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Polyethylene as a Material

Polyethylene materials are manufactured from natural gas derived feedstocks by two basic polymerisation processes.

The low pressure polymerisation process results in linear polymer chains with short side branches. Density modifications to the resultant polymer are made by varying the amount of comonomer used with the ethylene during the polymerisation process.

The high pressure polymerisation process results in polymer chains with more highly developed side branches. Density modifications to the resultant polymer are made by varying the temperatures and pressures used during the polymerisation process.

The physical properties of PE materials are specific to each grade or type, and can be modified by both variations in density, and in the molecular weight distribution. General physical properties are listed in Table 2.1.

A large number of grades of PE materials are used in pipe and fittings systems and the specific properties are tailored for the particular application. Advice can be obtained from Vinidex as to the most effective choice for each installation.

The most general types of PE materials are as follows:

Low Density PE (LDPE)

LDPE has a highly branched chain structure with a combination of small and large side chains.

The density of LDPE ranges between 910-940 kg/m^3 and LDPE exhibits high flexibility and retention of properties at low temperatures.

The main use for LDPE in piping is in the micro irrigation or dripper tube applications with sizes up to 32 mm diameter.

LDPE materials may be modified with elastomers (rubber modified) to improve Environmental Stress Crack Resistance (ESCR) values in micro irrigation applications where pipes operate in exposed environments whilst carrying agricultural chemicals.

Linear Low Density PE (LLDPE)

LLDPE has a chain structure with little side branching and the resultant narrower molecular weight distribution results in improved ESCR and tensile properties when compared to LDPE materials.

LLDPE materials may be used either as a single polymer or as a blend with LDPE, in micro irrigation applications to take advantage of the material flexibility.

Medium Density PE (MDPE)

MDPE base resin is manufactured using a low pressure polymerisation process, and the limited side branch chain structure results in a material density range of 930-940 kg/m^3.

MDPE materials qualify as PE63 and PE80B in accordance with AS/NZS 4131.

MDPE materials provide improved pipe properties when compared to the earlier high density materials used in pipes. These properties include life, flexibility, ductility, slow crack growth resistance and crack propagation resistance.

These properties of the MDPE materials are utilised in gas reticulation, small diameter pipe coils, travelling irrigator coils and water reticulation applications.

High Density PE (HDPE)

HDPE base resins are manufactured by a low pressure process, resulting in a chain structure with small side branches and a material density range of 930-960 kg/m^3.

HDPE materials qualify as PE80C and PE100 in accordance with AS/NZS 4131.

HDPE materials are widely used in both pressure and non pressure applications such as water supply, liners, drains, outfalls, and sewers in pipe sizes up to 1000 mm diameter. The increased stiffness of HDPE is used to advantage in such applications as electrical and communications conduits, sub-soil drainage, sewer and stormwater.

Table 2.1 Properties of Polyethylene

Typical values of the most commonly used properties

Property		Test Method	PE80B	PE80C	PE100
Density kg/m^3		ISO1183D, ISO1872-2B	950	960	960
Tensile Yield Strength MPa		ISO527	20	21	23
Elongation at Yield %		ISO527	10	8	8
Tensile Break Strength MPa		ISO527	27	33	37
Elongation at Break %		ISO527	> 800	> 600	> 600
Tensile Modulus MPa	Short term	ref. AS/NZS 2566	700	750	950
	Long term	ref. AS/NZS 2566	200	210	260
Hardness Shore D		DIN 53505	59	60	64
Notched Impact Strength kJ/m^2 (23°C)		ISO179/1 e A	35	24	26
Melt Flow Rate 190/5, g/10min		ISO1133	0.7 - 1.0	0.4 - 0.5	0.3 - 0.5
Thermal Expansion x 10^{-4}/C		DIN 53752	2.4	1.8	2.4
Thermal Conductivity W/m.k (20°C)		DIN 52612	0.43	0.43	0.40
Crystalline Melt Point °C		DIN 53736	125	130	132
Dielectric Strength kV/mm		DIN 53481	70	53	53
Surface Resistivity Ohm		DIN 53482	$> 10^{15}$	$> 10^{15}$	$> 10^{15}$
Volume Resistivity Ohm.cm		DIN 53482	$> 10^{15}$	$> 10^{15}$	$> 10^{15}$
Poissons Ratio μ			.4	.4	.4

Stress Regression Curves

To design a pipe with the required thickness for a given pressure and diameter, for example, the following formula applies:

σ = MRS/C

σ = p(D-e)/2e

where

σ = wall tension, dimension stress

MRS= Minimum Required Strength

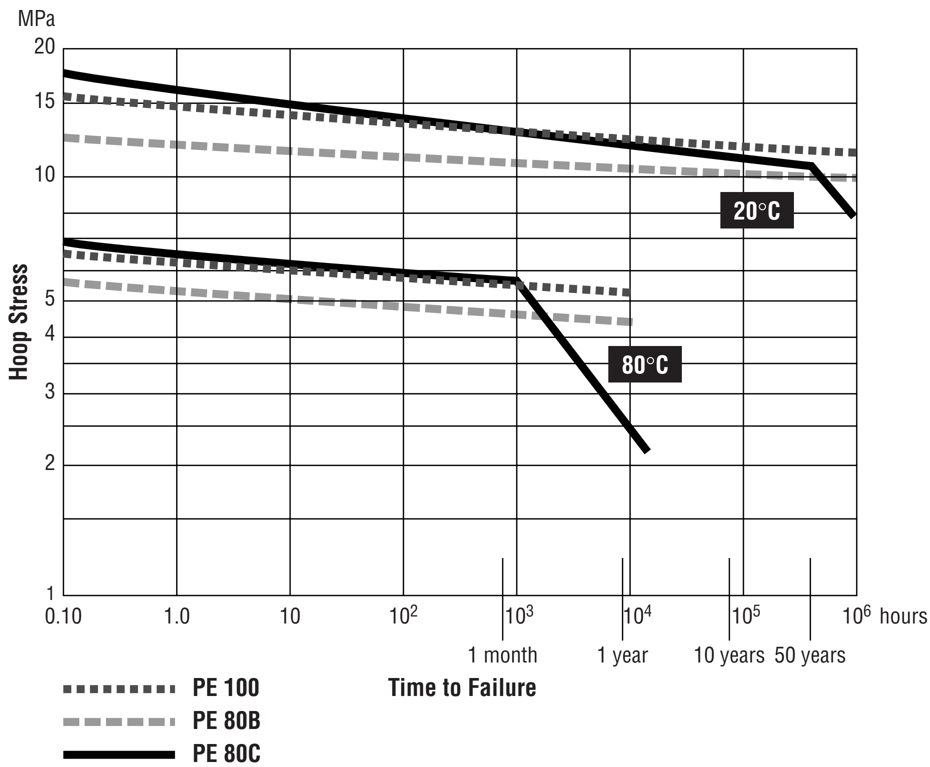
C = safety factor, typically 1.25 for water

p = internal pipe pressure

D = external pipe diameter

e = pipe thickness

Figure 2.1 Typical Stress Regression Curves



Material Classification and Stress Regression

Hydrostatic Design Stress

The allowable hydrostatic design stress is based on the Minimum Required Strength (MRS) which is in turn obtained from stress regression curves.

Stress regression curves are developed from short and long term pressure testing of pipe specimens.

As there is a linear relationship between the logarithm of the applied stress and the logarithm of time to failure, the test points are plotted and extrapolated to an arbitrarily chosen 50 year point.

In some cases, especially at higher temperatures, there is a sudden change in slope of the regression curve, known as the 'knee'. The knee, as illustrated in Figure 2.1 represents the transition from ductile failure mode to brittle failure mode.

The relationship between the curves for different test temperatures enables prediction of the position of the knee at 20°C, based on a known position at elevated temperature – see Figure 2.1. This in turn enables prediction of ductile life at 20°C.

The value of the predicted hoop stress (97.5% lower confidence limit) at the 50 year point, is used to determine the MRS of the material, i.e. 6.3, 8.0 or 10.0 MPa.

The hydrostatic design stress is obtained by application of a factor, not less than 1.25, to the MRS value.

It is emphasised that stress regression curves form a design basis only, and do not predict system life.

Chemical Resistance Classification

Introduction

The following section tabulates the classes of chemical resistance of thermoplastic and elastomeric materials most commonly used in pipe and fittings systems for the conveyance of liquids and gases.

It is generally known that pipes and fittings in thermoplastic material are widely used in industries where conveyance of highly corrosive liquids and gases requires high-quality construction materials, featuring excellent corrosion resistance.

Stainless steel, coated steel, glass and ceramic materials can often be advantageously replaced by thermoplastic materials, ensuring safety, reliability and economic benefits under similar operating conditions.

Important Information

The listed data are based on results of immersion tests on specimens, in the absence of any applied stress. In certain circumstances, where the preliminary classification indicates high or limited resistance, it may be necessary to conduct further tests to assess the behaviour of pipes and fittings under internal pressure or other stresses.

