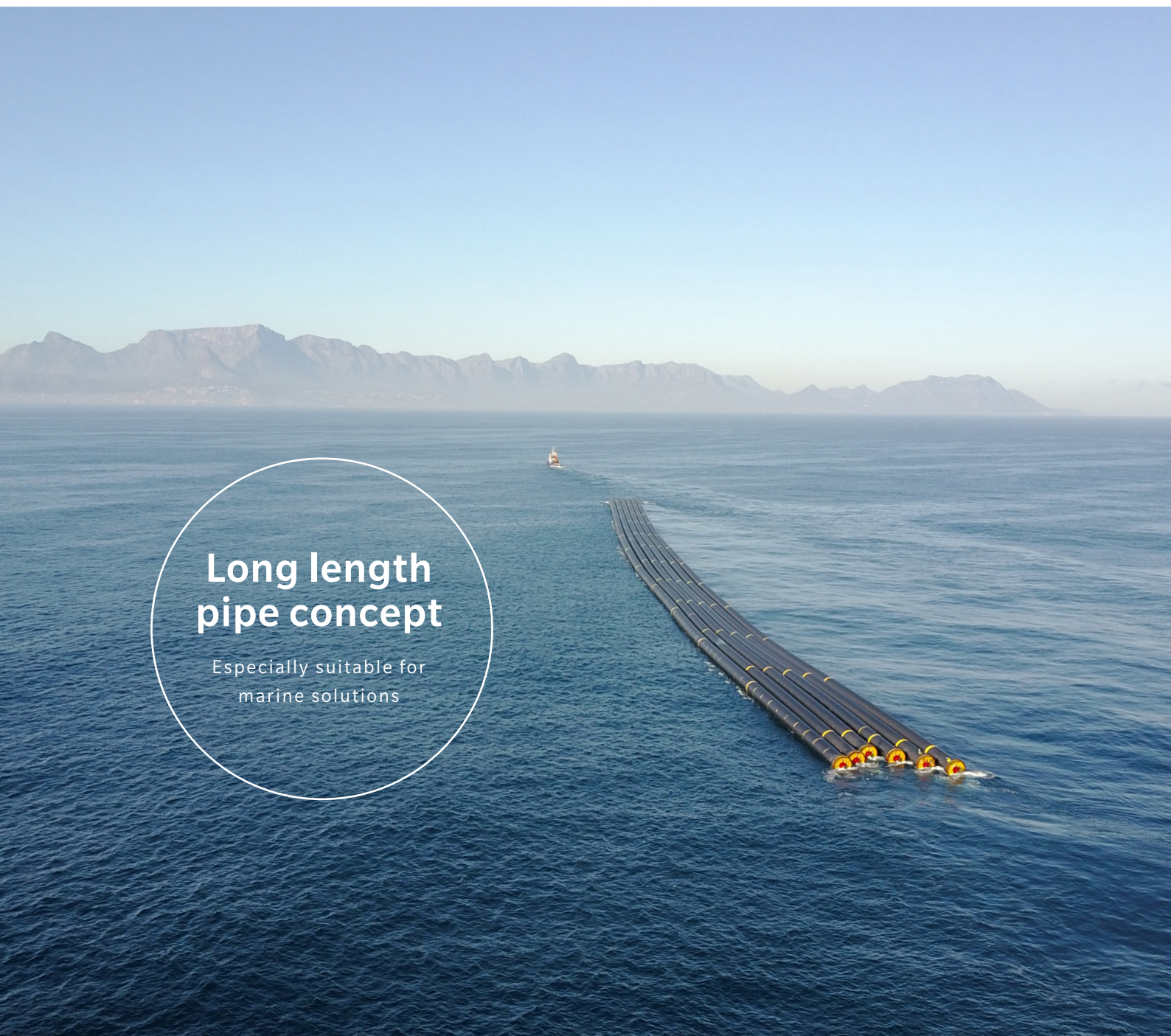


Long length large diameter PE100 pipes

PRODUCT TECHNICAL GUIDE

PIPELIFE 



**Long length
pipe concept**

Especially suitable for
marine solutions

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1. INTRODUCTION TO PIPELIFE NORGE AS

Pipelife are an established and well respected supplier of polyethylene pipes and are recognised as a global leader in the supply of long length extruded solid wall PE pipes. Pipelife operate from a number of locations across Europe.

The company's long length extruded pipelines are produced by Pipelife Norge AS in Norway. The company's Stathelle plant is located on the shore of a protected narrow fjord, providing the perfect environment for long length pipe production. The plants position on

the coast provides a number of unique benefits to enable continuous production in a clean environment and with direct access to the sea. The pipe length that can be produced is limited only by the size of the fjord itself and the diameter of the pipe. The plant has its own large storage areas on land and on sea, as well as a dedicated wharf for direct access by ocean going tugs. Norway's infrastructure guarantees a stable energy supply and reliable provision of materials necessary for the production process.

The production line used to manufacture the pipes is of the highest quality, made with special modifications which enable unique advantages to our products.



Pipelife Norge Stathelle plant

2. PIPE RANGE OVERVIEW

Production range at a glance:

Material: High Density Polyethylene (HDPE)

Pipe diameters: 20mm to 2500 mm OD (Outside Diameter)

Lengths: Standard delivery length from 12m up to 620m for pipes up to 2500mm OD. For pipes less than 1000mm OD, continuous pipe lengths up to 2km are possible - please contact us to enquire about specific requirements.

Standard Dimensional Ratio (SDR) classes: SDR all standard values (7.4 - 33) with flexibility as described in Chapter 3.3 in detail (SDR value = Pipe OD/pipe wall thickness).

Full details are given in Enclosure 1: Pipe production range.

3. PIPELIFE'S UNIQUE PRODUCTION PROCESS AND ITS BENEFITS

In 2004 Pipelife installed the world's first PE pressure pipe extrusion system, enabling the manufacture of long length PE pipes up to OD2000mm. The diameter range expansion continued with the installation of an additional extrusion line in 2012, allowing us to deliver pipes up to OD2500mm. Pipelife continues to pioneer the long length large diameter PE system, pushing industry borders to provide its clients with new opportunities.

The Long Length Large Diameter (LLLLD) concept was developed in the Pipelife Norge AS plant and has since proved a huge success with our clients due to the unique advantages the approach delivers.

Today, Pipelife produces pipes in many sizes using a number of modified pressure calibration extrusion lines. To ensure that the pipe is of the highest quality, special processes are used to manufacture to consistent and reliably high standards. Some key points and benefits of our production are mentioned in the following chapters.

3.1 Long length

Pipes are produced within controlled conditions by a continuous extrusion process using a number of purposebuilt production lines. Pipes are cut to the desired length within the process. This method of production ensures consistent quality, with no interruptions in the process. Pipe sections are fabricated in continuous

lengths up to the client-specified length and sealed at both ends with PE end plugs or end plate flange connections.

The maximum continuous pipe length is limited mainly by the size of the fjord. This limits large diameter (>1200mm OD) to around 620m in length. However, smaller pipes can be made well beyond the width of the fjord, up to 2km in length depending on the diameter of the pipe. Please contact Pipelife for more information for a specific project requirement.

3.2 Large diameter solid wall pipe

The plant at Stathelle can produce up to OD2500mm solid wall pipe, produced according to "EN12201 – 2:2024 – Plastic piping systems for water supply, and for drainage and sewerage under pressure" and "ISO 4427-2 – Plastic piping systems – Polyethylene (PE) pipes and fittings for water supply".

3.3 SDR classes

Pipelife's production process enables additional benefits when determining possible SDR values for the project.

Pipelife can produce standard SDR ratios (e.g. 11, 17, 21, 26, 33) and in addition almost all other non-standard values (e.g. 13, 14, 22, 23, 24, 25, 30).

Another benefit of Pipelife's unique process is that the SDR class can be varied throughout the length of the pipe, allowing Pipelife to tailor the pipes to the specific needs of our customers. For example, a pipe can be produced as a continuous extruded length starting with a SDR class of 26 and changing to SDR30 for the middle of the pipe with a gradual transition between the classes. This unique feature allows the production of pipe to complex specifications, such as 500 m long OD2500 mm pipe with 200 m of SDR26 and 300 m of SDR30. This feature provides flexibility and can offer substantial financial savings as higher wall thickness can be targeted at the locations where it is actually needed whilst maintaining all the benefits of a long length pipe system.

3.4 Pipe delivery by sea

Pipelife's towing delivery method is both effective and safe – we have done it successfully for over 50 years on over 200 projects and to a wide range of destinations. Individual lengths of pipes for delivery are sealed off at both ends with PE end plugs or flange connections and normally grouped into similar lengths connected by maritime towing gear. The closed pipe sections are then towed as a group by tugboat to the marine destination.



Departure of eleven OD1600 and OD2100 mm pipes, lengths between 500-600m.

4. FITTINGS RANGE

Pipelife has developed a complete range of fittings which enables the delivery of the complete pipe system, with a special focus on marine projects. Solutions have been developed for all parts of the pipeline: connection to concrete structures, pipe connections, t-pieces, bends, manholes and diffusers. These solutions guarantee longevity and excellent quality throughout the lifetime of the project, even for the largest pipes (OD2500 mm).

