Plastics Data File – PVC

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1. Introduction

PVC is one of the most versatile of the bulk polymers. The ability to be used in either the rigid or soft (plasticised) forms doubles the market for this exceptional material. The material is available in clear or coloured formats and it is durable, weatherproof, flame resistant with good overall mechanical properties.

The material has come under attack by 'Greenpeace' and other environmental groups – all of which ignore the immense service that the material plays in the modern industrial society. PVC is claimed to be dangerous by some but it is the main material used for blood bags and medical tubing and has been responsible for saving countless lives.

PVC has been the subject of more research than most plastic materials and is acknowledged to be safe by increasing numbers of researchers.

Note:

- PVC-S = PVC manufactured by suspension polymerisation.
- PVC-E = PVC manufactured by emulsion polymerisation.
- PVC-M = PVC manufactured by mass polymerisation.

There is a Plastics Topics sheet on Polymer Chemistry which gives details of the various types of polymerisation.

2. Typical applications

Rigid PVC

Building: Waste water pipes, grating covers, guttering, drain pipes, waste water fittings, roofing sheets, sanitary installations, window frames, fascia boards.

Electrical engineering: Insulation pipes, acoustic panels, electricity distribution boxes, telephone housings, transparent distributor box housings, plug housings, sound carrier sheet, battery terminals.

Mechanical engineering: Pressure pipes, ventilation ducts, thermostat housings, fittings, pipe connections, claddings, ventilators.

Packaging: Disposable pots, spice and cream containers, ball point pen cases, oil and beverage bottles.

Plasticised PVC

Electrical engineering: Cable and wire insulation, plugs, cable jackets, sockets, cable heads and distributors.

Mechanical engineering: Gaskets, stuffing boxes, pipes, hoses, coatings, and protective caps for pipes.

Building: Seals for windows and doors, swimming bath linings, floor coverings, doorstops, garden hoses, wire coverings.

Others: Shoe soles, divers masks, car body seals, ski sunglasses, toys, tablecloths, boots, cases. inflatable dinghies, balls, handbags, book covers, office equipment.

3. Physical and mechanical properties

General

PVC is an amorphous, polar thermoplastic. Its properties depend on the average degree of polymerisation, the production process and the plasticiser content. Production processes give rise to emulsion polymers (PVC-E), suspension polymers (PVC-S) and mass polymers (PVC-M).

Rigid PVC

Rigid PVC is a hard, rigid material. Under a tensile load, once it has reached its high tensile strength, it flows in a plastic manner as the tensile stress is removed, until plastic fracture occurs. In contrast to the impact strength, the notched impact strength is low. Surface notches in rigid PVC should be avoided if at all possible. Impact-resistant types are less notch-sensitive. As the K value rises, the toughness and creep strength increase. Rigid PVC has good abrasion resistance but because of it's notch sensitivity it has only a low tear strength.

The material is easily welded and glued and certain formulations are physiologically safe.

Plasticised PVC

Mechanical properties are determined primarily by the type and quantity of plasticiser added. There are soft rubber-like blends with a Shore A hardness of 50, and hard rubber-like blends with a Shore A hardness of 95, which is roughly comparable with that of PE-HD. The elastic behaviour is characterised by strong damping, whilst rubber has good resilience. The high damping and the associated slow recovery make the material very suitable for absorbing shocks and vibrations.

Mechanical properties

Property	Approximate Value
Tensile Strength	55 - 80 MN/m^2
Tensile Modulus	3-4 GN/m^2
Elongation at Break	10 - 50%
Flexural Strength	50 - 100 MN/m^2
Notched Impact Strength	3 - 10 kJ/m^2
Specific Heat	2.15 - 2.6 kJ/kg/°C
Glass Transition Temperature	87°C
Heat Deflection Temperature	<100°C
Coefficient of Thermal Expansion	6 x 10^{-5} /°C (PVC-U)
Long Term Service Temperature	-30< LTST<100°C (70°C is recommended as maximum)
Specific Gravity	1.1 to 1.3 for plasticised PVC, 1.4 for PVC-U (rigid)
Mould Shrinkage	0.001 - 0.005 m/m
Water Absorption	<0.1 % (50% rh)
Transparency	Transparent

4. Thermal, electrical and optical properties

Thermal properties

Rigid PVC

Rigid PVC can be used only in a narrow temperature range. The lower limit is -5˚C and the upper limit is 60°C. Copolymers can be used up to 80°C and impact-resistant types can be used at temperatures as low as -25°C.

