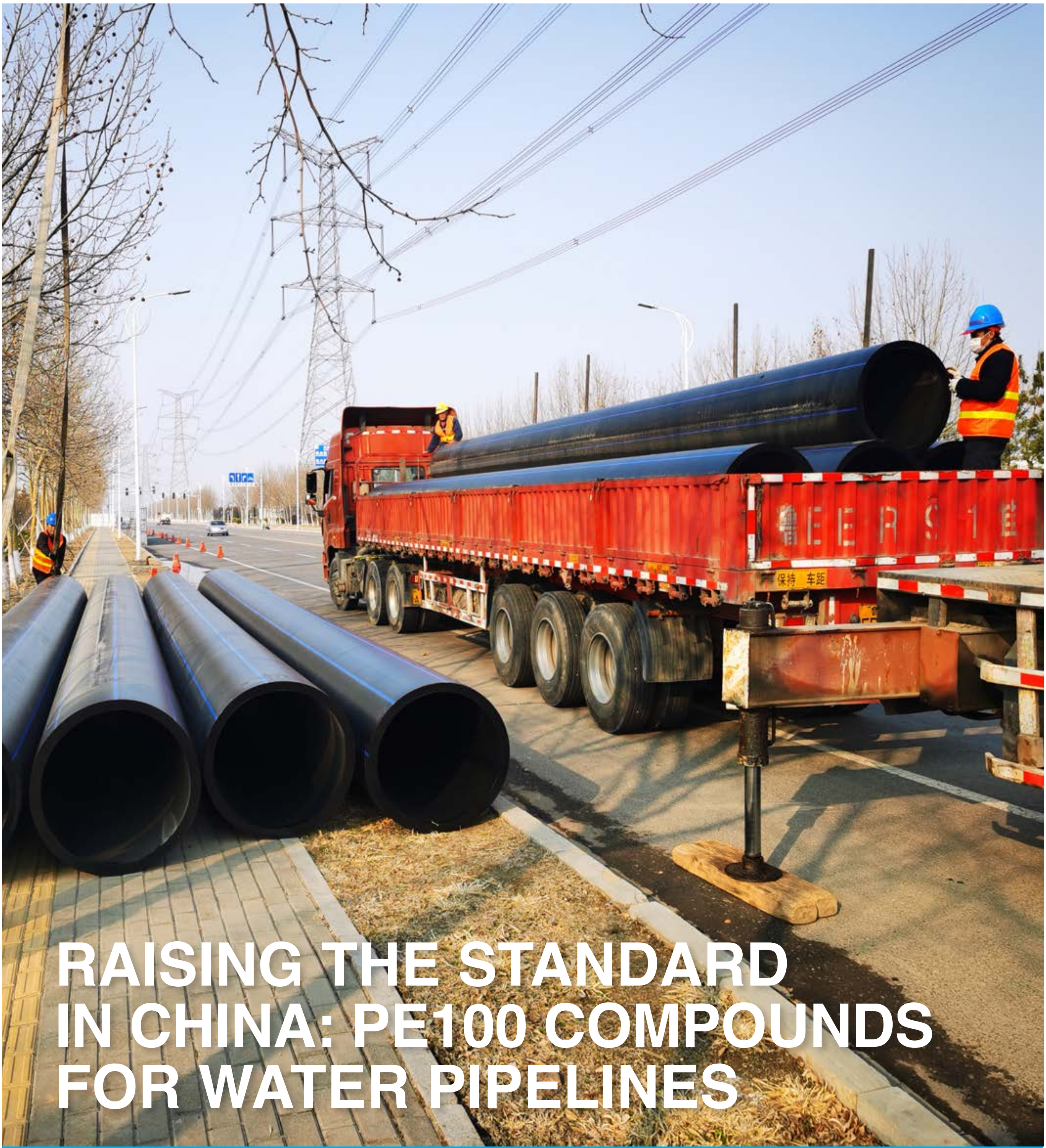

RAISING THE STANDARD IN CHINA: PE100 COMPOUNDS FOR WATER PIPELINES

Water for the World initiative brings 24/7 supply to a village in Morocco

World's longest tow of long length large diameter (LLLD) PE100 pipes to Malaysia

Lifetime assessment of ZADCO subsea PE100 effluent pipeline

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INSPIRING TOMORROW

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A note from the editor

Greetings on the start of a new decade! While the year itself didn't start too pleasantly with the horrific bushfires in Australia to the epic floods in Jakarta on New Year's Day and the current spectre of the coronavirus sweeping the world seemingly unstoppable, we should take heart that this too shall pass.

The cover features what we hope is the start of a growing trend towards the use of PE100 compounds in China's water distribution pipeline projects. While certainly not the first of its kind in China, this project in Shandong province is symbolic as it comes right after the national standards were updated to specify the use of compounds in 2019. The implications of this could not be more significant given that China is today the world's largest plastic pipe market by volume and a shift towards the use of higher quality compounds will lead to pipes with superior operational life and lower life cycle costs.

The trend towards large diameter PE100 continues in Pakistan and in Myanmar we feature an interesting development in multilayer pipeline. In the Industrial segment, we feature a study validating the remaining lifetime of a PE100 pipeline that was originally meant as a temporary solution in hydrocarbon effluent disposal – highlighting again the tremendous versatility of polyolefin pipeline solutions. We also feature the details of a world record tow of long length large diameter PE100 from Norway to Malaysia. In PE100 RC/HSCR, we highlight the move towards the acceptance of the Strain Hardening and Cracked Round Bar test methods as the industry moves closer to harmonising a set of globally acceptable performance criteria for materials with higher resistance to crack propagation.

In the indoor plumbing application, we stress the importance and benefits of using specially formulated and fit-for-purpose colour master batch for PP-R pipes and wrap up this edition with a heartwarming story, under the Water for the World umbrella, of bringing water to a remote Moroccan village.

We hope you enjoy reading this issue and look forward to crossing paths in the coming months!

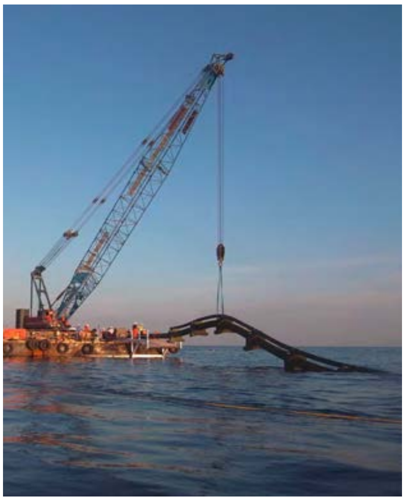
Your editor,

KH Lou

CONTENTS

MAIN STORY

TOP STORIES



Raising the standard in China: PE100 compounds for water pipelines

by Jinghui Li

China has 2.8 trillion m^3 of fresh water resources and ranks fourth in the world. However, its water resources per capita is only approximately 2,000m^3, which is 25% of the world average, making China one of the most water scarce country. Making matters worse, China also has serious water resources imbalance between its northern and southern regions as well as its inner (western) and coastal regions. As a result, two-thirds of Chinese cities suffer water shortages and about 300 million of its rural population do not have access to clean and safe drinking water. The national average water leakage rate of 16% from its pipe networks exacerbates the water scarcity problem.

Pipes being unloaded on site.

In order to further reduce the water leakage rate and protect its drinking water quality, China recently revised its GB/T13663 national standards to specify that only pre-compounded PE resin be used to produce polyethylene water pressure pipes. In the past, poor quality pipes made by mixing natural PE100 with carbon black masterbatch (CBMB) (also known as salt and pepper) often resulted in premature failures that led to water leakage and gave plastic pipes a bad image in China. Pre-compounded PE reduces the risk of mistakes during pipe production thus ensuring more consistent pipe quality enabling the utility to reap the full benefits of PE such as corrosion resistance, long operational lifetime (more than 50 years), better water quality and lower leakage rates.

Previously published studies (as shared in BorPipe issue 45 and 46) have shown that using pre-compounded PE resin to produce pipes results in better carbon black distribution, mechanical and welding properties as compared to mixing natural PE100 with CBMB. In addition, the Borouge material identification service that has successfully helped the Chinese gas utilities reduce instances of counterfeit pipes can also do the same for the water utilities.

Jointing a section of the pipeline.

A recent water supply integration project that was planned to link the water supply for Dongying City with that of rural Dingzhuang and Chenguan Town started in 2019 and is scheduled to be completed in 2020. Dongying City is located in Guangrao County in the province of Shandong, China. The plan is actually made up of four projects which will integrate the city and rural water supply. This will reduce water shortages and address water quality issues. The current water quality suffers from high water hardness, with fluorine levels that exceeded limits at some villages due to insufficient water treatment capacity.

A 55.4km pipeline mostly made up of 710mm OD SDR17 PE100 linking Dongying City Centre with the Dingzhuang Town water treatment plant aims to cater to the total water demand for Dingzhuang Town. The surplus water will then be supplied to Chenguan Town with a separate 21km PE100 pipeline of similar size from Shiji Road to Guangging Road. This will help secure the drinking water supply for 60,000 residents in the city and the surrounding 63 villages. This investment with a total value of USD55.4 million will provide a solid foundation for future expansion to cater for future growth.

The owner of the pipeline system selected PE100 pipes from Shandong Shengli who has been using the BorSafe PE100 for almost two decades and are very comfortable and familiar with its quality, supply consistency and track record.