4.1 Branch Connections

Welded connections to smaller adjoining pipes can be provided in most size combinations. For connecting pipes less than 400mm OD, this is usually done by socket welding which forms a joint through heated fusion welding of the two pipe surfaces, similar to butt fusion welding. Where connecting pipes larger than 400mm OD are required, this is usually undertaken by electrofusion saddle jointing.



The electrofusion PE saddles have been developed as an answer to the need for safe and corrosion-free solutions for incorporating large diameter manholes and diffusers onto the main pipe. They have been successfully pressure tested to well above 2 bar in full scale test conditions to confirm the quality of the welded joint. All saddles are supplied as a single piece in PE100 material and typically include a top flange for direct fixing of other fittings (such as riser pipes).

Saddles are available for attachment to pipes above 900mm OD in a variety of size combinations - see Table 1 for standard manufactured combinations. Other size combinations may also be available. Please consult with Pipelife for specific requirements and advice on suitable application.

Full scale pressure test of OD1000 saddle on OD2500 pipe to 2 bar

Table 1 - Standard sizes of Electrofusion Saddles

Main Pipe Size	Inlet size												
	355	400	450	500	560	630	710	800	900	1000	1200	1400	1600
900		✓											
1000	✓	✓	✓	✓	✓	✓							
1200	✓	✓	✓	✓	✓	✓	✓	✓					
1300		✓	✓	✓	✓	✓	✓	✓					
1400		✓	✓	✓	✓	✓	✓	✓	✓				
1600		✓	✓	✓	✓	✓	✓	✓	✓	✓			
1800		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
2000		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
2100		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
2300		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2500		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

4.2 PE Fittings

Fittings are produced as segment welded parts to form a smooth transition and ensure optimal flow and minimal hydraulic loss. Production of fittings takes place in an enclosed welding workshop located at the Stathelle plant. The workshop is equipped with various welding tables, machines, tools and saws which enable the production of any fitting up to OD2500 mm size with the only real constraint being the practical limit of transportation to the project location.

We are experienced in producing fitting types including bends, T-pieces, manhole and diffuser risers, puddle flange fittings and other bespoke elements.

All fittings produced by Pipelife are bespoke and tailor-made to suit each project's specific requirements. Pipelife's technical team produce 3D design models of all elements which are used to design and plan the assembly of the fittings and ensure they meet the dimensional specifications and site requirements. assembly of the fittings and ensure they meet the dimensional specifications and site requirements.



Completed saddle fittings with temporary blank flanges ready for installation

5. PE MATERIAL PROPERTIES AND BEHAVIOUR

5.1 General

A solid form of polyethylene was first created in 1935 by British chemists Eric Fawcett and Reginald Gibson. This discovery was used for the first time during the Second World War in pipes that were used for the protection of radar cables. PE pipes began to be used more extensively in the 1950s. The PE raw materials have been further developed over the years and the PE resins used for pipe extrusion today are significantly improved from the resins used in the early days. PE pipe manufacturers normally purchase PE resins compounded from resin suppliers (i.e. with additives and pigments included) and do not add any further additives when extruding the pipes.

5.2 PE raw material classification

There are a number of standards used to classify PE materials for pipe extrusion. Today, the most common materials used for pipes in Europe are PE80 and PE100, where the number refers to the long-term material strength according to EN standards. The ASTM standard for PE pipe resins classifies the strength properties of the different PE resins in a similar way, but refers to a cell classification for strength properties.

All our extruded large diameter pipes are manufactured in our factory in Stathelle in compliant PE100 resins to provide optimal strength performance. Furthermore, we typically use a PE100-RC resin, an improved variant of the standard PE100 polyethylene resin. The PE100-RC resin imparts additional low sag and high crack-resistance properties to the pipes and is the standard resin of choice for our pipes.

5.3 High Temperature (HT) Resin

Recent developments in PE material technology have extended the range of suitable PE100-RC resins to include PE100-HT. These HT resins have the same basic properties and performance as PE100-RC materials, but are less impacted by prolonged exposure to high temperatures and therefore extends the LLD solution to pipes operating at higher temperatures. Standard PE100-RC materials are typically recommended for long term exposure at temperatures up to 45°C (higher for short durations). PE100-HT resins are suitable for long term exposure up to 70°C and short duration exposure of temperatures up to 100°C and are therefore more appropriate for pipes operating at prolonged high temperatures.

Pipelife are now able to produce the same pipe range in PE100-HT resin. Please consult with Pipelife further if you are interested in pipes supplied in PE100-HT resin.



Fabricated 90 deg bend fitting for OD2000 mm



OD2100 mm SDR26 incorporated bend

4.3 Special reinforced PE fittings

For occasions when it is necessary to increase the load bearing capacity and safety during installation, Pipelife has developed a special wrapping solution for the fittings. Wrapping protects sensitive weld areas and provides an extra layer of protection during transport, handling and installation.



OD2500 mm fabricated tee with GRP reinforcing wrap

All PE100-HT resins used by Pipelife are also rated as PE100-RC. Products in PE100-HT resin can be considered to have the same strength and performance properties as PE100-RC.

Note that some references and standards, may refer to 'PE-RT' (Raised Temperature PE) which is a term commonly used in the domestic pipe market for hot water supply pipework. This term is sometimes used in design specifications to describe the need for high temperature PE resins such as PE100-HT. If in doubt, please contact Pipelife to check your specification requirements.



5.4 PE pipe classification

A PE pipe is classified by the type of PE material from which the pipe has been extruded and the SDR ratio of the pipe (pipe OD/pipe wall thickness). Alternative ways to classify PE pipes include using PN and SN values.

For further information or clarification on pipe classifications, please consult Pipelife.

5.5 PE material properties

Resin polymers for PE pipe manufacture are available in different material designations (PE 80 and PE 100). Pipelife uses only PE100 resin materials for LLLD pipes compliant with international and European standards ISO 4427 and EN 12201 from established European suppliers.

Specific properties of PE100-RC and PE100-HT material, including relevant test standards, minimum requirements and typical supplied material values are summarised in Table 2.

Table 2 - PE100-RC material properties to ISO 4427 / EN 12201

Characteristics	Test Standard	Required Value	Typical Value for PE100-RC / PE100-HT resins
Compound density at 23 °C	ISO 1183-2	≥ 930 kg/m ³	960 kg/m ³
Carbon black content	ISO 6964	2 to 2.5% by mass	2.25 % by mass
Carbon black dispersion	ISO 18553	≤ 3	< 3
Water content	ISO 15512	≤ 300 mg/kg	< 300 mg/kg
Volatile content	EN 12099	≤ 350 mg/kg	< 350 mg/kg
Oxidation induction time (OIT)	ISO 11357-6	≥ 20 minutes at 210 °C	> 20 mins at 210 °C
Melt mass-flow rate (MFR)	ISO 1133 Cond. T	0.2 to 1.4 g/10 minutes	0.25 g/10 minutes
Thermal Conductivity at 20 °C	ISO 22007	N/a	0.4 W/m.K
Tensile Strength at Yield at 23 °C	ISO 6259	N/a	24 MPa
Tensile Strain at Yield at 23 °C	ISO 6259	≥ 8 %	9 %
Elongation at Break at 23 °C	ISO 6259	≥ 350 %	> 500 %
Tensile strength for butt-fusion welds	ISO 13953	Ductile failure	Ductile failure
Resistance to Slow Crack Growth for PE100-RC Accelerated Notched Pipe Test (ANPT)	ISO 13479	≥ 300 hours at 9.2bar	> 500 hours
Resistance to Slow Crack Growth for PE100-RC Cracked Round Bar (CRB) Test (e >16mm)	ISO18489	> 1.5 x 10 ⁶ cycles at 12.5 MPa	> 1.5 x 10 ⁶ cycles
Hydrostatic strength at 80 °C	ISO 1167	≥ 165 hours at 5.4 MPa	> 165 hours
Hydrostatic strength at 80 °C	ISO 1167	≥ 1000 hours at 5.0 MPa	> 1000 hours
Hydrostatic strength at 20 °C	ISO 1167	≥ 100 hours at 12.0 MPa	> 100 hours
Allowable long term stress value	EN 12201-2	10 MPa	10 MPa
Design long term stress value (F=1.25)	EN 12201-2	8 MPa	8 MPa

The allowable stress in the pipe wall of a PE pipe is normally calculated with a design factor of 1.25 on the minimum required strength value according to EN 12201. Based on this, a PE 100 pipe subjected to an internal pressure corresponding to its PN designation will experience a pipe wall stress of 8 MPa with a lifetime of over 100 years at a temperature of +20°C. However, due to the temperature and time-dependent behaviour of PE material during loading, the actual pressure pipes can be subjected to will vary depending on the loading and ambient conditions. For short-term loading, such as surge pressures, pipes can tolerate substantially higher pressures than their PN designation without failure or a decreased life expectancy.

The strength properties of a PE pipe vary with temperature. A reduction in the pipe design strength and E-modulus should normally be applied for application in temperatures exceeding 20°C. For PE pipes (including PE100-RC and PE100-HT) proposed for prolonged use at temperatures higher than +20°C, the reduction factors for design strength provided in Table 4 can be used. For temperatures exceeding 50°C, please contact Pipelife's technical team for further advice. At temperatures below +20°C, strength values will logically increase slightly. However, enhanced properties are not normally applied to the design and they should instead be considered as an increased factor of safety.

