TECHNICAL GUIDE

MUNA NOOR

www.munanoor.com

Introduction

Muna Noor Manufacturing & Trading LLC, subsidiary of Boubyan Petrochemical Company (K.S.C) is a leading manufacturer of thermoplastic pipe systems in the Sultanate of Oman.

The company has achieved enviable growth since its establishment in 1975 and has expanded its manufacturing facilities many fold and added several new products to its credit. Muna Noor has a combined production capacity of 40,000 metric tons of PE and uPVC pipes annually.

Muna Noor manufactures and markets polyethylene and uPVC pipes for a wide range of applications such as potable water supply, irrigation, fire water mains, building plumbing and drainage, waste water collection networks, municipal sewerage, electrical and telecommunication ducting, transportation of gaseous fuels and industrial fluids etc.

Muna Noor's polyethylene pipe plant operates under technical collaboration with Wavin Overseas BV, The Netherlands, one of the largest processors of plastic pipes in the world who has operations in 26 countries and more than 40 licensees world-wide.The tie up with Wavin has helped the company in acquiring world class technology and expertise in the manufacture of polyethylene pipe systems. Muna Noor owns a state-of-the-art manufacturing facility and full fledged quality control laboratory for the manufacture of polyethylene pipes.

Apart from normal pressure pipes the company also manufactures polyethylene pipes for special applications such as liner pipes for the oil & gas industry, electrical and telecommunication cable ducting, slurry pipes for mining and dredging, drag pipes for directional drilling, etc.

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Polyethylene Pipe

Polyethylene, since its discovery in 1933 has grown to become one of the world's most widely used and recognized thermoplastic piping materials. Today's modern polyethylene resins such as PESO and PE I 00 are highly engineered for rigorous applications such as pressure-rated water and gas pipes, industrial pipe for transportation of abrasive materials, liner for petroleum flow lines and water/steam injection etc.

The success of polyethylene as a piping material over decades of use has led to its recognition in a wide spectrum of piping applications where a tough, ductile material is required to assure long-term performance.

Polyethylene pipes provide a cost-effective solution for a wide range of piping applications including pressure-rated, above-ground, buried, trench-less, floating & submarine installations, pipe-lining etc. One of the major factors that contribute to the growth of polyethylene as a piping material is the cost savings in installation, labor and equipment coupled with lower maintenance cost and increased service life as compared to traditional piping materials.

Advantages of Polyethylene Pipe

- Light weight
- High impact resistance
- Flexible
- Corrosion resistance
- Self-restrained joints
- Leak proof system
- Low installation cost
- Negligible maintenance cost
- Long-term service life

Figure 2

Product Classification

PE material for pipe manufacture is classified according to the minimum hoop stress required for a service life of 50 years.This minimum hoop stress is termed as Minimum Required Strength (MRS).
Thus PE pipes with strength classifications PE 80 and PE I 00 have Minimum Required Strength of 8 MPa and IO MPa respectively for 50 years.
The following chart shows the comparison between the MRS values of PE 80 and PE I 00 materials at 20°C

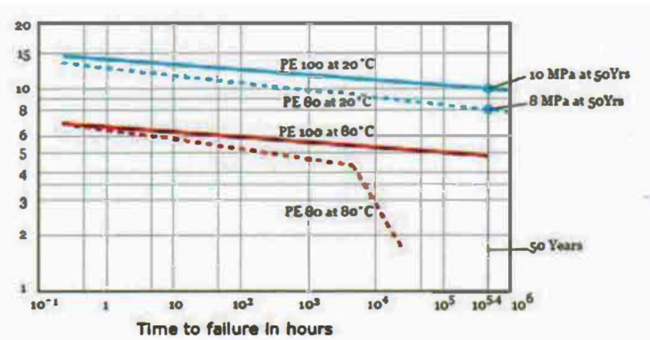


Figure 3: Regression curves for PE 80 and PE I 00 materials

Pipe Dimensions

Polyethylene pipes are specified in terms of nominal Outside Diameter (OD) rather than by the bore diameter of the pipe. The Standard Dimension Ratio (SDR) is used to describe the relationship between the pipe diameter and wall thickness.
SDR = Nominal Outside Diameter / Nominal Wall Thickness

Hydrostatic Design Stress

The hydrostatic design stress of polyethylene pipes is obtained by applying a safety factor (not less than 1.25) to the MRS value depending on the severity of the application. The safety factors for water and gas application are given in the table below:

Pipe application at 20°C	Safety factor
Water supply	1.25
Natural gas	2.0

Figure 4

Maximum Allowable Operating Pressure

The maximum allowable operating pressure can be calculated using Lame's formula as given below:

Hoop stress s = P(D-t) / 2t

Where: s = Hoop stress (MPa)

P = Max. allowable operating pressure Outside diameter (mm)

D =

t = Wall thickness (mm)

Therefore: P = 2s/ (SDR-1) , where SDR=D/t

If this equation is applied to polyethylene pipe system it is possible to calculate the maximum allowable operating pressure and the pipe wall thickness as given below;

MOP = 2 x MRS/ (SDR-1)∂

Where: ∂ = safety factor and

t = PD/ (2 σ +P)

Where: σ = Design stress = MRS/∂

Example: Calculation of maximum allowable operating pressure for PE 100 SDR 11 pipe at 20° C.

For PE I 00 pipe MRS = 10

∂ = I .25 for water application at 20°C

Therefore, for SDR I I pipe:

MOP = 2 MRS/ ((SDR-1) X 1.25)

= (2 X I 0)/ ((I 1-1) X 1.25)

= 1.6 MPa

= 16 bar

Figure 5

Pressure Reduction for Elevated Temperature

Polyethylene is a thermoplastic material and a loss in strength occurs with rise in temperature. The MOP calculated above is based upon 50 years design life at 20°C. With increase in temperature above 20°C, the maximum operating pressure or the service life time of the pipe decreases.

Material Classification	Pressure Reduction Factors				
	20°C	25°C	30°C	35°C	40°C
PE 100	1.OO	O.93	O.87	O.80	O.74
PE 80	1.OO	0.90	0.81	0.72	0.62

Figure 6: Pressure reduction faaors at elevated temperatures
For more spec1f1c values contaa the manufaaurer.

Material Properties

Property	Units	Typical Value for PE 100 grade of Material
Density	Kg/m³	959
Tensile strength at yield	MPa	23
Elongation at Break %	%	>600
Tensile Modulus MPa. Short term	MPa	950
Melt Flow Rate 190/5	g/ 1Omin	0.2
Hardness		64
Thermal Expansion x IO-4/°C	-	2.4
Thermal Conductivity (20°C)	W/m.k	0.4
Poisson's Ratio	m	0.4
Softening point	°c	124
Brittleness Temperature	°c	{-100

Figure 7: Material Properties Table

Standards

Muna Noor manufactures polyethylene pipes in accordance with various international standards:

1. ISO 4427 / BS EN 1220 I - Water Supply
2. DIN 8074 / EN 13244 - General Applications
3. ISO 4437/ EN 1555-2 - Gaseous Fuel Supply
4. API 15 LE/ ERO 43-15/ DEP 31.40.30.34-Gen - Liner Pipes
5. NEMA TC?/ BS EN 50086 - Electrical & Telecom Duct

Design Considerations

The following factors also have to be considered while designing a Polyethylene piping system.

Chemical Resistance

Polyethylene is exceptionally resistant to most chemicals and generally, there are no naturally occurring ground conditions which affect the material. Under normal operating conditions it neither supports micro-biological growth of algae, bacteria, fungi etc. nor is it affected by such conditions.

Polyethylene does not corrode, rot, pit or lose its mechanical properties through electrical or chemical reactions with backfill soils. Where soil conditions are unknown or known to be harmful, a soil analysis should be carried out to determine any likely contaminants. The degree of chemical resistance depends on the type of chemical, its concentration, operating temperature and pressure and the period of contact.
When polyethylene pipe has to be laid under suspect conditions such as brownfield sites and petrol forecourts expert advice should be sought before installing the pipes.

Abrasion Resistance

The transportation of solids in either liquid or gaseous carriers in pipelines causes abrasion of the internal pipe walls due to friction between the pipe wall and the transported particles. Polyethylene has an excellent low co-efficient of friction and therefore has significant advantages over other pipe materials for the transportation of abrasive slurries and mine tailings. The external effect of abrasive backfill materials on polyethylene is negligible. This, coupled with flexibility, lightweight and ease of installation, makes polyethylene the ideal choice for abrasive slurry applications.

Expansion & Contraction

Polyethylene has a co-efficient of linear expansion of I .Sx I 0-4/0C, which is approximately IO times greater than metallic pipes. Therefore, expansion and contraction is an important factor which should be considered in the design of pipeline where a significant variation in temperature is expected, particularly in the case of above-ground pipe-works.