Lifetime assessment of ZADCO subsea PE100 effluent pipeline

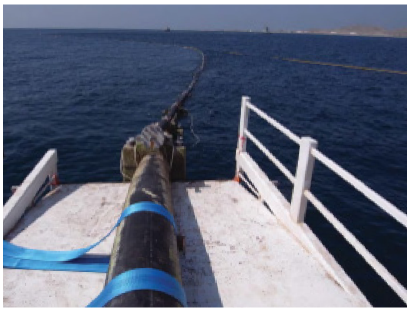
Extract of paper prepared by Farraj Tashman, Mohamed Ali Jaber and Sultan Al Kendi for PPXIX 2018 Conference

INTRODUCTION

Polyethylene and polymeric materials in general are being used more increasingly as non-metallic solutions for the oil and gas industry. For moderate operational temperature and pressure, recommendation of pipe grade PE material for many applications in this sector is growing. Moreover, major oil companies are very keen to develop these non-metallic solution to reduce capital and operational expenditure (CAPEX & OPEX).

In this paper, we will showcase a project where a PE100 pipeline was installed to replace a corroded and leaking carbon steel subsea pipe. It was supposed to be a temporary solution for two years until the new carbon steel pipeline is installed permanently. However, after conducting two studies [1] [2] on the design and expected remaining lifetime of the pipeline, ADNOC Offshore decided to keep the line. It has been operating since then without any leaks.

Moreover, the volume of produced water delivered (175,000 barrels per day (B/D) at 260psig) is 40% more than anticipated (125,000 B/D at 350psig) – thanks to the much lower friction factor of the smooth internal surface of the PE100 pipe. By relying on the leak-tight PE100 pipeline, ADNOC Offshore did not only reduce the project's CAPEX & OPEX, they preserved the marine environment by eliminating the threat of continuous contamination through the corroded carbon steel pipe.

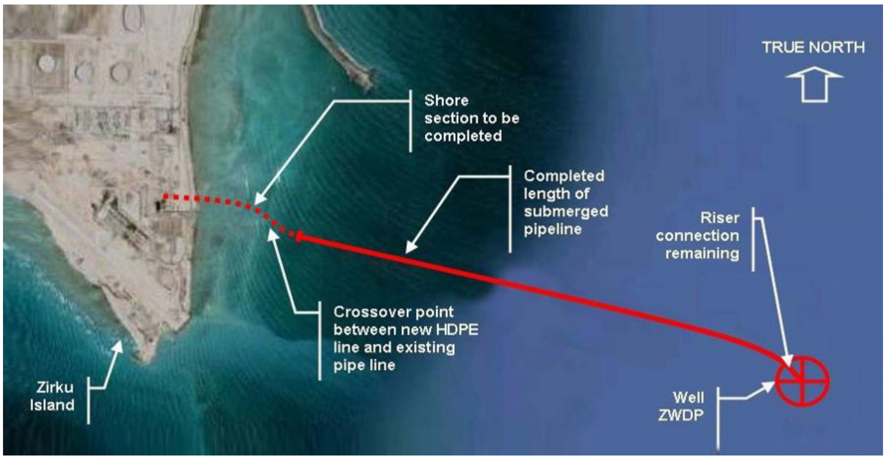


Preparing the PE100 pipeline to be submerged on site.

The PE100 pipeline in operation after several years.

BACKGROUND

In late 2011, ADNOC Offshore (known at that time as Zakum Development Company – ZADCO) decided to replace its leaking 4.5km 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 7,000ft deep well, after separation from crude oil. The quality of the re-injected water is strictly monitored after treatment with demulsifiers to reduce hydrocarbon contents to the acceptable industry level of 500-1,000ppm. However, increasing leaks from the corroded carbon steel pipe was posing a continuous risk of contaminating the marine environment with hydrocarbons. This threat was resolved by replacing carbon steel pipeline with leak-tight PE100 pipeline system.



Location of the subsea pipeline with respect to Zirku Island off Abu Dhabi.

Previous studies conducted

ADNOC Offshore hired two reputed professional bodies to assess if the PE100 pipeline can be relied on to continue operating after the initial two years.

The first assessment was carried out by UK-based Intertek CAPCIS in 2013 to analyse the design of the PE100 pipeline and estimate the remaining lifetime of the pipeline. Using several techniques, in light of the pipe dimensions – wall thickness in particular – and operating conditions, it was predicted that the original design allows the PE100 pipeline to operate safely in excess of 50 years if the pipeline is operated under the same pressure and temperature regime used in the first two years of its operation. It was recommended to reduce the operating pressure from 350 to 260psig to avoid operating the pipeline at the upper boundary of the maximum allowed hoop stress. This was not an issue since the actual volume of the delivered water at 260psig is 40% higher than the anticipated volume at 350psig.

The second assessment was carried out by Exova (UK) Ltd in 2016 to quantify degradation in properties of pipe/material, estimate remaining lifetime and revise design life of the PE100 pipe with boundary conditions. Many tests were conducted on a pipe sample with fused joint taken from the pipeline and a reference sample. The properties of the pipe/material were found intact and the estimated remaining life of pipeline was analogous with the first assessment. A third assessment, which is the subject of this paper, was conducted by Borouge Innovation Centre [3] on a pipe sample taken from the line and benchmarked with a reference pipe.

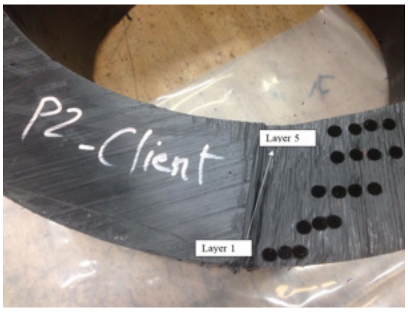


Figure 1: Sample of used pipe, P2

CURRENT STUDY (2018)

Material samples

Two pipe specimen were investigated; one taken from the pipeline after operating for several years, marked as P2. The other one was a reference spool that was never used, kept for this purpose, marked as R2. Five samples were collected from each pipe through the pipe wall layers as shown in figures 1 and 2 below. Sample 1 was taken from layer 1 near the outer surface of the pipe and sample 5 was taken from layer 5 near the inner surface of the pipe. Measurements have been conducted on those five samples of each specimen along with the inner and outer skin layers.

In addition, lifetime assessment of the pipe was conducted on an ISO 9080 based regression analysis programme [7] that uses regression data of the raw material resin used to produce this pipe.

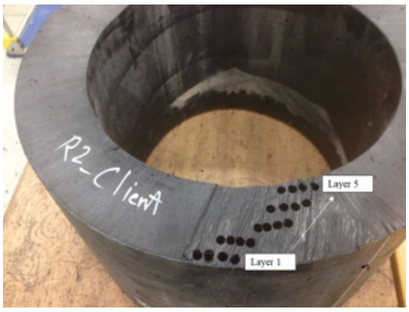


Figure 2: Sample of reference pipe, R2

Test Method	Code	Ref. Standard	Remarks
Headspace Gas Chromatography/ Mass Spectrometry	HS-GC-MS	ASTM E1388 [4]	–
Oxidation Induction Time	OIT, 210°C	ISO 11357-6 [5]	Directly from pipes
High-Performance Liquid Chromatography	HPLC	ASTM D6042 [6]	UV detection @ 225/210nm, ACN / H_2O gradient

Table 1: Test methods used in the Borouge Innovation Centre analysis

CONCLUSION

Head Space GC-MS

It is observed from the HS-GC-MS analysis of samples from R-2 and P-2 pipes layers 1-4 that both are comparable. The significant difference is seen only in the case of samples taken from layer 5, the innermost core layer, of P-2 wherein more hydrocarbon group peaks are seen. This means that up to layer 5 the migration of hydrocarbons had occurred in sample P-2 from the inner core. There is no significant difference in hydrocarbon peaks of the outer layer towards the inner layer in samples from R-2. The major hydrocarbon group peaks observed for both R-2 and P-2 are typically n-alkanes. However acetone (peroxide residue-presence which is a sign of polymer degradation) is observed in minor quantity in R-2 outermost skin sample probably because of prolonged exposure to UV sunlight and oxygen. These results are within expectation given that P-2 is continuously exposed to water containing hydrocarbons.

OIT

It can be noted that in the bulk of the pipe (layers 1 to 5), residual OIT of both P-2 and R-2 pipe samples are very high and well above the minimum requirement. Moreover, values are similar to the value of the PE100 resin batch used to produce the pipe. It is safe to assume that the lower value of OIT at the outer and inner superficial skins can be attributed to depletion of some of the antioxidants due to UV and exposure to hydrocarbon traces in the produced water – in case of P-2.

OIT at 210°C, minutes (average)							
	Outer Layer	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Inner Layer
P-2 Pipe	5.8	26.7	31.7	28.4	33.9	35.2	11.3
R-2 Pipe	6.4	26.7	27.7	28.7	30.7	28.1	14.2

Table 2: Summary of OIT results at 210°C across the pipe cross-section

Scenario	Pressure, psi	Temperature, °C	Time, years	Safety Factor	Design Lifetime, year
P-2 Pipe	360	32	1	1.25	27
	260	32	Rest of lifetime	1.25	27
R-2 Pipe	360	32	1	1.22	99
	260	32	Rest of lifetime	1.22	99

Table 3: Pipe operational conditions with safety factor

HPLC

The additives concentration in both R-2 and P-2 pipes are comparable. However, AO1 in samples taken from P-2 is observed to be slightly less than samples from R-2. It is assumed that this observation may be due to the consumption of AO1 due to peroxide molecules (though not conclusive) formed as a result of PE pipe exposure to the environmental conditions like UV and oxygen.