5.6 E-modulus

The most important parameter for structural design in a PE pipe system is the E-modulus of the PE pipe material, also sometimes referred to as the Modulus of Elasticity or Young's Modulus. Many formulae used for the design of pipelines require a value for the E-modulus to be selected. Since PE is a visco-elastic material, the E-modulus for a PE pipe is not a constant as it is with many other materials and appropriate values need to be

selected from a set of curves or from tables to suit the design conditions. This requires a good understanding of the nature and behaviour of polyethylene under stress loading and should be determined by experienced and competent designers.

The E-modulus will determine the elongation properties of the pipe and for PE pipes it is heavily influenced by the temperature, the duration of loading and the stress level in the material. A higher temperature will give a slightly decreased E-modulus and a lower temperature will give a slightly increased E-modulus, broadly similar to the variation in strength properties indicated in Table 4. Representative design E-modulus values for pipes of PE 100 resins are given in Table 5 based on a stress level of 4 MPa in a typical PE 100 pipe at +20°C. At higher stress levels lower E-modulus values should be applied. For this reason the E-modulus is also sometimes referred to as the creep or relaxation modulus.

5.7 Bending

Polyethylene is a flexible material and can be subjected to a significant degree of bending without detriment to its performance or longevity. The amount of bending a PE pipe can take is dependent on its SDR rating and the conditions during which the bending is taking place, including the duration.

There are significant risks involved with bending pipes, both to the pipe itself and potentially the installation workforce, due to the forces involved and potential stored energy within the pipe. Pipe bending should only be undertaken by experienced contractors with a full understanding of the risks involved. Over-bending of pipes can lead to a serious health and safety incident or permanent deformation or buckling of the pipe.

In marine installations, pipes are typically subjected to high bending forces which are caused by its self weight during the sinking process. Under such conditions, pipes

Table 3 - Pressure ratings

Class	S	MRS	C	Pressure rating (PN) for selected SDR class									
				33	30	26	22	21	17	13.6	11	9	7.4
PE100	8	10	1.25	5	5.5	6.4	7.7	8	10	12.5	16	20	25

MRS: Minimum Required Strength by ISO 9080-2; C: Safety factor; S: Design stress; SDR: Outside pipe diameter divided by wall thickness.

Table 4 - Strength reduction coefficients as per EN12201-1:2024 and ISO 13761:1996

Temperature (°C)	20	25	30	35	40	45	50
Reduction factor for PE100 (incl. HT)	1.00	0.92	0.85	0.79	0.73	0.67	0.62

can usually be sized to tolerate the theoretical maximum design bending limits. Specific guidance on these limits for marine installation are provided in Section 8.1 of this guide.

Where a pipe is proposed to be installed with a curvature via mechanically forced bending, then consideration and allowance must be given to additional practical issues and uncertainties such as the loading application, the reliability of bending and handling methods, physical restraint and pipe behaviour.

In practice, it is usually not practical to install pipes to long term fixed curvatures of less than 100 x pipe OD. For short duration bending other than sinking operations (e.g. handling, temporary works and storage operations), it is advised that bending is also restricted to not less than 100 x pipe OD, unless valid and specific measures are in place to restrain and control the pipe.

The following is provided as general good practice for bending of LLLD pipes on site during handling and storage:

- Avoid unnecessary bending of pipes during storage or movement, especially when pipes are unsupported or partially supported.
- Avoid forced bending of the pipe around objects, such as piles, which may cause pressure concentrations and risk localised buckling of the pipe.
- Do not exceed bending below $100 \times \text{OD}$ during handling unless specifically engineered and justified.
- Use appropriate, rounded or soft supports and lifting equipment to prevent unintended deformation or stress concentrations from hard point or edge loading. For long lifts or supports, use multiple lifting or support points.

5.8 Ring Stiffness

The nominal pipe (or ring) stiffness is often used to describe the loading bearing capacity of the pipe. However, this can be misleading for flexible pipes as it does not define the overall ability of a supported or buried pipe to withstand a load which is usually much higher.

Where design codes refer to the pipe nominal ring stiffness (SN), values in Table 6 are provided for guidance. Note that the ring stiffness (SN) values provided in Table 6 are based on an E modulus of 850MPa which Pipelife consider most appropriate for typical short term (<2min) load response. The values may be lower than those quoted by other manufacturers for similar products as they may assume performance at a shorter (higher) E modulus value. It does not mean the pipes have an actual lower load capacity.

It is therefore very important that the designer understands flexible pipe design and is clear on the correct application of these values. If in doubt, please consult with Pipelife.



Table 5 - Representative E-modulus values for PE pipes at +20°C

Type of material	Representative E-modulus values* (MPa)						
	3 min	1 h	10 h	100 h	1000 h	1 year	50 years
PE 100 / PE 100-RC (Stress level 4 MPa)	800	550	425	325	250	200	150

* The value is dependent on the stress level in the pipe wall and the duration of loading.

Table 6 - Nominal Ring Stiffness

Class	Pipe Nominal Ring Stiffness (SN) for selected SDR class in kN/m ²									
	33	30	26	22	21	17	13.6	11	9	7.4
PE100 / PE100-RC	2.2	2.9	4.5	7.6	8.8	17.3	35.4	70.8	138.4	270.2

SN values to EN 12201-2 using short term E modulus of 850 Mpa - for guidance only. Refer to EN 12201 or contact Pipelife for suitable application of values.

5.9 Thermal expansion and anchoring

Temperature changes or pressurising may give rise to a noticeable change in the length of a PE pipeline. As a result of this change, movements in axial direction can occur. A PE pipeline with restrained joints on supports can accommodate limited changes in length, for example minor movements and angular deflections in bends. However, consideration by the designer must be given to the potential contraction or expansion of the pipe if significant changes in temperature or pressure are expected to occur. Anchoring or restraining joints may be necessary at fittings and connections in order to limit or accommodate movements and angular deflections.

A coefficient of thermal expansion of 0.18 mm/m°C can generally be applied for the calculation of thermal movements in PE100 pipe systems.

Where axial movements are prevented in a PE pipe, the prohibited expansion will give rise to axial forces in the pipeline. Most types of joints used for PE pipes are restrained and hence the pipe system is able to transfer these forces along the pipeline and thrust blocks are not normally required. However, the designer should check that all joints can accommodate the predicted axial forces and that there are no elements that could pull apart under axial tension.

Due to the visco-elastic behaviour of PE pipes, axial forces will generally decrease over the lifetime of the pipeline as a result of relaxation in the pipe material. The initial force will depend on how fast and to what extent the pipe is elongated at assembly and how fast any temperature change occurs in the pipe. The E-modulus for calculation of the initial force should be determined from Table 5 with due consideration of the full design conditions.

Welded joints in PE pipes have almost the same strength as the pipe itself and fully welded PE systems therefore normally only require:

- anchoring of the PE pipe at connections to rigid structures such as valve chambers, and at connections to socket-jointed pipe systems.
- anchoring at each side of bends for PE pipes placed on supports.

Anchoring of the ends of PE pipelines with welded joints is usually necessary because the internal pressure will cause a small diameter increase in the pipeline, and a corresponding shortening of the pipeline will occur unless the end points are anchored. The anchoring of the end points is especially important for PE pipe placed on supports or laid in ducts. For a buried pipe, the soil friction will, to a certain extent, contribute to the anchoring of the pipe ends and constrain the axial movement. However, for large diameter PE pipes particularly, additional anchoring

Be aware that axial forces may be transferred from the pipe system to valve chambers and pumping stations via the pipe connections. All connection points should be designed to accommodate or resist the resulting forces, which can be large. For cast in connections, this often requires the inclusion of specific anchoring (puddle) flanges welded onto the outside of the PE pipeline. Along with the anchorage of buried PE pipes in concrete walls, the risk for water leakage between the pipe and the surrounding concrete also needs to be considered. It is therefore recommended that a cast-in PE pipe section also has a water stop flange welded on to the PE pipe.

For this purpose, Pipelife is able to provide special puddle flange fittings on request. Please contact Pipelife for further details.



5.10 Burial and backfill

In order to minimize movements at bends and tees in buried PE pressure pipelines backfill of friction material should be placed as shown in Figure 1. The backfill material is recommended to be compacted to > 90 % mod. Proctor in the following locations:

- all bends >10° at a distance of minimum 5 x OD on each side of the bend (if bends larger than 45° are substituted with two bends of half angle, an improved hydraulic function and a decreased soil pressure around the bend will be achieved.)
- all tees at a distance of minimum 10 x OD around the tee (where OD is the diameter of the branch)

Segment-welded PE tees and fittings are sometimes cast in concrete as a protection for the fitting or as thrust restraint. Where fittings are cast in, consideration should be given to whether the surrounding concrete needs to be reinforced to withstand the movement and stress from possible expansion and contraction of the pipe under internal pressure or thermal expansion.

5.11 Contaminated ground

PE pipes are generally highly resistant to naturally occurring chemicals in soils. However, they can be susceptible to some diffusion (permeation of the pipe material) from long term burial in low molecular organic substances, also termed VOCs (Volatile Organic Compounds). The level of permeability differs for different types of PE materials and increases with temperature. PE100 has a significantly higher diffusion resistance compared to most PE materials.

