Global expertise in
Pipe insulation
Introduction

Building pipelines to carry valuable resources such as heat, oil and gas involves huge commercial investments. But whether it is a trans-continental oil supply line or a local community district heating system, rigid polyurethane foam plays a vital part in protecting and enhancing the effectiveness of the project.

Rigid polyurethane foam has been used for the insulation and protection of pipes for more than 30 years. It is now more widely used than ever, increasingly displacing alternative materials such as mineral wool.

GLOBAL TECHNICAL CONTINUUM

A continuum of resource is available to customers around the world through Huntsman Polyurethanes’ three-pronged approach to R&T –

- The global R&T center for the business is at Everberg in Belgium, where new product and process technologies are developed.
- Regional Development Centers (RDCs) tune technology to meet local needs and introduce new technology to customers.
- Technical Service units are located throughout the world and offer technical support to customers at the national level.
In December 1999 Huntsman Polyurethanes and Shell Chemicals formed a strategic alliance – bringing together Shell’s long-standing expertise in the pipe insulation market with Huntsman Polyurethanes’ international capability in the manufacture of rigid polyurethane foam systems.

This combined force now offers the pipe manufacturing industry an unrivalled service that includes:

- the benefits of backward integration, available through the resources of parent company, the Huntsman Corporation
- global access to the highest quality polyol and isocyanate based polyurethane systems
- strong fundamental research programmes which help develop new foam systems
- exceptional levels of technical knowledge and customer support
- an ability to supply customers with specific foam systems, tailor made for any particular production line or pipe manufacturing technique
- dedicated account management with fast response to customer requirements
- practical assistance and implementation of crucial environmental, health and safety (EHS) matters and procedures

The importance of this market to Huntsman Polyurethanes is reflected by the dedicated team of pipe insulation experts based at the company’s global headquarters in Everberg, near Brussels, Belgium. This core group is involved in the constant development of new and improved pipe insulation systems and techniques. They are supported by an international network of technical service specialists covering each of the major national markets.

This global infrastructure provides the pipe industry with a fully integrated polyurethane foam service to customers, which in turn fosters close, long term working relationships, with a common goal of innovative product development and world wide service support.

Huntsman Polyurethanes is a world class producer of polyurethane systems, with more than 40 years expertise in developing highly effective insulation products for industry. It is an international business serving customers in more than 70 countries from 41 sites world wide. Of more than 3,000 employees a quarter are devoted to research or technical support functions.
Polyurethane foam is produced by reacting two liquid chemicals, an isocyanate and a polyol. For foams used in pipe insulation, polymeric diphenylmethane diisocyanate (polymeric MDI) and polyether polyols are usually used. The chemical reaction is controlled by the choice of manufacturing process together with a selection of further additives and catalysts. The inclusion of blowing agents expands the polymer and produces polyurethane foam.

Rigid polyurethane foam is a good insulant because it consists of 92-98% of closed cells. Only 2-8% of the foam, depending on the density, is solid polyurethane polymer. The closed cells are filled with insulating gases that are released by blowing agents during the manufacture of foam.

The cell gas composition can be influenced by different blowing agents. Blowing agents that have a lower vapour thermal conductivity will lower the foam thermal conductivity. The insulating gas accounts for 60-65% of the final foam thermal conductivity.

Polyurethane foam’s popularity is based on these outstanding insulation properties, which prevent heat loss, or alternatively maintain temperatures in cold environments to prevent freezing or cracking. These energy conservation qualities improve the overall cost efficiency of customers’ networks and pipeline systems.

In the table below, the thermal conductivity at 50°C is given for a number of pipe insulation materials, along with the relative insulation thickness at an equal heat loss. Polyurethane foam is clearly the most effective material. Further advantages are that the polyurethane foam adheres well to both the service pipe and the casing pipe. As a result of the closed cell structure of the foam, penetration of water in the foam and along the length of the pipe is inhibited should the casing pipe be damaged.

Other important characteristics include high mechanical strength, flexibility and good flow-ability, necessary for the consistent fill and insulation of pipe sections.

