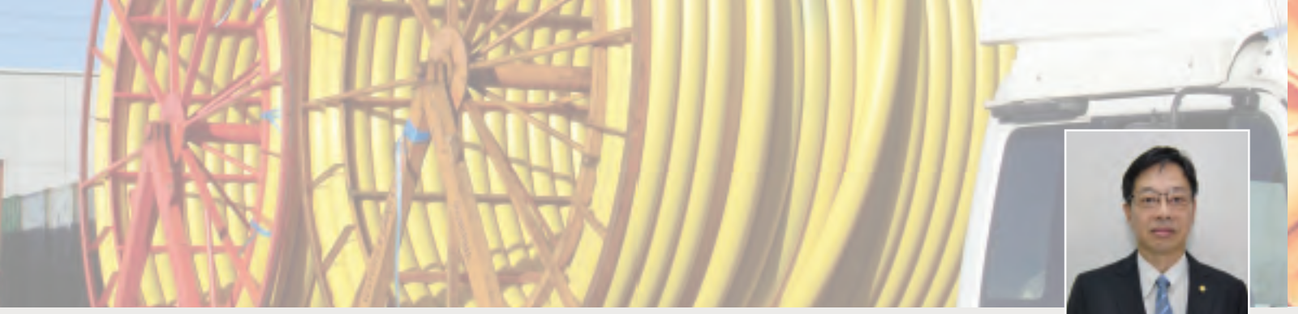

Application Trend of Polyethylene (PE) Pipes

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Pipeline is a line of pipe with plumbing parts, pumps, valves and control devices in delivering liquid, gas and slurries[1].

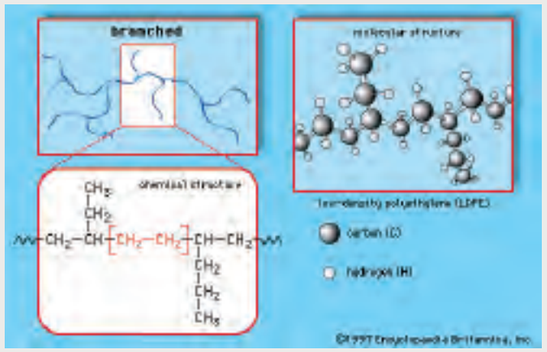
Marvel of Engineering for pipes in England has been found back in 43 AD when the Roman invaded England.

Pipe technology was developed slowly during the Roman period. Examples include Aqueducts, canals and rolled lead piping. Wooden piping was still found in use as recent as the 1890's.

Cast iron and light-gauge copper were imported from U.S. in 1960's and 1930's respectively for pipe manufacturing.

Metallic piping materials has been applied in plumbing and drainage for decades, commonly used pipe materials includes steel, cast iron, and copper, bronze in Hong Kong.

Polymer is used for plastic pipeline manufacturing. Common plastic materials for drainage pipeline manufacturing is PVC since 1950.[2]



Polyethylene (PE) is one of common materials applied in drainage system recently. PE is a partly crystalline thermoplastic polymer and is composed of a long molecule chain with branches.

This kind of materials can be said fully neutral to environment because there are no additives and it mainly consists of carbon and hydrogen.

PE is classified based on densities, there are PE-LD, PE-MD and PE-HD. Their suffixes, LD, MD, HD are referring to low density, medium density, high density respectively.

In engineering point of view, material strength is one of important factors for the considerations of selection of materials. For example, PE-HD can be divided into different materials class. PE-80, and PE-100 present strength information. RC means higher resistance to crack (RC). With such presentation, the pipe application is preliminary presented. For example, PE100-RC means that the pipe can give long-term hydrostatic strength of 10MPa with water at 20°C for 50 years.

PE pipe has been widely used in plumbing system for years in Water Supplies Department (WSD) projects. Recently, PE pipe has been applied in Drainage Services Department (DSD) projects for drainage system. The standard and requirements of the PE pipes are summarized below.

