INTRODUCTION

SPIRAL HDPE PIPE produces a spirally wound structured wall pipe manufactured from PE-HD known as SPIRAL Structured Wall HDPE Pipe. It is available in diameters ranging from 400mm to 3500mm.

The SPIRAL Structured Wall HDPE Pipe system is economical and competitive, as the structured wall concept creates a pipe with superior ring stiffness, utilising considerably less raw material than conventional solid walled thermoplastic pipes of equal stiffness.

SPIRAL Structured Wall HDPE Pipe features include:
- Resistance to chemical attack, abrasion, scale, sediment build-up and UV degradation.
- No electrolytic or galvanic corrosion
- Lightweight
- Long lengths
- High impact strength
- Superior flow characteristics
- Flexibility
- Variety of jointing methods
- Comprehensive range of fittings
- Cost savings in transportation, handling and installation.

Principal applications for SPIRAL Structured Wall HDPE Pipe include:
- Gravity trunk sewer mains
- Sewer rising mains
- Storm water drainage
- Sub soil drainage
- Corrosion resistant tanks.

Over the years, traditional material used for sewerage and waste disposal pipelines have been found to be deficient. Some become brittle and others are subject to attack from the effluent carried and gasses created in the pipe or from aggressive soil conditions. This led to the use of flexible pipes such as High Density Polyethylene (HDPE), which can withstand present day traffic loads, deep laying conditions and chemical attack.

MANUFACTURE

In the manufacture of SPIRAL Structured Wall HDPE Pipe a specially designed inner liner is wound upon a heated rotating mandrel. A hollow extruded rectangular profile, is then wound over the inner liner and intimately bonded to it. This innovative wall construction uses geometric efficiency to maximizes ring stiffness.

A wide range of profile sizes and winding Pitches are available for almost all requirements in any type of soil condition. Because SPIRAL Structured Wall HDPE Pipe is manufactured on a mandrel, the internal diameter remains constant for each nominal size, irrespective of wall profile or thickness. The versatile nature of HDPE permits the custom fabrication of bends, tees and manhole units to compliment the pipes, as well as corrosion resistant tanks to meet a wide range of applications.
MATERIAL PROPERTIES

SPIRAL Structured Wall HDPE Pipe offers an optimum combination of strength and durability.

Chemical and corrosion resistance

High density polyethylene (HDPE) is an ideal pipe material due to its outstanding resistance to corrosive and aggressive chemical environments. The material is used extensively for sewer applications as it is inert to hydrogen sulphide gas. SPIRAL Structured Wall HDPE Pipe is not affected by scale and sediment build-up experienced in pipes made of traditional materials and is not subject to electrolytic or galvanic corrosion.

Abrasion resistance

HDPE is highly resistant to abrasion (two to three times that of steel) and is vastly superior to other commonly used pipe materials as shown in Fig 1. HDPE pipelines are used extensively in industrial and mining applications for the discharging of effluents containing chemicals and sediments. *Reference; Tiede, W ; Abriebuntersuchung an einer halbschale aus Hostalen GM 5010. Bericht No. 205/77 Techn. Hochschule Darmstadt 1977.

Temperature effects

Generally with buried pipe applications, variable temperatures are not a design concern because of the restraining action of the surrounding soil and the inherent stress absorbing capabilities of HDPE. The working temperature of HDPE extends up to +60ºC. As with all thermoplastics, an increase in temperature tends to reduce stiffness and improve ductility. With a decrease in temperature, the opposite effect occurs. When working outside the ambient temperature range, these effects should be taken into consideration by the designer.

Weather resistance

The most common stabilizing material used in pipe grade HDPE is carbon black, which acts as a barrier to ultraviolet rays. This enables SPIRAL Structure Wall Pipe to be used for above ground applications or to be stored for extended periods in direct exposure to sunlight without damaging the properties of HDPE material.