Lifetime Assessment

Based on actual operational conditions (pressure, temperature and time), the lifetime assessment of SDR 7.4 with safety factor of 1.25 is 27 years, however if the safety factor used is reduced to 1.22, the expected lifetime is expected to reach 99 years. Note that the lifetime assessment is done on SDR 7.4 (75mm thickness) and the nominal SDR of the subject pipe is 7.27 which means the minimum required thickness is 77mm. For this pipe the minimum measured wall thickness for P-2 and R-2 was 79mm. Hence, there is a safe margin of confidence that allows us to reduce the safety factor from 1.25 to 1.22 without compromising the accuracy of the assessment. Based on the above, the properties of the pipe in operation are intact and it is expected to provide reliable service for more than 25 years.

Thanks to the robust properties of PE100, the inevitable threat of continuous contamination of the surrounding marine environment is mitigated for years to come.

References

[1] Assessment report by UK-based Intertek CAPCIS: Analysis of the Design of the 560mm Subsea PE100 Pipeline for Projected Long Term Use

[2] Testing report by Exova UK Ltd: Condition Assessment of 16" HDPE Pipes

[3] Technical Report by Borouge Innovation Centre – BIC UAE: Assess and quantify degradation in properties of the material/pipe

[4] ASTM E1338. Standard Practice for Static Headspace Sampling of Vapors from Fire Debris Samples

[5] ISO 11357-6. Plastics - Differential scanning calorimetry (DSC). Determination of oxidation induction time (isothermal OIT) and oxidation induction temperature (dynamic OIT)

[6] ASTM D 6042. Standard Test Method for Determination of Phenolic Antioxidants

[7] Pipeson Analyser http://pipeson.com/products/analyzer/

Importance of colour masterbatch selection for PP-R pipes

by Soke Meng Chan and Phairat Phetchamnan; Ampacet (Thailand) Ltd and Amos Tay

PP-R hot and cold water systems operate at high temperatures and pressures and therefore high product quality and system integrity is essential. However, unlike the pressure pipe market most systems are manufactured from natural polymer and a coloured masterbatch. Whilst this gives the system producer a greater flexibility of supply and reduced storage it demands greater vigilance with regard to the quality of the masterbatch and the consistency of the mixing process in pipe production as these are key to system performance.

Ampacet are a company with considerable experience in the manufacture and supply of coloured masterbatches for a wide variety of applications. From their regional headquarters in Rayong, Thailand and their network of regional manufacturing sites they supply products throughout Asia and Australasia. In this article they share some of the important considerations when selecting a coloured masterbatch for PP-R hot and cold water systems.

Colour masterbatches are not only used for colour indication but can also provide functionality to PP-R pipes. Improper selection of PP-R masterbatch may lead to problems during pipe production and affect service life of the pipes.

THE CHALLENGE

PP-R pipe resins are designed to meet the requirements of established industry standards; e.g. the Borstar® PP-R pipe resin from Borouge have been designed and formulated to fulfill all the requirements for hot & cold water plumbing service.

Colour masterbatches available from the market may affect the performance of the pipe if the following aspects are not considered:

- Processing compatibility
- Durability when subjected to heating and cooling cycles
- Extraction resistance of colourants and additives
- Good organoleptic properties, hence no taste or odour
- Food contact compliance

In an extreme case, the pipe may not meet the product standards, which could lead to pipe failures and a loss of confidence in plastic systems.

Examples of problems that can be encountered by pipe producers when selecting improper colour masterbatches are:

- Poor processability; inconsistent flow of melt exiting die, difficult to guide the melt to orifice
- Productivity; significant volumes of waste from uneven melt and pipes with poor quality
- Pipe quality; rough surface and poor colour dispersion
- Odour during processing; wrong masterbatch carrier (e.g. PE) or pigments used are not suitable for PP-R pipe processing
- Non-compliance to food contact approval due to raw materials used
- Lower heat stability in hot water due to polymer degradation or presence of low molecular weight or low heat stability ingredients

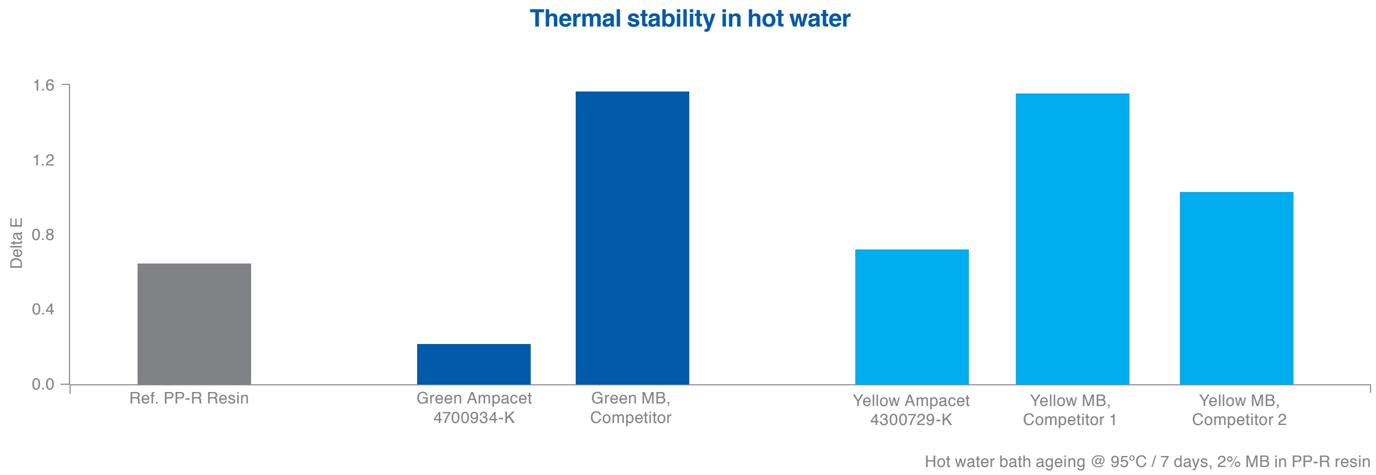


Figure 1: Comparison of PP-R masterbatch to colour masterbatch from market

THE SOLUTION

Ampacet initiated a study to identify the most optimal colour masterbatches for PP-R pipes using the appropriate type of carrier, colourants and additives. Borstar RA140E was used as the base resin in the studies and the different coloured masterbatches were let down at 2% into the resin. The samples using both Ampacet and competitor colour masterbatches were then subjected to water bath ageing in the laboratory to simulate typical PP-R pipe end use conditions. The results given in figure 1 show the colour change in the samples after 7 days of immersion in the water bath at 95°C. The colour change is expressed as the Delta E and values for Delta E below 1 are normally considered acceptable. The samples of green and yellow masterbatches collected from the market showed poor colour fastness and warping after hot water ageing, suggesting a lower melting temperature carrier resin was used in the masterbatch production.

Trials also showed that using a properly designed masterbatch reduced the scrap rates in the production of PP-R pipes. Pipe converters also reported better handling of melt and easier processing. The pipe quality is also improved when compared to using standard off the shelf normal colour masterbatch that may not have been specially formulated for PP-R hot water pipes.

Ampacet has produced a series of standard colour PP-R masterbatches with full performance data that is tailored for Borstar RA140E. All three colours shown in Figure 3 can enhance the heat stability of RA140E PP-R resin while giving better colour fastness after hot water ageing.

CONCLUSION

The benefits of using properly designed PP-R pipe masterbatch is proven as it preserves the good properties of the PP-R resin in terms of processing and further improves its heat stability. Selection of the optimal masterbatch provides good cost performance and contribute to sustainability in terms of reduced material wastage.

