HIGH DENSITY POLYETHYLENE (HDPE) PIPES

PRODUCT INFORMATION

GULF Eternit TRADING

Member of FPi Group

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PRODUCT INFORMATION

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1. INTRODUCTION

Since polyethylene was discovered in 1993, and was first polymerized to be high density polyethylene in 1954, the superior properties of HDPE material were discovered in use of many products around the world.

Polyethylene is the polymerization product of ethylene, through chemical process. Number of each individual ethylene molecules bonded together to form long linear macromolecular chains, in semi- crystalline polymer form.

By development of polymerization process, catalytic system and manufacturing methods, new HDPE materials were derived with better macromolecular chain and molecular weight distribution, which enhanced performance characteristics and reliability of HDPE materials, especially for Pipe applications. High density polyethylene had been introduced into pipe application since 1950's and overcame traditional pipe materials by its advantageous properties.

HDPE grades in pipe application are classified by individual performance on pressure testing in the form of regression curve according to ISO 9080.

Minimum Required Strength, MRS, based on performance of the material at 20°C, for 50 years, will classify HDPE compound to its designation.

Until 1996 HDPE pipe grade material was developed to the 3rd generation classified as PE100, according to ISO 12162.

It has been a practice to use the following terms in describing polyethylene plastics: Type III (0.941 to 0.965) = High Density (**HDPE**)

2. HDPE PIPE APPLICATIONS

HDPE pipes can be used for several domestic, municipal, industrial and utility services. The following are the most commonly used applications.

a. Potable water supply networks
b. Sprinkler Irrigation Systems & Drip Irrigations Systems verity
c. Handling Saline Water, Sea water intake
d. Suction & delivery of Water with Pump sets
e. Bore well application for submersible pumps
f. Submarine & Underwater pipelines
g. Horizontal and Directional Drilling
h. Septic Tank/ Leach Bed Lines, Condensates, Aeration & Caustic Lines
i. Conveying corrosive effluents of chemical & other process industries like Petrochemicals, Dyestuff, Paints, Rayon & Fertilizers
j. Hydro transport systems - Cement/ Clinker, Coal, Sand slurry & other abrasive slurries like ironer, fly ash conveyance, etc.
k. Water & Wastewater Treatment plants/Corrosive & Reclaimed Water
l. Handles edible oils, fruit juices & pulps, Milk and other Food Materials.s
m. Ducting for Air Conditioning, Ventilation, Fiber Optic and Electric cables
n. Sewer, Storm and Sanitary Pipelines
o. Diffuser, Outfalls & Dredging Applications
p. Treats Radio-active waste
q. Conveys acids, alkalis & other highly corrosive chemicals
r. Fish Farming

3. GENERAL PROPERTIES OF HDPE PIPES

Property		PE80		PE100	
		Typical Value	Unit	Typical Value	Unit
Density	(Base resin)	946	Kg/m³	949	Kg/m³
Density	(Compound)	956	Kg/m³	959	Kg/m³
Melt Flow Rate	(190°C/2.16Kg)	<0.1	g/10min	<0.1	g/10min
Melt Flow Rate	(190°C/5.0Kg	0.3	g/10min	0.3	g/10min
Tensile Stress at Yield	(50mm/min)	22	Mpa	25	Mpa
Tensile Modulus	(50mm/min)	1000	Mpa	-	
Elongation at Yield		9	%	-	
Elongation at Break		>600	%	>800	%
Charpy Impact, notched	(0 °C)	14	Kj/m²	16	Kj/m²
Hardness, Shore D		-		60	-
Carbon Black Content		>2	%	>2	%
Brittleness Temperature		< -70	°C	< -70	°C
ESCR	(10% Igepal)	>10000	h	>10000	h
Thermal Stability	(210°C)	>15	min	>15	min

