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NTG PLASTİK

TECHNICAL HANDBOOK

PE PIPE FITTINGS

OUR MISSION

Produce high quality, reliable and competitive pipe fittings for the gas and fluid transmission systems.

CONTENT

INTRODUCTION

The purpose of preparation of this book is to give you professional solutions about pipe and pipe fittings; from material to calculations, from welding methods to applications.

Our production is carried upon in accordance with relevant standards such as, DIN, ISO, TSE, EN with the continuous support of our R&D laboratory facilities. TSE, ISO 9001:2000, DVGW and Gost-R are just some of the certificates that we were awarded and our work continues to achieve better results.

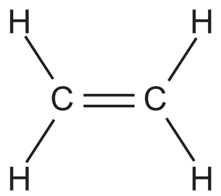
This PE pipe fittings handbook could help you with your project. However, the given definitions and the technical information in this handbook should be considered only as reference. For binding issues one should refer for further technical assistance.

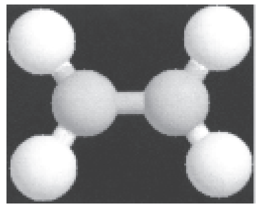
MATERIAL

ETHYLENE

Ethylene (IUPAC name; ethene) is the colourless gaseous from alkene group. As an unsaturated hydrocarbon, it contains a double bond between two carbon atoms. It is a flammable gas with the formula C_2H_4, boils at -69,4 °C, melts at -103,3 °C, and it's density is 0.978 g/cm^3. Its solubility in water is medium, but it is highly soluble in alcohol, ether, benzene (benzol), and acetone (dimethyl ketone). It can go through many types of reactions with high ability. As it reacts quickly with double bonded materials such as halogens and sulphuric acid; ethylene also polymerizes to produce polyethylene. The air mixture is explosive, if the air contains at % 3- %34 ethylene. It has low level poisonous effect, but can cause to unconsciousness at high concentration in air.

Approximately 30,4% of ethylene is used to create ethyl alcohol (ethanol), 25% for ethylene oxide, %10 styrene, % 10 ethyl chloride, % 15 used for polyethylene. It is rarely used for other purposes. Big portion of Ethylene is produced by steam cracking of petroleum gases in pyrolise ovens.

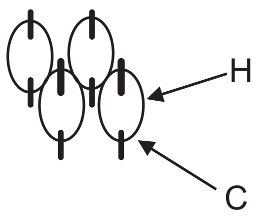




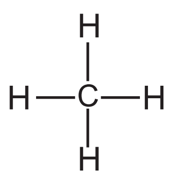
PLASTIC MATERIALS

They are organic materials, used in structures with metals and ceramics. Plastics are typically polymers as to chemical composition. Polymers are large molecules composed of repeating small structural units. Plastic molecules that consist of repeating monomer subunits, can be in solid, liquid, or gas phase due to number of mer. Definition of plastics refers to the material type. It is defined as a material which undergoes a permanent change of shape under pressure. Copper is a plastic material but not from plastics chemically. On the other hand, baculite is a plastic, but since it is breakable it is not generally considered as a plastic material. Thus, industrial plastic defined as fluid and plastic (elastic) in some phases of their production, and it can take shape of the mould under pressure. Plastics can be classified in two groups: Natural and Synthetic. Wood, leather, wool etc. fibre materials are natural. Others, which are commonly used in industry, are synthetic polymers.

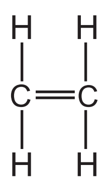
The word "polymer" originated from two words. While "poly" refers to many, "mer" refers to unit (molecule), therefore "polymer" refers to many units. Hence, polymer comprises of repeating unit molecules. Polymers, which are capable of recovering their original shape after being stretched to great extents, called elastomers. Synthetic and natural rubbers are elastomers.



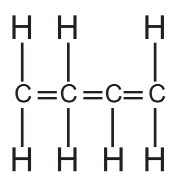
Polymerization: Polymerization is a process of forming monomer molecules together, to form bigger molecules. One of the simplest compound that forms polymer is methane.



Methane CH_4



Ethylene (monomer)



Polyethylene (polimer)

DEGREE of POLYMERIZATION is the average length of a polymer chain that can extend. If a polymer contains one type of monomer, its polymerization degree is the average number of mers or molecules in chain. This value is between 75 and 750 for industrial plastics.

$$\text{Polimerization Degree} = \frac{\text{Molecular weight of Polymer}}{\text{Molecular weight of Mer}}$$

Plastics are generally resistant to acids and natural factors, neutral against water but they are flammable. Plastics soften above 80ºC.

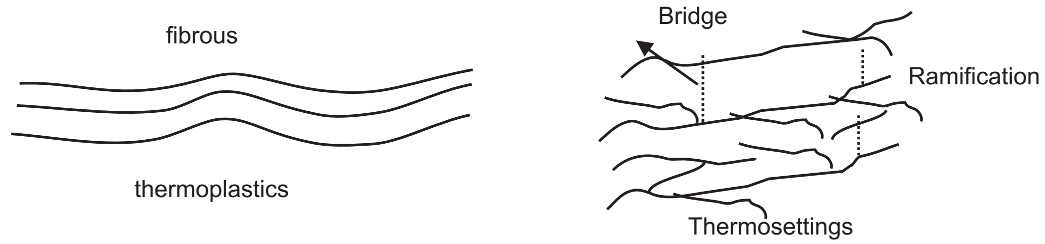
Polymers specific gravity is low; about 1-2 gr/cm^3.

Due to their behaviours under temperature, there are two groups of plastics in industry; thermoplastics (linear polymers) and thermosetting plastics (space-network polymers).

Thermoplastics are linear polymers and they go to liquid phase when heated, and hardens when cool down. Thermoplastics are generally ductile substances and mechanical properties vary under different loading speed, loading time and temperature. Its shape changes under static pressure at room temperature.

Thermosetting plastics get hard after polymerization process and they do not soften again. Some linear polymers turn into space-network polymers after double covalent compound is formed between molecule chains. These different behaviours of plastics come from chemical structure of molecules. Hence, this changes due to molecule's size (number of mer), lining up of molecules and strong bonds between molecules. Thermosetting plastics are brittle, prone to crack without plastic elasticity. Resistance decreases while temperature goes up. Molecules ramify at thermoplastics, and new bond connections exist between nearby molecules. Mechanical resistance increases. Ramify occurs when a macromolecule connects another. Bridging causes corrosion of polymers.

But in thermoplastics, molecules are long, fibrous and disjointed. They can bend easily and have no resistance to slipping.



Elasticity of plastics is quite low compared to metals, about % 1 those of metals. Increasing of deformation under constant tension is called viscous deformation, time-dependent deformation and returning to initial form is called viscoelastic behaviour and this group of materials is called viscoelastic material. Linear polymer materials are viscoelastic materials.

The reason plastics are also called organic material is carbon (C) in their composition. Long chains of C atoms held together by covalent bonds, builds up polymer's keystone. Carbon is a high resistant material with a tensile strength of 3100 Mpa. Most important atom that joins C chains is H (Hydrogen) atom.

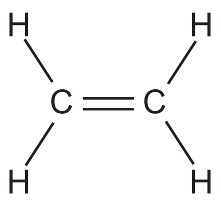
Molecular structure of polymers is dependent on polymerization degree, ramify and diagonal bond formation, thus no certain values can be given. Polymers mass or resin resistance are low comparing to other materials but this can be lift up by transforming it to fibrous composite material.

POLYETHYLENE

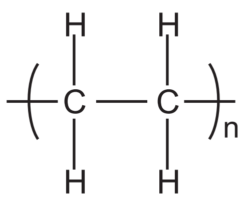
Polyethylene was first synthesized at 1930’s. Then different process methods and crystal systems are used for improving new polyethylene for various applications. First PE applications were for military purposes. It is used broadly during the 2nd World War, mainly for covering underground pipes and for radar insulation etc.

Polyethylene is used in various consumer products. Polyethylene’s name comes from ethylene in monomer form, and it consists of ethylene. PE is abbreviation for Polyethylene in plastic industry. The ethylene molecule C_2H_4 is actually CH_2=CH_2, Two CH_2 groups connected by a double bond. Polyethylene is created through polymerization of ethylene. It can be produced through radical polymerization, anionic polymerization, ion coordination polymerization or cationic polymerization. Each of these methods results in a different type of polyethylene.

Polyethylene had started with the production as low density, later improved to three new more type: high density, linear and medium density. Each of these four type contains monomer ethylene and different structures of polymer molecule caused others existence. Different branching ways of chain shaped macromolecules which form polymer molecules, cause polyethylene’s variety. For example, linear low density polyethylene has very short branches, high density has a bit more, and medium density polyethylene has more. At low density polyethylene, branching level is maximum, and its length also has effects on polymer’s characteristics. These four types of polyethylene are the basic polymeric materials of industry and they have variety of usage fields.



Ethylene



Polyethylene

CLASSIFICATION of POLYETYHLENE

Polyethylene is classified into different categories based on its density and branching. The mechanical properties depend on variables such as the type of branching, the crystal structure and the molecular weight.

UHMWPE	(Ultra High Molecular Weight PE)
HDPE	(High Density PE)
HDXLPE	(High Density Cross-Linked PE)
PEX	(Cross-Linked PE)
MDPE	(Medium Density PE)
LDPE	(Low Density PE)
LLDPE	(Linear Low Density PE)
VLDPE	(Very Low Density PE)

PROPERTIES

General characteristics of PE:

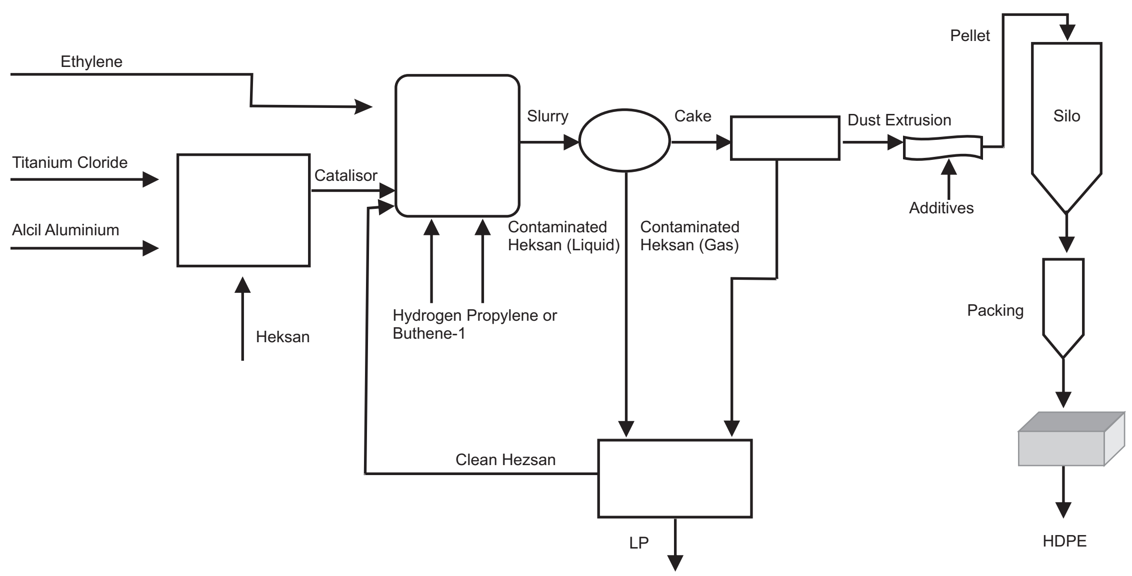
- Durable
- Resistant to acid, base and solvents
- Superior dielectric features
- Resistance to environmental conditions
- Easily processed

Ramifications of polymer chain determine the degree of crystallite. Ramification in linear and high density polyethylene is very little and its molecule structure is linear. If molecule structures’ ramification is small, crystallite is generally too much. As the crystallite of polymer increases; hardness increase, mechanical and chemical features improve and resistance to liquids and gases increase. The best feature defining polymers is the average molecule weight of polymer. Average molecule weight is approximately determined by melting index. Melting index is inversely proportional to the molecule weight. Polyethylenes with high molecule weight have higher hardness and durability, their melting flow indexes (MFI) is lower. According to the rule which is generally valid for all polymers, high molecule weight is equivalent to low melting flow index. Molecule weights of polymers are measured by Gel Permeation Chromatography (GPC) device. This device is latest technological device and its operation is very special. The chemicals below are added into polyethylene by melting with mixing method under pressure to improve the features of polyethylene and increase its durability against outer effects.

Antioxidants: These kind of chemicals are usually phenolic and divided into two groups: primary or secondary. Primary antioxidants (sometimes referred to as radical scavenging antioxidants) terminate free radicals which occurs from termination of macromolecule with increasing temperature, and prevent their augmentation. Secondary antioxidants fragment hydrogen peroxide in decomposing of polymer's oxidation and prevent decomposing. Different mixtures of these two antioxidants makes the polymer resist against decompositions for long term, this is called as synergetic effect. If phenolic antioxidant increase over 500 ppm., paling problem may occur while storing under dark areas.

UV stabilizers: Ultraviolet sun light impacts every kind of carbon-carbon bond, weakens the bonds and finally breaks it. To prevent this, some chemicals is added to polymer which absorb the ultraviolet effect. These chemicals are gathered in two groups: UV absorber and UV quencher. Also, synergetic effected mixtures of these groups are used for increase the UV stabilization. UV additives are generally three type: Benzophenone, Nickel quencher and HALS. UV additives in today's industry are the materials given above or combinations of them at different ratios. HALS are new materials and their chemical name is "Hindered Amin Light Stabilizers". Although coloured pigments are also have noticeable ability to prevent UV. In particular, carbon is commonly used for increasing the UV resistance of black polymer.

Sliders and anti-blockings: Amines of oil acids (stearic acid, oleic acid, erusic acid) and inorganic compounds including over 90% silicon dioxide are used to prevent blocking. Distribution of granule size and oil absorbance of the substance is very important in anti-blocking additives .Oil absorption in anti-blocking substance used by slider is very important. Properties change type by type, but their general properties are: resistance to environment and moisture, flexibility, low mechanical strength and high chemical resistance. They have very low cost and have very spread usage, as in containers, plastic boxes, kitchen objects, coverings, pipe and tube, insulating cables, packing and wrapping films etc.



Shape 1: HDPE production

POLYETHYLENE 100 (PE100)

The fast improvements in the plastic technology caused important progress raw materials production. PE32-LDPE type polyethylene, which has been improved in 1950's has been successfully used in drinking water piping system which does not need high pressure. Polyethylene producers improved PE80 (=6.30 Mpa) after PE63 as the second generation and presented to usage. Thus PE80 raw material started production for water pipes and natural gas network. Economic and highly performing PE100, third generation raw material, has been produced at 1999. It s most important advantage is, it has high stretching resistance and security coefficient. PE100's greatest advantage is having a high stretching resistance and security coefficient. For example a pipes permitted working pressure is 10 bar if it is being produced by PE80 according to SDR11, and 16 bar if PE100 is being used. It means that pipes produced with PE100 allows working in higher pressures in less wall thickness. Pipes that produced with PE100 have more quality as well as bring %30 material savings and economy.

Depending on molecular weight, polyethylene is either unimodal or bimodal. PE100 is bimodal polyethylene. A good quality polyethylene should have high molecular weight. If polyethylene material does not have high molecular weight, it cannot be processed well. So, the PE pipe would not be at desired mechanical properties and strength. High durability and required mechanical properties of polyethylene pipe could only obtain by bimodal polyethylene raw material (PE100). Bimodal polyethylene is fabricated by a mixture of two different molecule weights that applicable with previous requirements. Bimodal molecule's structure, contains both long polymer chains of a polymer grain that strengthen the pipe and short polymer chains that gives plasticity to product in a polymer particle in most suitable and optimum way. Besides, combination of long and short chain adds high strength to PE100, against stretch and high resistance against cracks in low and fast progress.

PROPERTIES OF POLYETHYLENE PIPES AND FITTINGS:

- Not affected by earthquake because of flexible structure, absorbs some degree of extension at areas where landslide is possible.
- Maintain flexibility features at temperatures down to -40 °C.
- Small diameters can be transported in coils by allowing easy handling at site.
- High resistance to chemicals, no corrosion.
- High abrasion resistance, resistant to worn out. No cancerous effect as no molecule transfers to fluid.
- No corrosion from fluid flow and/or ground structure.
- Low density, 8 times lighter than steel.
- Resistant to strokes.
- Lifetime of minimum 50 years under normal operating pressure.
- 100% leak-free with high quality and easy welding methods, no waste at montage.
- Hygienic, no effect on colour and taste of water.
- High stroke resistance in low temperatures.
- Ease in transportation.
- Resistance to weather conditions and UV.
- Resistance to strike and breakings.
- No need to cathodic protection.
- Various welding methods are applicable.

These are some of the advantages of PE100 pipe and fittings.

