PRODUCT CATALOGUE HIGH DENSITY POLYETHYLENE

TIPELIN

MOLGROUP

MOL PETROCHEMICALS

Slovnaft

TIPELIN

CERTIFICATES

SLOVNAFT

MOL Petrochemicals

Introduction

The Hungarian **MOL Petrochemicals Co. Ltd.** and Slovak **SLOVNAFT, a.s.** are an integrated part of the Downstream division within the MOL Group which is the biggest chemical complex in the region producing ethylene and propylene from naphta and gas oil and processing them into low, medium and high density polyethylene and polypropylene through the application of up-to-date technologies.

MOL Group considers **petrochemicals** as an **important strategic field. We can highly lean** on the refinery integration benefits in the MOL Downstream Division: the secured feedstock supply, the robust financial background and strong position in the regional markets, together with the high quality products of the optimized production capacities. We keep operational reliability up by regular maintenance programs, carried out at our production units.

Our prime objective is maintaining our petrochemical leadership in the Central and Eastern European polymer market by taking advantage of the **synergies** provided by the ownership structure and making the names of MOL Petrochemicals and Slovnaft as the symbol of stable and reliable quality via exploiting optimized refinery and petrochemical production processes in accordance with the group's philosophy **"from crude oil to plastics"**.

Our advantageous location in the Central European markets and our competitive portfolio of high quality polyolefin products - optimized in line with customer requirements - provide a firm basis for exploiting the opportunities arising from the surge of demand for polymers in Central and Eastern Europe.

Optimising operation with refining, the Division runs its production **plants** on 2 production sites in **Tiszaújváros** (the plants of MOL Petrochemicals Co. Ltd.) and **Bratislava** (the polymer plants of SLOVNAFT, a.s.), 3 olefin plants and 7 polymer units. We are one of the ten biggest polymer market players in Europe and more than half of our products are sold abroad. We have several **sales offices** throughout **Europe**, in Austria, Germany, Italy, Poland, Romania and the Ukraine. These offices deal with the sales of the products of both companies.

CORPORATE HISTORY

1999	MOL acquired minority stake in former TVK Plc.
2001	MOL became majority owner in former TVK with a stake over 33.34%
2004	MOL acquired majority stake in TVK (44.31%) and in SLOVNAFT (98.4%)
	MOL Petrochemicals Division established: the product range has been streamlined and the sales channels integrated in order to provide competitive edge to our customers on their markets
2011	Petrochemical business integrated into the Downstream Division of MOL Group
2015	MOL acquired 100% of shares in TVK and renamed the company to MOL Petrochemicals Co. Ltd.
	The petrochemical production operates on an integrated Group level (MOL Group), using a unified brand name and international background.

TIPELIN is the registered trade mark for medium and high density polyethylene grades manufactured by MOL Petrochemicals Co. Ltd.

MOL Petrochemicals unimodal medium and high density TIPELIN grades (MDPE and HDPE) are produced by continuous suspension polymerization using low pressure catalytic process under licence of Phillips Petroleum Co. The density range of co-polymers produced with hexene-1 co-monomer grades is 0.934 - 0.961 g/cm^3.

The bimodal high density TIPELIN types are produced by CX Process under licence of Mitsui. This slurry phase polymerization employing a super-high-activity catalyst and a two-reactor system. The density range of co-polymer grades produced with butene-1 co-monomer is 0.948-0.959 g/cm^3.

