Technical Information

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Resistance of Ultramid®, Ultraform® and Ultradur® to chemicals

1 General information

The information given in this publication is based on our current knowledge and experience. In view of the many factors that may affect processing and application, these data do not relieve processors of the responsibility of carrying out their own tests and experiments; neither do they imply any legally binding assurance of certain properties or of suitability for a specific purpose.

The information given relates to unreinforced, unmodified base grades (eg, Ultramid A3K and B3S, Ultraform N 2320, Ultradur B 4250). Reinforced and impact-modified grades may behave slightly differently. For example, glass-fibre reinforced Ultraform is less resistant to hot water than unmodified grades, or impact-modified Ultra products may be more prone to swelling in polar solvents, fuels and oils than unmodified ones.

If you cannot find the information you require here, please contact our Technical Centre.

2 Column headings

wt. %: Figures under this heading refer to the concentration in wt.% of (unless otherwise stated) an aqueous solution of the substance; **SS** refers to a saturated solution of the substance; a blank means the information given relates to the pure substance.

°C: The temperature at which the given data is valid. RT means "room temperature" which is taken to be between 15°C and 35°C.

Notes: Miscellaneous information such as references to other publications, figures, permeability data (diffusion coefficient at 20 °C, D_{20}; permeability at 50°C, P_{50}) is given here. Values are written in scientific notation, eg, 2.5E-9 means 2.5×10^{-9}.

The degree of saturation w_t/w_s of a specimen after a given time can be found from the expression:

$$\frac{w_t}{w_s} = \frac{2.256}{s}\sqrt{Dt}$$

where:

w_t = increase in mass at time t (in s)
w_s = increase in mass at saturation
s = wall thickness in cm
D = diffusion coefficient in cm^2/s
t = time in seconds

The above formula can also be used to determine the diffusion coefficient for a particular chemical substance by measuring the rate of absorption.

BASF

3 Symbols used to describe the chemical resistance

+ : Resistant. Only slight changes to weight, dimensions, properties. According to current knowledge, the medium causes no irreversible damage to the polymer.

○ **:** Limited resistance. Noticeable change in properties. Prolonged exposure to the medium may cause irreversible damage (eg, polymer degradation).

– : Not resistant. Medium attacks polymer and/or causes environmental stress-cracking within a short time. Irreversible damage.

S : Plastic dissolved by the chemical.

Number after the resistance symbol: This number refers to the mass increase after the polymer specimen has been saturated. The values given are only rough values and refer to unreinforced grades. The actual weight change depends on the grade of plastic and its crystallinity. The percentage change in length can be taken as being roughly a quarter of the percentage weight change.

Overview of the chemical resistance of Ultramid, Ultraform and Ultradur

Rating	Ultramid	Ultraform	Ultradur
Very resistant	Aliphatic and aromatic hydrocarbons Alkalis Brake fluids Ethers, esters Greases Ketones Fuels (gasoline, diesel) Paints Lubricants Detergent	Aliphatic and aromatic hydrocarbons Alkalis Alcohols Brake fluids Ethers, esters Greases Ketones Fuels (gasoline, diesel) Paints Detergent Water up to approx.100 °C	Aliphatic and aromatic hydrocarbons Brake fluids Ethers, esters Greases Ketones Fuels (gasoline, diesel) Paints Acids (dilute) Lubricants Detergent Water up to approx. 40 °C
Not resistant	Halogens (fluorine, chlorine, bromine, Iodine) Mineral acids and certain organic acids Oxidants Phenols Zinc chloride solutions	Halogens (fluorine, chlorine, bromine, iodine) Nitrous gases Oxidants Acids Sulfur dioxide Concentrated zinc chloride solutions at elevated temperature	Alkalis Halogens (fluorine, chlorine, bromine, Iodine) Water above approx. 60 °C
Solvent for the resin			
1. Room temperature	Formic acid (> 60 %) Fluorinated solvents m-Cresol Phenol Sulfuric acid (96 %)	Fluorinated solvents (eg, hexafluoroisopropanol)	Fluorinated solvents (eg, hexafluoroisopropanol)
2. Elevated temperature	Benzyl alcohol Glycols Formamide	N-methylpyrrolidone Dimethylformamide	Phenol Dichlorobenzene

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Acetaldehyde soln.	40	RT	○ (12%)	+		
Acetamide soln.	50	RT	○ (7%)	+		[2], [11]
Acetamide soln.	50	> 140	S			
Acetic acid	95	RT	–	–	–	
Acetic acid	10	RT	○	+	+	POM: up to 1000 h no damage
Acetic acid	5	RT	+ (10%)	+	+	PA: D_{25} = 1.4E-8 cm^2/s
Acetone		RT	+ (2%)	+	○	PA: creep strength see fig. 2; P_{20} = 0.01 ($g.mm/m^2h$)
Acetone		60	+	+	–	
Acetophenone		RT	+	+	+	
Acetyl chloride		RT	–	–		
Acetylene		RT	+	+	+	
Acrylic acid		> 30	S	–		[11]
Acrylic acid (soln. in aliphatic hydrocarbons)	3	80	○ (2%)	–		
Air		RT	+	+	+	
Alcohols: see “Methanol”, “Ethanol” etc.						
Aliphatic hydrocarbon blend		RT	+	+	+	
Alkylbenzenes (Shellsol® A)		RT	+	+		
Allyl alcohol		RT	○		+	
Aluminium acetate soln.	SS	RT	+	+	+	
Aluminium hydroxide soln.	SS	RT	+	+	+	
Aluminium salts of mineral acids in soln. (eg, chloride, sulfate, nitrate)	20	RT	○	○	+	PA: may cause stress cracking [6]
Aluminium salts of mineral acids in soln. (eg, chloride, sulfate, nitrate)	SS	50	–	–		
Amines, aliphatic		RT	+ (≤ 8%)	+	+	
Amino acids	SS	RT	+	+	+	
Ammonia soln.		RT	+	+	○	PA 6 (10 bar/50°C): D_{50} = 2E-8 cm^2/s [9]; PA: P_{20} = 1E-10 ($cm^2/s \cdot mbar$)
Ammonia soln.		70	○	+	–	
Ammonia soln.	20	RT	+	+	+	PA: P_{20} = 0.06 ($g \cdot mm/m^2 \cdot h$)
Ammonia soln.	20	60	+	+	–	
Ammonium thiocyanate soln.	SS	RT	+	+		
Ammonium hydrogen carbonate soln.	SS	RT	+	+	+	
Ammonium salts of minerals acids in soln.	10	RT	+	+	+	
Ammonium salts of minerals acids in soln.	10	50	○	○		

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Amyl acetate		RT	+	+	+	
Amyl acetate		100	–		–	
Amyl alcohol		RT	+ (≤ 5%)	+	+	PA: creep strength see fig. 1
Aniline		RT	○	○		
Anodizing baths (30% nitric acid/10% sulfuric acid)		RT	○	–	○	
Anthraquinone		85	○	+		
Antifreeze: see “Coolants”						
Antimony trichloride soln.	SS	RT	–	–		
Aqua regina (HCl/HNO_3)		RT	–	–	–	
Argon		RT	+	+	+	
Aromatic hydrocarbon blend		80	+	+	○	
Asphalt		RT	+	+	+	
Asphalt		> 100	○	○	○	
Bacteria (DIN 53739)		RT	+	+	+	
Baking enamels		150	+	○	+	Baking up to 30 min; particularly suitable for glass-reinforced grades
Barium salts of mineral acids		RT	○	+	+	PA: conc. solns. of barium thiocyanate cause stress cracking [9]
Benzaldehyde		RT	○	+		
Benzene		RT	+	+	+	PA: $P_{20} = 0.5$ (g · 100 µm/m^2 · h)
Benzene		80	+	+	–	
Benzoic acid soln.	20	RT	○	○	+	
Benzoic acid soln.	SS	RT	–	–	+	
Benzyl alcohol		RT	○ (3–30%)	+		
Beverages		RT	+	+	+	See also “Fruit juices”, “Brandy”, “Wine”
Bitumen (DIN 51567)		RT	+	+	+	
Bitumen (DIN 51567)		> 100	○	○	○	
Bleaching agent (aqueous; 12.5% active chlorine)		RT	–	–	○	
Boric acid soln.	10	RT	○	○	+	
Boron trifluoride		RT	–	–	–	
Brake fluids		RT	+ (3–10%)	+	+	
Brake fluids: (DOT 3–5, FMVSS 116)		125	○	+	+	Weight change after 14 days’ immersion at 120 °C: Ultramid A3WG6 +3% POM at 120 °C stable over 2000 h

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Brake fluids: (SAE J 1703; DIN 53521)		150	–	–		
Brake fluids: Hydraulan® (BASF)		60	+	+	+	
Brake fluids: Hydraulan® (BASF)		120	+	+		Weight change after 14 days' immersion: Ultramid A3WG6 + 3%; Ultraform N 2200G53 +6%
Brandy		RT	+ (10%)	+	+	
Bromine vapour		RT	–	–	–	
Bromine water	SS	RT	–	–	–	
Bromochlorodifluoromethane		RT	+	+	+	
Bromotrifluoromethane		RT	+	+	+	
Butadiene		RT	+	+	+	
Butane		RT	+	+	+	PA 66: $P_{20} < 10$ ($cm^3 \cdot 100\ \mu m/m^2 \cdot d \cdot bar$)
Butanediols		RT	+	+	+	
Butanediols		> 140	○	–	–	
Butanols		RT	+ (2–9%)	+	+	PA: P_{20} approx. 2E-12 mol/cm · s; D_{20} = 3E-12 cm^2/s
1-Butene, cis-2-butene, (liquefied gas DIN 51622)		RT	+	+	+	
Butene glycol		RT	+	+	+	
Butene glycol		> 160	○	○	–	
Butter, buttermilk		RT	+	+	+	
Butyl acetate		RT	+	+	○	
Butyl acrylate		RT	+	+	○	
n-Butyl ether		RT	+	+	+	
n-Butyl glycol (glycol monobutyl ether)		RT	+	+	+	
Butyl glycolate		RT	+	+	+	
Butyl phthalate		RT	+	+	+	
Butyric acid soln.	20	RT	○	○	+	
γ-Butyrolactone		RT	+ (2%)	+		[16]
γ-Butyrolactone		>90	○	○		[16]
Calcium chloride soln.	SS	RT	+ (10%)	+	+	
Calcium chloride soln.	SS	60	○			
Calcium chloride soln. (alcoholic)	20	RT	○	+		Dissolves PA
Calcium hydroxide soln. (lime water)	SS	RT	+	+	+	