DIMENSIONS

A variety of sizes is available, ranging from 400mm – 3,500mm

![Fig 1: Average abrasion values for pipes made from various materials.](image)
SPIRAL Structured Wall HDPE Pipe is available in the following sizes and ring stiffness classes:

<table>
<thead>
<tr>
<th>Dia (mm)</th>
<th>ISO 9969 / SANS 21138</th>
<th>KN/m²</th>
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<tbody>
<tr>
<td>400</td>
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<td>3500</td>
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</table>

Depending on the quantity required, special sizes and ring stiffness can be manufactured.

**FEATURES**

**Lightweight**

SPIRAL Structured Wall HDPE Pipe is considerably lighter than other pipe materials as shown in Fig. 2.

The savings which result from the use of lightweight pipe can be significant. Transport costs are reduced, installation equipment may be smaller and less expensive to operate and job site handling efficiency improved, usually resulting in earlier completion.

**Easy installations with the integral socket and spigot.**

**Durability**

The impact resistance of HDPE is quite outstanding. The tough ductile nature of the pipe enables it to withstand stresses from transportation and site handling that would normally cause breakages with brittle pipe materials. The pipe can inherent flexibility and accommodate considerable soil movement.

**Length**

Standard pipe length is 6m, and multiples of 6m. Non-standard lengths are available on request. The advantages of longer length standard pipes are well recognized. Installations are normally faster than for conventional pipe materials. Fewer joints and longer lengths result in an increase in the amount of pipe laid per day.

SPIRAL Structured Wall HDPE effluent pipes are nominally designed for an internal pressure of 1 bar, for a 50 year working lifetime at 20ºC. However pipes can be produced for working pressures of up to 20 bar. Solid wall SPIRAL Pipe, produced by the spiral winding technique, is designed to comply with the performance requirements of SABS ISO 4427:1996.
INNER COLOUR

Traditionally customers had to be content with the black inner surface of HDPE pipes, however now SPIRAL Structured Wall HDPE Pipe can be supplied with an optional extra light reflecting yellow inner surface, assisting with the laying and inspection of pipe lines. During installation as well as with future CCTV inspections.

Jointing

SPIRAL Structured Wall HDPE Pipe offers a number of jointing methods: The socket and spigot extrusion weld joint is recommended for sewerage, low pressure water supply or drainage situations where joints may be subject to longitudinal tensile forces. This is a field joint which is accomplished by using portable HDPE extrusion welding equipment in conjunction with ultra-high frequency spark testing to ensure leak tight joints. For pipe sizes up to 500mm in diameter, the joints are welded on the outside only. For pipe sizes 600mm and above, joint welding is usually on the inside of the pipe, but can be on the outside or both. In some applications, particularly storm water drainage, welding of these joints is often not necessary, and a rubber Ogee type sheath, obtainable from Spiral HDPE Pipe is used.

Butt-welded joint is used for high pressure applications. Hot plate butt welding equipment is required and can be used either in the field or factory.

BURIED PIPE PERFORMANCE

The major consideration for the performance of all buried pipe is the pipe material characteristics.

Rigid pipe materials such as reinforced concrete (RC) and fiber cement (FC) can withstand very little deformation before structural failure occurs from external loading. In addition, materials such as RC are subject to chemical attack and traditionally their wall thickness has been increased by the use of a sacrificial layer, thus decreasing the internal diameter.

Generally flexible pipes have a much higher tolerance to wall strain than rigid materials and consequently can withstand relatively large deformation without failure. This characteristic of flexible pipe allows it to deflect under external load without damage, and transfer a significant amount of the overburden load to the surrounding soil.

Consequently the design principles for flexible pipes are based on the interaction between the pipe and the surrounding soil.

Within the category of plastics used for flexible pipe manufacture, some materials have a much higher tolerance to strain than others. Thermoplastics such as HDPE have the highest tolerance and are extremely ductile in nature. Consequently, flexible pipes manufactured from material other than HDPE require a higher stiffness in order to maintain deflection and wall strain within allowable design limits for the same ground and loading conditions.