Plasticised PVC

Plasticised PVC becomes softer and more flexible as the service temperature rises and parts subjected to mechanical stresses can be used only up to 40°C or, with some types, 60°C. Without any substantial stress the limits are 80°C and 105°C. The material starts to become brittle at -10 to -50°C, depending on the plasticiser type and content.

Fire behaviour

The chlorine content of PVC means that it is difficult to ignite and will self-extinguish when the flame is removed. The material will conform to Class 1 (most resistant) of BS 476: Part 7: 1987 for surface spread of flame. PVC raw material is flame resistant. Rigid PVC is flammable with difficultly. The flammability of plasticised PVC is determined by the plasticiser type and content.

Electrical properties

The insulation properties of rigid PVC are satisfactory and those of plasticised PVC are poor. The values, which are only mediocre in any case, are impaired still further by the plasticisers. As a result of the high dissipation factor, PVC is not suitable for high frequency applications.

Optical properties

Except for PVC-E and PVC copolymers, all types of PVC can be produced in a transparent formulation.

PVC-S, PVC-M and plasticised PVC can be produced in transparent formulations. PVC-E is opaque because of its emulsifier content.

5. Chemical resistance properties

PVC is a relatively inert polymer that is not attacked by the majority of common acids and alkalis, petrol, oil, dilute alkalis and acids, and salt solutions.

PVC is not resistant to organic solvents such as alcohols, ethers, esters, ketones (such as acetone), aromatic hydrocarbons, chlorinated hydrocarbons, strong alkalis and nitric acid.

Plasticised PVC has slightly worse chemical resistance than rigid PVC due to the presence of the plasticiser and the effect that some materials have on the plasticiser retention in the bulk polymer.

A detailed chemical resistance chart for plasticised PVC is given in Section 11.

A detailed chemical resistance chart for rigid PVC is given in Section 12.

Resistance to weathering

The resistance of PVC to weathering, light and ageing is good but again rigid PVC has slightly better properties than plasticised PVC. Rigid PVC shows degradation in strong UV conditions and requires a UV stabiliser for colour retention.

6. Advantages and limitations

Advantages	Limitations
1. The versatility of PVC (rigid to soft) enables the production of materials ranging from elastomers to rigid engineering thermoplastics, and processing possibilities from paste coatings to injection moulding.	1. Heat distortion and softening temperatures are relatively low temperatures.
2. Good weathering properties.	2. Material tends to degrade at high temperatures.
3. Low cost.	3. Rapidly becomes stiff and brittle at low temperatures (for both rigid and flexible

	formulations) and impact modifiers may be necessary.
4. Good resistance to acids, alkalis, oils and many corrosive inorganic chemicals, oxygen, ozone; good water barrier; PVC polymer is resistant to alcohols, aliphatic hydrocarbons and detergent solutions but these reagents may extract plasticisers from flexible formulations.	4. Attacked by ketones; some grades swollen or attacked by chlorinated and aromatic hydrocarbons, esters, some aromatic ethers and amines, and nitro-compounds.
5. Good electrical insulation properties.	5. Some plasticised materials are susceptible to microbiological attack unless expensive fungicides or bactericides are used.
6. Non-flammable and does not support fire after source of ignition is removed (this can be affected by the formulation).	6. Some plasticised materials are susceptible to staining.
7. Good combination of stiffness and impact strength (rigid formulation), and toughness, extensibility, and high ratio of strength to weight (flexible formulations).	7. May need primer to get good adhesion to some materials.
8. Wide range of colours possible.	8. Can suffer from higher compression set than rubbers when used in gasket types of applications.
9. Rigid formulations have dimensional stability at room temperature.	9. High specific gravity for plastic material.

7. Processing

Injection moulding

Rigid PVC

Thermal stabilisation is required for processing rigid PVC, otherwise the material may decompose during processing. PVC is sensitive to the thermal history and the window of processing temperatures is quite small. Injection moulding is only possible with screw injection moulding machines with an L/D ratio of 15 to 18.

The material temperature should be between 170 and 210°C, depending on the type.

Mould temperatures of 20 to 60°C are suitable.