Pipes for Water Supply

DIMENSIONS OF POLYETHYLENE PIPE PE I 00 - AS PER ISO: 4427 I BS EN 12201-2

Design Stress = 8 MPo

Nominal Outside Diameter	SDR 26	SDR 21	SDR 17	SDR 13.6	SDR 11	SDR 9	SDR 7.4
	PN 6	PN 8	PN 10	PN 12.5	PN 16	PN 20	PN 25
	Nominal Wall Thickness						
mm	mm	mm	mm	mm	mm	mm	mm
20	-	-	-	-	2.0	2.3	3.0
25	-	-	-	2.0	2.3	3.0	3.5
32	-	-	2.0	2.4	3.0	3.6	4.4
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	4.2	5.3	6.6	8.1	10.0	12.3	15.1
125	4.8	6.0	7.4	9.2	11.4	14.0	17.1
140	5.4	6.7	8.3	10.3	12.7	15.7	19.2
160	6.2	7.7	9.5	11.8	14.6	17.9	21.9
180	6.9	8.6	10.7	13.3	16.4	20.1	24.6
200	7.7	9.6	11.9	14.7	18.2	22.4	27.4
225	8.6	10.8	13.4	16.6	20.5	25.2	30.8
250	9.6	11.9	14.8	18.4	22.7	27.9	34.2
280	10.7	13.4	16.6	20.6	25.4	31.3	38.3
315	12.1	15.0	18.7	23.2	28.6	35.2	43.1
355	13.6	16.9	21.1	26.1	32.2	39.7	48.5
400	15.3	19.1	23.7	29.4	36.3	44.7	54.7
450	17.2	21.5	26.7	33.1	40.9	50.3	61.5
500	19.1	23.9	29.7	36.8	45.4	55.8	-
560	21.4	26.7	33.2	41.2	50.8	62.5	-
630	24.1	30.0	37.4	46.3	57.2	70.3	-
710	27.2	33.9	42.1	52.2	64.5	79.3	-
800	30.6	38.1	47.4	58.8	72.6	89.3	-
900	34.4	42.9	53.3	66.1	81.7	-	-
1000	38.2	47.7	59.3	72.5	90.2	-	-

Figure 9

Pipes for General Purpose

DIMENSIONS OF POLYETHYLENE PIPE - AS PER DIN 8074: 1999

Nominal Outside Diameter	SDR 26		SDR 21	SDR 17		SDR 13.6	SDR 11		SDR 9		SDR 7.4
	Nominal Wall Thickness										
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
20	-					1.8	1.9	2.3	2.8	3.4	4.1
25	-				1.8	1.9	2.3	2.8	3.5	4.2	5.1
32	-				1.9	2.4	2.9	3.6	4.4	5.4	6.5
40	-		1.8	1.9	2.4	3.0	3.7	4.5	5.5	6.7	8.1
50	-	1.8	2.0	2.4	3.0	3.7	4.6	5.6	6.9	8.3	10.1
63	1.8	2.0	2.5	3.0	3.8	4.7	5.8	7.1	8.6	10.5	12.7
75	1.9	2.3	2.9	3.6	4.5	5.6	6.8	8.4	10.3	12.5	15.1
90	2.2	2.8	3.5	4.3	5.4	6.7	8.2	10.1	12.3	15.0	18.1
110	2.7	3.4	4.2	5.3	6.6	8.1	10.0	12.3	15.1	18.3	22.1
125	3.1	3.9	4.8	6.0	7.4	9.2	11.4	14.0	17.1	20.8	25.1
140	3.5	4.3	5.4	6.7	8.3	10.3	12.7	15.7	19.2	23.3	28.1
160	4.0	4.9	6.2	7.7	9.5	11.8	14.6	17.9	21.9	26.6	32.1
180	4.4	5.5	6.9	8.6	10.7	13.3	16.4	20.1	24.6	29.9	36.1
200	4.9	6.2	7.7	9.6	11.9	14.7	18.2	22.4	27.4	33.2	40.1
225	5.5	6.9	8.6	10.8	13.4	16.6	20.5	25.2	30.8	37.4	45.1
250	6.2	7.7	9.6	11.9	14.8	18.4	22.7	27.9	34.2	41.6	50.1
280	6.9	8.6	10.7	13.4	16.6	20.6	25.4	31.3	38.3	46.5	56.2
315	7.7	9.7	12.1	15.0	18.7	23.2	28.6	35.2	43.1	52.3	63.2
355	8.7	10.9	13.6	16.9	21.1	26.1	32.2	39.7	48.5	59.0	-
400	9.8	12.3	15.3	19.1	23.7	29.4	36.3	44.7	54.7	66.5	-
450	11.0	13.8	17.2	21.5	26.7	33.1	40.9	50.3	61.5	-	-
500	22.3	15.3	19.1	23.9	29.7	36.8	45.4	55.8	68.3	-	-
560	13.7	17.2	21.4	26.7	33.2	41.2	50.8	62.5	-	-	-
630	15.4	19.3	24.1	30.0	37.4	46.3	57.2	-	-	-	-
710	17.4	21.8	27.2	33.9	4.21	52.2	64.5	-	-	-	-
800	19.6	24.5	30.6	38.1	47.4	58.8	-	-	-	-	-
900	22.0	27.6	34.4	42.9	53.3	66.1	-	-	-	-	-
1000	24.5	30.6	38.2	47.7	59.3	-	-	-	-	-	-

Figure 10

Pipes for Drainage, Sewerage & General Purpose

DIMENSIONS OF POLYETHYLENE PIPE PE I 00 -AS PER BS EN 13244-2

Design Stress = 8 MPo

Nominal Outside Diameter	SDR 26	SDR 21	SDR 17	SDR 13.6	SDR 11	SDR 9	SDR 7.4
	PN 6	PN 8	PN 10	PN 12.5	PN 16	PN 20	PN 25
	Nominal Wall Thickness						
mm	mm	mm	mm	mm	mm	mm	mm
20	-	-	-	-	2.0	2.3	3.0
25	-	-	-	2.0	2.3	3.0	3.5
32	-	-	2.0	2.4	3.0	3.6	4.4
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	4.2	5.3	6.6	8.1	10.0	12.3	15.1
125	4.8	6.0	7.4	9.2	11.4	14.0	17.1
140	5.4	6.7	8.3	10.3	12.7	15.7	19.2
160	6.2	7.7	9.5	11.8	14.6	17.9	21.9
180	6.9	8.6	10.7	13.3	16.4	20.1	24.6
200	7.7	9.6	11.9	14.7	18.2	22.4	27.4
225	8.6	10.8	13.4	16.6	20.5	25.2	30.8
250	9.6	11.9	14.8	18.4	22.7	27.9	34.2
280	10.7	13.4	16.6	20.6	25.4	31.3	38.3
315	12.1	15.0	18.7	23.2	28.6	35.2	43.1
355	13.6	16.9	21.1	26.1	32.2	39.7	48.5
400	15.3	19.1	23.7	29.4	36.3	44.7	54.7
450	17.2	21.5	26.7	33.1	40.9	50.3	61.5
500	19.1	23.9	29.7	36.8	45.4	55.8	-
560	21.4	26.7	33.2	41.2	50.8	62.5	-
630	24.1	30.0	37.4	46.3	57.2	70.3	-
710	27.2	33.9	42.1	52.2	64.5	79.3	-
800	30.6	38.1	47.4	58.8	72.6	89.3	-
900	34.4	42.9	53.3	66.1	81.7	-	-
1000	38.2	47.7	59.3	72.5	90.2	-	-

Figure 11

For design purpose pipe expansion can be more particularly understood and taken as 1.5 mm/ I 0°C/m. In above-ground installations careful considerations should be given to the positioning of support brackets and anchor points and the use of end load bearing joints. It may be ideal to accommodate expansion and contraction at changes of directions in the pipeline.

Wherever non-end load bearing fittings are used it is important that such fittings are securely anchored to prevent pipe pull-out. Where above-ground pipes installed in confined conditions such as industrial or chemical process plants, the movements in pipeline due to expansion and contraction can be taken care of with sliding expansion joints.

With below-ground installations, new pipeline should be allowed to stabilize to ambient temperatures before making the final tie-in connections. Partial backfilling of the pipe will help in minimizing the effect of direct sunlight.

