Typical Properties

Table 2.1 Properties of PVC

Property	Value	Conditions and Remarks
Physical properties		
Molecular weight (resin)	140,000	cf: K57 PVC 70,000
Relative density	1.42 - 1.48	cf: PE 0.95 - 0.96, GRP 1.4 - 2.1, CI 7.20, Clay 1.8 - 2.6
Water absorption	0.12%	23°C, 24 hours cf: AC 18 - 20% AS1711
Hardness	80	Shore D Durometer, Brinell 15, Rockwell R 114, cf: PE Shore D 60
Impact strength - 20°C	20 kJ/m2	Charpy 250 µm notch tip radius
Impact strength - 0°C	8 kJ/m2	Charpy 250 µm notch tip radius
Coefficient of friction	0.4	PVC to PVC cf: PE 0.25, PA 0.3
Mechanical properties		
Ultimate tensile strength	52 MPa	AS 1175 Tensometer at constant strain rate cf: PE 30
Elongation at break	50 - 80%	AS 1175 Tensometer at constant strain rate cf: PE 600-900
Short term creep rupture	44 MPa	Constant load 1 hour value cf: PE 14, ABS 25
Long term creep rupture	28 MPa	Constant load extrapolated 50 year value cf: PE 8-12
Elastic tensile modulus	3.0 - 3.3 GPa	1% strain at 100 seconds cf: PE 0.9-1.2
Elastic flexural modulus	2.7 - 3.0 GPa	1% strain at 100 seconds cf: PE 0.7-0.9
Long term creep modulus	0.9 - 1.2 GPa	Constant load extrapolated 50 year secant value cf: PE 0.2 - 0.3
Shear modulus	1.0 GPa	1% strain at 100 seconds G=E/2/(1+µ) cf: PE 0.2
Bulk modulus	4.7 GPa	1% strain at 100 seconds K=E/3/(1-2µ) cf: PE 2.0
Poisson's ratio	0.4	Increases marginally with time under load. cf: PE 0.45
Electrical properties		
Dielectric strength (breakdown)	14 - 20 kV/mm	Short term, 3 mm specimen PE 70-85
Volume resistivity	2 x 1014Ω.m	AS 1255.1 PE > 1016
Surface resistivity	1013 - 1014 Ω	AS 1255.1 PE > 1013
Dielectric constant (permittivity)	3.9 (3.3)	50 Hz (106 Hz) AS 1255.4
Dissipation factor (power factor)	0.01 (0.02)	50 Hz (106 Hz) AS 1255.4

Thermal properties		
Softening point	80 - 84°C	Vicat method AS 1462.5 (min. 75°C for pipes)
Max. continuous service temp.	60°C	cf: PE 80*, PP 110*
Coefficient of thermal expansion	7 x 10-5/K	7 mm per 10 m per 10°C cf: PE 18 - 20 x 10-5, DI 1.2 x 10-5
Thermal conductivity	0.16 W/[m.K]	0 - 50°C PE 0.4
Specific heat	1,000 J/[kg.K]	0 - 50°C
Thermal diffusivity	1.1 x 10-7 m2/s	0 - 50°C
Fire performance		
Flammability (oxygen index)	45%	ASTM D2863 Fennimore Martin test, cf: PE 17.5, PP 17.5
Ignitability index	10 - 12 (/20)	cf: 9 - 10 when tested as pipe AS 1530 Early Fire Hazard Test
Smoke produced index	6 - 8 (/l0)	cf: 4 - 6 when tested as pipe AS 1530 Early Fire Hazard Test
Heat evolved index	0	
Spread of flame index	0	Will not support combustion. AS 1530 Early Fire Hazard Test

Abbreviations

PE	Polyethylene
PP	Polypropylene
PA	Polyamide (nylon)
CI	Cast Iron
AC	Asbestos Cement
GRP	Glass Reinforced Pipe

Conversion of Units

1 MPa = 10 bar	= 9.81 kg/cm2	= 145 lbf/in2
1 Joule = 4.186 calories	= 0.948 x 10-3 BTU	= 0.737 ft.lbf
1 Kelvin = 1°C	= 1.8°F temperature differential	

Mechanical Properties

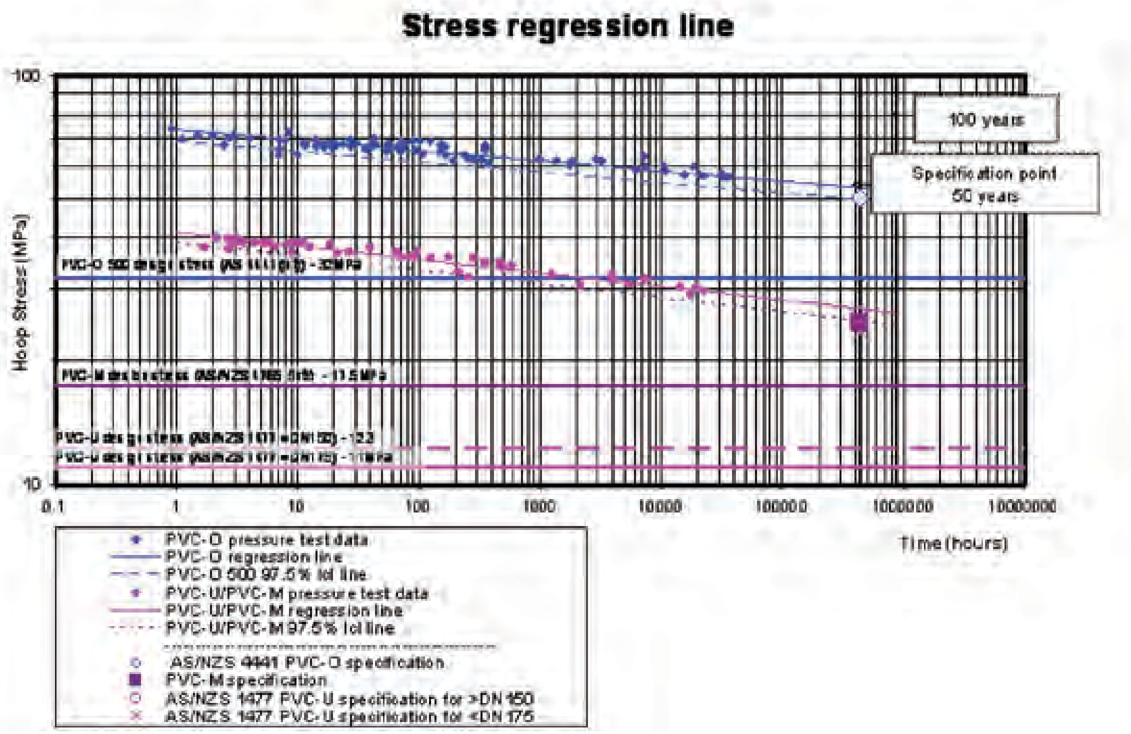
For PVC, like other thermoplastics materials, the stress /strain response is dependent on both time and temperature. When a constant static load is applied to a plastics material, the resultant strain behaviour is rather complex. There is an immediate elastic response, which is fully recovered as soon as the load is removed. In addition there is a slower deformation, which continues indefinitely while the load is applied until rupture occurs. This is known as creep. If the load is removed before failure, the recovery of the original dimensions occurs gradually over time. The rate of creep and recovery is also influenced by temperature. At higher temperatures, creep rates tend to increase. Because of this type of response, plastics are known as viscoelastic materials.

The Stress Regression Line

The consequence of creep is that pipes subjected to higher stresses will fail in a shorter time than those subjected to lower stresses. For pressure pipe applications, long life is an essential requirement. Therefore, it is important that pipes are designed to operate at wall stresses which will ensure that long service lives can be achieved. To establish the long term properties, a large number of test specimens, in pipe form, are tested until rupture. All of these separate data points are then plotted on a graph and a regression analysis performed. The linear regression analysis is extrapolated to obtain the 97.5% lower prediction limit failure stress at the design point which must exceed a minimum required stress (MRS).

A safety factor is then applied to the MRS to obtain a maximum operating stress for the pipe material which is used to dimension pipes for a range of pressure ratings. In Europe and Australasia, the ISO design point of 50 years, or 438,000 hours, is adopted. In North America, the design point of 100,000 hours has historically been used. This design point is quite arbitrary and should not be interpreted as an indication of the expected service life of a PVC pipe. The stress regression line is traditionally plotted on logarithmic axes showing the circumferential or hoop stress versus time to rupture.

Typical Stress Regression Curves



* For MPVC, the 50 year specification point is a 97.5% lower confidence limit point to ensure that the minimum factor of safety is obtained.

Creep Modulus

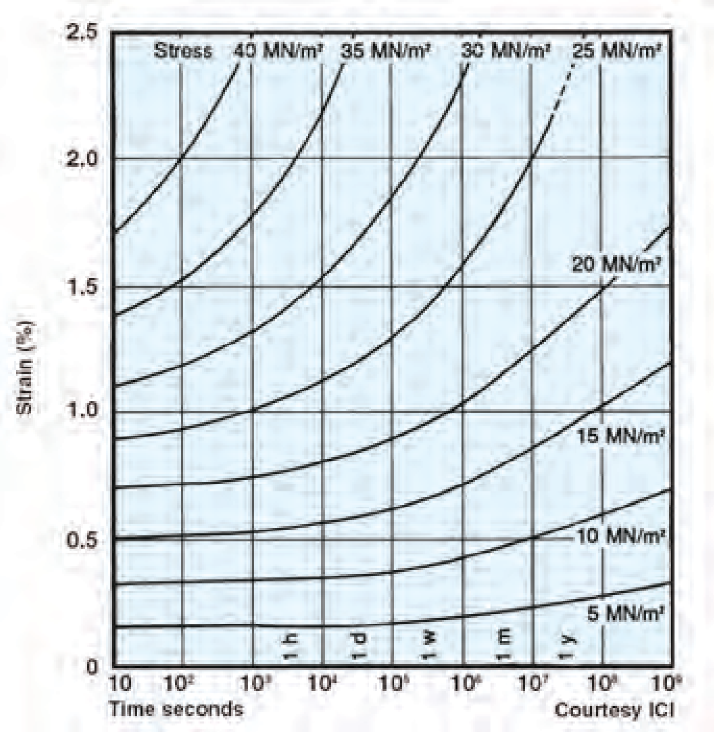
For PVC, the modulus or stress/strain relationship must be considered in the context of the rate or duration of loading and the temperature.

A universal method of data presentation is a curve of strain versus time at constant stress. At a given temperature, a series of curves is required at different stress levels to represent the complete picture. A modulus can be computed for any stress/strain/ time combination, and this is normally referred to as the creep modulus.

Such curves are useful, for example, in designing for short and long term transverse loadings of pipes.

Tests conducted in both England and Australia have shown that PVC-O is stiffer, i.e. it has a higher modulus, than standard PVC-U by some 24% for equivalent conditions in the oriented direction. From other work, there appears to be no significant change in the axial direction.

Creep in Tension at 20°C



Elevated Temperatures

Pressure Ratings at Elevated Temperatures

The mechanical properties of PVC are referenced at 20°C. Thermoplastics generally de-crease in strength and increase in ductility as the temperature rises and design stresses must be adjusted accordingly.

See Section on Design for the design ratings for pipes at temperatures other than 20°C.