The injection pressure for rigid PVC is between 800 to 1600 bar. Keep the injection speed and screw speeds low to ensure the material is not subjected to high shear rates.

Shrinkage is 0.2 to 0.5% for rigid PVC.

Material can be reused depending on degree of thermal degradation.

Plasticised PVC

Mould temperatures of 20 to 60°C are suitable.

Use an injection pressure of 600 - 1000 bar with a back pressure of 50 - 100 bar. Keep the injection speed and screw speeds low to ensure the material is not subjected to high shear rates.

Shrinkage is 1 to 2.5% for plasticised PVC.

Material can be reused depending on degree of thermal degradation.

Extrusion

PVC-E or PVC-S moulding materials are more suitable, particularly in the case of plasticised PVC. The extrusion temperatures are 10 to 20°C below the injection moulding temperatures to avoid premature thermal degradation.

Process selector

Processing Method	Applicable
Injection Moulding	Yes. The presence of possible HCl means that many moulders do not like to process PVC and it can be difficult to find moulders willing to use this material.
Extrusion	Yes Possibly the largest processing method for PVC. Co-extrusion can be used to produce a rigid PVC base with soft PVC sealing lips or other forms. Co-extrusion can also be used to produce not only dual hardness PVC products but also dual material products, e.g., a rigid PVC base with an ABS second material.
Extrusion Blow Moulding	Yes
Rotational Moulding	Yes
Thermoforming	Yes
Casting	No
Bending and joining	Yes

8. Finishing

Machining

PVC can be easily machined. High machining speeds can be used if there is sufficient cooling. Dust and swarf are not regarded as a Health hazard other than normal dust etc.

Surface treatment

Material can be surface treated with a variety of processes (painted, decorated etc). A solvent wipe or primer is recommended and either urethane or nitrocellulose paints are recommended.

Welding

Rigid PVC can be welded by all common welding processes with hot plate welding being used extensively for window frames.

Plasticised PVC requires high frequency, hot gas or heated tool welding.

Bonding

The following adhesives are suitable:

For rigid PVC: polyurethane, polychloroprene and acrylonitrile butadiene adhesives and epoxy resins all bond well to rigid PVC.

For plasticised PVC: polyurethane, polychloroprene and acrylonitrile butadiene adhesives, PC and THF solvent adhesives, polyester two-component adhesives, vinyl copolymers.

The parts to be bonded must be cleaned carefully before bonding.

9. Health and safety

Rigid PVC is physiologically safe and has no Health and Safety implications. Plasticised PVC is used extensively in food contact grades but the suitability of the plasticiser should be checked to avoid plasticiser migration.

PVC contains no products likely to give rise to health and safety concerns. In fabrication areas where the product is sawn or otherwise machined there is a possibility of dust generation. Such dust does not present a specific health hazard but good housekeeping with regard to dust collection and control should always be exercised.

10. Other information

Identification

Rigid PVC burns with a greenish-edges flame with some sputtering and a smell of hydrochloric acid (HCl). It is generally self-extinguishing.

Plasticised PVC is as for rigid PVC but the smell of the plasticiser is often distinctive.

Production of PVC

All polymers are long chain molecules made up of many repeated unitsof a basic building block or monomer. The basic building block for PVC is 'vinyl chloride' and this is manufactured from chlorine (obtained from the electrolysis of salt) and ethylene (obtained from the catalytic cracking of oil). The use of a commodity material, such as salt, both reduces the energy used in the production of PVC and helps to keep the price more stable than that of materials based on petrochemicals alone.

The ethylene and chlorine are then used to produce the basic vinyl chloride monomer (VCM).

The VCM is then reacted by one of several methods so that it polymerizes (or joins together) in long chains of about 1000 repeated units to form PVC. The resulting white powder is ‘stripped’ so that no unreacted VCM is left and is ready for compounding into a usable material.

Compounding of PVC

The PVC resulting from the polymerisation process is not suitable for processing and must first be compounded to form a useful material. The PVC before compounding can be thought of as similar to flour, by adding various ingredients flour can be used to make for bread, cakes or many other items but on its own the flour is useless. PVC at the raw stage is useless and the compounding is essential for further processing.

