Corrosion Resins
Chemical Resistance Guide
EMEA - Norm UN 13121

Introduction to the use of this Corrosion Guide

ASTM C 581 has been developed to assist in determining if there is deterioration of a thermoset resin when a laminate is immersed in a corrosive medium. Long-term exposure and experience supports the data that has been obtained from laboratory tests carried out in accordance with ASTM C581 or EN 13121-2.

Factors such as laminate thickness, thermal conductivity, structural design performance and the effect of condensation must be taken into account when designing composite products for anticorrosion application. Effectiveness of the laminate in a given corrosion environment depends also on other factors like but not only its manufacturing, post curing and transport of the GRP.

Consistent with resin industry practices, the following advice does not represent any form of warranty for the use of GRP laminates based on its resins. Polynt recommend to follow existing official norms for the design of the GRP equipment so as more in general the good manufacturing practice and the proper post-curing as indicated also by the International standards.

Forecast of service life of the GRP equipment falls under manufacturer and final user responsibilities and POLYNT advice cannot be interpreted as a warranty in any form. All products are intended for sale to knowledgeable industrial and commercial customers. Customers are required to inspect and test products before use and satisfy themselves as to the suitability for their specific end-use. POLYNT products will meet their standard written specifications reported in the Technical Data Sheet, nothing contained in these guidelines shall constitute any other warranty, expressed or implied, including any warranty of merchantability or fitness for a particular purpose, nor any protection from any law or patent to be inferred. All patent rights are reserved. The exclusive remedy for all proven claims is limited to replacement of our materials and in no event shall POLYNT be liable for any incidental or consequential damages.

This document overrules all its previous issues. POLYNT will continue this practice with updates and corrections of this document based on new findings or tests. It is then responsibility of the reader to be sure to hold the latest version.

Composite in Anticorrosion Application

Fiber Reinforced Plastics (FRP) based on corrosion resistant resins have been proven to be a very cost-effective and durable solution for a vast variety of acidic, alkaline, oxidizing and solvent environments. In addition to excellent corrosion resistance and cost-effectiveness, FRP offers many other advantages over competing materials including lightweight, suitability over a wide temperature range both sub-zero and high temperature, low thermal conductivity and good electrical properties. Composite material systems also exhibit high design freedom relating to shape, size, weight and manufacturing process to provide technical solutions for proven long-term performance. Easy maintenance is another benefit of FRP in the corrosion sector.

Corrosion Processes – Multiple Challenges

Industry indicates generally as corrosion what it is in reality a wide range of different possible processes and environments which may singularly or even together affect the composite performances.

It is essential for designers to make the correct material selection based on the required service life while developing structural parts exposed to industrial environments. In order to prevent that, as in metal, composites corrosion effects might occur, FRP can be and have been designed to cope with a vast variety of chemical environments where metals cannot be used or would be less cost-effective.

Uniform corrosion: Some chemical environments can chemically attack the resin. Examples are chlorine, chlorine dioxide, highly concentrated nitric acid or sulfuric acid. The attack normally is limited to the surface and within the recommended temperature and concentration range reasonable/good service life can be obtained.

Diffusion and swelling: Small molecules may diffuse into FRP including water, solvents or certain acids

such as hydrochloric acid. Solvent like chemicals may also cause polymer swelling.

Surface cracking: When exposed to temperature and chemical/moisture fluctuations surface cracks or crazing may occur. Examples are e.g. flue gas stacks or reactor type of equipment.

Stress-corrosion cracking: Stress corrosion cracking refers to a corrosion process of the glass fibre when simultaneously exposed to acid (e.g. by diffusion) and stress, and can result in dramatic failure if acid-sensitive glass has been used.

Blistering: Blisters may form in the laminate in aqueous and also acid environments through diffusion and osmotic processes.

Abrasion/erosion: Slurries or process streams containing particles may, in combination with uniform corrosion, cause abrasion or erosion leading to a reduction of the wall thickness of the laminate.

By choosing the appropriate resin chemistry and laminate build-up, the target mechanical performance can be achieved and the above outlined corrosion effects can be successfully prevented or forecasted and mitigated throughout the part service life.

Corrosion Test Methods

Polynt performs corrosion tests according to ASTM C 581 “Determining chemical resistance of thermosetting resins used in glass fiber reinforced structures intended for liquid service”, ISO 175 “Plastics, Methods of test for the determination of the effects of immersion in liquid chemicals” and EN 13121 “GRP tanks and vessels for use above ground”. Fully cured laminates with specific laminate build-up are immersed in the corrosive medium and evaluated for mechanical and other properties.