Permeability

Polyethylene under normal conditions is impermeable to gas and is extensively used for Natural Gas and LPG systems. However; organic compounds of the non-polar; low molecular type such as aliphatic hydrocarbons, chlorinated hydrocarbons and alkylated benzenes are of concern. When such conditions are encountered polyethylene pipe system should be evaluated based on the application it is intended for:

Electrolytic Reaction/Electrical Conduction

Polyethylene is a poor conductor of electricity and does not undergo electrolytic corrosion when in contact with metal components, eg. connecting to valves and other metallic pipes. As a non-conducting material polyethylene should not be used for the earthing of electrical equipment nor can it be used as a conductor for frost protection system. In situations where polyethylene pipe has to be used where there are high levels of static electricity it is necessary to discharge all the static charges from the pipe before it is used.

Hydraulic Properties

Polyethylene pipe has excellent flow characteristics. As polyethylene is non-corrosive and maintains smooth bore throughout its lifetime there is seldom any deterioration in its hydraulic performance.

The hydraulic frictional coefficients used for design of polyethylene pipe systems are as given below:

The velocity of flow in PE pipes does not normally exceed 1-2 meters per second in distribution mains. When higher velocities are expected considerations should be given to the effects of surge.

Figure 12

Cole-brook White	Ks = 0.003 mm
Hazen Williams	C = I SO

Flow calculations

For given flow rates the pipe size and pressu1·e drop in polyethylene pipes can be determined by using the Colebrook-White formula. The Colebrook-White formula for the velocity of water in a smooth bore pipe under laminar conditions takes the form:

$$V = -2\sqrt{2gDi} \times \log\{ Ks/3.7D + 2.51\, v / D\sqrt{2gDi} \}$$

Where:

V = velocity in meters per second

g = gravitational acceleration (a value of 9.807 m/s^2 may be assumed)

i = hydraulic gradient

v = kinetic viscosity (a value of 1.141 x I 0^6 m^2/s may be assumed for water at I 5 °C)

Ks = linear measure of roughness in mm 0.003 mm

D = mean internal diameter of pipe in meters

Using the required design flow rate (1/sec) the frictional head loss (m/1000m) and the flow velocity (m/sec) for various pipe sizes can be obtained from the flow chart.

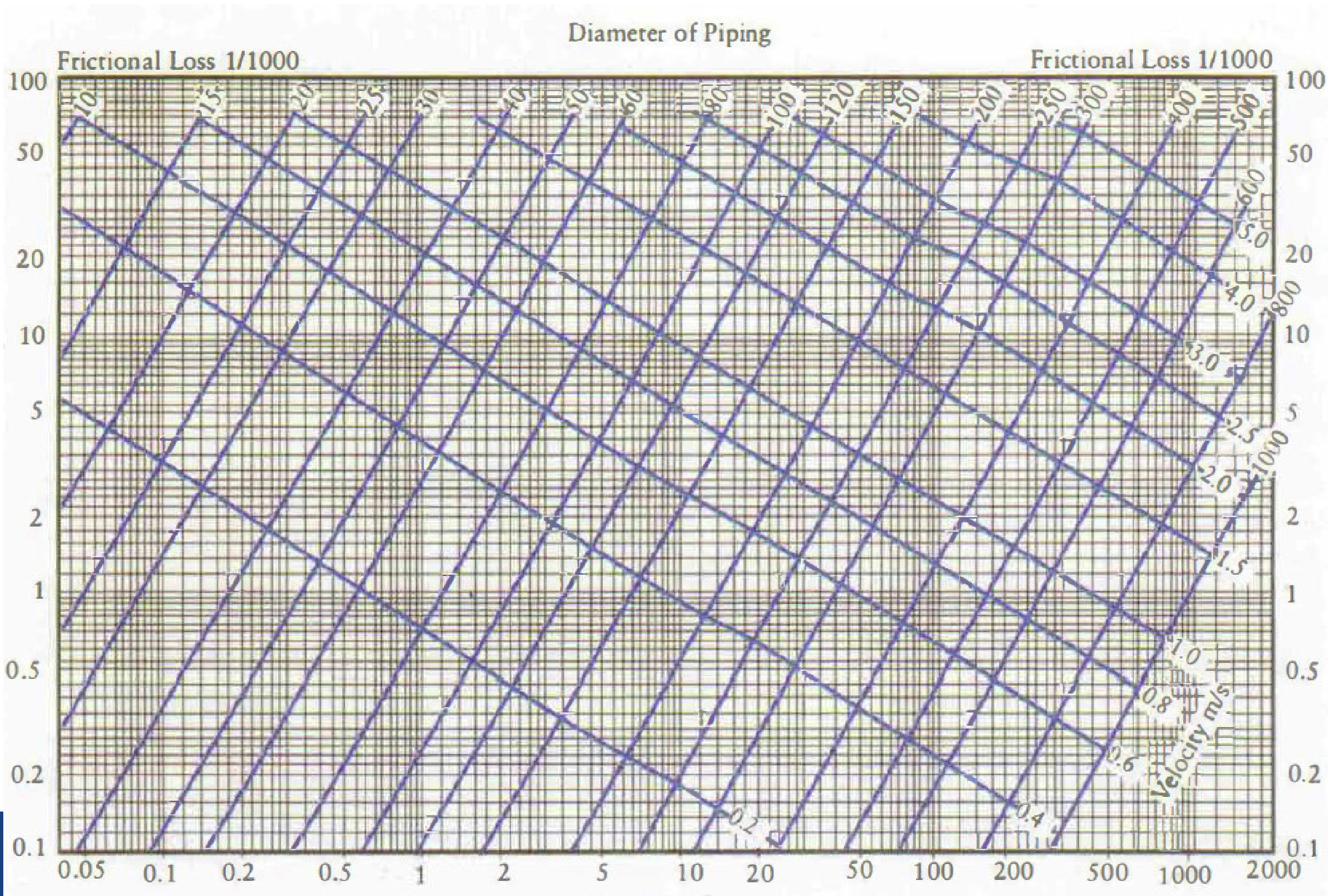


Figure 13: Flow chart for PE pipes

Flow Liter/ ec

Head Loss in Fittings

Fluids flowing through a fitting or valve will also experience a frictional loss that can be directly expressed using a resistance coefficient K for a particular fitting as given in the formula below:

$H = K (V^2/2g)$
Where
H = head loss (m)
V = velocity of flow (m/s)
K = head loss coefficient

Generally, in long pipeline installations the fittings involved are minimal and therefore, the head losses are very small compared to the head loss due to the total pipe wall friction. But this can be significant in short pipe runs or complex installations where a large number of fittings are included.

Pressure Surge

Pressure surge in a pipeline is caused by a sudden increase or decrease in flow velocity. The common causes for pressure surge found in practice are pump failure, pump startup or shutdown, rapid valve closure, malfunctioning of check valves etc.These fluctuations can be severe enough to rupture the pipeline. Potential pressure surge problems should be considered when a pipeline design is evaluated and a thorough surge analysis should be undertaken in order to avoid damage to the pipeline and malfunctioning of the distribution system.

Rapid Crack Propagation

The phenomenon in which the pipe fails rapidly with a very long crack in the axial direction is called Rapid Crack Propagation. New generation polyethylene material such as PE I 00 is very tough and highly resistant to brittle failure even at very low temperatures. Failure is typically of a ductile nature and extensive testing has shown that rapid crack propagation failure will not occur in a pipeline full of liquid. The raw material manufacturers of PE I 00 grade generally declare the value of critical hoop stress for their material as determined by international laboratories.

Notch Sensitivity

Scratches or scoring on the pipes occurred during handling and installation will have no 'long-term effect' on the pipe, provided the damage does not exceed I 0% of the pipe wall thickness. If the damage is greater than I 0% the pipe should be discarded.

Figure 14

Quality Control

Muna Noor is equipped with a state-of-the-art laboratory to carry out almost all the required tests in-house as per the standards. Physical and mechanical properties are tested at regular intervals on OMANPLAST polyethylene pipes during manufacture along with long-term tests as required by the relevant standards.

Figure I 5: Quality Control

Jointing Techniques

Polyethylene pipe systems are relatively simple to join and install. Two jointing methods are available in the installation of PE pipe systems. They are:

1. Fusion welded joints
   a) Butt fusion
   b) Electrofusion
2. Mechanical joints

1) Fusion Welded Joint

Fusion welding is carried out by melting the polyethylene material at the joint surfaces and bringing the molten surfaces together under closely controlled pressure and holding the surfaces together until the joint has cooled. In all fusion weld processes, the field pipe jointing should only be performed by trained fusion operators using properly maintained and calibrated fusion machines. The fusion compatibility of polyethylene material must be established before carrying out welding work.

a) Butt-Fusion

The principle of heat fusion is to join molten surfaces of pipes under controlled pressure causing the molten materials flow, mix, and fuse together. When PE pipe is heated, the molecular structure is transformed from a crystalline state into an amorphous condition and under fusion pressure the molecules from each pipe end mix together.As the joint cools, the molecules return to their crystalline form making the joint a homogenous weld. A fusion joint is as strong as the pipe itself The standard DVS 2207 Part I gives the full guidelines on welding procedures.