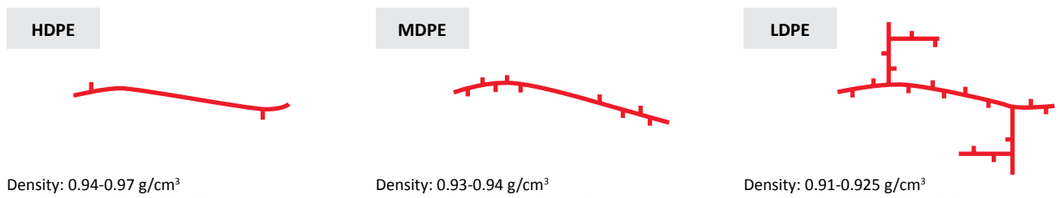
Polyethylene characteristics

MOLECULAR AND CRYSTAL STRUCTURE, DENSITY

Polyethylene macromolecules and their co-polymers build chains consisting of thousands of $-CH_2-$ units. Depending upon polymerisation, this chain develops different branches (Fig. 1). Owing to its molecular structure with branches of chain length, LDPE is referred to as branched polyethylene. In contrast with this, medium and high density grades have only short branches on their chains and are referred to as linear polyethylene. LDPE has long chain branches, which themselves are branched as well. These products are manufactured in a high pressure process (>1000 bar). Linear polyethylene is produced in a low pressure process (by Phillips grades about 40 bar and by Mitsui grades about 10 bar). Hexene-1 (Phillips grades) and butene-1 (Mitsui grades) comonomer built in the chain of these polyethylene grades produces side chains.

The number of side chains is proportional to the amount of co-monomer built in the chain. As a result of the built-in co-monomer, the density and the degree of crystallinity will decrease. Polyethylene density (0.910-0.970 g/cm^3) and molecular weight depend on polymerisation circumstances to some extent. Melt flow rate and density are characteristics indicative of the polyethylene grade. Higher density is associated with a higher crystallisation ratio and a lower number of branches.

Figure 1

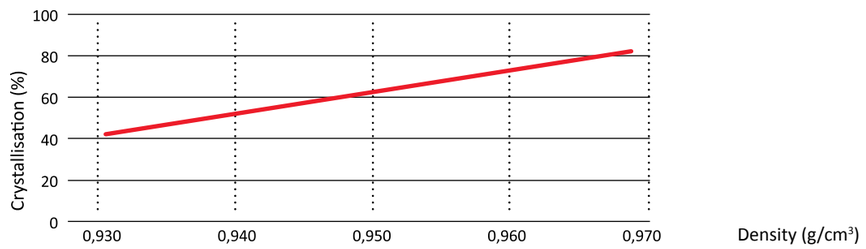


The schematic diagrams demonstrate the structure and number of branches of various polyethylene grades.

Polyethylene is a partially crystalline polymer. The relationship between crystallisation ratio and density of HDPE is shown in Fig. 2. The proportion of crystalline matter or the density decides the polyethylene's melting characteristic.

The melting point rises with the increase in crystallinity and density. The melting point varies between the melting point of LDPE (ca. 110 °C) and that of HDPE (ca. 128 °C).

Figure 2



Degree of crystallinity as a function of density

MOLECULAR WEIGHT, MELT FLOW RATE, MELT VISCOSITY AND FLOW CHARACTERISTICS

Chain length, or the average molecular weight is one of the important characteristics indicative of the degree of linkage. Changes in the molecular weight will definitely change melt viscosity, highly effecting on the processing properties. A high molecular weight polymer has a high melt viscosity. To measure flow properties, a parameter, melt flow rate is used according to ISO 1133. High melt flow rate means easy flowing and low molecular weight. Melt flow rate is defined by a one-point method, a test that can be performed quite easily under laboratory circumstances. It is important, however, that the molecular weights, melt flow rates and flow characteristics of identical polyethylene grades manufactured in different processes may differ even though they have the same melt flow rate.

MOLECULAR WEIGHT DISTRIBUTION

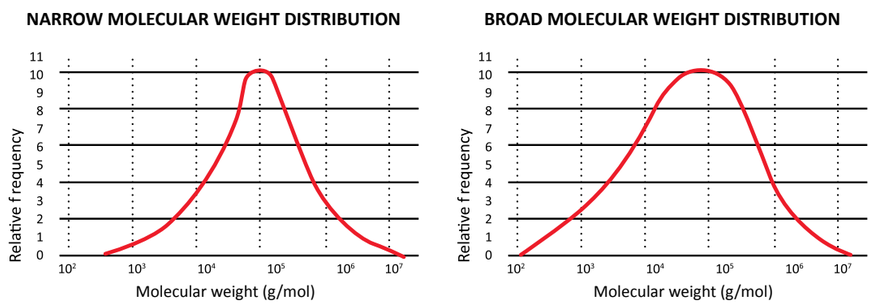
Polyethylene consists of molecules of different chain lengths, giving different molecular weights. This is clearly shown by the diagram demonstrating the frequencies of various molecular weight. Molecular weight distribution influences both processing and end product properties. For example, a narrow molecular weight distribution is needed for the injection moulding of resins if the moulded parts are to be free from all distortion and internal stresses which might compromise their environmental stress cracking resistance (ESCR).