Reversion

The term “reversion” refers to dimensional change in plastics products as a consequence of “material memory”. Plastics products “memorise” their original formed shape and if they are subsequently dis-torted, they will return to their original shape under heat.

In reality, reversion proceeds at all temperatures, but with high quality extrusion it is of no practical significance in plain pipe at temperatures below 60°C and in PVC-O pipe at temperatures below 50°C.

The Chemical Performance of PVC

PVC is resistant to many alcohols, fats, oils and aromatic free petrol. It is also resistant to most common corroding agents including inorganic acids, alkalis and salts. However, PVC should not be used with esters, ketones, ethers and aromatic or chlorinated hydrocarbons. PVC will absorb these substances and this will lead to swelling and a reduction in tensile strength.

Chemical Attack

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

1. Swelling of the plastic occurs but the plastic returns to its original condition if the chemical is removed. However, if the plastic has a compounding ingredient that is soluble in the chemical, the plastic 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 plastic cannot be restored by the removal of the chemical. Examples of this type of attack on PVC are aqua regia at 20°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, the rate of attack increases as the 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 plastics under stress can undergo higher rates of attack. In general PVC is considered relatively insensitive to “stress corrosion”.

Considerations for PVC Pipe

For normal water supply work, PVC pipes are totally unaffected by soil and water chemicals. The question of chemical resistance is likely to arise only if they are used in unusual environments or if they are used to convey chemical substances.

For applications characterised as food conveyance or storage, health regulations should be observed. Specific advice should be obtained on the use of PVC pipes.

Although PVC-O is chemically identical to standard PVC-U, rates of attack may vary and this material is not recommended for use in chemical environments or for chemical conveyance.

In most environments, the chemical performance of PVC-M is expected to be similar to standard PVC-U. However, where concentrated chemicals are to be in prolonged contact with PVC-M or elevated temperatures are likely, it is recommended that some preliminary testing should be carried out to determine the suitability of the material.

Sewage Discharges

PVC will not be affected by anything that can be normally found in sewerage effluent. However, if some illegal discharge is made then most chemicals are more likely to attack the rubber ring (common to all modern pipe systems) than the PVC pipe. Because of modern pollution controls on sewage discharges PVC can be safely used in any municipal sewerage network including areas accepting industrial effluent.

Chemical Resistance of Joints

When considering the performance of pipe materials in contact with chemical environments, it is important not to overlook the effect of the environment on the jointing materials. In general, solvent cement joints may be used in any environment where PVC pipe is acceptable. However, separate consideration may need to be given to the rubber ring.

Chemical attack on rubbers can occur in two ways. Swelling can occur as a result of absorption of a chemical. This can make it weaker and more susceptible to mechanical damage. On the other hand, it may assist in retaining the sealing force. Alternatively, the chemical attack may result in a degradation or change in the chemical structure of the rubber. Both types of attack are affected by a number of factors such as chemical concentration, temperature, rubber compounding and component dimensions. The surface area exposed to the environment may also influence the severity of the attack.

See the chemical resistance tables for guidance on chemical resistance of rubber materials commonly used in pipe seals.

OTHER MATERIAL PERFORMANCE ASPECTS

Permeation[1]

The effect on water quality due to the transport of contaminants from the surrounding soil through the pipe wall or rubber ring must be considered where gross pollution of the soil has occurred in the immediate vicinity of the pipe.

For permeation to occur through the pipe wall, the chemical must be a strong solvent or swelling agent for PVC such as aromatic or chlorinated hydrocarbons, ketones, anilines and nitrobenzenes. Permeation through PVC is insignificant for alcohols, aliphatic hydrocarbons, and organic acids.

The mechanism of permeation depends on the effective concentration (activity) of the chemical contaminant. At lower concentrations, permeation rates are so slow that permeation may be considered insignificant. Thus, in the majority of cases, PVC pipe is an effective barrier against permeation of soil contaminants.

At high chemical concentrations (activity >0.25) a different mechanism applies and both the PVC pipe and water quality may be adversely affected in a short time. This corresponds to a gross spill or leak of the chemical in close proximity to the pipe.

It should be noted that rubber rings are generally considered more susceptible to perme-ation than PVC and should be considered separately.

Weathering and Solar Degradation

The effect of "weathering" or surface degradation by radiant energy, in conjunction with the elements, on plastics has been well researched and documented.

Solar radiation causes changes in the molecular structure of polymeric materials, including PVC. Inhibitors and reflectants are normally incorporated in the material which limits the process to a surface effect. Loss of gloss and discolouration under severe weathering will be observed.

The processes require input of energy and cannot proceed if the material is shielded, e.g. under-ground pipes.

From a practical point of view, the bulk material is unaffected and performance under primary tests will show no change, i.e. tensile strength and modulus.

However, microscopic disruptions on a weathered surface can initiate fracture under conditions of extreme local stress, e.g. impact on the outside surface. Impact strength will therefore show a decrease under test.

1. Berens, Alan R., "Prediction of Organic Chemical Permeation Through PVC Pipe," Journal American Waterworks Association, Denver, CO (Nov. 1985) pp. 57-65. Vonk, Martin W., "Permeation of Organic Soil Contaminants Through Polyethylene, Polyvinylchloride, Asbestos Cement and Concrete Water Pipes," Some Phenomena Affecting Water Quality During Distribution: Permeation, Lead Release, Regrowth of Bacteria, KIWA Ltd., Neuwegen, The Netherlands (Nov. 1985) pp. 1-14.

Protection against Solar Degradation

All PVC pipes manufactured by Vinidex contain protective systems that will ensure against detrimental effects for normal periods of storage and installation.

For periods of storage longer than one year, and to the extent that impact resistance is important to the particular installation, additional protection may be considered advisable.

This may be provided by under-cover storage, or by covering pipe stacks with an appropriate material such as hessian. Heat entrapment should be avoided and ventilation provided. Black plastic sheeting should not be used.

Above-ground systems may be protected by a coat of white or pastel-shade PVA paint. Good adhesion will be achieved with simply a detergent wash to remove any grease and dirt.

Material Ageing

The ultimate strength of PVC does not alter markedly with age. Its short-term ultimate tensile strength generally shows a slight increase.

It is important to appreciate that the stress regression line does not represent a weakening of the material with time, i.e. a pipe held under continuous pressure for many years will still show the same short-term ultimate burst pressure as a new pipe.

The material does, however, undergo a change in morphology with time, in that the “free volume” in the matrix reduces, with an increasing number of cross-links between molecules. This results in some changes in mechanical properties:

- A marginal increase in ultimate tensile strength.
- A significant increase in yield stress.
- An increase in modulus at high strain levels.

In general, these changes would appear to be beneficial. However, the response of the material at high stress levels is altered in that local yielding at stress concentrators is inhibited, and strain capability of the article is decreased. Brittle-type fracture is more likely to occur, and a general reduction in impact resistance may be observed.

These changes occur exponentially with time, rapidly immediately following forming, and more and more slowly as time proceeds. By the time the article is put into service, they are barely measurable, except in the very long term.

Artificial ageing can be achieved by heat treatment at 60°C for 18 hours. PVC-O undergoes such ageing in the orientation process and its characteristics are similar to a fully aged material, but with greatly enhanced ultimate strength.

Microbiological Effects

PVC is immune to attack by microbiological organisms normally encountered in under-ground water supply and sewerage systems.

Macrobiological Attack

PVC does not constitute a food source and is highly resistant to damage by termites and rodents.

Effect of Soil Sulphides

Grey discolouration of under-ground PVC pipes may be observed in the presence of sulphides commonly found in soils containing organic materials. This is due to a reaction with the stabiliser systems used in processing. It is a surface effect, and in no way impairs performance.

Table 2.1: Performance Chart - Chemical Resistance of PVC

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.

Sources for Chemical Resistances of PVC

Source 1
The Water Supply Manual for PVC Pipe Systems, First Edition, Vinidex Tubemakers Pty Limited, 1989

Source 2
Chemical Resistance Guide For Thermoplastic Pipe and Fitting Systems, Vinidex Tubemakers Pty Limited

Source 3
ISO/TR 10358 Technical Report: Plastic Pipes and Fittings-Combined Chemical-resistance Classification Table, First Edition, International Organisation for Standardisation, 1993

Source 4
Chemical Resistance, Volume 1- Thermoplastics, Second Edition, Plastics Design Library, 1994

Source 5
Chemical Resistance Data Sheets, Volume 1-Plastics, Rapra Technology Limited, 1993

Abbreviations

S	Satisfactory Resistance
L	Limited Resistance
U	Unsatisfactory Resistance
dil.sol.	dilute aqueous solution at a concentration equal to or less than 10%
sol.	Aqueous solution at a concentration greater then10% but not saturated
sat.sol.	saturated aqueous solution prepared at 20°C
tg-g	technical grade, gas
tg-l	technical grade, liquid
tg-s	technical grade, solid
work.sol.	working solution of the concentration usually used in the industry concerned
susp.	Suspension of solid in a saturated solution at 20°C

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	$Al_2(SO_4)_3.K_2SO.nH_2O$	dil	25	1	1	1			1		1
- AQUEOUS SOLUTION			60	2	1	1					
			100								
	$Al_2(SO_4)_3.K_2SO_4.nH_2O$	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.

Material

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.

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.

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_4H10	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.

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								
		10g/m³	25	2		3	1		3		
			60	2		3	1				
			100								
		66g/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	

Class 1: High Resistance Class 2: Limited Resistance Class 3: No Resistance.

Material

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
			60	2	1	1	1		1		
			100								

Class 1: High Resistance Class 2: Limited Resistance Class 3: No Resistance.

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								

Class 1: High Resistance Class 2: Limited Resistance Class 3: No Resistance.

Material

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	CICOCI	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.

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.

Material

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	$(H_2NOH)_2H_2SO_4$	12	25	1	1	1	1		1		
SULPHATE			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								

Class 1: High Resistance Class 2: Limited Resistance Class 3: No Resistance.

Vinidex Systems & Solutions

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.

Material

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	CH_2Cl_2	100	25	3	3	3	1	3			2
CHLORIDE			60	3		3	2	3			
			100			3	3	3			
METHYL	CH_3COOSO_4	50	25	1	2	2	1	1		1	1
SULPHORIC ACID			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		nd	25	1	1	1	1	1	1	1	1
WATER			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	$NiCl_3$	all	25	1	1	1	1	1	1	1	
- CHLORIDE			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.

Vinidex
Systems & Solutions

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	$HCIO_4$	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.

Material

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	PCl_3	100	25	3	1	1	1	3			1
TRICHLORIDE			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.

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.

Material

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	SnCl2	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								

Class 1: High Resistance Class 2: Limited Resistance Class 3: No Resistance.

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	H_2SO_4+HNO_3+H_20	48/49/3	25	1	3	3					1
SOLUTION			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	$C_{14}H_{10}O_9$	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	$CHCl_2CHCl_2$	nd	25	3	2	2	1		3		2
- ETHANE			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.

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	CCl_3COOH	≤50	25	1	1	1	2		2	2	3
ACID			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	$CO(NH_2)_2$	²10	25	1	1	1	1	1			1
AQUEOUS SOLUTION			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	$ZnCl_2$	dil	25	1	1	1	1	1	1	1	1
- CHLORIDE			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.