At this stage the PVC is combined with a range of additives to tune the properties to the particular application. The versatility of PVC is due to this ability to tune the properties. Typical additives are:

Impact Modifiers - These are generally acrylic compounds added to PVC to increase the impact strength of the material at low temperatures. The base PVC is a tough material but the resistance to impact is increased even more by the addition of these materials. PVC is a thermoplastic material and the properties therefore change with changes in temperature. At high temperature the material becomes softer and at low temperature the material becomes stiffer and more brittle. The addition of impact modifiers is necessary to allow usage of PVC-U down to temperatures of -40°C. The material has a softening point in the region of 80°C and should not be put under stress at high temperatures (>>60°C) or distortion will occur.

Stabilisers - These are added to the PVC to improve the resistance to heat, UV light, general weathering and oxidation. In some cases, a blend of stabilisers is used to give the optimum for all conditions. Stabilisers are generally tin, lead or mixed metal-based soaps and changes are being made throughout the industry to improve the environmental aspects of stabiliser usage.

Lubricants - These are added to prevent the PVC sticking to the hot metal surfaces during processing and to improve the flow properties of the PVC. A variety of waxes or fatty acids are used depending on the stabiliser system used.

Colours - These are added for obvious reasons and must be heat and light stable to give the best product life. It is often necessary to consider the climate for the best mix, a stable colour in Britain may not be suitable for use in the Arabian desert.

Processing Aids - These are added to improve general processing.

Fillers - These are added to improve the mechanical properties by acting as a reinforcing agent in the compound, typical fillers are minerals such as clay and calcium carbonate.

11. Detailed chemical resistance of plasticised PVC

Important Note:

Whilst we try to ensure that this table is as accurate as possible, we cannot guarantee that the data contained in the tables is accurate for all blends and grades. In all cases the supplier of the material should be contacted to determine the exact chemical resistance of the material.