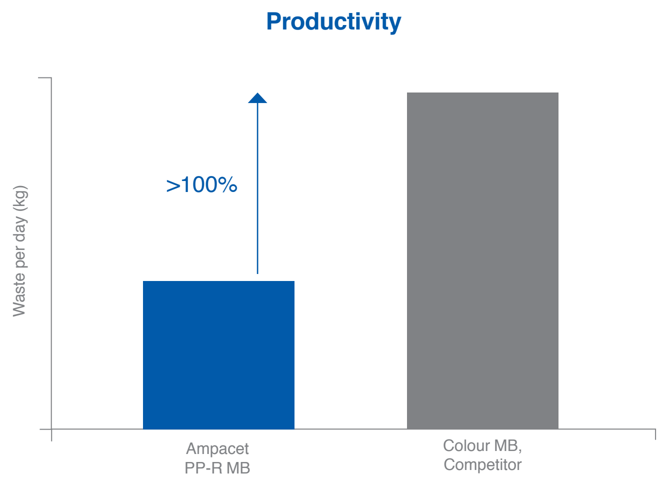


Figure 2: Comparison of PP-R masterbatch to colour masterbatch from market

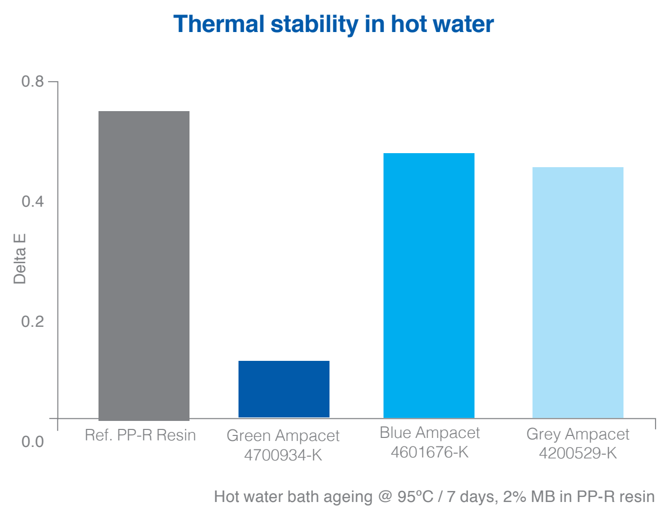
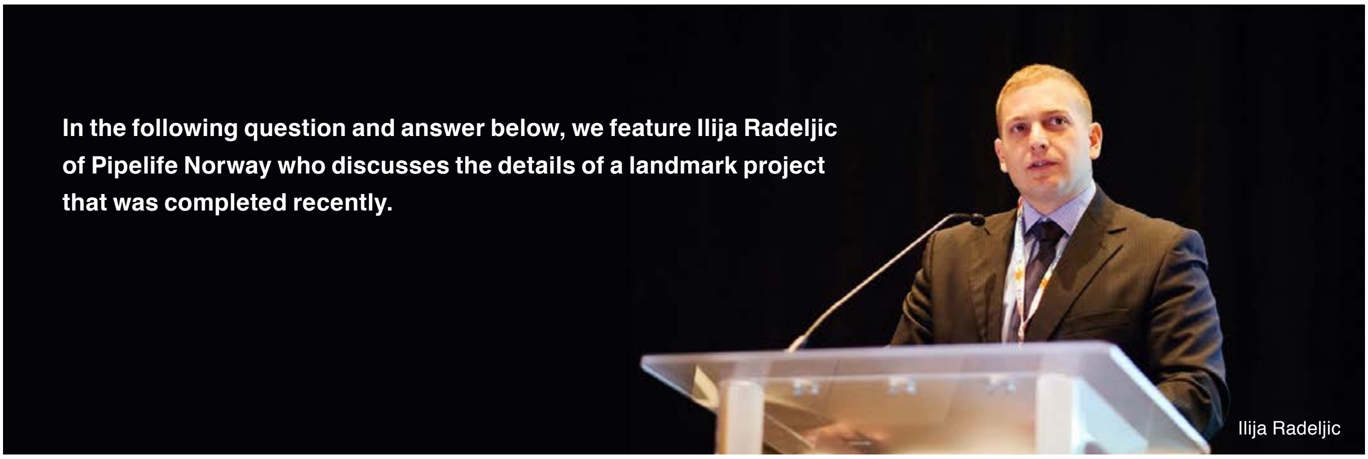


Figure 3: Heat stability of standard PP-R masterbatch

World's longest tow of long length large diameter (LLLD) PE100 pipes to Malaysia

by KH Lou



In the following question and answer below, we feature Ilija Radeljic of Pipelife Norway who discusses the details of a landmark project that was completed recently.

Ilija Radeljic

Can you give our readers some background on Pipelife Norway?
Pipelife Norway has been the pioneer for the last 25 years with the concept of large PE pipe extrusion directly into the sea and then towed to the project destination. Such a concept was developed between the 1960-70's to minimise welds on the pipe due to unreliable welding technology at the time. Towing the pipes to the project location and sinking with the S-bend method has been a key method in Scandinavia at the time. In the 1990's Pipelife started focusing on the export of such a concept with the world largest pipe sizes.

Pipelife Norway is part of a Pipelife Group which is in turn owned by Wienerberger Group. Wienerberger Group is a construction materials group that has been in operation for over 200 years and is today one of the world leaders in clay building materials and plastic pipe solutions. With the powerful backing of the Group, Pipelife Norway has delivered and successfully installed more than 140 major international projects around the world.

Can you give us some background about yourself especially your involvement in LLLD pipes?
I am a qualified MSc civil engineer with a career focus on plastic pipes (in particular solid wall polyethylene) in the marine environment. I have over 14 years experience in dealing with the technical challenges with plastic pipes in various land and marine projects. I am currently the Technical Manager in the long length large diameter (LLLD) export department at Pipelife Norway where I continue to further develop the LLLD concept and perform various engineering tasks related to projects and research & development. I have been fortunate to work on a range of projects from multi-billion dollar power plants, sewer outfalls, desalination plants and wastewater treatments plants which are designed and constructed by world-class companies around the world. My work on these projects was often done in collaboration with the recognised authorities in the field of plastic pipes for marine applications, such as Ingemar Björklund, Ian Larsen, Jan Molin and others.

Workers carrying long lengths of pipes.

Transporting long lengths of pipe by jeeps.

Departure of 6 x 2,500mm OD, 555m long each, welds only on the ends.

Pipe storage in Pipelife Stathelle plant, Norway.

Production of 2,500mm OD SDR26 directly into the protected fjord.

Tell us more about this landmark record tow to Malaysia?

This project is for the seawater intake pipelines for the 842MW Tanjung Kidurong Combined Cycle Power Plant, located in Bintulu, Sarawak, Malaysia. The project is being built by a joint venture of General Electric and Sinohydro (PowerChina) for the client Sarawak Energy.

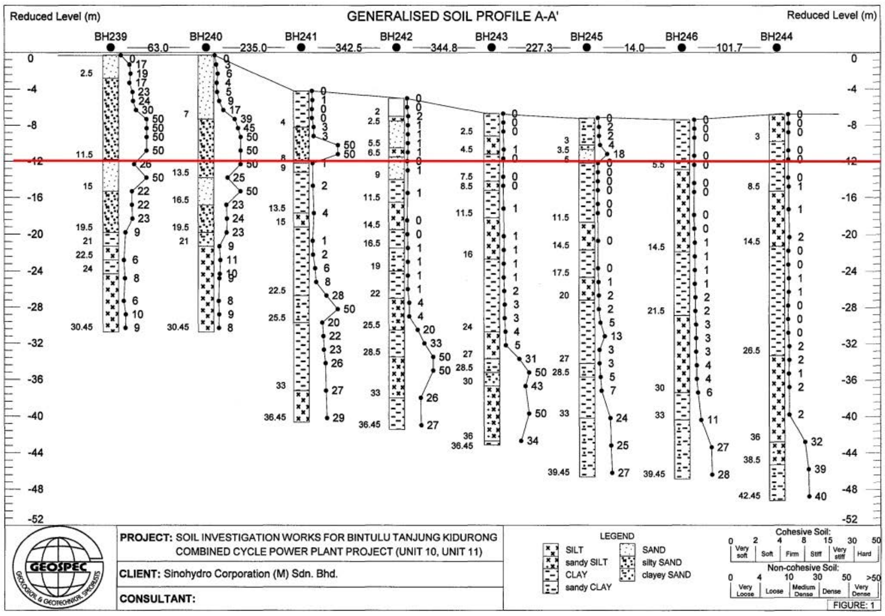
For the project, three parallel intake lines were needed, each over 1.1km long. At the intake location, a cylindrical GRP intake structure was installed, and on the nearshore end, HDPE pipe was connected to the prestressed concrete pipe. The prestressed concrete pipe was buried under the gas transmission line located in parallel to the shoreline.

The LLLD pipes had the following specification:

- Material: Mostly BorSafe PE100
- Quantity: 2,600MT for pipe and fittings
- Type of pipe: HDPE, PE100, seamless
- Pipe sizes: 2,500mm OD, 6 x 555m long
- Pipe wall thickness: min 95.5mm, SDR26

Pipe production started in December 2017 and was completed in just over three months.

The pipes departed for the record-breaking trip from Norway to Malaysia on 30 April 2018 in a tow that lasted 177 days and covered 14,959 nautical miles or 27,704km. This was double the previous record which was a tow to Uruguay.



Geotechnical report and weak soil up to 40m deep. (Courtesy of Geospec Sdn Bhd)

Why was HDPE pipe selected?

The project was initially designed with GRP pipes which is the usual case with power plants. It was only in the last decade that HDPE had achieved the larger sizes needed for the energy industry. Due to the very weak soil, the initially installed GRP pipes had numerous failures. The silt and clay soil at the project location had very weak conditions up to 40 metres deep and hence there was a danger of the pipe sinking into the soil and/or failing due to excessive stresses. Other traditional materials such as steel and concrete were also considered but it was concluded that they would also not be suitable.

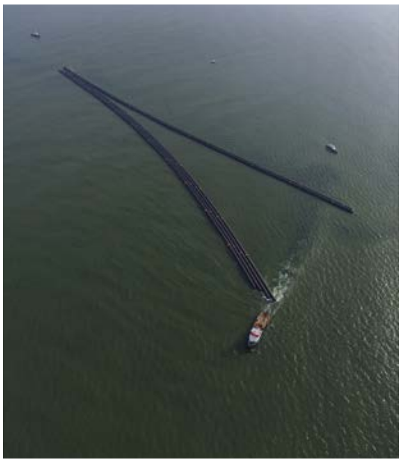
If traditional pipe materials were to be installed in the silt soil, extensive soil replacement would have to be made together with importing a large quantity of engineered aggregate to be used for backfilling and pipe stability of traditional materials in such soils would still be questionable.