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

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.

Sources for Chemical Resistances of Rubbers

Source 1
Chemical Resistance Data Sheets, Volume 2-Rubbers, Rapra Technology Limited, 1993

Source 2
Handbook of PVC Pipe Design and Construction, Third Edition, Uni-Bell PVC Pipe Association, 1993

Abbreviations

Material and Designation

NR	Natural Rubber
NBR	Nitrile Rubber
CR	Polychloropene (Neoprene)
SBR	Styrene Butadiene Rubber
EPDM	Ethylene Propylene Diene Monomer
S	Satisfactory Resistance
L	Limited Resistance
U	Unsatisfactory Resistance

Form Resistance to Flow

In a pipeline, energy is lost wherever there is a change in cross section or flow direction. These energy losses which occur as a result of disturbances to the normal flow show up as pressure drops in the pipeline.

These “form losses” which occur at sudden changes in section, at valves and at fittings are usually small compared with the friction losses in long pipelines. However, they may contribute a significant part to the total losses in short pipeline systems with several fittings.

It can be shown that form losses in pipes may be expressed as a constant multiplied by the velocity head:

i.e. loss in pressure head

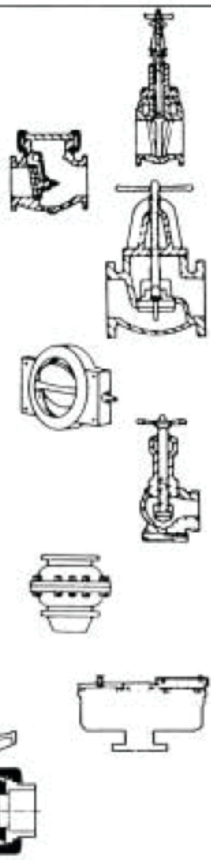
$$H_L \ (m) = K \frac{V^2}{2g}$$

Where:
V = velocity (m/s) from the flow chart
K = resistance coefficient (from Table 3.4)

Table 3.4 Resistance Coefficients for Valves, Fittings and Changes in Pipe Cross Section

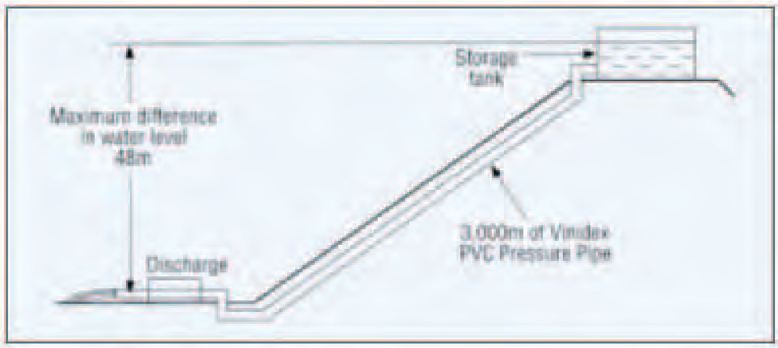
Fitting Type		K
Pipe Entry Losses		
Square Inlet		0.50
Re-entrant Inlet		0.80
Slightly Rounded Inlet		0.25
Bellmouth Inlet		0.05
Pipe Intermediate Losses		
Elbows R/D < 0.6	45°	0.35
	90°	1.10
Long Radius Bends (R/D > 2)	11¼°	0.05
	22½°	0.10
	45°	0.20
	90°	0.50
Tees		
(a) Flow in line		0.35
(b) Line to branch flow		1.00
Sudden Enlargements		
Ratio	d/D	
	0.9	0.04
	0.8	0.13
	0.7	0.26
	0.6	0.41
	0.5	0.56
	0.4	0.71
	0.3	0.83
	0.2	0.92
	<0.2	1.00
Sudden Contractions		
Ratio	d/D	
	0.9	0.10
	0.8	0.18
	0.7	0.26
	0.6	0.32
	0.5	0.38
	0.4	0.42
	0.3	0.46
	0.2	0.48
	<0.2	0.50

Fitting Type		K
Gradual Enlargements		
Ratio d/D	q = 10° typical	
	0.9	0.02
	0.7	0.13
	0.5	0.29
	0.3	0.42
Gradual Contractions		
Ratio d/D	q = 10° typical	
	0.9	0.03
	0.7	0.08
	0.5	0.12
	0.3	0.14
Valves		
Gate Valve (fully open)		0.20
Reflux Valve		2.50
Globe Valve		10.00
Butterfly Valve (fully open)		0.20
Angle Valve		5.00
Foot Valve with strainer		15.00
Air Valves		zero
Ball Valve		0.10
Pipe Exit Losses		
Square Outlet		1.00
Rounded Outlet		1.00



Worked Examples

Example 1: Gravity Main
Water is required to flow at a discharge of 36,000 litres per hour from a storage tank on a hill to an outlet 3 km away.
The difference in water level between the tank and the discharge end is 48m.



1. What size and class of Vinidex PVC-U pipe is required?

2. What is the flow velocity and actual discharge?

Discharge Q = 36,000 L/s = 10 L/s

Hydraulic Gradient =

$$\frac{H}{L} = \frac{48m}{3{,}000m} \times 100 = 1.6m/100m$$

1. Minimum Class required is PN 6. From flow chart: find intersection of

Q = 10 L/s (Left hand scale) and H/L = 1.6 (Top scale)

Read off nearest larger pipe DN 100 (Right hand scale). Therefore DN 100, PN 6 pipe is required.

2. Now that the pipe has been selected, check actual flow. Using PN 6 flow chart find the intersection of DN 100 line and Hydraulic Gradient = 1.6m/100m.

Velocity V = 1.41m/s (Bottom scale)

discharge Q = 12.8L/s (Left hand scale) = 46,080L/h

Example 2: Gravity Main

A pipeline 6.5km long is required to deliver a flow of at least 30L/s. The storage tank at the pipeline inlet has a minimum water level 45m higher than the outlet. Pipe is required to be selected from the Series 2 diameter range. What size and class of Vinidex pipe should be selected?

Try Vinidex Hydro.

Discharge = 25L/s

Hydraulic Gradient =

$$\frac{H}{L} = \frac{40}{6500} \times 100 = 0.6m/100m$$

From the Vinidex Hydro Series 2 flow chart, find the intersection of Q=30 L/s and H/L=0.6. Read off the nearest larger pipe size which gives DN 200.

The maximum pressure is 45m; therefore, a PN 6 pipe would be suitable.

Using the flow chart, find the intersection of the DN 200, PN 6 with H/L = 0.6. Read of the flow velocity from the bottom scale and the actual flow rate from the left hand scale. This gives V = 1.43 m/s and Q =54 L/s.

Example 3: Pumping Main and Form Losses

A pumping line is required to deliver 35 L/s from a low level dam to a high level holding tank. The length of the line is 5 km. The maximum level of the holding tank is 100 m and the minimum level of the dam is 60 m. To avoid the need for sophisticated water hammer control gear, the engineer wishes to restrict flow velocity to a maximum 1 m/s. Calculate:

1. The size and class of Vinidex PVC-U pipe required.
2. The form head losses due to valves and fittings.
3. The head required at the pump.

Try PN6 PVC-U pipe.

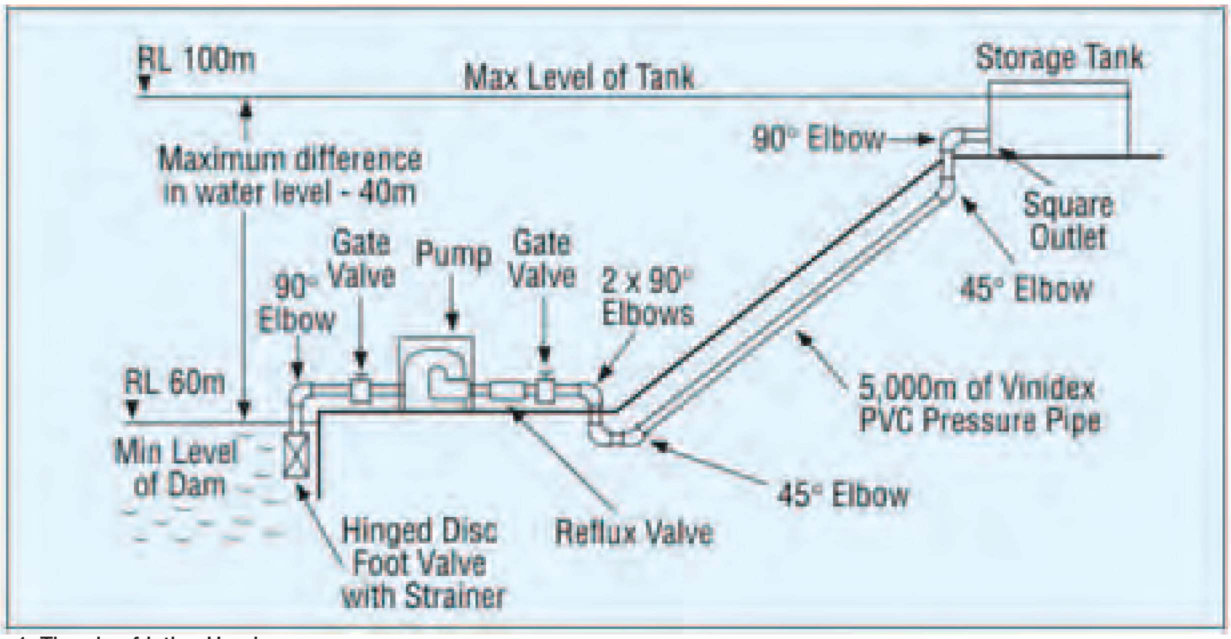
Discharge Q = 35L/s (Left hand scale).

This intersects the 1m/sec velocity line (Bottom scale) at approximately DN 200 pipe. Try DN200 and DN225:

Size DN	Flow velocity (Bottom scale)	Hydraulic gradient (Top scale)
200	0.99 m/s	0.36m/100m
225	0.81 m/s	0.22m/100m

Calculate friction head in pipelines

Size DN	Pipe friction head
200	0.36 x 5000m/100m = 18m
225	0.22 x 5000m/100m = 11m



1. The pipe friction Head

JOINTING PROCEDURES

Cutting

During manufacture pipes are cut to standard length by cut-off saws. These saws have carbide-tipped circular blades which produce a neat cut without burrs.

However, pipes may be cut on site with a variety of cutting tools. These are:

- Proprietary cutting tools - These tools can cut, deburr and chamfer the pipe in one operation. They are the best tools for cutting pipe.
- A portable petrol-driven 'quick cut saw - This is quick and easy to use . However, care must be taken and some deburring will be required
- Air-driven tools - This produces a neat, clean cut. It does, however require a compressor.
- A hand saw and mitre box - This saw produces a square cut but requires more deburring. It takes comparatively more time and effort and requires a stand.

The use of roller cutters is not recommended.

Solvent Cement Joints

Vinidex recommends Vinidex solvent cements and priming fluid for use with Vinidex PVC pipes and fittings, thus ensuring a complete quality system. Vinidex premium solvent cements and priming fluid are specially formulated for PVC pipes and fittings and should not be used with other thermoplastic materials.