4. TYPICAL PHYSICAL PROPERTIES OF HDPE PIPE

1. Abrasion Resistance	HDPE pipes have excellent resistance to abrasion/ wear. Due to this unique property, these pipes are used for dewatering, dredging in ports, and transportation of abrasive slurries and sand stowing of mines.
2. Flexibility	The flexibility of HDPE pipe allows it to adapt to the contour of the land as well as to directional changes. In some cases, the flexibility of HDPE pipe reduces the need for fittings & saves installations costs. It can bend to a minimum radius of 20 to 40 times the pipe diameter.
3. Flow Factors	HDPE pipes have a very smooth internal surface. Smooth internal surface offer excellent flow characteristics and minimum pressure losses. Lower friction leads to energy saving in pumping of liquids.
4. Life Expectancy	HDPE pipes have a projected life expectancy of 50 years transporting water at 20 deg. C.
5. Lightweight	It is lighter than Mild steel, Stainless steel, Concrete & Cast Iron. It is easier to handle & install as compared to above materials. Density = 0.95kg/cm²
6. Toughness	HDPE has low notch sensitivity, high tear strength & excellent scratch & abrasion resistance. Its resistance to environmental stress cracking is outstanding.
7. UV Protection	As Black coloured HDPE pipe contains 2 to 2.5% carbon black, it can be safely stored for some time outside in the sun without being damaged from U.V exposure.
8. Welding	HDPE pipe can be joined by mechanical & butt-fusion methods. In butt-fusion, the strength of the joint is stronger than the pipe itself & the welding is homogenous. It can be flanged, tapped and reduced, like other piping materials.
9. Coiled Pipe HDPE	Pipe is available in coil form up to 200 mtrs (for sizes 20 mm up to 63 mm dia.) and up to 100 mtrs (for sizes 75 mm to 110 mm dia). It leads to significant saving in installation / welding costs.
10. Corrosion Resistance	HDPE pipes are corrosion resistant, do not rust, rot, or corrode.
11. Leak Proof	Leak tight, Heat-fused joints create a homogeneous, monolithic systems.
12. Jointing	Polyethylene pipe is normally joined by heat fusion. Butt-Fusion Welding creates a joint that is as strong as or even stronger than the pipe itself, and is virtually leak free. This unique joining method produces significant cost reductions compared to other materials.

5. DESIGN CONSIDERATIONS

INTERNAL PRESSURE:

The burst pressure of polyethylene pipe is time dependant and therefore it is necessary to define the strength of the material at a reference lifetime.

The lifetime chosen for this reference value is 50 years. It should be noted that it does not mean that the pipeline will fail after 50 years, as the various safety factors that are incorporated into the design mean that the actual lifetime will be many times greater.

In order to generate the burst strength of the material at 50 years, a number of pipe samples are pressure tested to failure at lifetimes between 10 and 10,000 hours. The results of these tests are graphically or numerically analysed to obtain the minimum required strength (MRS) at 50 years. Thus material classification PE 80 has a minimum required strength of 8 Mpa while PE 100 has a minimum required strength of 100 Mpa. Depending upon the operating conditions (eg: surge, elevated temperature, conveyance of gas, poor ground condition etc) the pipeline engineer has the option to include additional design factors (safety factor) in order to account for the "unknown" loading or environmental conditions.

For polyethylene pipeline systems, the recommended design factor is 1.25, which enables the allowable operating pressure to be calculated for each system using Lame's formula for thick walled pipes;

Hoop stress: $s = \frac{p}{2t}(D-t)$

Where:
S = Hoop stress (Mpa)
P=Max. operating pressure (Bar)
D = Outside diameter (mm)
T = wall thickness (mm)

Therefore:

$$S = \frac{p}{2}\left(\frac{D}{t} - 1\right)$$

Now the standard dimensional ratio (SDR) is related to the diameter and wall thickness of the pipe by the formula:

$$SDR = \frac{D}{t}$$

Therefore: $S = \frac{p}{2}(SDR-1)$ or $P = \frac{2s}{(SDR-1)}$

If this equation is applied to a polyethylene pipe system it is possible to calculate the maximum allowable operating pressure (MOP) as given below.

$MOP = \frac{2 \times MRS}{(SDR1-)\partial}$, ∂ = minimum design factor

This equation gives the stress in Mpa. For environmental use, and to express the pressure in bar rating, the value in Mpa is multiplied by 10 for example:

For PE80:

$$MOP = \frac{2x8x10}{(SDR-1) \times 1.25} \quad , MOP = \frac{128}{(SDR-1)}$$

For PE100:

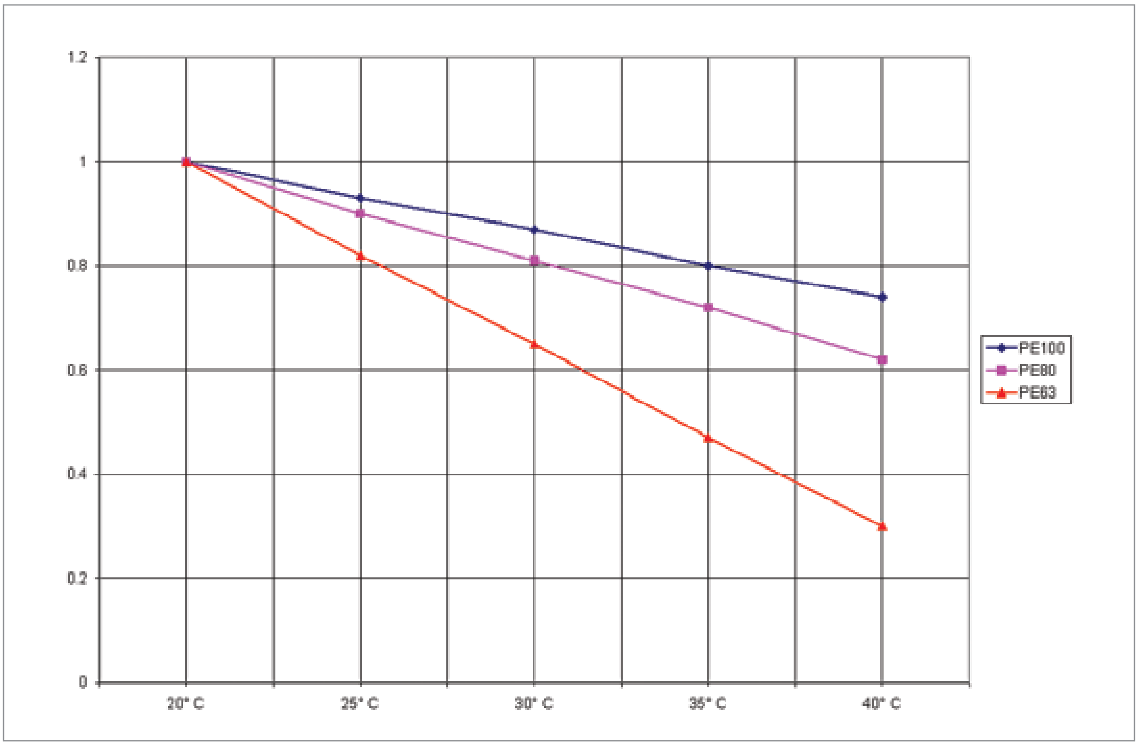
$$MOP = \frac{2x10x10}{(SDR-1) \times 1.25} \quad , MOP = \frac{160}{(SDR-1)}$$

In calculating the operating pressure, it is customary to round up or down the values to the nearest pressure class.

It should be noted that this pressure class will represent the maximum operating pressures for the pipeline and additional consideration may cause engineers to reduce the operating pressure to a lower level. For example, on large diameter, PE80 pipelines where rapid crack propagation may be of concern.

ELEVATED TEMPERATURES

When operating a pipeline above 20°C it is important to allow reduction in the strength of the material at elevated temperatures. Pressure reduction factors at elevated temperatures up to 40°C applicable to a 50 year lifetime are given in graph below.



Pressure reduction factor versus temperature.

When operating a pipeline above 20°C it is important to allow reduction in the strength of the material at elevated temperatures.

NOTCH SENSITIVITY:
Many materials may be extremely strong in laboratory tests but when they are notched or scored in handling they become very brittle. The classic material in this category is glass, which i is brittle enough to snap along a defined line when it is lightly scored. When laying a pipeline, it is common for the pipe surface to become lightly scored.

This is particularly true when the pipe is being inserted into an existing main, or where trench less laying methods are being used. In order to ensure that brittle failure will not develop in the short or long term from these surface notches, it is usual to carry out elevated temperature pressure tests on notched pipe samples.

It is recommended that pipe with notches greater than 10 % of the wall thickness should not be used.

FAST FRACTURE:
For virtually all materials, it is possible for a dynamic crack to grow along the pipe length provided that sufficient energy is available to overcome the material's resistance to crack growth. Fractures of this type have travelled many kilometres in welded steel pipelines and are only arrested by a valve or other pipeline fittings.

Over the past 10 years considerable test work has been carried to investigate the relevance of this mode of fracture to polyethylene pressure pipelines. The conclusions of this work may be summarized as follows.

Crack propagation cannot occur if the pipeline is full of water. However, if the pipeline contains 10% or more air than propagation can occur.

Cracks will not propagate through fittings including flanges or electro fusion couplers. Therefore, the crack will be limited to one pipe length in these cases.

Crack propagation cannot occur in small diameter pipelines and therefore only large pipelines need to be considered. The critical pressure at which rapid crack propagation will occur depends on the pipe material and the pipe diameter

Flow Calculations:
Polyethylene pipe is classified as hydraulically smooth. The hydraulic frictional coefficients used for design purposes are as follows:
1. Colebrook – white Ks = 0.003 mm
2. Hazen - Williams C = 150