The time it takes for a substance to penetrate the wall of PE pipes is directly proportional to the square of the pipe wall thickness. Hence, it takes 100 times longer for VOCs to permeate the pipe wall of a 2500 mm pipe than a 250 mm pipe of the same material and SDR rating. Larger diameter pipes also have a smaller contact surface area to volume ratio. Hence, in most cases large diameter PE pipes do not need additional protection even if installed in contaminated ground. Where small diameter PE pipes are required to be installed in contaminated ground or particularly high concentrations or potentially reactive contaminants (see Chemical Resistance 5.14) are expected, pipes with a diffusion barrier can be considered.

5.12 Abrasion resistance

PE pipes have been shown to have a high level of abrasion resistance, substantially higher than other common pipe materials, including steel. Being made from a homogenous material, they are also not dependent on any surface linings which can be damaged by abrasion. At typical pipe flows (up to 5m/s fluid velocity) the amount of abrasion from potable or clean raw water can be considered insignificant.

For media containing significant levels of particulates, such as slurries, PE pipes remain one of the best choices of pipe material and they are often used for slurry pipelines in the mining industry. However, for these situations we advise that suitability should still be confirmed as the degree of abrasion can vary greatly depending on the size, shape and concentration of the solids in the flow as well as the angle of impact and flow characteristics.

For further information, please consult Pipelife.

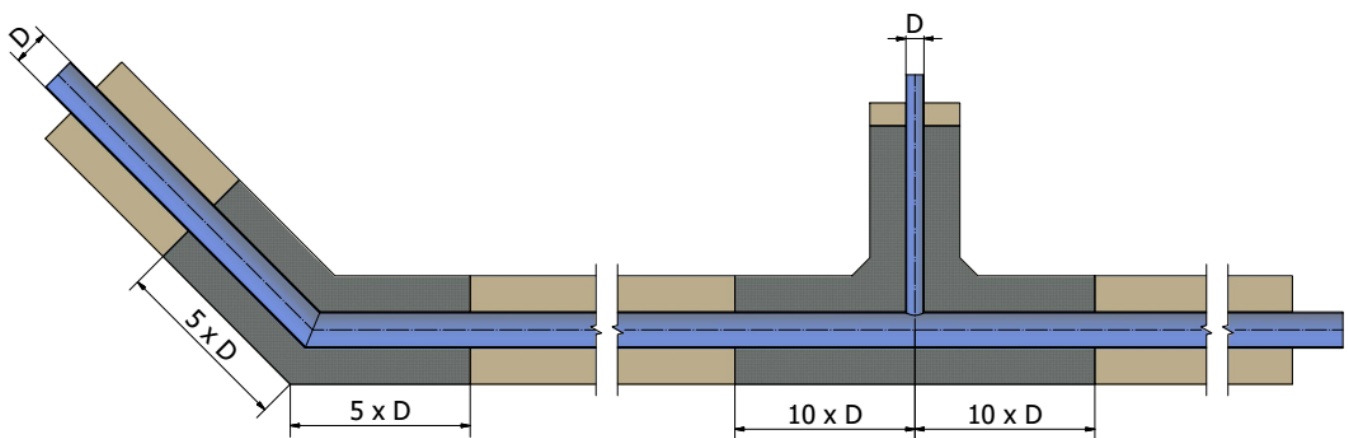
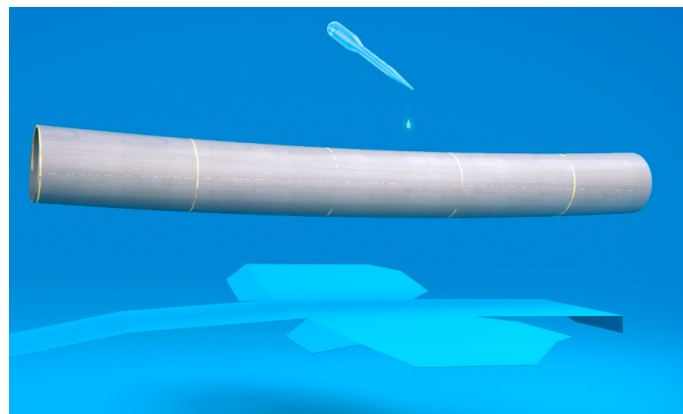
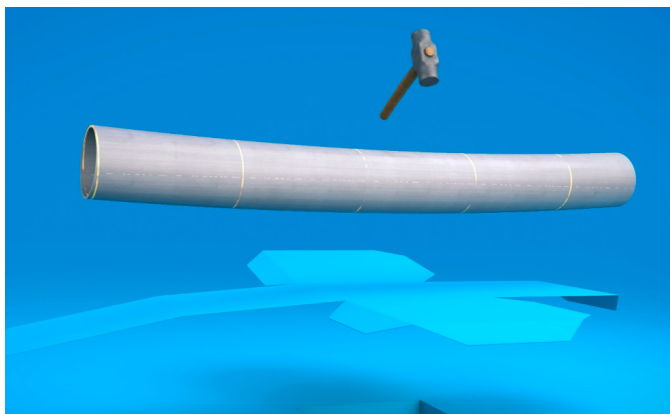


Figure 1 - Backfill with compacted friction material around bends and tees to minimize movements in buried PE pressure pipe systems



5.13 Crack resistance

PE pipes are relatively soft and can be scratched if carelessly handled. However, they are also very resilient and do not rely on surface coatings for integrity.

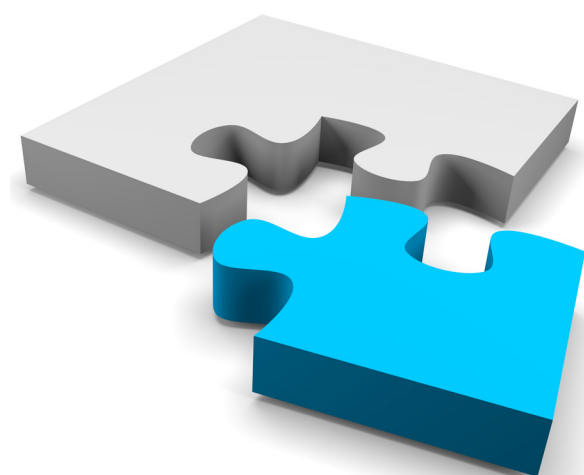
The continued development of PE resins also means that crack resistant PE resin materials are now available which have reduced the amount of impact any scratches have on the strength of the pipe. Pipelife Norge prefer to manufacture all LLD pipes from a crack-resistant resin, termed PE100-RC, which has the same strength and performance properties as PE100, but with an increased resistance to crack propagation.

Normal handling should not result in more than minor surface scratching and shallow notches which will not significantly influence the strength properties of the pipes.

Scratches on PE pipes often appear worse than they really are. The depth and significance of scratches can be measured and assessed and Pipelife are usually able to carry out specialised surface repairs to reduce the impact of deeper scratches if necessary.

Scratches up to a depth of 10 % of the pipe wall thickness will not significantly affect the strength properties of a PE pipe and localised scratches above this depth can usually still be safely accommodated with minor treatment.

For further information, please consult Pipelife.



5.14 Chemical resistance

PE pipes generally have a good level of resistance to low to medium concentrations of nearly all chemicals, salts, acids and alkalis at typical ambient temperatures (20°C). However, as a rough guide, the following substances are highlighted as potentially having a significant negative effect on the pipe material:

- petroleum products (hydrocarbon fuels) can permeate and cause slight swelling of the PE material, particularly at elevated temperatures. This typically does not cause actual degradation of the material though.
- chlorine products containing free residual (oxidising) chlorine can cause premature aging and swelling of the PE material. The effects are highly dependent on the exposure conditions. For low pressure pipe applications in marine conditions, the risk of pipe failure through material degradation from typical dosing concentrations (<5.0 ppm) can be considered very low. PE Pipes are generally considered suitable and commonly utilised as chlorination pipes.
- wetting agents and strong oxidising liquids may impair the stress cracking resistance of PE and shorten the lifetime of the pipes.

The effects will be elevated where contact substances are in high concentrations or at high temperatures (typ. >40°C) and specific consideration should be given to exposure to all chemicals in these circumstances.

There is no significant material impact from permanent immersion in seawater.

Detailed information on the extent to which various chemicals may affect the lifetime and performance of PE pipes can be found in chemical resistance tables published by PE resin manufacturers and plastic pipe organisations.

For further information, or if in doubt, please consult Pipelife.

5.15 UV resistance

All pipes contain a minimum 2% carbon black content which has been proven to provide long term resistance to degradation from ultraviolet radiation. However, depending on the intensity and longevity of exposure, some precautions may be recommendable to reduce exposure and the risks of degradation, particularly for long term, above ground applications.

The effects of UV on pipes exposed to daylight for a period of up to 1 year can be assumed to be negligible. Please consult with Pipelife for more details on specific risks and guidance on UV resistance.

5.16 Hydraulic performance

For hydraulic design purposes, HDPE is classified as a 'smooth' material with a low surface roughness value. It is not susceptible to corrosion and is resistant to abrasion, both of which can otherwise lead to significant deterioration of the hydraulic performance over time.

Whilst it is often not separately considered in the surface roughness value, research indicates that a significant part of pipe hydraulic losses relates to the jointing in the pipe, particularly in long lengths. The long length extruded nature of LLD pipes massively reduces the number of joints and welds and means this impact can be largely ignored. This may provide some justification

and increased confidence for lower surface roughness values to be applied by the designer.