The following procedure should be strictly observed for best results. The steps and precautions will allow easy and efficient assembly of joints. Users may refer to AS/NZS 2032 - Installation of UPVC pipe systems, for further guidance.

Incorrect procedure and short cuts will lead to poor quality joints and possible system failure.

Solvent Cement Joint Principles

Sockets on Vinidex pressure pipes and fittings for solvent cement jointing are tapered, ensuring the right level of interference. This may not apply to all pipes and fittings, particularly from other countries which may have a low interference joint requiring a gap filling solvent cement.

Vinidex offers three types of solvent cements formulated specifically for pressure and non-pressure applications. They are colour coded, along with the primer, in accordance with AS/NZS 3879:

- Type 'P' for pressure, including potable water installations, designed to develop high shear strengths with an interference fit (green solvent, green print & lid)
- Type 'N' for non-pressure applications, designed for the higher gap filling properties needed for clearance fits (blue solvent, blue label & lid)
- Type 'G'" gap filling for parallel or low interference pressure and non pressure joints (clear)
- Priming fluid for use with all solvent cements (red priming fluid, red label & lid)

Always use the correct solvent cement for the application.

Solvent cement jointing is a 'chemical welding', not a gluing process. The priming fluid cleans, degreases and removes the glazed surface thus preparing and softening the surface of the pipe so that the solvent cement bonds the PVC. The solvent cement softens, swells and dissolves the spigot and socket surfaces. These surfaces form a bond into one solid material as they cure.

Note: PVC-O pipes are not suitable for solvent cement jointing.

Jointing Pipes with Couplings

Procedure

To simplify the jointing process it is suggested that the initial joint made with the coupling is carried out before the pipe is placed in the trench.

1. Clean the socket of the coupling and spigot of the pipe.
2. Apply Vinidex jointing lubricant to the spigot of the pipe as far back as the witness mark and especially to the chamfered section. Align the spigot with the coupling and apply a firm even thrust to push the spigot into the coupling. For this joint, ensure that the spigot is inserted until the witness mark is no longer visible. It is possible to joint the 150mm pipe by hand. It may be found helpful to brace the coupling against a solid vertical surface.The second joint is made with the coupling of the pipe already in the trench.
3. Use the same technique as before but only insert the spigot into the coupling sufficiently to leave one witness mark visible at the face of the coupling. This is necessary to allow for possible expansion of the pipe after installation.

If a joint is inserted too far, it may be withdrawn immediately, but once the lubricant is dry (which only takes a few minutes in hot weather) mechanical aids are required to pull the joint apart.

Ensure the coupling to be jointed is supported to prevent closing of preceding couplings.

The diagram below indicates the correct pipe positions in the coupling.

Pipeline Fittings

Vinidex Superlink ductile iron fittings have been designed with deep sockets to be suitable for PVC pressure pipes in all situations.

The depth of sockets on pipes and fittings must be sufficient to accommodate the axial movements due to the combined effect of a number of factors, such as thermal contraction and Poisson contraction which occurs when a pipe is pressurised. The Poisson effect is more significant for PVC-M and PVC-O pipes because of their higher operating stress. Vinidex Superlink® ductile iron fittings have socket lengths adequate for all situations and are recommended for use with PVC pipe.

Use of Other Brand Fittings

A variety of other cast/ductile iron, bronze, aluminium, steel ABS and PVC fittings may be used with Vinidex PVC pipes. In most cases the fittings have sockets that are shorter than pipe sockets. When the socket is too short for the spigot to be inserted to the witness mark, the pipe should be fully homed and special precautions should be taken during construction to ensure that no contraction of the pipe will be taken up at these joints, i.e. it should be taken up at other joints.

Flanged Joints

The main functions of a flanged joint is to create a demountable joint, to connect valves and vessels where strength in tension is required, or to joint to other materials.

The three types of flanges available are:

1. Full-faced PVC socketed flanges.
2. PVC socketed stub flanges with loose PVC or metal backing rings.
3. Tapered cores with either metal or PVC flanges.

Flange joints require gaskets to seal them. In high stress situations, metal backing plates or flat washers are also required to spread the force and prevent damage to the flange. Bolts should not be over tightened.
Epoxy-coated aluminium or ductile iron flange adaptors are also available.

Threaded Joints

or normal water supply purposes, the cutting of threads on PVC pipes is not an acceptable practice. A moulded threaded adaptor should be used. (See Section 5 for details.)

When making threaded joints the following points should be observed:-

1. A thread sealant is recommended and the only acceptable material is PTFE (TEFLON) tape. Hemp, grease or solvent cement should never be used.

Test the 'fit' of the joint, particularly when connecting to other materials or to other manufacturers' fittings. Judge the amount of tape accordingly. Under no circumstances should the thread bottom against a stop on either the male or female fitting.

2. Hand tighten initially. Usually a further two more turns are sufficient to effect a seal. Tighten only just enough to seal, plus half a turn more.

Note. Over tightening will over stress the fitting. Avoid using serrated grip tools particularly on the plain barrel of fittings or pipes.

3. If a threaded connection is made to a metal fitting, it is preferable that the male thread be PVC. For female PVC fittings special care should be taken to avoid overstressing.

GOLDEN RULE
DO NOT OVERTIGHTEN

Compression Joints

There are various types of compression joints available for use with PVC pipes. (See Section 5 for details.) In principle all of these effect a seal by mechanical compression of a rubber ring by means of threaded caps or bolted end plates. Because immediate pressurisation is possible such joints are generally preferred for repair work.

They are also used frequently for final connections in difficult situations where slight misalignment cannot be avoided.

When making compression joints the manufacturers' recommendations should be followed. Over-tightening should be avoided. It may be found advantageous to use a lubricant on the rubber ring.

Connection to Other Materials

A wide range of adaptors to joint PVC pipes and fittings to pipes and fittings of other materials is available.

See Product Data section for more details

SERVICE CONNECTIONS

Tapping Saddles

Only tapping saddles complying with AS/NZS 4793 - Mechanical tapping bands for waterworks purposes and designed for use with PVC pipe should be used. These saddles should:

1. Be contoured to fit around the pipe, have an "O" or "V" seal and not have lugs or sharp edges that dig in.
2. Have a positive stop to avoid overtighting of the saddle around the pipe.

Tapping saddles, which employ U-bolt fastenings, are not suitable for PVC pipes. Tapping clamps with full face flat gaskets have no diameter control and the high force required to seal may crush the pipe. Plastic and reinforced plastic units should be used only with specific recommendation from the supplier that they have been tested for use with the pipe material.

The maximum hole size that should be drilled in a PVC pipe for tapping purposes is 50 mm, or 1/3 the pipe diameter, whichever is smaller.

This does not prevent the connection of larger branch lines via tapping saddles, provided the hydraulic loss through the restricted hole size is acceptable.

For larger branches generally, a tee is preferred.

Holes should not be drilled into PVC pipe:

1. Less than 300 mm from a spigot end.
2. Closer than 500 mm to another hole on a common parallel line.
3. Where significant bending stress is applied to the pipe.

Live Tapping

Various tools are available to allow live tapping of a line using a specially adapted tapping band.

The tapping band should be fitted to the pipe and correctly tightened. A specially adapted main cock for live tapping should be fitted to the tapping saddle using PTFE tape and a drilling machine fitted with a "shell" cutter or hole saw. The hole is drilled and the tapping flushed. The hole saw is then withdrawn and the main cock sealed. The tapping machine is removed along with the hole cut-out and the main cock plunger or cap is then fitted.

Dry Tapping

The procedure is the same as above except that the hole can be drilled before the main cock is fitted. It is also possible to dry tap using a twist drill with razor sharp cutting edges ground to an angle of 80°. Removal of the swarf, however, is more difficult and wherever possible the use of a hole saw is recommended.

Note: A spade bit is not suitable for drilling PVC pipes.

Direct Tapping

Vinidex does not recommend direct tapping (threading of the pipe wall) for PVC pressure lines.

HANDLING AND STORAGE

PVC pipe is very robust, but still can be damaged by rough handling. Pipes should not be thrown from trucks or dragged over rough surfaces. Plastic piping becomes more susceptible to damage in very cold weather so extra care should be taken when the temperature is low.

Since the soundness of any pipe joint depends on the condition of the spigot and the socket, special care should be taken not to allow them to come into contact with sharp edges or protruding nails.

Transportation of PVC Pipes

While in transit pipes should be well secured and supported. Chains or wire ropes may be used only if suitably padded to protect the pipe from damage. Care should be taken that the pipes are firmly tied so that the sockets cannot rub together.

Pipes may be unloaded from vehicles by rolling them gently down timbers, care being taken to ensure that the pipes do not fall onto one another or onto any hard or uneven surface.

Storage of PVC Pipes

Pipes should be given adequate support at all times. Pipes should be stacked in layers with sockets placed at alternate ends of the stack and with the sockets protruding.

Horizontal supports of about 75 mm wide should be spaced not more than 1.5 m centre-to-centre beneath the pipes to provide even support.

Vertical side supports should also be provided at intervals of 3 m along rectangular pipe stacks.

For long-term storage (longer than 3 months) the maximum free height should not exceed 1.5 m. The heaviest pipes should be on the bottom.

Crated pipes, however, may be stacked higher provided that the load bearing is not taken directly by the lower pipes. In all cases, stacking should be such that pipes will not become distorted.

If it is planned to store pipes in direct sunlight for a period in excess of one year, then the pipes should be covered with material such as hessian, placed so as to not restrict the circulation of air in the pipes which has a cooling effect. Coverings such as black plastic must not be used as these can greatly increase the temperatures within the stack.

Pipes should not be stored close to heat sources or hot objects, eg., heaters, boilers steam lines or engine exhaust, or against reflective metal fences which may concentrate heat.

BELOW-GROUND INSTALLATION

(See also AS 2032)

Preparing the Pipes

Before installation, each pipe and fitting should be inspected to see that its bore is free from foreign matter and that its outside surface has no large scores or any other damage. Pipe ends should be checked to ensure that the spigots and sockets are free from damage.

Pipes of the required diameter and class should be identified and matched with their respective fittings and placed ready for installation.

Preparing the Trench

PVC pipe is likely to be damaged or deformed if its support by the ground on which it is laid is not made as uniform as possible. The trench bottom should be examined for irregularities and any hard projections removed.

Trench Widths

A trench should be as narrow as practical but adequate to allow space for working area and for tamping the side support. It should be not less than 200 mm wider than the outside diameter of the pipe irrespective of soil condition.

Wide Trenches

For deep trenches where significant soil loading may occur, the trench should not exceed the widths given in the Table 4.2 without further investigation.

Table 4.2 Recommended Trench Widths

Size DN (mm)	Minimum (mm)	Maximum (mm)
100	320	800
125	340	825
150	360	825
200	425	900
225	450	925
250	480	950
300	515	1000
375	600	1200

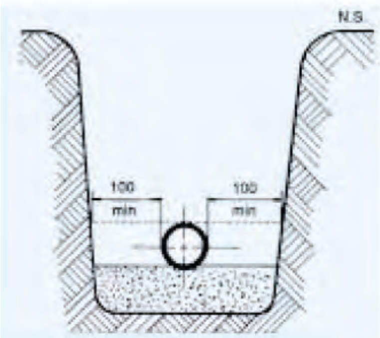
Unstable Conditions

Where a trench, during or after excavation, tends to collapse or cave in, it is considered unstable. If the trench is located, for instance, in a street or a narrow pathway and it is therefore impractical to widen the trench, support should be provided for the trench walls in the form of timber planks or other suitable shoring.