At the same time, a high molecular weight polyethylene with a wider molecular weight distribution is more suitable for blowing processes to manufacture pipes and films. It should be remembered, however, that the low and medium molecular weight fractions account for easy processing. The high molecular weight fraction gives good mechanical properties (impact strength, creep and warp resistance and ESCR).

The narrower the molecular weight distribution

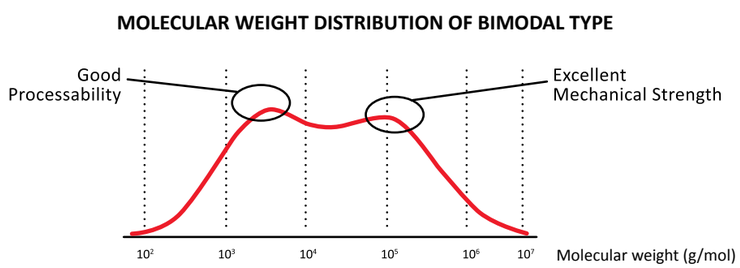
- The lower the internal stresses
- The higher the stretchability when molten

Figure 3



The most important property of HDPE is its mechanical strength with easy processing capability, and this can be realized through bimodal high molecular weight HDPE. The low molecular weight component provides good processability, while the high molecular weight component gives excellent mechanical strength.

Figure 4



Other properties

SHRINKAGE

The shrinkage of finished products manufactured from HDPE takes place in the crystallization phase. The extent of crystallisation depends on the processing parameters (temperature, pressure, throughput, thickness, cooling speed, etc.), but molecular structure (molecular weight and weight distribution) is a further factor having an effect on crystallisation. Shrinkage accounts 3-4% in pipe diameters. Shrinkage can be max. 5% in fittings made from pipe grades. Shrinkage can be exactly determined only after 24 hours following injection moulding, because after crystallisation and the compensation of the generated internal stresses will result in further dimensional changes in the finished products. The extent of after shrinkage is time and temperature dependent. After shrinkage time, when shrinkage can reach 1% max., can be reduced by increased storage temperatures.

WEATHER RESISTANCE

HDPE grades have a good resistance to light in the visible spectrum. However, when stored in the open air, they can get damaged by the combined effects of atmospheric oxygen and UV radiation. As a result, their durability and tensile strength lessen, and they may discolour. The useful life of polyethylene can be increased by two or four times with a UV stabiliser added to the blend. The great number of available UV stabilisers allows manufacturers to select the right grade to make a product most suitable for the weather conditions, end product and the environment of application. Special carbon blacks, the best UV stabilisers so far, can extend the useful lives of the products by 10-15 times when added in amounts of 2-3%. Pigments also can improve UV resistance, although, these additives may cause some undesirable side effects, as well

Application

The wide range of grades and the careful selection of characteristics of the individual grades allow various applications including:

Blown film grades
for heavy duty bags, industrial bags, shopping bags, garbage bags and packaging films for medicines and foods;

Blow moulding grades
to manufacture household plastic products, bottles and cans for foods including oils, soft drink extracts, dairy products and large capacity barrels for household or industrial chemicals, corrugated pipes;

Pipe grades
corrugated and protective pipes, steel pipe coating;

Sheet extrusion grades
for sheets and thermoformed sheets.

Coding system

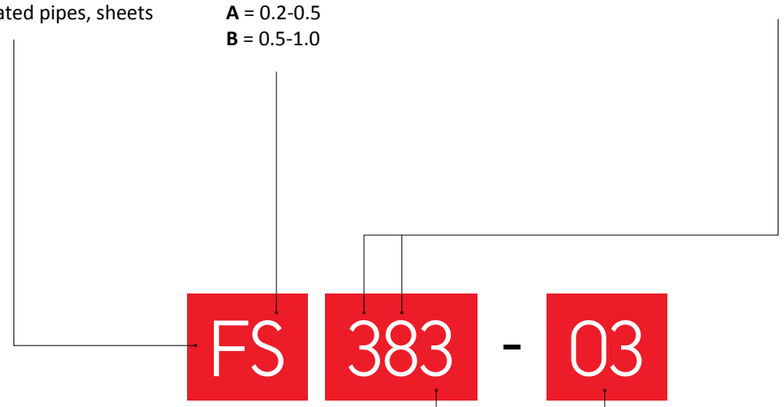
Grades produced by Phillips technology:

TIPPELIN MEDIUM AND HIGH DENSITY POLYETHYLENE GRADES (MDPE AND HDPE) ARE IDENTIFIED BY A CODE SYSTEM CONSISTING OF TWO LETTERS AND FIVE DIGITS.

The first letter is for the application of the polymer
F = Film
B = Blow moulding, corrugated pipes, sheets

The second letter indicates the melt flow rate (MFR) range in g/10 min at 190 °C and 2.16 kg
S < 0.2
A = 0.2-0.5
B = 0.5-1.0

The first and second digits are identical with the second and the third decimals of the number indicating nominal density



The third digit is an internal plant code

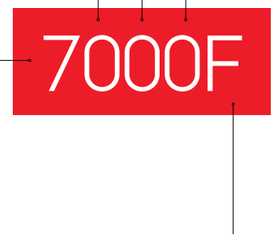
The fourth and fifth digits identify the additive system in the polymer

Grades produced by Mitsui technology:

TIPELIN HIGH DENSITY POLYETHYLENE GRADES ARE IDENTIFIED BY A CODE SYSTEM CONSISTING OF FOUR DIGITS AND ONE LETTER.

The first digit indicates the melt flow rate (MFR) range in g/10 min at 190 °C and 2.16 kg
6 = 0.1-0.9
7 = 0.05-0.10
8 < 0.05

The second, third and fourth digit
Internal code



Letters at the end of the grade name show main application of the grade
B = Blow moulding
F = Film
M = Pipe extrusion
S = Sheet extrusion, fiber

		Grade/Parameter	Melt Mass - Flow Rate (MFR)	Density 23 °C [4]	Tensile Strength at Yield [4]	Tensile Strain at Yield [4]	Tensile Strength at Break (MD/TD) [4]	Tensile Strain at Break (MD/TD) [4]	Elmendorf Tear Resistance (MD/TD)	Dart Drop (F50)	Flexural Modulus [4]	Notched Izod Impact [4]	Spencer Impact Strength	Vicat Softening Tempera-ture [4]	Shore D Hardness [4]	ESCR F50 B method	OIT 200 °C	Application
		Units	g/10 min	kg/m³	MPa	%	MPa	%	cN	g	MPa	kJ/m²	MPa	°C	-	h	min	-
		Test methods	ISO 1133-1	ISO 1183-2	ISO 527-3	ISO 527-3	ISO 527-3	ISO 527-3	ISO 6383-2	ISO 7765-1 method A	ISO 178	ISO 180/A	ASTM D 3420	ISO 306 /A 120	ISO 868	ASTM D 1693	EN 728	-
BLOW MOULDING GRADES	UNIMODAL	BS 501-17	0.18 [1] 0.94 [2] 22 [3]	950	26	-	32	1000	-	-	1400	15	-	127	64	180 [7]	7	bottles and cans of max. 10 litre capacity for aggressive, household chemicals and detergents, corrugated pipes
		BS 520-14	0,1 [1] 0.45 [2] 10.0 [3]	952	27	-	30	1290	-	-	1450	29	-	128	64	540 [7]	90	balloons and drums up to 220 l for aggressive industrial chemicals, thermoforming
		BA 550-13	0.35 [1] 1.5 [2] 28 [3]	954	29	-	-	1000	-	-	1590	15	-	129	66	45 [7]	10	bottles and cans of max. 30 litre capacity for non-aggressive house-hold chemicals, cosmetics and oils. corrugated pipes
		BB 620-17	0.65 [1] 2.9 [2] 50 [3]	962	32	10	-	1000	-	-	1900	14	-	130	67	18 [7]	8	small bottles for liquid food (yoghurt, milk, juice, water) packaging, corrugated pipes
	BIMODAL	6000B	0.30 [1] 1.3 [2] 30 [3]	958	32	9	-	1000	-	-	1700	9	-	127	65	200 [8]	30	thin walled bottles of max. 5 litre capacity for consumer goods (cosmetics, daily care), corrugated pipes,
		6010B	0.30 [1] 1.3 [2] 30 [3]	958	30	10	-	1300	-	-	1700	9	-	126	65	650 [8]	90	thin walled bottles of max. 5 litre capacity with long colour stability, consumer goods (cosmetics, daily care)
		6300B	0.30 [1] 1.3 [2] 30 [3]	954	29	10	-	1000	-	-	1550	9	-	126	65	665 [8]	34	bottles and containers of max. 10 litre capacity for detergents and household chemicals, corrugated pipes
		7300B	0.10 [1] 0.40 [2] 11 [3]	955	29	10	28	1040	-	-	1600	18	-	127	64	1375 [8]	53	jerry can for aggressive industrial chemicals, sheet extrusion
		8200B	0.025 [1] 0.20 [2] 5.0 [3]	952	28	12	37	1300	-	-	1500	31	-	129	65	> 1200 [8]	85	jerry cans, drums, containers up to 1 m3 for aggressive, industrial chemicals
Pipe and Sheet		7700M [9]	0.06 [1] 0.26 [2] 8.0 [3]	948	25	12	30	1320	-	-	1300	23	-	125	63	> 10000 [8]	120	non-pressure pipes and sheet manufacturing
		7111S [9]	0.12 [1] 0.50 [2] 13 [3]	949	25	11	30	1215	-	-	1350	19	-	125	63	> 10000 [8]	120	non-pressure pipes and sheet manufacturing