PROPERTIES	PE 100	UNIT	STANDARD
PHYSICAL PROPERTIES			
Density	0,955	g/cm^3	ISO 1183
Viscosity Number	360	cm^3/g	ISO 1628-3
Melt Flow Rate (190° C / 5 Kg)	0,20-0,45	g/10 min	ISO 1133
MECHANICAL PROPERTIES			
Yield Strength	>22	MPa	ISO 527
Yield Strain	9	%	ISO 527
Elongation at Breaking	>600	%	ISO 527
Tensile Modulus	900	MPa	ISO 527
Charpy Impact Resistance –Notched +23 °C	26	kj/m^2	ISO 179/1eA
Charpy Impact Resistance – Notched -20 °C	13	kj/m^2	ISO 179/1eA
OTHER PROPERTIES			
Oxygen Induction Time (OIT) (210 °C)	≥ 20	min	ISO TR 10837
Carbon Black Ratio	2-2,3	%	ISO 6964
Carbon Black Distribution	≤ 3		ISO 18553
MRS (Minimum Required Strength)	>10	MPa	ISO TR 9080
Slow Crack Growth Resistance 4,6MPa 80°C Notched	>3000	Hour	EN ISO 13479
Linear Expansion Coefficient	1,8x10^{-4}	C^{-1}	ASTM D 696 (20-60 °C)
Specific Heat	1,9	j/gC	BPLC
ELECTRICAL PROPERTIES			
Electrical Resistance	>20	kV/mm	BS 2782:201 B
Volumetric Resistance	>10^{13}	m	BS 2782:230 A
Surface Resistance	>10^{15}	-	BS 2782:231 A
Relative Permeability	2,6	-	BS 2067

Table 1: Properties of PE100

ABRASION RESISTANCE

Comparing to other type of pipes which convey abrasive slurries, polyethylene has highest resistance against abrasion with its very low friction coefficient. Its widespread usage and some laboratory tests has shown that PE's performance exceeds the performance of metallic pipe systems. PE pipes has become the ideal choice for viscous applications with its elasticity, lightness, and easy montage. Abrasive filling stuff has minor exterior effect on PE. If the pipe is cut with a sharp tool, and the cut deepness was more than %10 of wall thickness, damaged part should be replaced with a new one.

THERMAL PROPERTIES

PE pipes can be used in range of temperatures -50 °C to +60 °C. Higher temperatures reduce the hardness and stretch tension. Like all other thermoplastics, also PE shows bigger thermal expansion than metals. PE's thermal expansion coefficient is 0,15-0,2 mm/mK and this value is 1,5 times higher than PVC. PE's thermal conductivity is 0,38w/mK and this characteristic is more economic comparing to metal systems, such as copper.

REACTION to COMBUSTION

Polyethylene is combustive material, burns drop by drop without soot. Toxics is released to atmosphere when burns. Generally most harmful churn is carbon monoxide. Carbon monoxide, carbon dioxide and water occur when the PE burned. PE is self combustible at temperature of +350 °C. Ideal fire extinguisher is water, foam and/or carbon dioxide.

CHEMICAL RESISTANCE

PE shows high resistance to chemical attacks with its non-polar structure like high molecular weighted hydrocarbons. PE cannot be decayed, worn out, or weakened mechanically, by electrical or chemical reactions.

PE shows high resistance to acids, alkaline solutions, solvents, alcohol and water, and low resistance against oxidant acids, ketones, aromatic hydrocarbons and chloral hydrocarbons. Level of chemical resistance, depends on chemical's concentration, temperature and working pressure. This three specifications determine pipe’s life.

Table.2 below shows the resistance of polyethylene against various chemicals at 23 °C and 60 °C. (+) signs in the table indicates polyethylene has chemical resistance, (/) means polyethylene has limited resistance and (-) means polyethylene has no resistance against chemicals.

Name of Chemical	% Concentration	23 °C	60 °C
Acetic acid	100	+	+
Acetic anhydride	100	+	
Acetone	100	+	+
Akkumulator acid	38	+	+
Aluminium salt, aq.	sat	+	+
Ammonia, aq	sat	+	+
Ammonium salts,aq,	sat	+	+
Amyl alcohol	100	+	+
Aniline	100	+	+
Antifreeze glycol	50	+	+
Asphalt	100	+	/
Barium salts, aq.	sat	+	+
Benzaldehyde	100	+	+
Benzene	100	/	-
Benzine	100	+	/
Benzine, normal	100	+	/
Benzine, super	100	/	-
Benzoic acid, aq.	sat	+	+
Bone oil	100	+	+
Borax, aq.	sat	+	+
Boric acid, aq.	sat.	+	+
Break fluid	100	+	+
Bromine	100	-	
Bromine water	sat	-	-
Butane, liquid	100	+	
Bytyl acelate	100	+	/
Butyl alcohol, -n	100	+	+
Calcium salts, aq.	sat	+	+
Carbon disulphide	100	/	
Carbon tetrachloride	100	/	-
Carbonic acid, aq.	sat	+	+
Caustic potash solution	50	+	+
Chlorbenzene	100	/	-
Chlorine water	sat	/	-
Chlorine, liquid	100	-	
Chloroform	100	/	-
Chlorosulfonic acid	100	-	-
Chromic acid	20	+	+
Chromium salts, aq	sat	+	+
Chromiumtrioxide, aq.	sat	+	-
Copper (III)-salts, aq.	sat	+	+
Cresol, aq.	sat	+	/
Cumolhydroperoxide	70	+	
Cyclohexane	100	+	+
Cyclohexanole	100	+	+

Table 2 : Resistance of Polyethylene against Chemicals

Name of Chemical	% Concentration	23 °C	60 °C
Cyclohexanone	100	+	/
Decahydronaphthalene	100	/	-
Detergents, aq.	10	+	+
Dibutylphthalate	100	+	/
Dibutylsebacate	100	+	/
Diesel oit	100	+	/
Diethyether	100	+	
Dihexylphthalate	100	+	+
Diisononylphthalate	100	+	+
Dimethylformamide	100	+	+
Dinonyladipate	100	+	
Dioctyladipate	100	+	
Dioctylphthalate	100	+	+
Dioxane, -1,4	100	+	+
Ethanol	96	+	+
Ethanol amine	100	+	+
Ethyl hexanol, -2	100	+	
Ethyl-2-hexane acid	100	+	
Ethyl-2-hexane acid chloride	100	+	
Ethyl-2-hexyl chloroformiat	100	+	
Ethylacetate	100	+	/
Ethylbenzene	100	/	-
Ethylchloride	100	/	
Ethylene chlorhydrin	100	+	+
Ethylene chloride	100	/	/
Ethylene daimine tetraacetic acid, aq.	sat	+	+
Ethylglykolacetate	100	+	
Fatty acids > C6	100	+	/
Ferrous salt, aq.	sat	+	+
Floor polish	100	+	/
Fluoride, aq.	sat	+	+
Fluosilicic acid	32	+	+
Formaldehyde, aq.	40	+	+
Formalin	industrial	+	+
Formic acid	98	+	+
Frigen 11	100	/	
Fuel oil	100	+	/
Furfuryl alcohol	100	+	/
Glycerine	100	+	+
Glycerine, aq.	10	+	+
Glycol	100	+	+
Glycol acid	70	+	+
Glycol, aq.	50	+	+
Heptane	100	+	/
Heafluosilicic acid, aq.	sat	+	+
Hexane	100	+	+
Humic acids, aq.	1	+	+
Hydrazine, aq.	sat	+	+
Hydriodic acid, aq.	sat	+	
Hydrochinone, aq.		+	
Hidrochloric acig	38	+	+

Table 2 : Resistance of Polyethylene against Chemicals

Name of Chemical	% Concentration	23 °C	60 °C
Hydrochloric acid	10	+	+
Hydrofluoric acid	40	+	+
Hydrofluoric acid	70	+	/
Hydrogen peroxide	30	+	+
Hydrogen sulphide	low	+	+
Hydrosylammonium sulphate	sat	+	+
Hydroxyacetone	100	+	+
Isononan acid	100	+	/
Isononan acid chloride	100	+	
Isooctane	100	+	/
Isopropanol	100	+	+
Lactic acid, aq.	90	+	+
Lauric acid chloride	100	+	
Lithium salts	sat	+	+
Lysol	industrial	+	/
Magnesium salts, aq.	sat	+	+
Menthol	100	+	
Mercuric salts, aq.	sat	+	+
Mercury	100	+	+
Methan suphonic acid	50	+	
Methanol	100	+	+
Methoxyl butanol	100	+	/
Methoxy butyl acetate	100	+	/
Methyl cyclohexane	100	+	/
Methyl ethyl ketone	100	+	+
Methyl glycol	100	+	+
Methyl isobutyl ketone	100	+	/
Methyl sulphuric acid	50	+	
Methyl-4-pentanol-2	100	+	+
Methylacetate	100	+	+
Methylene chloride	100	/	
Mineral oil	100	+	/
Monochloracetic acid ethyl ester	100	+	+
Monochloracetic acid methyl ester	100	+	+
Morpholine	100	+	+
Motor oil	100	+	/
Na-dodecyl benz.sulphon	100	+	+
Nail polish remover	100	+	/
Neodecana acid	100	+	
Neodecana acid chloride	100	+	
Nickel salts, aq.	sat	+	+
Nitric acid	50	/	/
Nitric acid	25	+	+
Nitrobenzene	100	+	/
Nitrohydrochloric acid HCl:HNO3	3:1	+	-
Nitromethane	100	+	
Oils, etherial		+	
Oils, vegetable	100	+	+

Table 2 : Resistance of Polyethylene against Chemicals

Name of Chemical	% Concentration	23 °C	60 °C
Oleic acid	100	+	/
Oleum	>100	-	-
Oxalic acid, aq.	sat	+	+
Parafin oil	100	+	/
Paraldehyde	100	+	
PCB	100	/	
Pectin	sat	+	+
Perchlorethylene	100	/	-
Perchloric acid	20	+	+
Perchloric acid	50	+	/
Perchloric acid	70	+	-
Petroleum	100	+	/
Petroleum ether	100	+	/
Phenol, aq.	sat	+	+
Phenylchloroform	100	/	
Phosphates, aq.	sat	+	+
Phosphoric acid	85	+	/
Phosphoric acid	50	+	+
Potassium permanganate, aq.	sat	+	+
Potassium persulphate, aq.	sat	+	+
Potassium salt, aq.	sat	+	+
Potassium soap	100	+	+
Propane, liquid	100	+	
Pyridine	100	+	/
Salad oil	100	+	+
Salted water	sat	+	+
Sea water		+	+
Shoe polish	100	+	/
Silicone oil	100	+	+
Silver salts, aq.	sat	+	+
Soap solution	sat	+	+
Soap solution	10	+	+
Soda lye	60	+	+
Sodium chlorate, aq.	25	+	+
Sodium chlorite, aq.	5	+	+
Sodium hypochlorite, aq.	5	+	+
Sodium hypochlorite, aq.	30	/	/
Sodium hypochlorite, aq.	20	+	+
Sodium salts, aq.	sat	+	+
Succinic acid, aq.	sat	+	+
Sulphur dioxide, aq.	low	+	+
Sulphuric acid	96	-	-
Sulphuric acid	50	+	+
Tannic acid	10	+	+
Tar	100	+	/
Tartaric acid, aq.	sat	+	+
Test fuel, aliphatic	100	+	/
Tetrachlorethane	100	/	-

Table 2 : Resistance of Polyethylene against Chemicals

Name of Chemical	% Concentration	23 °C	60 °C
Tetrachlorethylene	100	/	-
Tetrahydro naphthalene	100	+	-
Tetrahydrofuran	100	/	-
Thiophene	100	/	/
Tin-II-chloride, aq.	sat	+	+
Toluene	100	/	-
Transformer oil	100	+	/
Trichlorethylene	100	/	-
Tricresyl phosphate	100	+	+
Two-stroke oil	100	+	/
Urea, aq.	sat	+	/
Uric acid	sat	+	+
Urine		+	+
Washing-up liquid, fluid	5	+	+
Water glass	100	+	+
Wetting agent	100	+	/
Xylene	100	/	-
Zinc salts, aq.	sat	+	+

Table 2 : Resistance of Polyethylene against Chemicals

- sat (saturate): saturated

STANDARDS

STANDARD NO	STANDARD NAME
TS pr EN 728	Plastic pipes and duct systems- Thermoplastic pipes and fittings - Determination of oxidation induction time
TS EN ISO 1167-1	Thermoplastics pipes, fittings and assemblies for the conveyance of fluids - Determination of the resistance to internal pressure - Part 1: General method
TS EN 12099	Plastics piping systems-Polyethlene piping materials and components- Determination of volatile content
TS EN 12107	Plastics piping systems-Injection-Moulded thermoplastics fittings, valves and ancillary equipment-Determination of the long-Term hydrostatic stregth of themoplastics materials for injection-Moulded piping components
TS EN 12118	Plastics piping systems - Determination of moisture content in thermoplastics by coulometry
TS EN ISO 1133	Plastics – Thermoplastics - Determination of the melt mass - Flow rate (MFR) and the melt volume - Flow rate (MVR) of thermoplastics
TS EN ISO 1872-1	Plastics-Polyethylene (PE) moulding and extrusion materials Part 1:Designation system to show specifications by signs and bases.
TS EN ISO 12162	Thermoplastics materials- Pipes and fittings used in high pressure applications- Classification and designation-Overall service (design) coefficient
TS EN ISO 13478	Thermoplastic pipes for the conveyance of fluids - Determination of resistance to rapid crack propagation – Test with exact measure.
TS EN ISO 13479	Polyolefin pipes for the conveyance of fluids-Determination of resistance to crack propagation-Test method for slow crack growth on notched pipes (notch test)
TS EN ISO 1183-1	Plastics - Non-cellular plastics - Methods for determining the density-Part 1: Immersion method, liquid pyknometer method and titration method (ISO 1183-1:2004)
TS 7792	Polyolefin pipes and fittings - Determination of carbon black content by calcination and pyrolysis - Test method and basic specification
TS ISO 11414	Plastics pipes and fittings-Preparation of polyethylene (PE) pipe/pipe or pipe/fitting test piece assemblies by butt fusion
TS ISO 11420	Method for the assessment of the degree of carbon black dispersion in polyolefin pipes, fittings and compounds
TS ISO 13480	Polyethlene pipes – Resistance to slow crack growth – Cone test method
TS EN 682	Elastomeric seals - Materials requirements for seals used in pipes and fittings carrying gas and hydrocarbon fluids
TS EN 1716	Plastic piping systems-Polyethylene(pe) tapping tees-Test method for impact resistance of an assembled tapping tee.
TS EN 12117	Plastic piping systems-fittings, valves and ancillaries-determination of gaseous flow rate/pressure drop relationships.
TS ISO 10838-1	Mechanical fittings for polyethylene piping systems for the supply of gaseous fuels - Part 1: Metal fittings for pipes of nominal outside diameter less than or equal to 63 mm
TS ISO 10838-2	Mechanical fittings for polyethylene piping systems for the supply of gaseous fuels- Part 2: Metal fittings for pipes of numinal outside diameter greather than 63 mm
TS ISO 13953	Polyethylene(PE) pipes and fittings - Determination of the tensile strengt and failure mode of test pieces from a butt-fused joint

STANDARD NO	STANDARD NAME
TS ISO 13954	Plastics pipes and fittings- Peel decohesion test for polyethylene (PE) electrofusion assemblies of nominal outside diameter greater than or equal to 90 mm
TS ISO 13955	Plastics pipes and fittings-Crushing decohesion test for polyethlene (PE) electrofusion assemblies
TS ISO/DIS 13956	Plastics pipes and fittings -Determination of cohesive strength- Tear test for polyethylene (PE) Assemblies
TS EN 1555-1	Plastic piping systems for the supply of gaseous fuels-Polyethylene (PE) Part1:General
TS EN 1555-2	Plastics piping systems for the supply of gaseous fuels-Polyethlene (PE) Part 2:Pipes
TS EN 1555-3	Plastics pipingsystems for the supply of gaseous fuels-Polyethylene (PE) Part 3:Fittings
TS EN 1555-4	Plastics pipinng systems for the supply of gaseous fuels-Polyetylene (PE) Part 4:Valves
TS EN 1555-5	Plastics piping systems for the supply of gaseous fuels-Polyethylene (PE) Part 5:Fitness for purpose of the system
TS ISO 11413	Plastics pipes and fittings - Preparation of test piece assemblies between a polyethylene (PE) pipe and an electrofusion fitting
TS 8084 ISO 4065	Thermoplastics Pipes-Universal wall thickness table
TS ISO 4433-1	Thermoplastics pipes - Resistance to liquid chemicals - Classification Part 1: Immersion test method
TS ISO 4433-2	Thermoplastics pipes - Resistance to liquid chemicals - Classification Part 2: Polyolefin pipes
TS EN 681-1	Elastomeric seals-Materials requirements for pipe joint seals used in water and drainage applications-Part 1: Vulcanized rubber
TS EN 681-2	Elastomeric seals-Materials requirements for pipe joints seals used in drainage and sewerage applications - Part 2:Thermoplastic elastomers
TS 6694	Polyethylene (PE) Pipes - Pressure Drop in Mechanical Pipe - Jointing Systems - Method of Test and Requirements
TS EN 713	Plastic piping systems-Mechanical joints between fittings and polyolefin pressure pipes- Test method for leaktightness under internal pressure of assemblies subjected to bending
TS EN 715	Thermoplastic piping systems-End-Load bearing joints between small diameter pressure pipes and fittings-Test method for leaktightness under internal water pressure, including end thrust
TS 418-1 EN 12201-1	Plastic piping systems for water supply - Polyethylene (PE) - Part 1: General
TS 418-2 EN 12201-2	Plastics piping systems for water supply - Polyethylene (PE) - Part 2: Pipes
TS 418-3 EN 12201-3	Plastics piping systems for water supply - Polyethylene (PE) - Part 3: Fittings
TS 418-4 EN 12201-4	Plastics piping systems for water supply-Polyethylene (PE) - Part 4: Valves
TS 418-5 EN 12201-5	Plastics piping systems for water supply - Polyethylene (PE) - Part 5: Fitness for purpose of the system
tst 418-7 CEN/TS 12201-7	Plastics piping systems for water supply - Polyethylene (PE) - Part 7: Guidance for the assessment of conformity

CALCULATIONS

PN, MRS, S, SDR

S (Pipe Classification)

S = ([SDR]-1)/2
SDR (Standard Dimension Ratio)
SDR = d/e
(d= diameter, e= wall thickness)

σ = [MRS]/C
C:Total Design Coefficient or Safety Factor

PN (Nominal Pressure), MRS (Minimum Required Strengtht)

$[PN]= 10\ \sigma_s / [S]$ or
$[PN]= 20\ \sigma_s / [SDR-1]$

SDR	S	Nominal Pressure (PN) Bar	
		PE 80	PE 100
41	20	3,2	4
33	16	4	5
26	12,5	5	6
21	10	6	8
17,6	8,3	-	-
17	8	8	10
13,6	6,3	10	12,5
11	5	12,5	16
9	4	16	20
7,4	3,2	20	25
6	2,5	25	32

Chart 1: Some PN, MRS, S and SDR relations - at 20°C and C=1,25 (for water)

SDR	S	Nominal Pressure (PN) Bar	
		PE 80	PE 100
41	20	2	2,5
33	16	2,5	3,1
26	12,5	3,2	4
21	10	4	5
17,6	8,3	4,8	6
17	8	5	6,2
13,6	6,3	6,3	7,9
11	5	8	10
9	4	10	12,5
7,4	3,2	12,5	15,6
6	2,5	16	20

Chart 1: Some PN, MRS, S and SDR relations - at 20°C and C=2 (for gas)

Type	Min. Required Strengh (MRS) MPa	$\sigma_s{}^a$ MPa
PE 100	10,0	8,0
PE 80	8,0	6,3
PE 63	6,3	5,0
PE 40	4,0	3,2
*Design Tension (σs), total design coefficient or safety factor are derived from MRS, when C=1,25		
Note: A bigger C value can be used. For example, when C=2 (for gas), maximum design resistance (σs) values must be 4,0 MPa for PE 80, and 5,0 MPa for PE 100.		