The international standard EN 13121 is one of the most important standards providing a truly comprehensive description of tanks and vessels manufacturing. EN 13121 describes the use of a corrosion barrier laminate of certain thickness, i.e. a laminate layer protecting the structural laminate from corrosion attack. In addition to the choice of resin, the type of glass, the type of surface veil, the curing system, the thickness of the corrosion barrier or e.g. fillers can be adapted for optimum performance. EN 13121 specifies acceptance criteria to let a resin or a laminate be considered either resistant or suitable for the specific intended use. EN-13121 also describes how partial design factors, used to consider the effect of chemicals on the laminate in the design, can be obtained either from corrosion testing or on long-term experience.

EN 13121 consists of four main parts:

- Part 1: Raw materials - Specification and acceptance conditions.
- Part 2: Composites material - Chemical resistance.
- Part 3: Design and workmanship.
- Part 4: Delivery, installation and maintenance.

Part 1 specifies requirements for all raw materials used to manufacture tanks or vessels: resins, additives, reinforcing materials, curing agents and thermoplastic linings. In particular polyester and vinyl ester resins are classified based upon eight categories according to their composition, mechanical and thermal properties.

Part 2 provides the requisites for the chemical barrier and structural laminate in terms of type of resins and reinforcing materials according to temperature and chemical environment. Furthermore, it describes the determination of partial design factor A2, which is necessary for the design of tanks or vessels as described in the Part 3. The partial design factor A2 can be determined according to the following criteria: use of Media List present in Part 2, data from resin or thermoplastic manufacturers, service experience or sample testing. Polynt has analyzed its product portfolio according to the norm EN 13121. The mechanical and thermal properties of the resins included in this Guide meet the specific requirements of EN 13121 Part 1, therefore the partial design factor A2 can be determined by using the Media List.

Product Summary Table

Resin name	Resin type	HDT (°C)	Tensile Strength (MPa)	Elongation at Break (%)	Flexural Strength (MPa)	Category according to EN 13121-1
DISTITRON® 1629	Isopthalic	105	75	2.3	135	2B
DISTITRON® 183	Isopthalic	95	70	4.0	130	2B
NORSODYNE® H 44173	Isopthalic	95	70	2.6	140	2B
DISTITRON® 155 F	Isophthalic -neopentylic	94	80	3.6	135	4
NORSODYNE® R 55082	Isophthalic -neopentylic	100	70	3.6	130	4
EPOVIA® OPTIMUM KRF 1001	Vinyl ester	101	76	5.0	135	7A
DISTITRON® VE 100	Vinyl ester	104	85	6.6	145	7A
NORSODYNE® 46900	Isopthalic	105	75	2.3	135	2B

Pursuant to current EN 13121 norm, Polynt advices the maximum temperatures reported in this brochure, which anyway do not represent any form of warranty for the use of GRP laminates based on those resins.

Polynt Corrosion Technologies

Isophthalic resin

DISTITRON® 1629, DISTITRON® 183, NORSODYNE® H 44173, and NORSODYNE® 46900 are reactive isophthalic resins showing good mechanical and thermal properties, and providing good chemical resistance to a wide range of medium aggressive chemical substances. A key feature is the high crosslink density, which yields good heat distortion and chemical resistance properties. These resins are specially developed for production of tanks and pipes, by hand lay-up and filament winding processes.

Isophthalic neopentylic resin

DISTITRON® 155 F and NORSODYNE® R 55082 are isophthalic-neopentylic resins showing a very good hydrolytic stability and resistance to a wide range of acidic chemicals. These resins series could be used in marine and swimming pool applications due to their low water absorption. NORSODYNE® R 55082 is specially developed for hand lay-up and spray up technology.

Bisphenol A vinyl ester resin

Polynt bisphenol epoxy based Vinyl Ester chemistry offers the most versatile resins in the product range. It provides excellent chemical resistance in a wide variety of acidic and alkaline environments together with high mechanical properties. Very good toughness and fast wetting properties enable these Vinyl Ester resins to be used to produce laminates with high impact and fatigue resistance. DISTITRON® VE 100 series and EPOVIA® OPTIMUM KRF 1001 are ideal for hand lay-up and filament winding processes and for applications requiring good resistance to corrosive environments and thermal cycling. Due to their very low water absorption and good water ageing properties, these resins series are also an optimum choice to be used in a skin laminate in marine and swimming pool applications.