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Calcium hypochlorite and bleaching powder soln.	SS	RT	–	–	○	
Camphor soln. in alcohol	50	RT	+	+	+	Weight increase owing to alcohol uptake
ε-Caprolactam (aqueous solution)	50	RT	+	+	+	
ε-Caprolactam (aqueous solution)	50	> 150	○			Dissolves PA 6 above 150 °C, PA 66 above 170 °C
ε-Caprolactam (molten)		> 120	○	–	–	[2]
Carbon dioxide		70	+	+	+	PA: P_{20} = 40–60 ($cm^3 \cdot 100\ \mu m/m^2 \cdot d \cdot bar$)
Carbon disulfide		RT	+	+		PA: P_{20} = 0.02 ($g.mm/m^2 \cdot h$)
Carbon disulfide		60	–			
Carbon monoxide		70	+	+	+	
Casein		RT	+	+	+	
Caustic soda soln.: see “Sodium hydroxide soln.”						
Cellulose lacquers		RT	+	+	+	see also “Paint solvents”
Cement		RT	+	+	+	[1], [8]
Ceresin		RT	+	+	+	
Chloral hydrate		RT	–			[11]
Chloramines	< 10	RT	–		–	
Chlorinated biphenyls		80	○			see also “Clophen A 60/petroleum ether”
Chlorine, chlorine water		RT	–	–	–	see also “Bleaching agent”
Chloroacetic acid soln.	10	RT	–	–	–	
Chlorobenzene		20	+	+	+	PA: P_{50} = 1.0 ($g \cdot mm/m^2 \cdot 10^3\ h$)
Chlorobenzene		50	+	+	–	
Chlorobromomethane		RT	○ (3–30%)		+	
Chlorodifluoroethylene		RT	+	+	+	
Chlorodifluoromethane, chlorodifluoroethane		RT	+	+	+	
Chloroform		RT	○ (5–25%)	○	–	PA: P_{20} = 0.1 ($g \cdot mm/m^2 \cdot h$)
Chlorosulfonic acid soln.	<10	RT	–	–	–	
Chlorothene®: see 1,1,1-Trichloroethane						
Chromic acid	10	RT	–	–	○	
Chromic acid	1	RT	○	○	+	
Chromyl chloride		RT	–	–		
Citric acid soln.	10	RT	+ (≤ 10%)	○	+	PA: D_{25} = 1E-8 cm^2/s
Citric acid soln.	10	50	+	–	○	

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Citric acid soln.	20	80	+	–		
Citrus fruit juices		RT	+	+	+	
Citrus oils		RT	+	+	+	
Cleaning agent: all-purpose cleaner		RT	+	+	+	
Cleaning agent: household cleaner (Ajax, ATA, Domestos, Rilan)	10	RT	+	+	+	
Cleaning agent: toilet cleaner (pH < 3)		RT	○	–	+	
Cleaning agent: window cleaner		RT	+	+	+	
Clophen A 60/petroleum ether (1 : 1)		RT	+	+	+	
Cobalt salt solns.	20	RT	○	+		PA: stress cracking possible eg, with $CoCl_2$, $Co(SCN)_2$; [6], [15]
Concrete		RT	+	+	+	PA: [1]
Coolants: Glysantin®/Water 1 : 1		106	○	+	–	PA: see figs. 3 & 4
Copper (II) salt solns.	10		○	+	+	PA: nitrate and chloride cause stress cracking; [6], [10]
Coumarone and coumarone resins		RT	+	+	+	
Cresols		RT	S		S	
Crude oil: see “Petroleum”						
Cutting oils: see Lubricating oils						
Cycloalkanes		RT	+	+	+	
Cyclohexane, cycloheptane		RT	+	+	+	
Cyclohexanol (and esters thereof)		RT	+ (2 – 6%)	+	+	
Cyclohexanone		RT	+	+	+	
Decontaminating agent (MIL-D-50030 F)		RT	+	+	+	= diethylenetriamine/NaOH/ethylene glycol monoethyl ether (70 : 2 : 28)
Dekalin®		RT	+ (1 – 2%)	+	○	
Descaler (based on formic, acetic, citric acids)	10	RT	+	○	+	
Descaler (based on formic, acetic, citric acids)	10	50	○	–	○	
Descaler (based on sodium hydrogen sulfate)	10	RT	+	○	+	
Detergent soln, heavy-duty	< 10	RT	+	+	+	
Detergent soln, heavy-duty	< 10	80	○	+	○	POM: oxidizing detergent may cause corrosion
Developer soln. (Rodinal®, Agfa, pH 11)		RT	+	+	+	
Dibutyl phthalate		RT	+	+	+	
Dibutyl phthalate		60	+	+	○	
p-Dichlorobenzene		RT	+ (2%)		–	

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
1,2-Dichloroethane		RT	+ (2–5%)	+	–	
Dichloroethylene		RT	+	–	–	
Dichlorofluoromethane		RT	+	+	+	
Dichloromethane: see “Methylene chloride”						
Dichlorotetrafluoroethane		RT	+	+	+	
Diesel fuel: see “Fuels”						
Diethyl ether		RT	+ (3%)	+	+	PA: $P_{20} = 0.03$ (g · mm/m^2 · h)
Diethylene glycol		> 140	S		–	See also “Glycol”
Difluoromethane		RT	+	+	+	
Dimethyl ether		RT	+	+	+	
Dimethylacetamide		RT	+	+		PA 6 and POM on prolonged exposure: ○; [11]
Dimethylacetamide		> 150	–			
Dimethylamine		RT	+			
Dimethylformamide		RT	+ (5%)	+	+	
Dimethylformamide		90	○ (15%)			
Dimethylformamide		> 140		S		
Dimethylsilane		RT	+			
Dimethylsulfoxide (DMSO)		RT	+		+	
Dimethylsulfoxide (DMSO)		125	S			
Dioctyl phthalate		RT	+	+	+	
Dioxan		RT	+	+	+	PA: $P_{20} = 0.001$ (g · mm/m^2 · h)
Dioxan		60	+		–	
Diphyl® (biphenyl and diphenyl ether)		80	+	+	–	
Disopropyl ether		RT	+	+	+	PA: $P_{20} = 0.005$ (g · mm/m^2 · h)
Dishwasher detergent soln.	< 10	95	+	○	–	POM: oxidizing detergents may cause corrosion
Disinfectant (alcohol-based)	< 10	RT	+	+	+	[3], [4]
Disinfectant (aldehyde-based)	< 10	RT	+	+	+	[3], [4]
Disinfectant (based on phenols)	< 10	RT	○	○	○	PA is however resistant under normal conditions of use
Disinfectant (based on quaternary ammonium compounds)	< 10	RT	+	+	+	[3], [4]
Disinfectant (based on quaternary phosphonium compounds)	< 10	RT	+	+	+	[3], [4]
Disinfectant (chlorine-based)	< 10	RT	○	–	+	[3], [4]
Disinfection by boiling		100	+	+	○	

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Disinfection by fractional vacuum process			+	+		
Disinfection by gas sterilization: see “Ethylene oxide”						
Disinfection by hot air/steam/hot air			+	+	○	See also “Steam (sterilization over 50 cycles)”
Disinfection by irradiation (25 kGy for 6 h)			+	○	+	PA: slight yellowing
Dispersions, aqueous (BASF Acronal®, Propiofan®)			+	+	+	
Edible fats and oils		100	+	+	+	
Electroplating baths, acidic		RT	–	–	+	see also: “Anodizing baths” and solutions of metal salts
Electroplating baths, alkali (cyanides)		RT	+	+	○	
Engine oils: see “Lubricating oils”						
Epichlorhydrin		RT	○			
Ethane		RT	+	+	+	PA: P_{20} < 10 ($cm^3 \cdot 100\ \mu m/m^2 \cdot d \cdot bar$)
Ethanol		RT	+(15%)	+	+	PA: P_{20} = 0.2 ($g.mm/m^2 \cdot h$)
Ethanol, dilute	40 vol.	RT	+	+	+	
Ethereal oil		RT	+	+	+	
Ethyl acetate		RT	+ (1%)	+	○	PA: P_{20} = 0.008 ($g \cdot mm/m^2 \cdot h$)
Ethyl chloride		RT	+	+		
Ethylene		RT	+	+	+	PA: P_{20} < 10 ($cm^3 \cdot 100\ \mu m/m^2 \cdot d \cdot bar$)
Ethylene carbonate		50	+		–	
Ethylene carbonate		100	–		–	
Ethylene chlorohydrin		RT	○			
Ethylene oxide		RT	+	+	+	PA: P_{20} < 100 ($cm^3 \cdot 100\ \mu m/m^2 \cdot d \cdot bar$)
Ethylene oxide		> 80	–			
Ethylene oxide (gas sterilization)			○	+		PA: 30–70 °C up to 8 h: +
Ethylenediamine		RT	+ (8–15%)			
Exhaust fumes from internal combustion engine		RT	+	+	+	
Fats and waxes, edible fats		RT	+	+	+	see also “Edible fats and oils”
Fatty acids		RT	+	+	+	
Fatty alcohols		RT	+	+	+	
Fatty alcohols, sulfonated		RT	+	+	+	
Fluorinated hydrocarbons, fluorocarbons		70	+	+	+	POM: P_{20} = 50–150 ($cm^3 \cdot 100\ \mu m/m^2 \cdot d \cdot bar$)

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Fluorine		RT	–	–	–	
Formaldehyde		RT	+	+	+	
Formaldehyde solution	30	RT	+ (5–15%)	+	+	
Formamide		RT	+	+		
Formamide		> 150	S			
Formic acid soln.	10	RT	○	○	+	POM: no damage after 1000 h Conc. acid dissolves nylons (50% for PA 6, 80% for PA 66); [2]
Formic acid soln.	10	50	–	–	○	
Fruit juices		RT	+	+	+	
Fuel, engine: Diesel		85	+	+	+	PA: P_{40} = 0.001 ($g \cdot mm/m^2 \cdot h$)
Fuel, engine: FAM test fuel (5% ethanol)		55	+ (9–14%)	+	+	
Fuel, engine: Gasoline (normal & premium grade)		RT	+	+	+	PA: P_{40} = 0.006 ($g \cdot mm/m^2 \cdot h$); POM: see figs. 24–25
Fuel, engine: Gasoline (normal & premium grade)		85	+	+		
Fuel, engine: High-performance fuels (Dekalin®, perhydrofluorene)		85	+	+	○	
Fuel, engine: M15 mixture (15% methanol)		55	+ (9–14%)	+	+	PA: see figs. 8–10; D_{20} = 1E-8 cm^2/s; POM: see figs. 24–25
Fuel, engine: M15 mixture (15% methanol)		70	○	+	○	PA: see figs. 8–10; PBT: see figs. 26–27
Fungi (DIN 53739; ISO 846)			+	+	+	[19]
Furfural		RT	+ (2–7%)	+	+	
Furfuryl alcohol		RT	+	+	+	Solvent for PA 610 above 90 °C
Gas sterilization: see “Ethylene oxide (gas sterilization)”						
Gasoline: see Fuels						
Gear oils (EP, hypoid, ATF, manual transmission)		≤ 110	+	○	+	See also “Lubricating oils”; PA: temperature/time limits see fig. 13
Gelatine		RT	+	+	+	
Glue		RT	+	+	+	
Glycerol		RT	+	+	+	PA: creep strength see fig. 5
Glycerol		170	S	–	–	
Glycolic acid soln.	30	RT	–	–		
Glycols, alkyl glycol ethers		RT	+ (2–10%)	+	+	See also “Brake fluids”, “Coolants”; [11]
Glysantin® (BASF): see “Coolants”						
Grease (based on ester oils, diester oils, phosphoric acid esters, synthethic oils)		≤ 110	○	+	+	[5]