Chart 3 : Representing the material by type and their biggest design tension values

DETERMINATION OF RESISTANCE TO INTERNAL PRESSURE AT CONSTANT TEMPERATURE

CALCULATING TEST PRESSURE

$$P = 10.\sigma.\ \frac{2.e_{min}}{d_m - e_{min}}$$

where;
σ : Environmental stress caused by applied pressure, MPa;
d_m : Average outer dimension of test piece, mm;
e_{min} : Minimum wall thickness of test piece through length, mm

PE80		PE100	
Tension (MPa)	Test duration (h)	Tension (MPa)	Test duration (h)
	h		h
4,5	165	5,4	165
4,4	233	5,3	256
4,3	331	5,2	399
4,2	474	5,1	629
4,1	685	5,0	1000
4,0	1000		

Chart 4: Test parameters for internal hydrostatic pressure resistance test in 80°C water.

PE80		PE100	
Tension (MPa)	Test duration (h)	Tension (MPa)	Test duration (h)
	h		h
10	100	12,4	100

Chart 5: Test parameters for internal hyrostatic pressure resistance test in 20°C water

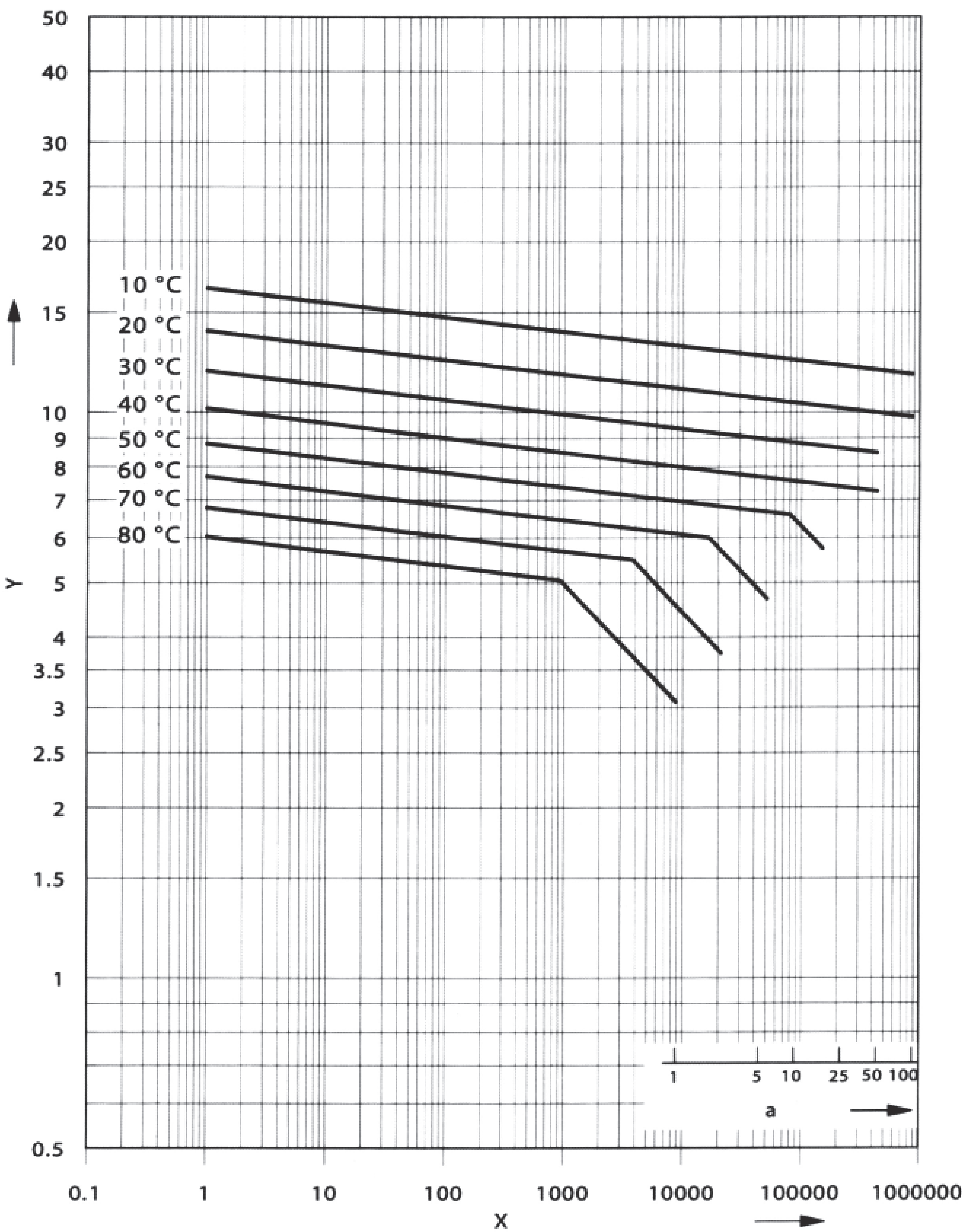


Figure 1 : Endurance Diagram of PE 100 pipes due to temperature
Y : Circumferential Stress
X : Life (h)
a : Years

PRESSURE DECREASE FACTORS

If PE100 and PE80 pipe types will be used permanently between 20 °C and 40 °, working pressure can be found by using pressure lowering factors below:

Temperature (°C)	Factor (fT)
20	1,00
30	0,87
40	0,74

For each temperature between given values above, interpolation could be done.
Permitted working pressure(PFA) is found by this equation below:
PFA=fT x fA x PN
fT: Pressure decrease factor
fA: Decrease (or increase) factor due to application (for water transmission fA=1)
PN: Nominal Pressure

REQUIRED PIPE DIAMETER

By the formulation below, pipe sizes can be calculated for the given flow rate :

$d_i=18,8(Q_1/v)^{1/2}$ or $d_i=35,7(Q_2/v)^{1/2}$
v= flow speed (m/s)
d_1= pipe internal diameter (mm)
Q_1 = flow rate m^3/h
Q_2 = flow rate l/s
18,8 = convertion coefficient
35,7 = convertion coefficient

STANDARD VALUES FOR FLOW RATE

Fluids
v= 0,5-1,0 m/s (for vacuum)
v= 1,0-3,0 m/s (for spreading)

Gases
v= 10-30 m/s

Hydraulic losses have not been considered when calculating pipe diameters.
After outer pipe diameter is determined, real flow rate is calculated with the formula below:

$v=1275(Q2/d_i^2)$ or $v=354(Q_1/d_i^2)$
v= flow rate m/s
d_1= pipe internal diameter (mm)
Q_1 = flow rate m^3/h
Q_2 = flow rate l/s
354 = convertion coefficient
1275 = convertion coefficient

USING NOMOGRAM TO CALCULATE PRESSURE LOSS and DIAMETER SIZE

Nomogram below helps to determine the pressure loss per meter of pipe and required diameter.
To use the nomogram, at least two values must be known (for example: internal diameter, flow rate).
Then a line is drawn by two points. The point where the line intersects the ≥P bend is, pressure difference for the pipe which internal diameter has given.

For example, line is drawn for both diameters on reductions, and ≥P value is read. Difference between ≥P values shows the pressure loss.

Note: Pressure loss in this nomogram, suitable for the fluids, has density lower than 1000 kg/m3 (e.g. water)

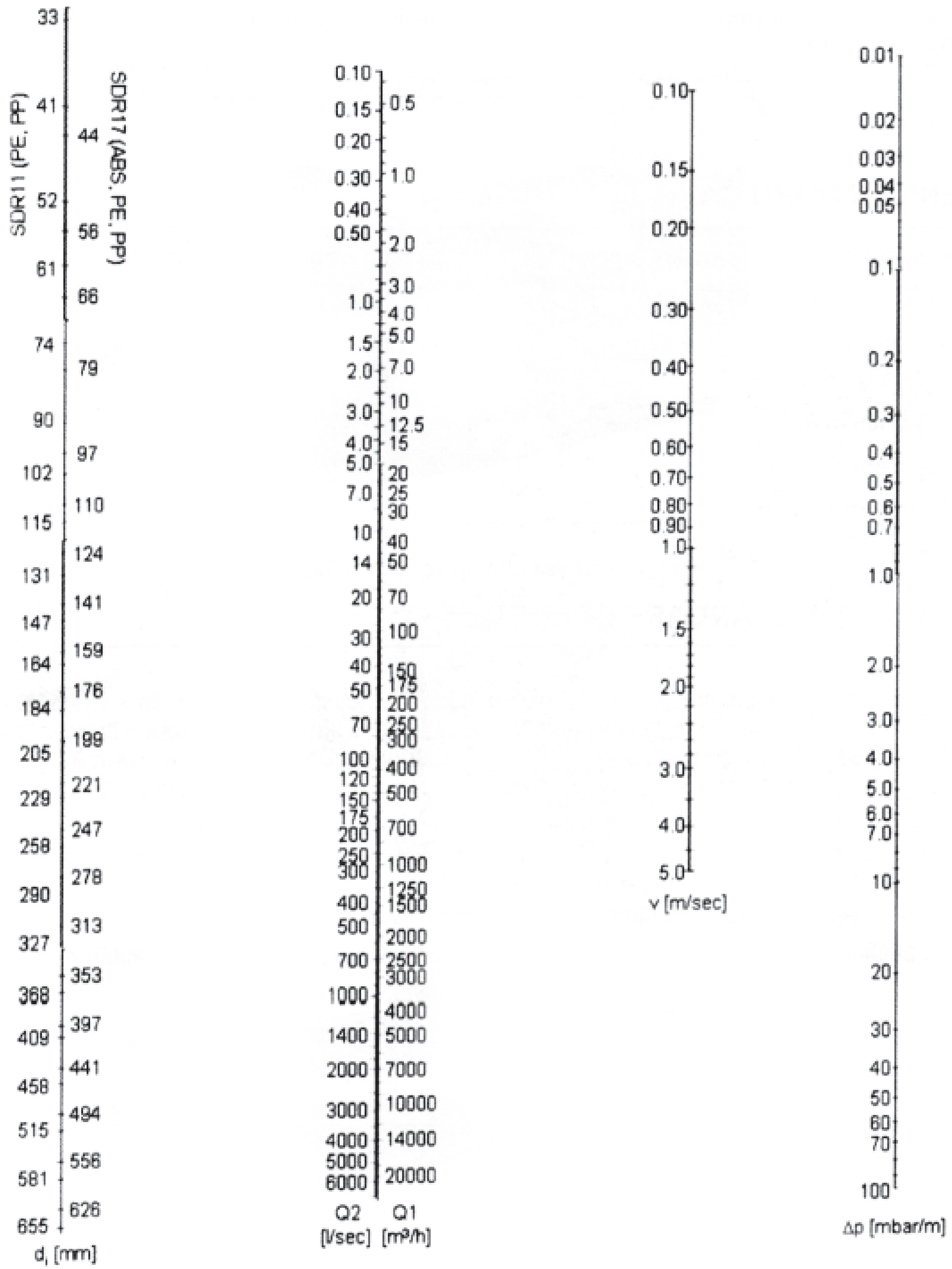


Chart 2: Flow Nomogram

TRANSPORTATION AND STORAGE

HANDLING AND STORAGE

Transportation and storage of polyethylene pipes and fittings is an important issue for every type of installations. Transportation and storage method is the same for all PE pipes because they have similar hardness. Although polyethylene is weak against sharp objects, it is light, flexible and durable material which can be easily transported. Sharp objects must be kept away from pipes during transportation. Signs and explanations on pipe should not be exceed 10% of the outer diameter of pipe. If its exceed 10% of the outer diameter, this kind of pipes must be considered as out of quality.

Generally polyethylene pipe is not effected by low temperature however because of the smooth surfaces of polyethylene pipes and fittings, they become slippery in moist or cold air. Products should be kept in packing till usage. If the products will be stored in the open air for a long time, they should be covered with a canvas or black polyethylene overlay in order to provide protection from UV. For providing hygiene during the storage, open ends of the pipes should be covered against materials (soil, stone etc.) penetration.

TRANSPORTATION

- If the load would be carried in bulk, loading surface of the vehicle should be smooth and free of sharp objects.
- Pipes and fittings must be carefully placed away from heat sources and from materials, such as oil which may cause contamination.
- Metal chains or suspension straps must not directly contact to the products during transportation. Straps made of polypropylene or nylon is recommended.
- Small fittings must be prevented from rubbing against other parts in order to avoid abrasion.
- Although special measures must be taking during horizontal transportation, pipes can be transported both vertically and horizontally.

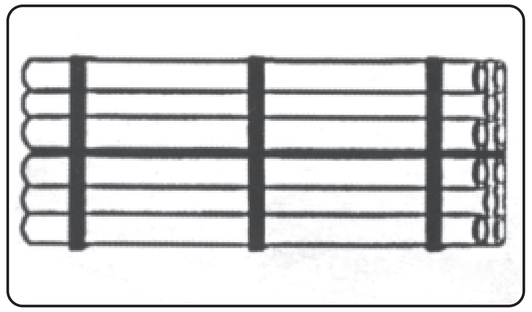


Figure 1: Frame packaging of PE pipes

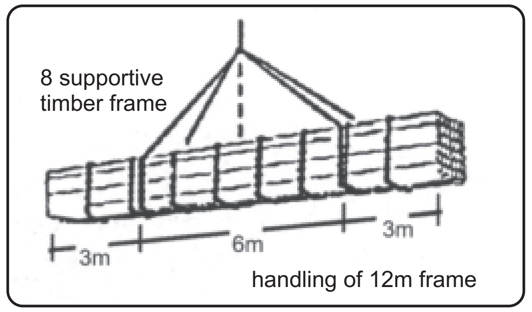


Figure 2: Handling of frame packaging via crane

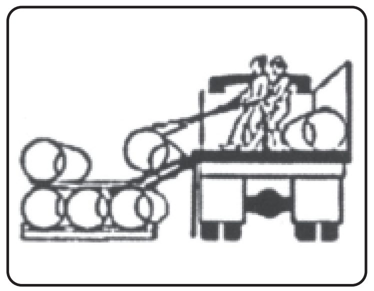


Figure 3: Unloading by using timber slides

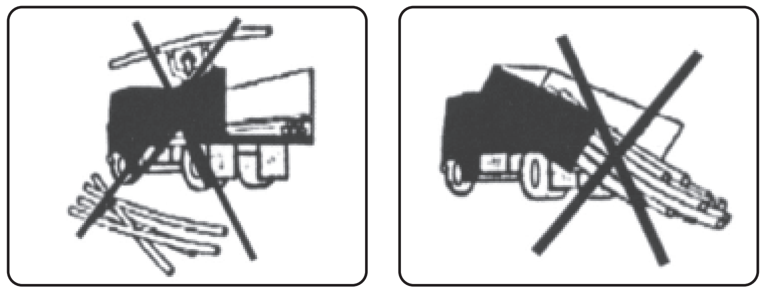


Figure 4-5 : Wrong unloading

Hooks should not be used for carrying fittings that usually packed in cartoon boxes or bags.

STORAGE IN WAREHOUSES

All materials should be carefully examined during transportation and all defected products should be determined before acceptance to the warehouse. The supplier should be notified about defected products before acceptance.

If the same product is supplied by a different suppliers, these products should be kept separately.

Pipes and fittings should be used through the First In - First Out (FIFO) principle, for the verification of the control on stocking rotations.

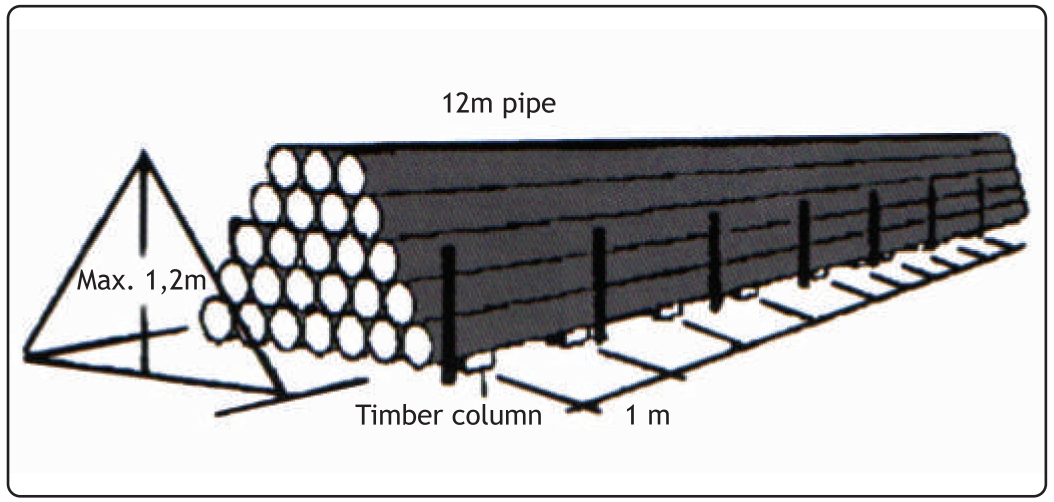
Only the pipes with known producer and production date should be purchased and pipes must be used in according to First In-First Out rule.

