

# EPDM in Contact with Potable Water



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# **General: Potable Water Distribution in Europe**

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**From the source or waste water treatment plant to the consumer's tap = CPDW\* Regulation**

**After passing the final consumer's tap = Food Regulation**

\* CPDW = Construction Products for Drinking Water

# Introduction

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Transportation of water is usually taking place from a source, via a treatment facility, to the consumer's tap.

The waste is then discharged via a sewer system into a purification installation for treatment before it is discharged in the waterways

For the supply and drainage of the water, piping systems are used of which the joints are mostly sealed with rubber gaskets

These rubber gaskets have to fulfill specific standards with respect to physical and sanitary requirements

# Health and environmental aspects

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**Water is a very strategic medium, because of:**

- increasing demands on quality regarding organoleptic- and microbial growth properties
- maintaining water quality without or with limited use of disinfectants
- improved water management: renewal of older piping systems; request for at least 50 years of life time guarantees for the whole piping system ( including seals)

# Microbial growth aspects

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During treatment, storage and transportation interactions between water and organic substances (e.g. rubber) can take place:

- by physical breakdown of the material leading to undesirable substances
- by the release of metabolic by-products leading to unpleasant taste and odor (appears as a visible slime on the surface)

# Applications

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## Typical rubber components coming into contact with potable water

- Reservoir Linings
- Hoses and Tubes
- Valve seats
- Diaphragms and O-rings in heaters and appliances
- Washer in taps
- Seals in coupling/fitting systems (pipe joints)

# Seals in Pipe Joints

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**Depending on pipe material elastomeric- or other sealing systems are used**

Pipe Material*	Estimated share of elastomeric material %
PVC	± 15
PE	± 5
Glass Reinforced Polyester	100
Steel	100
Ductile Iron	100
Clay	± 60
Concrete	100
Fiber cement	± 80

\* Choice of pipe material depends on type of soil

**EPDM is main elastomeric material used in Europe, others are amongst others SBR, NBR**

# Typical Fittings/Couplings with sealing element

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## Tyton Coupling + Seal



Push-Fit Flexible Joints



Anchored push-fit flexible joints



Mechanical Flexible Joint



## Vicking-Johnson Coupling + Seals





# Main Standards and Regulations (overview)

Property	EN 681.1	ISO 4633	China HG/T 3091	US ASTM F-477	JapanK6353
Hardness	35-95	35-95	35-95	40-60	45-85
Tensile MPa	9	9	9	8.3-13.8	18-12
Elongation %	400-100	400-100	400-100	325-400	400-280
<b>Compression Set</b>					
72 hrs. 23 ° C %	12-15	12-15	12-15	-	12-20
24 hrs 70 ° C %	20	20	20	25-20	20-30
72 hrs -10 ° C %	40-60	40-60	40-60	-	-
<b>Stress Relaxation</b>					
168 hrs. 23 ° C %	13-18	13-18	13-18	-	-
100 days 23 ° C %	19-26	19-26	19-26	-	-
<b>Low Temperature</b>					
Test method	-	-	-	ΔH (-10 C)	-
<b>Ozone test</b>					
Hrs/O3 conc.	48 / 50	48 / 50	48 / 50	72 / 50	-
<b>Optional requirements</b>	Yes	Yes	Yes	No	No
<b>Microbial / Hygienic</b>	National Issues	ISO 10221(ductile iron)	In development	NSF 61	K6353

# Standards and Regulations: Conclusions

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- EN 681 is the harmonized standard for Mechanical / Physical properties in Europe
- This EN 681.1 standard is divided in 4 parts:
  - EN681.1: vulcanized materials for pressurized pipe systems (potable water)
  - EN 681.2: TPE materials for gravity pipes (waste water)
  - EN 681.3: Cellular material
  - EN 681.4: Polyurethane
- EN 681 has more focus on compression set and stress relaxation
- Requirements of EN 681 standard are used by ISO and in other countries
- One harmonized standard for hygienic issues is still lacking in Europe (EAS?)