After some market research, Sinohydro contacted Pipelife for a solution. Pipelife proposed the solution with long length solid wall PE100 pipes which can remain stable in the silt seabed conditions even during an earthquake. Extensive engineering was needed to prove to the client's engineer, WSP and the owners that solid wall PE is the best solution in the local conditions. I led the Pipelife team in proposing an engineering solution that include the design of the reinforced concrete ballast blocks, on-bottom stability analysis, submersion analysis, guidelines for the bend restrictors when connecting two pipes, cathodic protection, compensator design and selection and pipeline stability under earthquake-induced liquefaction among others.

All this gave the contractor and client the necessary confidence that solid wall HDPE pipe in long lengths was the best pipe material choice. Together with the technical merits of PE100, the contractor and client also had to be convinced that the demanding delivery can be undertaken safely and on time. Approval to proceed with and HDPE solution was finally given after extensive investigation, planning and selection of a reliable and renowned tug company that convinced the client in the overall solution.

Passing the Cape of Good Hope, South Africa.

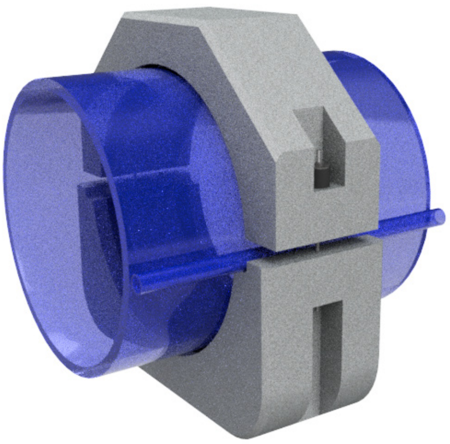
Flexible HDPE pipes during transport and waves.



Handover in Malaysia.

Entering the river on the way to a storage location.

Landfall location of the pipes.



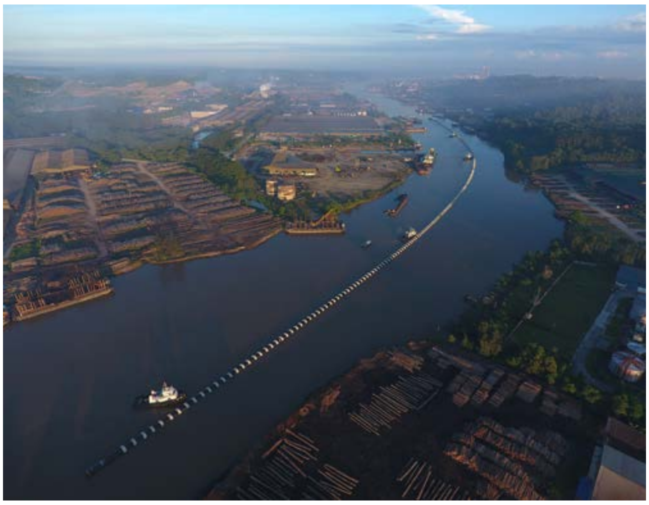
Design of the reinforced concrete ballast block.

What were the biggest challenges/lessons learnt?
This project has established many milestones for Pipelife. The first big challenge was planning and executing the long length pipe tow to Asia which was never done before. It was over double the length of the previous longest tow to Uruguay (approximately 13,000km vs 27,704km). Special care was taken for the route with stops taking into account the weather while passing of Cape of Good Hope and the Indian Ocean. On one occasion the tug even had to adjust its route to avoid the risk of a hurricane.

The weak soil at the landfall was the centrepoint of the whole project and Pipelife had been involved in every aspect of the engineering details especially that of the pipeline behaviour. A team of external experts led by Pipelife was established to address all the concerns raised by the client and provide the best solutions. The scope of analysis included the potential pipe movement due to liquefaction and the optimum ballasting of the pipeline to maintain neutral buoyancy.

The project storage site was another challenges due to the lack of proper port facilities. In the end, the contractor decided to store, assemble and connect the pipeline in the river. The river was relatively shallow, and entering and exiting had to be done at a certain time of the day to catch the high tide and avoid stranding the ballasted pipeline. On top of all the manoeuvring challenges, the river is filled with crocodiles making the ballasting work especially risky.

Six 2,500mm OD SDR26 L=555m each in the storage location.



Ballasted pipe 1.1km long pipe string towed through the river. (Courtesy of PowerChina)

Towage of pipe string on the open sea towards the installation location. (Courtesy of PowerChina)

Submersion of 2,500mm OD SDR26 1.1km long string. (Courtesy of PowerChina)

Any other interesting project information that you can share?

The pipes were connected into three 1.1km long strings, joint strengthened with the specially designed bend restrictor and ballasted with reinforced concrete blocks in a river full of crocodiles. This long pipeline was then towed through the river bends, showing remarkable flexibility even when stiffened with blocks. The pipeline was towed under the bridge, outside the mouth of the river and to the installation location. Each pipeline was positioned over the trench and installed in one go. In total, the installation lasted one day while the actual submersion of 1.1km long 2,500mm OD pipeline lasted only 3.5 hours once the water started being pumped into the pipes.

Another interesting fact is that the trench slope was very wide due to the silty soil and was easily backfilled during a storm. This lead to some increased costs in dredging and trench maintenance. The huge benefit of solid wall long length HDPE pipe was in backfilling with the excavated material.

What is the future of such application?

The future of such application is very bright due to the far superior properties, reliability and longevity of solid wall PE pipes in marine applications. Pipelife has noticed a worldwide interest in solid wall PE pipes for exposed (sea, ocean) and more than 500m long intakes or outfalls. Such pipes are used in many industries such as desalination intakes and outfalls, wastewater treatment outfalls, power plant intakes and outfalls, cable landfall conduits for offshore windfarms, industrial and mining outfalls, sea water air conditioning and potable water transmission lines. The extensive track record of successful installations speaks for itself with over 140 major projects with Pipelife solid wall PE pipes. For wider adoption, more focused promotion and education for the conservative designers and clients is needed. Many are not aware that today there is an alternative to traditional materials.

The overall installation and lifetime cost of long-length solid wall PE solutions are superior to GRP or concrete due to the lack of corrosion, far fewer welds or weak points and resistance to earthquakes and soil settlements. With these advantages, the future is bright for plastic pipes in the marine environment.

What other promotion activities are being planned at the moment?

The success in Malaysia is not the only one since Pipelife has already secured the order for another power plant in Bangladesh. The major EPC contractors are becoming aware of alternatives to traditional materials. If you want to meet Pipelife to discuss your project in person, visit us this year at the MENA Desalination Projects 2020 in Abu Dhabi, Plastic Pipes XX in Amsterdam or Wisa2020 in Johannesburg.

New testing requirements for PE100-RC/HSCR to better define material and pipe performance

by KH Lou and Suleyman Deveci

SUMMARY

Polyethylene (PE) pipe material development has gone through more than six decades of continuous improvement. It is the preferred material for water, gas and slurry distribution/disposal due to its corrosion resistance, light weight, flexibility, weldability and durability. The latest generation of PE100 materials offered today are designed to ensure the best balance of toughness, flexibility and processability thus allowing the pipe to be used in a wide range of applications. The confidence and recognition of the benefits that PE100 materials can offer to asset or project owners have now reached the point where contractors and installers are increasingly looking at more aggressive installation methods such as trenchless/no dig methods or the use of sandless/as-dug excavated soil to reduce installation costs and construction duration. To address the concerns of potential pipe surface damage when exposed to such conditions, the industry has moved towards further increasing the material's resistance to failure through the slow crack growth (SCG) mechanism – the primary failure mode for a PE100 pipe when scores/scratches are introduced to the surface of a continuously pressurised pipe – leading to containment failure when a crack fully propagates through the entire wall thickness. The crack propagation is driven by the continuous hoop stress during normal operation. In recognition of this, pipe resin producers have introduced PE100 grades with higher stress crack resistance and these have been available for more than a decade.

The earliest attempt to define a set of criteria for PE100-RC/HSCR materials was set forth by the German PAS 1075 standard published in 2009 [1]. Subsequently, PIPA published its POP016 guidelines [2] for the Australian and New Zealand markets mirroring closely the PAS1075 requirements with some modifications. The key testing criteria referenced by both specification is the Notch Pipe Test (NPT) according to ISO 13479, which is used to qualify the pipe performance and also for regular quality assessment. Due to the extremely long testing times to obtain a positive NPT result and the wide data spread of NPT results for the same material, several alternative accelerated test methods have been developed. This helps to better define a more unified industry definition of what constitutes a PE100-RC/HSCR and also gives confidence to the designers and specifiers.