Variations in the analysis of the chemical compounds as well as in the operating conditions (pressure and temperature) can significantly modify the actual chemical resistance of the materials in comparison with this chart's indicated value.

It should be stressed that these ratings are intended only as a guide to be used for initial information on the material to be selected. They may not cover the particular application under consideration and the effects of altered temperatures or concentrations may need to be evaluated by testing under specific conditions. No guarantee can be given in respect of the listed data. Vinidex reserves the right to make any modification whatsoever, based upon further research and experiences.

Three Different Classes of Chemical Resistance are Conventionally Used in this Guide.

Class 1: High Resistance (Corrosion proof)

All materials belonging to this class are completely or almost completely corrosion proof against the conveyed fluid according to the specified operating conditions.

Class 2: Limited Resistance

The materials belonging to this class are partially attacked by the conveyed chemical compound. The average life of the material is therefore shorter, and it is advisable to use a higher safety factor than the one adopted for Class 1 materials.

Class 3: No Resistance

All materials belonging to this class are subject to corrosion by the conveyed fluid and they should therefore not be used.

The absence of any class indication means that no data is available concerning the chemical resistance of the material in respect of the conveyed fluid.

Abbreviations

Code	Denomination
uPVC	unplasticized polyvinyl chloride
PE	polyethylene PE63 PE80 PE100
PP	polypropylene
PVDF	polyvinylidene fluoride
PVC-C	chlorinated polyvinyl chloride
NBR	butadiene-acrylnitrile rubber
EPM	ethylene-propylene copolymer
FPM	vinylidene fluoride copolymer

Notes

nd	undefined concentration
deb	weak concentration
comm	commercial solution
dil	diluted solution

Chemical Attack on Thermoplastics & Elastomers

Chemicals that attack polymers do so at differing rates and in differing ways. There are two general types of chemical attack on polymer:

1. Swelling of the polymer occurs but the polymer returns to its original condition if the chemical is removed. However, if the polymer has a compounding ingredient that is soluble in the chemical, the properties of the polymer may be changed because of the removal of this ingredient and the chemical itself will be contaminated.
2. The base resin or polymer molecules are changed by crosslinking, oxidation, substitution reactions or chain scission. In these situations the polymer cannot be restored by the removal of the chemical. Examples of this type of attack on PVC are aqua regia at 200°C and wet chlorine gas.

Factors Affecting Chemical Resistance

A number of factors can affect the rate and type of chemical attack that may occur. These are:

Concentration:
In general, the rate of attack increases with concentration, but in many cases there are threshold levels below which no significant chemical effect will be noted.

Temperature:
As with all processes, rate of attack increases as temperature rises. Again, threshold temperatures may exist.

Period of Contact:
In many cases rates of attack are slow and of significance only with sustained contact.

Stress:
Some polymers under stress can undergo higher rates of attack. In general PVC is considered relatively insensitive to "stress corrosion".

Chemical Resistance Of Polyethylene

The outstanding resistance of Vinidex polyethylene systems to a variety of chemical reagents, allows their use in a wide range of chemical processes.

Chemical resistance of polyethylene is due to the non polar or paraffinic nature of the material and is a function of reagent concentration and temperature. Some attack may occur under specific conditions however, use of Vinidex polyethylene systems provides a cost effective solution when the behaviour of polyethylene is compared to that of alternative materials.

Where rubber modified LDPE blends are used for improved ESCR properties in irrigation applications, the effect of speciality chemicals may require evaluation eg. micro-irrigation tube/ dripper tube.

General Effect of Chemicals on Polyethylene Pipe:

Resistant:
Water, solutions of inorganic salts, weak acids, strong organic acids, strong alkaline solutions, aliphatic hydrocarbons.

Has adequate resistance:
Strong acids, hydrofluoric acids, fats and oils.

Has limited resistance:
Lower alcohols, esters, ketones, ethers, aromatic hydrocarbons, mineral oil.

In most cases non-resistant:
Light naphtha, fuel mixture.

Completely non-resistant:
Unsaturated chlorinated hydrocarbons, turpentine.

Chemical Resistance of Joints

Fusion Joints (PE)

Fusion joints include those made by butt fusion, electrofusion and socket fusion and these types will have the same chemical resistance as listed for PE.

Rubber Ring Joints (Elastomers)

Chemical resistance of Rubber Ring Joints may be assessed by reference to the accompanying Table 2.2 General Guide for Chemical Resistance of Various Elastomers as well as the pipe material guide.

Other Fittings

PE pipe systems often employ fittings and accessories manufactured from materials dissimilar to the pipe material, such as brass, aluminium, iron and polypropylene. In such cases, the designer should refer to the appropriate manufacturer for advice on the chemical resistance of these materials.

Table 2.2 General Guide for Chemical Resistance of Various Elastomers (Rubber Rings)

Material & Designation	Generally resistant to	Generally not resistant to
Natural Rubber **NR**	Most Moderate Chemicals Wet or Dry, Organic Acids, Alcohols, Ketones, Aldehydes	Ozone, Strong Acids, Fats, Oils, Greases, Most Hydrocarbons
Styrene Butadiene Rubber **SBR**	As for Natural Rubber	As for Natural Rubber
Polychloropene (Neoprene) **CR**	Moderate Chemicals & Acids, Ozone, Fats, Greases, Many Oils and Solvents	Strong Oxidising Acids, Esters, Ketones, Chlorinated, Aromatic and Nitro Hydrocarbons
Ethylene Propylene Diene Monomer **EPDM**	Animal & Vegetable Oils, Ozone, Strong & Oxidising Chemicals	Mineral Oils & Solvents, Aromatic Hydrocarbons
Nitrile Rubber **NBR**	Many Hydrocarbons, Fats, Oils, Greases, Hydraulic Fluids, Chemicals	Ozone, Ketones, Esters, Aldehydes, Chlorinated & Nitro Hydrocarbons

Source: Uni-Bell PVC Pipe Association - Handbook of PVC Pipe 1982

Note:

The chemical performance of elastomers is influenced by a number of factors including:

- temperature of service
- conditions of service
- grade of polymer
- the compound specified

Contact the Vinidex technical department for further information, if required.

Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
ACETALDEHYDE	CH_3CHO	100	25	3	1	2	3	3	3	1	2
			60	3	2			3			
			100					3			
- AQUEOUS SOLUTION		40	25	3	1	1	1	1	3	1	1
			60	3	2	2	1		3		
			100				1				2
ACETIC ACID	CH_3COOH	≤25	25	1	1	1	1	1	3	1	1
			60	2	1	1	1	1	3	3	
			100			1	1	1			
		30	25	1	1	1	1	1	2	1	1
			60	2	1	1	1		2	3	
			100			1	1	2			
		60	25	1	1	1	1	1	2		1
			60	2	1	1	1		3		
			100			2	2	2		3	
		80	25	1	2	1	1	1	3	2	1
			60	2	3	3	1		3	3	
			100			3	2	2	3	3	2
- GLACIAL		100	25	2	1	1	1	2	3	3	2
			60	3	2	2	2	3	2	1	3
			100			3	3	3		3	3
ACETIC ANHYDRIDE	$(CH_3CO)_2O$	100	25	3	2	1	3		3	2	1
			60	3	2	2	3	3			
			100			3	3				3
ACETONE	CH_3COCH_3	10	25	3	1	1	1	3	3	1	3
			60	3		3	1	3		3	3
			100			3	1	3		3	3
		100	25	3	2	1	2	3	3	1	3
			60	3	2	3	3	3	3	3	3
			100			3	3	3		3	3
ACETOPHENONE	$CH_3COC_6H_5$	nd	25			1	1		3	1	
			60			3	1				
			100								
ACRYLONITRILE	CH_2CHCN	technically pure	25		1	1	2		3	2	
			60	3	1	1	3				2
			100				3				
ADIPIC ACID	$(CH_2CH_2CO_2H)_2$	sat.	25	1	1	1		1	1	1	1
- AQUEOUS SOLUTION			60	2	1	1			1		
			100								
ALLYL ALCOHOL	CH_2CHCH_2OH	96	25	2	1	1	1	1			2
			60	3	2	1					
			100			1					3
ALUM	$Al_2(SO_4)_3 \cdot K_2SO_4 \cdot nH_2O$	dil	25	1	1	1			1		1
- AQUEOUS SOLUTION			60	2	1	1					
			100								
	$Al_2(SO_4)_3 \cdot K_2SO_4 \cdot nH_2O$	sat	25		1	1	1		1		
			60	2	1	1					
			100								
ALUMINIUM	$AlCl_3$	all	25	1	1		1	1	1	1	1
- CHLORIDE			60	1	1		1	1	2		
			100								
- FLUORIDE	AlF_3	100	25	1	1		1	1	1		
			60	1	1		1				
			100								
- HYDROXIDE	$Al(OH_4)_3$	all	25	1			1	1		1	1
			60	1			1				
			100								
- NITRATE	$Al(NO_2)_3$	nd	25	1			1	1		1	1
			60	1			1				
			100								
- SULPHATE	$Al(SO_4)_3$	deb	25	1	1	1	1	1	1	1	1
			60	1	1	1	1		1		
			100								
		sat	25	1	1	1	1	1	1	1	1
			60	1	1	1	1	1	1		1
			100			2	1	1			1