PE pipes can accommodate high flow velocities and demonstrate very good performance under transient pressure surge conditions.

Pipelife are able to assist with your hydraulic design if required – please enquire.

5.17 Carbon Footprint and Recycling

The application of LLD polyethylene PE100 pipes delivered by sea-tow can reliably demonstrate a low overall carbon impact when compared to other pipe products in marine applications. Our solution produces very little waste product, requires minimal packaging and utilises efficient sea transportation.

There are no significant waste residues or hazardous chemicals produced in the manufacturing process that require disposal. Any waste polyethylene product created during the manufacturing process is collected for recycling into other PE products. Recycling rates within the factory are typically >95%.

Our products are made to last; typically for up to 100 years design life. The pipe material remains inert throughout its lifetime and the embodied carbon remains within the material such that in theory it can be recovered and recycled into lower grade products even at its end of life. This makes the pipe 100% recyclable and highly applicable to a circular economy.



6. WELDING

Welding is normally an integral part of every project, therefore Pipelife has invested substantial resources in determining the best possible procedure and parameters to obtain reliable results and constant improvement across the field.

All Pipelife welding is performed by trained and certified welders with many years of experience in the field. In addition, Pipelife owns and operates a comprehensive fleet of butt fusion welding machines covering the whole pipe size range.

6.1 Butt fusion welding

Pipelife has pioneered the welding process of large diameter solid wall pipes and has developed and perfected its welding techniques and procedures over its many years of direct project experience.

Pipelife Norge follows the guidelines and standards defined within INSTA-2072:2021 (Parts 1-7) for all butt fusion welding, including undertaking suitable weld sampling and testing. These standards are Scandinavian but are very similar to the more widely cited ISO 21307:2017 and DVS Technical Code 2207-1.

Butt welding is generally carried out in factory conditions where possible for maximum quality control, but can be undertaken on site if required using specialist equipment and skilled operatives. All welding is undertaken to strict quality control procedures.



7. ADVANTAGES OF LLLD CONCEPT

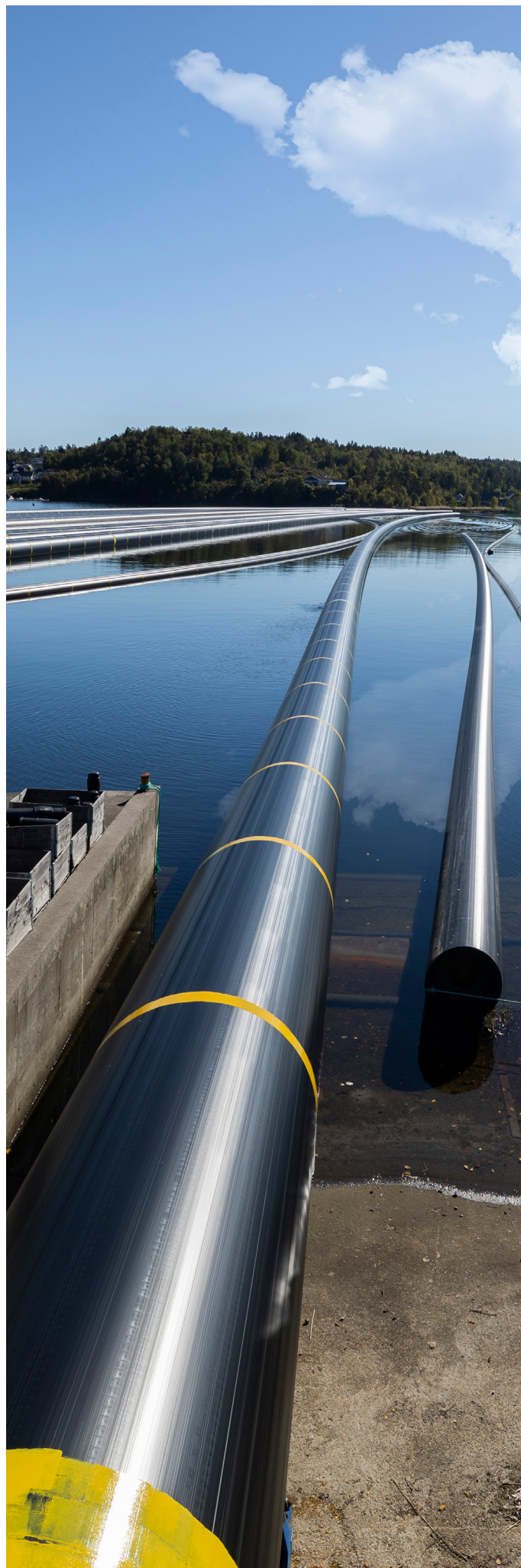
The Long length Large Diameter (LLLD) concept offers a cost effective and easy to install solution for offshore and near shore marine projects. Fundamentally, the concept is based on minimising the number of weak points in the system and hence the number of risks, both during installation and over the lifetime of its application.

LLLD pipes are therefore simplistic by design, but they require a high degree of manufacturing and engineering expertise and a focus on detail and quality to produce and perfect.

- With long length pipe delivery, welding/jointing work of the pipe on site can be entirely avoided. If supplied in short lengths, lengthy welding work would be required.
- Significantly reduced risk from bad welds, as very few welds are required on our long length pipes, and any necessary welds are carried out by Pipelife specialists using high quality welding rigs.
- No risks of ovalisation, as the pipes are stored in the sea. Due to the temperature difference, the pipes are free to rotate in the water, which additionally ensures the roundness of the pipes.
- No need for on-land storage. Storing pipes on land would require a large area as well as stacking limitations of pipes.
- Easier handling of stored pipes.
- Low environmental impact as sea transport typically has much lower carbon footprint than equivalent land transportation. Pipes are stored and handled mostly on the sea with minimal packaging or waste.
- Reduced risk of scratches and other damage to the pipes.
- Short installation time, and thus low installation cost. All the pipe sections are supplied with flange connections and blind flanges already on the pipe ends, so the assembly work is done at our plant. Thus, costs for the contractor are reduced.

As a result, the overall safety and reliability of the installed pipe system is substantially increased. This is of great importance to both the contractor and the client of the project.

Pipelife is focused on providing a complete system solution with product and technical support based on years of experience in marine projects worldwide.





8. MARINE APPLICATIONS

The Pipelife LLLD concept is perfectly suited for marine projects, outfalls and intakes for various purposes: power generation, desalination, sewer outfalls, sea water air conditioning, LNG terminals and floating LNG, aquaculture, industrial outfalls and intakes.

Solid wall PE pipes have an outstanding track record in marine pipe projects. Current production limitations are:

- Maximum pipe size is OD2500 mm
- Maximum supplied length for an OD2500 mm pipe is 620 m. Longer lengths up to 2000m may be feasible for smaller diameters (< OD1000) - please enquire.
- Installation depth up to 900 m depending on the pipe size and SDR ratio.

8.1 Marine installations

The “S-bend installation method” (also known as “Float and sink”) is a fast and economical installation method, which has been practiced since the 1950s. During installation, the PE pipe can be extensively bent, and the pipe will usually be subjected to much higher stresses and strains than it will for the subsequent duration of its service life. Consequently, in order to be able to provide a good structural pipeline design, the designer should have a knowledge of marine PE pipeline installation issues.

The high degree of flexibility of PE pipes is utilized during the submersion process. PE pipes can be subjected to

5% strain without overstressing the material. However, buckling or kinking of the pipe may often occur well below this level due to ovalisation. Therefore, it is usually the risk of kinking or buckling of the pipe, rather than overstressing which limits the practical bending radius during submersion. The degree of bending at which buckling starts depends on the SDR class of the pipe.

Table 7 below shows the theoretical critical bending radius and the corresponding strain value in the pipe when the pipe will have reached 8 % ovality due to bending.

As can be seen from Table 7, buckling due to kinking is likely to occur before a strain level of 5 % is reached for all SDR classes higher than 11.

Table 7 - Bending radius and strain in pipe wall when a PE pipe has reached 8 % ovality due to bending

SDR value	Bending radius/OD	Strain in pipe wall (%)
33	27	1.8
26	22	2.3
21	17	2.9
17	14	3.5
13.6	11	4.4
11	9	5.5

To ensure a safe installation of a PE pipe utilising the S-bend sinking procedure, the bending radius must be closely monitored during the submersion process. The bending radius is dependent on the SDR ratio, the amount of weighting on the pipe, the installation depth, the wave height during the submersion operation, the submersion speed and the pulling force applied on the floating end of the pipe.

The sinking of a PE pipe is usually in the range of 500-700 m/h, enabling the submersion operation to be fast, but safely controlled. Since the bend progressively moves along the pipeline, the bending stress will normally act on the pipe as a short-term stress (lasting only a few minutes). Since PE is a visco-elastic material, the material will creep when subjected to stress. This creep effect in the PE material will also lead to an increase in the bending of the pipe if the submersion operation is stopped or slowed down. Hence it is important to plan, monitor and control the installation process and timing carefully to avoid overstressing the pipe.