With Butt Fusion, it is essential that only similar grades of polyethylene materials are welded, eg:

Figure 17: Typical Butt Fusion Equipment

PE 100 – PE 100
PE 100 – PE 80
And similar SDR's are used, eg:
SDR 11 – SDR 11
SDR 11 – SDR 33

It is important to observe the following points when carrying out butt fusion jointing:

1. Cleanliness of the welding surfaces and heating plate
2. Squareness of the welding surfaces
3. Alignment of pipe surfaces
4. Uniform heating of the plates

b) Electro-fusion

Electro-fusion fittings incorporate an electrical heating element, which is energized via an electro-fusion control box to heat the elements. When the fitting is energized, the material around the heating element becomes molten and in turn causes the pipe surface also to melt, resulting in a molten pool of material, fusing the materials of fitting and pipe. Once cooled, it produces a fully fused leak-proof joint. This operation is carried out in a fully automatic specialist machine. Electro-fusion fittings are supplied with a barcode sticker pasted on it. By scanning the bar code the Electro-fusion machine inputs all the welding parameters and automatically carries out the welding. The machine also stores the welding data in its memory which can be retrieved or printed out later.
It is important to observe the following points when carrying out electro-fusion jointing:

1. Squareness of the pipe ends and cleanliness of the welding surface.
2. Scraping of the outer surface of the pipe before welding.
3. Marking of the insertion length on pipe and proper insertion of the pipe inside Electro-fusion fitting.
4. Proper power supply

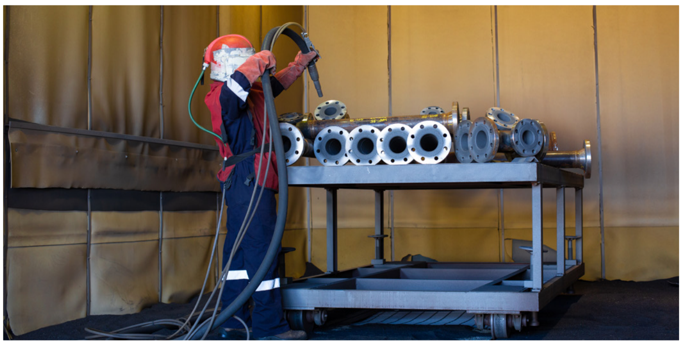


Figure 18: Typical Electro-fusion equipment

2. Mechanical Joints

Flanged Joints

One of the simple methods for connecting polyethylene pipe to valves, hydrants and metallic pipes is to use a polyethylene stub flange. In this technique polyethylene stub is welded to the end of the pipe either by butt-fusion or by using an electro-fusion coupler in conjunction with a metal backing ring, and a rubber sealing gasket. Different grades of metal backing rings and sealing gaskets should be used depending on the environmental conditions and the nature of the fluid being transported. As polyethylene pipe is sized on the outside diameter whereas ductile iron pipe, for example is sized by its internal bore, allowances must be made for differences in pipe bore and discrepancies in the corresponding mating flanges. This occurs more with large diameter pipes. A flange converter will be required in these cases to ensure compatibility of pipe bores.

Compression Fittings

Compression fittings uses the design principle, where an elastomeric ring seal is compressed between pipe and fitting. Some fittings require the use of pipe bore inserts (pipe stiffener) to provide sufficient rigidity for the compression seal.

Hydrostatic Pressure Testing of Plastic Pipeline

Compression Fittings

Reference Standard

SFS 3115 E: Plastic Pipes: Water Tightness Test for Pressure Pipelines

Purpose

- SFS 3115 E specification is originated from "The Finnish Plastics Industries Federation" and is widely adapted for testing PE pipes after installation.
- The basic purpose of hydrostatic pressure testing is to detect any unacceptable leakage in the piping system

Test Procedure

1. If the test is to be carried out with the pipe covered, the test must be started at the earliest 48 hours after the covering of excavation.
2. Before the test the pipe must be filled with water without any pressure for at least 2 hours. This is necessary to equalize the temperatures. The
test water temperature shall not exceed 20°C.
3. Protect pipeline from direct sunlight in order to maintain temperature within ± 1°C. Test pressure in the pipe section is raised to the Normal value.
4. (Normal value is the operating pressure for which the system is de signed, which is generally lower than the pressure rating of the pipe, taking into account the temperature variations, water hammer effects and any other safety measures).
5. Maintain this pressure for a period of 2.0 ± 0.1 hours by adding water whenever the pressure drops by 20 KPa (0.2 Bar).
6. The excess pressure is then raised to a value which is equal to 1.3 times the value of the normal pressure. Maintain this pressure level for a period of 2.0 ± 0.1 hours by adding water whenever the pressure drops by 20 KPa (0.2 Bar).
7. The excess pressure is then reduced within a period of not less than 6 minutes – to the initial value, and the valve is then closed.
8. After 1 hour measure the quantity of water, if any, which is added to maintain the initial pressure.

9. The quantity of water added should be within the acceptable area shown in the graph of Quantity of water vs Pipe inside diameter given below.

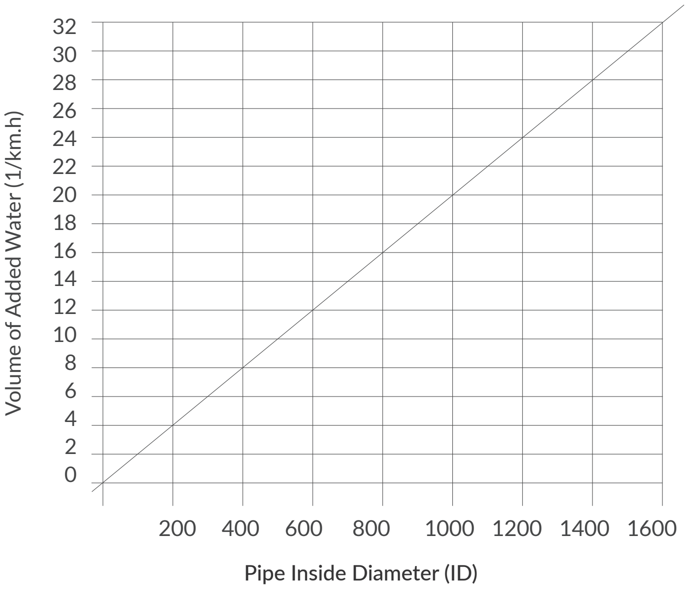


Figure 19: Test Requirement for Pressure Pipes

Precautions:

1. Test lengths should be reasonable – on longer pipelines, testing in 500-meter sections is recommended.
2. Ensure that all fixed points are securely anchored and that any concrete used to protect the pipeline should be cured to sufficient strength before testing. Where anchor or thrust blocks are used, pressure testing should be done only after 7 days of casting the blocks.
3. Pipelines should be backfilled, but joints (particularly mechanical and transition joints) may be left exposed for inspection during testing. It is recommended that the pipes are backfilled and covered with 0.5m of cover to prevent sudden uncontrolled movements in case of rupture.
4. In hotter environments, ensure that the temperature of the pipeline has stabilized before the testing commences.
5. The test section should be blanked off with steel blank flanges of adequate thickness and suitably supported to resist end thrust forces. Do not conduct the pressure test against closed valves unless unavoidable.
6. Ensure that all air valves are positioned at all high points and are kept open to release trapped air. Provisions must be made at test ends for the removal of water.
   ASTM F 1668 recommends certain maximum filling rates for the pipes, depending upon the size of the ARV installed on the system, and the maximum filling rate shall be as follows:

Air valve size (mm)	Maximum filling rate to limit surges (m3 / sec)
50	0.06
100	0.24
150	0.55
200	0.98
250	1.54

Figure 20

7. The test section should be charged with water slowly from the lowest point with all air valves open. If in doubt about air removal a foam swab ahead of water column should be used. The charged test section should preferably be left for 24 hours, or overnight to stabilize its temperature.
8. Test pressure indicating gauge shall be provided at the lowest point of the system in order to include static head in the test pressure.
9. Venting is sometimes done by loosening the flanges. In such cases, it is essential to re-tighten the loosened flanges before applying the test pressure.
10. Bring the main up to the test pressure slowly for the designated period. Release the pressure carefully after testing.
11. The maximum permissible filling speeds can be taken from the following table

Inside Dia (mm)	100	125	150	200	250	300	400	500	600	800	1000
Q	0.3	0.5	0.7	1.2	1.9	2.7	4.8	7.5	11	19	30

Figure 21

Where Q is the quantity of water fed per unit time, in 10-3 m3/Sec (liters/ Sec.)