Class 1: High Resistance **Class 2:** Limited Resistance **Class 3:** No Resistance. *Refer page 2.5 for explanation of classes*

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Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
AMMONIA	NH_3	deb	25	1	1	1	1	1		1	1
- AQUEOUS SOLUTION			60	2	1		1				
			100								
		sat	25	1		1	1	1		1	
			60	2			1				
			100								
- DRY GAS		100	25	1	1	1	1	1	1	1	1
			60	1	1	1	1	1	2	2	
			100								
- LIQUID		100	25	2	1	1	1		1	1	3
			60	3	1	1	1				3
			100								
AMMONIUM	CH_3COONH_4	sat	25		1	1	1		1	1	1
- ACETATE			60	2	1	1	1		2		1
			100				1				1
- CARBONATE	$(NH_4)_2CO_3$	all	25	1	1	1	1	1	3	1	1
			60	2	1	1	1				
			100								
- CHLORIDE	NH_4Cl	sat	25	1	1	1	1	1	1	1	1
			60	1	1	1	1	1	1		1
			100			2	1	1			1
- FLUORIDE	NH_4F	25	25	1	1	1	1	1			1
			60	2	1	1	1	1			
			100				3				3
- HYDROXIDE	NH_4OH	28	25		1	1	1		1	1	1
			60	2	1	1	1				
			100								
- NITRATE	NH_4NO_3	sat	25	1	1	1	1	1	1		1
			60	1	1	1	1	1	2		1
			100			1	1	1			1
- PHOSPHATE DIBASIC	$NH_4(HPO_4)_2$	all	25	1	1	1	1	1	1		1
			60	1	1	1	1		2		
			100				1	2			
- PHOSPHATE META	$(NH_4)_4P_4O_{12}$	all	25	1		1	1	1		1	1
			60	1		1	1				
			100								
- PHOSPHATE TRI	$(NH_4)_2HPO_4$	all	25	1		1	1	1	1	1	1
			60	1		1	1		2		
			100								
- PERSULPHATE	$(NH_4)_2S_2O_8$	all	25	1		1	1	1		1	1
			60	1			1				
			100								
- SULPHIDE	$(NH_4)_2S$	deb	25	1	1	1	1	1	1	1	1
			60	2	1	1	1		1		
			100								
		sat	25	1	1	1	1	1	1	1	
			60	1	1	1	1		1		
			100								
- SULPHYDRATE	NH_4OHSO_4	dil	25	1	1	1	1	1			1
			60	2	1	1	1				1
			100								
		sat	25	1	1	1	1	1			1
			60	1	1	1	1				1
			100								
AMYLACETATE	$CH_3CO_2CH_2(CH_2)_3CH_3$	100	25	3	1	2	1	3	3	3	3
			60	3	2		2	3		3	3
			100				2	3		3	3
AMYLALCOHOL	$CH_3(CH_2)_3CH_2OH$	nd	25	1	1	1	1	1	1	1	1
			60	2	1	1	1	1	2		1
			100			1	1	1			1
ANILINE	$C_6H_5NH_2$	all	25	3	2	1	1	3	3	1	1
			60	3	2	1	2	3	3		
			100				3	3			1
- CHLORHYDRATE	$C_6H_5NH_2HCl$	nd	25	2	2	2	1	3			1
			60	3	2	2		3			
			100			3	2	3			2

Class 1: High Resistance **Class 2:** Limited Resistance **Class 3:** No Resistance. *Refer page 2.5 for explanation of classes*

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Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
ANTIMONY	$SbCl_3$	100	25	1	1	1		1			1
- TRICHLORIDE			60	1	1	1					
			100								
ANTHRAQUINONE		suspension	25	1	1	1	1	1		1	1
SULPHONIC ACID			60	2		1					
			100								
AQUA REGIA	$HC+HNO_3$	100	25	2	3	3	2	2			2
			60	2	3	3		2			
			100			3		2			
ARSENIC ACID	H_3AsO_4	deb	25	1	1	1	1	1		1	1
			60	2	1	1	1			1	1
			100				1	2		1	1
		80	25	1	1	1	1	1	1	1	1
			60	2	1	1	1	2	1	1	1
			100			2	1	2	3	1	1
BARIUM		all	25	1	1	1	1	1		1	1
- CARBONATE	$BaCO_3$		60	1	1	1	1				
			100								
- CHLORIDE	$BaCl_2$	10	25	1	1	1	1	1	1	1	
			60	1	1	1	1			1	
			100								
- HYDROXIDE	$Ba(OH)_2$	all	25	1	1	1	1	1	1	1	1
			60	1	1	1	2		1		
			100								
- SULPHATE	$BaSO_4$	nb	25	1	1	1	1	1		1	1
			60	1	1	1	1				
			100								
- SULPHIDE	BaS	sat	25	1		1	1	1		1	
			60	1			1				
			100								
BEER		comm	25	1	1		1	1	1	1	1
			60	1	1		1				
			100								
BENZALDEHYDE	C_6H_5CHO	nd	25	3	2	3	1		3	1	3
			60	3	2	3	2		3	1	3
			100								
BENZENE	C_6H_6	100	25	3	3	3	1	3	3	3	1
			60	3	3	3	2	3	3	3	
			100			3		3		3	2
- + LIGROIN		20/80	25	3		3		3		3	
			60	3		3		3		3	
			100								
- MONOCHLORINE	C_6H_5Cl	technically pure	25	3	2	1	1				
			60								
			100								
BENZOIC ACID	C_6H_5COOH	sat	25	1	1	1	1	1	3	1	1
			60	2	1	1	1	2			1
			100			3	1			3	1
BENZYL ALCOHOL	$C_6H_5CH_2OH$	100	25		1	1	1	1	3	1	2
			60		2	2	1				
			100								
BLEACHING LYE	NaOCl+NaCl	12.50%	25	1	2	2	1	1		2	1
		Cl	60	2	2		1				
			100								
BORIC ACID	H_3BO_3	deb	25	1	1	1	1	1	1	1	1
			60	2	1	1	1	1		1	
			100			1	1	1		1	
		sat	25	1	1	1	1	1	1	1	1
			60	2	1	1	1			1	
			100			1	1			1	
BRINE		comm	25	1		1	1	1		1	1
			60	1			1	1			
			100								
BROMIC ACID	$HBrO_3$	10	25	1	1		1	1			
			60	1	1		1	1			
			100				1	1			

Class 1: High Resistance **Class 2:** Limited Resistance **Class 3:** No Resistance. *Refer page 2.5 for explanation of classes*

Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
BROMINE	Br_2	100	25	3	3	3	1	3	3	3	1
- LIQUID			60	3	3	3	1	3		3	1
			100			3	1	3		3	1
- VAPOURS		low	25	2	3	3	1	2	3		1
			60		3	3	1				1
			100								
BUTADIENE	C_4H_6	100	25	1		1	1	1	3	2	1
			60	1	3	3	1		3		
			100								
BUTANEDIOL	$CH_3CH_2CHOHCH_2OH$	10	25	1		1	1		1		1
AQUEOUS			60	3			1		1		
			100								
		concentrated	25	2	2	2	1				1
			60	3	3	2	1				
			100								
BUTANE	C_4H_{10}	10	25	1	1	1	1	1	1		1
GAS			60		1		1				
			100								
BUTYL	$CH_3CO_2CH_2CH_2CH_2CH_3$	100	25	3	3	2	1	3	3	3	2
- ACETATE			60	3	3	3	1	3		3	
			100			3	2	3		3	3
- ALCOHOL	C_4H_9OH		25	1	1	1	1	1	1		
			60	2	1	1	1		1		
			100			2	2			1	2
- PHENOL	$C_4H_9C_6H_4OH$	100	25	2	3	3	1	1	3		2
			60	2	3	3	1				
			100								
BUTYLENE GLYCOL	$C_4H_6(OH)_2$	100	25		1	1	1				1
			60	2	1		1				
			100								
BUTYRIC ACID	$C_2H_5CH_2COOH$	20	25	1	1	3	1	1		1	1
			60	2	2	3					
			100			3		3			
		concentrated	25	3	3	3	1	3		2	2
			60	3	3	3		3			
			100			3		3			
CALCIUM	$Ca(HSO_3)_2$	nd	25	1	1	1	1	1	1	1	1
- BISULPHITE			60	1	1	1	1				
			100								
- CARBONATE	$CaCO_3$	all	25	1	1	1	1	1		1	1
			60	1	1	1	1	1			
			100								
- CHLORATE	CaHCl	nd	25	1	1	1	1	1			1
			60	1	1		1				
			100								
- CHLORIDE	$CaCl_2$	all	25	1	1	1	1	1	1	1	1
			60	2	1	1	1		1		1
			100			2	1				1
- HYDROXIDE	$Ca(OH)_2$	all	25	1		1	1	1	1	1	1
			60	1		1	2		2		
			100				2				
- HYPOCHLORITE	$Ca(OCl)_2$	sat	25		1	1	1		2	1	1
			60	2	1	1	1				
			100				2				
- NITRATE	$Ca(NO_3)_2$	50	25	1	1	1	1	1	1		
			60	1			1	1			
			100								
- SULPHATE	$CaSO_4$	nd	25	1	1	1	1	1		1	1
			60	1	1		1				
			100								
- SULPHIDE	CaS	sat	25	1	2	1	1	1		1	
			60	1	2		1				
			100								
CAMPHOR OIL		nd	25	1	3	3	1				1
			60		3	3	1				
			100								