Blue polyethylene pipes should be kept under cover and should not be exposed to direct sun light until used.

If it is necessary to keep the pipes in the open air, pipes should be covered with sun-proof (not transparent) covers.

In order to store pipes properly, a levelled surface capable of carrying the full load should be provided, necessary handling should be used and stacking heights should be kept at minimum and an optimum, safe area is needed for the manoeuvre of carriages. For a proper and safe transportation height of stored pipe piles should not exceed 3 meters.

If the pipes are stored in a pyramid shape, the pipes at the bottom sides may be subject to deformation at moist air. Therefore, height of pyramid stacks should not exceed 1.2 meters.



Polyethylene fittings should be kept on shelves and under a cover. Protecting package or carton boxes used by the manufacturer should be kept until the use of these products.

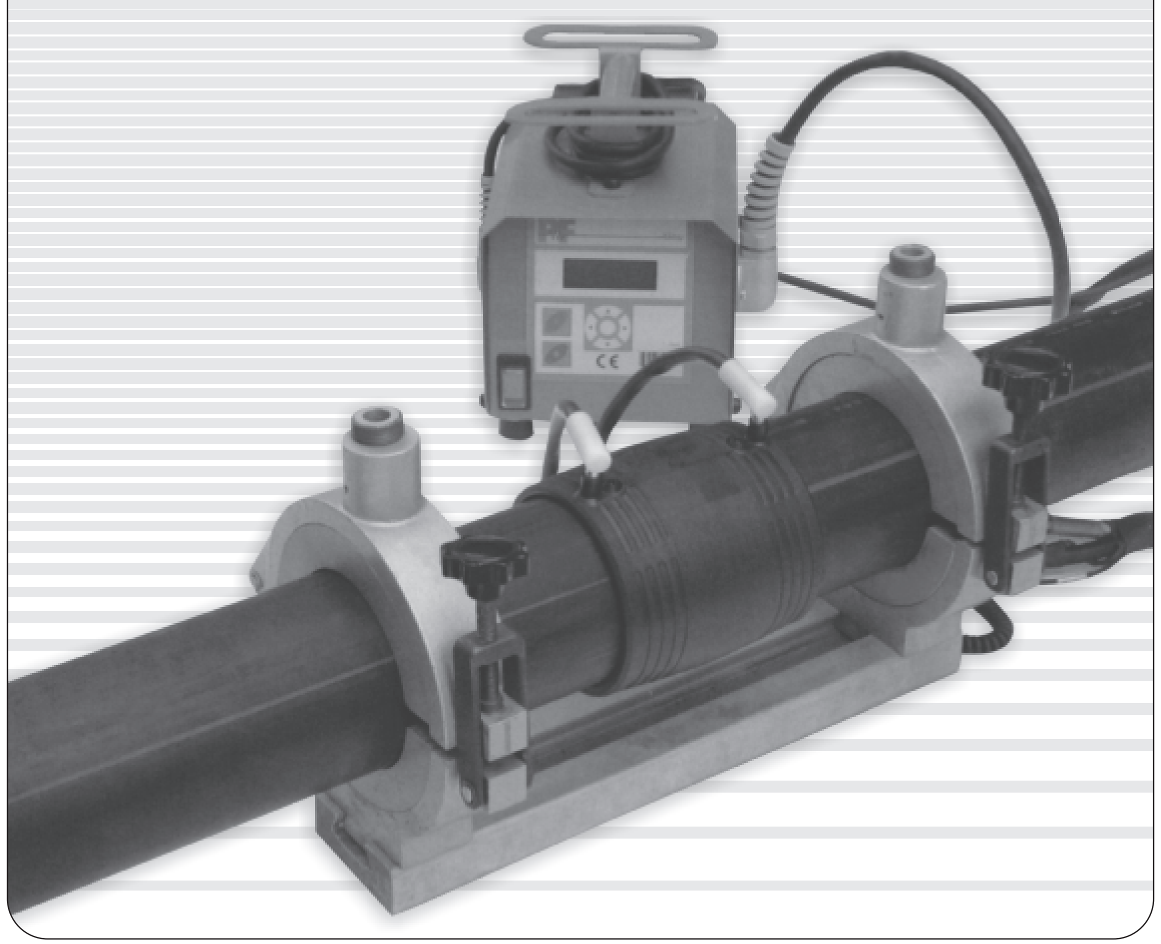
Polyethylene pipes and fittings should be always stored away from heat sources such as vehicle exhausts.

Polyethylene pipe and fittings should not be stored in the same place with the machines that works with oil, hydraulic oils, gases, solvents, and other flammable chemicals.

All special tools and equipments used for connecting polyethylene pipes and fittings should be kept separately and safely till used. Heating parts of the welding machines should be avoided of scratching during storage.

If it is necessary to store pipes and fittings in the open air for long time, they should be covered with canvas or black polyethylene in order to provide protection from sun light (UV).

WELDING METHODS



BUTT WELDING

Quality of butt welding directly depends on operator's ability, quality of equipment, and to supervisor who is responsible from related standards. The process should be observed carefully from the beginning till the end. Before starting butt welding process it is important to check and verify all parameters. Every operator should be educated and certificated.

The issues should be considered before starting butt welding process

- The welding environment should be over +5 °C, and it should be done in a sheltered area at rainy and cold weathers.
- Pipe ends should be closed to prevent air circulation and fast cooling.
- Before starting welding process for coil pipes, bending must be taken away from the pipes.
- Welding zone should be clean and free of damage.

Butt welding method

The principle of butt welding system is heating the welding surfaces for a certain time and pressure, for the pipes at same diameter and outer diameter. The joining area of the welding components should be cleaned smoothly and heated up to 200-220 °C. Then they bond together under certain pressure. Welding pressure, heat and time should be properly chosen in order not to change the chemical and mechanical properties of the welded parts.

In butt welding method, butt areas is pressed on the heater plate, left at zero pressure until they arrive at welding temperature and joined together under pressure (welding).

At good welding applications, welded zone provides at least the same strength with the original pipe. To have a quality welding application; butt welding pressure, temperature and time parameters should be set carefully.

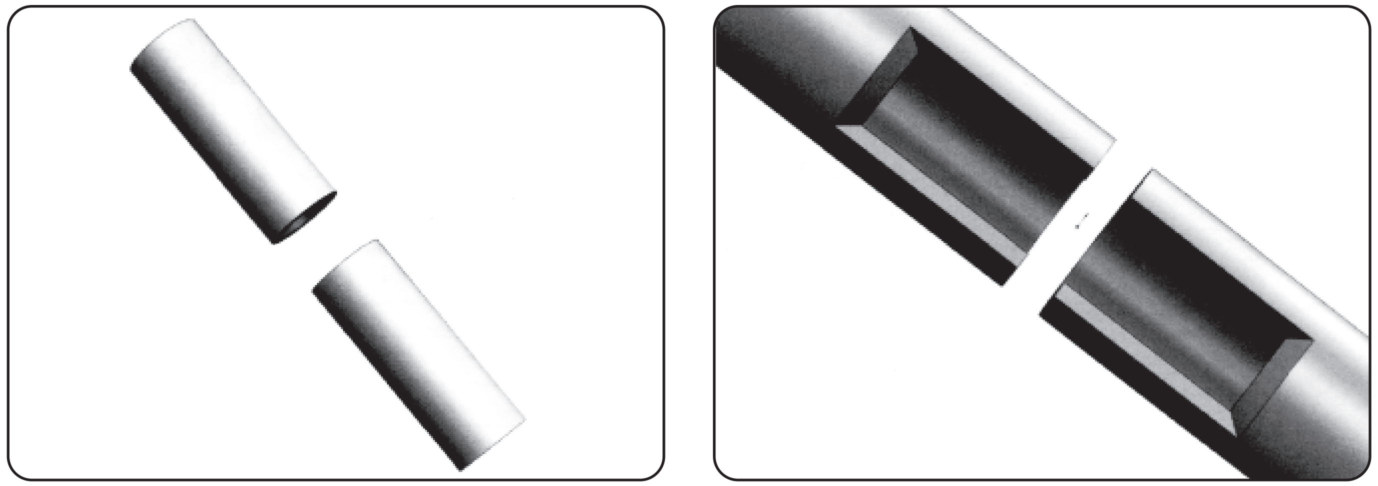


Figure 1: Pipes for butt welding

Butt Welding Preparation

Temperature on the butt welding machine should be controlled just before starting butt welding process. This must be done by an infrared thermometer. The heater plate should be left for a minimum of 10 minutes after reaching the set temperature. To ensure an optimum welding quality, the heater plate has to be cleaned before every welding operation. Cleaning should be done by a soft cleaning material and using alcohol etc. The heater plate (teflon coating) must be free of damages.

The joining forces and joining pressures have to conform the machine working instructions. These can be based on manufacturer information, calculated or measured values. Moving pressure is taken from the indicators of the welding machine during the slow movement of the part to be welded. This value has to be added to the determined joining pressure. Moving pressure may change depending on machine, diameter of pipe, and length of pipe. Therefore, before every welding process moving pressure should be read and added to joining pressure.

The joining areas have to be planed before the butt welding. (Figure 2) So with this way pipes can be exact aligned and have clean surface.

The gap width and the misalignment have to be controlled. Misalignment must be avoided as much as possible. Even in the worst circumstance, it may not exceed 1/10 of wall thickness.

The trimmed welding zones should not be touched and allow for further contamination. Otherwise trimming should be repeated. The ribbon of shavings and any other cut pieces must be cleared from the welding zone without touching the trimmed faces.

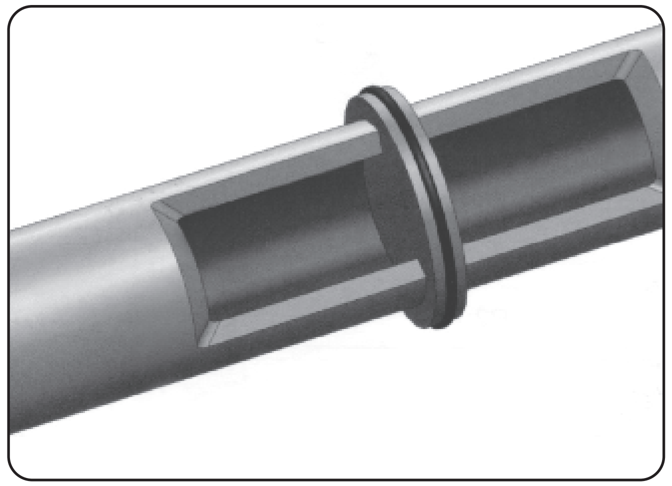
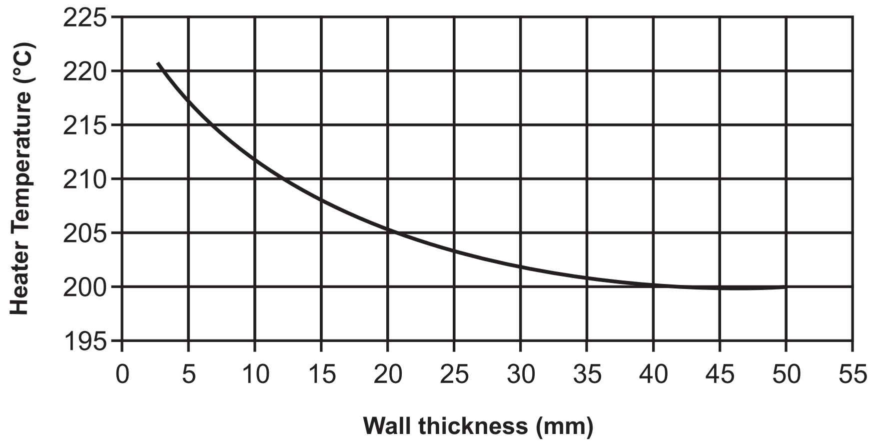


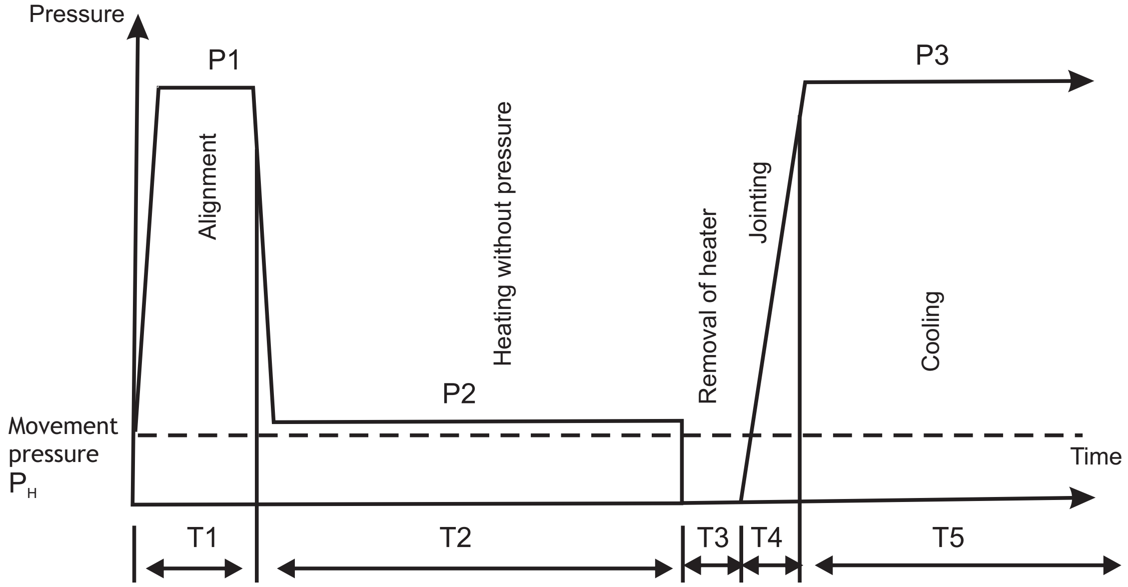
Figure 2: Trimming pipe surface

Butt Welding Process

In butt welding process, the welding zones are heated-up to the welding temperature by the heater plate and the pipes are joined under pressure after removing the heater plate. The heating temperature should be 200 to 220 °C. Higher temperatures are required for thinner wall thicknesses, and the lower temperatures for thicker wall thicknesses (Graph 1).



Graph 1 : Required temperatures for different wall thickness



Graph 2 : Regime of heater plate shaped butt welding

Alignment

The joining areas are aligned to the heater plate until all areas are plane-parallel on it. This fact is visible on the kind of beads. The exact alignment should be checked by type of the pipe circumference. If the alignment was faulty, optimum bead height will not be obtained. The alignment is done in duration T1 time and with certain pressure (P1). T1 time is depending on the bead height. Required bead heights are shown in table 1, column 2. Placement of heater and bead creation can be seen on diagram 3 and 4. P1 interfacial plane pressure is 0,15 N/mm², but this value is not the one that read from welding machine's manometer. The welder should determine or calculate the manometer pressure according to the instructions given by the manufacturer of the welding machine to get the required interfacial pressure.

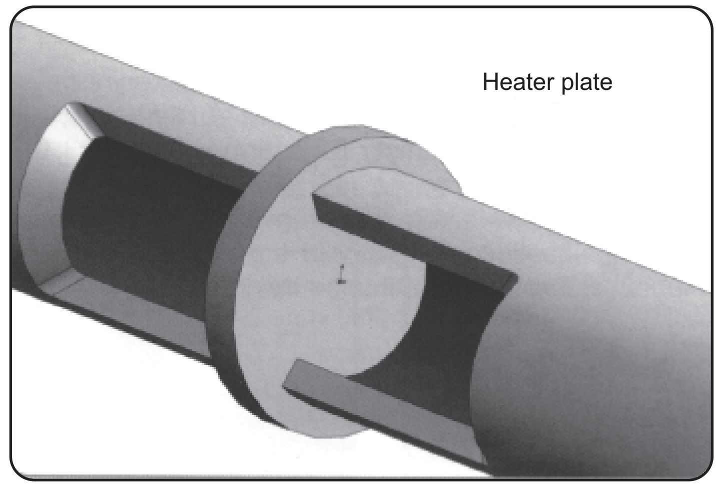


Figure 3: Placement of heater

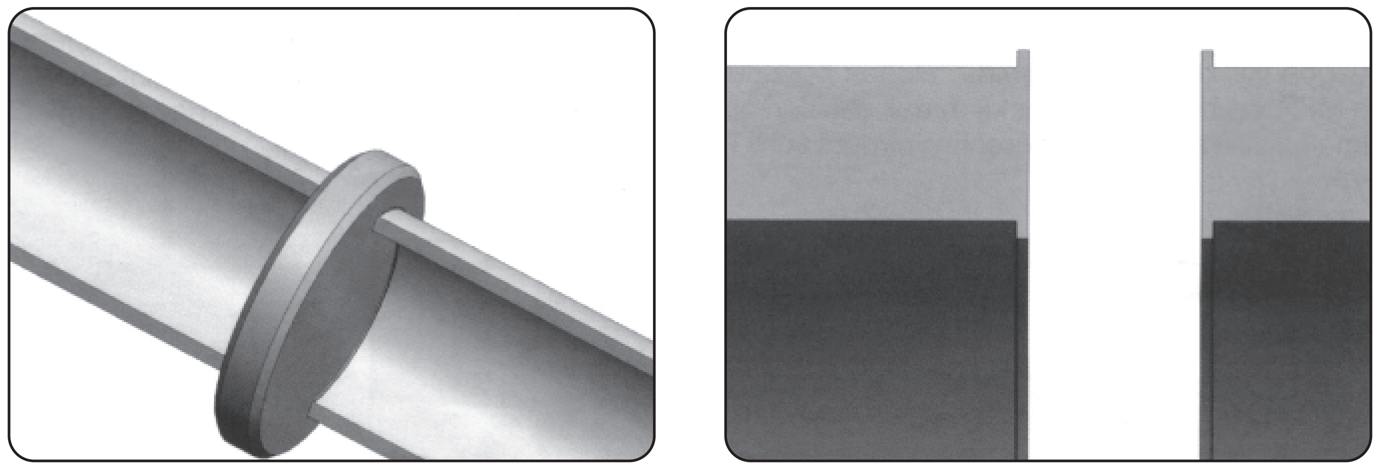


Figure 4: Pressurized heating (alignment) and shape of welding faces afterwards

Heating-up without pressure

For heating-up, the joining areas must contact the heater plate, and pressure must decrease. Pressure between joining areas and heater plate is nearly zero ($P2 \leq 0.02$ N/mm²). At this time the heat penetrates during pipe axis. Heating up times (T2) are mentioned in table 1, column 3. If this time is applied less than requirement, the deepness of plastic part will be shorter than needed; contrary welding area will melt and corrode.