Note: In case of submerged pipe lines, where the pipe can not be made into sections, the entire pipe line shall be assumed as one section and the test pressure shall be calculated in such a way that the lowest point be considered as the "point of the test pressure"

Storage and Handling

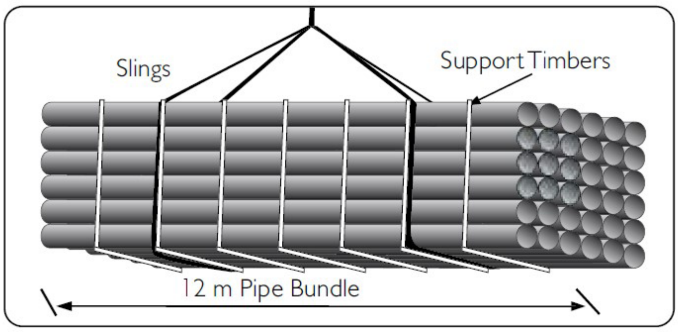


Figure 22: Handling of Pipe Bundles

OMANPLAST polyethylene pipes are available in sizes ranging from 20 mm to 1000 mm. As per customer requirements small diameter pipes are generally supplied in coils and large diameter pipes supplied in straight lengths varying from 12 to 19 meters. Polyethylene is a tough resilient material which is relatively light and easy to handle although it is prone to damage due to scoring by sharp objects.
Therefore, careful handling is always required and dragging of straight pipes and coils should be avoided. A maximum scoring of up to 10% of the wall thickness of the pipe is acceptable and scoring exceeding 10% should be rejected.

Handling

Care must be exercised to avoid damage to the pipe walls, pre-assembled end fittings, or sub assemblies. Safety aspects need to be addressed, as the nature of PE pipes is such that in cold and wet weather the pipes become slippery and difficult to handle. In these circumstances, additional care should be exercised when handling coils or bundles of pipe. In hot weather, especially with black pipes, the pipe surface temperature may reach up to 70°C, when the ambient temperature reaches 40°C. Handling PE pipes at these temperatures requires gloves or other protection to prevent the possibility of skin burns. Fabric slings are recommended for lifting and handling polyethylene pipes in order to prevent damage (see fig 22). Where wire ropes or chains are used, then all of the contact points between the slings and the pipe must be protected by suitable padding. Where pipes are in coils, the slings must be placed evenly around the entire coil. Similarly, where coils or straight lengths are lifted by fork lift the contact points must be protected.

When lifting coils, the lifting must be performed on the entire coil, and the fork lift tynes should not be inserted into the coil winding. When lifting crates of pipes, the tynes must be placed under the entire crate, and the tynes not pushed into the pack. Pipes must not be lifted by placing metal hooks into the ends of straight lengths.

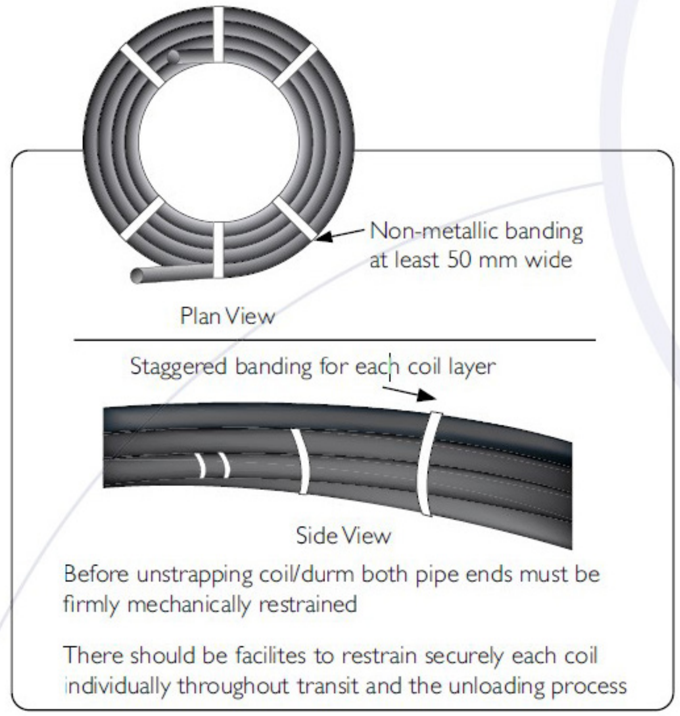


Figure 23: Storage of Coiled Pipes

Pipe lengths greater than 6 metres should be lifted using a spreader bar, and wide band slings. PE pipes will flex during lifting, and care needs to be exercised to prevent damage to pipes or end fittings arising from contact with the ground. Care needs to be taken to center the pipe in the slings.

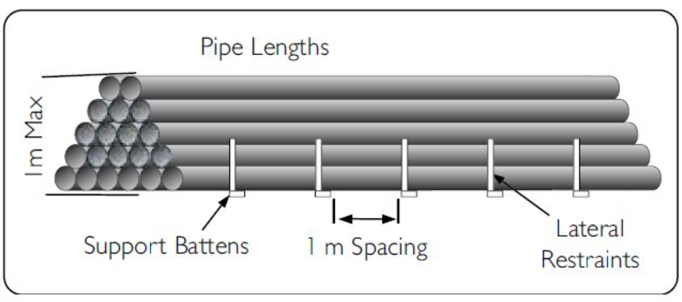


Figure 24: Storage of Loose Pipes

For coiled pipes reinforced adhesive tape at least 50 mm wide band is used for banding. Complete coils are secured by outer band and intermediate bands and individual layers are also independently secured as shown in fig 22. These bands should be removed just before using and after securing the ends properly.

PE pipes stacked for transport must be evenly supported in order to prevent distortion. All load bearing surfaces must be free from contact with sharp objects. Any projecting sections such as stub flanges must be supported to prevent damage.

For straight lengths of pipe, suitable support beneath the pipes is provided by beams of minimum width 75 mm, spaced horizontally at 1.5 m centres.

Where end treatments such as flanges are applied in the factory, these treatments must be protected from damage.

Storage

Straight length pipes must be supported by timber spacers of minimum width 75 mm placed at 1.5 meter apart. For rectangular stacks, additional vertical supports at 3 meter spacing should be used. The recommended maximum height of long-term stacks is 1 m.

For pyramid stacks, the bottom pipe layers also need to be chocked to prevent stack collapse. For large diameter pipes (DN 630 and above) it may be necessary to tom, or internally support the ends of the pipe in order to prevent distortion. The height of the stack shall be limited to 1 m (see fig 26)

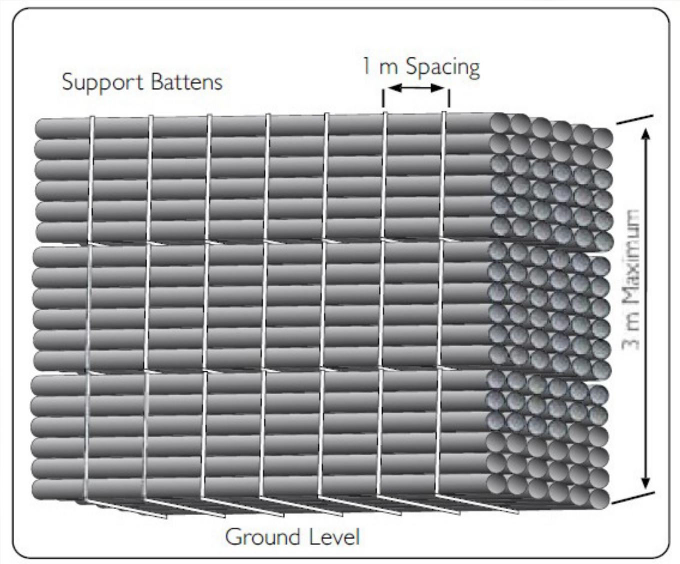


Figure 26: Storage of Pipe Bundles

Where pipes are crated, the crates may be stacked on timber to timber, in stacks up to 3 meters high (see fig 26). PE pipes are capable of supporting combustion, and need to be isolated from ignition sources.

PE pipes must be kept away from high temperature sources, and not be in contact with objects of temperature higher than 70°C. Black pipes do not need protection from the effects of UV exposure. In selecting the method of protection consideration may need to be given to temperature effects, as elevated temperatures may lead to pipe distortion.

Transport

Installation

One of the key advantages of polyethylene pipe is its ability to be fusion welded to form a continuous flexible string of pipe which can be easily snaked in to pre-dug trenches. Wherever site conditions permit, welding can be easily carried out above ground. Polyethylene also has the advantages of several installation techniques many of which are specifically developed around polyethylene pipe systems such as narrow trenching, pipe bursting, directional drilling, guided drilling, slip lining etc.