# Tests to determine effects on water quality

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Organoleptic / Hygienic	Microbiological Growth	Migration / Leaching	Toxicological
Taste	MDOD	TOC	Cytotoxicity
Odor	Bacterial Count	Chlorine -consumption	Genotoxicity
Color	W270	KMnO4 value	
Appearance	KIWA (ATP)	Metal extraction	
Foaming	BS 7874*	Specific organics	
Turbidity		Unknown (GC/MS)	

\* BS7874 is the old so called "Thames test", which measures the weight loss of presence of loose filler on the rubber surface

Besides the different tests determining the effects on water quality countries like France, Germany and The Netherlands also using a positive list of rubber ingredients

# Main Microbial Growth Tests in Europe

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Parameters	Method	W270	KIWA (ATP)
<b>Determination</b>	Depletion of dissolved oxygen	Bio-film formation	Biomass density
<b>Method</b>	Measurement of dissolved oxygen by means of electrochemical probe	Quantity and type of surface slime, scraped by a wiper	ATP concentration measured by Lumac biocounter
<b>Duration</b>	7-8 weeks	3 month	2-6 month
<b>Surface area</b>	130-190 cm <sup>2</sup>	800 cm <sup>2</sup>	8-9 cm <sup>2</sup>
<b>Water</b>	Tap (1000 ml)	Continuous flowing potable water	Tap (600 ml)
<b>Innoculum</b>	River water	-	River water
<b>Requirements</b>	MDOD $\leq$ 2.3 mg/L	Depending on application (surface to volume) ratio  Maximum slime < 0.1 ml / 800 cm <sup>2</sup>	Under development

# **Main European Microbial Growth Tests (cont.1)**

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## **Principle of measurement:**

- KIWA: Concentration of ATP as a surrogate measure of overall microbial activity  
( living / suspended mass)
- W270: Biomass formation: volume of biofilm-organism + dead cells + growth  
related substances
- MDOD: Dissolved oxygen uptake (living biofilm + planktonic organism)

# Main European Standards / Regulations

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## **France:** ACS (Attestation de Conformité Sanitaire)

### Approval on finished articles

3 Stages:

- XP P41-250-1: Quick screening test: taste; TOC; chlorine demand; conductivity; pH; ammonium; nitrite; Kjeldahl nitrogen and permanganate value)
- XP P41-250-2: After fulfilling part1: Determination of metals; PAH's; volatile solvents
- XP-P241-250-3: After fulfilling part 1 and 2: GC/MS (contaminants) and cytotoxicity test

**Approval criteria: All components of the material must be listed in the French positive list (Arreté 1994) including processing- and polymerization aids**

### Test Institutes:

CRECEP Paris: IPL (Institute Pasteur) Lille: IPL Maxeville; CARSO Lyon

# European Standards /Regulations (cont.1)

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## Germany: KTW 1.3.13 from 1986\* / “Arbeitsblatt” W270 (2007)

(\* will be replaced by new “Elastomer Leitlinie”; active from January 1, 2012)

### Approval on finished articles

- Testing requirements: organoleptic requirements; TOC; Chlorine demand; aromatic- and aliphatic amines; phenol; presence of heavy metals (Zn, Pb); Formaldehyde
- Approval criteria; ingredients have to fulfill positive list, KTW requirements, W270

Testing requirements are based on 5 categories (s / v ratios of applications involved)

A: Pipes (1:1)

B: Reservoirs and Linings (1:4)

C: Fittings, connection pipes (1:6)

D1: Gaskets with large contact surface (1:25)

D2: Gaskets with small contact surface, other gaskets and adhesives (1: 50)

- Known test institutes: Hygiene Institut Gelsenkirchen; TZW Karlsruhe
- Certification from DVGW Bonn

# European Standards / Regulations (cont.2)

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## Germany: new UBA “Elastomer Leitlinie” (will probably be valid from 01-2012)