Notes: Typical properties, not to be used as specification.
(1) MFR at 190 °C and 2.16 kg
(2) MFR at 190 °C and 5 kg
(3) MFR at 190 °C and 21.6 kg
(4) Values have been measured on standard pressed specimens (ISO 293) conditioned at room temperature (ISO 291)
(5) The thickness of the film: 0.025 mm for the mechanical measurement (MD/TD: MD = machine direction, TD = trans direction)
(6) The thickness of the film: 0.015 mm for the mechanical measurement (MD/TD: MD = machine direction, TD = trans direction)
(7) Values have been measured in 100% Igepal CO-630 on standard pressed specimens (ISO 293) conditioned at room temperature (ISO 291)
(8) Values have been measured in 10% Igepal CO-630 on standard pressed specimens (ISO 293) conditioned at room temperature (ISO 291)
(9) Values have been measured on standard injection moulded specimens (ISO 294-1) conditioned at room temperature (ISO 291)

		Grade/Parameter	Melt Mass - Flow Rate (MFR)	Density 23 °C[4]	Tensile Strength at Yield	Tensile Strain at Yield	Tensile Strength at Break (MD/TD)	Tensile Strain at Break (MD/TD)	Elmendorf Tear Resistance (MD/TD)	Dart Drop (F50)	Flexural Modulus	Notched Izod Impact	Spencer Impact Strength	Vicat Softening Temperature	Shore D Hardness	ESCR F50 B method	OIT 200 °C	Application
		Units	g/10 min	kg/m³	MPa	%	MPa	%	cN	g	MPa	kJ/m²	MPa	°C	-	h	min	-
		Test methods	ISO 1133-1	ISO 1183-2	ISO 527-3	ISO 527-3	ISO 527-3	ISO 527-3	ISO 6383-2	ISO 7765-1 method A	ISO 178	ISO 180/A	ASTM D 3420	ISO 306 /A 120	ISO 868	ASTM D 1693	EN 728	-
INJECTION MOULDING GRADES	UNIMODAL	1100J	8.0 [1]	961	28 [9]	8 [9]	12 [9]	580 [9]	-	-	1500	5 [9]	-	128 [9]	63 [9]	7 [7]	35	recommended for making daily necessaries, kitchen housewares, boxes, crates, trays, toys, caps, cartridges.
		1108J	8.0 [1]	961	28 [9]	8 [9]	13 [9]	620 [9]	-	-	1500	5 [9]	-	129 [9]	63 [9]	6 [7]	120	recommended for making daily necessaries, kitchen housewares, boxes, crates, trays, toys, caps, cartridges, contains UV stabilizer package
		2100J	4.0 [1]	953	23 [9]	10 [9]	12 [9]	560 [9]	-	-	1100	7 [9]	-	124 [9]	60 [9]	6 [7]	45	recommended for making bottle closures (for non-carbonated drinks), pails, crates, pallets, dust bins, large containers, lids (for pails, drums and containes)
		2108J	4.0 [1]	953	25 [9]	9 [9]	13 [9]	450 [9]	-	-	1100	7 [9]	-	124 [9]	60 [9]	5 [7]	120	recommended for making bottle closures (for non-carbonated drinks), pails, crates, pallets, dust bins, large containers, lids (for pails, drums and containes), contains UV stabilizer package