Class 1: High Resistance **Class 2:** Limited Resistance **Class 3:** No Resistance. *Refer page 2.5 for explanation of classes*

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Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
CARBON	CO_2		25	1	1	1	1	1	1	1	1
- DIOXIDE			60	2	1	1	1		1		1
AQUEOUS SOLUTION			100								
- GAS		100	25	1	1	1	1	1	1	1	1
			60	1	1	1	1		1		
			100								
- DISULPHIDE	CS_2	100	25	2	2	1	1	3	3	3	1
			60	3		3	1	3	3	3	
			100			3	1	3	3	3	
- MONOXIDE	CO	100	25	1	1	1	1	1		1	1
			60	1	1	1	1				
			100								
- TETRACHLORIDE	CCl_4	100	25	2	2	3	1	1	2	3	1
			60	3	3	3	1				
			100								
CARBONIC ACID	H_2CO_3	sat	25	1			1	1			
- AQUEOUS SOLUTION			60	1			1				
			100								
- DRY		100	25	1			1	1			
			60	1			1	1			
			100								
- WET		all	25	1			1	1			
			60	2			1				
			100								
CARBON OIL		comm	25	1		3	1	1	2	1	1
			60	1		1	1				
			100								
CHLORAMINE		dil	25	1	1	1	1	1		1	1
			60								
			100								
CHLORIC ACID	$HClO_3$	20	25	1	1	1	1	1	3	1	1
			60	2	3	3	1			1	
			100			3	1			1	3
CHLORINE	Cl_2	sat	25	2			1	2		3	1
			60	3			1				
			100								
- DRY GAS		10	25	1		3	1	1	3		1
			60	2		3	1				1
			100								
		100	25	2		3	1	1	3		1
			60	3		3	1	1			1
			100								
- WET GAS		5g/m³	25	1		3			3		
			60	3		3					
			100								
		10 g/m³	25	2		3	1		3		
			60	2		3	1				
			100								
		66 g/m³	25	2		3	1		3		
			60	2		3	1				
			100								
- LIQUID		100	25	3	3	3	1		3	3	1
			60			3	1				
			100								
CHLOROACETIC ACID	$ClCH_2COH$	85	25	1	2	1	1		3	2	1
			60	2	3	3	1		3		
			100			3	1			3	3
		100	25	1	3		1	3	3		
			60	2	3	3	3	3			
			100			3	3	3		3	3
CHLOROBENZENE	C_6H_5Cl	all	25	3		3	1	3	3	3	1
			60	3		3	2	3	3	3	
			100								
CHLOROFORM	$CHCl_3$	all	25	3	2	2	1	3	3	3	2
			60	3		3	1	3		3	
			100			3	1	3		3	

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Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
CHLOROSULPHONIC	$ClHSO_3$	100	25	2	3	3	2	1	3	3	2
ACID			60	3	3	3	3			3	
			100			3	3			3	
CHROME ALUM	$KCr(SO_4)_2$	nd	25	1	1	1		1		1	1
			60	2	1	1		1			1
			100			2		1			1
CHROMIC ACID	CrO_3+H_2O	10	25	1	2	1	1	1		1	1
			60	2	3	2	1	1			
			100			3	3	1			
		30	25	1	2	2	1	1	3	1	1
			60	2	3	3	1	1	3	3	
			100			3	2	1	3	3	
		50	25	1	2	2	1	1	3	2	1
			60	2	3	3	1				
			100			3	2	2			
CHROMIC SOLUTION	$CrO_3+H_2O+H_2SO_4$	50/35/15	25	1	3	3					1
			60	2	3	3					1
			100								
CITRIC ACID	$C_3H_4(OH)(CO_2H)_3$	50	25	1	1	1	1	1	1	1	1
AQ. SOL. min			60	1	1	1	1				
			100			1	1	2			
COPPER	$CuCl_2$	sat	25	1	1	1	1	1		1	1
- CHLORIDE			60	1	1	1	1	1			
			100				1	1			
- CYANIDE	$CuCN_2$	all	25	3		1	1	1			
			60	3		1	1				
			100								
- FLUORIDE	CuF_2	all	25	1	1	3	1	1			1
			60	1	1	3	1				
			100								
- NITRATE	$Cu(NO_3)_2$	nd	25	1	1	1	1	1		1	1
			60	2	1	1	1				1
			100								
- SULPHATE	$CuSO_4$	dil	25	1	1	3	1	1	2	1	1
			60	1	1	3	1				
			100								
		sat	25	1	1	1	1	1	2	1	1
			60	1	1	1	1				1
			100								
COTTONSEED OIL		comm	25	1		1	1	1	1	2	1
			60	1		1	1				1
			100								
CRESOL	$CH_3C_6H_4OH$	≤90	25	2	1	1	1	2	3	3	1
			60	3			1	3		3	
			100								
		>90	25	3		2	1	3	3	3	2
			60	3			1	3		3	
			100								
CRESYLIC ACID	$CH_3C_6H_4COOH$	50	25	2			1	1			1
			60	3			2		3	2	1
			100								
CYCLOHEXANE	C_6H_{12}	all	25	3	1	1	1	3	1	3	1
			60	3		2	1	3		3	
			100				2				
CYCLOHEXANONE	$C_6H_{10}O$	all	25	3	1		1	3	2	3	
			60	3		3	2	3		3	
			100			3	3	3		3	
DECAHYDRONAFTALENE	$C_{10}H_{18}$	nd	25	1	1	3	1			3	1
			60	1	2	3	1			3	
			100								
DEMINERALIZED WATER		100	25	1	1	1	1	1		1	1
			60	1	1	1	1	1		1	1
			100			1	1	1		1	1
DEXTRINE	$C_6H_{12}OCH_2O$	nd	25	1	1	1	1	1	1	1	1
			60	2	1	1	1		1		
			100								

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Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
DIBUTYLPHTALATE	$C_6H_4(CO_2C_4H_9)_2$	100	25	3	3	3	1	3	3	1	2
			60	3		3		3			
			100								
DICHLOROACETIC	$Cl_2CHCOOH$	100	25	1	1	1				1	2
ACID			60	2	2	2					3
			100								
DICHLOROETHANE	CH_2ClCH_2Cl	100	25	3	3	1	1	3			3
			60	3	3		1				
			100								
DICHLOROETHYLENE	$ClCH_2Cl$	100	25	3	3	2	1		3	1	1
			60	3	3		1				
			100								
DIETHYL ETHER	$C_2H_5OC_2H_5$	100	25	3	3	1	1	3	2		3
			60	3	3	1	3	3			3
			100								
DIGLYCOLIC ACID	$(CH_2)_2O(CO_2H)_2$	18	25	1	1	1				1	1
			60	2	1	1					1
			100								
DIMETHYLAMINE	$(CH_3)_2NH$	100	25	2		1	2		2	3	2
			60	3	2	2	3		3		
			100								
DIOCTYLPHTHALATE		all	25	3	1	2	1	3	2	2	3
			60	3	2	2		3			3
			100								
DISTILLED WATER		100	25	1	1	1	1	1	1	1	1
			60	1	1	1	1	1	1	1	1
			100			1	1	1	1	1	1
DRINKING WATER		100	25	1	1	1	1	1	1	1	1
			60	1	1	1	1	1		1	1
			100			1	1	1		1	1
ETHERS		all	25	3		3		3	2	2	
			60	3		3		3		3	
			100								
ETHYL	$CH_3CO_2C_2H_5$	100	25	3	1	2	2	3	3	1	3
- ACETATE			60	3	3	3	2	3		3	3
			100			3	3	3		3	3
- ALCOHOL	CH_3CH_2OH	nd	25	1	1	1	1	1	1	1	1
			60	2	2	1	1		2		1
			100			1	1				1
- CHLORIDE	CH_3CH_2Cl	all	25	3	2	3	1	3	2	1	2
			60	3		3	1	3			
			100								
- ETHER	$CH_3CH_2OCH_2CH_3$	all	25	3		3	1	3	2	2	3
			60	3		3		3		3	3
			100								
ETHYLENE	$ClCH_2CH_2OH$	100	25	3			1	3	3	3	
- CHLOROHYDRIN			60	3			2	3		3	
			100				3				
- GLYCOL	$HOCH_2CH_2OH$	comm	25	1	1	1	1	1	1	1	1
			60	2	3	1	1		2		1
			100								
FATTY ACIDS		nd	25	1			1	1			1
			60	1			1	1			
			100								
FERRIC	$FeCl_3$	10	25	1		1	1	1	1	1	1
- CHLORIDE			60	2		1	1			1	
			100								
		sat	25	1	1	1	1	1	1	1	1
			60	1	1	1	1	1		1	
			100			1	1	1		1	
- NITRATE	$Fe(NO_3)_3$	nd	25	1	1		1	1			1
			60	1	1		1	1			
			100								
- SULPHATE	$Fe(SO_4)_3$	nd	25	1	1	1	1	1	1	1	1
			60	1	1		1				
			100								