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Grease (based on polyphenylester)		≤ 110	+	+		
Grease (based on silicone oils): see “Silicone oils”						
Grease: antifriction bearing grease DIN 51825 (based on metal soaps)		≤ 110	+	+	+	PA: temp./time limits correspond to fig. 13; Lithium grease may cause increased swelling under some circumstances.
Hair dyes		RT	○ (≤ 11%)	+		
Hardening oils		RT	+	+	+	
Heating oil (DIN 51603)		RT	+	+	+	
Helium		RT	+	+	+	
Heptane		RT	+	+	+	PA: P_{20} = 0.1 (g · mm/m^2 · h)
Hexachloroethane		RT	+	+		
Hexachlorobenzene		80	+ (1%)	+		
Hexafluoroisopropanol		RT	S	S	S	
Hexamethylenetetramine		RT			+	
Hexane		RT	+	+	+	
Humic acids		RT	○	○	+	PA, POM: chemical attack possible under extreme conditions
Hydraulic fluids		100	+	+	+	
Hydraulic oil (DIN 51525)		100	+		+	
Hydraulic oil (MIL-H 5606)		100	+		+	
Hydraulic oil (VDMA 24318)		100	+		+	
Hydrazine		RT		+		
Hydriodic acid, hydrogen iodide soln.		RT	–	–	○	
Hydrobromic acid soln.	10	RT	–	–	○	
Hydrochloric acid	> 20	RT	–	–	○	
Hydrochloric acid	2	RT	–	○	+	PA: figs. 1 & 12; [17]
Hydrofluoric acid	40	RT	–	–	–	
Hydrofluosilicic acid	30	RT	–	–	–	
Hydrogen		RT	+	+	+	PA: P_{20} = 300 – 400 (cm^3 · 100 µm/m^2 · d · bar)
Hydrogen chloride gas		RT	–	–	–	see also “Hydrochloric acid”
Hydrogen fluoride		RT	–	–	–	
Hydrogen peroxide soln.	0.5	RT	+	+	+	
Hydrogen peroxide soln.	30	RT	–	–	+	

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Hydrogen sulfide	< 10	RT	○	○	+	PA & POM: possible damage by sulfuric acid formed by oxidation
Hydrogen sulfide (dry)		RT	+	+	+	PA: P_{20} = 2.4E-12 ($cm^2/s \cdot mbar$)
Hydroquinone soln.	5	RT	–		+	
Hyraulan® (BASF): see “Brake fluids”						
Impregnating oils		RT	+	+	+	
Ink		RT	+	+	+	
Iodine (alcoholic solution)		RT	–	–		
Iron (III) chloride	SS	RT	–			
Iron (III) chloride soln., acidic	10	RT	–	–		
Iron (III) chloride soln., neutral	10	RT	+ (4–10%)		+	
Iron (III) thiocyanate soln.	10	RT	○		+	
Isocyanates, aromatic		RT	+	+	+	
Isooctane		80	+	+	+	
Isopropanol		RT	+ (5–15%)	+	+	PA: P_{20} = 20 ($g \cdot 100\ \mu m/m^2 \cdot d$); D_{20} = 1E-11 cm^2/s
Isopropanol		60	+	+	○	PA: creep strength see fig. 7
Ketones (aliphatic)		RT	+	+	○	
Lactic acid		10	+	+	+	
Lactic acid		90	–	–		
Laughing gas: see “Nitrous oxide”						
Lead acetate soln.	10	RT	+	+	+	
Lime: see “Cement”						
Linseed oil		RT	+	+	+	
Lithium bromide, lithium chloride soln. (aqueous)	10	RT	○	+	+	PA: environmental stress-cracking in saturated solutions
Lithium chloride soln. (alcoholic)	20	RT	S	+		
Lithium hydroxide	10	20	+	+	+	
Lithium hydroxide	10	80	–	+	–	
LPG (DIN 516222): see “Propane, propene”						
Lubricating oils						
Lubricating oil: gear oil (eg, ATF)		≤ 130	+	+	+	PA: temperature/time limits see fig. 13

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Lubricating oil: HD engine oils, hydraulic oils, transformer oils		≤ 130	+	+	+	PA: temperature/time limits see fig. 13; PBT see fig. 28.
Lubricating oil: hypoid gear oil (with EP additives, MIL-L 2105 B)		≤ 110	+	○	○	PA: see fig. 13
Lubricating oil: hypoid gear oil (with EP additives, MIL-L 2105 B)		120	–			
Lubricating oil: without HD or EP additives (ASTM reference oil)		100	○	○	+	Possible attack by acids formed by oxidation
Lutensit®, Lutensol® (BASF)		RT	+	+	+	
Magnesium salt solns. (chloride, nitrate, sulfate)	10	RT	+ (5–10%)	+	+	
Maleic acid soln.	25	RT	○	–		
Malic acid	SS	RT	+	○	+	
Malt		RT	+	+	+	
Manganese salt solns (chloride, sulfate)	10	RT	+	+	+	
MAPP gas (C_3, C_4 aliphatic hydrocarbons)		RT	+	+	+	
Mercury		RT	+	+	+	
Mercury (II) chloride	SS	RT	–			
Mersolates®		RT		+	+	
Methane		RT	+	+	+	
Methanol		RT	+ (9–14%)	+	+	PA: P_{20} = 0.2 (g · mm/m^2 · h); D_{20} = 1E-8 cm^2/s; creep strength see fig. 11
Methyl acetate		RT	+ (2%)	+	○	
Methyl chloride		RT	+	+		
Methyl chloroform: see “1,1,1-Trichloroethane”						
Methyl ethyl ketone		RT	+ (2%)	○	+	PA: P_{20} = 0.001 (g · mm/m^2 · h)
Methyl formate		RT	+	+	+	
Methyl glycol		RT	+			
Methylamine		RT	+ (7%)	+		
Methylaniline		RT	+ (3–15%)			
Methylbromide		RT	+	+		PA: P_{60} = 6E-13 (cm^2/s · mbar)
Methylene chloride		RT	○	○	–	
N-methylpyrrolidone		RT	+	+		
N-methylpyrrolidone		> 150		S		
Microbes		RT	+	+	+	
Milk		RT	+	+	+	
Mineral oils: see “Lubricating oils”						

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Molasses		RT	+	+	+	
Mortars: see “Cement”						
Moulds (DIN 53739; ISO 846 A, B; MIL-T 18404)		RT	+	+	+	[19]
Naphtha		RT	+	+	+	
Naphthalene		RT	+	+	+	
Naphthalenesulfonic acids		RT	–	–		
Naphthenic acids		RT	+	+	+	
Naphthols		RT	–			
Natural gas		RT	+	+	+	
Nekanil®, Nekal® surfactants (BASF)	< 10	50	+	+	+	PA: see fig. 1
Neon		RT	+	+	+	
Nickel nitrate	10	RT	○			PA: environmental stress-cracking possible; [6]
Nickel plating baths: see “Electroplating baths”						
Nickel salt solns. (chloride, sulfate)	10	RT	+	+	+	
Nitric acid	> 50	RT	–	–	○	
Nitric acid	2	RT	–	–	+	
Nitrilotriacetic acid (sodium salt)		RT	+	+	+	
Nitrobenzene, nitrotoluene		RT	○	○	+	
Nitrobenzene, nitrotoluene		> 100	S			[12]
Nitrocellulose lacquers (alcoholic, hazard class A I)		RT	○	+	○	
Nitrocellulose lacquers (alcohol-free, hazard class A II)		RT	+	+	○	
Nitrogen (200 bar)		RT	+	+	+	PA: $P_{20} = 6$ ($cm^3 \cdot 100\ \mu m/m^2 \cdot d \cdot bar$)
Nitrogen oxides (dinitrogen tetraoxide)		RT	○	–	+	[8]
Nitrogen oxides (under pressure)		RT	–	–		
Nitromethane, nitropropane		RT	○			
Nitrous fumes		RT	○	–	○	
Nitrous oxide		RT	+	+	+	
Noble gases (argon, helium, neon)		RT	+	+	+	PA: for helium $P_{20} = 340$ ($cm^3 \cdot 100\ \mu m/m^2 \cdot d \cdot bar$)
Octane, octene		RT	+	+	+	
Oil, for transformers, switchgear (DIN 51507)		50	+	+	+	PA: creep strength see fig. 1

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Oils (vegetable, ethereal, mineral)		RT	+	+	+	See also “Lubricating oils”
Oleic acid		RT	+	+	+	
Oleum		RT	S	–	–	
Oxalic acid soln.	10	RT	○	–	+	
Oxalic acid soln.	10	80	–	–		
Oxygen (atmospheric pressure)		RT	+	+	+	PA: P_{20} = 10–15 ($cm^3 \cdot 100\ \mu m/m^2 \cdot d \cdot bar$); D_{20} = 1.3E-9 cm^2/s
Oxygen (high pressure)		RT	– (*)	– (*)	– (*)	(*): not BAM-approved (German materials testing institute)
Ozone		RT	–	–	–	
Ozone (1 ppm in water)		RT	+		+	
Ozone (20 ppm in air)		RT	○	○	+	[8]
Paint solvents		RT	+	+	○	Alcoholic solvents cause PA to swell
Paints: see “Paint solvents”, “Baking enamels”						
Palamoll®, Palatinol® grades (BASF)		RT	+	+	+	
Palatal® resins (BASF): see “Polyester resins”						
Palmitic acid		80	+	+	+	
Paraffin wax, liquid paraffin		RT	+ ($<$0.2%)	+	+	
Peracetic acid		RT	–	–		
Perchloroethylene: see “Tetrachloroethylene”						
Perfume (alcoholic solution)		RT	+	+	+	
Perhydrol: see “Hydrogen peroxide soln.”						
Petroleum		RT	+	+	+	
Petroleum ether, petroleum solvents		80	+	+	+	
Phenol		> 43	S	–	–	[11], [12]
Phenol	88	RT	S	–	–	
Phenol (alcoholic soln.)	70	RT	○	–	–	
Phenyl ether (guaiacol, cresol)		RT	–			
Phenylethyl alcohol		RT	○			[11]
Phenylethyl alcohol		> 160	S			
Phosphate (inorganic) solns. (neutral and alkaline)	10	RT	+	+	+	
Phosphate esters: see “Hydraulic fluids”						
Phosphine		RT	+	+	+	