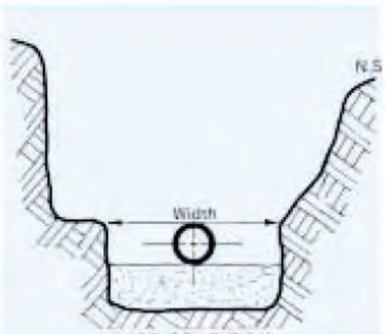
Alternatively the trench should be widened until stability is reached. At this point, a smaller trench may then be excavated in the bottom of the trench to accept the pipe. In either case do not exceed the maximum trench width at the top of the pipe unless allowance has been made for the increased load.

Trench Depths

The recommended minimum trench depth is determined by the loads imposed on the pipe such as the mass of backfill material, the anticipated traffic loads and any other superimposed loads. The depth of the trench should be sufficient to prevent damage to the pipe when the anticipated loads are imposed upon it.



Minimum Trench Width



Wide Condition

Table 4.3 Minimum Cover

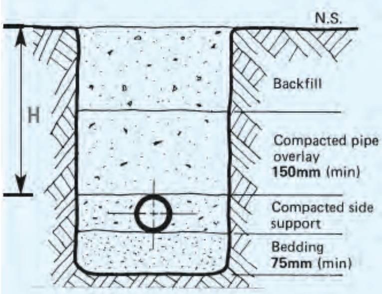
Loading	Cover, H (mm)
No vehicle loading	300
Vehicular loading:-	
not roadways	450
sealed roadways	600
unsealed roadways	750
Embankments	750
Construction equipment loading	750

Minimum Cover

Trenches should be excavated to allow for the specified depth of bedding, the pipe diameter and the minimum recommended cover, overlay plus backfill, above the pipes. Table 4.3 provides recommendations for minimum cover.

The above cover requirements will provide adequate protection for all classes of pipe. Where it is necessary to use lower covers, several options are available.

1. Use a high quality granular backfill, eg crushed gravel or road base.
2. Use a higher class of pipe than required for normal pressure or other considerations.
3. Provide additional structural load bearing bridging over the trench. Temporary steel plates may be used in the case of construction loads.



Minimum Cover Requirement

Bedding Material

Preferred bedding materials are listed in AS 2032 as follows:

1. Suitable sand, free from rock or other hard or sharp objects that would be retained on a 13.2 mm sieve.
2. Crushed rock or gravel of approved grading up to a maximum size of 14 mm.
3. The excavated material may provide a suitable pipe underlay if it is free from rock or hard matter and broken up so that it contains no soil lumps having any dimension greater than 75 mm which would prevent adequate compaction of the bedding.

The suitability of a material depends on its compactability. Granular materials (gravel or sand) containing little or no fines, or specification graded materials, require little or no compaction, and are preferred.

Sands containing fines, and clays are difficult to compact and should only be used where it can be demonstrated that appropriate compaction can be achieved.

Variations in the hard bed should never exceed 20% of the bedding depth. Absolute minimum underlay should be 75 mm. It may be necessary to provide a groove under each socket to ensure that even support along the pipe barrel is achieved.

Pipe Side Support

Material selected for pipe side support should be adequately tamped in layers of not more than 150 mm. Care should be taken not to damage the exposed pipe and to tamp evenly on either side of the pipe to prevent pipe distortion.

Unless otherwise specified, the pipe side support and pipe overlay material used should be identical with the pipe bedding material.

Pipe Overlay

The pipe overlay material should be levelled and tamped in layers to a minimum height of 150 mm above the crown of the pipe. Care should be taken not to disturb the line or grade of the pipeline, where this is critical, by excessive tamping.

Backfill

Unless otherwise specified, excavated material from the site should constitute the back-fill.

Gravel and sand can be compacted by vibratory methods and clays by tamping. This is best achieved when the soils are wet. If water flooding is used and extra soil has to be added to the original backfill, this should be done only when the flooded backfill is firm enough to walk on. When flooding the trench, care should be taken not to float the pipe.

PVC Pipes Under Roads

PVC pipes can be installed under roads in either the longitudinal or transverse direction.

The type of rock / granular materials specified for road subgrades have a very high soil modulus and offer excellent side support for flexible pipes as well as minimising the effects of dead and live loads. This represents an ideal structural environment for PVC pipes.

Consideration should be given at the time of installation to ensure:

1. Construction loadings are allowed for;
2. The pipes are buried at sufficient depth to ensure they are not disturbed during future realignments or regrading of the road; and
3. Minimum depths of cover and compaction techniques are observed.

See also Vinidex Technical Note - Flexible pipe in roadways. www.vinidex.com.au

Pipeline Buoyancy

Pipe, under wet conditions, can become buoyant in the trench. PVC pipe, being lighter than most pipe materials, should be covered with sufficient overlay and backfill material to prevent inadvertent flotation and movement. A depth of cover over the pipe of 1.5 times the diameter is usually adequate.

Expansion and Contraction

Pipe will expand or contract if it is installed during very hot or very cold weather, so it is recommended that the final pipe connections be made when the temperature of the pipe has stabilised at a temperature close to that of the backfilled trench.

When the pipe has to be laid in hot weather, precautions should be taken to allow for the contraction of the line which will occur when it cools to its normal working temperature.

For solvent cemented systems, the lines should be free to move until a strong bond has been developed (see Solvent Cement Jointing Procedures) and installation procedure should ensure that contraction does not impose strain on newly made joints.

For rubber ring jointed pipes, if contraction accumulates over several lengths, pull-out of a joint can occur. To avoid this possibility the preferred technique is to back-fill each length, at least partially, as laying proceeds. (It may be required to leave joints exposed for test and inspection.)

It should be noted that rubber ring joint design allows for contraction to occur. Provided joints are made to the witness mark in the first instance, and contraction is taken up approximately evenly at each joint, there is no danger of loss of seal. A gap between witness mark and socket of up to 10 mm after contraction is quite acceptable.

Further contraction may be observed on pressurisation of the line (so-called Poisson contraction due to circumferential strain). Again this is anticipated in joint design and is quite in order.

Electrical Earthing

PVC piping is a non-conductive material and cannot be used for earthing electrical installations or for dissipating static charges. Local authorities, both water and electrical, should be consulted for their requirements.

INSTALLING PIPES ON A CURVE

When installing pipes on a curve, the pipe should be jointed straight and then laid to the curve. Bending of pipes is achieved in practice after each joint is made, by laterally loading the pipe by any convenient means, and fixing in place by compacted soil, or appropriate fixings above ground. The technique used depends on the size and class of pipe involved, as clearly the forces required to induce bending vary over a very large range.

For buried lines in good soil, the compaction process can be used to induce bending as illustrated below. Bending aids, crowbars etc. must always be padded to prevent damage to pipes. Permanent point loads are not acceptable.

Significant bending moments should not be exerted on rubber ring joints, since this introduces undesirable stresses in the spigot and socket that may be detrimental to long term performance. To avoid this, reaction supports should be placed adjacent to the socket rather than on the sockets. For buried pipes this also allows the joint to be left open for inspection during testing. Because of this restriction, the length available for bending is less than the full length of the pipe. It is also not practicable to maintain a constant radius of curvature by application of point load forces.

The calculations shown in Table 4.4 are derived from beam theory and assume a 5m bending length for calculation of the deflection angle. For other pipe lengths or loading configurations, see the Design Section for the relevant formulae.

Solvent cement jointed pipes may be curved continuously, ie., bending moments may be transmitted across the joints, but bending may be applied only after full curing, 24 hours for pressure and 48 hours for non-pressure joints. For solvent cement jointed pipelines, the angular deflection figures should be increased by 20%

Table 4.4 Maximum deflection angles, centre displacements and end offsets for 6m PVC pressure pipes.

Size DN (mm)	Force applied at centre span			Forces applied at quarter points		
	Max. deflection angle	Max. displace-ment	Max. end offset	Max. deflection angle	Max. displace-ment	Max. end offset
	deg	mm	mm	deg	mm	mm
Minimum radius of curvature/diameter ratio				300		
Series 1 diameters						
15	23	470	1200	34	650	1800
20	18	380	950	27	520	1400
25	14	300	740	21	410	1100
32	11	240	580	17	330	900
40	9.9	210	520	15	290	790
50	7.9	170	410	12	230	630
65	6.3	130	330	9.5	180	500
80	5.4	110	280	8.1	160	420
100	4.2	88	220	6.3	120	330
125	3.4	71	180	5.1	98	270
150	3.0	63	160	4.5	86	240
175	2.4	50	130	3.6	69	190
200	2.1	44	110	3.2	61	170
Series 2 diameters						
100	3.9	82	200	5.9	110	310
150	2.7	56	140	4.0	78	210
200	2.1	43	110	3.1	59	160

Note: Beam theory is applicable to small deflections and figures for small bore pipes with centreline displacements greater than 5% of span should be treated as very approximate

Thrust Blocks

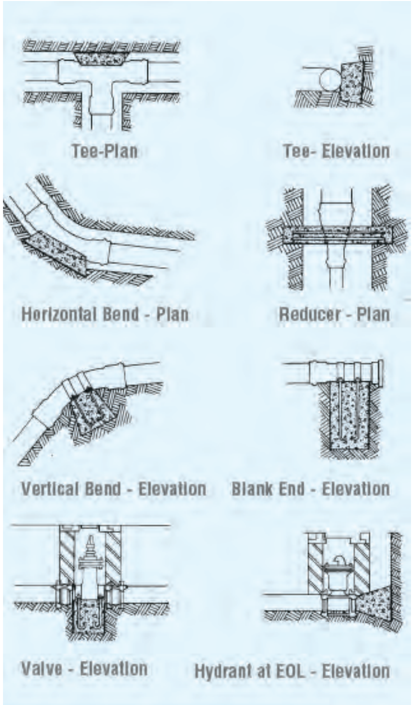
Underground PVC pipelines jointed with rubber ring joints require concrete thrust blocks to prevent movement of the pipeline when a pressure load is applied. In some circumstances, thrust support may also be advisable in solvent cement jointed systems. Uneven thrust will be present at most fittings. The thrust block transfers the load from the fitting, around which it is placed, to the larger bearing surface of the solid trench wall.

Construction of Thrust Blocks

Concrete should be placed around the fitting in a wedge shape with its widest part against the solid trench wall. Some forming may be necessary to achieve an adequate bearing area with a minimum of concrete. The concrete mix should be allowed to cure for seven days before pressurisation.

A thrust block should bear firmly against the side of the trench and to achieve this, it may be necessary to hand trim the trench side or hand excavate the trench wall to form a recess. The thrust acts through the centre line of the fitting and the thrust block should be constructed symmetrically about this centre line. (See Thrust Support for design of thrust block size.)

PVC pipes and fittings should be covered with a protective membrane of PVC, polyethylene or felt when adjacent to concrete so that they can move without being damaged. (See Setting of pipes in concrete)



Pipelines on Steep Slopes

Two problems can occur when pipes are installed on steep slopes, i.e. slopes steeper than 20% (1:5).