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Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
FERROUS	$FeCl_2$	sat	25	1	1	1	1	1	1	1	
- CHLORIDE			60	1	1		1	1			
			100								
- SULPHATE	$FeSO_4$	nd	25	1	1	1	1	1	1	1	
			60	1	1		1				
			100								
FERTILIZER		≤10	25	1	1	1		1		1	1
			60	1	1	1					
			100								
		sat	25	1	1	1		1		1	1
			60	1	1	1					
			100								
FLUORINE GAS - DRY	F_2	100	25	2	2	3	1		3		
			60	3	3	3					
			100								
FLUOROSILICIC ACID	H_2SiF_6	32	25	1	1	1	1	1	2	2	1
			60	1	1	1	1	1	3		
			100				1	1			
FORMALDEHYDE	HCOH		25	1	1	1	1	1	3	1	1
			60	2	1	1	1		3		
			100				1	2			3
FORMIC ACID	HCOOH	50	25	1	1	1	1	1	3	1	1
			60	2	1	1	1		3	2	
			100				1	2			3
		100	25	1	1	1	1	1	2	2	3
			60	3	1	1	1		2	2	3
			100				1	3			3
FRUIT PULP AND JUICE		comm	25	1	1	1	1	1		1	1
			60	1		1	1				
			100								
FUEL OIL		100	25	1		1	1	1	1	3	1
			60	1		2	1	1			
			100								
		comm	25	1		1	1	1	1	3	1
			60	1	2	2	1	1			
			100								
FURFUROLE ALCOHOL	$C_5H_3OCH_2OH$	nd	25	3	2	2			3		1
			60	3	2	2					
			100								
GAS EXHAUST		all	25	1			1	1		1	
- ACID			60	1			1				
			100								
- WITH NITROUS VAPOURS		traces	25	1	1	1	1	1	1		1
			60	1	1	1	1				
			100								
GAS PHOSGENE	ClCOCl	100	25	1	2	2		1			1
			60	2	2	2		3			
			100								
GELATINE		100	25	1	1	1	1	1	1	1	1
			60	1		1	1				
			100								
GLUCOSE	$C_6H_{12}O_6$	all	25	1	1	1	1	1	1	1	1
			60	2	1	1	1		1		1
			100								
GLYCERINE	$HOCH_2CHOHCH_2OH$	all	25	1	1	1	1	1	1	1	1
AQ.SOL			60	1	1	1	1	1	1		1
			100			1	1	1			1
GLYCOGLUE		10	25	1	1	1	1	1	1	1	1
AQUEOUS			60	1	1	1	1	1	1		
			100			1	1	1			
GLYCOLIC ACID	$HOCH_2COOH$	37	25	1	1	1	1	1			1
			60	1	1		1				
			100								
HEPTANE	C_7H_{16}	100	25	1	1	3	1	1		1	1
			60	2	3	3	3	1		1	
			100								

Class 1: High Resistance **Class 2:** Limited Resistance **Class 3:** No Resistance. *Refer page 2.5 for explanation of classes*

Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
HEXANE	C_6H_{14}	100	25	1	1	1	1	1		3	
			60	2	2	2	1				
			100								
HYDROBROMIC ACID	HBr	≤10	25	1	1	1	1	1	3	1	1
			60	2	1	1	1				
			100			3	1	2		3	
		48	25	1	1	1	1	1	3	1	1
			60	2	1	1	1				
			100			3	1	2		3	3
HYDROCHLORIC ACID	HCl	≤25	25	1	1	1	1	1	1	1	1
			60	2	1	1	1	1	3	1	1
			100			1	1	1	3	3	1
		≤37	25	1	1	1	2	2	1	1	1
			60	1	2	1	1	1	2	2	
			100			2	1	1		3	2
HYDROCYANIC ACID	HCN	deb	25	1	1	1	1		2	1	1
			60	1	1	1	1		3	3	
			100								
HYDROFLUORIC ACID	HF	10	25	1	1	1	1	1		1	1
			60	2	1	1	1				
			100			3	1	2			2
		60	25	2	1	1	1	1	3	2	1
			60	3		3	1		3		
			100			3	1	2			2
HYDROGEN	H_2	all	25						1		
			60						1		
			100								
HYDROGEN	H_2O_2	30	25	1	1	1	1	1	1	1	1
- PEROXIDE			60	1	1	1	1	1			
			100		1			1			
		50	25	1	2	1	1	1			1
			60	1		2		1			
			100					1			
		90	25	1	1	1	1	1	3	2	1
			60	1	2	2		1			
			100					1			3
- SULPHIDE DRY		sat	25	1	1	1	1		3	1	1
			60	2	1	1	1		3		
			100								
- SULPHIDE WET		sat	25	1	1	1	1		3	1	1
			60	2	1	1	1		3		
			100								
HYDROSULPHITE		≤10	25	1		1	1	1		1	1
			60	2		1	1				
			100								
HYDROXYLAMINE SULPHATE	$(H_2NOH)_2H_2SO_4$	12	25	1	1	1	1		1		
			60	1		1	1		2		
			100								
ILLUMINATING GAS		100	25	1	1	1		1	1	1	1
			60								
			100								
IODINE	I_2	3	25	2		1	1				
- DRY AND WET			60	3			1				
			100								
- TINCTURE		>3	25	2	2	1	1	1			1
			60	3	3	3	1				
			100								
ISOCTANE	C_8H_{18}	100	25	1	2	2	1		1		3
			60			3	1				3
			100								
ISOPROPYL	$(CH_3)_2CHOCH(CH_3)_2$	100	25	2	2	2	1		3		3
- ETHER			60	3	3	3					3
			100								
- ALCOHOL	$(CH_3)_2CHOH$	100	25			1	1				1
			60	2		1					1
			100								

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Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
LACTIC ACID	$CH_3CHOHCOOH$	≤28	25	1	1	1	1	1	1	1	1
			60	2	1	1	2				1
			100			1	2				1
LANOLINE		nd	25		1	1			1		1
			60	2	1	2			1		
			100								
LEAD ACETATE	$Pb(CH_3COO)_2$	sat	25	1	1	1	1	1	1	1	1
			60	1		2	1	1	1		1
			100			2	1	1			1
LINSEED OIL		comm	25	1		1	1	1	1	1	1
			60	2	2	1	1		1		1
			100								
LUBRICATING OILS		comm	25	1	3	1	1	1	1	3	1
			60	1		2	1				1
			100								
MAGNESIUM	$MgCO_3$	all	25	1		1	1	1		1	1
- CARBONATE			60	1		1	1				
			100								
- CHLORIDE	$MgCl_2$	sat	25	1	1	1	1	1		1	1
			60	1	1	1	1	1			
			100			2	1	1			
- HYDROXIDE	$Mg(OH)_2$	all	25	1		1	1	1	1	1	1
			60	1		1	1				
			100								
- NITRATE	$MgNO_3$	nd	25	1	1	1	1	1		1	1
			60	1	1	1	1				
			100								
- SULPHATE	$MgSO_4$	dil	25	1	1	1	1	1	1	1	1
			60	1	1	1	1	1			
			100								
		sat	25	1	1	1	1	1		1	1
			60	1	1	1	1	1			
			100								
MALEIC ACID	COOHCHCHCOOH	nd	25	1	1	1	1	1	2	2	1
			60	1	1	1	1				1
			100			1	1	2			1
MALIC ACID	$CH_2CHOH(COOH)_2$	nd	25	1	1	1	1	1	1	3	1
			60			1	1				
			100								
MERCURIC	$HgCl_2$	sat	25	1	1	1	1	1	1		
- CHLORIDE			60	1	1	1	1				
			100								
- CYANIDE	$HgCN_2$	all	25	1		1	1	1			
			60	1		1	1				
			100								
MERCUROUS NITRATE	$HgNO_3$	nd	25	1	1	1	1	1			
			60	1	1	1	1				
			100								
MERCURY	Hg	100	25	1	1	1	1	1	1	1	1
			60	2	1	1	1				
			100								
METHYL	CH_3COOCH_3	100	25			1	1		3	2	
- ACETATE			60			1				3	
			100								
- ALCOHOL	CH_3OH	nd	25	1	1	1	1	1	1	1	2
			60	1	1	2	1				2
			100			2	1				2
- BROMIDE	CH_3Br	100	25	3	3	3	1				1
			60			3	1				
			100								
- CHLORIDE	CH_3Cl	100	25	3	1	3	1	2	3	2	2
			60	3		3	1				
			100			3	1	3			
- ETHYLKETONE	$CH_3COCH_2CH_3$	all	25	3	1	1	2		3	1	3
			60	3	2	2	3		3		3
			100								