R = Resistant, LR = Limited Resistance, NR = Not Recommended, ND = No Data

Chemical	Resistance		
	20°C	60°C	100°C
Acetaldehyde	NR	NR	ND
Acetic acid (10%)	R	NR	ND
Acetic acid (glac./anh.)	NR	NR	ND
Acetic anhydride	NR	NR	ND
Aceto-acetic ester	ND	ND	ND
Acetone	NR	NR	ND
Other ketones	NR	NR	ND
Acetonitrile	NR	NR	ND
Acetylene	ND	ND	ND
Acetyl salicylic acid	ND	ND	ND
Acid fumes	ND	ND	ND
Alcohols	ND	ND	ND
Aliphatic esters	ND	ND	ND
Alkyl chlorides	ND	ND	ND
Alum	R	R	ND
Aluminium chloride	R	R	ND
Aluminium sulphate	R	R	ND
Ammonia, anhydrous	NR	NR	ND
Ammonia, aqueous	ND	ND	ND
Ammonium chloride	R	R	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Amyl acetate	NR	NR	ND
Aniline	NR	NR	ND
Antimony trichloride	R	R	ND
Aqua regia	ND	ND	ND
Aromatic solvents	ND	ND	ND
Ascorbic acid	ND	ND	ND
Beer	R	NR	ND
Benzaldehyde	NR	NR	ND
Benzene	NR	NR	ND
Benzoic acid	ND	NR	ND
Benzoyl peroxide	ND	ND	ND
Boric acid	R	NR	ND
Brines, saturated	R	R	ND
Bromide (K) solution	R	R	ND
Bromine	NR	NR	ND
Bromine liquid, tech.	NR	NR	ND
Bromine water, saturated aqueous	NR	NR	ND
Butyl acetate	NR	NR	ND
Calcium chloride	R	R	ND
Carbon disulphide	NR	NR	ND
Carbonic acid	R	R	ND
Carbon tetrachloride	NR	NR	ND
Caustic soda & potash	R	NR	ND
Cellulose paint	ND	ND	ND
Chlorates of Na, K, Ba	ND	ND	ND
Chlorine, dry	ND	ND	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Chlorine, wet	ND	ND	ND
Chlorides of Na, K, Ba	R	R	ND
Chloroacetic acid	NR	NR	ND
Chlorobenzene	NR	NR	ND
Chloroform	NR	NR	ND
Chlorosulphonic acid	NR	NR	ND
Chromic acid (80%)	NR	NR	ND
Citric acid	R	NR	ND
Copper salts (most)	R	R	ND
Cresylic acids (50%)	NR	NR	ND
Cyclohexane	ND	ND	ND
Detergents, synthetic	R	NR	ND
Emulsifiers, concentrated	R	R	ND
Esters	NR	NR	ND
Ether	ND	ND	ND
Fatty acids (>C6)	ND	ND	ND
Ferric chloride	R	R	ND
Ferrous sulphate	R	R	ND
Fluorinated refrigerants	NR	NR	ND
Fluorine, dry	NR	NR	ND
Fluorine, wet	NR	NR	ND
Fluorosilic acid	ND	ND	ND
Formaldehyde (40%)	R	NR	ND
Formic acid	ND	ND	ND
Fruit juices	R	R	ND
Gelatine	ND	ND	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Glycerine	R	NR	ND
Glycols	ND	ND	ND
Glycol, ethylene	R	R	ND
Glycolic acid	ND	ND	ND
Hexamethylene diamine	ND	ND	ND
Hexamine	ND	ND	ND
Hydrazine	ND	ND	ND
Hydrobromic acid (50%)	R	R	ND
Hydrochloric acid (10%)	R	R	ND
Hydrochloric acid (conc.)	R	LR	ND
Hydrocyanic acid	ND	ND	ND
Hydrofluoric acid (40%)	R	NR	ND
Hydrofluoric acid (75%)	NR	NR	ND
Hydrogen peroxide (30%)	R	NR	ND
Hydrogen peroxide (30 - 90%)	R	NR	ND
Hydrogen sulphide	R	NR	ND
Hypochlorites	R	LR	ND
Hypochlorites (Na 12-14%)	R	R	ND
Iso-butyl-acetate	ND	ND	ND
Lactic acid (90%)	NR	NR	ND
Lead acetate	R	R	ND
Lead perchlorate	ND	ND	ND
Lime (CaO)	R	ND	ND
Maleic acid	NR	NR	ND
Manganate, potassium (K)	R	R	ND
Meat juices	ND	ND	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Mercuric chloride	NR	NR	ND
Mercury	R	R	ND
Methanol	R	R	ND
Methylene chloride	NR	NR	ND
Milk products	R	NR	ND
Moist air	R	R	ND
Molasses	R	R	ND
Monoethanolamine	ND	ND	ND
Naptha	ND	ND	ND
Napthalene	NR	NR	ND
Nickel salts	R	R	ND
Nitrates of Na, K and NH3	R	R	ND
Nitric acid (<25%)	R	ND	ND
Nitric acid (50%)	R	ND	ND
Nitric acid (90%)	NR	NR	ND
Nitric acid (fuming)	NR	NR	ND
Nitrite (Na)	NR	NR	ND
Nitrobenzene	NR	NR	ND
Oils, diesel	ND	ND	ND
Oils, essential	ND	ND	ND
Oils, lubricating + aromatic additives	ND	ND	ND
Oils, mineral	R	NR	ND
Oils, vegetable and animal	R	ND	ND
Oxalic acid	R	NR	ND
Ozone	R	NR	ND
Paraffin wax	ND	ND	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Perchloric acid	ND	NR	ND
Petroleum spirits	R	NR	ND
Phenol	ND	NR	ND
Phosphoric acid (20%)	R	R	ND
Phosphoric acid (50%)	ND	ND	ND
Phosphoric acid (95%)	ND	ND	ND
Phosphorous chlorides	ND	ND	ND
Phosphorous pentoxide	R	ND	ND
Phthalic acid	NR	NR	ND
Picric acid	R	ND	ND
Pyridine	ND	ND	ND
Salicyl aldehyde	ND	ND	ND
Sea water	R	R	ND
Silicic acid	ND	ND	ND
Silicone fluids	ND	ND	ND
Silver nitrate	R	R	ND
Sodium carbonate	R	ND	ND
Sodium peroxide	R	R	ND
Sodium silicate	R	R	ND
Sodium sulphide	R	R	ND
Stannic chloride	R	R	ND
Starch	R	R	ND
Sugar, syrups & jams	ND	ND	ND
Sulphamic acid	ND	ND	ND
Sulphates (Na, K, Mg, Ca)	ND	ND	ND
Sulphites	ND	ND	ND