Removal of heater plate

After heating-up, the joining areas are to be detached from the heating plate. The heating plate should be carefully removed and the heated joining faces should be free of damage and contamination. The joining areas should be joined together quickly after heating tool removal. If operator delays at joining the welding joint quality will be insufficient because of oxidation and cooling. Maximum time for this process is given at Table 1, column 4.

Joining

After heater plate is removed, areas aligned closer. There must be no strike or hit during this process. The demanded pressure (interfaced pressure) time is obtained possibly linear (Graph 2). The required time (T4) is shown in table 1, column 5. The joining pressure (P3), is 0,15±0,01 N/mm^2.

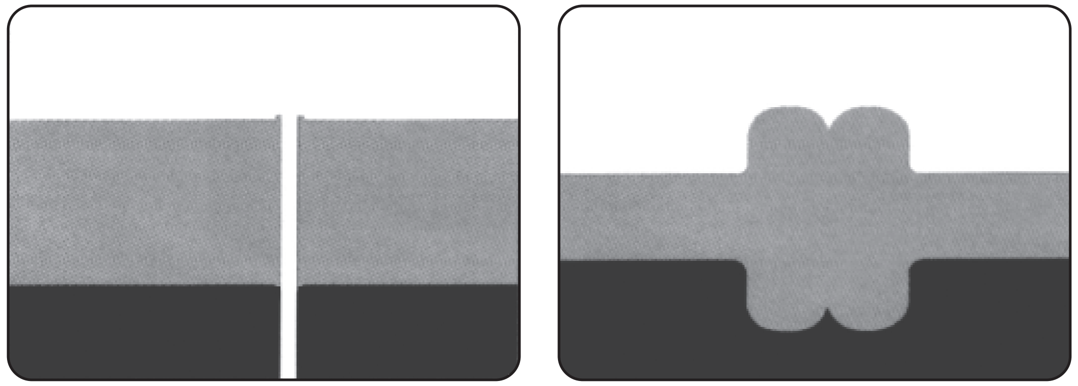


Figure 5: Pipe alignment and joining, beads appear under pressure

Cooling

The joining pressure (P3-interfaced pressure) has to be kept during the cooling time. After process, a regular double bead must appear. The bead size shows the regularity of welding. Different beads could be caused by different MFR (melt flow rate) of the pipes. K must always be larger than 0 (see figure 6). Minimum time (T5) for this phase is given at Table 1, column 5.

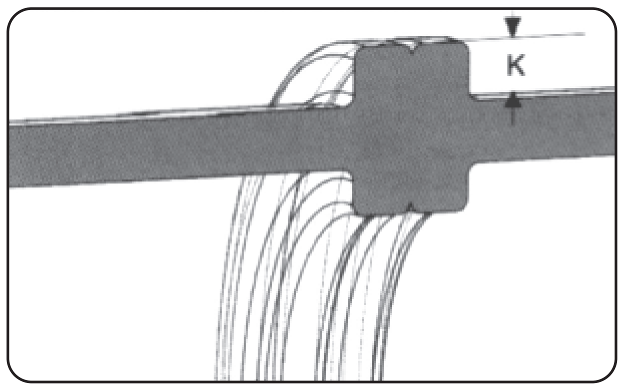


Figure 6: Cross section of beads

1	2	3	4	5	
Nominal Wall Thickness	Alignment (T1)	Heating without pressure (T2)	Removal of heater (T3)	Joining	
	Bead height on heated pipe	Heating up time		Joining time (T4)	Cooling Time (T5)
mm	mm (min.)	sec.	sec. (max)	sec.	min. (min)
4,5	0,5	55	5	5	7
4,5-7	1,0	55-84	5-6	5-6	7-11
7-12	1,5	84-135	6-8	6-8	11-18
12-19	2,0	135-207	8-10	8-11	18-28
19-26	2,5	207-312	10-12	11-14	28-40
26-37	3,0	312-435	12-16	14-19	40-55
37-50	3,5	435-600	16-20	19-25	55-75
50-70	4,0	600-792	20-25	25-35	75-100

Table 1: Suggested butt welding parameters for PE100 pipe and fittings

Step by step Butt Welding Processing

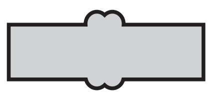
1. Prepare of working site (e.g. cover welding site)
2. Connect the welding equipment to the electrical net or generator and test the function
3. Adjust the pipes with easy axial movement
4. Scrape welding faces of pipe and/or fittings
5. Take off the scraper at the welding machine
6. Remove shaved parts from the welding area (use brush, paper towel)
7. Close the pipe's open ends to prevent air circulation
8. Check the alignment of surfaces by bringing together (misalignment must be maximum 0,1 x wall thickness).
9. Check the heater plate surface temperature (figure 1)
10. Clean the heater plate with smooth and non-fuzzy rag or paper towel
11. Read the moving pressure from the welding machine
12. Determine the value for aligning, heating-up and joining pressures due to producer's instructions
13. Apply the values to the machine according table 1
14. Set the heating tool to the welding position
15. Align the welding areas to the heating tool quickly and wait until minimum bead height occurs (according table 2,column 2)
16. Decrease pressure to P2. This pressure is nearly zero ≤ 0.02 N/mm². Wait during the time shown at table 1 column 3, at P2 pressure.
17. Remove the connection areas to be welded from the heater plate without damage and remove it from the welding position.
18. The joining areas should be joined together within the time (table 1, column 4) immediately until directly before the contact. At contacting, they have to meet with a speed of nearly zero and right then Build-up a linear joining pressure P3 in the time shown at (table 1, column 5)
19. After joining with pressure 0.15 N/mm², a bead must exist. According figure 6, K has to be > 0 on every section
20. Wait during the time shown at table 2 column 5 for cooling
21. Remove the welded parts from the welding machine after cooling completes

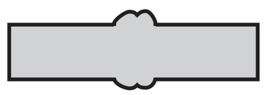
Important issues at butt welding

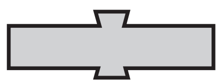
• Materials to be welded should match each other
• In order to maintain correct welding parameters at high humid, extreme temperature and windy environments working place should be protected against such weather conditions.
• Pieces should be avoided from direct sun lights to keep the pipes at the same temperature.
• Pieces to be welded should be cleaned from dust, dirt, e.g.
• Pipes should be fastened carefully before welding. This is required both for an accurate centring and to keep the operator away from any harm during cutting and welding.
• During butt welding (cooling included), pieces should never face to mechanical force or rupture.
• Other end of the welding pipe should be on a slippery surface to move freely. This is required to do back/forward feeding without applying any force on welding area.
• Cutter tool should be at required sharpness. Knife of tool should be changed or sharpened at certain intervals.
• There should be no deep scratch, notch, etc on teflon surface of heater. Surface of heater should be checked occasionally.

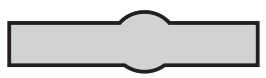
Butt welding problems and possible causes

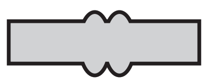
Beads are too wide	Overheating, Over (aligning) pressure
Gap length between beads is too much	Over joining pressure, Insufficient heating
	Applying pressure during heating
Bead's upper side is straight	Over joining pressure, over heating
Not uniform bead around pipe	Misaligning, Defected heater plate
Beads are too small	Insufficient heating, insufficient joining pressure
Beads do not overlap on to pipe's outer surface	Gap height is low; Insufficient heating and insufficient joining pressure Gap height is high; Insufficient heating and over joining pressure
Beads are too large	over heating
Bead outer edge is square	Pressure applied during heating
Rough bead surface	Hydrocarbon (soil) contamination


Proper welding


Different heating time and/or different heating temperature


Over pressure and narrow bead width


Low pressure and low bead height

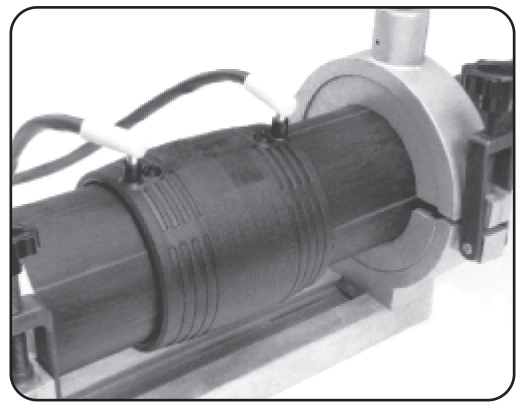

Split on the welding surface, low heating or long changing time

ELECTROFUSION WELDING

Electrofusion is safe and presents high performance. In this method, the most important aspects are the preparation and assembly geometry. Another issue to take care is the welding energy.

Welding is done by heating resistances at muff section. After pipes are placed in the muff, cables of welding machines are connected to pins of the muff and resistances are heated by the electric current. The muff wall thickness is usually higher than the pipe thickness, as a result of this, the heat of pipe wall will be higher than the muff wall heat. Pressure is formed in the pipe, because of the heat difference. The pipes weld to each other by the pressure on and in the pipe.

In electrofusion welding, only pipes made of same raw material may be welded. Solution flow speed for HDPE electrofusion joining is 0,2-1,7 gr/10 min (190°C / 5 kg). Pipes and muff's solution flow speed should be between these values. The area where the welding will be made must be weather-proof. Temperature around the welding environment must be between -10°C and +40°C.



Main reasons to choose Electrofusion Welding

EF is accepted as a safe, easily assembling system for pressured fluids by today's gas and water network companies.

Technically, electrofusion welding is done after assembly and parts gathered tightly. Thus almost no movement occurs between pipe and muff during welding.

Practically, all pipe sizes between 20-315 mm could be welded with EF. It is the only method to allow pipes (diameter up to 125 mm.) to be used for long distances. Besides, EF can be used in all networking building areas, connections under pressure, and in maintenance purposes.

EF welding usually does not require visual control after welding. Welding parameters can be systematically applied to next welding process. Once conditions are defined, welding process is done in automatic machines. Generally, electrofusion welding machines have barcode readers, and the barcodes contains welding parameters to report automatically to the machine. Most welding machines also allows the operator to put the data in manually. Therefore a basic education is sufficient for electrofusion.

Advantages of EF welding:
• pipe interior diameter does not shrink.
• welding machines & equipment have low cost, easy to use, light.
• high welding speed.
• no pressure loss is considered at welding point.

Electrofusion welding capabilities

While joining PE pipes with electrofusion welding method, PE made materials, such as couplers, tapping saddles, reducers with resistant wire inside, are used. When electric current is applied on resistance wire of the electrofusion fittings, heat spreads on a large area and melts the material. Winding number and resistance values of wires are set in according to required energy for melting the material.

Welding principles are similar apart from electrofusion fittings type or diameter. Required heat for electrofusion welding, is obtained by joule effect of metallic resistance wires.

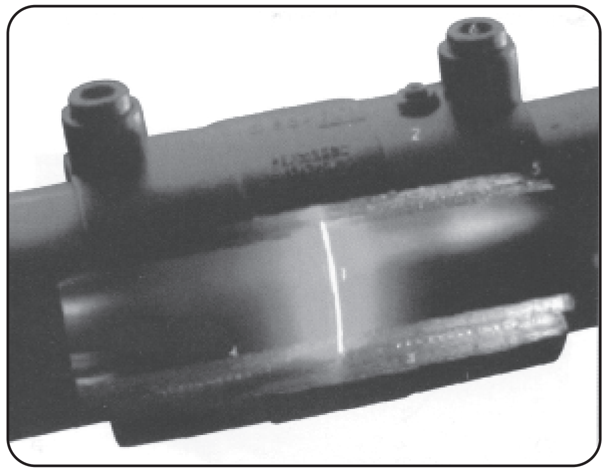
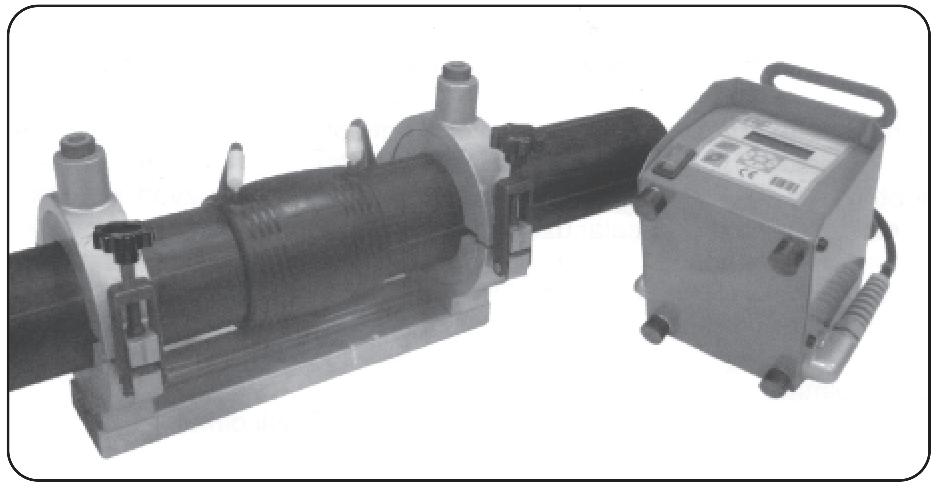


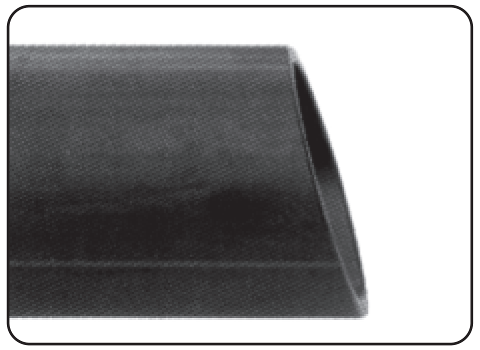
Figure 7: Welding area during operation

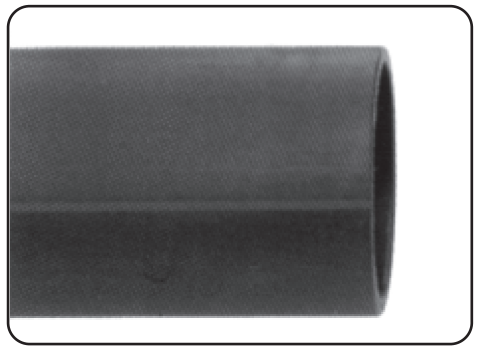
During electrofusion welding, the resistance inside electrofusion fittings is kept connected to the energy for a certain of time specified by manufacturer. This resistance heats up the surfaces, it touches and increase up to melting temperature. Temperature arises between 130°C - 250°C during welding.



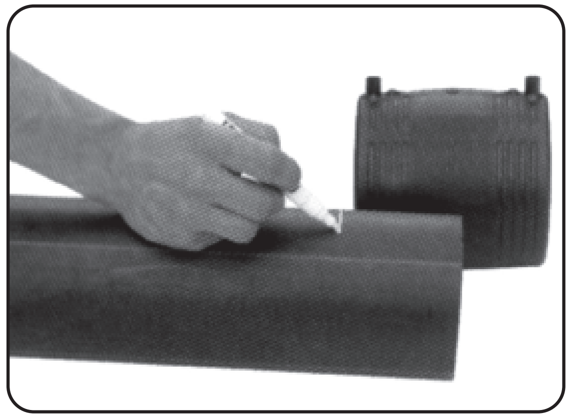
EF Welding Steps

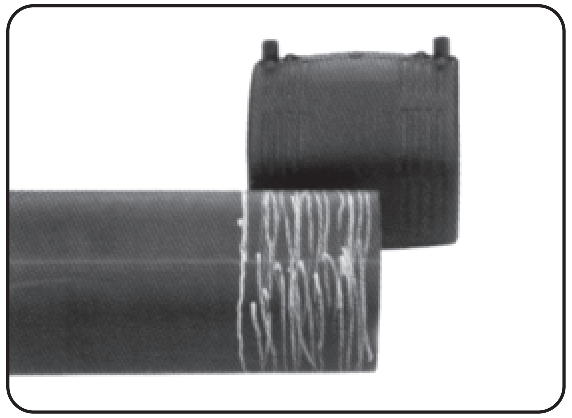
Pipe should be cut clean and smoothly from the welding ends, must be and perpendicular to its own axis. If the pipe is not cut precisely, this results in contact between heating coils and the pipe, which causes uncontrolled flow of melted material due to overheating.