Fiber Grade	UNIMODAL	5700S	0.5 [1] 1.7 [2] 25 [3]	946	23/24 [6]	15 [6]	52/54 [6]	800/900 [6]	20/115 [6]	53 [6]	1250	11	33	127	61	100	105	split yarn fibres for agricultural applications, films, bags
BLOWN FILM GRADES	UNIMODAL	FS 340-03	0.18 [1] 0.78 [2] 15 [3]	935	22/19 [5]	-	51/44 [5]	700/790 [5]	48/390 [5]	100 [5]	-	-	39 [5]	117	59	-	65	heavy duty bags, industrial films, multilayer films, blend component for LDPE
		FA 381-10	0.28 [1] 1.2 [2] 21 [3]	937	20/17 [5]	-	47/42 [5]	710/840 [5]	49/380 [5]	95 [5]	900	-	34 [5]	118	60	-	69	bags, shopping bags, multilayer films, blend component for LDPE
		FS 383-03	0.18 [1] 0.80 [2] 15 [3]	938	23/19 [5]	-	51/45 [5]	670/800 [5]	45/370 [5]	96 [5]	900	-	37 [5]	119	60	-	65	bags, shopping bags, multilayer films, blend component for LDPE
		FS 471-02	0.18 [1] 0.80 [2] 15 [3]	946	24/21 [5]	-	53/45 [5]	700/840 [5]	25/290 [5]	78 [5]	1190	-	36 [5]	125	63	-	70	extra thin packaging films, bags, shopping bags, garbage bags
		FB 472-02	0.69 [1] 2.7 [2] 40 [3]	947	22/21 [5]	-	47/41 [5]	740/900 [5]	29/290 [5]	42 [5]	1120	-	29 [5]	124	63	-	50	bags, shopping bags, garbage bags, blend component for LDPE primarily for shrink film
	BIMODAL	7000F	0.08 [1] 0.30 [2] 9.0 [3]	955	26/25 [6]	-	67/50 [6]	500/600 [6]	15/150 [6]	220 [6]	-	-	120 [6]	126	64	-	45	ultra-thin film, merchandise bags, disposal waste bags
		7500F	0.095 [1] 0.30 [2] 10.0 [3]	952	25/22	-	60/37	550/500	20/160	170	-	-	90	-	-	-	-	ultra-thin film, merchandise bags, disposal waste bags

Notes: Typical properties, not to be used as specification.
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(2) MFR at 190 °C and 5 kg
(3) MFR at 190 °C and 21.6 kg
(4) Values have been measured on standard pressed specimens (ISO 293) conditioned at room temperature (ISO 291)
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Processing conditions of TIPELIN MDPE and HDPE grades

FILM MANUFACTURING

Considering their characteristics, TIPELIN film grades are medium and high density polyethylenes with a typically wide molecular weight distribution. To manufacture these grades an HDPE production unit with a 0.7-1.2 mm die gap and melt temperatures of 200-220 °C are recommended. To produce optimum mechanical properties a high blow up ratio (minimum 4:1) should be applied. Generally the frost line height is 5-8 times the die diameter. TIPELIN FS 340-03, FS 383-03, FA 381-10 and FB 472-02 may be processed on machines designed for LDPE as LDPE, LLDPE or other blends containing HDPE. Depending on the extruder design and processing conditions, the thickness range can be 0.007-0.200 mm.