The compounds for manufacturing PE pipe and fittings shall conform to BS EN 12201-1 “Plastics piping system for water supply and for drainage and sewerage under pressure – Polyethylene (PE) part 1: General”

For PE100-RC, PE compounds shall meet requirement as defined in Clause 3.1 of PAS 1075 “ Pipes made from Polyethylene for alternative installation techniques”.

For pipes with a burial depth to the top of the pipes less or equal to 3.8m, Standard Dimension Ratio (SDR) of 17 shall be used. Smaller SDR usually for greater burial pipe depth.

PE piping for Gravity Sewer and Stormwater Drain shall be made from 100% virgin, pre-coloured compounds as per DSD specification.

Typically, the pipes and fittings are Graphite Black in colour with Reichs-Ausschuss fur Lieferbedingungen (RAL) Code 9011 and have an internal co-extruded pastel orange colour layer (RAL Code 2003). The co-extrusion can be referred to standard BS EN 12201-2 Annex B. The thickness of layer shall be 15% of nominal pipe wall thickness around the entire internal circumference.

Colour is as an identification reference, pre-compounded strip with Red brown - RAL code 8012 for gravity sewer and Fern Green with RAL 6025 for gravity stormwater drain. For underground pipes, striping system follows below tables.

Pipeline is usually made up with pipes and fittings to extend their length, network. There are fittings like connector, transition fittings, puddle flanges. All fittings shall have permanent and legible marking in compliance with BS EN 12201-3, “Plastic piping systems for water supply and for drainage and sewerage under pressure -PE part and fittings”.

Puddle flanges shall not be made from welded or with joint. They shall be moulded and shall be machined from a single piece of PE.

Apart from the puddle flanges, butt or side fusion for fittings refers to ISO21307, plastic pipes and fittings - butt fusion jointing procedures for polyethylene (PE) pipes and fittings used in the construction of gas and water distribution systems.

Transition fittings and manhole connectors, a PE/rubber ring for sealing shall comply BS EN 12666-1, Plastics piping systems for non-pressure underground drainage and sewage Polyethylene (PE) – Specifications for pipes, fitting and the system.

In selection of PE pipe materials, we must check the engineering properties of PE-HD.

Specific properties of PE-HD*

Properties	Standard	PE80	PE100	Unit
Density	DIN EN ISO 1183	0.935 0.94–0.965	0.95 0.95–0.965	g/cm³
Bearable stress at 20 °C/50a	DIN 8074/75	≥ 8	≥ 10	MPa
Melt flow rate (MFR 190/5	ISO 1133	0.4–0.7 0.8–1.2	0.2–0.4	g/10min
Yield stress	DIN EN ISO 527	19–23	23–25	N/mm²
Yield strain	DIN EN ISO 527	8.5–10	8–9	%
Tensile strain at break	DIN EN ISO 527	>700	>700	%
Tensile stress at break	DIN EN ISO 527	32–35	35	MPa
E-modulus (secant)	DIN EN ISO 527	750–1000	900–1100	MPa
Flexural creep modulus (1 h/1 a)	DIN 19537-2	900–1000	1200	N/mm²
Notched impact strength at +23 °C	DIN EN ISO 179	12–24	25–28	kJ/m²
Notched impact strength at –20 °C	DIN EN ISO 179	4–9	6–13	kJ/m²
Ball indentation hardness	DIN EN ISO 2039	46	48	N/mm²
Shore hardness D	DIN 53505	57–62	59–63	
Thermal conductivity 20 °C	DIN 52612	0.4	0.4	W/mK
Coefficient of linear thermal expansion	DIN 53752	2 x 10⁻⁴	2 x 10⁻⁴	K⁻¹