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Phosphoric acid	10	RT	–	–	–	
Phosphoric acid	85	RT	S	–	–	
Photographic developer		RT	+	+	+	
Photographic fixer		RT	+	+	+	
Phthalic acid soln.	SS	RT	○	+	+	
Plasticizers: see “Palamoll®, Palatinol®”						
Plastomoll® (adipates, BASF) DDA, NA, DIDA		RT	+	+	+	
Polyester resins (eg, BASF Palatal® resins)		RT	+	+	+	
Polyglycols, polyols		RT	+	+	+	
Potassium bromide soln.	10	RT	○	+	+	
Potassium chloride soln.	10	RT	+	+	+	
Potassium chloride soln.	10	70	+	+	–	
Potassium dichromate soln.	5	RT	○	+	○	
Potassium hydroxide soln.	50	RT	○	○	–	Unfilled PA & POM: +; glass fibres attacked in reinforced grades.
Potassium nitrate soln.	10	RT	+	+	+	
Potassium permanganate soln.	1	RT	–	+	+	
Potassium thiocyanate soln.	SS	RT	–			
Propane, propene		RT	+	+	+	PA: $P_{20} < 10$ ($cm^3 \cdot 100\ \mu m/m^2 \cdot d \cdot bar$) for propane
Propanol (n-, iso-)		RT	+ (5–15%)	+	+	PA: D_{20} = 1E-11 cm^2/s; $P_{20} = 20$ ($g \cdot 100\ \mu m/m^2 \cdot d$); creep strength see fig. 7
Propanol (n-, iso-)		> 100	S		–	
Propionic acid soln.	5	RT	+	+	+	
Propionic acid soln.	10	RT	–	○	+	
Propionic acid soln.	50	RT	–	–		
Protein solutions		RT	+	+	+	
Pulp slurries		≤ 60	+			
Pulp slurries		95	–		–	
Pyridine		RT	+	○		PA: $P_{20} = 0.0002$ ($g \cdot mm/m^2 \cdot h$)
Pyridine		80	○ (15–20%)			
Pyrocatechol soln.	6	RT	–			
Pyrrolidone		RT	+			
Pyruvic acid soln.	10	RT	○	–	+	

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Rainwater (acidic)		RT	+	+	+	
Refrigerator oil		RT	+	+	+	
Resorcinol (alcoholic soln.)	50	RT	○	○	–	
Resorcinol/methanol/benzene/water (40 : 35 : 10 : 5)		RT	○	○	–	adhesive solvent
Road salt, road-salt solutions		RT	+	+	+	PA and POM may be attacked by any zinc chloride that forms
Salicylic acid soln.	SS	RT	+	–	+	
Seawater: see "Water"						
Silane (tetramethylsilane)		RT	+		+	
Silicone oils		≤ 80	+	+	+	PA: see figs. 14–15
Silicone oils		> 100	○			PA: see fig. 15
Soap solution	< 10	80	+	+	+	
Soda soln.	10	RT	+ (3–10%)	+	+	
Sodium bromide soln.	10	RT	○			
Sodium chlorate soln.	10	RT	+	+	+	
Sodium chlorite soln.	10	RT	○			
Sodium dodecylbenzenesulfonate soln.		RT	+	+	+	
Sodium hydrogen carbonate soln.	10	RT	+	+	+	
Sodium hydrogen sulfate soln.	10	RT	+		+	
Sodium hydrogen sulfite soln.	10	RT	+	–	+	
Sodium hydroxide soln.	10	RT	+	+	–	
Sodium hydroxide soln.	50	RT	○	○	–	Unfilled PA & POM: +; glass fibres attacked in reinforced grades.
Sodium hydroxide soln.	10	80	–	○	–	
Sodium hypochlorite soln.	10	RT	○	○	○	POM: damage after more than 1000 h
Sodium hypophosphite soln.	10	RT	+	+	+	
Sodium lauryl sulfate paste	30	RT	+	+		
Sodium lignosulfonate		RT	+	+	+	
Sodium nitrilotriacetate soln.	10	RT	+	+	+	
Sodium oleate		RT	+	+	+	
Sodium pentachlorophenolate		RT	+			
Sodium perborate soln.	3	RT		+		
Sodium pyrosulfite soln.	10	RT	+			

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Sodium salt solns. (neutral, eg, chloride, nitrate, sulfate)	10	RT	+	+	+	
Soil (acidic: pH 3)		RT	+	○	+	see also “Humic acids”
Soil (neutral; alkaline: pH 10)		RT	+	+	+	see also “Bacteria”, “Moulds”
Soldering fluid		RT	–	–	+	
Steam		100	○	+	–	
Steam (50-µm film)		116	–			Evidence of molecular degradation after 5 cycles
Steam (sterilization over 50 cycles)		134	○	+	○	Sterilization (DIN 58946 parts 1 – 5): PA 66: +; PA 6: –
Stearic acid, stearate, alkyl stearate		RT	+	+	+	
Sterilization, sterilizing agent see “Disinfectant”						
Stoving enamels: see “Baking enamels”						
Styrene		80	+	+	+	
Sulfolane (tetramethylenesulfone)		RT	+ (1%)	+	+	
Sulfolane (tetramethylenesulfone)		> 80	S			
Sulfonates (eg, alkyl aryl sulfonate)	<10	RT	+	+	+	
Sulfur		RT	+	+	+	
Sulfur dioxide (dry)		RT	+	–	+	PA: P_{20} = 2.3E-11 ($cm^2/s \cdot mbar$) [13]; high absorption under high pressure [16]
Sulfur dioxide (moist)		RT	○	–	+	
Sulfur hexafluoride (20 bar)		RT	+	+	+	
Sulfuric acid	> 80	RT	S	–	–	
Sulfuric acid	2	RT	–	○	+	POM: no damage caused by 5% solution up to 1000 h
Sulfurous acid soln.	SS	RT	○	○	+	
Sweat (DIN 54020)		RT	+	+	+	[7]
Tall oil		RT	+	+	+	
Tallow		RT	+	+	+	
Tar: see “Bitumen”						
Tartaric acid	10	RT	+ (4 – 10%)	+	+	
Tartaric acid	50	RT	○		+	
Termites		RT	+	+	+	Surface may be eaten into slightly
Tetrachloroethylene		RT	○	+	○	[18]
Tetrachloroethylene		80	–	○	–	[18]

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Tetrachloromethane		RT	+ (1–4%)	○	+	PA: P_{20} = 0.08 (g · mm/m^2h)
Tetrafluoromethane		RT	+	+		
Tetrafluoropropanol		RT	–			
Tetrahydrofuran		RT	+ (2–10%)	○	+	PA: P_{20} = 0.001 (g · mm/m^2h)
Tetralin®		RT	+ (2–3%)	+	+	
Tin (II) salts of mineral acids	10	RT	○	+	+	
Toluene		RT	+	+	+	PA: P_{20} = 0.005 (g · mm/m^2h)
Toluene		100	+	+	–	
Town gas		RT	+	+	+	
Trichloroacetic acid ethyl ester		RT	○	–	–	PA 66: limited resistance; PA 6: not resistant
Trichloroacetic acid soln.	50	RT	–	–	–	
1,1,1-Trichloroethane (Chlorothene®)		45	+		+	[18]
Trichloroethanol, trifluoroethanol		RT	–		–	[11]
Trichloroethylene		RT	○ (4–10%)	–	–	PA: P_{50} = 0.02 (g · mm/m^2 · d)
Trichloroethylene		> 40	–	–	–	
Trichlorotrifluoroethane		RT	+	+	+	
Triethanolamine		RT	+	+	+	
Trilon® A, B (BASF)	10	RT	+	+	+	
Trilon® A, B (BASF)	10	60		+		
Trimethylamine		RT	+	+		
Tri-p-cresyl phosphate		RT	+	+	+	
Turpentine oil		RT	+ (1%)	+	+	
Turpentine substitute (white spirit)		RT	+	+	+	
Uranium fluoride		RT	–	–	–	
Uric acid soln.	20	RT	+	+	+	
Urine		RT	+	+	+	
Vacuum		RT	+	+	+	
Vaseline		RT	+	+	+	
Vinyl chloride, bromide, fluoride		80	+	+	+	
Vulcanization		≤ 180	+	○	–	

	Wt. %	°C	Ultramid	Ultraform	Ultradur	Notes
Water (including seawater)		RT	+	+	+	PA: see figs. 1, 17, 18, 19; POM: see figs. 22 & 23
Water (including seawater), chlorinated (≤ 0.5 mg/l)		80	+	+	○	
Water glass		RT	+	+	+	
Wax		80	+	+	+	
Wax polishes		RT	+	+	+	
WC cleaner (pH < 3)		RT	○	–	+	
Wine		RT	+	+	+	
Xylene		RT	+	+	○	
Xylene		100	+	+	–	
Yeast		RT	+	+	+	
Zinc (galvanized metal surfaces) exposed to weather		RT	+	+	+	Formation of zinc chloride possible on exposure to salt water (see "Zinc chloride")
Zinc chloride		RT	+	+	+	
Zinc chloride soln.	10	RT	○	+	+	PA: stress cracking under certain circumstances (see figs. 20–21); POM: corrosion under certain circumstances above 60°C
Zinc chloride soln.	37	RT	–	○	+	POM: corrosion possible above 60°C
Zinc thiocyanate, bromide, iodide, nitrate	30	RT	–		+	

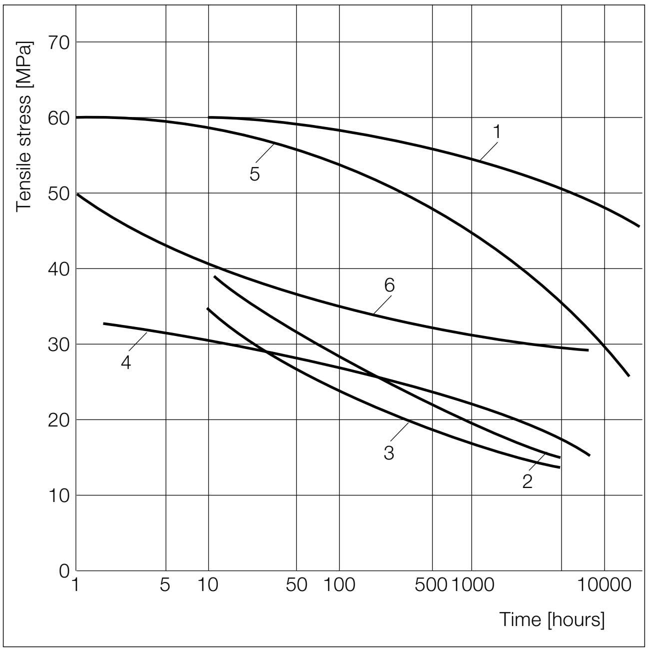

Fig 1: Creep behaviour of Ultramid B5 in air and various chemicals at 23, 40 and 50°C.
Test specimens: DIN 53455, no. 3, made from extruded sheet.
1 air, 23 °C/50 r.h.
2 water (distilled), 23 °C
3 hydrochloric acid, pH 1.5, 23 °C
4 Nikanil W Extra, 5 %, 50 °C
5 transformer oil, 50 °C
6 amyl alcohol, 23 °C