Class 1: High Resistance **Class 2:** Limited Resistance **Class 3:** No Resistance. *Refer page 2.5 for explanation of classes*

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Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
METHYLAMINE	CH_3NH_2	32	25	2	1	1	2				1
			60	3	2						
			100								
METHYLENE CHLORIDE	CH_2Cl_2	100	25	3	3	3	1	3			2
			60	3		3	2	3			
			100			3	3	3			
METHYL SULPHORIC ACID	CH_3COOSO_4	50	25	1	2	2	1	1		1	1
			60	2	2	2	1				
			100			3	2			3	3
		100	25	1	3	3		1		1	2
			60	2	3	3					
			100			3				3	3
MILK		100	25	1	1	1	1	1	1	1	1
			60	1		1	1	1			
			100			1	1	1			
MINERAL ACIDOULOUS WATER		nd	25	1	1	1	1	1	1	1	1
			60	1	1	1	1	1		1	1
			100			1	1	1		1	1
MOLASSES		comm	25	1	1	1	1	1		1	1
			60	2	2	1	1				
			100			2	1	2			2
NAPHTA		100	25	2	2	1	1	1	1	3	1
			60	3	3	3	1				1
			100								
NAPHTALINE		100	25	1	1	3	1	2	3	3	1
			60		2	3	1				
			100			3	1	3			
NICKEL - CHLORIDE	NiCl3	all	25	1	1	1	1	1	1	1	
			60	1	1	1	1	1			
			100			1	1	1			
- NITRATE	$Ni(NO_3)_2$	nd	25	1	1	1	1	1		1	1
			60	1	1	1	1				
			100			2	1				
- SULPHATE	$NiSO_4$	dil	25	1	1	1	1	1	1	1	1
			60	1	2	1	1				
			100								
		sat	25	1	1	1	1	1		1	1
			60	1	1	1	1			1	
			100								
NITRIC ACID	HNO_3	anhydrous	25	3		3	2	3			1
			60	3		3	3	3			
			100			3	3	3			3
		20	25	1	1	1	1	1		1	1
			60	2	2	2	1	1			1
			100			3	1	1		2	1
		40	25	1		2	1	1		1	1
			60	1	2	3	1	1			
			100			3	1	1		3	3
		60	25	1	3	2	1	1		3	2
			60	2	3	3	1	1		3	3
			100			3	1	1		3	3
		98	25	3	3	3	1	3		3	3
			60	3	3	3	1	3		3	3
			100			3	2	3		3	3
NITROBENZENE	$C_6H_5NO_2$	all	25	3		1	1	3	2	3	2
			60	3	2	2	1	3		3	3
			100								
OLEIC ACID	$C_8H_{17}CHCH(CH_2)_7CO_2H$	comm	25	1		1	1	1	1	2	1
			60	1	2	2	1				
			100								

Class 1: High Resistance **Class 2:** Limited Resistance **Class 3:** No Resistance. *Refer page 2.5 for explanation of classes*

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Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
OLEUM		nd	25	3	3	3	3	3	3	3	1
			60	3	3	3	3	3		3	
			100								
- VAPOURS		low	25	3		3	3	3	3	3	1
			60	3		3	3	3		3	
			100								
		hight	25	3		3	3	3	3	3	1
			60	3		3	3	3		3	
			100								
OLIVE OIL		comm	25			1	1		1	2	1
			60	2	3	1	1		1		
			100								
OXALIC ACID	HO_2CCO_2H	10	25	1	1	1	1	1	2	1	1
			60	2	1	2	1			1	1
			100			2	2			1	1
		sat	25	1	1	1	1	1	2	1	1
			60	1	1	2	1	1			1
			100			3	3	1			1
OXYGEN	O_2	all	25	1	1	3	1	1	1	1	1
			60	1	2	3	1	1			
			100								
OZONE	O_3	nd	25	1	2	3	1	1	3	1	1
			60	2	3	3	2		3		
			100								
PALMITIC ACID	$CH_3(CH_2)_{14}COOH$	10	25	1			1	1	1	2	1
			60	1		3	1				1
			100								
		70	25	1			1	1	2		
			60	1	3	3	1		3		1
			100								
PARAFFIN		nd	25				1		3		1
			60	2	2	1	1				
			100								
- EMULSION		comm	25	1	2	3	1	1			1
			60	1	2	3	1				
			100								
- OIL		nd	25	1		1	1				
			60	1		3	1				
			100								
PERCHLORIC ACID	$HClO_4$	100	25	1	1	1	1	1	3	2	1
			60	2	1	1	1		3		1
			100								
		70	25	1	1	1	1		3	2	1
			60	2	2		1		3		1
			100								
PETROL		100	25	1		1	1	1	2	3	1
- REFINED			60		1	3	1				
			100								
- UNREFINED		100	25	1		1	1	1	2	3	1
			60	1		3	1				
			100								
PHENOL	C_6H_5OH	1	25	1	1	1	1	1	3	1	1
- AQUEOUS SOLUTION			60			1	1				1
			100			3	1				1
		≤90	25	2	1	1	1	1	3		1
			60	3		3	1				1
			100			3	1				1
PHENYL HYDRAZINE	$C_6H_5NHNH_2$	all	25	3	2	2	1	3	3		1
			60	3	2	2	1	3			2
			100								
- CHLORHYDRATE	$C_6H_5NHNH_3Cl$	sat	25	1	1	1					1
			60	3	3	3					2
			100								

Class 1: High Resistance **Class 2:** Limited Resistance **Class 3:** No Resistance. *Refer page 2.5 for explanation of classes*

Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
PHOSPHORIC	H_3PO_4	≤25	25	1	1	1	1	1	2	1	1
- ACID			60	2	1	1	1		3	1	1
			100			1	1	2		1	1
		≤50	25	1	1	1	1	1	2	1	1
			60	1	1	1	1		3	1	1
			100			1	1	2		2	1
		≤85	25	1	1	1	1	1	3	1	1
			60	1	2	1	1				
			100			1	1				2
- ANHYDRIDE	P_2O_5	nd	25	1	1	1		1	2	1	1
			60	2	1	1			3		
			100								
PHOSPHORUS TRICHLORIDE	PCl_3	100	25	3	1	1	1	3			1
			60	3			1	3			
			100								
PHOTOGRAPHIC		comm	25	1			1	1		1	
- DEVELOPER			60	1			1	1			
			100								
- EMULSION		comm	25	1	1		1	1			
			60	1			1	1			
			100								
PHTHALIC ACID	$C_6H_4(CO_2H)_2$	50	25		1	1	1			1	1
			60	3	1	1	1			1	
			100								
PICRIC ACID	$HOC_6H_2(NO2)_3$	1	25	1	1	1	1		2	1	1
			60	1			1		3		1
			100								
		>1	25	3	1	3	1		1	1	1
			60	3	1	3	1		2	2	1
			100								
POTASSIUM	K_2CrO_7	40	25	1	1	1	1	1	1	1	1
- BICHROMATE			60	1			1		3		
			100								
- BORATE	K_3BO_3	sat	25	1		1	1				1
			60	2		1	1				
			100								
- BROMATE	$KBrO_3$	nd	25	1		1	1	1		1	1
			60	2		1	1				1
			100			2	1				1
- BROMIDE	KBr	sat	25	1	1	1	1				1
			60	1	1	1	1				
			100								
- CARBONATE	K_2CO_3	sat	25	1	1	1	1		1		1
			60	1	1		2		1		
			100								
- CHLORIDE	KCl	sat	25	1	1	1	1	1	1	2	1
			60	1	1	1	1		1		1
			100			2	1				1
- CHROMATE	$KCrO_4$	40	25	1	1	1	1	1		1	1
			60	1	1	1	1				
			100								
- CYANIDE	KCN	sat	25	1	1	1	1		1		1
			60	1	1	1	2		1		
			100								
- FERROCYANIDE	$K_4Fe(CN)_6.3H_2O$	100	25	1	1	1	1	1		1	1
			60	1	1	1	1				1
			100			2	1				1
- FLUORIDE	KF	sat	25		1	1	1				
			60		1	1	1				
			100								
- HYDROXIDE	KOH	≤60	25	1	1	1	2	1	2	1	1
			60	2	1	1	2	1	3		
			100			1	3	1			
- NITRATE	KNO_3	sat	25	1	1	1	1	1	1	1	1
			60	1	1	1	1	1	1		
			100				1	1			

Class 1: High Resistance **Class 2:** Limited Resistance **Class 3:** No Resistance. *Refer page 2.5 for explanation of classes*