Influence of Manufacturing Process on Laminate Performance

It is know that the best laminate performance requires that it is well manufactured and properly cured because both mechanical and chemical resistance properties are directly related to the degree of cure of the resin. Post-curing is in general recommended to enhance the performance of a composite product in corrosive environments. When post-curing at elevated temperature is required that the composite structure is gradually heated to avoid the sudden build-up of stresses. On the other hand, practical reasons may prevent large composite structures from post-curing before being brought into service. Since post-cure

starts fast when the laminate is exposed to elevated temperature, a post-cure in service can be considered in some applications.

How we can help You

Polynt offers on a global base a wide range of corrosion resistant resins under the brand DION® and the competence for tailor-making these resins to satisfy specific needs.
Our resins are used in anticorrosion applications in many industrial segments including chemical industry, mining or flue gas cleaning, where process conditions can cause extremely corrosive environments for traditional construction materials such as metals, steel or concrete. A deep knowledge of corrosion processes, polymer chemistries and application process is a must to choose the best solution for your corrosion challenge. Our Research & Development and Technical Support Teams can help you to identify the best possible resin for your specific need and to advise the most appropriate laminate design for optimum service reliability and service life. You can contact us on corrosion@polynt.com.

EMEA Corrosion Resins - Maximum Temperature °C				
Chemical Environment	*Conc. %*	*DISTITRON® 1629, DISTITRON® 183, NORSODYNE® H 44173,* NORSODYNE® 46900	*DISTITRON® 155 F, NORSODYNE® R 55082*	*DISTITRON® VE 100, EPOVIA® OPTIMUM KRF 1001*
Acetic acid	≤10	40	60	60
	≤50	30	40	60
Adipic acid, aq	all	40	60	80
Aluminium sulphate	all	40	60	60
Ammonium bromate, aq	all	40	80	100
Ammonium bromide, aq	all	40	80	100
Ammonium chloride, aq	all	40	80	100
Ammonium hydroxide, aq, pH>10[1)]	≤5	NR	30	60
	>5, ≤25	NR	NR	60
Ammonium nitrate, aq	all	40	80	100
Ammonium phosphate, aq	all	40	80	100
Ammonium sulphate, aq	all	40	80	100
Barium chloride, aq	all	40	80	100
Barium nitrate, aq	all	40	80	100
Beet syrup (3≤pH≤8)	100	40	80	100
Alcohols (2 to 10 C atoms), aq	≤20	40	60	80
Benzoic acid, aq	all	40	60	80
Boric acid, aq	all	40	60	80
Brine, aq, saturated	all	40	80	100
Butanediol 1,2	all	40	60	80
Butanediol 1,3	all	40	60	80

Chemical Environment	*Conc. %*	*DISTITRON® 1629, DISTITRON® 183, NORSODYNE® H 44173,* NORSODYNE® 46900	*DISTITRON® 155 F, NORSODYNE® R 55082*	*DISTITRON® VE 100, EPOVIA® OPTIMUM KRF 1001*
Butanediol 1,4	all	40	60	80
Calcium chloride, aq	all	40	80	100
Calcium hydroxyde, aq, pH>10[1)]	≤10	NR	30	60
	>10	NR	40	60
Calcium hypochlorite, aq, pH≥12[1)]	≤17 active chlorine	NR	30	60
Calcium nitrate, aq	all	40	80	100
Calcium sulphate, aq	all	40	80	100
Caprolactam, aq	≤50	NR	40	40
Castor oil	100	40	80	100
Chlorinated lime, aq[1)]	all	NR	NR	60
Chromic acid	≤10	30	40	60
Citric acid, aq	≤50	40	60	80
Cobalt chloride, aq	all	40	80	100
Cobalt nitrate, aq	all	40	80	100
Copper (I) choloride, aq	all	40	80	100
Copper (I) sulphate, aq	all	40	80	100
Copper (II) choloride, aq	all	40	80	100
Copper (II) nitrate, aq	all	40	80	100
Copper (II) sulphate, aq	all	40	80	100
Cotton seed oil	100	40	80	100
Cyclohexanol	100	40	40	40
Cyclohexanone	100	NR	30	30
Decanes	100	40	60	80
Decenes	100	40	60	80
Diesel oil (EN590) no aromatics, no methanol	100	40	80	100
Diethylene glycol	all	40	60	80
Dipropylene glycol	all	40	60	80
Ethanol, aq	≤20	40	60	80
	>20, ≤96	30	30	40
Ethylene glycol	all	40	60	80
Fatty acid (> 12 C atoms)	100	40	80	100
Ferric chloride	all	40	60	60