Trench Preparation

The general practice is to lay service pipe at 750 mm cover and the mains at 900 mm cover measured from the crown of the pipe. Polyethylene pipe may in some instances be laid directly on to the trimmed trench bottom where soil is uniform, fine grained and free from large stones and flints. In other cases trench should be excavated to a depth to allow for a minimum 100 mm bed of gravel or coarse sand. A typical open-cut trench is given below.

Open-cut trenching

A typical 'open-cut trench' is as shown in figure below. Preparation of trench and laying of pipes are explained in detail below.

1. Digging out the trench of specified dimensions. Generally the depth and width of the trench are calculated as follows.

Trench Depth = Bedding (100 mm) + pipe diameter in mm + Initial backfill + main backfill

Trench Width = pipe diameter in mm + 300 mm (150 mm on each side)

Initial backfill is 150 mm and main backfill for PE mains is 750mm (for service lines it is 600 mm.)

2. Preparation of bedding by leveling and compacting. A suitable soil type should be used as Bedding material.
3. Laying the pipe
4. Preparation of side fill by compacting and then preparing Initial backfilling.
5. Preparation of main backfill using as-dug material or suitable backfill material.

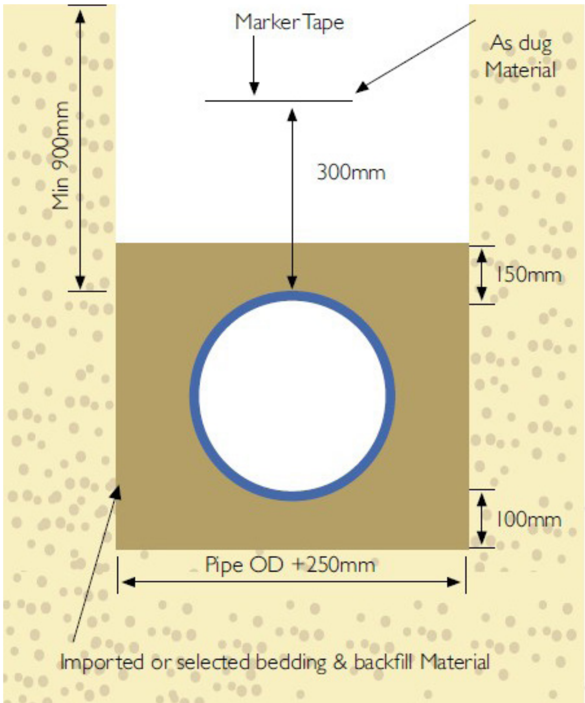


Figure 27: Typical open cut trench detail

Back Filling

Polyethylene is a flexible material and therefore, can deform under excessive load. It is however, important that any deformation is minimized and that the placement of the correct side-fill and initial backfill material is carried out with adequate compaction. A minimum of 150 mm cover should be placed above the crown of the pipe, with heavy compaction equipment not being used below 300 mm cover.

For buried pipes the 'Embedment' plays a very important role as the deflection of the pipe is function of 'secant modulus' of the soil too. The secant modulus of soil differs with type of soil and the level of the compaction. To achieve required soil modulus, embedment has to be performed in a defined and controlled way. imported material or as dug material, if suitable can be used for embedment. The data on soil modulus of various types of soil at different compaction level is available with WRC and other research organizations.

Trench backfilling should commence as soon as possible after laying the pipe to give the pipe protection from damage from objects possibly falling in to the trench. Backfilling can be carried out in 300 mm layers.

It s a good practice to lay a marker tape 300 mm above the pipe crown in order to protect the pipe from damages due to potential future interference. Marker tape also can include a tracer wire to allow future identification of the pipe line.

Narrow Trenching

This is a modification of traditional open-cut trenching. Using either narrow backhoe buckets or chain trenchers, trenches of 100 mm wider than the pipe to be installed are excavated. Coiled, drummed or pre-welded pipe strings can be quickly installed. Significant savings can be achieved through less volume of excavation, usage of less imported fill material and reduced labour.

Shallow Cover

There may be situations where pipes cannot be laid at the recommended depths of cover. In such situations for highways or traffic areas the pipes should be protected by placing a reinforced concrete bridging slab of appropriate strength above the pipe as shown in figure 17 below. A 150 mm thick granular cushion should be placed between the pipe crown and the slab.

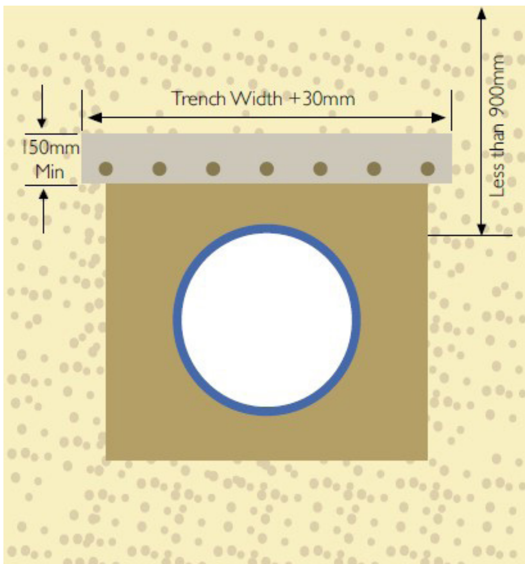


Figure 28: Recomended Protection for Shallow pipe

Pipe Bending

One of the major benefits of PE is its flexibility and this can be utilized to full advantage for buried pipework. Gradual changes of direction up to 11.5° can normally be accommodated by the pipe itself, without the need for additional fittings and costs of jointing. The accepted rule of thumb for PE pipe system (warm conditions for SDR 11 pipe) is, Bend radius = 15 x pipe OD For colder weather and SDR 17 pipe a safe bending radius is 25 x pipe OD.

In very cold winter temperatures, this increases to 35 x pipe OD. Where thinner walled SDR 26 and SDR 33 pipes are being used these values should be increased by 50%. Fittings and pipe joints should not be included in bent pipe sections; formed bends and elbows should be used instead to prevent undue stresses in the pipeline.

Pipe Anchorage & Thrust Blocks

A key feature of a welded PE pipeline is that it is a fully end load resistant system and thrust blocks are not required at changes of direction / diameter or branches, providing significant time and cost benefits to the total installed cost of the system. It should be remembered that any connection to a non-end load-bearing fitting will require anchorage to prevent pipe pull-out. Where heavy ancillary plant is installed on a PE pipeline, provision should be considered for concrete support. This should provide under operating conditions, eg. Valves and hydrants.

Pipe Entry into Structures

Pipe entry into rigid concrete or brickwork structures needs to take account of a number of design factors and should include:

1. Differential Settlement

This can usually be accommodated by the flexibility of the pipe itself and by incorporating a flexible annular seal to the pipe sleeve through the structure.

2. Watertight Seal

The protective sleeve should provide both a watertight seal to the structure and to the PE pipe passing through the sleeve. In some situations PE pipe may be connected to the structure by a rigid flanged joint. To prevent undue stresses through movement and settlement, support can be provided by a reinforced concrete plinth. The plinth should extend one pipe diameter or 300 mm (min) from the flange face, with pipe straps bolted to the plinth.

Above ground pipework. max. support spacings (m)			
Pipe Diameter (mm)	SDR 11	SDR 17	SDR 26
32	0.06	-	-
63	0.80	-	-
90	0.95	0.80	-
110	1.00	0.90	-
125	1.15	1.00	-
160	1.40	1.30	1.20
180	1.50	1.40	1.30
225	1.80	1.60	1.50
250	2.00	1.80	1.70
315	2.25	2.10	1.90
355	2.75	2.50	2.30
400	3.00	7.75	2.50
450	3.25	3.00	2.80
500	3.50	3.20	3.00
560	3.75	3.70	3.20
630	400	3.70	3.40

Figure 29: Maximum support spacings for above ground pipework

The above table gives recommendations for maximum support spacings for a pipe full of water at an ambient temperature of 20°C or below. At a temperature of 40°C and above, continuous support is required. Above ground pipework should ideally be installed at or near the maximum operating temperature. The pipe will therefore be in its expanded state when installed.

As the pipeline cools, any contraction will be resisted by the pipe clamps, and when reheated to its normal operating temperature pipe sagging between supports will be minimized. Polyethylene is a good insulating material (thermal conductivity 0.4 w/m°C) and will help prevent or delay the freezing of the pipe contents.

The pipe itself will not fail if the contents do freeze as PE can safely expand to cater for the increased volume. It is however, good practice for operational reasons to insulate pipe work to prevent freezing and to ensure the insulation is waterproof. Pipework should be protected from possible impact damage and provision should be made for draining down horizontal pipe runs at low points in the system.