Bends, fittings and manholes are manufactured to customer specifications.
DESIGN

HDPE is a unique material. It is highly viscoelastic and, as such, its behavior under load differs from conventional materials. Polyethylene cannot be equated directly to the more rigid and semi-rigid materials such as reinforced concrete, clay, steel and fiberglass. SPIRAL Structured Wall Pipe selected for a particular project need only have sufficient stiffness to withstand the construction forces resulting from backfill compaction, initial soil loads and any external hydrostatic pressure from ground water.

Beyond this, performance of the buried pipes determined by the interaction between the pipe and its environment. The critical factors are the soil modulus at the interfaces between pipe and bedding and the in-situ soil. The main pipe design parameters are deflection, resistance to buckling and wall strain.

The pipe design must take into account the interaction between these parameters in the installed environment. This includes the in-situ soil, the introduced pipe embedment material, the quality of its placement and the presence of groundwater.

Deflection

Controlled deflection is essential with flexible pipe to maximise the interaction between pipe and soil. Deflection is defined as the ratio of the deformed diameter to the un-deformed diameter and is expressed as a percentage (%). It has become normal practice in Europe to limit the long-term diametrical deflection for pipes manufactured from HDPE to a maximum of 6% at 50 years to maintain the full pipe design hydraulic performance and joint integrity.

Buckling

For installations where the water table is above the pipe level, consideration must be given to additional load created by the external hydrostatic pressure, acting around the pipe. Appropriate bedding material and installation techniques; however increase the ability of the pipes to resist buckling. A check on the pipe’s resistance to buckling is always carried out at design stage where ground water is present. Consideration is given as to whether the pipe is installed in a constrained or unconstrained environment e.g. backfilled trench or on the sea bed.

Wall strain

All buried pipes, regardless of the material used in manufacture, are subject to localised strain. This is a function of the stresses caused by external loading. A major consideration in design is to ensure that the resultant wall strains do not exceed the allowable strain of the pipe material. Pipes made of materials having a high elastic modulus (E), i.e. more rigid materials, require high stiffness in load-carrying situations. This is because they cannot deflect sufficiently to transfer load to the surrounding soil without exceeding their allowable wall strain capacity, often resulting in failure. Conversely, materials such as HDPE, with low E values and high tolerance to wall strain can accommodate large localized deflections without failure. Even if the allowable wall strain is exceeded in the highly ductile materials, plastic hinging will occur with a redistribution of stresses in the adjacent soil. Consequently, SPIRAL Structured Wall HDPE Pipe has considerable reserve capacity for wall strain, unexpected service conditions such as unstable ground or poor quality installation. As an example of the pipe’s strain capability, SPIRAL Structured Wall HDPE Pipe is required to withstand a flattening test of 60% deflection without structural failure. Fig. 3 represents a comparison of allowable strain values of the commonly used pipe materials and graphically demonstrates the importance of wall strain in pipe selection. This is why pipes made from less ductile material have a higher stiffness requirement under the same loading conditions.

Ring stiffness

SPIRAL Structured Wall HDPE Pipe can be manufactured with variable ring stiffness depending on inner liner thickness, profile size, and profile winding pitch. Popular classes of ring stiffness are:

- 2kN/m²
- 4kN/m²
- 8kN/m²
- 12kN/m² (on request)

Pipes with higher ring stiffness can be manufactured on request.

Ring stiffness is determined in accordance with ISO 9969 / SANS 21138 Thermoplastics pipes – determination of ring stiffness.
The crown deformation under earth load is determined by the Rs value on the X-axis of the Watkins graph. (See Fig 1)

$$Rs = \frac{EB}{ER} \times \frac{1}{Dm^3}$$

where:
- $EB = \text{soil modulus}$
- $Dm = \text{mean pipe diameter}$
- $ER = \text{Elastic modulus of material}$

On the Y-axis of the Watkins graph the relative pipe deformation $\sigma_v/\xi_B$ for a given Rs value can be read off.