Chemical	Percentage/ concentration *	Temperature 20 °C PE-HD	40 °C PE-HD	60 °C PE-HD
Chromic acid	50 %	●	○	○
Chromic acid/sulphuric acid/water	15/35/50 %	○	○	○
2.5 % acid	10	●	●	●
Copper chloride	10	●	●	●
Copper nitrate	10	●	●	●
Copper sulphate	10	●	●	●
Diesel*, aqueous	up to 90 %	●	●	●
Diesel*, aqueous	> 90 %	●	●	○
Dichloroethylene*	10	●	•	○

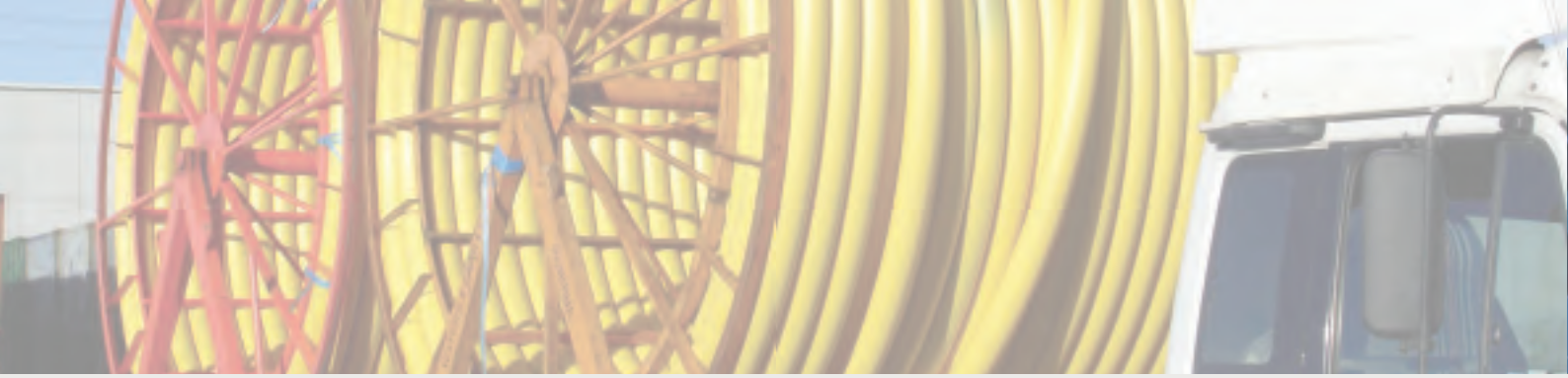
2.3 Dimensions and weights for GEROfit®R

Nom. size	Dimensions							Weights		
	Core pipe		Jacket		System pipe			System pipe [kg/m]		
	$d_{n,min}$	$d_{n,max}$	e_{min}	e_{max}	$d_{n,min}$	$d_{n,max}$	$d_{n,max}$	SDR 17	SDR 11	SDR 7.4
25	25.0	25.3	0.6	0.8	28.2	27.1	28.7		0.23	0.30
32	32.0	32.3	1.0	1.5	34.0	34.9	34.5	0.31	0.39	0.50
40	40.0	40.3	1.0	1.5	42.0	42.9	42.5	0.44	0.51	0.75
50	50.0	50.3	1.0	1.5	52.0	52.9	52.5	0.66	0.85	1.13
63	63.0	63.4	1.1	1.4	65.2	66.2	65.7	0.92	1.20	1.73
75	75.0	75.5	1.2	1.5	77.4	78.5	78.0	1.21	1.78	2.62
90	90.0	90.6	1.2	1.5	92.8	93.8	93.0	1.63	2.50	3.68
110	110.0	110.7	1.3	1.7	113.6	114.1	113.4	2.08	3.67	5.03
125	125.0	125.8	1.4	1.8	127.8	129.4	128.6	3.39	4.72	6.44
140	140.0	140.9	1.5	1.9	143.0	144.7	143.9	4.21	5.84	8.04
160	160.0	161.0	1.7	2.1	165.4	165.2	164.7	5.48	7.65	10.40
180	180.0	181.1	1.9	2.2	185.8	187.5	186.9	7.06	10.10	13.70
200	200.0	201.2	2.1	2.2	205.4	207.6	206.5	8.89	12.30	16.70
225	225.0	226.4	2.1	2.2	230.4	232.5	231.6	11.00	15.20	20.80
250	250.0	251.5	2.1	2.2	255.4	257.8	256.7	13.30	18.50	25.50
280	280.0	281.7	2.5	4.0	287.0	289.7	288.4	17.00	23.60	32.80
315	315.0	316.9	2.5	4.0	322.0	324.9	323.5	21.10	29.40	40.40
355	355.0	357.2	2.5	4.0	362.0	365.2	363.6	26.40	36.90	50.80
400	400.0	402.4	2.5	5.5	408.0	411.4	411.7	34.60	48.00	65.70
450	450.0	452.7	2.5	5.5	460.0	463.9	461.9	42.80	59.80	82.20
500	500.0	503.0	2.5	5.5	510.0	514.0	512.8	52.80	73.80	101.80
560	560.0	562.8	2.5	5.5	570.0	574.4	573.2	66.10	92.40	125.80
630	630.0	633.0	2.5	5.5	640.0	646.0	643.8	84.60	118.00	157.00