- more in harmony with EAS draft
- Designed for finished rubber articles (not valid for TPE's and Silicon rubber)
- Positive lists for monomers and additives, based on current KTW lists; BfR recommendations and Plastic Regulation EU) 10/2011
- Conversion factors according to S/V ratio and flow rate  
Migration (CEN methods): definition of DWPLL from SML ( $DWPLL = SML/20$ )
- W270 test will be part of the approval criteria

For more information see website: <http://www.umweltbundesamt.de/wasser/themen/trinkwasser/verteilung.htm>



## DWPLL: Drinking Water Positive List Limits

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- Toxicologically: DWPLL is max. tolerable concentration of material specific substances in drinking water
- DWPLL is derived from 10 % of the substance specific Tolerable Daily Intake (TDI), based on a 60 Kg weight person in 2 Liter drinking water
- $DWPLL = 1/20 \text{ SML}^*$  (specific migration limit)

\* SML is based on the toxicological data available or TDI set by the EFSA (SCF)

For calculation it's assumed that the person of 60 Kg consumes everyday during lifetime

- 1 Kg foodstuff
- always in contact with the material containing the referred substance
- at maximum permitted quantity

# European Standards / Regulations (cont.3)

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**The Netherlands: KIWA BRL K17504 (2008)**

**combined with ATA (Attest Toxicological Aspects) 1994**

- **Implementation is the responsibility of KIWA (certification)**
- **Evaluation guideline consists of mechanical properties based on EN 681.1 and organoleptic requirements**  
**Differs from EN681.1 with respect to prescribed application area and life time guarantee.**
- **Approval process requires:**  
**Information about chemical composition; total/specific migration; organoleptic and microbiology**  
**Total and specific migration**
- **Certification body: KIWA Rijswijk The Netherlands**

# European Standards / Regulations (cont.4)

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## United Kingdom

### Regulation in use for water in buildings WS-BS 6920

- **Standard 6920 (2000) prescribes test methods regarding effects on water quality**

Odor and Flavor; Appearance of water; Growth of aquatic micro-organisms; Extraction of substances  
Extraction of metals

- **Tests on rubber sheets and final articles are carried out by the following institutes:**

ITS Leatherhead; Law Laboratories Birmingham; LGC Middlesex; WQC Reading  
WRc-NSF Medmenham

- **Test results have to be send to the WRAS in Oakland**

- **WRAS generates the certificate and lists the material or product in its directory**

- **For Listing of approved rubber compounds see Water Fittings and Materials Directory, twice per year published by the WRAS**

[http://www.wras.co.uk/directory/fittings\\_and\\_materials.htm](http://www.wras.co.uk/directory/fittings_and_materials.htm)

# European Standards and Regulations (cont.5)

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## EAS and other European countries

- EAS: process has been started again, the commission has asked the 4 Member States (France; Germany; The Netherlands; UK) to prepare proposals to be reviewed / commented by the Commission Expert Group - CPDW

Process steps are:

- Declaration of intent
  - Positive lists organics; metallic compositions, cement materials (assessment on SCF/EFSA concepts)
  - Test methods
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- Other countries: similar regulations but usually certificates of the 4 main countries are accepted

# Draft Chinese Hygienic Standard

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Sanitary Safety Evaluation Norms for Living and Drinking Water Delivery and Distribution Facilities and Protective Materials

Based on:

- GB 5749: Standard for Drinking water
- GB/T5750: Test method for Drinking Water
- US NSF/ANSI 61: Drinking Water Systems / Health Effects

Tests to be carried out: Turbidity; Smell/Taste; Metallic content; Toxicological issues