PIPES AND SHEET EXTRUSION

Pipes and sheets can be manufactured from a TIPELIN grades in a profile extrusion process. For the extrusion of TIPELIN profiles, a screw of at least 20 D, shorter compression zone (1-3 D) and a 2-2.5 compression ratio should be applied. The constant pitch of the screw should be equal with or less than the diameter. Recommended processing temperatures are 170-220 °C for extrusion.

BLOW MOULDING

TIPELIN blow moulding grades are high density polyethylenes with typically low MFR and a wide molecular weight distribution.

TIPELIN blow moulding grades process well on extruders whose screw is not less 20 D, constant pitch is equivalent with or less than diameter, compression zone is shorter (1-2 D) and where compression ratio is 2.5-3. Recommended melt temperatures are 180-220 °C.

Physical properties*

Quantity	Method	Value	Unit
Thermal expansion (20 °C)	ASTM D696	12.6×10^{-5}	$°C^{-1}$
Thermal conductivity (20 °C)	ISO 8302	0.48	W/(m.K)
Thermal conductivity (150 °C)	ISO 8302	0.2	W/(m.K)
Electric resistivity	DIN IEC 93	10^{13} - 10^{16}	Ohm.m
Dielectric constant (1 MHz)	ASTM D150	2.4	-
Specific heat	ASTM C351	1800 - 2700	J/kg.K
Melting temperature	Internal method (DSC)	125 - 135	°C
Glass transitional temperature	ASTM E1356	-80	°C
Breakdown potential	IEC 243-1	17.7 - 19.7	kV/mm
Dielectric loss factor	ASTM D150	0.0005 - 0.0008	
Friction coefficient	ASTM D1894	0.25 - 0.3	
Refraction index	ISO 489	1.52 - 1.53	
Shrinkage	ISO 294-4	2.4 - 4.0	%
Water absorption	ASTM D570	0.01 - 0.015	%
Fatigue	ASTM D671	18 - 20	MPa

* these physical values are based on literature data. The values can change with different types, these values are not specified and not guarantied

Storage & Handling

Pellets are packed in 25 kg PE-LD bags and transported on stretch-wrapped pallets at load of polymer 1375 kg. We use adhesive between the bags in order to avoid their slipping. Pay attention to this fact during the removing of the bags from the pallets. The prefered method is to lift the bag at first without rotation. Heat treated pallets are available as well. Transportation in a road silo or rail silo is also available. For more detailed information please contact SLOVNAFT and MOL Petrochemicals sales representative.

Since polyethylene is a combustible substance, the fire safety rules applicable for combustible materials in warehouses and store rooms should be observed.

If polymer is stored in conditions of high humidity and fluctuating temperatures, then atmospheric moisture can condense inside the packing. If it happened, it is recommended the pellets to be dried before use. During the storage polyethylene should not be exposed to UV radiation and temperatures above 40 °C. Producer does not take responsibility for any damages caused by adverse storage.

Reach Statement

Polymers are exempt of REACH registration. However their raw materials which mean monomers, catalysts and relevant additives have been registered. MOL Petrochemicals Co. Ltd. is committed to fully respect this legislation and will only use REACH compliant raw materials. At this point in time HDPE TIPELIN does not contain any substances specifically identified as SVHC at greater level than 0.1%.

Application for foods

Most TIPELIN grade satisfy the regulations applied by the European countries (EEC). Because several European countries apply restrictive regulations for the allowed migration values of additives in packaging material in contact with food, it is recommended that customers contact MOL Petrochemicals for some special information or product licenses for food industry.

⚠ SAFETY

Under normal circumstances, polyethylene is not regarded as hazardous material when in contact with the skin or when inhaled.However, any contact with the molten polymer or the inhalation of the released gases should be avoided in processing. It is recommended to install exhaust units over processing machines and to secure good ventilation of the place. For further information see Material Safety Data Sheet.

♻ RECYCLING

Polyethylene resins are suitable for recycling using modern recycling methods. In-house production waste should be kept clean to facilitate direct recycling.

Disclaimer

The information provided in this publication has been compiled to the best of our present knowledge. However, in view of the various applications of polyethylene resins and the equipment used, the processing conditions may differ.

The recommendations and data herein are to be construed as informatory only and do not relieve users from carrying out their own tests and experiments prior to processing in order to check suitability for a specific use. It is the responsibility of those to whom we supply our products to ensure that any proprietary rights and existing laws and legislation are observed. Our products are under continuous development, therefore we reserve the right to change the information presented in this brochure at our own discretion.