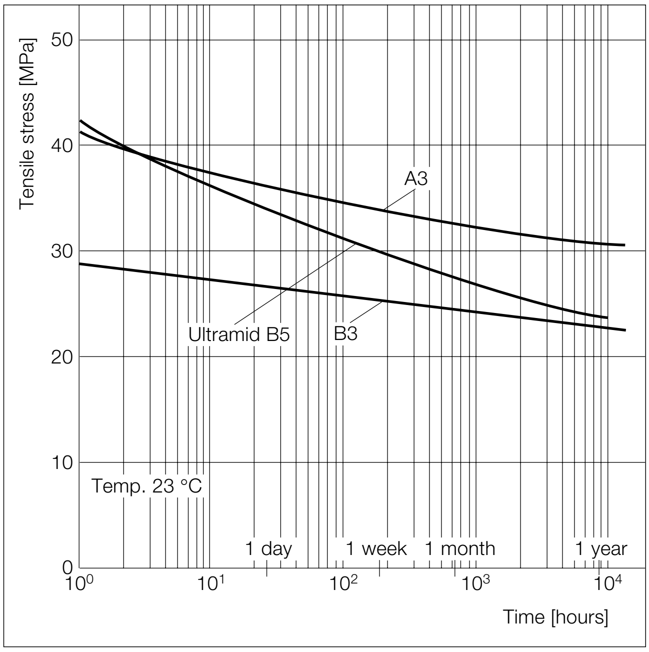

Fig 2: Creep behaviour of Ultramid A and B grades in acetone at 23°C.
Test specimens: DIN 53455, no. 3.

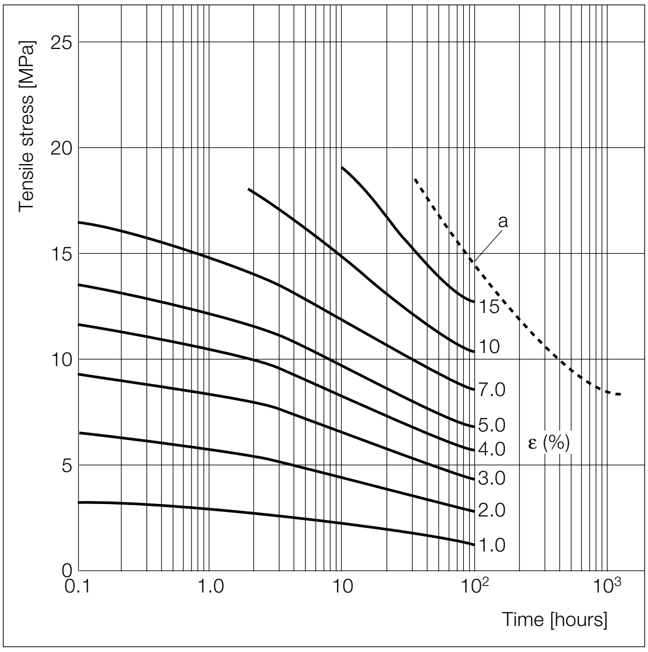

Fig 3: Creep behaviour of Ultramid A4K in a boiling 1 : 1 Glysantin®/water mixture at 106 °C.
Test specimens: 118 mm x 13 mm x 8 mm (initially dry).
Weight increase at saturation (150 h): 11.5 %.
a = creep-to-rupture curve; ε = strain

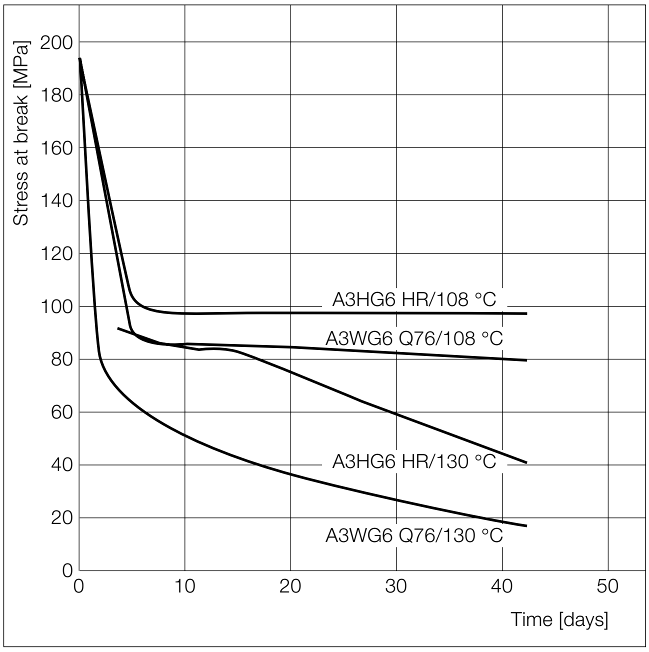

Fig. 4: Mechanical data after immersion in 1 : 1 Glysantin/water mixture at 108 °C and 130 °C.

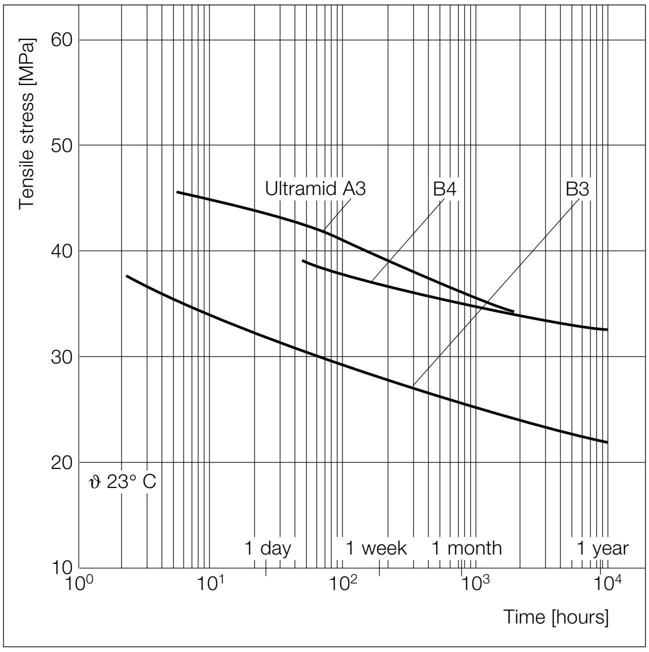

Fig 5: Creep behaviour of Ultramid A and B grades in glycerol at 23 °C.
Test specimens: DIN 53455, no. 3

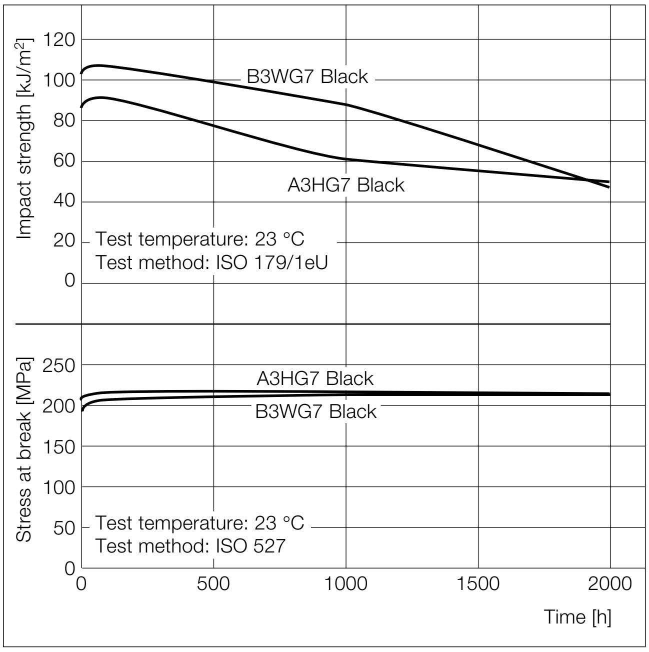

Fig. 6: Ultramid A3HG7 Black and B3WG7 Black Resistance to engine oil (Elf XT 3341) at 150 °C

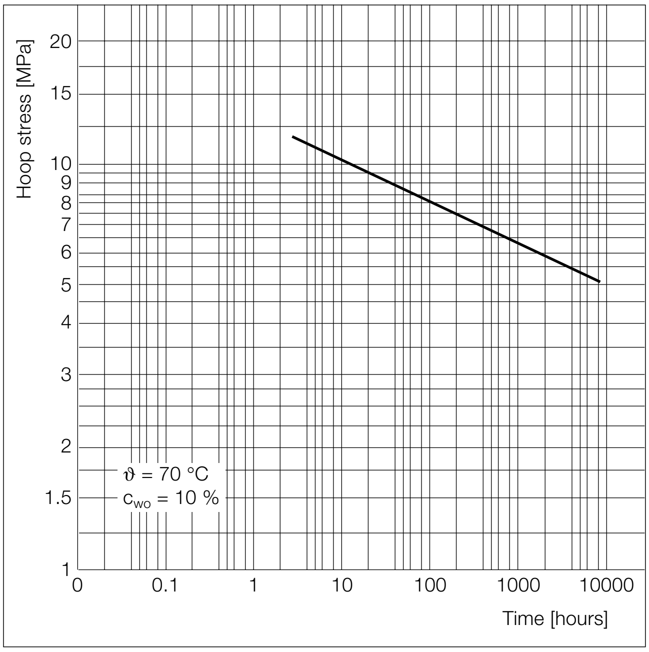

Fig. 7: Creep behaviour of water-saturated Ultramid B5 pipes in isopropanol at 70 °C

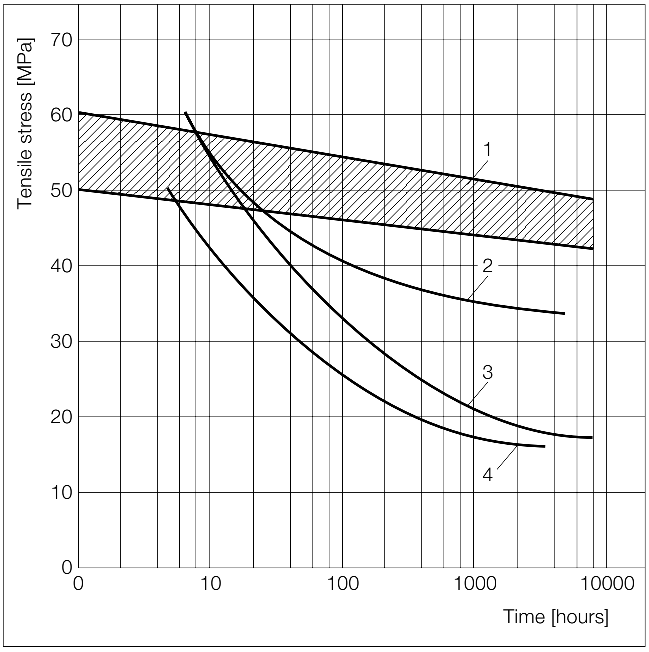

Fig. 8: Creep behaviour of Ultramid B grades in M15 fuel (85 : 15 gasoline/methanol), in water and in 23/50 standard atmosphere.
Test specimens: DIN 53455, no. 3
1 Ultramid B3S, B5 (conditioned at 23°C/50 r.h.)
2 Ultramid B3S (dry) in premium-grade gasoline at 23 °C
3 Ultramid B3S (dry) in M15 fuel at 23 °C
4 Ultramid B3S (initially dry) in water at 23 °C