Above Ground Installation

As polyethylene is a flexible pipe material, adequate pipe support must be provided to prevent sagging when PE pipes have to be installed above ground. Pipe supports should be designed to support both the pipe weights and its content and also accommodate the weight of any heavy fittings, valves etc. The pipe brackets, straps or plinths should have flat surfaces, and be 0.5 x pipe OD or 100 mm min wide (whichever is greater) and have non-abrasive surfaces to prevent damage to the pipe. The support and bracketing design should allow for the stresses generated from thermal movement and if, for aesthetic reasons pipe deflection is unacceptable,

continuous pipe support should be provided.

Trenchless systems

Directional drilling

This technique is generally used for larger diameter pipelines over longer distances with the pipe line following a shallow arc under an obstacle such as a river or railway track. A rotating and steerable drill around 80 -140 mm is launched from the surface at an angle of 8 – 15° and is used to drill a pilot bore under the obstacle. Either a fluid jet cutter or mud driven motor head is used, depending on ground conditions. The bore is enlarged by a rotating barrel reamer. Then the PE pipe is pre-assembled at the exit point and usually jointed and pressure tested prior to installation. The pipe line is then attached to the reaming head and pulled through the newly formed bore using the pullback capacity of the drilling rig.

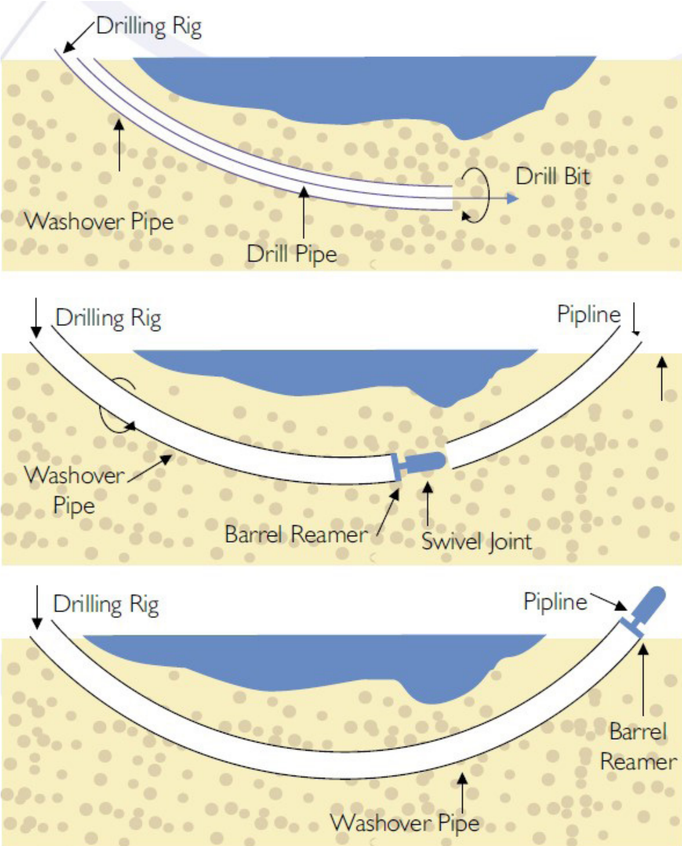


Figure 30: Typical Directional Drilling Operation

Pipe Bursting

This is a method of re-habilitating an existing pipeline where a nonstructural lining method would be unacceptable. With pipe bursting the exising pipe is cracked open and the new pe pipe is drawn into the hole created, and provides either a size or size replacement pipe or by use of reamers the original main can be upsized.

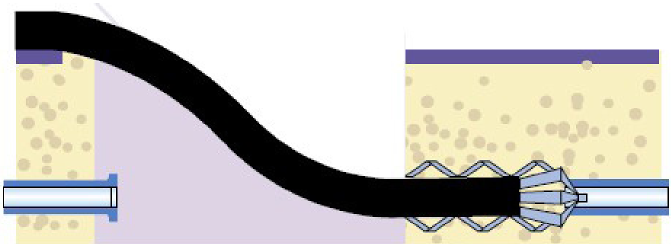


Figure 31: Typical Pipe Bursting Operation

Nowadays hydraulic bursting tools are capable of cracking out both pipes and fitting in very demanding situations, and further adaptations are now capable of splitting ductile iron and steel mains.

Slip Lining

The insertion of smaller diameter PE pipe, slip-lining into an existing pipeline is one of many no-dig techniques for rehabilitation of ageing pipelines. With slip-lining there is inevitably a reduction in pipe bore, although this can be minimized by thorough cleaning of the old main and choosing the largest possible pipe size for insertion.

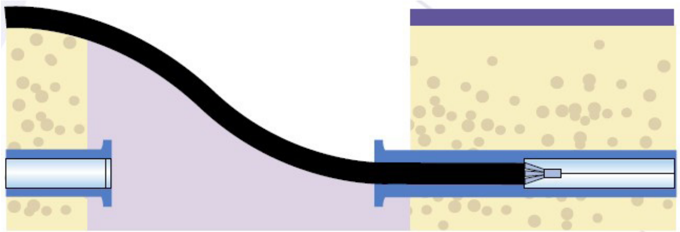


Figure 32: Typical Slip Lining Operation

The smaller bore is also compensated for by the greatly improved flow characteristics of polyethylene and in many case the higher operating pressure capability of the new pipe. Pressure grouting of the annular gap provides structural rehabilitation of the existing pipe and reinforces the overall strength of the new pipe. Grouting may also offer a more economical total installation by allowing the use of a thinner walled PE pipe. Consideration should be given to the resistance of the pipeline to grouting pressures and this will depend on pipe SDR and ovality (especially coiled or drummed pipe).

PE Liner pipes

Corrosion in steel pipes for gathering and injection systems is one of the major cost factors in the oil & gas industry today. A large amount of these costs are caused by maintenance, repairs or replacement of corroded pipes. Lining of carbon steel pipes with a carefully designed polyethylene pipe is a highly cost-effective solution to these problems. Muna Noor manufactures PE liner pipes as per PDO specification ERD43-15 as well as DEP 31.40.30.34. Liner pipes are manufactured to customer specified outer diameter and wall thickness in diameter ranging from 50 mm to 1000 mm. For more specific details contact the manufacturer.

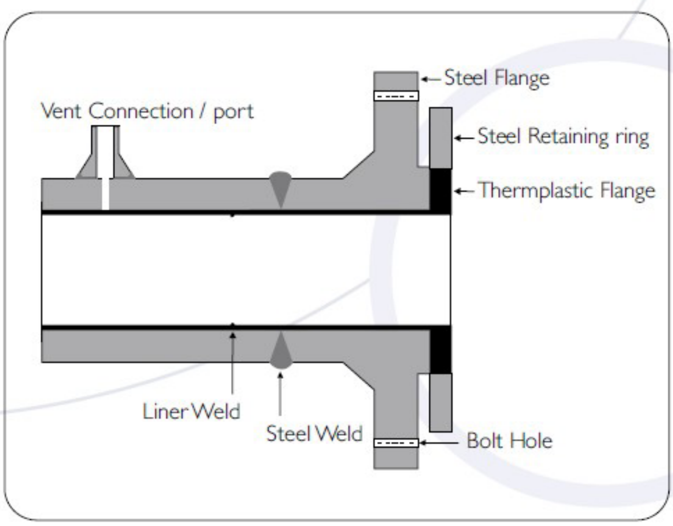


Figure 33: Typical PE liner flange connection

Other PE product lines

Gas Pipe

Pipes for supply of Gaseous fuels

Dimensions of POLYETHYLENE PIPE PE 100 - AS Per EN 1555-2: 2002

Nominal Outside Diameter	SDR 17.6	SDR 11	Nominal Outside Diameter	SDR 17.6	SDR 11
	Wall Thickness	Wall Thickness		Wall Thickness	Wall Thickness
mm	mm	mm	mm	mm	mm
20	2.3	3.0	180	10.3	16.4
25	2.3	3.0	200	11.4	18.2
32	2.3	3.0	225	12.8	20.5
40	2.3	3.7	250	14.2	22.7
50	2.9	4.6	280	15.9	25.4
63	3.6	5.8	315	17.9	28.6
75	4.3	6.8	355	20.2	32.3
90	5.2	8.2	400	22.8	36.4
110	6.3	10.1	450	25.6	40.9
125	7.1	11.4	500	28.4	45.5
140	8.0	12.7	560	31.9	50.9
160	9.1	14.6	360	35.8	57.3

Figure 34

For more than four decades HDPE pipe has proven its competence in distribution of natural gas where a safe, leak-proof system is absolutely critical. Omanplast Polyethylene gas pipe is a proven performer in the industry. Pipes in diameters from 20 mm to 1000 mm are manufactured by Muna Noor currently for gas distribution.