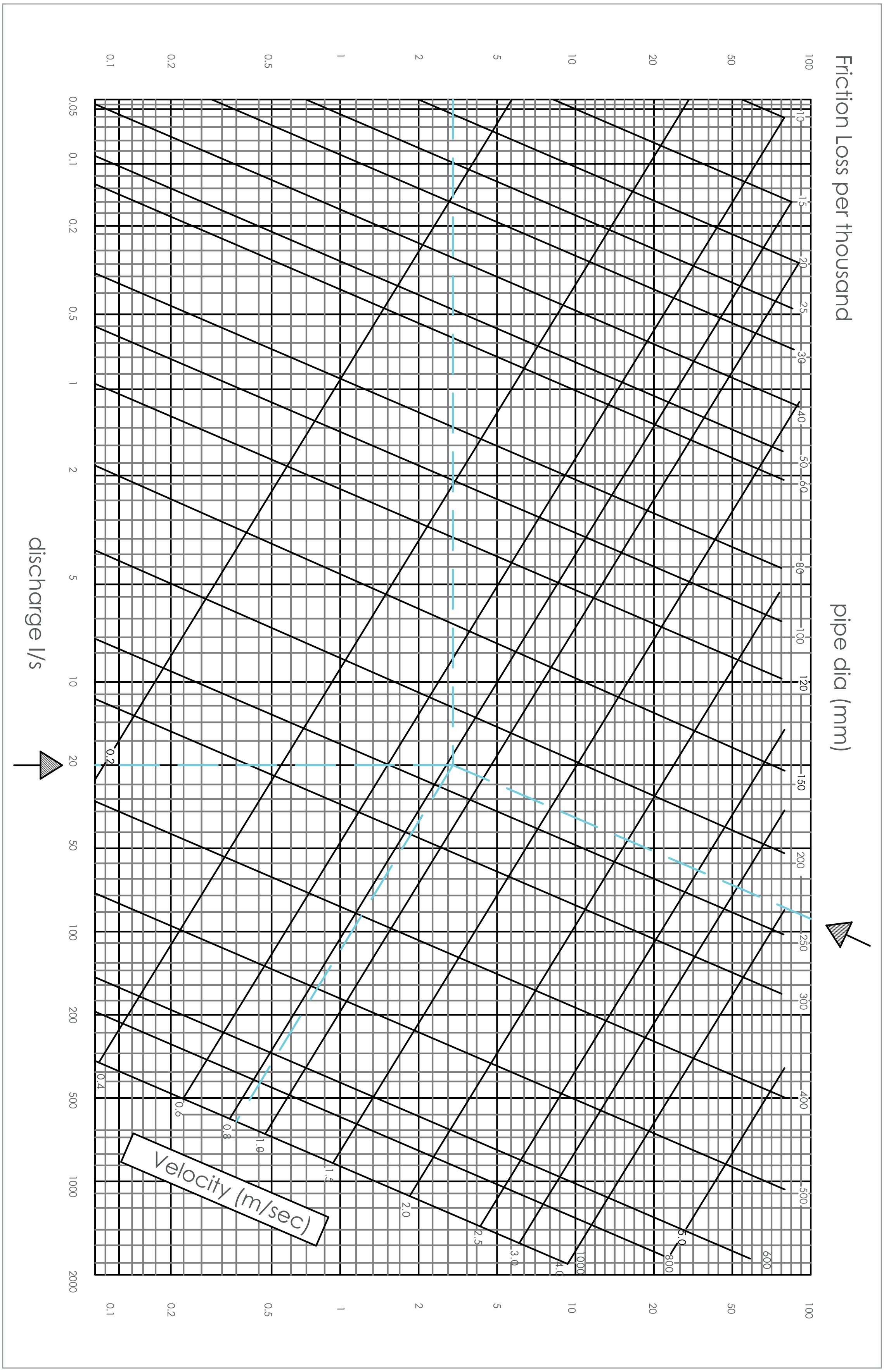
Pipe sizing and pressure drop can be determined using the flowchart below. These are based on the Colebrook – white formula:

Where:

$$V= 2\sqrt{2gDi}\ \text{Log}\ \frac{Ks}{3.7D}\ \frac{2.51v}{D\sqrt{2gDi}}$$

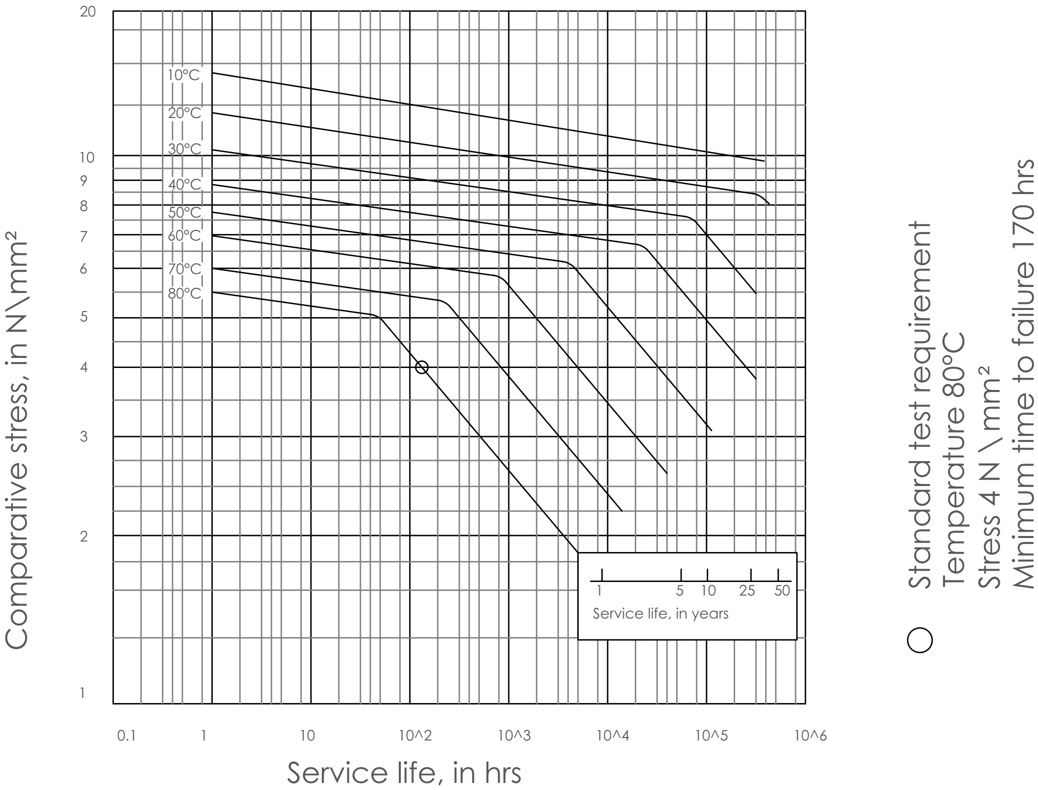
V = velocity in m/sec; g= acceleration due to gravity 9.807m/sec², i = hydraulic gradient
V = kinematic viscosity (a value of 1.141 x m²/s may be assumed for water at 15°C
Ks = linear measure of roughness in mm = 0.03
D = mean internal diameter of pipe in meters.

Using the required design flow rate (L/ sec) the frictional head loss (m/ 1000m) and the flow velocity (m /sec) for various pipe sizes can be obtained from the flow chart.

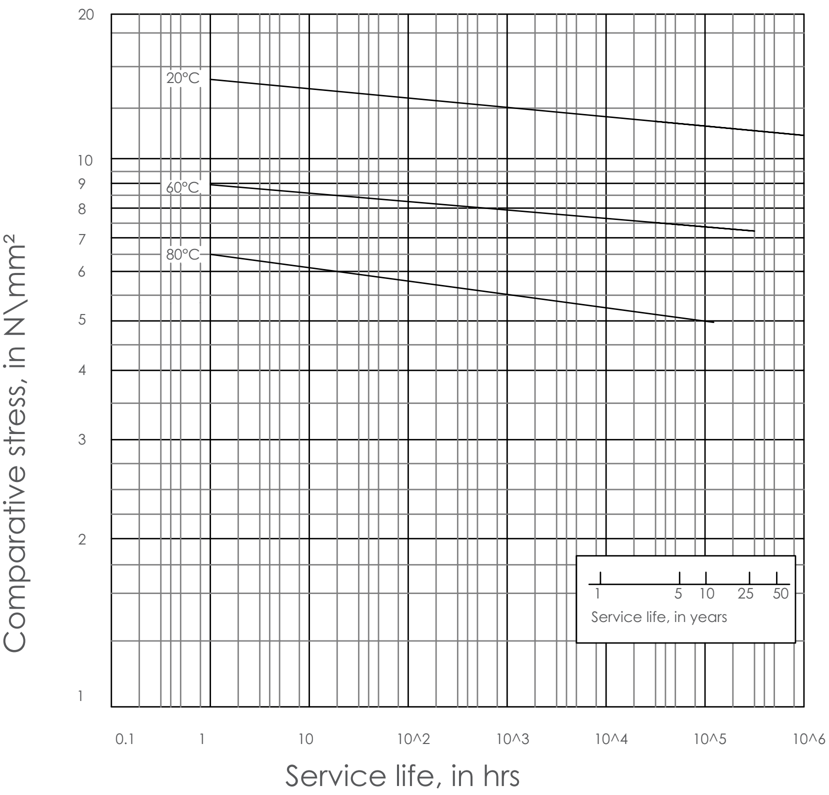

Friction Loss per thousand
pipe dia (mm)
discharge l/s
Velocity (m/sec)

BEHAVIOR OF HDPE PIPES UNDER LONG TERM STRESS:

Behaviour of PE-HD pipes under long term stress PE 80



Behavior of PE-HD pipes under long term stress PE 100



6. PIPE DIMENSIONS

PIPE DIMENSIONS ACCORDING TO ISO 4427
PIPE WALL THICKNESS AND CLASSIFICATION

Nominal Outside Diameter	SDR 17 PN 10	SDR 13.6 PN 12.5	SDR 11 PN 16	SDR 9 PN 20
32	2	2.4	3	3.6
40	2.4	3	3.7	4.5
50	3	3.7	4.6	5.6
63	3.8	4.7	5.8	7.1
75	4.5	5.6	6.8	8.4
90	5.4	6.7	8.2	10.1
110	6.6	8.1	10	12.3
125	7.4	9.2	11.4	14
140	8.3	10.3	12.7	15.7
160	9.5	11.8	14.6	17.9
180	10.7	13.3	16.4	20.1
200	11.9	14.7	18.2	22.4
225	13.4	16.6	20.5	25.2
250	14.8	18.4	22.7	27.9
280	16.6	20.6	25.4	31.3
315	18.7	23.2	28.6	35.2
355	21.1	26.1	32.2	39.7
400	23.7	29.4	36.3	44.7
450	26.7	33.1	40.9	50.3
500	29.7	36.8	45.4	55.8
560	33.2	41.2	50.8	62.5
630	37.4	46.2	57.2	70.3

MRS = Minimum Required Stress
SDR = Standard Dimension Ratio
PN = Nominal Pressure Rating (bar)

HDPE DRAINAGE PIPES TO EN 1519

HDPE Drainage Pipes to BS EN 1519 is the drainage systems for welding made of polyethylene which is exceptionally elastic and resistant to mechanical stress and vibrations.

The programme consists of pipes in diameter of 32 to 315mm and includes a wide range of joint fittings and connection to sanitary and sewage systems.

The high molecular weight of PEHD is a guarantee against fracture due to prolonged use. It is also particularly suited to absorb mechanical stresses of significant intensity; specifically, for installation in seismic areas,

Moreover, it offers excellent resistance to operating temperature between -40° /+70°C, with the capacity to handle peaks of up to 95°C. Pipes are compliant with UNI EN 1519.

PIPE DIMENSIONS ACCORDING TO UNI EN 1519

Size mm (OD)	Length	Size (ID)	Wall Thickness	Dimensional series
*32	*5000	*26	*3	*12,5
40	5000	34	3	12,5
50	5000	44	3	12,5
63	5000	57	3	12,5
75	5000	69	3	12,5
90	5000	83	3,5	12,5
110	5000	101,4	4,3	12,5
160	5000	147,6	6,2	12,5
200	5000	187,6	6,2	16
250	5000	234,4	7,8	16
315	5000	295,4	9,8	16

*This DIA available on special order and delivery time to be agreed

Pipes to this specification are normally supplied in 5 m lengths with plain ends.

7. JOINTING METHODS

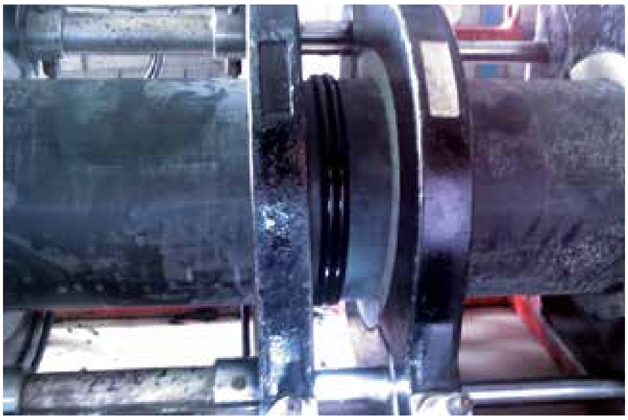
One of the greatest advantages of HDPE and MDPE pipes is the excellent weld ability. The following are the techniques used for joining HDPE and MDPE pipes:

A) BUTT-FUSION WELDING

Butt-Fusion Welding is normally used for pipe sizes over 90mm in diameter, but in waste pipe systems, even smaller sizes are also joined by this method. This jointing method combines the advantage of cheapness and simplicity with joints of strength equalling that of the pipe itself.

The Butt Fusion welding procedure:

1. Clean pipe ends.
2. Clamp pipe ends tightly into the fusion machine and trim both surfaces squarely by rotating the double-edged trimmer.
3. Remove trimmer and check for square uniform alignment by pressing the pipe ends together.
4. With pipe ends properly faced, insert the heater plate at 205° C ± 50° C and compress the pipe ends against the plate at the specified time and pressure. Watch for a proper melt bead formation uniformly around the circumference of both ends.
5. Once the heating process is complete, quickly withdraw the heater plate ensuring that the plate does not rub against the molten pipe ends.
6. Press the melted pipe ends together using the specified joining pressure forming a twin rollback fusion bead. Maintain pressure for sufficient time and further allow the joint to cool for another 30 minutes before exerting any stresses on the newly fused joints.