Chemical	Resistance		
	20°C	60°C	100°C
Sulphonic acids	ND	ND	ND
Sulphur	ND	ND	ND
Sulphur dioxide, dry	R	NR	ND
Sulphur dioxide, wet	R	R	ND
Sulphur dioxide (96%)	R	R	ND
Sulphur trioxide	ND	ND	ND
Sulphuric acid (<50%)	R	LR	ND
Sulphuric acid (70%)	LR	ND	ND
Sulphuric acid (95%)	ND	ND	ND
Sulphuric acid, fuming	NR	NR	ND
Sulphur chlorides	ND	ND	ND
Tallow	R	ND	ND
Tannic acid (10%)	R	ND	ND
Tartaric acid	R	ND	ND
Trichlorethylene	NR	NR	ND
Urea (30%)	R	R	ND
Vinegar	R	ND	ND
Water, distilled	R	R	ND
Water, soft	R	R	ND
Water, hard	R	R	ND
Wetting agents (<5%)	R	R	ND
Yeast	R	ND	ND
Zinc chloride	R	R	ND

12. Detailed chemical resistance of rigid PVC

Important Note:

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R = Resistant, LR = Limited Resistance, NR = Not Recommended, ND = No Data

Chemical	Resistance		
	20°C	60°C	100°C
Acetaldehyde	R	NR	ND
Acetic acid (10%)	R	R	ND
Acetic acid (glac./anh.)	R	NR	ND
Acetic anhydride	NR	NR	ND
Aceto-acetic ester	ND	ND	ND
Acetone	NR	NR	ND
Other ketones	NR	NR	ND
Acetonitrile	NR	NR	ND
Acetylene	R	R	ND
Acetyl salicylic acid	ND	ND	ND
Acid fumes	R	R	ND
Alcohols	R	NR	ND
Aliphatic esters	NR	NR	ND
Alkyl chlorides	ND	ND	ND
Alum	R	R	ND
Aluminium chloride	R	R	ND
Aluminium sulphate	R	R	ND
Ammonia, anhydrous	R	R	ND
Ammonia, aqueous	R	R	ND
Ammonium chloride	R	R	ND

Chemical	Resistance		
	20°C	60°C	100°C
Amyl acetate	NR	NR	ND
Aniline	NR	NR	ND
Antimony trichloride	R	R	ND
Aqua regia	R	LR	ND
Aromatic solvents	NR	NR	ND
Ascorbic acid	ND	ND	ND
Beer	R	ND	ND
Benzaldehyde	NR	NR	ND
Benzene	NR	NR	ND
Benzoic acid	LR	R	ND
Benzoyl peroxide	ND	ND	ND
Boric acid	R	R	ND
Brines, saturated	R	R	ND
Bromide (K) solution	R	R	ND
Bromine	NR	NR	ND
Bromine liquid, tech.	NR	NR	ND
Bromine water, saturated aqueous	NR	NR	ND
Butyl acetate	NR	NR	ND
Calcium chloride	R	R	ND
Carbon disulphide	NR	NR	ND
Carbonic acid	R	R	ND
Carbon tetrachloride	R	NR	ND
Caustic soda & potash	R	R	ND
Cellulose paint	ND	ND	ND
Chlorates of Na, K, Ba	R	R	ND
Chlorine, dry	R	NR	ND

Chemical	**Resistance**		
	20°C	**60°C**	**100°C**
Chlorine, wet	LR	ND	ND
Chlorides of Na, K, Ba	R	R	ND
Chloroacetic acid	R	NR	ND
Chlorobenzene	NR	NR	ND
Chloroform	NR	NR	ND
Chlorosulphonic acid	LR	ND	ND
Chromic acid (80%)	R	R	ND
Citric acid	R	R	ND
Copper salts (most)	R	R	ND
Cresylic acids (50%)	NR	NR	ND
Cyclohexane	NR	NR	ND
Detergents, synthetic	R	R	ND
Emulsifiers, concentrated	R	R	ND
Esters	NR	NR	ND
Ether	NR	NR	ND
Fatty acids (>C6)	R	R	ND
Ferric chloride	R	R	ND
Ferrous sulphate	R	R	ND
Fluorinated refrigerants	R	R	ND
Fluorine, dry	NR	NR	ND
Fluorine, wet	R	R	ND
Fluorosilic acid	R	R	ND
Formaldehyde (40%)	R	R	ND
Formic acid	R	NR	ND
Fruit juices	R	R	ND
Gelatine	R	R	ND