1. The pipes may slide downhill so that the witness mark positioning is lost. It may be necessary to support each pipe with some cover during construction to prevent the pipe slipping.
2. The generally coarse backfill around the pipe may be scoured out by water movement in the backfill. Clay stops or sandbags should be placed at appropriate intervals above and below the pipe to stop erosion of the backfill.

Where bulkheads are used, one restraint per pipe length, placed adjacent to the socket, is considered sufficient for all slopes.

ABOVE-GROUND INSTALLATION

(See also AS 2032)

General Considerations

In above ground installations, pipes should be laid on broad, smooth bearing surfaces wherever possible to minimise stress concentration and to prevent physical damage.

PVC pipe should not be laid on steam lines or in proximity to other high temperature surfaces.

Where a PVC pressure pipeline is used to supply cold water to a hot water cylinder, the last two metres of pipe should be made of copper and a non-return valve fitted between the PVC and copper line to prevent pipe failure.

Where connections are made to other sections or to fixtures such as pumps or motors, care should be taken to ensure that the sections are axially aligned. Any deviations will result in undue stress on the jointing fittings which could lead to premature failure.

If a pipeline is subjected to continuous vibration such as at the connection with a pump, it should be connected by a flexible joint or, if possible, the system should be redesigned to eliminate the vibration.

The pipe must be adequately supported in order to prevent sagging and excessive distortion. Clamp, saddle, angle, spring or other standard types of supports and hangers may be used where necessary. Pipe hangers should not be over-tightened. Metal surfaces should be insulated from the pipe by plastic coating, wrapping or other means.

A build up of static electricity on the outside surface of PVC pipes can occur. Where there is a risk of explosion, such as in some mining applications, safety precautions may be required.

Supports

Brackets and Clips

For either free or fixed pipeline supports using brackets or clips, the bearing surface should provide continuous support for at least 120° of the circumference.

Straps

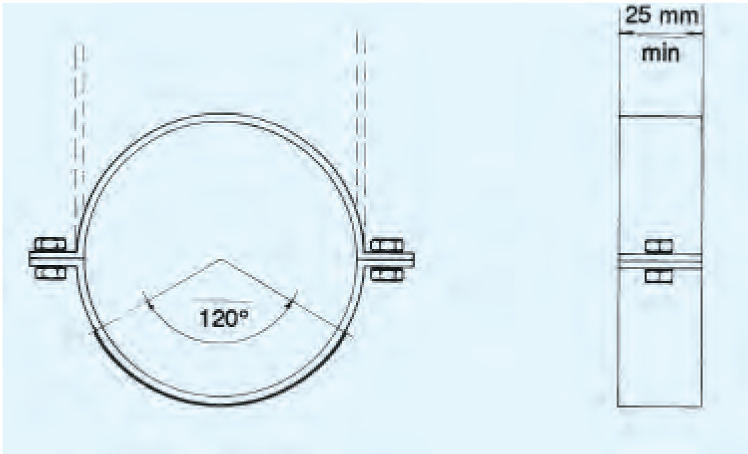
Metal straps used as supports should be at least 25 mm wide, either plastic-coated or wrapped in a protective material such as nylon or PE sheet. If a strap is fastened around a pipe, it should not distort the pipe in any way.

Free Supports

A free support allows the pipe to move without restraint along its axis while still being supported. To prevent the support from scuffing or damaging the pipe as it expands and contracts, a 6 mm thick layer of felt or lagging material is wrapped around the support. Alternatively, a swinging type of support can be used and the support strap, protected with felt or lagging, must be securely fixed to the pipe.

Fixed Supports

A fixed support rigidly connects the pipeline to a structure totally restricting movement in at least two planes of direction. Such a support can be used to absorb moments and thrusts.



Straps

Placement of Supports

Careful consideration should be given to the layout of piping and its support system. Even for non pressure lines the effects of thermal expansion and contraction have to be taken into account. In particular, the layout should ensure that thermal and other movements do not induce significant bending moments at rigid connections to fixed equipment or at bends or tees.

For solvent-cement jointed pipe any expansion coupling must be securely clamped with a fixed support. Other pipe clamps should allow for movement due to expansion and contraction. Rubber-ring jointed pipe should have fixed supports behind each pipe socket.

Setting of Pipes in Concrete

When PVC pipes are encased in concrete, certain precautions should be taken:-

1. Pipes should be fully wrapped with a compressible material, such as felt, with a minimum thickness of 5% of the pipe diameter, i.e. 5 mm for a 100mm diameter pipe.
2. Alternatively, flexible (rubber ring) joints should be provided at entry to and exit from the concrete as shown.

   This procedure also allows for possible differential movement between the pipeline and concrete structure.

   It must be borne in mind, however, that without a compressible membrane; stress transfer to the concrete will occur and may damage the concrete section.
3. Expansion joints coinciding with concrete expansion joints should be provided to accommodate movement due to thermal expansion or contraction in the concrete.

Anchorage at Fittings

It is advisable to rigidly clamp at valves and other fittings located at or near sharp directional changes, particularly when the line is subjected to wide temperature variations.

With the exception of solvent-cement jointed couplings, all PVC fittings should be supported individually and valves should be braced against operating torque.

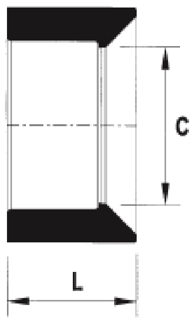
CAT 5 Reducing Bushes

This fitting is used for solvent cement jointing into the socket of a fitting such as a CAT 7 coupling or a CAT 19 tee to give a reduction in bore. It is most often used as an alternative to a reducing coupling (CAT 8) in situations where space is a problem.

Note: These fittings should not be jointed to pipe sockets.

Product Code	Size DN	C	L
34420	20x15	16.8	21
34430	25x15	16.1	24.7
34440	25x20	21.9	24.5
34450	32x25	26.8	33
34460	40x25	31	31
34470	40x32	34.7	31.6
34480	50x25	27	36.9
34490	50x40	41.3	36.8
34500	80x50	56.2	51.5
34510	100x50	57.4	61.5
34520	100x80	85	61.5
34530	150x100	107	89
34580*	200x150	132.2	121.5

*PN 9 fitting

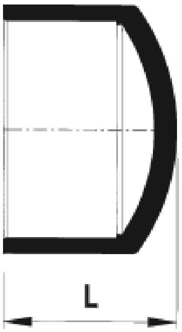


CAT 6 Caps

Caps are solvent cemented to the end of a pipe or fitting spigot to provide line termination. They can also be used to temporarily prevent the entry of dirt and foreign matter into a pipeline.

Product Code	Size DN	L
34590	15	25.8
34600	20	29.7
34610	25	34.3
34620	32	50
34630	40	46.6
34640	50	58.4
34650†	65	72
34660	80	78
34670	100	92
34680	125	133
34690	150	135
34705*	200	160

*PN 9 fitting † PN 12 fitting

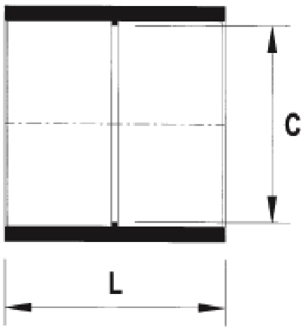


CAT 7 Couplings

Couplings are used for the solvent cement jointing of two lengths of PVC pipe.

Product Code	Size DN	C	L
34730	15	18.4	39
34740	20	24.1	43.5
34750	25	30.2	49 0
34760	32	36.6	69.5
34770	40	45.4	65.5
34780	50	56.6	77
34790*	65	66	110.5
34800	80	85.5	104.5
34810	100	110	124.5
34820	125	131.5	185
34830	150	149.5	190
30404*	200	215	238

*PN 12 fitting

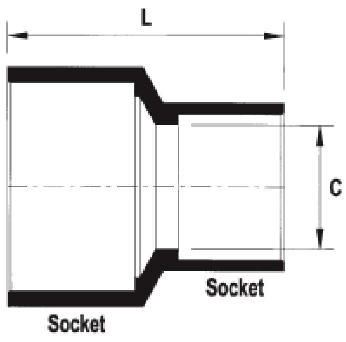


CAT 8 Reducing Couplings

Reducing couplings are used for the solvent cement jointing of two different sizes of PVC pipe.

Product Code	Size DN socket x socket	C	L
34880	20x15	16.5	45.5
34890	25x15	17.4	51
34900	25x20	21.1	51.5
34920	32x20	23	62.5
34930	32x25	25.3	67
34940	40x15	15.8	58
34950	40x20	23.5	64
34960	40x25	26.9	60
34970	40x32	38.4	71.5
34990	50x20	25	71
35000	50x25	29.3	78.5
35010	50x32	37	82
35020	50x40	42	74.3
35030†	65x50	51	104
35035*	80x40	41.2	99
35040	80x50	57.6	99
35050	80x65	66.5	120
35060	100x50	57.5	104
35070	100x80	86.6	123
35080	125x80	81.5	167.5
35090	125x100	106	172
35100	150x100	107.5	183

*Fabricated from other moulded fittings. † PN 12 fitting



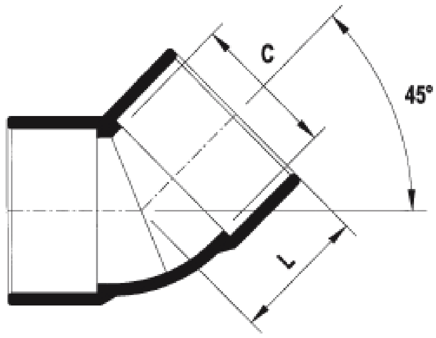
Product Data

CAT 10 45°Elbows

Elbows are used to provide 45° changes in direction in pipelines. They are often employed in confined space situations in place of CAT 12, 45° bends.

Product Code	Size DN	C	L
35180	15	17.5	33
35190	20	23.7	34.5
35200	25	30	39.5
35210	32	38.8	44.5
35220	40	47.9	40
35230	50	60	46
35240†	65	68.5	64
35250	80	78.7	81.5
35260	100	102.2	95
35280†	150	155	125
35290*	155	163	129
30388*	200	218	181

*PN 9 fitting; † PN 12 fitting



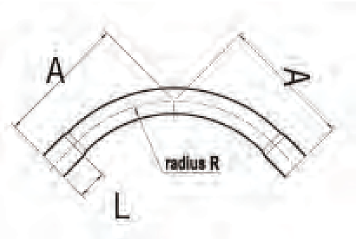
CAT 12 Bends (Fabricated)

CAT 12 bends are manufactured to AS/NZS 1477

Bends are used in pipelines to allow changes in direction. They are most often used in situations where space is not a problem, e.g. when laid in a large trench. They have significantly better flow characteristics compared to moulded elbows.

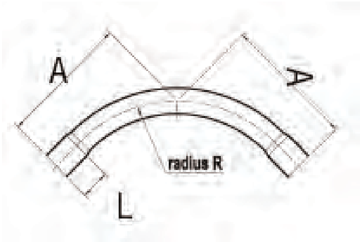
Note: These fittings have pipe sockets and should not be jointed to spigoted moulded fittings.