Soil compression value $EB$ can be derived from the calculated value $qv$ and soil modulus $EB$:

$$\xi_B = \frac{qv}{EB}$$

where:
- $qv = \rho \cdot H$
- $\rho = \text{backfill density}$
- $H = \text{Cover depth}$

Finally, pipe deformation $\sigma_v$ is obtained as follows:

$$\sigma_v = \left(\frac{\sigma_v}{\xi_B}\right) \cdot \xi_B$$

and should be designed not to exceed 6% in 50 years.

Soil Modulus $EB$ is sensitively dependent on embedment material and degree of compaction $PPr$ (%) as indicated in Table 1.

### RECOMMENDED INSTALLATION PRACTICE

SPIRAL Structured Wall HDPE Pipe is a flexible conduit, and is designed to deflect under external loading to transfer the load from the pipe wall to the surrounding soil. Requirements for achieving satisfactory installation of SPIRAL Structured Wall HDPE Pipe do not differ greatly from those of rigid pipe materials. Performance of flexible pipe–soil systems has been demonstrated by laboratory tests and confirmed in Europe, North America, South America, Australia and South Africa.

### Table 1: Deformation moduli of various soils

<table>
<thead>
<tr>
<th>Type of soil (Group)</th>
<th>Degree of compaction $D_{av}$ (%)</th>
<th>Deformation modulus $E_v$ (N/mm²) for particular case</th>
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<td>1</td>
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<tr>
<td>1</td>
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<tr>
<td>4</td>
<td>92</td>
<td>90</td>
</tr>
</tbody>
</table>

1) Soil group 1: non-cohesive soils, gravel
2) Soil group 2: non-cohesive soils, sand
3) Soil group 3: cohesive mixed soils (sand and gravel)
4) Soil group 4: cohesive soils (silt, clay, loam)

- Case 1: trench backfill compacted in layers against the undisturbed soil or embankment fill (without compaction test).
- Case 2: vertical bracing of pipe trench with planks or lightweight sheet piling or non-compacted backfill or hydraulic fill.
- Case 3: vertical bracing of pipe trench with sheet piling or wooden piles.
- Case 4: backfill compacted in layers or embankment fill (with compaction test).

### Installation

The most critical aspect for the successful installation of flexible pipe–soil system is achieving stable and permanent side support around the pipe. The bedding and initial backfill materials should be of a readily compactable nature.

### Trench excavation

The trench is excavated to the line and grade as specified. The trench width must be sufficient to allow placing and compaction of the pipe bedding material with suitable equipment.
Bedding

Bedding performs the important function of leveling the trench bottom, assuring uniform support and load distribution along the barrel as well as supporting the hunching material.

Pipe in trench

Pipe jointing

Following preparation of trench and bedding, pipes are lowered into the trench with suitable lifting equipment. Generally the excavator or backactor bucket is utilized with a single sling at the pipe’s midpoint. Pipes of all diameters can be joined using two chain blocks – The ribbed wall aids with grip for chains. Pipes can also be push–jointed using the backactor or excavator, the bucket bearing on a piece of timber laid across the pipe face to avoid damage to the jointing surface. The usual practice is to lay pipes with sockets facing upstream.

Traffic loading situations

In cases where the installed pipeline will be subjected to repetitive wheel loading with less than 1,0m of soil cover, the following practices are recommended:

Pipe should be encased in reinforced concrete where cover over the pipe is less than 300mm.

Care should be taken to avoid flotation of the pipe during pouring of concrete.

In situations where cover of pipe is between 300mm and 1000mm, crusher run material should be placed and compacted to the normal degree of 95% Standard Proctor. This material can be used either to bed and totally encase the pipe or it can be placed from the initial backfill – which should be soil type 1 or 2 and also compacted to 95% to the traffic surface level.
Transport is free, depending on quantities and site location.

We also manufacture specialised tanks of up to 3500mm in ID, according to the customer's requirements.

*2.5m Diameter Chemical Tank*  
*3.5m Diameter HF –Tank*
Specials and site installations.

Acknowledgement
Spiral HDPE Pipe (Pty) Ltd. acknowledges the research and development undertaken by manufacturers of structured wall pipes world-wide.

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Floats for pumps and mining purposes.

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