# US NSF / ANSI 61 Standard: General Information

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- Standard is product specific
- No positive list available (sometimes NSF is combined with FDA)
- Any ingredient can be used as long it's not exceeding the allowable concentration level
- NSF 61 is publishing the contaminant concentrations that the product is allowed to release into the water
- Depends on the surface area to volume ratio of the material
- Information links: International: [info@nsf.org](mailto:info@nsf.org) / Europe: [europe@nsf.org](mailto:europe@nsf.org)













# Chloramine disinfectant for drinking water

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- Formed by mixing chlorine with ammonia
- It's weaker but more stable as chlorine and extends disinfectant benefits throughout a water utility's distribution system
- Advantages:
  - fewer disinfectant by-products; better protection against bacterial re-growth; controlling bio-film; fewer taste/odor complaints; less expensive
- Disadvantages:
  - potential water quality problems like nitrification and corrosion; aggressive for rubber materials
- Standard used is ASTM 6284: Effect of aqueous solution with available chlorine or chloramine

# Sanitary Requirements Europe vs. USA

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Test	Europe	USA
Flavour/Odour		
Colour/Turbidity		
Metals Leachate		
- metallic materials		
- non-metallic materials		
Organic Leachate		
Microbial Growth Potential		
Chlorine Demand		
Positive List		 (FDA possible)

***While Europe is testing very broadly, USA is more focusing on leachates of end product***



# Compounding Issues (handling guidelines)

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## Moulding:

**clean moulds/polished surfaces/ aluminium  
or “Mylar” foil**

**High state of cure (+ post cure)**

**No mould release / anti sticking agents**

## Storage/Packaging:

**unsealed storage till packaging  
(evaporation of volatiles)**

**packaging in non-treated paper enveloppes**

**Storage of rubber products for at least 4 weeks  
prior to testing**

# Compounding Issues

Ingredient	Type	MDOD	W270	Cl-demand	Taste/Odour	Cytotoxicity
Polymer	Non-Diene	+	+	+	0	-/0
	Diene	-	-	-/0	-/0	-/0
Plasticiser	Paraffinic	-	-	+	0	0
	Naphtenic	+	-/0	0	0	0
	PIB	+	+	0	0	0
Filler	Hydrophobic.	+	+	+	0	0
	Hydrophylic	-	-	-	0	0
	Carbon black	0	0	0	-/0	-/0
Antidegradant	Wax	-	-	+	0	0
	Phenolic	+	+	0	-/0	-/0
	Amine	+	+	-	-	-
Curing agent	Sulphur	-/0	-/0	-/0	0	-/0
	Peroxide	0	0	+	-	-/0
Accelerator	Thiuram	0	0	-	-/0	-
	Mercaptan	0	0	-	-/0	-
	Guanidine	0	0	0	-/0	0
	Sulphenamide	0	0	0	-	0
	Metal -complex	+	0	-	-/0	-
Retarder	Pthalimide	+	0	0	-/0	-/0

# Typical Recipes (EN 681.1 / BS6920)

Ingredients	R2008	R8856	R2009	S9851	R2010	S9852
K4802	100.0		100.0		100.0	
K.8340A		100.0		100.0		100.0
ZnO	5.0	5.0	5.0	5.0	5.0	5.0
Stearic acid	0.3	0.3	0.3	0.3	0.3	0.3
Black N330	30.0	30.0	50.0	50.0	60.0	60.0
Whiting	75.0	75.0	80.0	80.0	85.0	85.0
BHP	0.5	0.5	0.5	0.5	0.5	0.5
Naphtenic oil	50.0	50.0	40.0	40.0	35.0	35.0
MBT-80	1.88	1.88	1.88	1.88	1.88	1.88
TMTD-80	0.5	0.5	0.5	0.5	0.5	0.5
S-80	1.56	1.56	1.56	1.56	1.56	1.56
FeDMC-75	0.25	0.25	0.25	0.25	0.25	0.25
Total	264.99	264.99	279.99	279.99	289.99	289.99