Product Code	Size DN	Class	A	Bore(Nom)	L(min)	Radius(Nom)
38850	15x90°	18	352	18.3	38	305
38860	20x90°	18	352	22.4	38	305
38870	25x90°	18	352	28.1	38	305
38880	32x90°	18	371	35.4	38	305
38890	40x90°	18	371	40.5	51	305
38900	50x90°	12	383	53.7	64	305
38920	65x90°	12	479	67.5	64	365
38950	80x90°	12	477	79	76	356
38970	100x90°	12	628	101.7	102	457
38990	125x90°	12	1085	124.9	127	635
39000	150x90°	12	1085	142.7	127	635
39047	200x90°	12	1730	206.6	152	1200
38670	20x60°	18	220	22.4	38	305
38680	25x60°	18	220	28.1	38	305
38690	32x60°	18	220	35.4	38	305
38700	40x60°	18	232	40.5	51	305
38710	50x60°	12	218	54.3	64	305
38740	80x60°	12	400	79	76	356
38750	100x60°	12	502	101.7	102	584
38760	125x60°	12	796	124.9	127	635
38770	150x60°	12	885	142.7	127	635
38480	20x45°	18	172	22.4	38	305
38490	25x45°	18	172	28.1	38	305
38500	32x45°	18	172	35.4	38	305
38510	40x45°	18	185	40.5	51	305
38520	50x45°	12	210	53.7	64	305
38540	65x45°	12	243	67.5	64	365
38550	80x45°	12	343	79	76	584



CAT 12 Bends (Continued)

Product Code	Size DN	Class	A	Bore(Nom)	L(min)	Radius(Nom)
38560	100x45°	12	358	101.7	102	584
38570	125x45°	12	776	124.9	127	635
38580	150x45°	12	776	142.7	127	635
38620	200x45°	12	1000	204.6	254	1200
38290	20x30°	18	129	22.4	38	305
38300	25x30°	18	129	28.1	38	305
38310	32x30°	18	129	35.4	38	305
38320	40x30°	18	142	40.5	51	305
38330	50x30°	12	154	53.7	64	305
38340	65x30°	12	190	67.5	64	365
38350	80x30°	12	239	79	76	584
38360	100x30°	12	279	101.7	102	584
38370	125x30°	12	588	124.9	127	635
38380	150x30°	12	652	142.7	127	635
38100	20x22½°	18	103	22.4	38	305
38110	25x22½°	18	103	28.1	38	305
38120	32x22½°	18	103	35.4	38	305
38130	40x22½°	18	115	40.5	51	305
38140	50x22½°	12	128	53.7	64	305
38150	65x22½°	12	185	67.5	64	365
38160	80x22½°	12	199	79	76	584
38170	100x22½°	12	247	101.7	102	584
38180	125x22½°	12	548	124.9	127	635
38190	150x22½°	12	599	142.7	127	635
38215	200x22½°o	18	76	22.4	38	305
37910	20x11¼°	18	76	22.4	38	305
37920	25x11¼°	18	76	28.1	38	305
37930	32x11¼°	18	76	35.4	38	305
37940	40x11¼°	18	83	40.5	51	305
37950	50x11¼°	12	102	53.7	64	305
37970	65x11¼°	12	108	67.5	64	365
37980	80x11¼°	12	140	79	76	584
37990	100x11¼°	12	170	101.7	102	584
38000	125x11¼°	12	508	124.9	127	635
38010	150x11¼°	12	572	142.7	127	635
38025	200x11¼°	12	730	206.6	178	1800

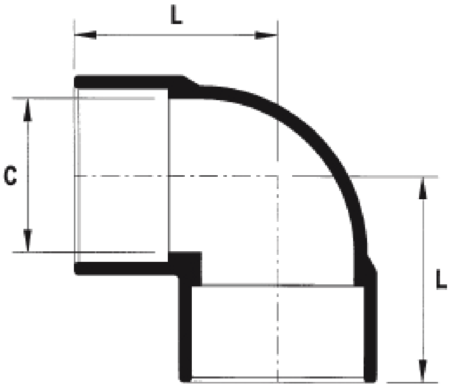


CAT 13 90° Elbows

These are moulded fittings, which are used to provide 90° bends in pipelines. They are most often employed in confined space situations in preference to CAT 12 90° bends.

Product Code	Size DN	C	L
35330	15	15.5	43.3
35340	20	20.6	43
35350	20x15	15.4	42.8
35360	25	26.8	46.3
35370	25x15	15.2	46.3
35380	25x20	20.5	46.3
35390	32	39.7	52
35400	40	45.7	57.7
35410	50	57.7	69.9
35420	65	74.8	87.4
35430	80	78.4	98.6
35440	100	101.5	137.3
35460[1]	150	143	182.9
35470[2]	155	163	178
303814[4]	200	217	241

(1) PN 12; (2) BS4346 Class D; (3) BS4346 Class C; (4) PN 9



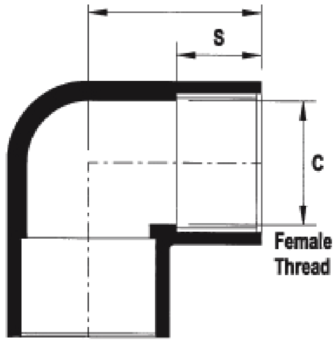
CAT 15 90° Faucet Elbows

The faucet elbow is used to provide a female BSP connection. In irrigation it is used as a means of connecting a threaded riser pipe to an underground pipeline.

Note: PVC threads should never be overtightened. Refer to our Installation Guidelines for procedures.

Product Code	Size DN	*C	L	S
35510	15x15	15.5	43.1	25.1
35520	20x15	20.9	43	24.9
35530	20x20	20.7	43	23.4
35540	25x15	26.9	46.4	24.7
35550	25x20	26.9	46.4	22.9
35560	25x25	26.8	46	24.7
35570	32x32	39.1	49.7	22.1
35580	40x40	44	59	30

*Smaller Bore



CAT 16 Flanges

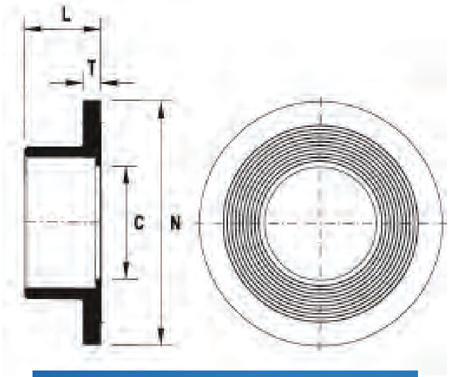
Flanges are used to bolt PVC pipes to pumps and valves etc. Flanged disconnectable fittings provide capability for maintenance and future changes to the pipeline.

The 50, 80, 100, 150, 195, 200 and 300 sizes are “stub” or short face flanges as opposed to the large full face flanges of other pipe sizes.

Refer to “Cast Iron Fittings” for further details on flanges.

Vinidex recommends the use of a metal backing ring with all flanges of 50 mm nominal size and over. (See Cat 16A.) Large washers should be used with bolts and nuts on smaller flanges. Do not overtighten.

Product Code	Size DN	C	L	N	T
35620	25	29	33.5	114.5	13.5
35630	32	36.8	34.1	121.4	13.5
35640	40	41.2	40.1	133.6	13.5
35651	50	54.5			
35660†	65	66.3	67.1	169.1	14
35671	80	81.5			
35681	100	103.8			
35690	125	128	100	253	19.4
35701	150	146			
35730*	200	209	125	272	31.5
35735*	225				
35738*	250				
35740*	300	297	180.5	380	40

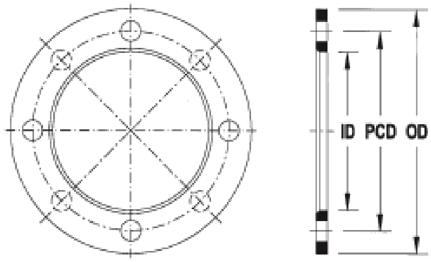


† PN 12 fitting
*This product is an imported stub flange, not to AS1477 so dimensions may vary at times. Designated PN 9.

CAT 16A Metal Backing Ring for Flanges

This galvanised mild steel backing ring has the effect of transferring the load from the flange attachment bolts to the total face of the flange. Flange backing rings conform to the drilling pattern of AS 2129 - Table E (Flanges for Pipes, Valves and Fittings) unless otherwise specified.

Product Code	Size DN	ID	OD	T	PCD	Hole Dia	No of Holes
83500	50	80	150	8	114	18	4
83510	65	100	166	10	126	18	4
83520	80	109	185	10	146	18	4
83530	100	140	215	10	178	18	8
83540	125	170	255	12	210	18	8
83550	150	203	280	12	235	22	8
83560	200	252	335	12	292	22	8
83590	300	360	455	12	406	26	12



CAT 16B Flange Gasket

A flange gasket is a sealing gasket located between the PVC flange and its mount. It is manufactured in elastomeric and is 3.2 mm thick. Any specific requirement should be stated when ordering.

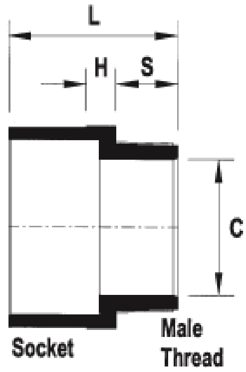
Product Code	Size DN	ID	OD	Hole Size	No of Holes
83620	50	60.3	150	18	4
83640	80	88.9	185	18	4
83650	100	114.3	215	18	4
83780	125	139.7	255	18	8
83670	150	168.3	280	22	8
83680	200	215	335	22	8
83830	300	302	455	26	12

Product Data

CAT 17 Valve Sockets

The valve socket is solvent cement jointed to a pipe spigot. The male-threaded end of the valve socket provides a connection for a PVC, brass or galvanised wrought iron threaded valve-type fitting.

Note: Care should be taken not to overtighten. Refer to our Installation Guidelines for procedures.



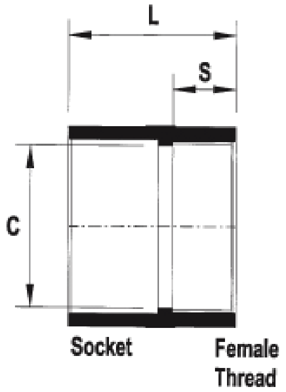
Product Code	Size DN	C	H	L	S
35760	15	14.5	6.6	48	16
35770	20	19	6.8	46.7	19.6
35790	25	24.2	8	58.5	22.1
35800	32	31.5	8	60.5	24.7
35810	40	36.5	8.9	56	24.5
35820	50	46.3	8.6	74.5	29
35830	65	62.5	10	92.5	28.5
35840	80	69.5	19.7	94.5	34.5
35850	100	90	20	112.5	41

CAT 18 Faucet Sockets

The faucet socket is solvent cement jointed to a pipe spigot. The female-threaded end of the faucet socket provides a connection for a faucet tap fitting or a spray nozzle.

Note: Care should be taken not to overtighten. Refer to our Installation Guidelines for procedures.