### COMPARISON OF INSULATING PROPERTIES OF INSULANTS USED IN PIPE INSULATION

<table>
<thead>
<tr>
<th>Insulant</th>
<th>Density (kg/m³)</th>
<th>Thermal conductivity 50°C (mW/m.K)</th>
<th>Relative insulation thickness at equal heat loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigid polyurethane foam</td>
<td>70</td>
<td>27-30</td>
<td>1</td>
</tr>
<tr>
<td>Mineral wool pipe scales</td>
<td>200</td>
<td>45</td>
<td>1.7</td>
</tr>
<tr>
<td>Foamed glass</td>
<td>125</td>
<td>52</td>
<td>1.9</td>
</tr>
<tr>
<td>LEBIT (bitumen/cork mixture)</td>
<td>880</td>
<td>105</td>
<td>3.9</td>
</tr>
<tr>
<td>Foamed concrete</td>
<td>400</td>
<td>160</td>
<td>5.9</td>
</tr>
</tbody>
</table>

Polyurethane foam is a material with a proven track record for reliability, durability and efficiency. Versatility is demonstrated by the ability to insulate over an extremely wide range of temperatures, from the extreme cold of −196°C to the intense heat of more than 150°C.

It is also suitable for applications ranging from small plumbing pipes, 10mm in diameter, up to the largest heating pipes with 2,000mm diameters and 250mm of insulation thickness.
As a market leader in the development and formulation of polyurethane foams, Huntsman is able to offer a variety of systems to meet different market requirements and pipe manufacturing techniques. These systems include:

- Fully water blown systems; in which expansion of the foam is due to the formation of carbon dioxide generated from a reaction of water with isocyanate. This is an environmentally friendly process, since carbon dioxide has zero ozone depletion potential and virtually zero global warming potential.

- HCFC-141b/water dual blown systems; these systems utilise both carbon dioxide and the physical blowing agent HCFC-141b to expand the polyurethane. However HCFC-141b has an ozone depletion potential and global warming potential and hence will be phased out in the future. New systems based on HFCs that have zero ozone depletion potential are being developed to replace HCFC-141b.

- Cyclopentane/water blown dual systems; these systems utilise both carbon dioxide and the physical blowing agent cyclopentane to expand the polyurethane. This is an environmentally sound process that has zero ozone depletion potential and virtually zero global warming potential.

Each of these Huntsman systems are certified to the relevant European standard, EN 253 for pre-insulated bonded pipe systems for hot water networks.

### COMPARISON OF INSULATING PROPERTIES OF INSULANTS USED IN PIPE INSULATION

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement acc. to EN 253</th>
<th>CO₂ (water)</th>
<th>HCFC-141b</th>
<th>HFC mixture</th>
<th>C-pentane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed cell content, %</td>
<td>≥88</td>
<td>94</td>
<td>94</td>
<td>93</td>
<td>93</td>
</tr>
<tr>
<td>Core density, kg/m³</td>
<td>≥60</td>
<td>86</td>
<td>73</td>
<td>79</td>
<td>78</td>
</tr>
<tr>
<td>Radial compressive strength, MPa</td>
<td>≥0.3</td>
<td>0.55</td>
<td>0.41</td>
<td>0.58</td>
<td>0.45</td>
</tr>
<tr>
<td>Water absorption at 100°C for 90min., %vol</td>
<td>≤10</td>
<td>6.1</td>
<td>4.8</td>
<td>5.6</td>
<td>4.3</td>
</tr>
<tr>
<td>Shear strength, MPa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>axial at 23°C</td>
<td>≥0.12</td>
<td>0.46</td>
<td>0.40</td>
<td>0.30</td>
<td>0.42</td>
</tr>
<tr>
<td>axial at 140°C</td>
<td>≥0.08</td>
<td>0.24</td>
<td>0.27</td>
<td>0.17</td>
<td>0.25</td>
</tr>
<tr>
<td>tangential at 23°C</td>
<td>≥0.20</td>
<td>0.73</td>
<td>0.55</td>
<td>0.43</td>
<td>0.64</td>
</tr>
<tr>
<td>Thermal conductivity at 50°C, mW/m.K</td>
<td>≤33.0</td>
<td>30.0</td>
<td>28.0</td>
<td>28.8</td>
<td>27.0</td>
</tr>
</tbody>
</table>

The performance features and benefits of polyurethane foam that makes it a material of first choice in pipe insulation can be summarised as:

**Feature**
- low thermal conductivity
- effective across wide temperature range
- factory manufactured or in-situ
- compatible with pipe materials
- tailor made Huntsman systems
- longevity

**Benefit**
- prevents heat loss/insulates in cold environments
- -196°C to 150°C
- production versatility to suit application
- steel, PE, PP, PVC, HDPE
- meeting specific customer needs
- low maintenance/long replacement cycle
There are two main types of pipe: straight and flexible – and two main forms of pipe production technique: discontinuous and continuous. The method adopted by an individual manufacturer will reflect the particular operations and applications of that company’s business. But whichever method the manufacturer uses, Huntsman Polyurethanes can provide effective foam systems to suit.