IMPLICATIONS FOR NPT TEST

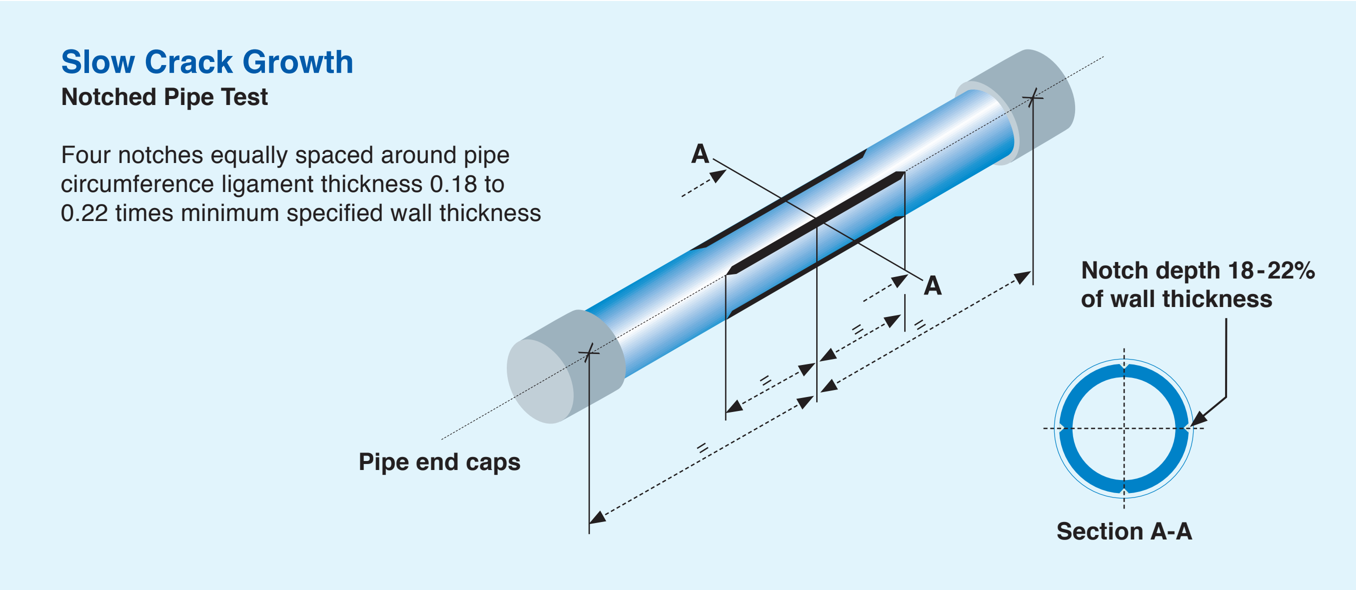
A round robin testing [3] of NPT was organised in 2014. Two different materials were tested in five repetitions at more than 10 different laboratories. Results showed significant scatter, with a range close to 10 times difference in failure times for the same material tested at different laboratories. Possible root causes of such a scatter were further investigated and reported. Following the conclusions from these reports from the round robin test, a systematic revision of ISO 13479 began at ISO TC 138 SC5 WG20 – Slow Crack Growth. The objective is to revise the NPT test method with more precise definitions. In addition, further investigation on the effect of notch radius is also being investigated. Because of this, it is currently unknown if the proposed revisions will improve the repeatability and reproducibility of the test method and reduce the scatter between the laboratories. More detailed studies need to be performed in this respect.

PE100-RC VERSUS PE100 HSCR

In Europe, the PE100-RC (RC - Resistant to Cracks) definition is used to indicate a material that conforms to the German PAS 1075 standard. Outside Europe, the more general HSCR (High Stress Crack Resistance) reference is used. Current definition of PE100 HSCR is based more on local standards or individual end user specifications – this includes the PIPA POP016 guidelines for Australia and New Zealand. There is currently no globally agreed performance definition of what constitutes a PE100-RC or PE100 HSCR material, however EN and ISO work groups are already established to work on the performance definitions of PE100 HSCR materials in the light of new and accelerated SCG test methods using data generated by participation of many laboratories and material suppliers [4].

ACCELERATED SCG TEST METHODS

Usually, the slow crack growth resistance of materials is determined by time consuming testing methods such as Notch Pipe Test (NPT), Full Notch Creep Test (FNCT), Pennsylvania Edge-Notch Test (PENT) etc. These methods often require the



use of notched samples, the use of specific detergents and/or elevated temperatures. SCG test method can be categorised into two groups, (1) test methods for materials such as PENT, FNCT, Cracked Round Bar (CRB), Strain Hardening Test (SHT) and (2) test methods for pipes such as NPT and Point Load Test (PLT). When the NPT, PENT and FNCT methods were developed, expected failure times for pipe materials then were around 500-1,000 hours. The latest RC/HSCR materials typically fails between 5,000 to 10,000 hours, sometimes even longer for both material and pipe tests. Apart from no longer being a feasible test method for development and quality control purposes, such long testing times induce many other variables in the test results, increasing the above mentioned data scatter even further. For such reasons, many researchers have been working on developing accelerated test methods for high crack resistant materials that still promotes slow crack propagation over ductile yielding and generates brittle failures.

Among these new accelerated test methods, the CRB (ISO 18489) and SHT (ISO 18488) test methods were published in 2015 as ISO test methods after several years of rigorous experimental work. With the SHT method, the resistance to slow crack growth is predicted from a simple tensile measurement at a temperature of 80°C. The slope of the stress-strain curve above its natural draw ratio (i.e. strain hardening) correlates very well with the results obtained by ESCR (environmental stress cracking resistance), FNCT and NPT of the same materials [5-7]. The strain hardening method also does not require a notched specimen and/or detergents, is easy to implement in laboratories and results in the dramatic decrease of measurement times to a matter of days.

The CRB method determines a material's resistance to slow crack growth under cyclic tensile loading. The test principle is similar to that of FNCT with a few major differences intended to make the test faster and more reproducible. The test specimen geometry is similar except that round bars with diameters more than 10mm are used. A circular notch is introduced around the circumference of the bar using a razor blade. CRB specimens may be produced from compression moulded plaques for material testing or from pipes or fittings for product testing. A strip is cut from the specimen and a round bar is then produced from the strip by turning on a lathe. The round bars are then clamped into a dynamic tensile testing instrument and tested till failure. The tests are carried out at room temperature without a detergent. The test duration is reduced by using a cyclic load instead of a static load. The fracture pattern is similar to FNCT fracture patterns and shows the well-known zones of crack initiation, slow crack growth (brittle fracture area) and residual ductile failure. An advantage of this method is that the entire process from crack initiation and growth to complete failure can be tested and that slow crack growth is the main type of failure.

Both the SHT and CRB methods shows very good reproducibility between test laboratories and shows good distinction between standard PE100 with PE100-RC/HSCR materials. An accelerated version of the FNCT test was published (ISO 16770:2019), describing a new solution and test parameters that accelerates the failure. This is known as the accelerated FNCT (or aFNCT). For pipe testing, point load test (PLT) and accelerated notched pipe tests (aNPT) are being investigated as accelerated SCG test methods for high crack resistant pipe materials. The aNPT method is reasonably well developed in the last decade with numerous research work showing that it is possible to obtain brittle failures in the range of 1,000 hours for all PE100-RC/HSCR materials in the market. Through all these data, it can be determined that there is a minimum correlation factor of 30 [8].

CONCLUSION

The test methods defining PE100-RC/HSCR performance continues to be improved together with the increased appreciation of their benefits. It is very likely that current PE100-RC/HSCR materials may not be sufficiently quantified on its stress cracking resistance just by relying on test methods that were developed earlier. The industry needs more updated and more practical methods and re-evaluate the criteria used by older test methods to ensure a more accurate characterisation of stress cracking performance. To facilitate the adoption and wider acceptance of PE100-RC/HSCR among pipeline designers and owners, a more harmonised set of criteria needs to be agreed by the industry and updated into the current product standards such as ISO 4427, ISO 4437 and EN 1555 among others. This needs to be done in parallel with the selection of the appropriate test methods such as those discussed above, taking into account the newer accelerated methods which shows very promising results.

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UTILITIES

BorSafe PE100 materials completes a decade of SIRIM QAS International audits and certification according to MS1058

by KH Lou

SIRIM QAS International is Malaysia's leading testing, inspection and certification body. It became a full subsidiary of the SIRIM Group in March 1997. SIRIM which stands for the Standards and Industrial Research Institute of Malaysia is entrusted as the national organisation for standards and quality. It is a corporate organisation wholly owned by the Malaysian government under the Ministry of International Trade and Industry.


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SIRIM QAS International is an accredited testing, inspection and certification services provider under numerous bodies such as the National Accreditation Body, the Department of Standards Malaysia (STANDARDS MALAYSIA) and the United Kingdom Accreditation Service (UKAS) among others.

To provide assurance and confidence to project owners, authorities and consultants that HDPE pipes produced and supplied in Malaysia are manufactured to internationally acceptable standards, the PE Pipe & Fittings group from the Malaysian Plastics Manufacturers Association (MPMA) spearheaded an effort in conjunction with SIRIM QAS to develop an annual quality monitoring and audit programme covering the entire manufacturing process from the procurement of resins to the supply of pipes. The audit is carried out in accordance with the local standard – MS1058, which follows ISO 4427 closely. The audit programme involves physical plant audits for the pipe converters as well as resin manufacturers.

As one of the earliest supplier of PE pipe resins in Malaysia, Borouge has been supportive of such a quality monitoring and audit programme and was the first foreign resin supplier to be audited and certified according to MS1058 as early as 2009. We have since completed a decade of successful plant audits by SIRIM QAS and anticipate continuing with this programme in the foreseeable future.