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Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
- PERBORATE	KBO_3	all	25	1		1	1	1		1	1
			60	1			1				
			100								
- PERMANGANATE	$KMnO_4$	10	25	1	1	1	1	1		1	1
			60	1	1	2	1				
			100								
- PERSULPHATE	$K_2S_2O_8$	nd	25	1	1	1	1	1		1	1
			60	2	1	1	1				
			100								
- SULPHATE	K_2SO_4	sat	25			1	1		1	2	1
			60	1	1	1	1			3	
			100								
PROPANE	C_3H_8	100	25	1	1	1	1	1	1	1	1
- GAS			60				1				
			100								
- LIQUID		100	25	1	2	2	1	1	1	3	1
			60				1				
			100								
PROPYL ALCOHOL	C_3H_7OH	100	25	1	1	1	1	1	2	1	1
			60	2	1	1	1				1
			100								
PYRIDINE	$CH(CHCH)_2N$	nd	25	3	1	2	1	3	3	3	3
			60	3	2	2	3	3		3	3
			100								
RAIN WATER		100	25	1	1	1	1	1	1	1	1
			60	1	1	1	1	1	1	1	1
			100			1	1	1		1	1
SEA WATER		100	25	1	1	1	1	1	2	1	1
			60	1	1	1	1	1		1	1
			100			1	1	1		1	1
SILICIC ACID	H_2SiO_3	all	25	1	1	1	1	1		1	1
			60	1	1	1	1			1	
			100								
SILICONE OIL		nd	25	1	1	1			1	1	1
			60	3	2	1					
			100								
SILVER	AgCN	all	25	1		1	1	1	1		1
- CYANIDE			60	1		1	1				
			100								
- NITRATE	$AgNO_9$	nd	25	1	1	1	1	1		1	1
			60	2	1	1	1	1			
			100			2	1	1			2
- PLATING SOLUTION		comm	25	1			1	1		1	
			60	1							
			100								
SOAP		high	25	1		1	1	1	1	1	1
- AQUEOUS SOLUTION			60	2			1				
			100								
SODIC LYE		≤60	25	1		1		1		1	1
			60	1				1			
			100								
SODIUM	CH_3COONa	100	25	1	1	1	1	1		1	
- ACETATE			60	1	1	1	1	1			
			100			1	1	1			
- BICARBONATE	$NaHCO_3$	nd	25	1	1	1	1	1	1	1	1
			60	1	1	1	1	1	1		
			100			1	1	1	1		
- BISULPHITE	$NaHSO_3$	100	25	1	1	1	1	1	2	1	1
			60	1	1	1	1	1	3		
			100			2	1	1			
- BROMIDE	NaBr	sat	25	1		1	1	1	1	1	1
			60	1		1	1		3		
			100								
- CARBONATE	Na_2CO_3	sat	25	1	1	1	1	1	1	1	1
			60	1	1	1	2				
			100				2				

Class 1: High Resistance **Class 2:** Limited Resistance **Class 3:** No Resistance. *Refer page 2.5 for explanation of classes*

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Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
- CHLORATE	$NaClO_3$	nd	25	1	1	1	1	1	1	1	1
			60	2	1		1		2		1
			100								
- CHLORIDE	NaCl	dil	25	1	1	1	1	1	1	1	1
			60	2	1	1	1		1		
			100								
		sat	25	1	1	1	1	1	1	1	1
			60	1	1	1	1	1	1		
			100			3	1	1			
- CYANIDE	NaCN	all	25	1		1	1	1		1	
			60	1		1	1				
			100								
- FERROCYANIDE	$Na_4Fe(CN)_6$	sat	25	1	1			1		3	3
			60	1	1						
			100								
- FLUORIDE	NaF	all	25	1	1		1	1	1		
			60	1	1		2		2		
			100				3				
- HYDROXIDE	NaOH	60	25	1	1	1	2	1	1	1	1
			60	1	1	1	2	1	3		
			100			1	3	1			3
- HYPOCHLORITE	NaOCl	deb	25	1	1	1	1	1	2	1	1
			60	2		2	1				
			100								
- HYPOSULPHITE	$Na_2S_3O_3$	nd	25	1		1	1	1			
			60	1			1				
			100								
- NITRATE	$NaNO_3$	nd	25	1	1	1	1	1	1	1	1
			60	1	1	1	1		1		
			100								
- PERBORATE	$NaBO_3H_2O$	all	25	1		1	1	1	1	1	1
			60	1			1				
			100								
- PHOSPHATE di	Na_2HPO_4	all	25	1		1	1	1	1	1	1
			60	1		1	1	1			
			100			1	1	1			
- PHOSPHATE tri	Na_3PO_4	all	25	1	1	1	1	1	1	1	1
			60	1	1	1	1	1	1		
			100			1	1	1	1		
- SULPHATE	Na_2SO_4	dil	25	1		1	1	1	1	1	1
			60	1		1	1				
			100								
		sat	25	1	1	1	1	1	1	1	1
			60	1	1	1	1				
			100								
- SULPHIDE	Na_2S	dil	25	1	1	1	2	1		1	1
			60	2	1	1	2				
			100								
		sat	25	1	1	1	2	1		1	1
			60	1	1	1	2				1
			100								
- SULPHITE	$NaSO_3$	sat	25	1		1	1	1	1	1	1
			60	1		1	1		2		1
			100								
STANNIC CHLORIDE	$SnCl_4$	sat	25	1	1	1	1	1			
			60	1	1	1	1	1			
			100								
STANNOUS CHLORIDE	$SnCl_2$	dil	25	1	1	1	1	1		1	1
			60	1	1	1	1				
			100								
STEARIC ACID	$CH_3(CH_2)_{16}CO_2H$	100	25	1		2	1	1	1		1
			60	1	2	2	1	1	2	2	1
			100								
SUGAR SYRUP		high	25	1	1	1	1	1		1	1
			60	2	1		1				
			100								

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Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
SULPHUR	S	100	25	1		1	1	1	3	1	
			60	2		1	1				
			100								
- DIOXIDE AQUEOUS	SO_2	sat	25	1	1	1	1	1	3	1	1
			60	2					3		
			100								
- DIOXIDE DRY		all	25	1	1	1	1	1	1	1	1
			60	1	1	1	1				1
			100			3	1				1
- DIOXIDE LIQUID		100	25	2	1				3		1
			60	3	2				3		
			100								
- TRIOXIDE	SO_3	100	25	2	3	3			1		2
			60	2	3	3					
			100								
SULPHURIC ACID	H_2SO_4	≤10	25	1	1	1	1	1	1	1	1
			60	1	1	1	1	1	1	1	1
			100			1	1	1	2	1	1
		≤75	25	1	1	1	1	1	3	1	1
			60	2	2	2	1		3		1
			100			2	1	2	3	2	1
		≤90	25	1	2	1	1	1	1	1	1
			60	2	2	2	1				1
			100			3	1	3			1
		≤96	25	2	2	3	1	1		2	1
			60	3	2	3	2	3		3	
			100			3	3	3		3	
- FUMING		all	25	2		3	3			3	1
			60	3		3	3			3	
			100			3	3			3	
- NITRIC AQUEOUS SOLUTION	H_2SO_4+HNO_3+H_20	48/49/3	25	1	3	3					1
			60	2	3	3					1
			100			3					1
		50/50/0	25	2	3	3	1				1
			60	3	3	3	1				1
			100			3					1
		10/20/70	25	1	2	2					
			60	1	2	2					
			100								
TALLOW EMULSION		comm	25	1	1	1				1	1
			60	1	2	2					
			100								
TANNIC ACID	$C_{14}H_{10}0_9$	10	25	1	1		1	1	1	1	1
			60	1	1		1	1			
			100								
TARTARIC ACID	$HOOC(CHOH)_2COOH$	all	25	1	1	1	1	1	1	1	1
			60	2	1	1	1		1	2	
			100								
TETRACHLORO - ETHANE	$CHCl_2CHCl_2$	nd	25	3	2	2	1		3		2
			60	3	3	3	2				
			100								
- ETHYLENE	CCl_2CCl_2	nd	25	3	2	2					1
			60	3	3	3					
			100								
TETRAETHYLLEAD	$Pb(C_2H_5)_4$	100	25	1	1	1		1		1	1
			60	2							
			100								
TETRAHYDROFURAN	C_4H_8O	all	25	3	2	2	1	3	3	3	2
			60	3	3	3	2	3	3		
			100			3	3	3	3		
THIONYL CHLORIDE	$SOCl_3$		25	3	3	3		3		3	1
			60								
			100								
THIOPHENE	C_4H_4S	100	25	3	2	2		3			3
			60	3	2	3		3			
			100								

Class 1: High Resistance **Class 2:** Limited Resistance **Class 3:** No Resistance. *Refer page 2.5 for explanation of classes*