**Straight pipes**

Straight pipes are pipe-in-pipe systems with an inner service pipe that is usually made of soft steel and they account for the majority of pre-insulated pipe applications. The casing pipe is usually made of high-density polyethylene (HDPE), though steel or PVC can also be used. After laying, the steel pipes are welded together and the resulting cavity is filled with polyurethane foam.

Standard lengths for straight pipes are 6, 12 and 16m and speciality variants of the straight pipe include curved pipes and bend fittings that allow directional changes of the pipe run.

A European standard, the EN 253 norm, has been developed for straight pipes specifying requirements and test methods for straight lengths of prefabricated thermally insulated pipe-in-pipe assemblies for underground hot water networks. It covers the steel pipes, rigid polyurethane foam insulation and the outer casing of HDPE. The standard is also often used as a reference for applications outside district heating.
Standards are devised by CEN, the European Committee for Standardisation and development work has been supported by considerable research effort among system manufacturers, raw material suppliers, users, universities and research institutes. As such, EN 253 is accepted as the state-of-the-art by both users and pipe producers. Huntsman Polyurethanes is a member of this working group and was an active participant during the development of these standards.

At present, similar quality standards are also being developed in Russia and China. Huntsman Polyurethanes is also actively supporting these efforts.

Flexible pipes
Flexible pipes are pipe-in-pipe systems with inner service pipes produced from materials including cross-linked polyethylene (PEX), thin-walled steel, soft annealed copper or aluminium. Flexible pre-insulated pipes offer both ease of handling during installation and cost saving potential during laying. They can be laid in lengths up to several hundred metres. Flow and return pipes can be fitted into a shared outer casing pipe.

Flexible pipes require specially designed polyurethane foam systems that provide a combination of high flexibility and increased thermal resistance, which are antagonistic properties. Huntsman Polyurethanes has developed new generations of semi-flexible foams that overcome this difficulty to provide this unique combination of properties.

Key benefits of flexible pipes include:
- continuous production, coiled for delivery
- can be laid continuously with fewer joints required
- no time consuming welding
- pipe flexibility allows obstacles to be circumvented
- easier handling contributes to higher laying speed
- the trench profile is narrower and therefore excavation costs are reduced
- no risk of corrosion of the service pipe, particularly when PEX pipes are used

Flexible pipes are being used more and more frequently because of the ease of handling and cost saving potential during pipe laying.
Discontinuous pipe manufacture involves filling of the cavity between, typically, a steel inner pipe within a high density polyethylene (HDPE) casing pipe. The gaps at both ends of the pre-assembly are sealed with tightly fitting caps equipped with injection and air venting holes.

Consistent, good quality pipe filling requires a number of preparatory factors to be in place. These include temperature control, treatment of pipe surfaces and filling density and time. Polyol and isocyanate temperatures should be between 18-25°C and the pipe assembly between 20-30°C.

Correct adhesion of the foam requires steel pipes to be grease, oil and rust free. The surface of the HDPE pipe should be pre-treated by Corona treatment to guarantee a strong bond.

The output of foam dispensing equipment should be calculated so that the mixed components can be injected within the cream time. The filling density should be high enough to allow the foam to completely fill the pipe well within the system fibre time. If the foam does not reach the pipe ends within that period the foam will be stretched, resulting in poor mechanical strength at the pipe ends.

Discontinuous techniques require relatively low capital investment and are generally flexible in producing a wide range of pipe dimensions. Limited training is required to use these techniques effectively. Huntsman Polyurethanes pipe specialists favour the top filling technique as it gives good density foam distribution throughout the pipe, as long as the correct filling angle is applied.
Lance withdrawal technique

Pour-and-rise technique

Top filling technique

Mid-point filling technique

Pull-through technique
Continuous pipe production consists of two stages. In the first stage, foam is applied to the inner pipe by a moulding, pour or spray operation.

During the second stage the outer casing pipe is extruded or wound around the pre-shaped foam. Finally, the pipes are cut into desired lengths. This process requires the use of modified polyurethane foam systems.