Chemical	Resistance		
	20°C	60°C	100°C
Glycerine	R	R	ND
Glycols	R	R	ND
Glycol, ethylene	R	R	ND
Glycolic acid	R	R	ND
Hexamethylene diamine	ND	ND	ND
Hexamine	NR	NR	ND
Hydrazine	ND	ND	ND
Hydrobromic acid (50%)	R	R	ND
Hydrochloric acid (10%)	R	R	ND
Hydrochloric acid (conc.)	R	R	ND
Hydrocyanic acid	R	R	ND
Hydrofluoric acid (40%)	R	LR	ND
Hydrofluoric acid (75%)	R	NR	ND
Hydrogen peroxide (30%)	R	R	ND
Hydrogen peroxide (30 - 90%)	R	R	ND
Hydrogen sulphide	R	R	ND
Hypochlorites	R	R	ND
Hypochlorites (Na 12-14%)	R	R	ND
Iso-butyl-acetate	ND	ND	ND
Lactic acid (90%)	NR	NR	ND
Lead acetate	R	R	ND
Lead perchlorate	ND	ND	ND
Lime (CaO)	R	R	ND
Maleic acid	R	R	ND
Manganate, potassium (K)	R	R	ND
Meat juices	R	R	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Mercuric chloride	NR	NR	ND
Mercury	R	R	ND
Methanol	R	R	ND
Methylene chloride	NR	NR	ND
Milk products	R	R	ND
Moist air	R	R	ND
Molasses	R	R	ND
Monoethanolamine	ND	ND	ND
Naptha	R	R	ND
Napthalene	NR	NR	ND
Nickel salts	R	R	ND
Nitrates of Na, K and NH3	R	R	ND
Nitric acid (<25%)	R	R	ND
Nitric acid (50%)	R	R	ND
Nitric acid (90%)	NR	NR	ND
Nitric acid (fuming)	R	R	ND
Nitrite (Na)	NR	NR	ND
Nitrobenzene	NR	NR	ND
Oils, diesel	ND	ND	ND
Oils, essential	R	R	ND
Oils, lubricating + aromatic additives	ND	ND	ND
Oils, mineral	R	R	ND
Oils, vegetable and animal	R	R	ND
Oxalic acid	R	R	ND
Ozone	R	R	ND
Paraffin wax	R	R	ND

Chemical	Resistance		
	20°C	60°C	100°C
Perchloric acid	R	R	ND
Petroleum spirits	R	LR	ND
Phenol	R	NR	ND
Phosphoric acid (20%)	R	R	ND
Phosphoric acid (50%)	R	R	ND
Phosphoric acid (95%)	R	R	ND
Phosphorous chlorides	NR	NR	ND
Phosphorous pentoxide	R	R	ND
Phthalic acid	R	R	ND
Picric acid	R	R	ND
Pyridine	ND	NR	ND
Salicyl aldehyde	ND	ND	ND
Sea water	R	R	ND
Silicic acid	R	R	ND
Silicone fluids	ND	ND	ND
Silver nitrate	R	R	ND
Sodium carbonate	R	R	ND
Sodium peroxide	R	R	ND
Sodium silicate	R	R	ND
Sodium sulphide	R	R	ND
Stannic chloride	R	R	ND
Starch	R	R	ND
Sugar, syrups & jams	R	R	ND
Sulphamic acid	ND	ND	ND
Sulphates (Na, K, Mg, Ca)	R	R	ND
Sulphites	R	R	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Sulphonic acids	R	R	ND
Sulphur	R	R	ND
Sulphur dioxide, dry	R	R	ND
Sulphur dioxide, wet	R	NR	ND
Sulphur dioxide (96%)	R	R	ND
Sulphur trioxide	R	R	ND
Sulphuric acid (<50%)	R	R	ND
Sulphuric acid (70%)	R	R	ND
Sulphuric acid (95%)	R	R	ND
Sulphuric acid, fuming	NR	NR	ND
Sulphur chlorides	ND	NR	ND
Tallow	R	R	ND
Tannic acid (10%)	R	R	ND
Tartaric acid	R	R	ND
Trichlorethylene	NR	NR	ND
Urea (30%)	R	R	ND
Vinegar	R	R	ND
Water, distilled.	R	R	ND
Water, soft	R	R	ND
Water, hard	R	R	ND
Wetting agents (<5%)	R	R	ND
Yeast	R	ND	ND
Zinc chloride	R	R	ND