Taking into consideration the typical uncertainties involved in such operations, it is advisable to have a safety factor against buckling of at least 1.5. Furthermore, it is also advisable not to subject PE pipes to fast short term bending which could give strain values exceeding 2 % in the pipe wall due to the high stresses induced. Thus, a bending radius of less than 25 times OD should not be accepted during the sinking operation even for thick-walled pipe.

For large diameter PE outfalls, operating at an internal pressure of less than 4 bar, a SDR 26 pipe will in most

cases be the optimal choice. SDR 26 pipe can be bent down to a radius of 30-40 times the diameter during installation, whilst still providing a reasonably high safety factor. Recommended minimum bending radii for PE pipes of different SDR classes are provided in Table 8.

Table 8 – Minimum recommended short term bending radius/OD

SDR class	Minimum recommended short term bending radius/OD
30	37
26	33
21 or lower	25

The values in Table 8 are based on controlled marine installation scenarios, such as the S-bend sinking method, where the pipe is subjected to temporary bending due to its own weight, ballasting, and installation dynamics. While these radii are technically achievable during such operations, they are not intended as practical targets for manual or mechanical bending on-site – refer to Section 5.7 on Bending.

It is important to engage a competent marine contractor who understands these issues. In order to safeguard deep installations it is advisable to have the contractor present their method of installation, calculation of bending radius and monitoring system for the laying of the pipeline prior to the installation itself.

For further information, please consult Pipelife.

Pipe tow through the Bosphorus Channel





Typical pipe collar weighting for marine installation

8.2 Ballasting

PE100 has a density of around 960kg/m³; a PE pipe will thus float even when filled with water if it is not ballasted. The amount of ballasting required depends on the wave and current forces that may affect the pipe, and whether the pipeline is placed directly on the sea bed or in an open excavated trench (pipelines in an open trench may be somewhat sheltered by the trench).

The pipes must therefore have concrete weights attached to ensure a sufficient stability on the sea bed against wave and current forces. The amount of loading applied largely depends on the water depth, the marine conditions and degree of exposure of the pipeline. A common weighting is in the range of 25-55 % of the pipe's displacement, but even higher weighting may in some cases be required. There is a range of different weight shapes.

For pipes that are to be installed in trenches in the sea bed, the ballasting of the pipe is selected with regard to the risks that the pipe faces in its design life and during installation. A ballasting of 35-50 % is normally needed for such pipes, depending on pipe size and method of backfilling.

A PE pipe with concrete weights attached will tend to settle to the trench bed profile, and so the sea bed must be suitably prepared to ensure that changes in profile are gradual (to suit acceptable long term bending radii) and collars are resting on the bed. A typical weight spacing is in the range of 3-6 m depending on the amount of loading and the pipe size.

There are two important requirements, which have to be fulfilled for the discrete concrete weights:

- The weights must be attached to the pipe in such a way that they do not slide on the pipe during the sinking operation.
- The weights must be able to take the forces to which they will be subjected from the PE pipe due to the internal pressure in the pipe.

If the weights slide on the pipe during the S-bend sinking operation, the whole operation may fail. The risk of sliding is less at shallow installation depths where the angle of installation typically remains relatively low, but for pipes which are to be installed at greater depth there will be a very high risk of sliding if the matter of attaching the weights has not been properly considered. It should also be noted that the diameter of the pipe might shrink during the sinking operation due to the decreased water temperature by depth and the longitudinal forces acting on the pipe during installation.

Proper design includes testing and selecting an adequate batch of elastic material (usually EPDM rubber) for compensators and inserts between ballast weights and HDPE pipe. In addition, bolts and torque are also to be tested.

When a PE pipe is subjected to internal pressure the diameter of the pipe will increase over time. This expansion of the pipe will transfer forces to the concrete weights, and the weights must be reinforced to be able to withstand these forces. For outfalls operating at low pressures the forces transferred to the weights will be limited. However, for marine PE pressure lines, the weights must be designed to resist significant forces due to the expansion of the pipes.

For further information, please consult Pipelife.

8.3 Marine trenching and backfilling

The load bearing capacity of PE pipes installed in trenches depends on the SDR rating of the PE pipe, the external loads and the nature and compaction of the surrounding backfill material in the trench. In general, pipes of lower SDR values can accommodate substantially greater overburden loads and are therefore more suitable at high burial depths.

PE Pipes up to SDR30 can be reliably buried in trenches in the seabed with a cover of up to 5 m if backfilling with sand, gravel or crushed rock (grain size < 38 mm). Covers substantially greater than this can usually be accommodated, depending on the SDR and installation conditions, but may occasionally require additional special measures. The method of installation of the backfill should be chosen carefully in order to minimize the risk of internal material separation during installation. The method of installation must also enable the backfill material to completely surround the whole pipe, including the parts under the haunches of the pipe. The backfill material should extend at least 0.4 m above the top of the pipe. Particular consideration should be given to ensure adequate cover is provided if rock is being placed directly

above the pipe. Excavated bed material can often be used as backfill around the pipe, but is subject to proper engineering and design of the whole system. Deeper installations or other backfill materials will require further calculations to check if a sufficient safety factor against pipe buckling can be achieved.

For advice on specific conditions or further information, please consult Pipelife.

8.4 Landfall applications

LLD pipes are ideal for use as the permanent pipe casing in Horizontal Directional Drilling (HDD) installations and have been successfully deployed in numerous installations for water and cable landfalls (offshore to inshore pipe connections). The smooth internal wall profile, gradual curvature and avoidance of joints also makes LLD pipes perfect for applications for fish return lines where fish must be transited through the pipe unharmed.

Please contact Pipelife to enquire about how we can support these operations.

Beginning of submerging of OD2500 mm SDR26 pipe



9. DESIGN AND SELECTION OF SDR

A marine PE pipeline must be designed to resist the stresses and strains to which the pipeline will be subjected to during its service life. The designer will need to select an appropriate SDR value for the pipeline noting that the worst case design condition for most marine pipeline applications is during installation of the pipe. It is noted that marine pipeline design differs considerably from traditional land-based pipe design and it should be undertaken by designers with suitable knowledge and experience.

Various load cases which will affect the selection of SDR class are:

- Out of roundness/buckling due to bending of the pipe
- Pipe buckling of buried pipes
- Expected out of roundness for buried pipes
- Pipe buckling without external support
- Loads on marine PE pipes in trenches
- Pressure and testing requirement

Pipelife are able to assist in the design if required - see Section 10. For further information, please consult Pipelife.

10. ENGINEERING AND DESIGN SUPPORT

Over the years, Pipelife has developed a wealth of specialist knowledge from its role in projects located around the world, dealing with challenging project requirements, different installation designs and methods. Many of Pipelife's projects have been completed in cooperation with many of the world's best consultants, engineers and marine contractors, leaving a legacy of good design decisions and successful installations.

Pipelife is committed to providing a complete system solution to help ensure the successful installation of our pipes. With its extensive resources Pipelife can offer a range of specialist engineering services and general technical advice to designers, marine contractors and clients on various issues to suit specific needs and levels of support.

10.1 Design guidelines

- Determining appropriate SDR pipe class
- Review of hydraulic design and assessment of pipe performance: hydraulic roughness, head losses, transient and operating under pressures, ovalization, etc.
- Assessment of wave and current forces on pipeline stability
- Design of weighting (ballasting) system: size, shape and spacing of blocks and block details including drawings for construction
- Proposal for towing head and bend restrictors
- Calculating flange connection forces and procedure for spool piecing
- Review of detailed design, drawings and method statements
- Design of corrosion protection system (sacrificial anodes)
- Calculation of pipe/soil interaction and defining backfill needs.

10.2 Installation guidelines

- Analysis of offshore pipe installation
- Determining required pull and air pressure
- Determining flooding by pumping with elevated air pressure procedure
- Determining valves for flooding and air venting
- Advice on installation risks and potential methods
- Review of drawings and method statements for pipe installation
- Review of design details due to changes in procedures and on-going support until completed installation.

For more information please contact Pipelife as each project has unique requirements and specifications.

11. TOLERANCES IN PRODUCTION

11.1 Pipe production tolerances

Pipes are manufactured to a target nominal Outside Diameter (OD). Variation in pipe wall thickness will therefore tend to produce a corresponding variation in the pipe Internal Diameter (ID).

Values for ovality and wall thickness are based on EN 12201:2024 where listed. For pipes larger than OD900 mm Pipelife has adopted the respective values in Table 9 based on the permitted maximum 3.5% ovality. It is worth noting that Pipelife's production technique typically enables the production of pipes with an average ovality lower than 1.5%.

Wall thickness minimum and maximum values are obtained from EN 12201-2:2024 and indicated in Table 10. Values for pipe sizes and SDR ratings not listed in EN 12201 are calculated as per the recommended formula for Grade V pipes (suitable for use with mechanical fittings) in ISO 11922-1:2018: $e=0,1e_{min}+0,1$ (mm).

Pipe OD is therefore produced to within -0 / +1% accuracy. Wall thickness and weight per m can typically vary by -0 / +10% above the allowable minimum value (e_{min}). For hydraulic design it is recommended to apply a pipe ID based on $1.07 \cdot e_{min}$.