Continuous techniques are mostly suited to bigger pipe manufacturers producing large quantities of the same diameter pipes. Benefits of this approach are its fast and consistent production runs at relatively low variable costs. Material costs can be reduced with lower foam overpack, filling density and casing pipe thickness.

The continuous moulding technique is particularly suitable for the production of flexible pipes, as this technique imposes no restrictions to the length of the pipes produced.

However, changes in pipe diameter and insulation thickness can involve lengthy set up times, which make this a less flexible process than discontinuous manufacture. It is also a higher capital cost technique than discontinuous methods.

**Associated filling techniques**

When a pipeline system is constructed, the resulting cavity between the single pipes needs to be insulated on-site. This can be done via joint-filling or application of pipe scales.
Continuous moulding technique

Continuous spray technique

Continuous techniques can provide a cost saving potential

Joint filling technique

Production of pipe scales
Customer support

Huntsman Polyurethanes’ customers have access to a great deal more than industry leading chemical systems. Close, long term working relationships have been established with like-minded companies to provide high levels of business support. This includes assistance with formulation technology and in optimising existing or planned production processes. Many other technical functions plus environmental, health and safety (EHS) matters are also covered.

Customers benefit from assistance with guidance and selection of the most appropriate chemical systems, processes and product performance. This is achieved by members of Huntsman Polyurethanes’ technical services team working alongside customer personnel, on site. Product testing and demonstrations can also be arranged. Relationships of this kind, which utilise customers’ expertise in processing and Huntsman Polyurethanes’ systems experience, create real value for both parties.

Huntsman Polyurethanes’ investment in a new machine hall at the company’s global headquarters allows realistic simulation of pipe manufacturing techniques to be carried out. Foam technologists study the processing performance of systems under semi-industrial conditions; a vital part of new product development and technical service support.

Facilities are available for discontinuous production of 12m long pre-insulated pipes using top, bottom and mid point filling techniques. Foam spraying onto a rotating pipe can also be reproduced and a small scale continuous moulding line replicates straight and flexible pipe manufacture.

The importance of product stewardship

Increasing demands for safer and more environmentally sustainable products places great responsibility on manufacturers such as Huntsman Polyurethanes. Careful stewardship of our products adds value, while minimising the risk of harm to users and the environment. It also reduces the risk of marketing a defective product and associated potential liabilities.

Product stewardship is a central part of Huntsman Polyurethanes’ approach to business. It demonstrates the company’s commitment to responsible care through ongoing assessment of all products at every stage of their life cycle, from sourcing of raw materials through manufacture and use to eventual disposal.

It is an inclusive process that involves close working relationships with customers, employees, suppliers and all parties involved in the supply chain.

The Huntsman Polyurethanes’ approach ensures that all customers are fully aware of the correct procedures for the safe storage, handling and use of all products supplied to them. The crucial customer relations aspects of product stewardship include:

- screening of all new customers
- joint assessment of customers’ environment, health and safety (EHS) systems and standards
- conducting product trials at customers’ premises
- training customers’ staff in the safe storage, handling and use of Huntsman Polyurethanes products
- regular occupational hygiene and environmental surveys

This process offers extensive support, advice and information to customers on an ongoing basis. Product stewardship is a major priority area for Huntsman Polyurethanes and its business partners.

More information on technical and sales support is available from all Huntsman Polyurethanes sales representatives. In addition to this introductory pipe insulation brochure there is a range of technical literature specific to the pipe manufacturing market. Copies are available upon request.
Diversifying into a new market sector requires technical expertise as well as investment in new plants and equipment. A case in point illustrates this perfectly.

New equipment had been purchased by a potential customer with the intention of moving into pipe production, but there was little relevant technical knowledge among the in-house team. Contact from specialists at Huntsman Polyurethanes resulted in them giving a full briefing covering the range of foam systems available. This led to a recommendation to the customer of a specific system to meet planned production objectives.

Following acceptance of this recommendation Huntsman Polyurethanes’ personnel worked alongside the in-house team to assist with initial set up and production of the pipe manufacturing line. This included advice and training on pipe filling techniques, plus important guidance on health and safety matters.

This successful entry into the pipe manufacturing business has since developed into a broader relationship involving further technical collaboration. This has included testing and evaluation of the customers’ pipes at Huntsman Polyurethanes’ laboratories.

**Case study 1**
Technical support launches new customer production of Polyurethane pre-insulated pipes

An existing Huntsman Polyurethanes customer of several years produced pipes based on HCFC-141b blown systems, which met all performance requirements of traditional markets.