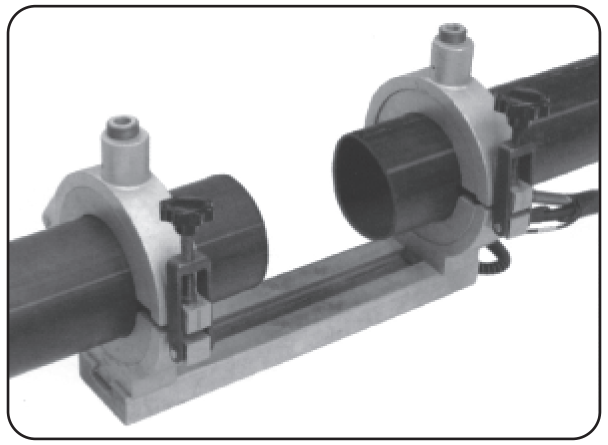
Smooth and clean cut pipes are placed into electrofusion fittings up to the stops (middle of the fittings) and pipe is marked. Scratch the pipe with a marker from marked area to the end.





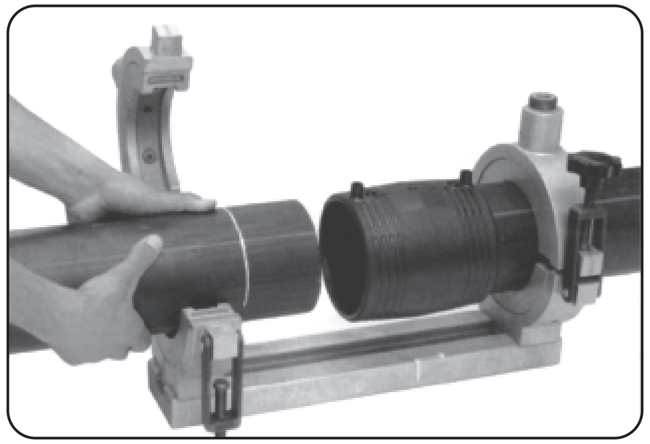
Clean the pipe fittings' surface and scrape the oxidation with a scraper. Following, the internal edge must be cleaned of fillings and the edges rounded off by a scraper.

Pipes may have ovality if stored inconveniently. Ovality should not exceed 1,5% of the external diameter of the pipe. When ovality exceeds this ratio fixing apparatus should be used.

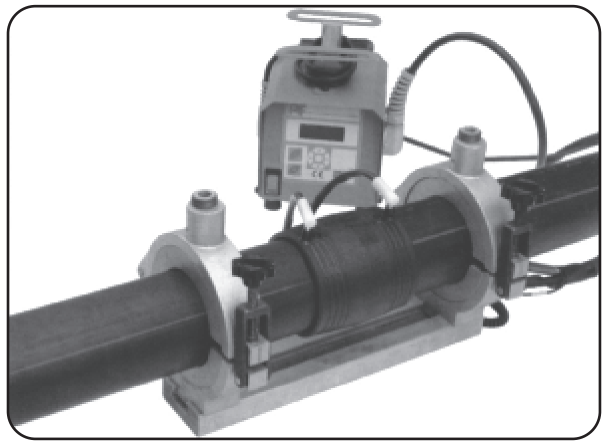


Pieces to be welded must have clean surface, have no dirt, oil e.g. Electrofusion surfaces be welded (coupler's interior, pipe and fittings' outer surfaces) must be cleaned by means of proper fluids (industrial alcohol, acetone) and by soft, non-fuzzy papers. After the surfaces of pipe and fittings are cleaned, they must not be touched.

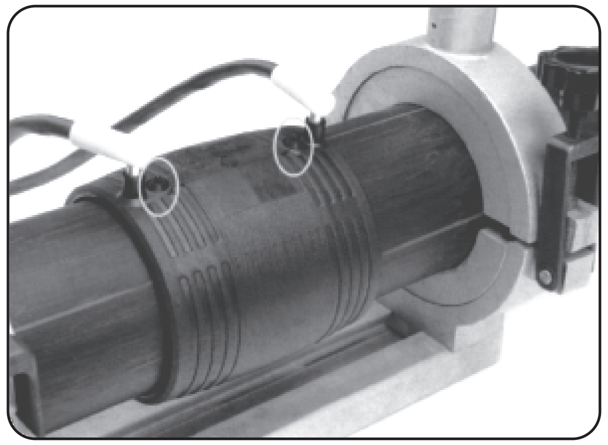
Then the couplers is placed on the pipe and pushed until the leaning limit of couplers (marked on the pipe). While joining, pipe and couplers must be parallel.



Electrofusion welding ends are fixed after aligned with the pipe, and ends faced upwards. Welding machine sockets are placed at the weld ends and prepared for welding.



After the ready signal is received from the machine, welding process is started having the barcode indicated to the machine or having welding parameters manually entered. Generally the welding machine indicates the welding time and voltage on monitor. After the welding process ended, indicators move out.

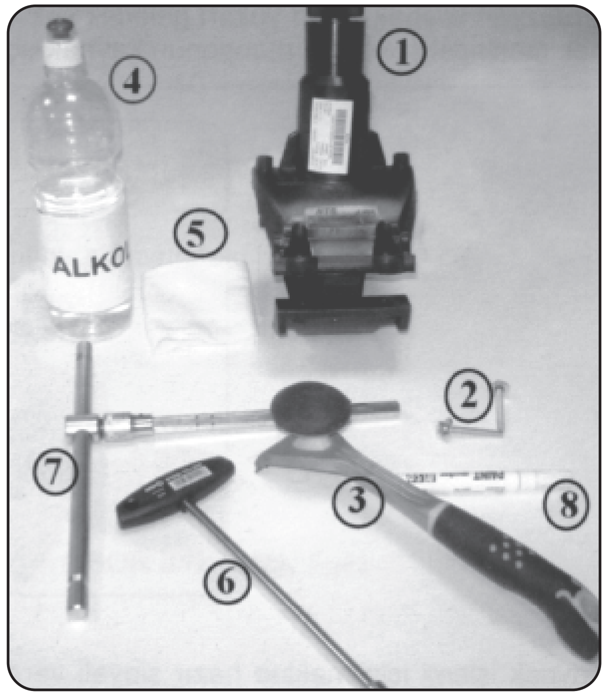


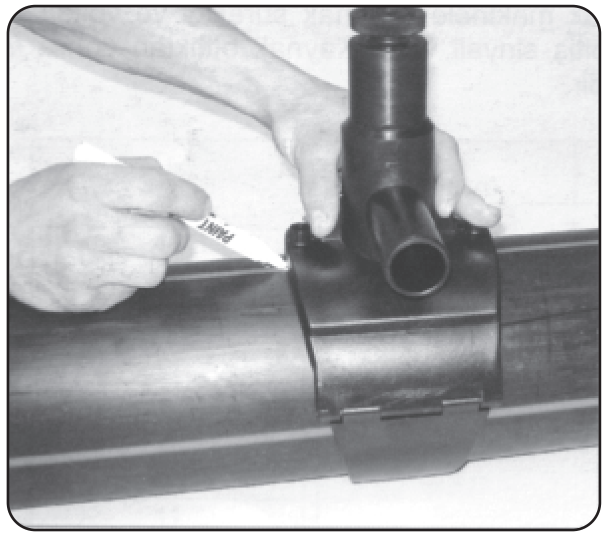
TAPPING SADDLES

During welding of an EF tapping saddle 8 hand tools and/or aiding apparatus are needed.

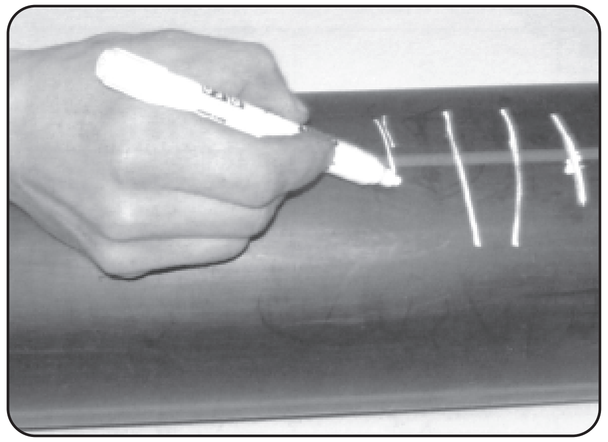
1. EF tapping saddle itself
2. Bolts (supplied with the EF tapping saddle)
3. Scraper (with suitable knife)
4. Cleaning fluids (acetone, alcohol, etc.)
5. Cleaning cloth
6. Hexagon wrench
7. Allen key for tapping
8. Marker

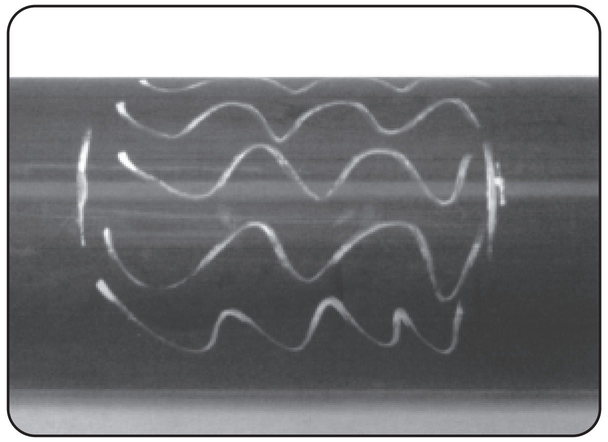
Tapping saddle's are marked on pipe for scraping.





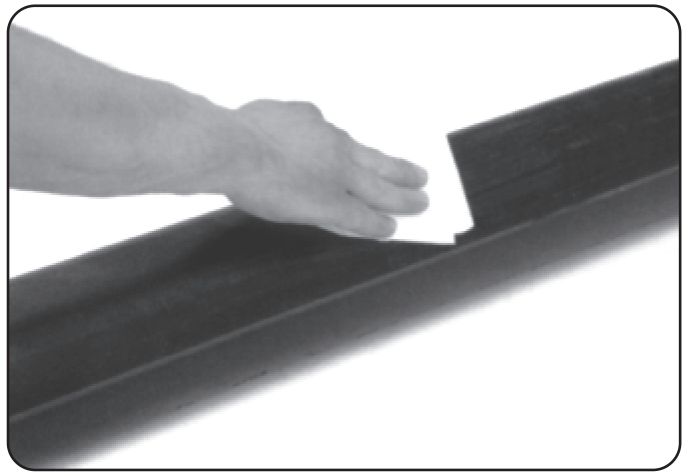
After marking, surface between the signs are scratched with a marker pen.

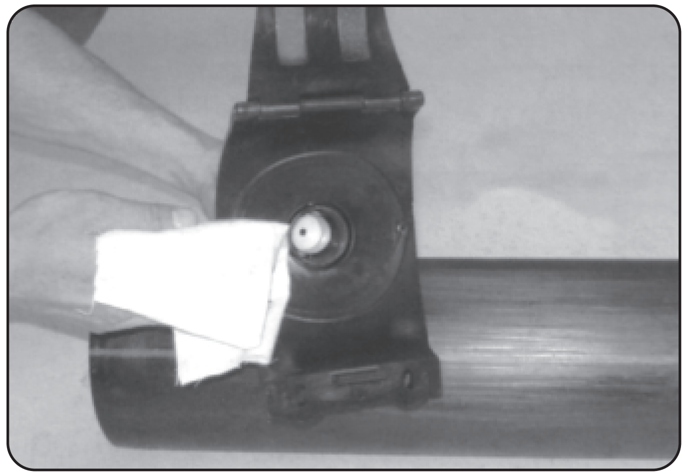




Dirts (oxide layer, coating e.g.) on scratched surface are scraped carefully. While scraping the oxide layer on the pipe, maximum scraping depth should be 0,1 mm for dn<63 mm pipes and 0,2 mm for dn>63 mm pipes. If the oxides are not scraped completely, leaks may be occurred because of improper welding.

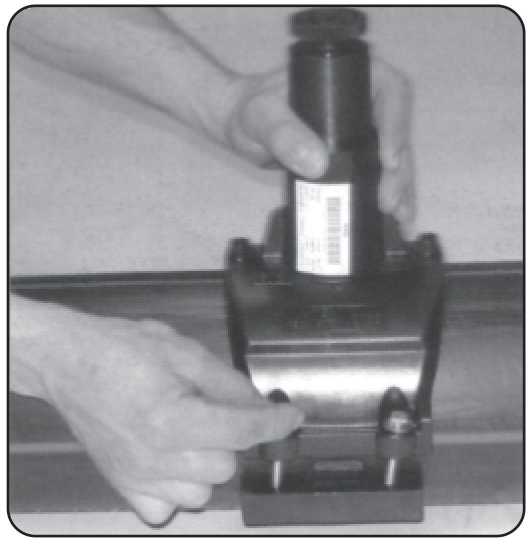
Scraped surface and tapping saddle's pad surfaces must be cleaned by means of proper fluids (industrial alcohol, acetone, etc) and by soft, non-fuzzy papers.

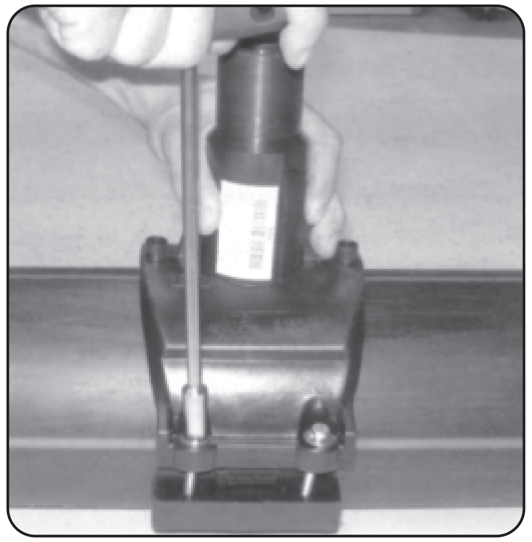




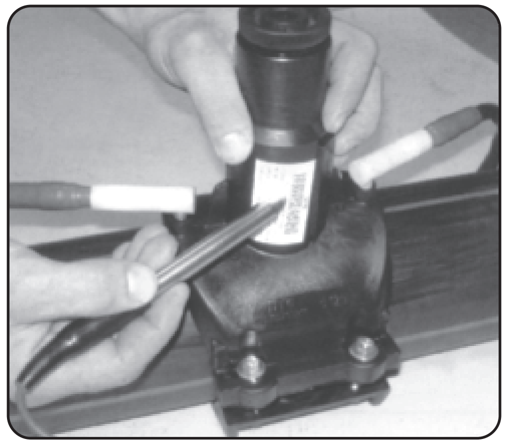
After cleaning, surfaces should not be touched. Place the tapping saddle welding side to scraped surface of pipe. Clip in the upper and down part of the saddle.

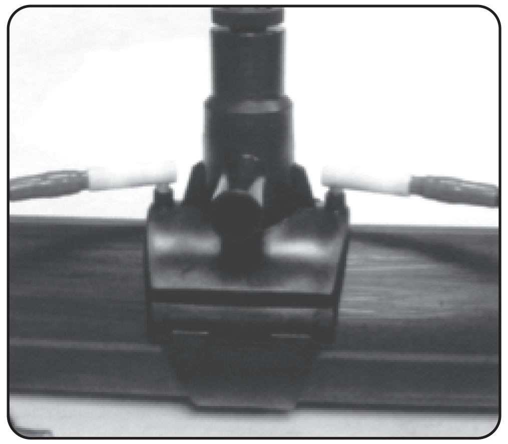
Place the assembling bolts and tighten them with an hexagon SW10 wrench till tapping saddle welding zone and saddle come to same level.



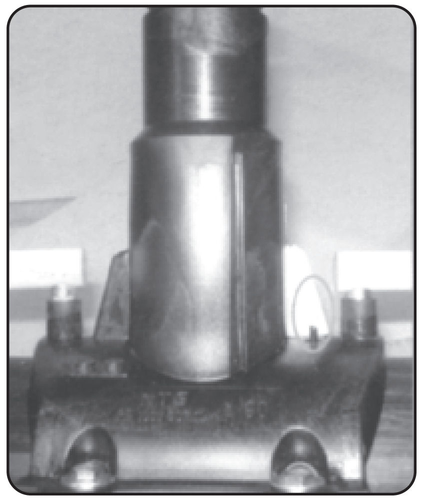


Connect the welding machine and tapping tee's prompts together. Set the parameters of product bar-code by manually or by means of bar-code reader. Check the welding parameters. Wait during the cooling time defined on bar-code.