International Industries Limited supplies largest PE100 pipe in Pakistan

by Farraj Tashman

Pipes on site in preparation for fusion.

International Industries Limited (IIL) is Pakistan's largest manufacturer of steel, stainless steel and plastic pipes with an annual manufacturing capacity of 817,000 tonnes and annual revenues of almost USD168m. IIL was incorporated in Pakistan in 1948, is listed on the Pakistan Stock Exchange and is the market leader in all segments of pipes in Pakistan and also has a significant export footprint with exports to 60 countries across six continents. IIL has consistently been recognised as one of the best managed companies and is a proud recipient of numerous awards including the "Corporate Excellence Award", the "Leading Exporter of Engineering Goods" for the last eighteen years and the "Top 25 companies" award consecutively for 11 years.

IIL, which started its polymer pipe production in 2006, has a current total production capacity of 30,000MT per annum of all polymer pipes comprising, PP-R hot & cold water pipes, MDPE gas pipe & fittings, HDPE water pipes and HDPE duct pipes. In 2016, IIL commissioned its 1,600mm OD HDPE pipe extruder which enabled them to produce the largest HDPE pipes in Pakistan.

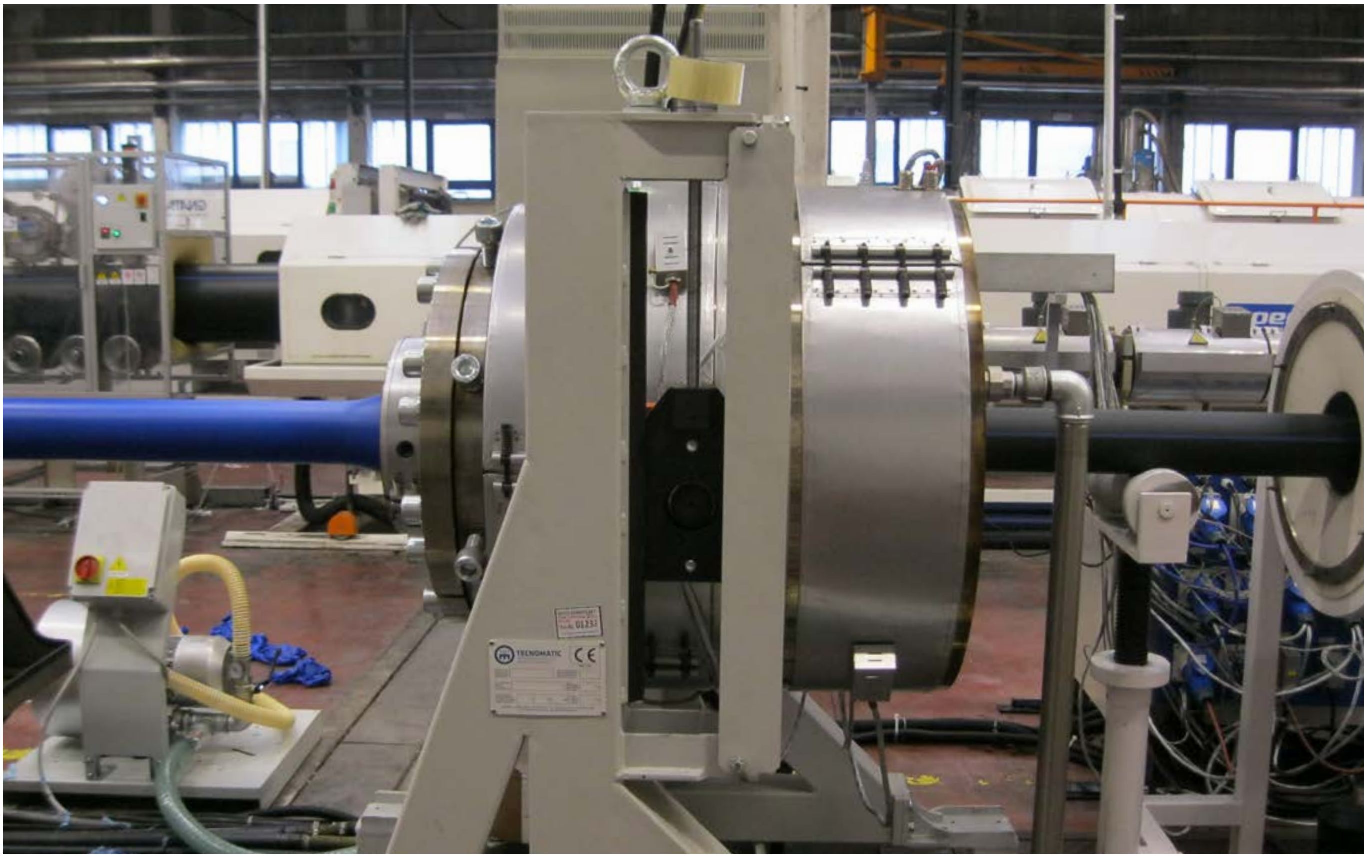
The company recently secured an order to supply 1.4km of 1,600mm OD PE100 SDR17 pipe. To achieve even wall thickness distribution that is within its standard tolerance, IIL decided to use the low sag batch made from BorSafe HE3490-LSH to achieve wall thickness distribution ranging from 94.1 to 103.7mm. The pipeline, which represents the first time a 1,600mm OD PE100 was used in Pakistan was supplied for a water project in Hyderabad and was completed in six months.

1,600mm OD SDR17 PE100 being produced from special low sag batches of BorSafe HE3490LSH.

Completed 1,600mm OD SDR17 pipes being prepared for shipment.

Innovation and enhanced performance in the production of multilayer pipes

by Massimiliano Vailati (Tecnomatic SRL) and KH Lou



Co-extrusion of HSCR PE100 using a coating die head on a standard PE100 pipe.

VENUS 630 die-head spiral distributor.

The market for polyolefin pipes is constantly evolving with more demanding customer and application requirements. Despite the constant improvement in polyolefin properties, single-layer solid wall pipes are still not able to always fulfill certain customer or application requirements. For such situations, multilayer pipes may be a solution. The key to producing a good multilayer pipe is the die-head. In this article, we showcase how Tecnomatic, a leading manufacturer of processing equipment for polyolefin and PVC pipes based in Bergamo, Italy continues to improve the technology and performance for the production of complex multilayer pipes with functional layers.

Developed on the basis of the VENUS monolayer concept, Tecnomatic currently has a full range of die-heads with multi helical spirals, for the production of two, three or four layer polyolefin pipes. This technology has been extended to large diameters, thanks to the years of experience supplying reliable and high performing lines for multilayer pipes. A recent delivery of a line to Authentic Production in Myanmar for the production of multi-layer pipes up to 630mm diameter shows that the Asia Pacific market is embracing innovations that may provide higher levels of performance.

Authentic Production, part of the Authentic Group of Companies, which started its PE pipe production several years ago, has rapidly gained market share and reputation because of its focus on quality. They benefitted from running Tecnomatic lines capable of producing pipes up to 1,200mm that offered production efficiency, reliability and reduced scrap rates when producing their recently launched multilayer product. The new product featured the BorSafe™ HE3494-LS-H PE100 High Stress Crack Resistant (HSCR) material in the outer layer to offer their clients maximum security against point loads and surface damage that may occur during installation.

Such multilayer pipes have been used extensively in Europe for installations either using trenchless techniques or where no imported backfill is used. By using the same material dug from the trench, the installers were able to reduce the costs and environmental impact of bringing sand or other backfill materials to the site. HSCR PE100 pipes can now offer contractors and installers such options in Asia as well.

The wall of the multilayer pipe produced by Authentic Production is made up of two layers equal to 10% and 90% of the total thickness. The outer layer is produced from HSCR PE100 material and the core from standard PE100. This requires two separate extruders, which was achieved by a main extruder from the ZEPHYR series in L/D 40 which offers extreme output performance and lower melt temperature and energy consumption, while the inner layer is produced from an ATLAS series in L/D 30. Both extruders are synchronised using gravimetric feed on each extruder to maintain a continuous raw material feed and to record variations in mass throughput, thereby ensuring perfect control of the weight per metre and wall thickness distribution.

The VENUS MULTI pipe heads series have been designed to achieve excellent processing using a wide range of materials at very high output. The spiral geometry has been optimised for the latest generation of PE and PP raw materials, while achieving improvements in reducing its overall length, volume and operating pressure. The heart of the VENUS MULTI heads consist of an innovative flow channel geometry, which has been calculated to take into consideration the current raw materials. This geometry ensures the same pressure and melt distribution in all the pipe extrusion heads in the range even at very high output rates. This new design of feeding system operates at a reduced working pressure throughout the complete size range. This reduces the energy consumption during extrusion since up to 10% of the extruder power is usually required for pumping capacity. Lower pressure results in a lower melt temperature and together with lower residence times ensures improved pipe characteristics such as its OIT (oxidation resistance) and reduction of thermal and sheer stresses.

Authentic Production has expressed a high degree of satisfaction for the quality of the multilayer line since its commissioning. The new product will offer project owners additional security for pipelines that are installed in demanding conditions. Additional features can be added to the pipe such as a peelable outer skin which provides further economic and environmental benefits for


Multilayer 1,200mm OD PE100 with HSCR outer layer pipes being welded in Myanmar.