In the production of continuously extruded long length PE pipes, the following length tolerances are generally applied unless specified otherwise:

- For pipe lengths <100m: - 0 to +2 m
- For pipe lengths >100m: - 0 to +5 m

Table 9 - Maximum out of roundness

Nominal size	Nominal outside diameter	Mean outside diameter		Maximum out-of-roundness (ovality)
DN / OD (mm)	d_n (mm)	$d_{em,min}$ (mm)	$d_{em,max}$ (mm)	(mm)
355	355	355	357.2	12.5
400	400	400	402.4	14.0
450	450	450	452.7	15.6
500	500	500	503.0	17.5
560	560	560	563.4	19.6
630	630	630	633.8	22.1
710	710	710	716.4	24.9
800	800	800	807.2	28.0
900	900	900	908.1	31.5 ⁽²⁾
1000	1000	1000	1009.0	35.0 ⁽²⁾
1200	1200	1200	1210.8	42.0 ⁽²⁾
1400	1400	1400	1412.6	49.0 ⁽²⁾
1600	1600	1600	1614.4	56.0 ⁽²⁾
1800	1800	1800	1816.2	63.0 ⁽²⁾
2000	2000	2000	2018.0	70.0 ⁽²⁾
2100 ⁽¹⁾	2100	2100	2118.9	73.5 ⁽²⁾
2300 ⁽¹⁾	2300	2300	2320.7	80.5 ⁽²⁾
2500	2500	2500	2522.5	87.5 ⁽²⁾

¹ Diameters are not standard listing in EN 12201-2:2024

² Values are not present in current standard, calculated based on maximum 3.5% ovality.

Table 10 - Maximum and minimum wall thicknesses

PE100	Pipe series							
	SDR 21		SDR 26		SDR 30		SDR 33	
	Nominal pressure, PN in bar							
	PN 8		PN 6		PN 5.5		PN 5	
Nom. Size DN/OD	Wall thicknesses ⁽⁴⁾							
	e _{min}	e _{max}	e _{min}	e _{max}	e _{min}	e _{max}	e _{min}	e _{max}
355	16.9	18.7	13.6	15.1	11.8	13.1 ⁽²⁾	10.9	12.1
400	19.1	21.2	15.3	17.0	13.3	14.8 ⁽²⁾	12.3	13.7
450	21.5	23.8	17.2	19.1	15.0	16.6 ⁽²⁾	13.8	15.3
500	23.9	26.4	19.1	21.2	16.7	18.5 ⁽²⁾	15.3	17.0
560	26.7	29.5	21.4	23.7	18.7	20.7 ⁽²⁾	17.2	19.1
630	30.0	33.1	24.1	26.7	21.0	23.2 ⁽²⁾	19.3	21.4
710	33.9	37.4	27.2	30.1	23.7	26.2 ⁽²⁾	21.8	24.1
800	38.1	42.1	30.6	33.8	26.7	29.5 ⁽²⁾	24.5	27.1
900	42.9	47.3	34.4	38.0 ⁽³⁾	30.0	33.1 ⁽²⁾	27.6	30.5
1000	47.7	52.6	38.2	42.2	33.3	36.8 ⁽²⁾	30.6	33.8 ⁽³⁾
1200	57.2	63.1	45.9	50.6	40.0	44.1 ⁽²⁾	36.7	40.5
1400	66.7	73.5	53.5	59.0	46.7	51.5 ⁽²⁾	42.9	47.3
1600	76.2	84.0	61.2	67.5	53.3	58.8 ⁽²⁾	49.0	54.0
1800	85.8	94.5	68.8	75.8	60.0	66.1 ⁽²⁾	55.1	60.8
2000	95.3	105.0	76.4	84.2	66.7	73.5 ⁽²⁾	61.2	67.5
2100 ⁽¹⁾	100.0	110.1 ⁽²⁾	80.3	88.5 ⁽²⁾	70.0	77.1 ⁽²⁾	64.5	71.1 ⁽²⁾
2300 ⁽¹⁾	109.6	120.7 ⁽²⁾	87.9	96.8 ⁽²⁾	76.7	84.5 ⁽²⁾	70.6	77.8 ⁽²⁾
2500	-	-	95.5	105.2	83.3	91.8 ⁽²⁾	76.5	84.3

¹ Diameters are not standard listing in EN 12201-2:2024.

² Values are not listed in current standard - calculated as per ISO 11922-1:2018 pipe Grade V

³ Minor correction to value in EN listing to follow stated calculation

⁴ Values listed in ISO 4427-2 are identical for all rows except for e-max values of SDR26 and SDR33 for 1800 and 2000mm diameters, which do not match EN12201 or follow the stated calculation guide and are hence assumed erroneous.

11.2 Fittings production tolerances

During the production of HDPE fittings, certain tolerances are necessary due to planning, welding and pipe production methods. Pipelife has adopted the following guideline tolerances for the production of fittings:

- For short pipe lengths up to 12m: ±40 mm
- For fittings and segments <Ø630: ±30 mm
- For fittings and segments >Ø710: ±50 mm
- For angles: ±3°
- All other according to EN 12201-3:2024

12. DISCLAIMER

The statements and recommendations made in this brochure are based on general assumptions and must not be considered as instructions, advice or guidelines for every individual situation. Pipelife cannot be held responsible in any way for the results of using and following the statements and recommendations made in this brochure. We especially dissuade non-professionals and consumers from operating based on the general statements and recommendations herein without any specific instructions from us or a suitably informed and qualified professional. To prevent potential damages, we strongly recommend that you consult on your individual situation with us.

If you have any queries relating to this statement, please do not hesitate to contact us.



Pipe preparation for stub-end welding prior to delivery (Tangiers) and manhole installation (Barcelona)

13. ENCLOSURE 1: PIPE PRODUCTION RANGE

OD (mm)	SDR class ⁽¹⁾								
	33	30	26	21	17	13.6	11	9	7.4
	Minimum Wall thickness ⁽²⁾								
	e (mm)	e (mm)	e (mm)	e (mm)	e (mm)	e (mm)	e (mm)	e (mm)	e (mm)
20							2.0	2.3	
25						2.0	2.3	3.0	
32					2.0	2.4	3.0	3.6	
40				2.0	2.4	3.0	3.7	4.5	5.5
50			2.0	2.4	3.0	3.7	4.6	5.6	6.9
63			2.5	3.0	3.8	4.7	5.8	7.1	8.6
75			2.9	3.6	4.5	5.6	6.8	8.4	10.3
90			3.5	4.3	5.4	6.7	8.2	10.1	12.3
110		3.7	4.2	5.3	6.6	8.1	10.0	12.3	15.1
125		4.2	4.8	6.0	7.4	9.2	11.4	14.0	17.1
140		4.7	5.4	6.7	8.3	10.3	12.7	15.7	19.2
160		5.3	6.2	7.7	9.5	11.8	14.6	17.9	21.9
180		6.0	6.9	8.6	10.7	13.3	16.4	20.1	24.6
200		6.7	7.7	9.6	11.9	14.7	18.2	22.4	27.4
225		7.5	8.6	10.8	13.4	16.6	20.5	25.2	30.8
250		8.3	9.6	11.9	14.8	18.4	22.7	27.9	34.2
280		9.3	10.7	13.4	16.6	20.6	25.4	31.3	38.3
315	9.7	10.5	12.1	15.0	18.7	23.2	28.6	35.2	43.1
355	10.9	11.8	13.6	16.9	21.1	26.1	32.2	39.7	48.5
400	12.3	13.3	15.3	19.1	23.7	29.4	36.3	44.7	54.7
450	13.8	15.0	17.2	21.5	26.7	33.1	40.9	50.3	61.5
500	15.3	16.7	19.1	23.9	29.7	36.8	45.4	55.8	
560	17.2	18.7	21.4	26.7	33.2	41.2	50.8	62.5	
600	18.4	20.0	22.9	28.6	35.6	44.1	54.4		
630	19.3	21.0	24.1	30.0	37.4	46.3	57.2	70.3	
710	21.8	23.7	27.2	33.9	42.1	52.2	64.5	79.3	
800	24.5	26.7	30.6	38.1	47.4	58.8	72.6		
900	27.6	30.0	34.4	42.9	53.3	66.1	81.7		
1000	30.6	33.3	38.2	47.7	59.3	73.5	90.8		
1100	33.8	36.7	42.0	52.4	65.2	80.9	99.8		
1200	36.7	40.0	45.9	57.2	71.1	88.2			
1300 ⁽³⁾	39.9	43.3	49.7						
1400	42.9	46.7	53.5	66.7	83.0	102.8			
1600	49.0	53.3	61.2	76.2	94.8				
1800	55.1	60.0	68.8	85.8	106.6				
2000	61.2	66.7	76.4	95.3	118.5				
2100	64.5	70.0	80.3	100.0					
2300	70.6	76.7	87.9	109.6					
2500	76.5	83.3	95.5	⁽⁴⁾					

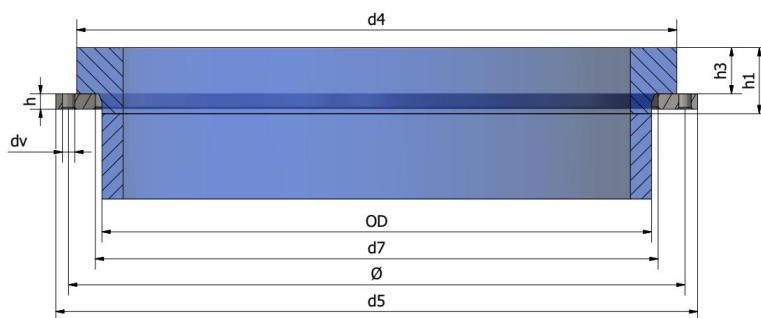
¹ For all pipes, intermediate or non-standard SDR values just beyond the limits shown can often be made available – please enquire with Pipelife