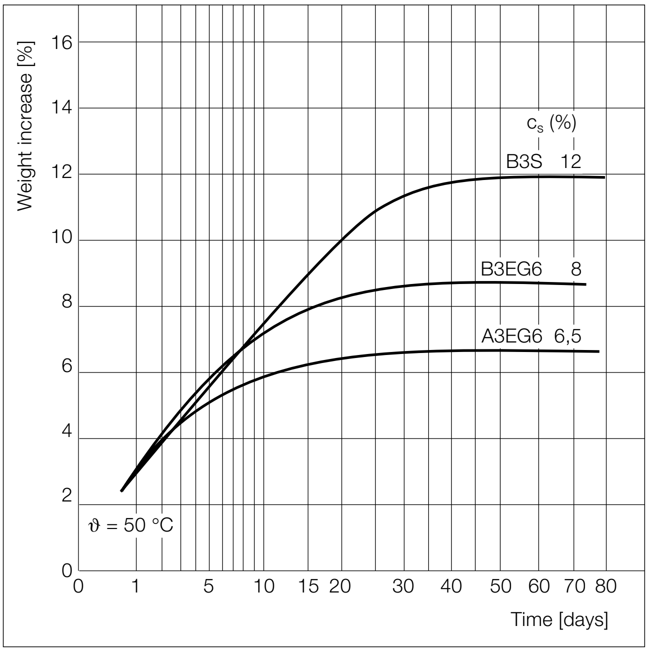

Fig. 9: Relative increase in weight of Ultramid grades in M15 fuel (85:15 gasoline/methanol) at 50 °C.
C_s (%) is the relative increase in weight at saturation.
Test specimens: DIN 53455, no. 3

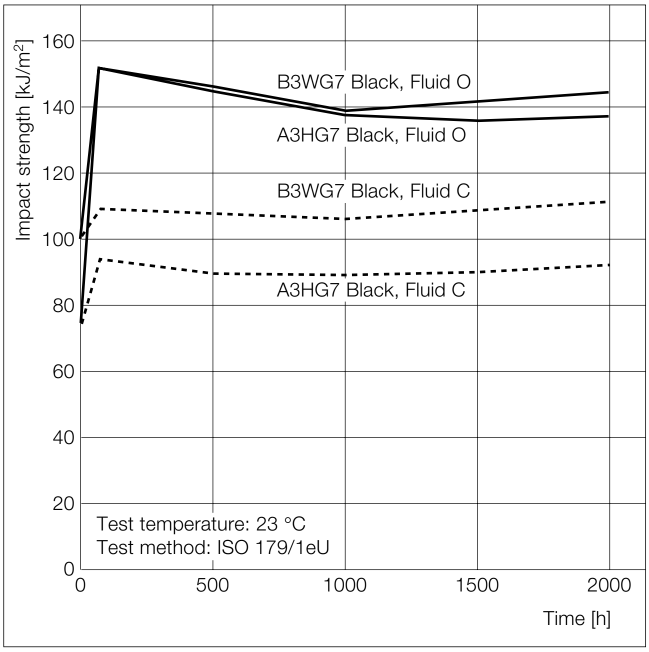

Fig. 10: Ultramid A3HG7 Black and B3WG7 Black Resistance to fuel mixtures at 70 °C: Fluid C (50% isooctane + 50% toluene); Fluid O (85% Fluid C + 15% methanol).

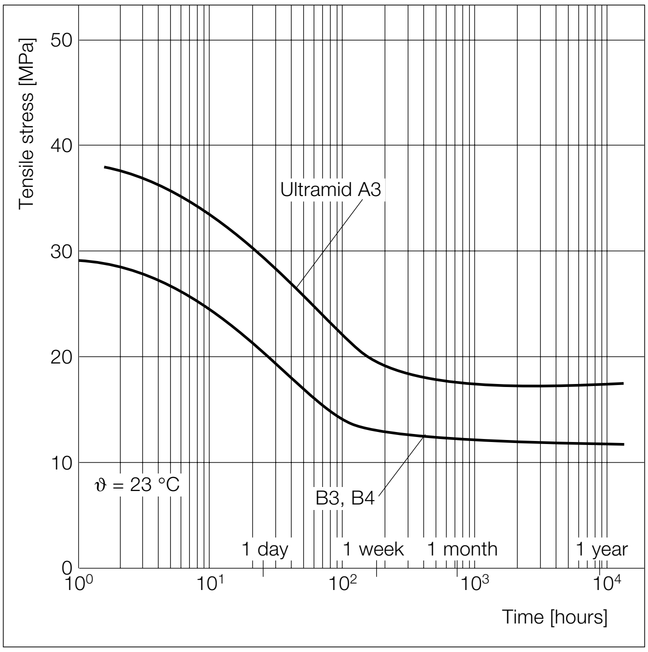

Fig. 11: Creep behaviour of Ultramid A and B in methanol.
Test specimens: DIN 53455, no. 3; temp.: 23 °C

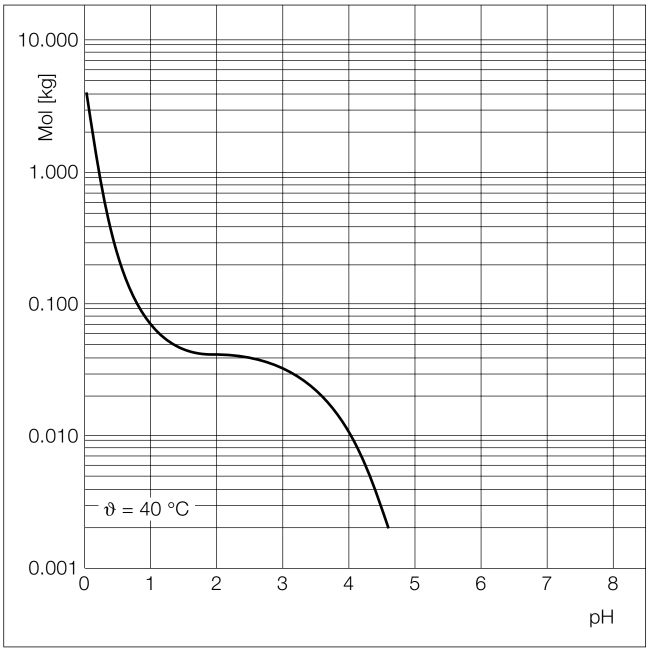

Fig. 12: Absorption of hydrochloric acid by Ultramid B3 as a function of the pH at 40 °C.
Test specimens: disks (Ø 60 mm x 1 mm) injection-moulded with a cold mould

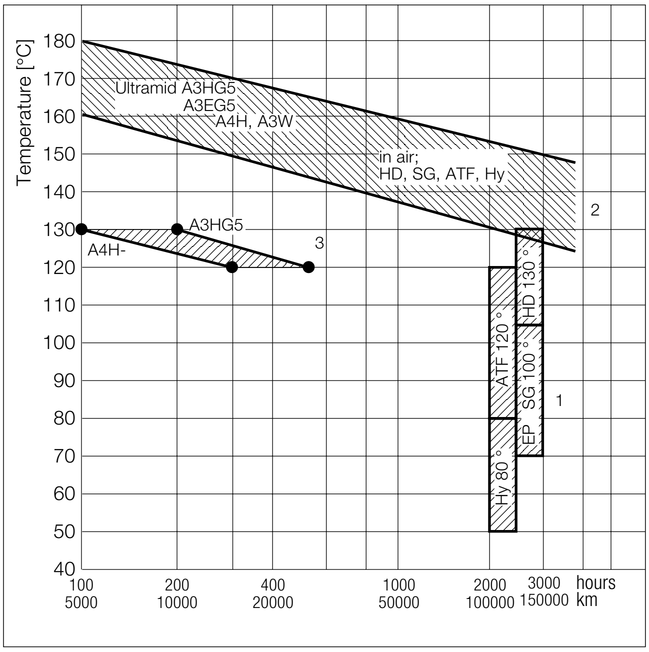

Fig. 13: Typical temperature and endurance data for Ultramid in contact with automotive lubricants
HD = HD engine oil
SG = Transmission oil (mechan.)
ATF = Transmission oil (autom.)
EP = EP hypoid-gear oil SAE90
Hy = Hydraulic oil (corresp. HD)

1 Long term temp. in driving operation (Peak temp. approx. + 130 °C)
2 In accordance with IEC-216
3 In EP hypoid-gear oil

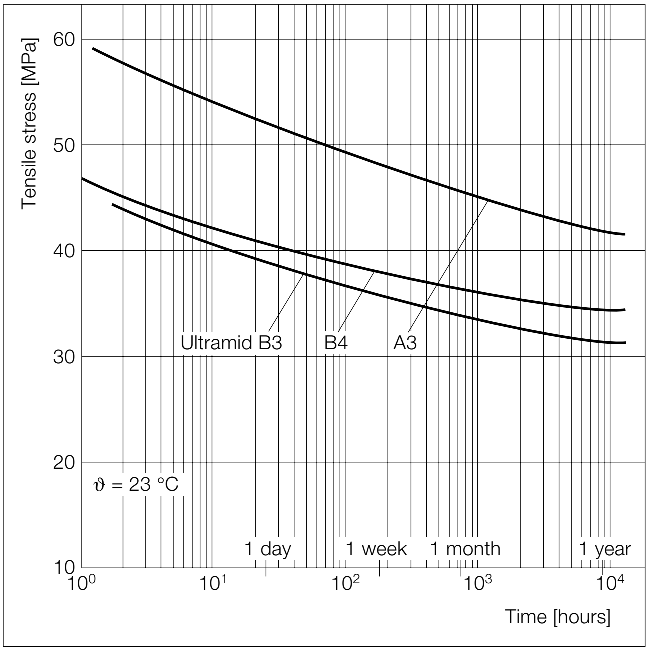

Fig. 14: Creep behaviour of Ultramid in silicone oil AK 1000 (Wacker)
Test specimens: DIN 53455, no. 3