Product Code	Size DN	C	L	S
35870	15	17	47	15.7
35880	20	22	50.2	18.5
35890	25	28.2	56.2	21.5
35900	25x15	17	50	15.7
35910	32	34.3	62.6	26.3
35920	40	39.2	69	29.2
35930	50	49.3	72.3	29.2
35950	80	82.8	95	35
35960	100	107.5	112.5	41.5

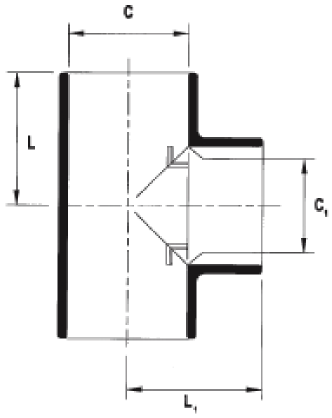


Vinidex Systems & Solutions

CAT 19 Tees

Tees provide a branch at 90° from a main line. Available in equal or reducing branches. See also tapping saddles.

Product Code	Size DN	C	C1	L	L1
35980	15x15	15.5	15.5	43.2	43
35990	20x15	20.4	15.5	42.9	42.7
36000	20x20	20.4	20.4	42.9	42.7
36010	25x15	26.7	15.6	46.2	46
36020	25x20	26.7	20.7	46.2	45.8
36030	25x25	26.7	26.7	46.2	46.1
36040	32x15	33.4	17	52.9	44.7
36050	32x20	41.5	20	48	45.8
36060	32x25	41.5	25	48	45.8
36070	32x32	41.5	41.5	52	52
36080	40x15	38.6	16.8	58.9	49.5
36090	40x20	47.5	20	50.9	49
36100	40x25	47.5	25	50.9	49
36110	40x32	38.6	33.5	58.9	59
36120	40x40	47.5	47.5	58	58
36130	50x15	48.3	16.8	74.2	54.4
36140	50x20	59.5	20	57	55.1
36150	50x25	59.5	25	57	55.1
36160	50x32	48.3	33.7	74.2	69.4
36170	50x40	48.3	39.3	74.2	72.5
36180	50x50	59.5	59.5	70	70
36200†	65x65	67.5	67.5	92.25	92
36210	80x25	78.5	29.8	98.2	79.6
36220	80x32	78.5	38.7	98.2	83
36230	80x40	78.5	38.8	98.2	86.6
36240	80x50	78.5	54	98.2	89.5
36250	80x80	78.5	78.5	98.2	98.6
36260	100x25	106	27	95	100.5
36270	100x50	106	55	95	100.5
36280	100x80	106	87	111	127
36290	100x100	107.3	107.3	131	129
36330†	150x100	143	101.5	158	153
36340†	150x150	143	143	172	172
36350*	155x155	167.8	167.8	175.5	175.5
30393*	200x200	220	220	233	233



† PN 12 fitting (°) Fabricated from other moulded fittings; *Not to AS 1477 PN 18

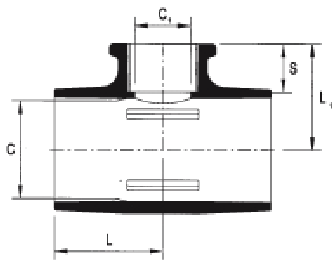
Product Data

CAT 21 Faucet Tees

Faucet tees are used mainly in irrigation pipelines. The female thread in the tee branch provides a connection for a threaded riser pipe.

Note: Care should be taken not to overtighten. Refer to our Installation Guidelines for procedures.

Product Code	Size DN	C	C1	L	L1	S
36390	15x15	15.5	15.5	43.2	43	17.1
36400	20x15	20.5	15.5	43	42.4	17.1
36410	20x20	20.5	20.5	43	42.4	20
36420	25x15	26.8	15.5	46.2	46.2	17.3
36430	25x20	26.8	20.5	46.2	46.2	19.7
36440	25x25	26.8	26.7	46.2	46.2	23.6
36450	32x15	33	15.5	52.5	35	16
36460	32x20	41.7	20	48	45.8	19.7
36470	32x25	41.7	26	48	45.8	22.8
36480	40x15	38	15.5	58.5	37.5	16
36490	40x20	47.7	20	50.9	49	19.7
36500	40x25	47.7	26	50.9	49	22.8
36510	50x15	48	15.5	74	47	16
36520	50x20	59.7	20	57	55.1	19.7
36530	50x25	59.7	26	57	55.1	22.8

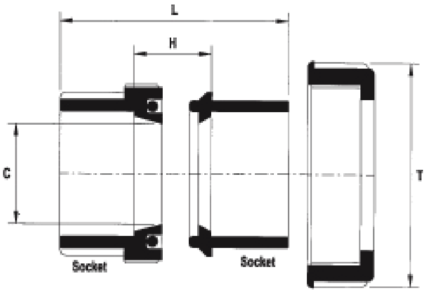


CAT 22 Unions

Unions are used to join together two sections of PVC pipe. In industrial applications they are used as an alternative to a flange in situations where future inspection of lines is anticipated. Easily assembled and disassembled, they can be used in pipeline repair situations.

Note: This fitting is not intended to provide for angular misalignment. Do not overtighten.

Product Code	Size DN	C	T	(Assembled) H	L
36550	15	17.3	55.9	25.8	68
36560	20	21.6	63	18.2	68
36570	25	27	70.2	18.1	75
36580	32	33.8	82.6	18.5	81.5
36590	40	40	96.5	22	91.5
36600	50	48.8	111.1	22.2	97.5

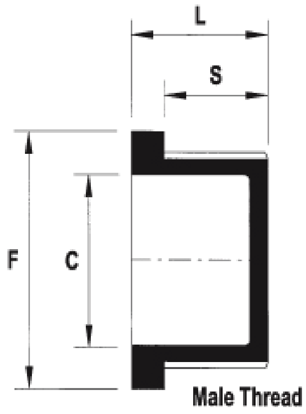


CAT 23 Threaded Plugs

Threaded plugs are used as blank-offs for female threaded fittings.

Note: Care should be taken not to overtighten. Refer to our Installation Guidelines for procedures.

Product Code	Size DN	C	F	L	S
36620	15	14.6	27	25	18
36630	20	17.8	32	26	19.1
36640	25	24.1	39.6	30	22.2
36650	32	31.8	50	32.4	24.4
36660	40	35.5	55.5	37.2	28.5
36670	50	45.5	70	37.7	28.5
36680	80	70	105	53.5	33.5
36690	100	Solid	134	68.5	43

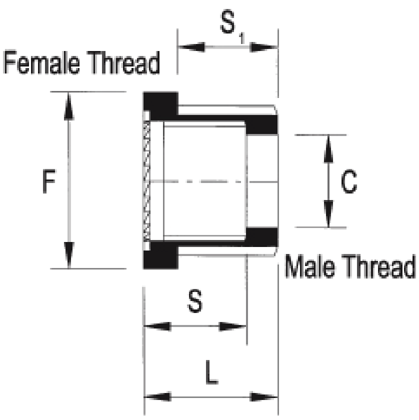


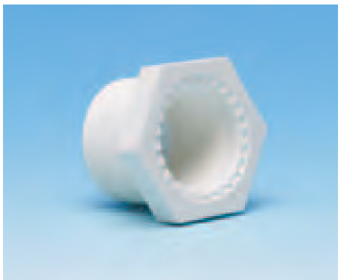
CAT 24 Threaded Bush

Threaded reducing bushes are used mostly in irrigation applications to reduce the size of faucet elbows, faucet tees and faucet sockets so that they can receive smaller sized faucet fittings.

Note: Care should be taken not to overtighten. Refer to our Installation Guidelines for procedures.

Product Code	Size DN	C	F	L	S	S1
36720	25x20	20.2	39.2	30.1	20	22.2



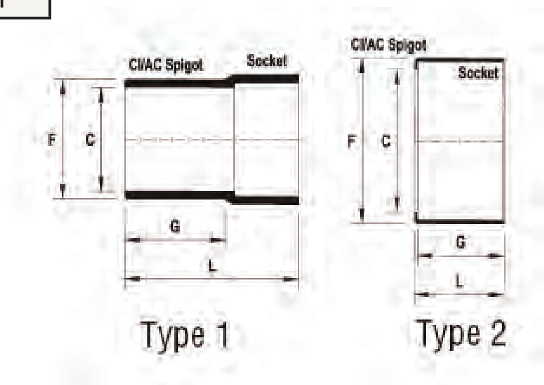


Product Data

CAT 28 Asbestos Cement and Cast Iron Adaptors*

These fittings are used to adapt PVC pipe spigots to asbestos cement, cast iron or ductile iron pipe sockets. The socket end is solvent cement jointed to the pipe spigots.

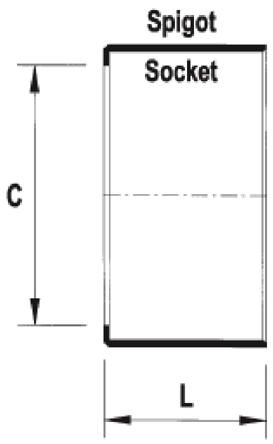
Product Code	Size DN	C	G	L	F	Type
36790	100	105.4	101.6	181	121	2
36800	150	151	87	97	176.7	1
36810	155	151	85	97	176.7	1



CAT 29 Reducing Sleeve

A reducing sleeve is used to adapt 155 fittings to a 150 line. This should be done by solvent cement jointing the sleeve to the 150 pipe spigot first.

Product Code	Size DN	C	L
36830	155x150	145.7	90

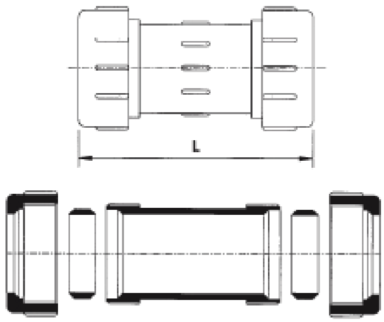


Quick Repair PVC Compression Coupling

This fitting is a “wet” or quick repair joint for small bore pressure lines. It is also used in demountable installations in laboratories, workshops and chemical processing plants. The advantage of this fitting is that pressure can be restored to the system immediately after installation. The compression coupling is slipped along the pipe to the desired position and the nuts are then tightened. Lubricant should be used on the pipe.

Note: Care must be taken not to overtighten. This fitting is rated Class 12.

Product Code	Size DN	Dimension L (sealed)
36850	15	85
36860	20	92
36870	25	108
36880	32	117
36890	40	122
36900	50	135
36910	80	215
36920	100	240



Sluice and Gate Valves and Accessories

Sluice Valves Resilient Seated, Flange - Flange PN 16

Product Code	DN	W (kg)
81452	80	27
81600	225	15
81635	250	145
81710	300	367
78872	375	
78873	450	
81467	80	27
81601	225	90
81559	225	85
81675	250	125
81560	250	145
81711	300	168
81561	300	192
81727	375	
81726	375	25
78874	450	750

NOTE: Manufactured to AS2638.2

Sluice Valves Resilient Seated, Socket - Socket PN 16

Product Code	DN	W (kg)
81450	80	
81651	225	10
81666	250	263
81685	300	3
78875	375	1
78876	450	240
80951	80	31
81592	225	85
81556	225	85
81667	250	145
81557	250	145
81700	300	192
81558	300	192
81725	375	25
78877	450	

Sluice Valves Resilient Seated, Spigot - Spigot PN 16

Product Code	DN	W (kg)
81504	100	25
81544	150	55
81506	100	41
81547	150	

NOTE: Manufactured to AS2638.2