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Chemical	Formula	Conc. (%)	Temp. (°C)	uPVC	PE	PP	PVDF	PVC/C	NBR	EPM	FPM
TOLUENE	$C_6H_5CH_3$	100	25	3	2	2	1	3	3	3	2
			60	3	3	3	1	3	3	3	
			100			3	1	3	3	3	
TRANSFORMER OIL		nd	25	1	1	1				3	1
			60	2	2	2					
			100								
TRICHLOROACETIC ACID	CCl_3COOH	≤50	25	1	1	1	2		2	2	3
			60	3	2	1	2				3
			100								
TRICHLOROETHYLENE	Cl_2CCHCl	100	25	3	2	3	1	3	3	3	1
			60	3	2	3	1	3		3	
			100								
TRIETHANOLAMINE	$N(CH_2CH_2OH)_2$	100	25	2	1	1	3	2	2	2	1
			60	3			3				
			100								
TURPENTINE		100	25	2	2	3			1		1
			60	2	3	3					
			100								
UREA AQUEOUS SOLUTION	$CO(NH_2)_2$	≤10	25	1	1	1	1	1			1
			60	2	1	1	1	2			
			100								
		33	25	1	1	1	1	1			
			60	2	1	1	1				
			100								
URINE		nd	25	1	1	1	1	1		1	1
			60	2	1	1	1				
			100								
URIC ACID	$C_5H_4N_4O_3$	10	25	1				1			
			60	2				2			
			100								
VASELINE OIL		100	25	1	1	1	1			3	1
			60	3	2	2	1			3	
			100								
VINYL ACETATE	$CH_3CO_2CHCH_2$	100	25	3			1	3		2	1
			60	3				3		3	
			100					3		3	
WHISKY		comm	25	1		1	1	1	1	1	1
			60	1			1				
			100								
WINES		comm	25	1	1	1	1	1	1	1	1
			60	1		1	1	1			
			100				1				
WINE VINEGAR		comm	25	1	1	1	1	1	1	1	1
			60	2	1	1	1	1		1	
			100				1	1		1	
ZINC - CHLORIDE	$ZnCl_2$	dil	25	1	1	1	1	1	1	1	1
			60	1	1	1	1				
			100								
		sat	25	1	1	1	1	1		1	1
			60	1	1	1	1				1
			100			2	1				1
- CHROMATE	$ZnCrO_4$	nd	25	1		1	1	1		1	
			60	1		1	1				
			100								
- CYANIDE	$Zn(CN)_2$	all	25	1			1	1		1	
			60	1			1				
			100								
- NITRATE	$Zn(NO_3)_2$	nd	25	1		1	1	1		1	1
			60	1		1	1				
			100								
- SULPHATE	$ZnSO_4$	dil	25	1	1	1	1	1	1	1	1
			60	1	1	1	1				
			100								
		sat	25	1	1	1	1	1		1	1
			60	1	1	1	1				1
			100								

Class 1: High Resistance **Class 2:** Limited Resistance **Class 3:** No Resistance. *Refer page 2.5 for explanation of classes*

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Material Performance Aspects

Abrasion Resistance

The transmission of solids in either liquid or gaseous carriers in PE pipelines results in abrasion of the internal pipe walls, especially at points of high turbulence such as bends or junctions.

The high resistance to abrasion, flexibility, light weight, and robustness of Vinidex PE pipes, have led to their widespread use in applications such as transportation of slurries and mine tailings.

Abrasion occurs as a result of friction between the pipe wall and the transported particles.

The actual amount and rate of abrasion of the pipe wall is determined by a combination of:

- the specific gravity of the solids
- the solids content in the slurry
- solid particle shape, hardness and size
- fluid velocity
- PE pipe material grade

The interaction of these parameters means that any prediction of the rate of abrasion wear can only proceed where testing of wear rates has been performed on the specific slurry under the proposed operational conditions.

Under varying test conditions the relative ranking of different pipe materials may change, and where possible testing should be performed.

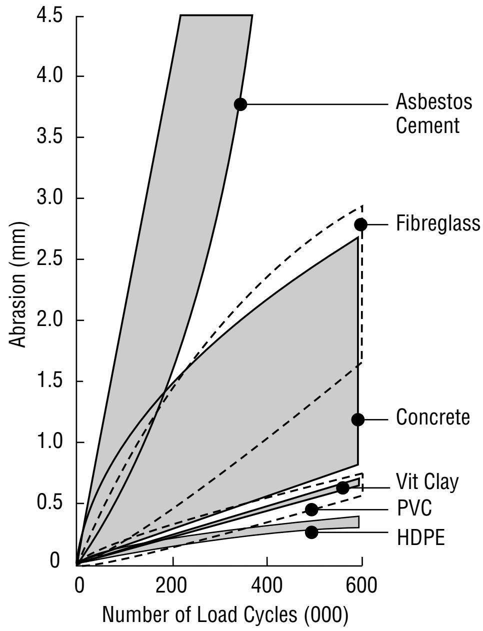

Figure 2.2 Comparative Abrasion Rates of Pipe Materials

A comprehensive collection of case history data has been assembled by Vinidex design engineers for particular applications, and this information is available on request.

In general terms, PE pipes have superior abrasion resistance to steel, ductile iron, FRP, asbestos and fibre reinforced cement pipes, providing a more cost effective solution for abrasive slurry installations.

Laboratory test programs have been performed in the UK, Germany and USA to obtain relative wear comparisons for various materials using sliding and rotating pipe surfaces.

The results of test programs using the Darmstadt (Germany) method of Kirschmer and reported by Meldt (Hoechst AG) for a slurry of quartz sand/ gravel water with a solids content 46% by volume and a flow velocity of 0.36m/s are shown in Figure 2.2.

These were performed across a range of materials and show the excellent abrasion resistance of PE pipe materials.

Similarly, Boothroyde and Jacobs (BHRA PR 1448) performed closed loop tests using iron ore slurry in a concentration range of 5 to 10% and ranked PE ahead of mild steel and asbestos cement in abrasion resistance.

For most grades, the difference in abrasion resistance between MDPE (PE80B) and HDPE (PE80C and PE100) is not significant. However, Vinidex offers grades which are specifically selected to maximise abrasion resistance, whilst also maximising pressure rating and crack growth resistance.

The design of fittings involving change of flow direction is critical in slurry lines. The lower the rate of change of direction, the lower the abrasion rate. For bends, a large centreline radius must be used. Where possible, a radius of at least 20 times the pipe diameter should be used, along with a long straight lead-in length containing no joints.

In practice, the effective lifetime of the PE pipeline can be increased by using demountable joints to periodically rotate the PE pipe sections to distribute the abrasion wear evenly around the circumference of the pipe.

Weathering

Weathering of plastics occurs by a process of surface degradation, or oxidation, due to a combined effect of ultra violet radiation, increased temperature, and moisture when pipes are stored in exposed locations.

All Vinidex PE pipe systems contain antioxidants, stabilisers and pigments to provide protection under Australian construction conditions.

Black PE pipes contain carbon black which act as both a pigment and an ultra violet stabiliser, and these pipes require no additional protection for external storage and use.

Other colours such as white, blue, yellow or lilac do not possess the same stability as the black pigmented systems and the period of exposure should be limited to one year for optimum retention of properties. With these colour systems the external surface oxidation layers develop at a faster rate than those in carbon black stabilised PE pipes.

For exposure periods longer than one year, additional protection such as covering should be adopted.

Permeation

Permeation of PE pipe systems from external sources may occur when the surrounding soils are contaminated.

Organic compounds of the non polar, low molecular type are those which permeate most rapidly through the PE pipe walls. Accordingly, where materials such as aliphatic hydrocarbons, chlorinated hydrocarbons and alkylated benzenes are encountered, consideration to impermeable ducting should be given.

Where contamination is suspected, soil sampling should be performed and in the case of potable water transmission lines, protection to the PE pipes should be provided where contamination is found.

Food Contact Applications

Where the pipeline system is used for food processing or transport purposes, Vinidex PE pipes can be supplied using PE materials complying with AS 2070 - Plastics for Use in Food Contact Applications. In these applications the advice of Vinidex engineers should be obtained as to the effect of the system on food quality, and the most appropriate jointing systems to prevent detention of the food materials through the pipe system.

Biological Resistance

PE pipes may be subject to damage from biological sources such as ants or rodents. The resistance to attack is determined by the hardness of the PE used, the geometry of the PE surfaces, and the conditions of the installation.

Small diameter irrigation applications using LDPE materials may be attacked by ants or termites due to the relatively thin wall sections and the hardness of the LDPE. In these instances the source of the ants should be treated by normal insecticide techniques.

Both MDPE and HDPE material types have a higher hardness value than LDPE, and together with the thicker pipe wall sections used in PE63, PE80, and PE100 applications provide a generally resistant solution. In small diameter pipes, the thin wall sections may be damaged by termites in extreme cases.

However damage often ascribed to termite attack in PE has subsequently been found to be due to other sources of mechanical damage.

PE pipe systems are generally unaffected by biological organisms in both land, and marine applications, and the paraffinic nature of the PE pipe surfaces retards the build up of marine growths in service.