The REACH statement herein does not constitute legal advice. The REACH statement is provided for informational purpose only.

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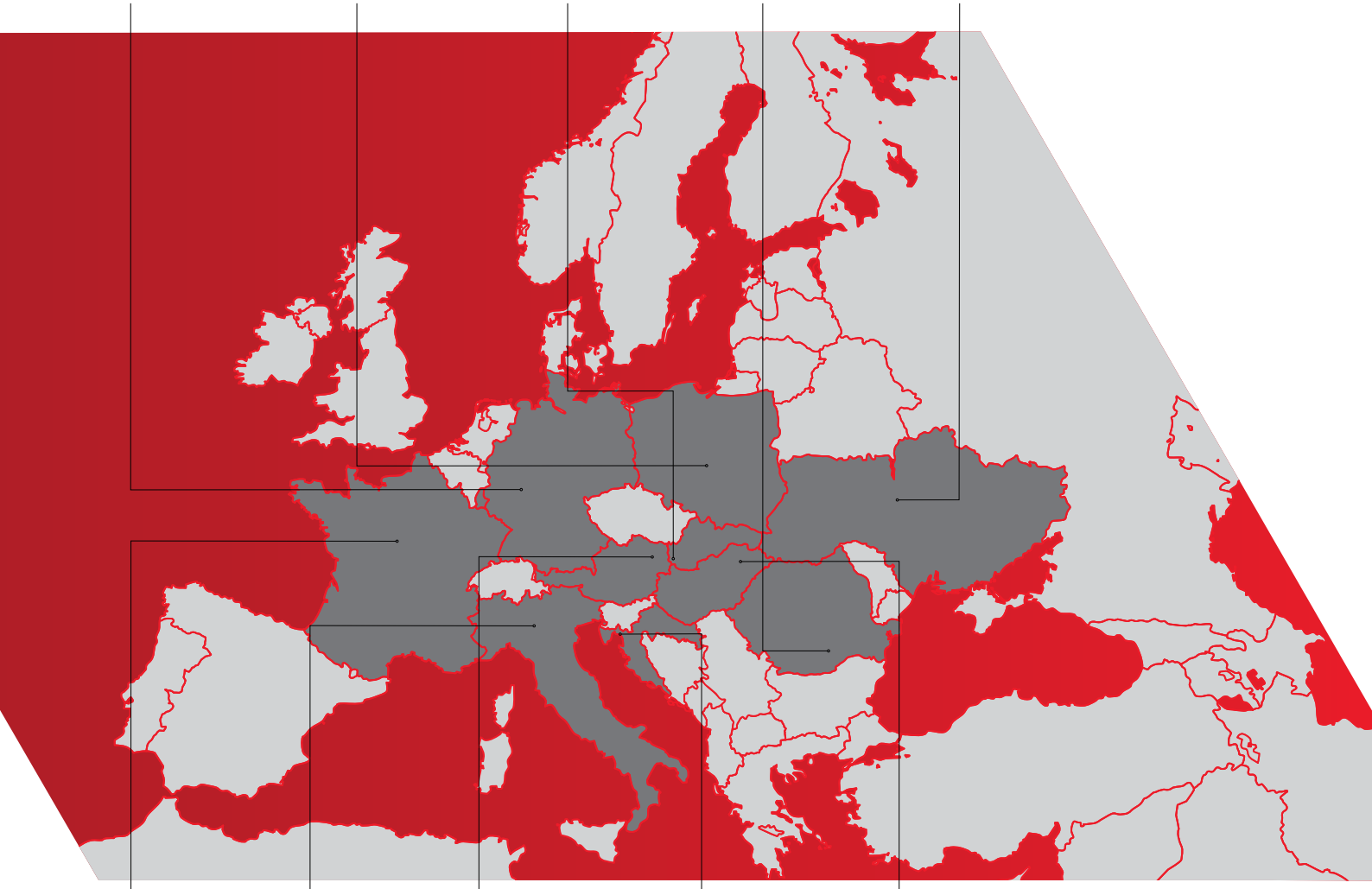

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