B) ELECTRO FUSION WELDING

Electro Fusion Jointing of HDPE pipes are done with an integral electrical heating coil embedded in the fitting. Welding is carried out by passing through the coils, and the coils acting as resistors dissipate heat and melts the surrounding material, which expands causing the fittings to be fully fused to the pipe. Once cooled this produces a fully fused and leak free joint.

When welding pipe to pipe or pipe to fittings it is important to ensure that wall thickness on either side of the butt weld is similar, and that there is no misalignment. As long as the pressure rating on the fitting is equal to or greater than that of the pipe, electro fusion fittings can be used on either MDPE or HDPE Pipe

C) FLANGED JOINTS

This type of joint is formed using a Flange Adaptor Assembly, comprised of Stub End, Backing Ring and Rubber Gasket. Flanged Joints are suitable for the integration of accoutrements into the piping system and for the transition to other pipe materials.

D) COMPRESSION FITTINGS

Compression type fittings are widely used for jointing pipes up to 110 mm diameter. With the innovation of new engineering thermoplastic materials, it has been possible now to use plastic fittings for jointing of HDPE pipes. The salient features of these fittings are:

- Can be used above and below ground
- Ease of installation
- Positive sealing and pull out is prevented by grab-rings
- Easy dismantling for removal or reuse of fittings
- Competitive price

8. INSTALLATION

HDPE pipes can be installed using the same methods, the same equipment as for any other rigid plastic pipes. But HDPE, though rigid, is flexible enough to facilitate laying of the pipelines easily and economically.

TRENCH PREPARATION

The width of the trench at the crown of the pipe shall be as narrow as possible but not less than the outside diameter of the pipe plus 300 mm to allow proper compaction of the side fills material.

Provided that the excavated trench bottom is reasonably even and free from sharp stones etc., which could cause abrasion to the pipe surface, no special bedding material is necessary for the laying of HDPE pipes.

PIPE LAYING

HDPE pipes can be welded or joined by compression fittings on the ground and then can be snaked in to the trench easily.

While no anchoring is required for buried HDPE pipelines, it is advisable to anchor at valves, Blank ends etc.

All temporary pipe supports levelling pegs etc., must be removed from beneath the pipe prior to back filling.

SIDE FILLING

In order to develop reaction from the side-fill, which is necessary for, a flexible pipe to sustain top load, some deformation of the pipes cross section must occur. It is generally considered that the maximum vertical deflection of the pipe should be within 5% of the pipes outside diameter, but considering the flexibility and toughness of HDPE pipe a higher deflection will not affect the long-term performance of the pipeline.

BACK FILLING

The material used in the back filling of trenches for HDPE pipes need not be a special grade and selected excavated material may be used, which is suitable for normal compaction.

DEPTH OF COVER

It is generally considered that the minimum depths of cover for HDPE pipes are:

- 500 mm for locations with no wheel load
- 600 mm for location with light vehicle loads
- 800 mm for locations with heavy vehicle loads

9. TESTING AND COMMISSIONING

TEST PRESSURE:

PE pipe system should be pressure tested up to maximum of 1.5 times the rated pressure of the pipes. However, for practical purposes it is usual and may only be necessary to pressure test up to 1.5 times the pipeline working pressure.

Test Section Preparation:

1. Test in sections of 1000 Mtr. or less
2. Pipe work should be back filled, with joints left exposed at the engineer's discretion.
3. Pipe work must not be tested at temperatures in excess of30°C.
4. Air valve should be placed at all high points in the system.

TEST PROCEDURE:

Type 1 pressure test:

This is a short simple test where by the creep in the PE pipe is sustained by maintaining the test pressure for a period of 30 minutes. By opening the control valve the pressure is then reduced to a nominal amount before reclosing the valve. The subsequent "recovery" of pressure in the pipeline is indicative of a sound pipeline. This simple PASS/FAIL test may be found appropriate for short lengths of small diameter main where there is no residual air in the test section.

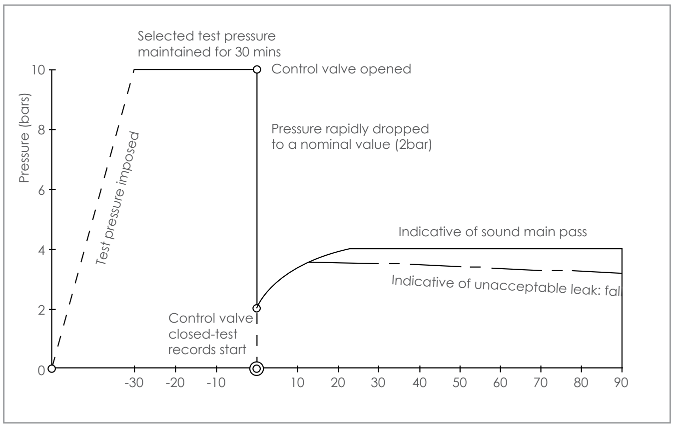
The detailed test procedure is as follow:

1. The selected test pressure is applied and this pressure is maintained by additional pumping as required for a period of 30 minutes. During this time an inspection should be carried out to identify any obvious leaks at this pressure within the system under test.
2. The pressure should then be reduced by rapidly bleeding water from the system to a nominal pressure of, say 2 bars at the test gauge. Close the control valve to isolate the installation.
3. Record and plot the pressure gauge readings at the following intervals:

0 - 10 mins	@	2 minute 5 readings
10 - 30 mins	@	5 minute 4 readings
30 - 90 mins	@	10 minute 6 readings

   The pressure should be seen to rise due to the visco-elastic response of the pipe material.
4. The resulting graph for a leak-tight system should have a characteristic profile similar to that shown in figure below.
5. Thedegreetowhichthecreepinthematerialaffectsthepressuregraphandthetimefor response to reduced pressure will be influenced by:
   - The length of the test section
   - The diameter of the pipe
   - The pressure of air
   - The efficiency of the bedding and compaction

   Within about a 90-minute period a good indication will normally be available. If during that period there is a falling away of pressure, this would indicate a leak within the system. It is advisable to check all mechanical fittings before visually inspecting the welded joints. Any defects in the installation revealed by the test should, of course be rectified and the test repeated after the line has been allowed to relax for an appropriate period of time.



Type 2 pressure test:
This is a more sophisticated and comprehensive testthanthetype1 Test and is used for large diameter pipes and long pipeline installations. Full details of the Type 2 Pressure Test are included in the WRc Manual for Polyethylene Pipe Systems for Water Supply Applications.

COMMISSIONING:
Upon the successful completion of a test the remaining pressure in the pipeline should be released slowly.

Following successful pressure testing all new mains, line door refurbished, should be commissioned in the following manner and in accordance with any local requirements.

1. Cleaning and / or swabbing of the main
2. Filling and sterilization
3. Flushing and / or neutralization
4. Refilling the main
5. Bacteriological sampling
6. Acceptance certification
7. Introduction of the main into service

10.HANDLING, STORAGE AND TRANSPORTATION OF HDPE PIPES

HDPE pipes are coiled or cut into straight lengths depending on the diameter and requirement and proper care should be taken while transporting and storing of these pipes.

The HDPE pipes should not be dragged, thrown or stacked on uneven surfaces. Whenever Loading or unloading is carried out, it is recommended to use cotton or nylon (synthetic) belts to avoid dam- age to the pipes. If at all metal slings are used, the pipe should be protected against scratches.

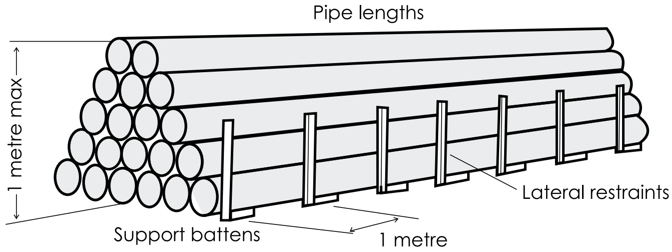
It is preferable to cover the pipes while transporting them over long distances involving exposure to the sun especially in the Arabian Gulf Cooperation Countries. Because irregular heat distribution on the pipe circumference may result in kinking or distortion.

Coils should be stored horizontally (see Fig. 3) just as they are normally delivered by the factory, if it is necessary to transport them vertically care should be taken to avoid any overloading or excess movement which may result in the deformation of the pipe.

Straight lengths should be stored on a flat, clean surface (see Fig. 1 & 2) without being allowed to bend in any direction.

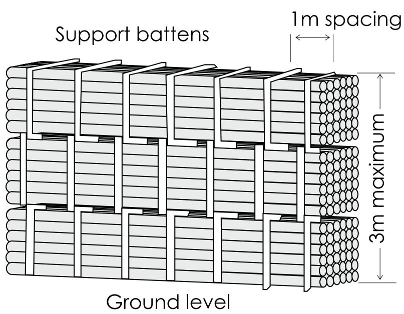
If different class pipes are stacked together, then the higher-class pipes, which are more resistant to deformation, should form the bottom layers.

Fig. 1



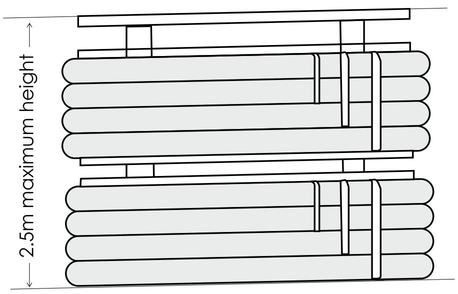
Storage of loose pipes

Fig. 2



Storage of pipe bundles

Fig. 3



Storage of coiled pipes

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