As the opening of the internal market and the free movement of goods and services within Europe, all manufacturers of construction products falling under the European Construction Products Directive (CPD) are obligated to put the CE mark on their products. The CE mark is based on harmonised European Norms which define the requirements and tests for the products.

Other engineering factors have also been taken into considerations for the application of PE Pipes. They include:

- Maximum allowable operating pressures
- Long-term hydrostatic strength for PE-80 / PE-100 (DIN 8075)
- Creep modulus for PE-80 / PE-100
- Standard dimension ratio SDR as basis for PE-HD pressure pipes use in vacuum sewerage systems
- Performance in fire



- Electrical properties - electrostatic charge accumulation, earthing (grounding)
- Light fastness and weather resistance
- Microbiological resistance
- Abrasion / abrasive strength
- Organoleptic properties – Health assessment of plastics
- Radiation resistance
- Water absorption
- Locating pipes underground
- Chemical resistance

Engineering calculations are recommended when application of PE Pipe such as:

- Length change in temperature & pressure
- Fixed-point loads
- Length of expansion bends
- Support spans
- Minimum allowable bending radii
- Pipe volume per meter for selected SDR classes
- Buckling pressures – external pressure loads
- Maximum allowable tensile forces
- Hydraulic calculations
  - o Flow rates in pipes
  - o Pressure drop (P.D.) in pipes -Nomogram for approximate P.D. calculations
  - o Pressure surges
  - o Velocity of the shock wave

Application of PE pipes for fluid is mature. PE pipes are widely used in industry areas, petrol stations, dumpsites, utilized agricultural area, harbour areas, station areas and road routes, flooded and high water areas, groundwater interchange zones.[3] PE-LD has both long-and short-chain branches attached to the main chain occasionally.

It is soft and flexible because of low melting point. PE-HD is unbranched polymer, semi-crystalline with a combination of amorphous and thin lamellae crystals. Therefore, it gives high toughness, high strength stiffness as well as good chemical resistance at room temperature. PE-HD, especially cross-link PE is very suitable for drainage application for acid waste, effluent or laboratory discharge.[4]

Reference:

[1] Encyclopaedia Britannica, Encyclopædia Britannica, Inc.©2019

[2] https://www.emergencyplumber.uk.com/plumbing/the-history-of-pipes/, 26 July 201907:43

[3] Technical Information: Piping systems – materials and uses, Gerodur, Eternity (P&D) Products) Company, 2019

[4] Dr. Muralisrinivasan Natamai Subramanian, Basics of Polymers – Fabrication and Processing Technology, Momentum Press Engineering, 2015