# Typical Recipes (EN 681 / BS6920) Cont.

Properties	R2008	S8856	R2009	S9851	R2010	S9852
Mooney 100 C (ML1+4)	56.26	52.26	79.91	74.69	100.48	91.29
Rheo 180 C						
T2 min.	1.38	1.33	1.23	1.20	1.15	1.12
T90 min.	7.97	6.82	8.08	7.18	9.10	7.50
Hardness IRHD	57	57	68	69	75	75
Tensile Mpa	8.6	9.9	15.3	15.1	14.5	15.7
Elongation %	601	545	605	518	521	455
Compression %						
72 hrs. 23 C	10	10	11	11	11	10
24 hrs. 70 C	15	14	15	14	17	13
72 hrs. -10 C	18	18	21	21	23	20
Ageing hot air						
168 hrs. 70						
Hardness IRHD	58	57	69	69	75	75
Tensile Mpa	7.9	3.7	14.7	13.4	14.4	15.0
Elongation %	549	524	570	474	506	418
Stress relaxation %						
168 23 C	6	5	6	6	8	6

# Typical Recipes (EN 681.1 / BS 6920)

Ingredients	S9021	S9022
Keltan 8340A	100.0	100.0
ZnO activ	3.0	3.0
Staeric acid	0.3	0.3
Black N550	55.0	100.0
Whiting	35.0	50.0
BPH	0.5	0.5
Nyflex 820	65.0	65.0
CBS-80	1.88	1.88
TBzTD	1.0	1.0
CuDBP-50	0.5	0.5
S-80	1.63	1.63
Total	263.81	323.81

# Typical Recipes (EN 681.1 / BS 6920)

Properties	S9021	S9022
Mooney (ML 1+4) 100 C	43.69	65.52
Rheometer 180 C		
T2	1.06	0.9
T90	3.14	3.22
Hardness IRHD	56	70
Tensile strength Mpa	12.2	13.1
Elongation at break %	530	423
Hot air ageing 168 hrs. 70 C		
Hardness IRHD	57	72
Tensile strength Mpa	13.3	13.7
Elongation at break %	590	414
Compression set %		
70 hrs. 23 C	5	6
24 hrs. 70 C	13	11
72 hrs – 10 C	13	15
Stress relaxation %		
168 hrs. 23 C	6	6

# Typical Recipe (EN 681.1 / KTW 1.3.13 / W270)

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Ingredients	P-cure	S-cure
Keltan 2340A	100.0	100.0
ZnO active	3.0	3.0
Stearic acid	0.3	0.3
Durex O	80.0	20.0
FEF N550	-	15.0
Calcined clay	-	15.0
PIB	15.0	20.0
BPH	0.8	0.5
Peroxide 101-50	6.0	-
TAC-70	0.7	-
S-80	-	1.0
ZBEC-70	-	1.7
DTDC-80	-	1.2
<b>Total phr</b>	<b>205.8</b>	<b>178.4</b>

## Typical Recipe(EN681.1/KTW1.3.13/W270) Cont.

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Properties	P-cure	S-cure
Hardness IRHD	71	59
Tensile strength MPa	10.4	11.2
Elongation at Break %	341	599
Compression set		
24 hrs. 70 °C		19
72 hrs 23 °C	9	11
72 hrs -10 °C	20	20
Water swell		
Volume change %	1.5	2.0



# Literature

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- WRc-NSF: European Approval Systems (2001))
- UBA: Guidelines for the mathematical estimate of the migration of individual substances from organic materials in drinking water (2010)  
Guidelines for hygienic assessment of organic materials in contact with water (2011)
- BASF: Materials and Articles in contact with drinking water in the EU (2011)
- DSM: Keltan EPDM in potable water applications (Nordic Rubber Conference 1995)
- DSM: Keltec about EPDM in contact with potable and waste water (2005)
- Bayer; Rubber compounds for contact with water (1992)
- DVGW/Kraiburg/TZW: Bio-film on rubber material as cause of coliform contamination of drinking water (2004)



**Thank You  
for Your Attention**



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