Chemical Environment	Conc. %	DISTITRON® 1629, DISTITRON® 183, NORSODYNE® H 44173, NORSODYNE® 46900	DISTITRON® 155 F, NORSODYNE® R 55082	DISTITRON® VE 100, EPOVIA® OPTIMUM KRF 1001
Ferric sulphate	all	40	60	60
Ferrous chloride	all	40	60	60
Ferrous sulphate	all	40	60	60
Formic acid	≤10	30	60	60
Fructose	100	40	80	100
Fruit syrups (3≤pH≤8)	100	40	80	100
Fuel oil (EN590) no aromatics, no methanol	100	40	80	100
Galactose	100	40	80	100
Glucose	100	40	80	100
Glycerin	all	40	60	80
Grease	100	40	80	100
Heptanes	100	40	60	80
Heptenes	100	40	60	80
Hexanes	100	40	60	80
Hexenes	100	40	60	80
Hydrazine hydrate, aq[1)]	≤16	NR	NR	30
Hydrochloric acid	≤18	NR	30	60
	>18, ≤37	NR	30	40
Hydrogen peroxide	≤30	NR	30	60
Isobutanol, aq	≤20	40	60	80
Isodecanol, aq	≤20	40	60	80
Isopropanol, aq	≤20	40	60	80
Lactic acid, aq	≤10	40	60	80
Magnesium chloride, aq	all	40	80	100
Magnesium nitrate, aq	all	40	80	100
Magnesium sulphate, aq	all	40	80	100
Manganese (II) chloride, aq	all	40	80	100
Manganese (II) nitrate, aq	all	40	80	100
Manganese (II) sulphate, aq	all	40	80	100
Mannitol	100	40	80	100
Mannose	100	40	80	100
Mercuric (I) chloride	100	40	80	100

Chemical Environment	Conc. %	DISTITRON® 1629, DISTITRON® 183, NORSODYNE® H 44173, NORSODYNE® 46900	DISTITRON® 155 F, NORSODYNE® R 55082	DISTITRON® VE 100, EPOVIA® OPTIMUM KRF 1001
Mercuric (II) chloride	100	40	80	100
Mercuric (II) nitrate	100	40	80	100
Mercury	100	40	80	100
Molasses (3≤pH≤8)	100	40	80	100
N,N-Diethyl aniline	100	NR	NR	NR
N,N-Dimethyl aniline	100	NR	NR	NR
Neopentyl glycole	all	40	60	80
Nickel chloride, aq	all	40	80	100
Nickel nitrate, aq	all	40	80	100
Nickel sulphate, aq	all	40	80	100
Nitric acid	≤30	NR	30	40
Nonanes	100	40	60	80
Nonenes	100	40	60	80
Octanes	100	40	60	80
Octenes	100	40	60	80
Oleic acid	100	40	80	100
Oxalic acid[1)]	≤10	30	60	60
Palmitic acid	100	40	80	100
Paraffin wax	100	40	80	100
Pentanes	100	40	60	80
Pentenes	100	40	60	80
Perchloric acid	≤20	NR	30	30
Phosphoric acid, aq	≤80	40	60	80
Phthalates / Phthalic ester	100	40	60	80
Phthalic acid(s)	all	40	60	80
Potassium alluminum sulphate, aq	all	40	80	100
Potassium bromate, aq	all	40	80	100
Potassium bromide, aq	all	40	80	100
Potassium chlorate, aq	all	40	80	100
Potassium chloride, aq	all	40	80	100
Potassium chromate, aq	all	40	80	100
Potassium ferric cyanide, aq	all	40	80	100
Potassium ferrous cyanide, aq	all	40	80	100