M.H. Aung, Authentic and Massimiliano Vailati, Tecnomatic.

water and gas distribution pipelines. This peelable outer jacket, frequently made from specially modified polypropylene, further protects the pipe surface against potential notches and cracks when using installation methods such as pipe bursting or wash-boring. Potentially deep scores in the protective jacket will not be transferred to the inner pipe when it is eventually exposed to service-related stresses.

The peelable jacket that is adhered to the outer wall of the core PE pipe is typically 0.6-0.7mm thick for all current dimensions of this new multi-layered pipe and the skin is added by a cross-head positioned before the last cooling bath. Tecnomatic has a full range of die-heads, based on spiral or radial technology suitable for plastic or metal pipes coating ranging from 5-800mm diameter and up to 4 layers. The die-heads are based on a typical spiral technology for large and single layer co-extrusion or a mixed solution with radial distributors or short path spiral alternative depending on material characteristics such as PA, EVOH, PVDF or adhesive bonds.

Pipeline delivers water, hope to remote Moroccan village

Article reproduced from the 24 September 2019 issue of McElroy Connections

Laying out the pipeline to the village in the Ait Bayoud Commune in Morocco.
The pipe was provided by Borealis and Borouge under their Water for the World programme.

Imagine if your health and livelihood depended on trekking across a hot and arid, rocky landscape for hours every day to collect water. This is life for 370 people in two of the poorest and most remote villages in the Ait Bayoud Commune of Morocco.

Local Peace Corps volunteers decided they deserved better. Five years ago, they initiated a water project and turned to the Columbia University chapter of Engineers Without Borders (EWB) for help. EWB saw this as a great opportunity to use their skills to improve these residents' way of life in a very basic, but life-changing way. Designing a six kilometer, hybrid-pumped, gravity fed water pipeline system would only be part of the equation. These EWB college students would have to secure funding, pipe, materials and equipment and they would have to do all that in addition to school work, writing their thesis and not to mention that they will have only a short, six-week window for the installation.

As they were researching various pipe materials, they were soon drawn to a high-density polyethylene (HDPE) system. To learn more, they contacted the Plastic Pipe Institute (PPI) and spoke to its director of engineering, Camille Rubeiz, who ended up mentoring them through the entire project. He also invited them to the PPI's municipal board meeting in Tulsa, Oklahoma, so they could meet some of the leading HDPE engineering experts across the country. While there, they were also able to visit McElroy, the leading maker of pipe fusion machines, and learn how to fuse pipe. They received further fusion training from ISCO Industries. At the end, eight of them were trained fusion operators.

"We saw many case studies on PE being used in the field," said Donald Swen, EWB technical leader. "It was a big validation that we were onto something. Seeing the material, talking to engineers and being in Tulsa boosted our confidence in what we were doing." Now more than ever, they were sure HDPE was the way to go — no leaks, no corrosion, long life and low cost. And now that they had secured funding for the project from pipe material manufacturers Borealis and Borouge, they would tackle another hurdle — communicating their honest intentions and building trust in the Islamic community.

Villagers from the Ait Bayoud Commune of Morocco.

Welding the pipe sections together.

"It was a project of many trials and error all within a country foreign to us," Swen said. "Luckily, we had the help of three skilled translators who were able to navigate us through negotiations, purchases and many sticky situations. To say the least, we have learned a lot." With an eight-member team at any given time, the combination of students, professional mentors and locals toiled through an intense six weeks which culminated at the end of August. Each day, started at 7:30am. They had lunch and avoided the heat from 1:30 to 3pm. then went back to work sometimes until 9pm.

"Things in Morocco happen sporadically. The solar panels were delivered at 1am. We had to make things work and some of us sacrificed our sleep. We really worked to the bones," Swen said. Borealis and Borouge, provided the PE100 90mm pipe for the project which was fused together with a McElroy Pit Bull® 14 machine — which fits 32mm to 110mm (1" IPS to 4" DIPS) size ranges — donated by McElroy.

"I fused the first 10 joints before falling into a supervision role. I guided the locals through each step of the fusion process. By the 20th joint, they were almost on auto pilot," Swen said. "They know what to look out for to ensure a proper fusion joint. There must be full contact with the heater plate and a big emphasis on clean joints!" The pipe was laid on grade. They hired a backhoe to expand a dirt road by about a meter. The backhoe cleared all the rocks and created a smooth surface.

It was a special and unforgettable day when they finally got to turn on the pump after connecting a 20-panel solar rack. Their first real world engineering project had come to fruition and they could feel the pipe getting heavier in the beginning sections as it filled with water. "We drove to the other end of the pipeline and could hear the hot air being pushed out of the other end. We knew the water was coming and we knew when, we had the velocity calculations!" Three hours later, they arrived at the village to check the end of the pipe. The locals had rerouted it into one of their dry wells and there was a crowd gathered around it watching a lot of water flow. As he approached, Donald said the villagers received him with deep smiles and eyes that spoke volumes. They said his name out loud and shook his hand. It was a special moment they were all able to share together. Their hard work had paid off.

"For the past few weeks, the locals had been coming out to help every day without pay," Swen said. "To see that our collaboration worked was the most special moment and there was a huge sense of relief and also a feeling that things were going to change in this village. Life would be different now and this was the start." Swen said the Morocco project taught him a lot about the business world and working with all the different stakeholders to get things done. He learned the importance of doing things right, doing a thorough job the first time and the importance of safety in construction. In essence, the experience was life changing for Swen too.

Water flowing from the pipeline after the completion of the project.

"This reinforces my value of always placing humans first. Engineering starts with solving a need that originates from humans," he said. "I know that in the future, I want to work with communities, empowering them to live their best lives. I want to continue doing meaningful work that can help others." Project mentor Rob Lawrence, CEO of ProjAC and a specialist in urban water supply in the UK, said the project was a lot of work and the students handled it really well.

"They did it in a very organised fashion despite the pressures on them. They kept everybody happy which is not easy," he said. "Donald showed a lot of talent as a manager and overcame all the daily difficulties to get to the stage where they were able to get the water flowing. I was very impressed."

The team plans to return next summer to expand the capacity of the system to the second village. Though they originally planned to provide service to both villages, funds were tight and time was limited so they scaled down the scope of the project to three kilometers.

Meanwhile, Swen said the residents are sending them updates on the pipeline through WhatsApp. Many of them are now fully trained in fusion procedures and they appear to have taken full ownership by forming a water association and making their own repairs and improvements. Currently, they are burying the pipeline to protect it permanently. It is a striking change from when the EWB first arrived and had difficulty gathering a meeting of more than eight people.

"On our last day there, we held a community-wide meeting. Almost every man from every household came to the meeting. We can safely say that we had the trust of the community," Swen said. The fact that there are no leaks in the pipeline makes everyone very happy. Swen said they are immensely grateful to the PE industry for their support. "Everyone on the Municipal Advisory Board, the PPI, Peter Dyke (Alliance for PE Pipe) to all the people at McElroy. Their belief in us carried us through this effort."

Acknowledgement

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Source
https://press.mcelroy.com/pipeline-delivers-water-hope-to-remote-moroccan-village/

SPE India Plastic Pipes 2019 Conference

Srinivas Goud & Prashant Nikhade at the conference.

Chanchal Dasgupta, Borouge presenting a gift of appreciation to Rob Lawrence.

The Society of Plastics Engineers India (SPE India) successfully conducted its biennial event, Plastic Pipes 2019 Conference at the Hotel Leela in Mumbai last November. The event attracted over 300 delegates where 30 speakers presented over two days. More than half the speakers did not present at the 2017 edition. The theme of the conference was "Pipe dream to dream pipes". The conference serves as an important platform to provide technical information to the Indian value chain involved in plastic pipes, additives, machinery, ancillaries, testing & certification bodies, project management consultants, manufacturers and above all, the end users themselves. Borouge was once again one of the major sponsors for this event and participated wholeheartedly in organising the event.

The welcome address at the opening of the conference.

Welcoming the gathering, Vijay Boolani, President, SPE India and Brian Landes, President, SPE Global highlighted the role that SPE played in spreading high quality plastics knowledge and education among the plastics community worldwide. India is one of the largest chapter of SPE and plastics pipe is a prominent growth segment in India.

Among the notable papers presented were from Rob Lawrence of ProjAC who gave a detailed overview of five decades of PE pipes in the Middle East & Africa and South Asia region. ProjAC is a project management consultancy specialising in onshore and offshore pipelines and Lawrence was previously the Chairman of the Gulf Plastic Pipe Academy (GPPA). In line with this year's theme, Prashant Nikhade of Borouge India presented case studies of large diameter industrial pipes in India and the lessons learnt from their successful completion. Nisha Anthony of Borouge Innovation Centre presented an important paper on "Investigative Techniques for Identification of Raw Material in PE Pipes". Other well-known presenters from McElroy, Krah, Tecnomatic, Worldpoly, Suez, Torrent Gas and USTS gave participants updates on developments from water and gas networks design, PE pipe welding, large diameter gravity drainage project developments, extrusion technology and PE lining projects.

The participants also heard from state government officials such as the Secretary of Water Services Department, Maharashtra and Telangana Rural Water Supply on how PE pipes played important roles in major irrigation and water supply programmes currently under development. Chanchal Dasgupta from Borouge was co-chairman of the conference and chaired two technical session.

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