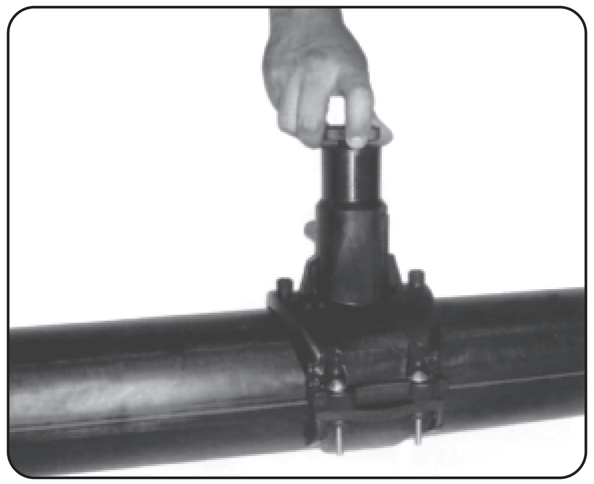




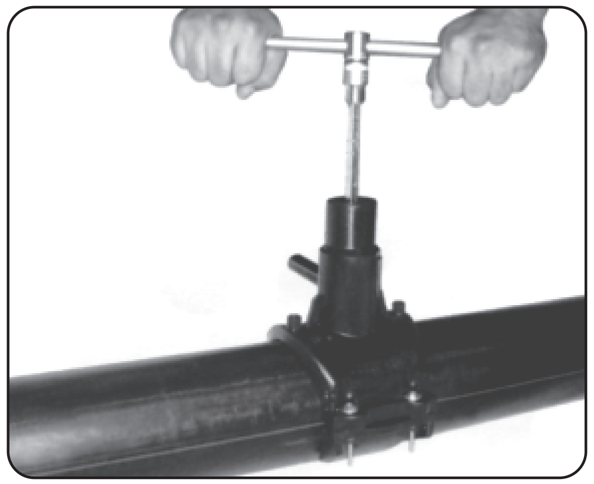
After welding process completes fusion indicator comes out.



After welding is completed and the cooling time is over, remove the cover at tapping saddle and keep it at a clean place.



Screw the driller clockwise with an Allen scraping (drill) wrench. After drilling is achieved remove the driller back to fully up position.



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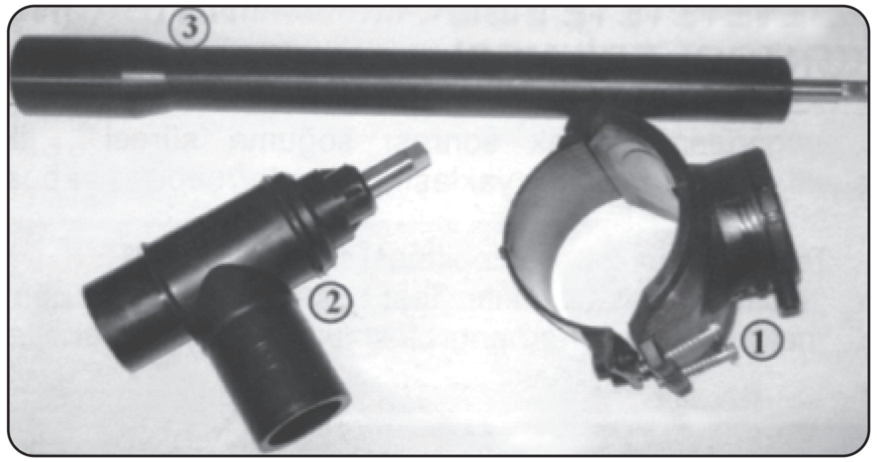
Tapping Valves

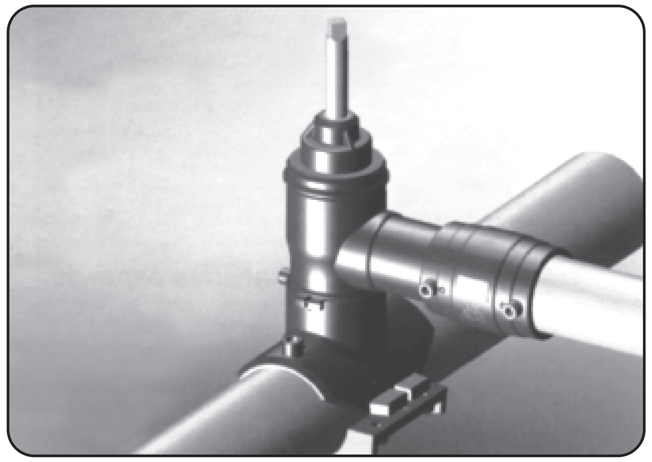
Tapping valve pieces are:

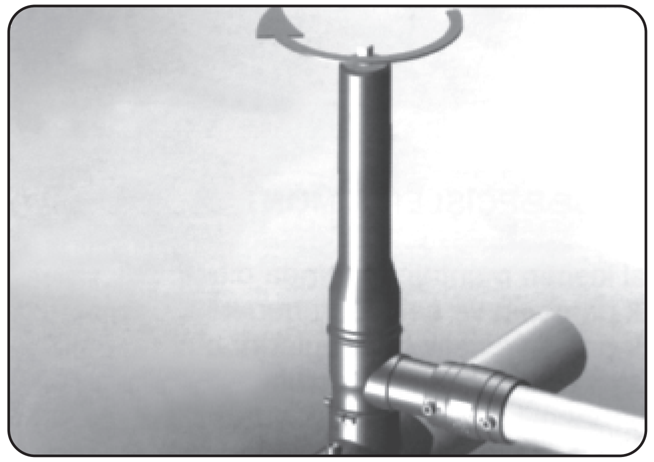
1. EF saddle
2. Valve with TEE outlet
3. Extension axle



Preparation of PE pipe and saddle, follow the steps at pages 43-44-45. After cleaning the Valve Tee's surface that will be assembling to saddle, place the valve on saddle from any side. Follow the instructions at page 45 for welding process.

Drilling process: After suggested cooling time is elapsed, extension axle is placed in quadrangle wrench inlet of valve tee. Drilling is done in clockwise with a suitable wrench. 16 times full turning round is needed to open or close completely.

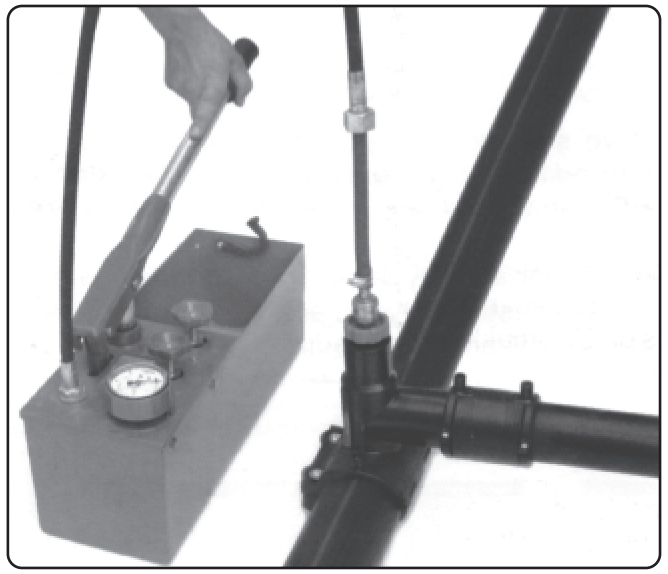




CONTROLLING NTG TAPPING SADDLE WELDING QUALITY WITH PRESSURE-LOAD TEST

After cooling time is elapsed, pressure test may be performed. Network water pressure which is about 6 bar is enough for before drilling test.

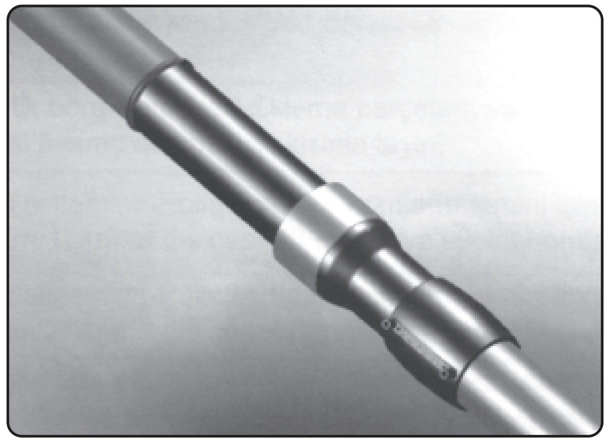
To give the test pressure, top cover of tapping saddle is removed and red coloured pressure test kit is attached. With the help of test pressure pump, water network pressure is transferred to welding zone. If there is no leak in the welded surface, welding is successful.



ASSEMBLY OF PE STEEL TRANSITION FITTINGS

Subjects to be considered while assembling the metal part.
1. Steel end of the fitting as well as the end of steel pipe should be properly prepared for welding.
2. Adjust the levels of fitting and steel pipe carefully.
3. Welding should be done by certified and experienced person without leaving any gap in welded area.
4. If any problem or any welding faults occurred, fitting metal side should not be cut more than twice.
5- During welding, PE part of fitting must not effect of heat, or must not melt.

For assembly PE side, please refer to electrofusion welding procedure (page.40).



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WELDING ERRORS AND REASONS

During welding pieces expose to inconvenient weather conditions

Bad weather condition during welding is an important effect on quality in electrofusion welding as well as in the other welding methods. Above all, it caused to new faults by effecting operators who cannot perform properly under such conditions. Welding under normal environment, such as normal temperatures, free of dust, moisture and contaminations, will have direct effect on the welding quality.

Unreleased pressurized air or gas flow in pipe, regional gas accumulations

Especially for maintenance applications pressurized air or gas will have various effects on welding before or after. When a damaged pipe is cut and repaired with a EF coupler pressurized pipe must be squeezed at both sides in order to prevent gas and water loses and endangering the working site. It is important that no water or gas is left at the welding zone otherwise welding might not be proper.

Low or high environment temperature

Air temperature (should be between 0°C and +35°C) at the welding site is an important issue and direct effect on the welding quality. While deciding welding time in welding parameters, environmental temperature is taken into consideration, and pipe and/or fittings temperatures are considered to be close to the outer temperature values. If there is big difference welding might not be correct.

Pause at welding operations

For some reasons, such as technical failures, energy cut off, electrofusion welding may stop at half way before welding is complete. In this case, the welding pieces must be left to cool down completely then the procedure could be started as it is a new welding. If the welding carried on before the welding zone is cool quality problems are likely to occur.

Mechanical forces on welding area

One of the important issue at welding is to protect the pipe and fitting against any mechanical loads during welding and cooling. If pipes are coiled, a positioning apparatus should be used at welding.

Insufficient cleaning of the welding zone

Cleaning has direct effect on the quality of welding at both electrofusion and butt welding techniques. Before welding oxidation layer on the pipe and fitting should be scraped out and then wiped with convenient solvents. Cleaned zones should not be touched with bare hands. Insufficient cleaning will end with welding failure.

Bends and ovality in pipes

PE pipes may have ovality and/or bends because of manufacture, storage and/or from various operations on pipe. These pipes must be straightened before welding by means of using suitable clamps and/or apparatus otherwise welding will result failure because of mismatch.

Low voltage or choosing wrong welding time

To have a proper welding quality, correct pressure, heat and voltage must be obtained at welding zone by using appropriate machinery. If required current (it is generally between 18 and 39 Volts at electrofusion welding) and the other welding parameters, which are determined at laboratory conditions, are not reached it is not possible to have a quality welding. If heating / welding time is too long flow or burnt is inevitable, contrary when the time is too short the material is not yet mature for welding. Both result in failure.

Using butt welding pipes on electrofusion welding method

PE pipes are produced based on outer diameter and classified in two groups: A (sensitive tolerance) and B (medium tolerance). For electrofusion welding A group pipes are preferred, B group is usually for butt welding. Butt welding pipes are not sensitive at outer diameter and may create problems when used together with electrofusion fittings.

Mismatching of pipe and EF fittings, gap between pipes in EF fittings

PE pipes must be prepared for electrofusion welding according to the fittings to be used. When pipe ends are not pushed in properly failure at welding is likely to occur. In this case melt material will flow inside the pipe and/or close ci,rcuit may happen.

Pipe and electrofusion fitting made of different resins

During welding material between electrofusion fittings internal surface and pipes outer surface must melt. Different resins will give different melting characteristics, therefore welding quality may decrease when two different resin based pipe and fittings are used.

Problems arising from electrofusion fittings

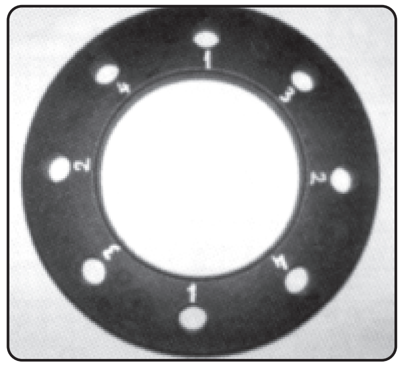
Although manufacturers apply various quality checks at production the end user may receive faulty electrofusion fittings. Ovality is the most common failure and using such fittings may result with low quality welding and/or failure as one experience at using pipes with unacceptable ovality.

Incorrect insert in electrofusion fittings

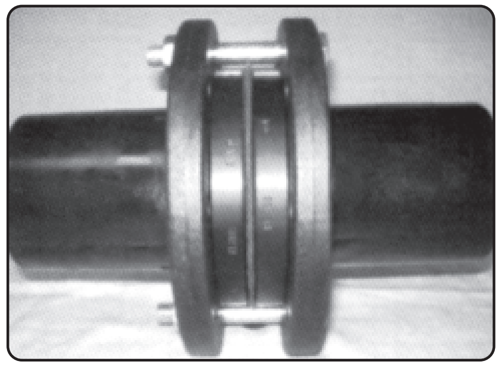
Preparation is the most critical phase of electrofusion welding. Pipe ends must be marked before scraping and cleaning so that pipe must be inserted in the fittings at desired length. Short insert will result flow in the pipe and/or short circuit, contrary long insert will push the other part out by giving the other part insufficient welding zone. In this case, from outside the welding operation is considered fine but in reality it fails.

ASSEMBLY OF PP COVERED FLANGES

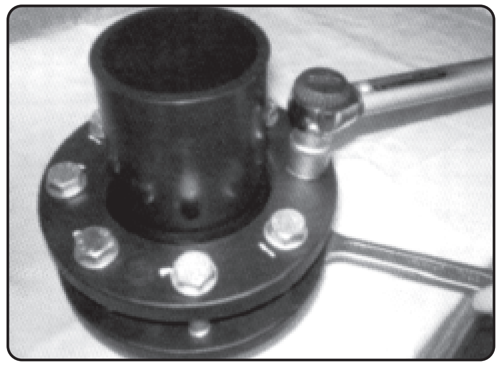
1. Flange holes are numbered



2. Gaskets are placed between flange adapters.
3. Flanges are placed parallel to head of adapters.



4. Screws and nuts are fixed on the flange holes.
5. Screws and nuts are fastened in consecutively in according to the numbers, and tightened in two cycles



6. At first cycle half of the maximum torque value should be applied. (Table 2)
7. At second cycle all screws are tightened at required torque values.

8. After tightening is completed it is advisable to make two more cycles at the same torque for all screws.

Note : PN 10 pressure group flanges should not be used instead of PN 16.

Diameter (mm)	Torque (Nm)
20	15
25	15
32	15
40	20
50	30
63	35
75	40
90	40
110	40
125	40
140	50
160	60
180	60
200	70
225	70
250	80
280	80
315	100

Table 2: Torque for PP covered flanges

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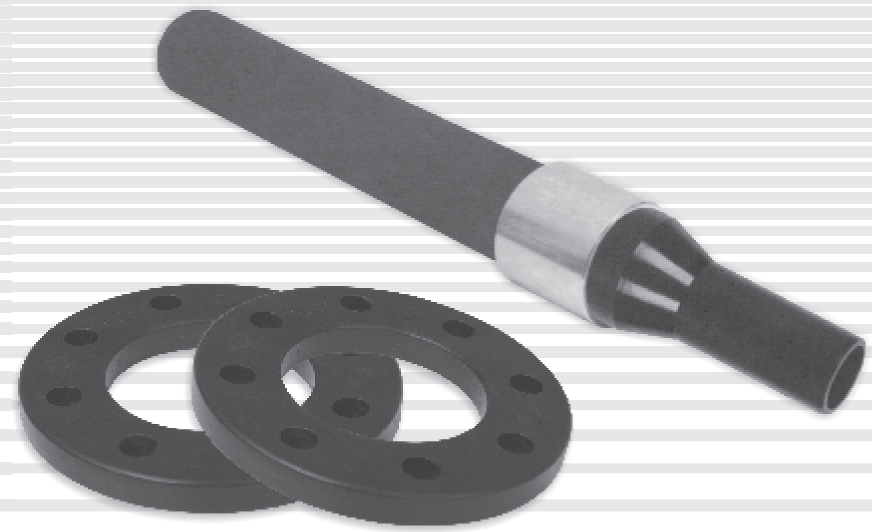
CERTIFICATES



DVGW

DVGW-Baumusterprüfzertifikat

DVGW type examination certificate

DV-8606BR0376

Registriernummer / registration number

Anwendungsbereich *field of application*	Produkte der Gas- und Wasserversorgung *products of gas and water supply*
Zertifikatinhaber *owner of certificate*	NTG Plastik Sanayi ve Ticaret A.S. Enser Sk. No. 30, TR-34906 Pendik-Istanbul
Vertreiber *distributor*	NTG Plastik Sanayi ve Ticaret A.S. Enser Sk. No. 30, TR-34906 Pendik-Istanbul
Produktart *product category*	plastic fittings and compression fittings : PE-HD fitting for gas and drinking water pipework, 75 up to 225 (8606)
Produktbezeichnung *product description*	PE-HD (PE 100) fitting for gas and drinking water pipes
Modell *model*	NTG HDP E 100 Fitting
Prüfberichte *test reports*	mechanical test: 72691/06 from 20.09.2006 (SKZ) KTW testing: 138A06_2 from 24.08.2006 (TZW) hygienic testing: M 006/00 from 31.01.2000 (TZW)
Prüfgrundlagen *basis of type examination*	DVGW GW 335-B2 (01.09.2004) BGA KTW (07.01.1977) DVGW W 270 (01.11.1999)
Ablaufdatum / AZ *date of expiry / file no.*	20.09.2011 / 06-0268-WNE

DVGW Deutsche Vereinigung des Gas- und Wasserfaches e.V.