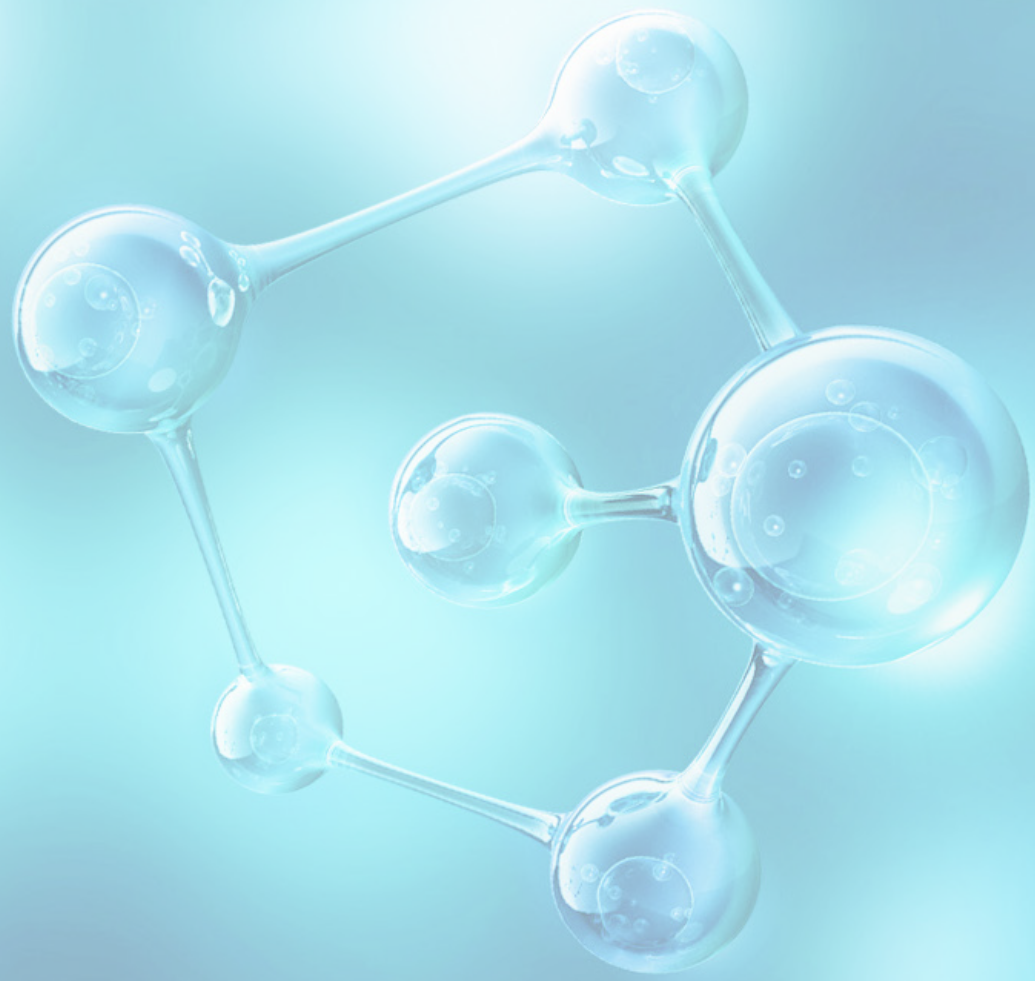
Chemical Environment	Conc. %	DISTITRON® 1629, DISTITRON® 183, NORSODYNE® H 44173, NORSODYNE® 46900	DISTITRON® 155 F, NORSODYNE® R 55082	DISTITRON® VE 100, EPOVIA® OPTIMUM KRF 1001
Potassium fluoride, aq[1)]	all	40	60	80
Potassium hydroxide, aq, pH>10[1)]	≤1	NR	30	60
	>1, ≤20	NR	NR	60
	>20, <50	NR	NR	60
Potassium iodide, aq	all	40	80	100
Potassium nitrate, aq	all	40	80	100
Potassium nitrite, aq	all	40	80	100
Potassium permanganate	≤50	30	40	60
Potassium phosphate, aq	all	40	80	100
Potassium sulphate, aq	all	40	80	100
Propanol, aq	≤20	40	60	80
Propylene glycole 1,2	all	40	60	80
Raspberry syrup (3≤pH≤8)	100	40	80	100
Seawater (3≤pH≤8)	100	40	80	100
Silicon oil	100	40	80	100
Sodium acetate, aq	all	40	60	80
Sodium aluminate, aq, pH>10[1)]	all	NR	NR	40
Sodium bicarbonate, aq	all	40	60	80
Sodium bromate, aq	all	40	80	100
Sodium bromide, aq	all	40	80	100
Sodium chlorate, aq	all	40	80	100
Sodium chloride, aq	all	40	80	100
Sodium fluoride, aq[1)]	all	40	60	80
Sodium hydroxide, aq, pH>10[1)]	≤1	NR	30	60
	≤20	NR	NR	60
	≤50	NR	NR	60
Sodium hypochlorite, aq, pH≥12[1)]	≤16 active chlorine	NR	30	60
Sodium nitrate, aq	all	40	80	100
Sodium phosphate, aq	all	40	80	100
Sodium sulfite, aq	all	40	80	100
Sodium sulphate, aq	all	40	80	100