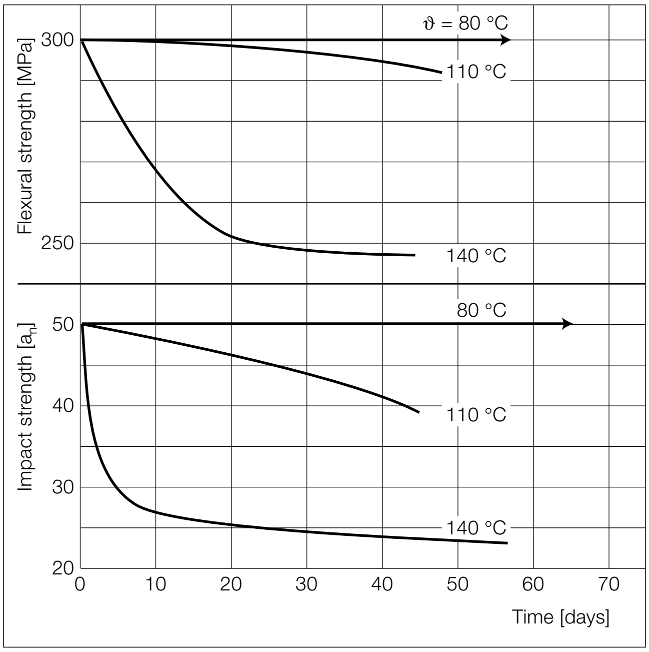

Fig. 15: Change in impact and flexural strength of Ultramid A3EG10 Black 564 in contact with silicone oil at 80, 110 and 140 °C (measured at 23 °C)

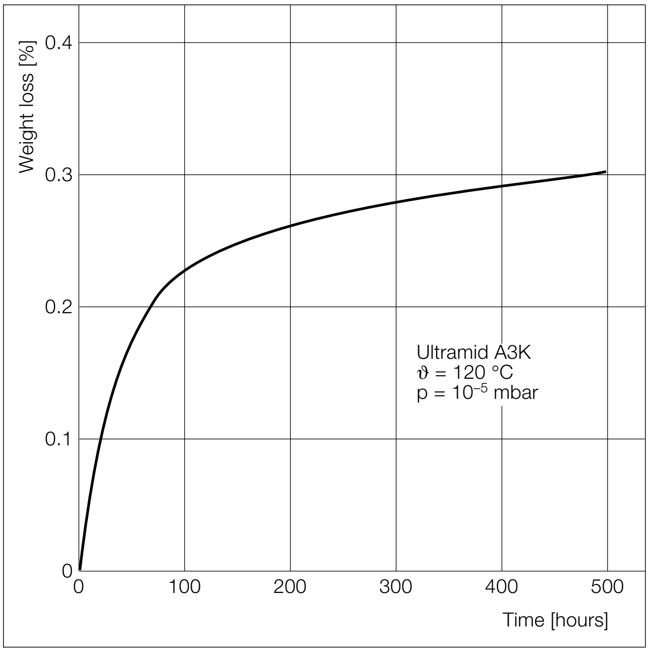

Fig. 16: Relative loss in weight of Ultramid A3K Black 464 (dry) at 120 °C in a 10^{-5}-mbar vacuum. (GLC analysis of volatile matter: 80% oligomers, 7% water).

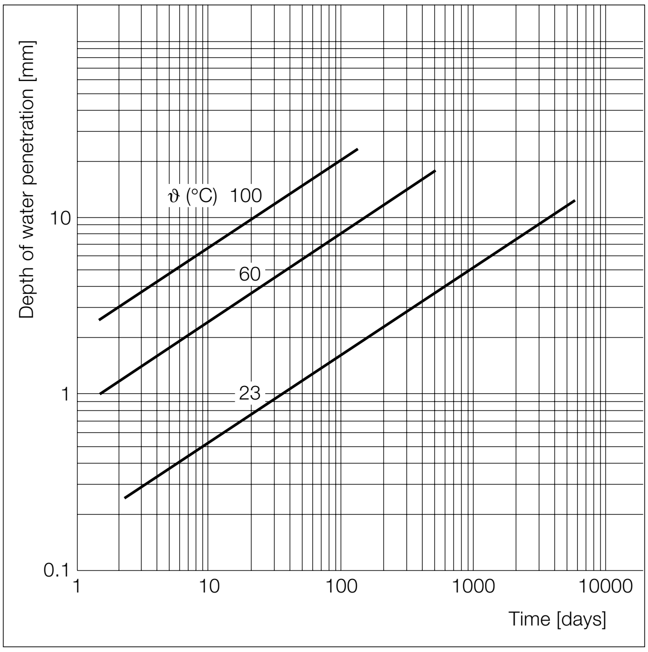

Fig. 17 Penetration of water into Ultramid B at 23, 60 and 100°C

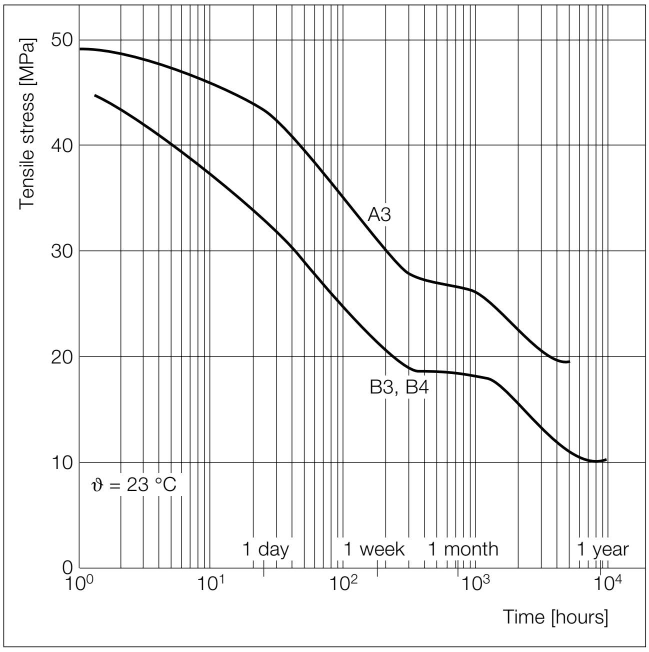

Fig. 18 Creep behaviour of Ultramid in distilled water at 23 °C
Test specimens: DIN 53455, no. 3

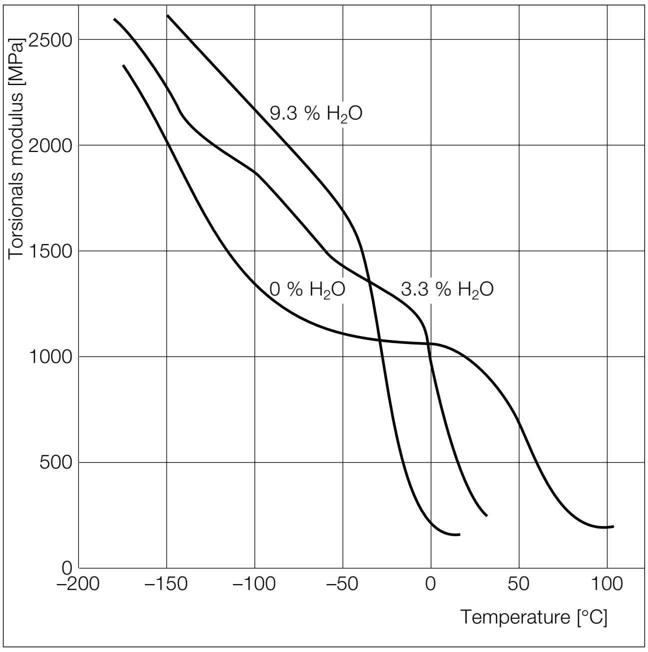

Fig. 19: Variation in torsional shear modulus of Ultramid B3 as a function of temperature. Water content of specimens: 0%, 3.3% and 9.3% (DIN 53445)

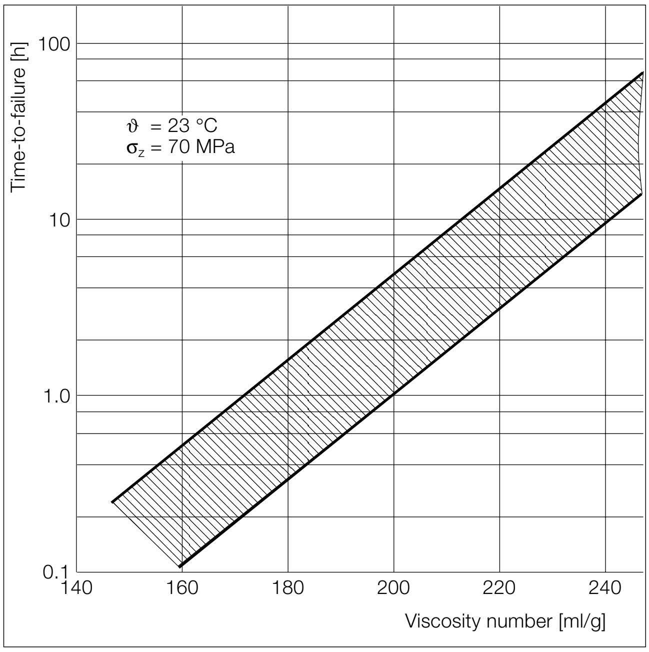

Fig. 20: Time-to-failure of dry PA 66 in 37.5% zinc chloride solution under a tensile stress of 70 MPa as a function of the viscosity number (DIN 53727, H_2SO_4 96%).