Technisch-wissenschaftlicher Verein

Zertifizierungsstelle

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53123 Bonn

DAT-ZE-006/98-02

ISO 9001

CERTIFICATE

This is to certify that the Quality system of

NTG Plastik San. Ve Tic. AS.

has been approved according to SS-EN ISO 9001:2000 standard.

The Quality management system is applicable to:

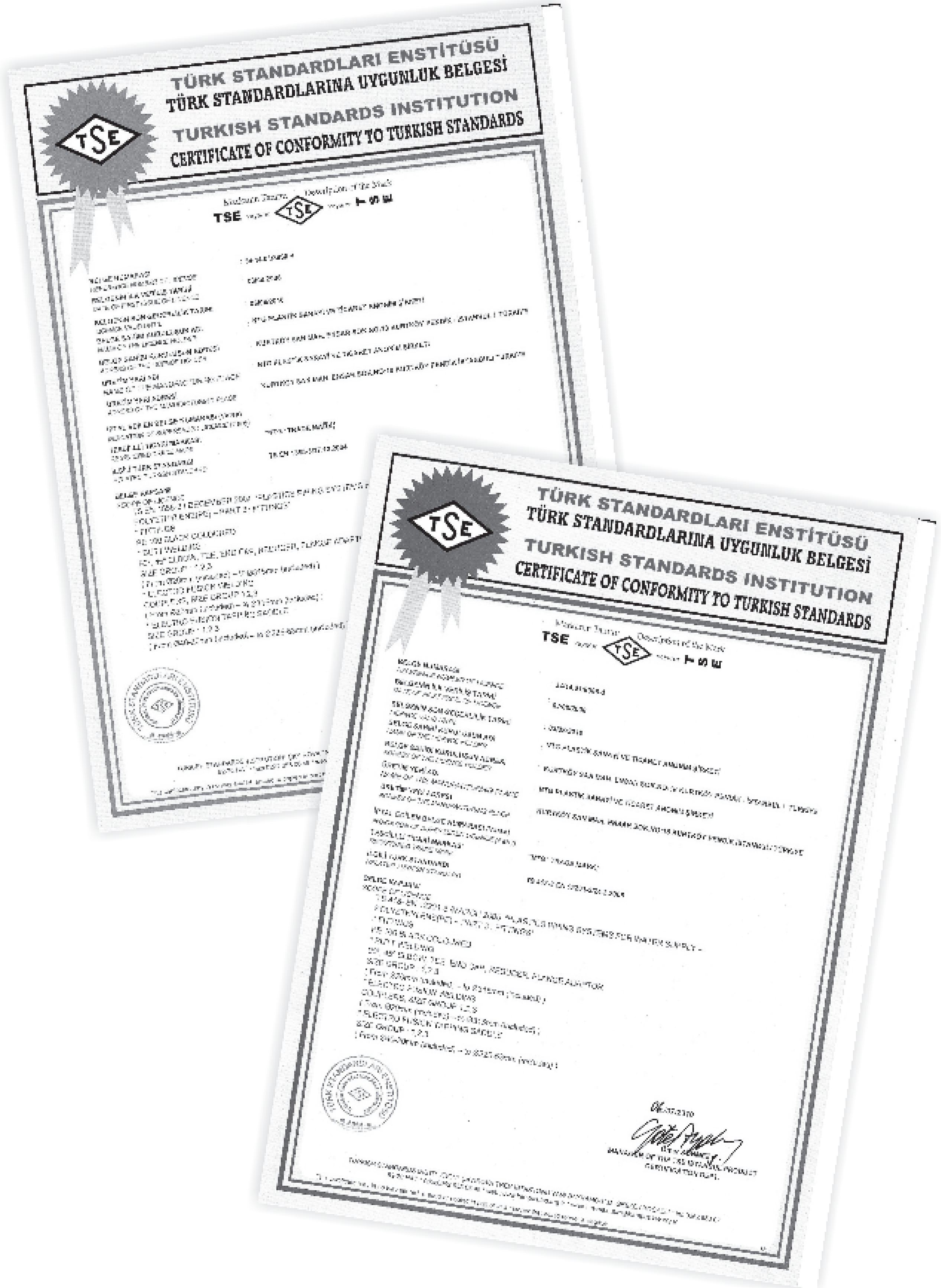
manufacturing and sales of plastic pipes, fittings valves and every kind of plastic equipments made of injection moulding

The scope and conditions of certification are specified in the certification decision.

Certificate no 14501803

BMG TRADA Certifiering AB

BMG TRADA CERTIFIERING



TÜRK STANDARDLARI ENSTİTÜSÜ

TÜRK STANDARDLARINA UYGUNLUK BELGESİ

TURKISH STANDARDS INSTITUTION

CERTIFICATE OF CONFORMITY TO TURKISH STANDARDS

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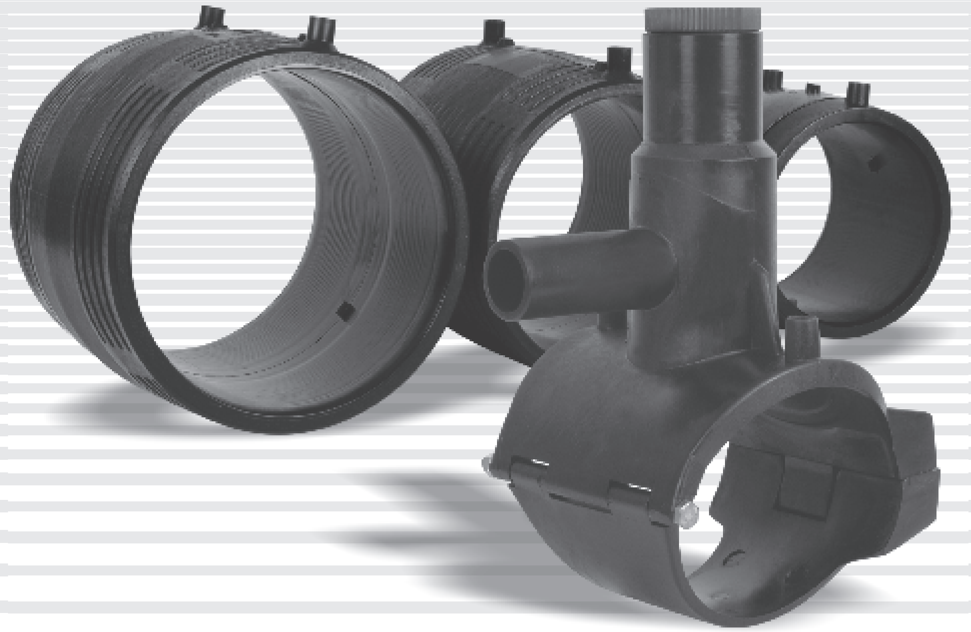
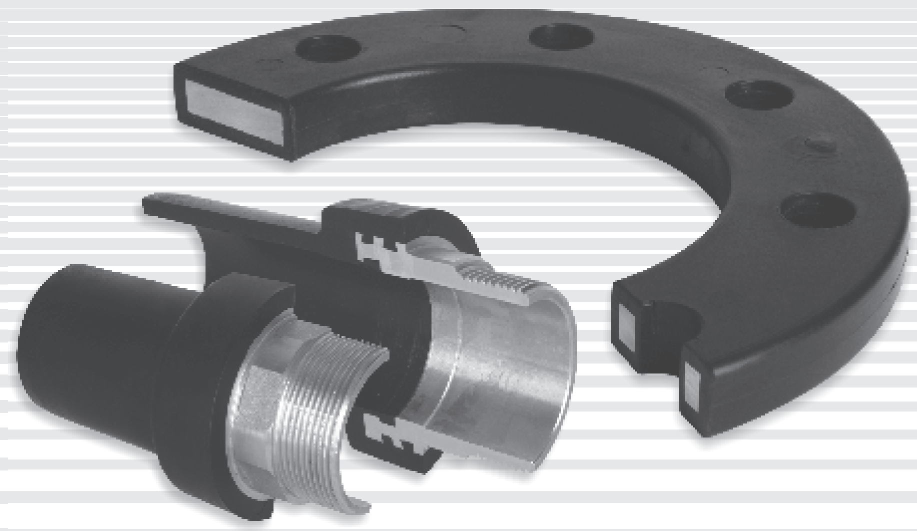
STANDARD SIZES TABLE



STANDARD DIMENSIONS (TS EN 1555-3, TS 418-3 EN 12201-3)

	OUTER DIAMETER		DEVIATION FROM ROUNDNESS	WALL THICKNESS				MINIMAL EF COUPLING LENGTH (mm)	
NOMINAL DIAMETER (mm)	MINIMUM (mm)	MAXIMUM (mm)	(mm)	SDR17 (PN 10) MINIMUM (mm)	SDR17 (PN 10) MAXIMUM (mm)	SDR11 (PN 16) MINIMUM (mm)	SDR11 (PN 16) MAXIMUM (mm)	(mm)	NOMINAL DIAMETER (mm)
16,0	16,0	16,3	0,3	2,3	2,7	3,0	3,4	41,0	16,0
20,0	20,0	20,3	0,3	2,3	2,7	3,0	3,4	41,0	20,0
25,0	25,0	25,3	0,4	2,3	2,7	3,0	3,4	41,0	25,0
32,0	32,0	32,3	0,5	2,3	2,7	3,0	3,4	44,0	32,0
40,0	40,0	40,4	0,6	2,4	2,8	3,7	4,2	49,0	40,0
50,0	50,0	50,4	0,8	3,0	3,4	4,6	5,2	55,0	50,0
63,0	63,0	63,4	0,9	3,8	4,3	5,8	6,5	63,0	63,0
75,0	75,0	75,5	1,2	4,5	5,1	6,8	7,6	70,0	75,0
90,0	90,0	90,6	1,4	5,4	6,1	8,2	9,2	79,0	90,0
110,0	110,0	110,7	1,7	6,6	7,4	10,0	11,1	82,0	110,0
125,0	125,0	125,8	1,9	7,4	8,3	11,4	12,7	87,0	125,0
140,0	140,0	140,9	2,1	8,3	9,3	12,7	14,1	92,0	140,0
160,0	160,0	161,0	2,4	9,5	10,6	14,6	16,2	98,0	160,0
180,0	180,0	181,0	2,7	10,7	11,9	16,4	18,2	105,0	180,0
200,0	200,0	201,2	3,0	11,9	13,2	18,2	20,2	112,0	200,0
225,0	225,0	226,4	3,4	13,4	14,9	20,5	22,7	120,0	225,0
250,0	250,0	251,5	3,8	14,8	16,4	22,7	25,1	129,0	250,0
280,0	280,0	281,7	4,2	16,6	18,4	25,4	28,1	139,0	280,0
315,0	315,0	316,9	4,8	18,7	20,7	28,6	31,6	150,0	315,0
355,0	355,0	357,2	5,4	21,1	23,4	32,3	35,6	164,0	355,0
400,0	400,0	402,4	6,0	23,7	26,2	36,4	40,1	179,0	400,0
450,0	450,0	452,7	6,8	26,7	29,5	40,9	45,1	195,0	450,0
500,0	500,0	503,0	7,5	29,7	32,8	45,5	50,1	212,0	500,0
560,0	560,0	563,4	8,4	33,2	36,7	50,9	56,0	235,0	560,0
630,0	630,0	633,8	9,5	37,4	41,3	57,3	63,1	255,0	630,0

UNIT WEIGHT OF PE 100 PIPES



Unit Weight of PE 100 Pipes

MRS=10 Mpa C=1,25 Ó=8,0MPa

PN	4		5		6		8		10	
SDR	41		33		27,6		21		17	
Çap (mm)	s (mm)	m (kg/mt)	s (mm)	m (kg/mt)	s (mm)	m (kg/mt)	s (mm)	m (kg/mt)	s (mm)	m (kg/mt)
16										
20										
25									2,0	0,140
32									2,0	0,190
40							2,0	0,240	2,4	0,280
50					2,0	0,300	2,4	0,360	3,0	0,440
63			2,0	0,380	2,3	0,440	3,0	0,570	3,8	0,710
75	2,0	0,460	2,3	0,530	2,9	0,660	3,6	0,810	4,5	1,000
90	2,3	0,640	2,8	0,770	3,3	0,900	4,3	1,160	5,4	1,440
110	2,7	0,910	3,4	1,140	4,0	1,340	5,3	1,750	6,6	2,150
125	3,1	1,190	3,9	1,490	4,6	1,740	6,0	2,250	7,4	2,740
140	3,5	1,510	4,3	1,840	5,1	2,170	6,7	2,810	8,3	3,440
160	4,0	1,970	4,9	2,390	5,8	2,820	7,7	3,690	9,5	4,500
180	4,4	2,430	5,5	3,020	6,5	3,550	8,6	4,640	10,7	5,710
200	4,9	3,010	6,2	3,790	7,3	4,430	9,6	5,760	11,9	7,050
225	5,5	3,800	6,9	4,740	8,2	5,600	10,8	7,290	13,4	8,930
250	6,2	4,760	7,7	5,880	9,1	6,910	11,9	8,930	14,8	10,970
280	6,9	5,940	8,6	7,350	10,2	8,670	13,4	11,250	16,6	13,770
315	7,7	7,450	9,7	9,330	11,4	10,900	15,0	14,180	18,7	17,450
355	8,7	9,490	10,9	11,820	12,9	13,900	16,9	18,000	21,1	22,190
400	9,8	12,050	12,3	15,020	14,5	17,610	19,1	22,920	23,7	28,090
450	11,0	15,210	13,8	18,960	16,3	22,270	21,5	29,020	26,7	35,600
500	12,3	18,900	15,3	23,360	18,1	27,480	23,9	35,850	29,7	44,000
560	13,7	23,580	17,2	29,410	20,3	34,510	26,7	44,860	33,2	55,100
630	15,4	29,820	19,3	37,130	22,8	43,610	30,0	56,700	37,4	69,820
710	17,4	37,960	21,8	47,260	25,7	55,400	33,9	72,200	42,1	88,580
800	19,6	48,190	24,5	59,850	29,0	70,440	38,1	91,450	47,4	112,380
900	22,0	60,850	27,6	75,850	32,6	89,080	42,9	115,830	53,3	142,170
1000	24,5	75,290	30,6	93,450	36,2	109,910	47,7	143,100	59,3	175,730
1200	29,4	108,420	36,7	134,490	43,5	158,480	57,2	205,930	70,6	251,190
1400	34,3	147,570	42,9	183,410	50,7	215,510	66,7	280,150	82,4	342,020
1600	39,2	192,740	49,0	239,420	58,0	281,740	76,2	365,790	94,1	446,410

s: Wall Thickness (mm) **m**: Unit Weight (kg/mt) **c**: Safety Coefficient **MRS**: Minimum Required Strength (Mpa) **ó**: Design Stress

Unit Weight of PE 100 Pipes

MRS=10 Mpa C=1,25 Ó=8,0MPa

PN	12,5		16		20		25		32	
SDR	13,6		11		9		7,4		6	
Çap (mm)	s (mm)	m (kg/mt)	s (mm)	m (kg/mt)	s (mm)	m (kg/mt)	s (mm)	m (kg/mt)	s (mm)	m (kg/mt)
16					2,0	0,090	2,3	0,100	3,0	0,120
20			2,0	0,110	2,3	0,130	3,0	0,160	3,4	0,180
25	2,0	0,150	2,5	0,170	3,0	0,210	3,5	0,240	4,2	0,280
32	2,4	0,220	3,0	0,270	3,6	0,320	4,4	0,380	5,4	0,450
40	3,0	0,350	3,7	0,420	4,5	0,500	5,5	0,600	6,7	0,700
50	3,7	0,540	4,6	0,660	5,6	0,780	6,9	0,940	8,3	1,090
63	4,7	0,860	5,8	1,050	7,1	1,250	8,6	1,470	10,5	1,740
75	5,6	1,220	6,8	1,460	8,4	1,760	10,3	2,100	12,5	2,460
90	6,7	1,760	8,2	2,110	10,1	2,540	12,3	3,010	15,0	3,540
110	8,1	2,600	10,0	3,150	12,3	3,790	15,1	4,510	18,3	5,290
125	9,2	3,360	11,4	4,080	14,0	4,900	17,1	5,810	20,8	6,830
140	10,3	4,210	12,7	5,090	15,7	6,150	19,2	7,310	23,3	8,570
160	11,8	5,510	14,6	6,690	17,9	8,010	21,9	9,530	26,6	11,180
180	13,3	6,980	16,4	8,450	20,1	10,120	24,6	12,040	29,9	14,140
200	14,7	8,580	18,2	10,420	22,4	12,530	27,4	14,900	33,2	17,450
225	16,6	10,900	20,5	13,210	25,2	15,860	30,8	18,840	37,4	22,100
250	18,4	13,420	22,7	16,250	27,9	19,520	34,2	23,250	41,5	27,260
280	20,6	16,830	25,4	20,370	31,3	24,520	38,3	29,160	46,5	34,200
315	23,2	21,330	28,6	25,800	35,2	31,030	43,1	36,920	52,3	43,280
355	26,1	27,040	32,2	32,740	39,7	39,430	48,5	46,830	59,0	55,020
400	29,4	34,320	36,3	41,590	44,7	50,030	54,7	59,500	66,7	70,030
450	33,1	43,470	40,9	52,710	50,3	63,340	61,5	75,270		
500	36,8	53,700	45,4	65,020	55,8	78,080				
560	41,2	67,330	50,8	81,490	62,2	97,540				
630	46,3	85,140	57,2	103,210						
710	52,2	108,170	64,5	131,160						
800	58,8	137,300	72,8	166,770						
900	66,2	173,890								
1000	73,5	214,520								
1200										
1400										
1600										

s: Wall Thickness (mm) **m**: Unit Weight (kg/mt) **c**: Safety Coefficient **MRS**: Minimum Required Strength (Mpa) **ó**: Design Stress