Chemical Environment	Conc. %	DISTITRON® 1629, DISTITRON® 183, NORSODYNE® H 44173, NORSODYNE® 46900	DISTITRON® 155 F, NORSODYNE® R 55082	DISTITRON® VE 100, EPOVIA® OPTIMUM KRF 1001
Sodium tetraborate (Borax), aq	all	40	60	80
Sodium thiosulphate, aq	all	40	80	100
Sorbitol	100	40	80	100
Soya oil	100	40	80	100
Starch syrup (3≤pH≤8)	100	40	80	100
Starch, aq (5≤pH≤8)	all	40	80	100
Stearic acid	100	40	80	100
Succinic acid, aq	all	40	60	80
Sulphuric acid	≤50	30	60	60
	>50, ≤60	NR	40	60
Surfactant, Alkyl amino poly-glycolether[1)]	3≤pH≤8	40	60	60
	8<pH≤9	NR	60	60
	pH>9	NR	30	60
Surfactant, Alkyl aryl ammonium salts (Na, K)[1)]	3≤pH≤8	40	60	60
	8<pH≤9	NR	60	60
	pH>9	NR	30	60
Surfactant, Alkyl aryl sulfonates[1)]	3≤pH≤8	40	60	60
	8<pH≤9	NR	60	60
	pH>9	NR	30	60
Surfactant, Alkyl Naphthol polyglycolether[1)]	3≤pH≤8	40	60	60
	8<pH≤9	NR	60	60
	pH>9	NR	30	60
Surfactant, Alkyl phenol polyglycolether[1)]	3≤pH≤8	40	60	60
	8<pH≤9	NR	60	60
	pH>9	NR	30	60
Surfactant, Alkyl phenol polyglycolether(sulphates)[1)]	3≤pH≤8	40	60	60
	8<pH≤9	NR	60	60
	pH>9	NR	30	60
Surfactant, Alkyl-/Aryl phosphates[1)]	3≤pH≤8	40	60	60
	8<pH≤9	NR	60	60
	pH>9	NR	30	60

Chemical Environment	Conc. %	DISTITRON® 1629, DISTITRON® 183, NORSODYNE® H 44173, NORSODYNE® 46900	DISTITRON® 155 F, NORSODYNE® R 55082	DISTITRON® VE 100, EPOVIA® OPTIMUM KRF 1001
Surfactant, Alkylol ether phosphates1)	3≤pH≤8	40	60	60
	8<pH≤9	NR	60	60
	pH>9	NR	30	60
Surfactant, Alkylol ether sulphates[1)]	3≤pH≤8	40	60	60
	8<pH≤9	NR	60	60
	pH>9	NR	30	60
Surfactant, Amides of fatty acids[1)]	3≤pH≤8	40	60	60
	8<pH≤9	NR	60	60
	pH>9	NR	30	60
Surfactant, EDTA salts (Na, K)[1)]	3≤pH≤8	40	60	60
	8<pH≤9	NR	60	60
	pH>9	NR	30	60
Surfactant, Ethylene diamine polyglycolether1)	3≤pH≤8	40	60	60
	8<pH≤9	NR	60	60
	pH>9	NR	30	60
Surfactant, NTA (Nitrilo Triacetic Acid) salts (Na, K)[1)]	3≤pH≤8	40	60	60
	8<pH≤9	NR	60	60
	pH>9	NR	30	60
Tartaric acid, aq	all	40	60	80
Toluene sulphonic acid	≤50	NR	40	60
Triethylene glycol	all	40	60	80
Tripropylene glycole	all	40	60	80
Urea, aq (5≤pH≤8)	all	40	60	80
Water, not deionised or distilled	100	40	60	80
Wheat germ oil	100	40	80	100

Note 1): Synthetic or carbon veils/nonwovens shall be used

For further information please contact us



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