However, a change of sales strategy saw a new emphasis on the export of polyurethane pre-insulated pipes to Western Europe. This posed a problem in that most Western European countries prohibit the use of HCFC-141b because of its ozone depletion potential. In order to overcome this barrier to expansion and business development Huntsman Polyurethanes was asked to pioneer the introduction of an environmentally friendly water-blown system.

A sample of the recommended water-blown system was supplied, together with a detailed explanation of the technology features related to the specific system. A successful trial was carried out at the customer’s production site under the direction of Huntsman Polyurethanes’ specialists. Several pipes were tested after filling to validate crucial technical parameters and results were positive.

As a result regular production commenced immediately with the water-blown system, allowing the customer to market products that complied with environmental legislation.

Further consultations and assistance are provided at the customer’s request.

**Case study 2**
Meeting market requirements with water-blown systems

A customer of several years standing had originally been supplied by Huntsman Polyurethanes with fully formulated HCFC-141b blown foam systems, before switching to in-house blending, based on the Huntsman Polyurethanes’ ‘recipe’. For this system special base polyol was used.

As a response to the imminent banning of HCFC-141b, due to its ozone depletion potential, a commercial decision was reached to switch to a cyclopentane blown system.

The use of cyclopentane requires equipment modification because of its high flammability and explosive potential under certain circumstances. Detailed technical information and guidance was required for safe pentane storage and recommended emission levels during pipe filling. This was necessary for the re-design of manufacturing equipment and to calculate the efficiency of the ventilation system. In other words, it was fundamental to the successful changeover from one system to another.

**Case study 3**
New systems and equipment re-design

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Huntsman Polyurethanes provided the required information and a study was set up to accurately measure and record pentane emissions during pipe filling.

After successfully assisting with the plant modification Huntsman Polyurethanes was asked to develop and introduce a new cyclopentane blown system, using the same base polyol as in the old HCFC-141b blown system.

This system was developed and introduced to the new manufacturing process at the customer’s plant.

During development trials 20 pipes of different diameters were filled and a set sent to the MPA Institute in Hanover for testing against the EN 253 norm, which governs standards for buried pre-insulated pipes. Properties recorded by this assessment were well above EN 253 requirements.
The way ahead for polyurethane pipe insulation

Over the past 30 years polyurethane foam has established a reputation as a high quality insulant in pipe manufacturing. It is a dynamic material that is constantly improving in performance and its contribution to industry. The global resources of Huntsman Polyurethanes ensure the constant development of new and improved foam systems in conjunction with our customers.

The main application of polyurethane pre-insulated pipes is the distribution of energy in district heating and cooling networks. A key factor in further developing the potential of district energy world-wide will be increased marketing efforts to highlight its long-term advantages and remove negative perceptions associated with old network systems. Huntsman Polyurethanes is supporting these initiatives through participation in workshops, seminars, conferences and industry working groups.

Flexible pipes are becoming more and more important and are expected to gain market share. This type of pipe delivers time and money savings during construction work and will be increasingly used as the benefits become better known. For example, for decentralised heat and power stations, local and smaller networks will be required, where the benefits of flexible pipes can be used to their fullest extent. To extend the application scope of flexible pipes, development work is being undertaken to create foam systems that allow the production of flexible pipes of increased diameter.

Another likely performance priority will be techniques to improve long-term heat resistance for polyurethane foam up to ca.180°C. This will enable polyurethane foam to be used for applications where foam glass, mineral wool or other inorganic materials are currently used.

Processing improvements are regularly studied to help achieve cost savings for the manufacture of pre-insulated pipes. The Huntsman Polyurethanes pipe insulation team is continuously looking into new advanced pipe production techniques that can provide cost saving potential for pipe manufacturers. Foam formulations are constantly optimised to allow material savings during pipe production.

Other developments include products that meet higher standards for flame retardancy and a further reduction of thermal conductivity, to reduce heat loss during the transport of liquids.

Because of the diversity and wide scope of polyurethane pre-insulated pipe applications, new products will constantly be developed. Huntsman Polyurethanes is committed to remaining at the forefront of this challenging industry.

If you would like to know more about working with one of the world’s leading companies supplying the polyurethane industry and sharing in the rewards of mutually beneficial commercial relationships, please contact your nearest Huntsman Polyurethanes technical service centre.
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