Grooved duct

Muna Noor manufactures internally grooved polyethylene ducts for protection of Fiber Optic Cables. The inner wall of the duct is provided with uniform longitudinal grooves. When the cable is pulled or blown through the duct the grooved design provides only point contacts between the cable and the internal surface of the duct, reducing the coefficient of friction significantly.

Figure 35: Polyethylene Pipe in Coils

Dimensional Chart for HDPE grooved duct

Normal Outsite Diameter mm	Tolerance mm	Max. Ovality mm	Wall Thickness mm t	Grooved Depth mm h
25	+0.3	1.3	2.6	0.3±0.1
32	+0.3	1.3	3.0	0.3±0.1
40	+0.3	1.3	3.5	0.3±0.1
50	+0.5	1.4	4.6	0.4±0.2
63	+0.6	1.4	5.0	0.4±0.2
Supplied in 100 / 200 / 500 Mtr. Coils.mm				

Figure 36

Double Wall Corrugated Duct

Double wall corrugated duct is manufactured from polyethylene with a double wall profile of corrugated outer wall and smooth inner wall.

Omanplast corrugated duct has a ring stiffness of 500N/cm2 and has exceptionally good flexibility, making it ideal for cable ducting.

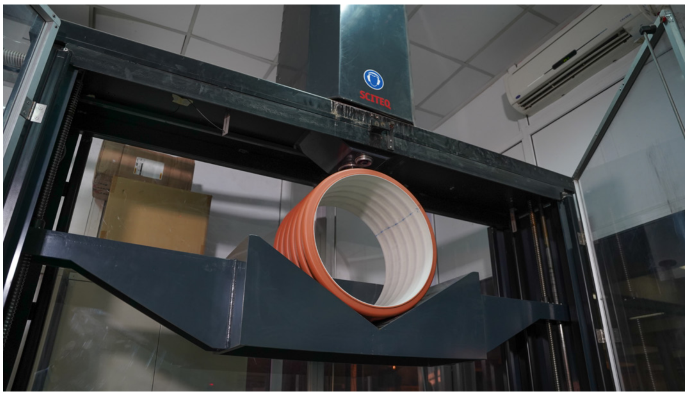


Figure 37: Polyethylene Pipe in Coils

Dimensional Table for Corrugated PE duct

Outside Diameter	Tolerance (mm)	Minimum Inside Diameter	Lengths
*63	+1.2	50	100 Meters coil
*75	+1.4	60	
*90	+1.7	71	
110	+2.0	94	
*160	+2.9	140	
* On Request			

Figure 38

Pipes for supply of Gaseous fuels

Dimensions of POLYETHYLENE CONDUIT - NEMA TC-7-2005 EP EC - 40 / ASTM D2447 SCH 40

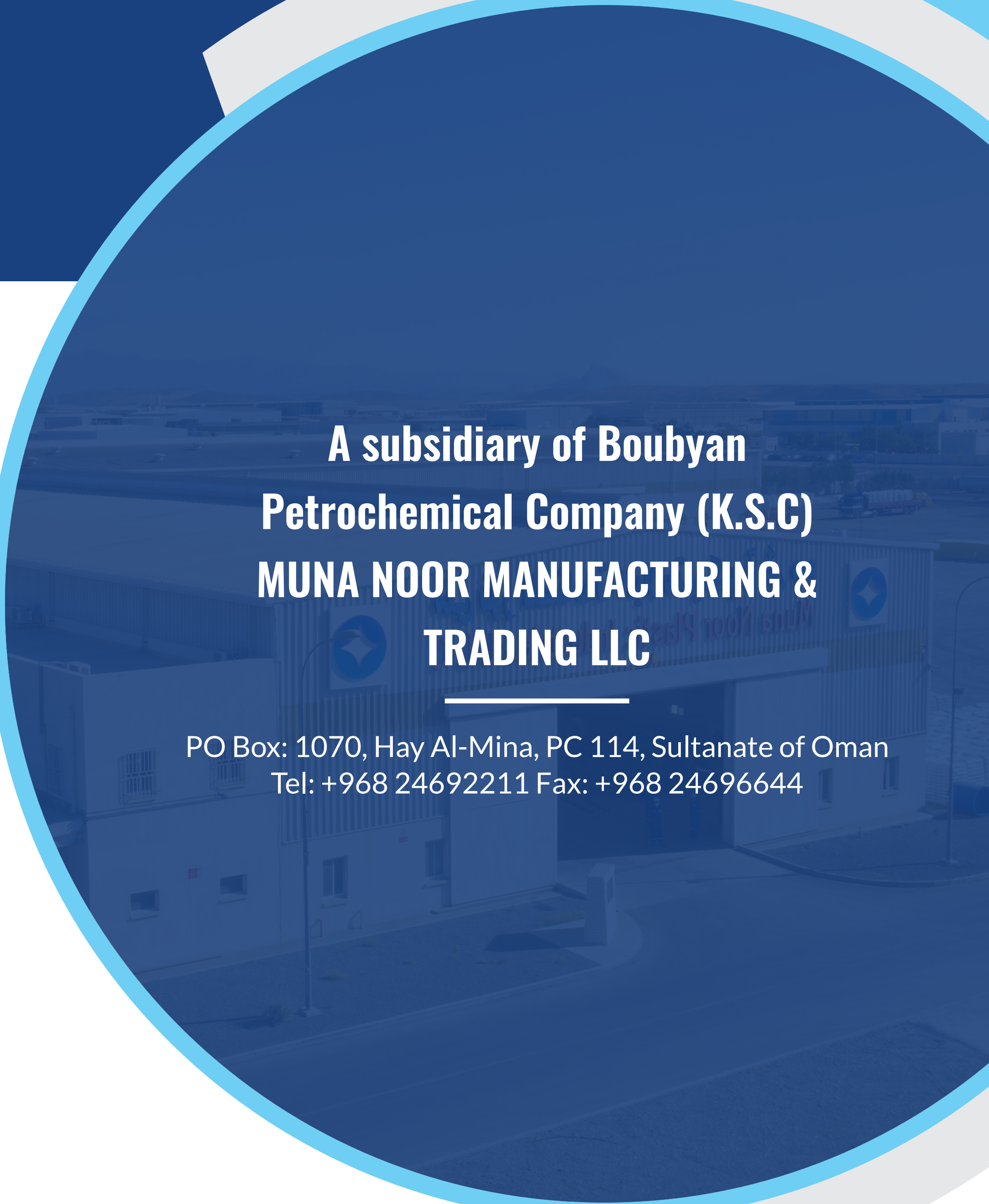
Nominal Size	Avarage Outside Diameter		Wall Thikness (WT)		WT Tolerance(+)	
	Inch	mm	Inch	mm	Inch	mm
1/2"	0.84	21.34	0.109	2.77	0.021	0.51
3/4"	1.05	26.67	0.113	2.87	0.020	0.51
1"	1.315	33.40	0.133	3.38	0.020	0.51
1-1/4"	1.66	42.16	0.14	3.56	0.020	0.51
1-1/2"	1.9	48.26	0.145	3.68	0.020	0.51
2"	2.375	60.33	0.154	3.91	0.020	0.51
2-1/2"	2.875	73.03	0.203	5.16	0.024	0.61
3"	3.5	88.90	0.216	5.49	0.026	0.66
4"	4.5	114.30	0.237	6.02	0.028	0.71
5"	5.562	141.27	0.258	6.55	0.031	0.79
6"	6.625	168.28	0.28	7.11	0.034	0.86
8"	8.625	219.08	0.322	8.18	0.039	0.99

Figure 39: *Since 8" is not listed in NEMA a proportionate wall thickness is assumed

Dimensions of POLYETHYLENE CONDUIT - NEMA TC-7-2005 EP EC - 80 / ASTM D2447 SCH 80

Nominal Size	Avarage Outside Diameter		Wall Thikness (WT)		WT Tolerance(+)	
	Inch	mm	Inch	mm	Inch	mm
1/2"	0.84	21.34	0.147	3.73	0.020	0.51
3/4"	1.050	26.67	0.154	9.91	0.020	0.51
1"	1.315	33.40	0.179	4.55	0.021	0.53
1-1/4"	1.660	42.16	0.191	4.85	0.023	0.58
1-1/2"	1.900	48.26	0.200	5.08	0.024	0.61
2"	2.375	60.33	0.218	5.54	0.026	0.66
2-1/2"	2.875	73.03	0.276	7.01	0.033	0.84
3"	3.500	88.90	0.300	7.62	0.036	0.91
4"	4.500	114.30	0.337	8.56	0.040	1.02
5"	5.562	141.27	0.375	9.53	0.045	1.14
6"	6.625	168.28	0.432	10.97	0.052	1.32
8"	8.625	219.08	0.507	12.88	0.052	1.32

Figure 40: *Since 8" is not listed in NEMA a proportionate wall thickness is assumed



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