² Minimum wall thicknesses stated are in accordance with EN 12201-2

³ Limited size range as non-standard pipe diameter

⁴ 2500mm OD pipe can be produced up to SDR23

14. ENCLOSURE 2: FLANGE CONNECTION TABLE



Stub ends											Backing rings					Bolt sets ⁽²⁾		
OD	DN	d4	SDR26		SDR21		SDR17		SDR11					PN2 ⁽¹⁾	PN10 ⁽¹⁾			
mm	mm	mm	h1	h3	h1	h3	h1	h3	h1	h3	d5	d7	Ø	h	h	No.	M	dv
20	15	45							35	10	95	32	65		14	4	12	14
25	20	58							35	9	105	38	75		14	4	12	14
32	25	68							40	10	115	45	85		16	4	12	14
40	32	78					40	11	40	11	140	55	100		16	4	16	18
50	40	88					60	12	60	12	150	66	110		16	4	16	18
63	50	102					75	14	75	14	165	78	125		16	4	16	18
75	65	122					80	16	80	16	185	92	145		16	4	16	18
90	80	138	90	17	90	17	90	17	90	17	200	108	160		18	8	16	18
110	100	158	100	18	100	18	100	18	100	18	220	128	180		18	8	16	18
125	100	158	110	18	110	18	110	18	110	25	220	135	180		18	8	16	18
140	125	188	120	18	120	18	120	18	116	25	250	158	210		18	8	16	18
160	150	212	130	18	130	18	127	18	127	25	285	178	240		18	8	20	23
180	150	212	140	18	140	20	138	20	138	30	285	188	240		18	8	20	23
200	200	268	145	18	145	22	145	24	145	32	340	235	295		20	8	20	23
225	200	268	150	18	150	22	150	24	150	32	340	238	295		20	8	20	23
250	250	320	160	20	160	23	158	25	158	35	395	288	350		22	12	20	23
280	250	320	170	20	175	23	180	25	180	35	395	294	350		26	12	20	23
315	300	370	190	20	190	23	190	25	190	35	445	338	400		26	12	20	23
355	350	430	120	30	120	42	110	50	110	66	505	376	460		28	16	20	23
400	400	482	120	33	120	45	120	54	120	72	565	430	515		32	16	24	27
450	450	535	120	46	120	52	120	56	120	74	615	465	565	35	36	20	24	27
500	500	585	120	46	120	54	120	58	120	76	670	515	620	35	38	20	24	27
560	600	685	120	50	120	56	120	60	120	80	780	575	725	35	42	20	27	30
600	Non-Standard - Size on Application										780	615	725	35	42	20	27	30
630	600	690	120	50	120	58	120	64	120	82	835	645	725	35	42	20	27	30
710	700	800	120	50	120	62	120	70	120	85	895	725	840	35	50	24	27	30
800	800	905	120	52	120	72	120	85	140	95	1015	815	950	35	56	24	30	33
900	900	1005	120	55	125	75	130	90	150	100	1115	915	1050	35	62	28	30	33
1000	1000	1110	140	60	140	82	140	100	160	110	1230	1015	1160	35	70	28	33	36
1100	Non-Standard - Size on Application										1455	1115	1380	35		32	36	39
1200	1200	1330	190	90	160	90	160	120			1455	1215	1380	35		32	36	39
1300	Non-Standard - Size on Application										1675	1340	1590	42		36	39	42
1400	1400	1535	180	70	180	105	180	130			1675	1440	1590	42		36	39	42
1600	1600	1760	200	80	215	115	220	140			1915	1650	1820	50		40	45	48
1800	1800	1965	215	120	230	140	250	160			2115	1860	2020	50		44	45	48
2000	2000	2168	240	140	230	140					2325	2060	2230	55		48	45	48
2100	2100	2290	240	150	250	160					2440	2160	2340	55		48	45	48
2300	2300	2500	270	180	290	200					2680	2360	2570	60		52	52	56
2500	2500	2730	300	210							2920	2560	2804	70		58	52	56

¹ Note that PN2 flanges are non-standard. They are offered as a practical, cost-effective alternative with reduced thickness for large diameter pipes where PN10 pressure rating is not required. All PN2 flanges retain the EN1092-1 PN10 drilling and bolt pattern. Flanges are generally supplied in S355J2 steel unless specified otherwise. Other ratings or special flanges can be provided on request.

² All bolt sets are to PN10 bolt sizes, numbers and pattern.

15. ENCLOSURE 3: PIPELIFE MARINE PROJECT REFERENCES

Pipelife has successfully delivered over 200 major projects in 50 different countries. Pipes have been towed from Norway to destinations as far as: Uruguay, Indonesia, Dominican Republic, Brazil, Colombia, Ghana, Algeria, Morocco, Ukraine and Cyprus.

Five example projects from the range of applications are presented below to illustrate our most common applications. However, the benefits of LLD pipes and sea tow delivery can provide solutions and benefits to a wide range of applications.

For more project examples or specific detail, please contact the Pipelife Norge AS team.



15.1 Power Plants

MATABARI POWER PLANT, BANGLADESH, 2020.

EPC project by POSCO E&C

Estimated project value: 4.5 billion USD

6810m total length of 2300mm OD SDR30 LLD PE100 pipes and fittings, including reinforced GRP sections, for installation of intake and outfall cooling water lines. Pipelife also provided additional engineering design support in pipeline design and installation.



15.2 Wastewater Outfalls

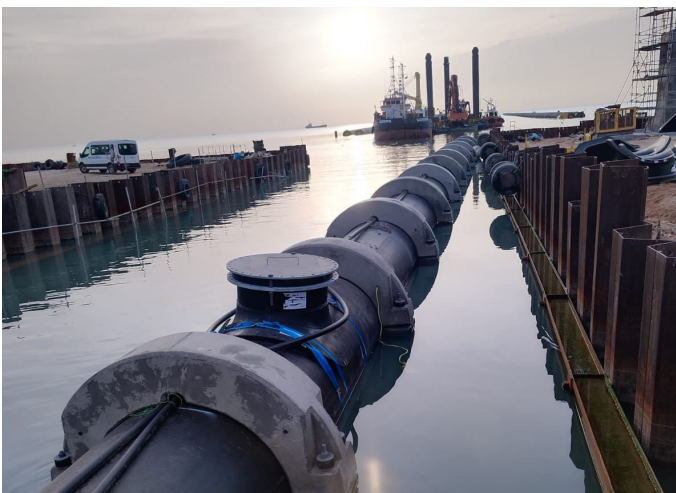
HARROWSIDE SEA OUTFALL, UK, 2015.

Main contractor: J. Murphy & Sons, UK.

Marine contractor: Land & Marine Engineering, UK

Estimated Project value: 100 million GBP

1000m length of 2100mm OD SDR26 LLD PE100 pipes and fittings for installation of long sea effluent discharge in exposed UK waters.



15.3 Desalination Plants

SFAX DESALINATION PLANT, TUNISIA, 2023.

Main Client: SONEDE

Main contractor: Orascom-Metito-Cobra JV

Estimated Project value: 200 million €

Over 11000m length of 2000mm SDR26, 21 and 17 PE100 pipes and range of fittings for installation as offshore brine intake and outfall pipeline, including diffuser and manholes. Delivered in 19 lengths.



15.4 Cable Interconnects and Landfalls

USTKA BALTIC 2 LANDFALLS, POLAND, 2025.

Main Client: Equinor & Polenergia

Main contractor: Visser and Smit Hanab

Estimated Project value: 6 billion €

Almost 6000m length of 710mm OD SDR 11 PE100-RC pipes and fittings for installation provided in lengths of between 1416 and 1504m for use as 4 No. landfall conduits for directionally drilled (HDD) electrical cables from a wind farm off the north coast of Poland.



15.5 Aquaculture (Fish Farming)

FISH FARMING PLANT, MIRA, PORTUGAL, 2008 & 2026.

Main Client: Acuinova, Portugal

Main Contractor: Somague (2008) / Etermar (2026), Portugal

Estimated Project Value: 140 million €

Original supply of 5300m of 2000mm OD SDR26 PE100 pipes in multiple lengths to provide intake and outfall facilities for large scale fish farming by aquaculture at plant facilities at Mira in Portugal in 2008. Supply of further 2280m of 2000mm OD pipe in 2026.

Innovative on site transport of OD2100 mm in Morocco





LLD PE pipes have many advantages and provide positive environmental benefits through smart transportation, installation and long lifespans.





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Pipelife Norway is Norway's largest producer and supplier of plastic pipe systems. The Pipelife Group is one of Europe's leading manufacturers of plastic pipes and associated parts. Our piping systems are used for water, sewage, gas, cable protection and electrical installations.

A significant proportion of our products are exported, particularly long length PE pipes in large diameters manufactured using Pipelife's unique production process at the Pipelife Norge AS plant in Stathelle, Norway. The factory has around 50 employees.

Date issued: July 2026

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