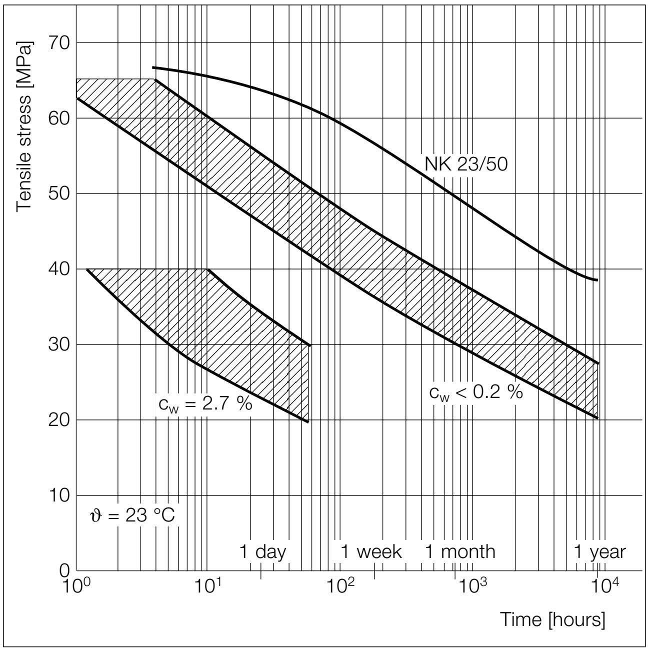

Fig. 21: Creep behaviour of stabilized high-molecular-weight PA 66 (dry and 2.7% water content) in 37.5% aqueous zinc chloride solution at 23 °C Test specimens: DIN 53455, no. 3

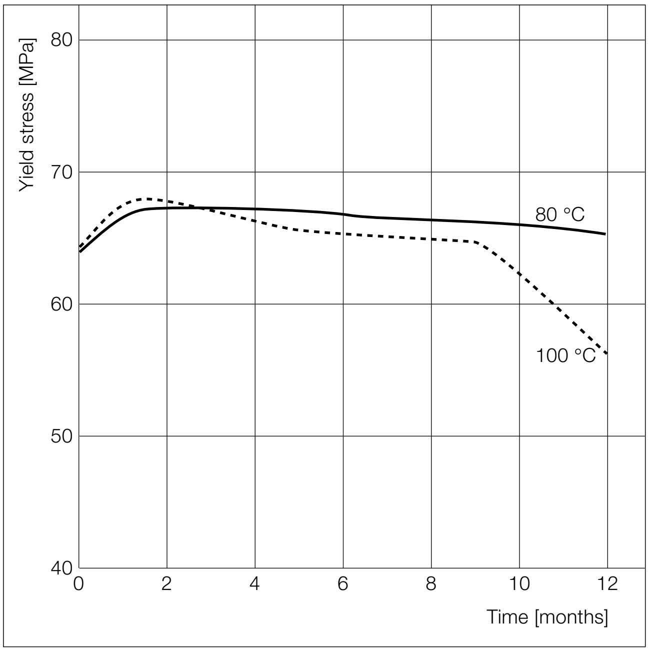

Fig. 22: Immersion of Ultraform N 2320 003 in water.

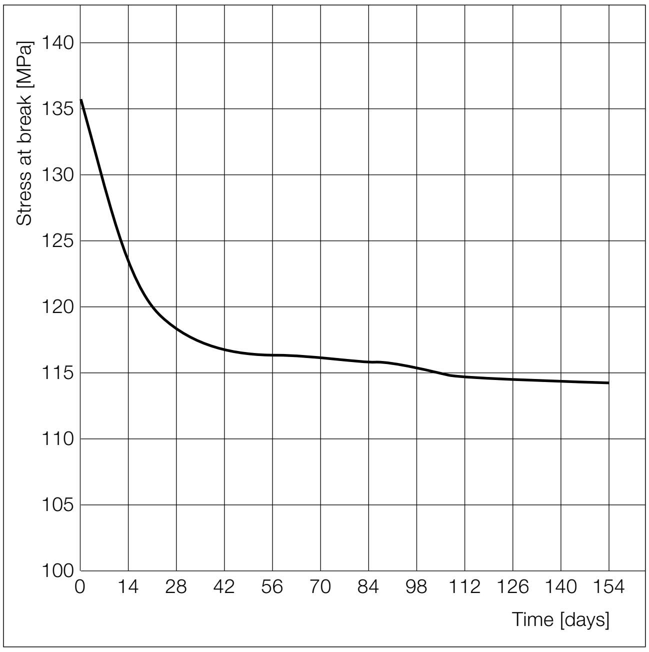

Fig. 23: Immersion of Ultraform N 2200 G53 in water at 40 °C

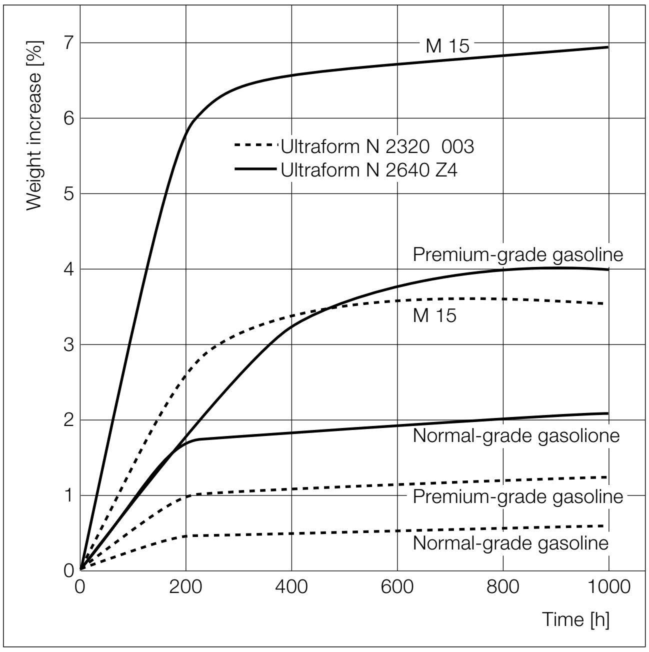

Fig. 24: Immersion of Ultraform in engine fuels at 50 °C

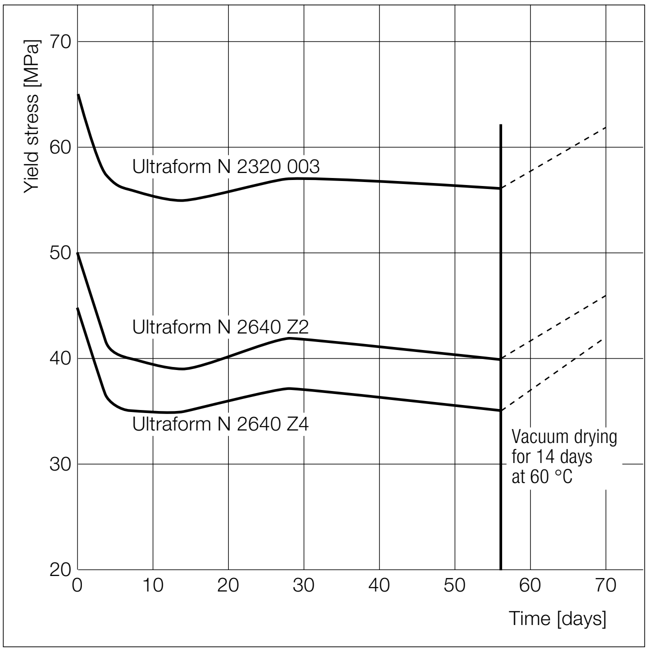

Fig. 25: Stress at yield after immersion in M15 fuel at 60 °C

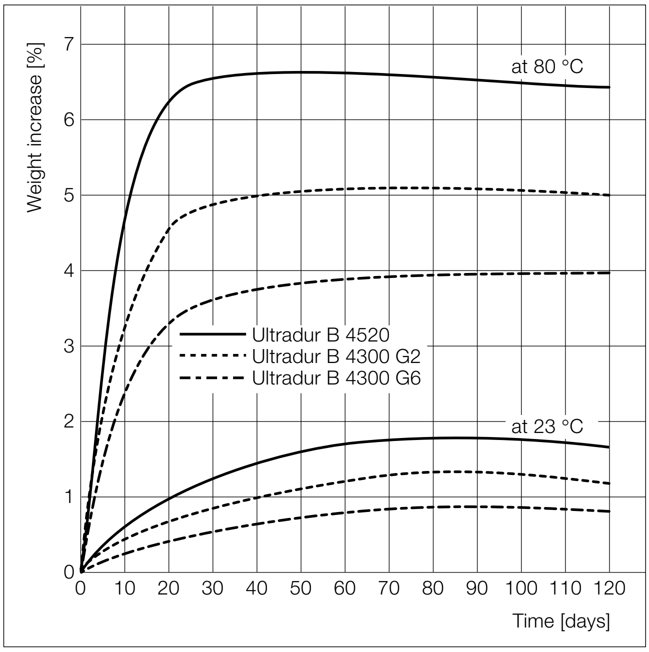

Fig. 26: Relative increase in weight of Ultradur after immersion in M15 fuel at 23 °C and 80 °C

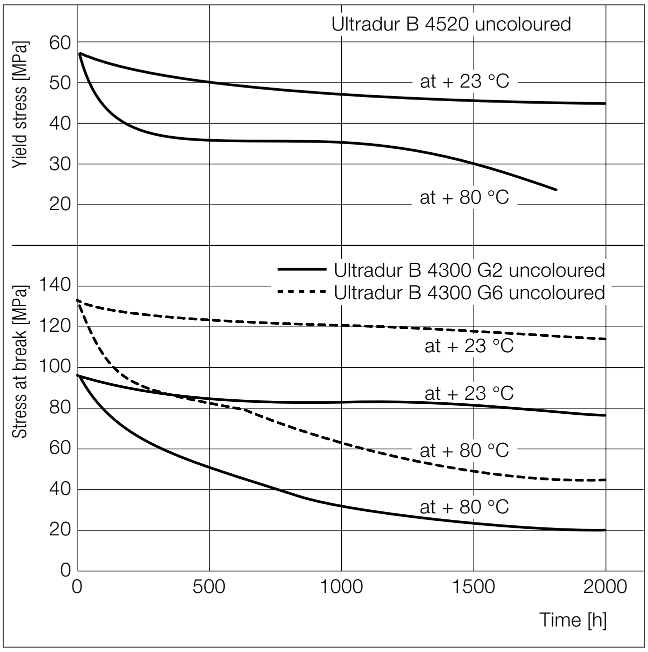

Fig. 27: Yield and breaking stress of Ultradur after immersion in M15 fuel at 23 °C and 80 °C

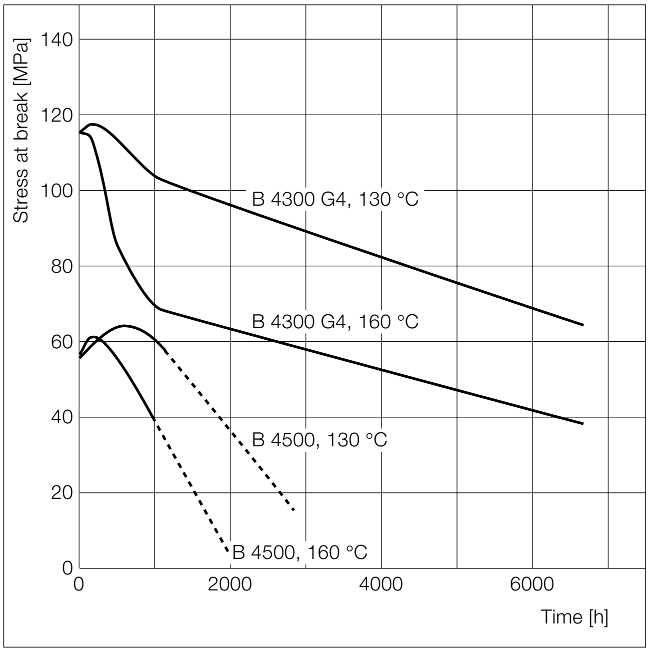

Fig. 28: Stress at break of Ultradur after immersion in synthetic engine oil (Castrol TXT Softec 10W-40)

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