Thioplast™ Polysulfides –
Resistive polymers for high-performance coatings & adhesives

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Thioplast

Nouryon

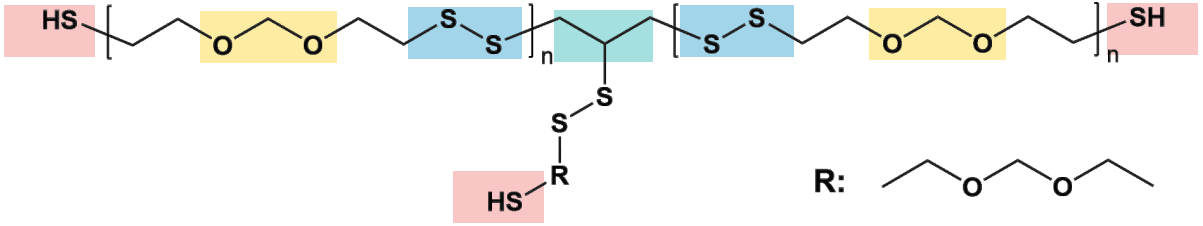
Thioplast™ Polysulfide Polymers

What are liquid polysulfide polymers?

- Liquid polysulfide polymers are versatile pre-polymer resins with water to honey-like viscosity
- Polysulfide polymers are available…
  - As SH-terminated grades (Thioplast™ **G** family)
  - As epoxy-terminated grades (Thioplast™ **EPS** family)
- Cured polysulfide polymers feature…
  - High chemical resistivity
  - Excellent gas barrier properties / low permeability
  - High weather resistance
  - (Low-temperature) flexibility
  - Crack-bridging ability

Thioplast™ Polysulfide Polymers

Thioplast™ G product family



- **Acetal groups** — Flexibilization of the polymer backbone; Working temperature: - 55°C – +120 °C
- **Disulfide linkages** — Exchange reactions; Stress relaxation; Chemical resistance against oils, fuels, bases, etc.
- **Trifunctional branching** — Increasing the structural toughness and strength
- **Mercaptan end groups** — Allow for crosslinking / polymerization via oxidation, NCO- and epoxy-curing; Highly reactive
- **No double / triple bonds** — High weathering-, ageing-, ozone-, UV- and O_2 stability
- **Availability** — Thioplast™ G is available in different grades with viscosities ranging from 1 Pas – 140 Pas

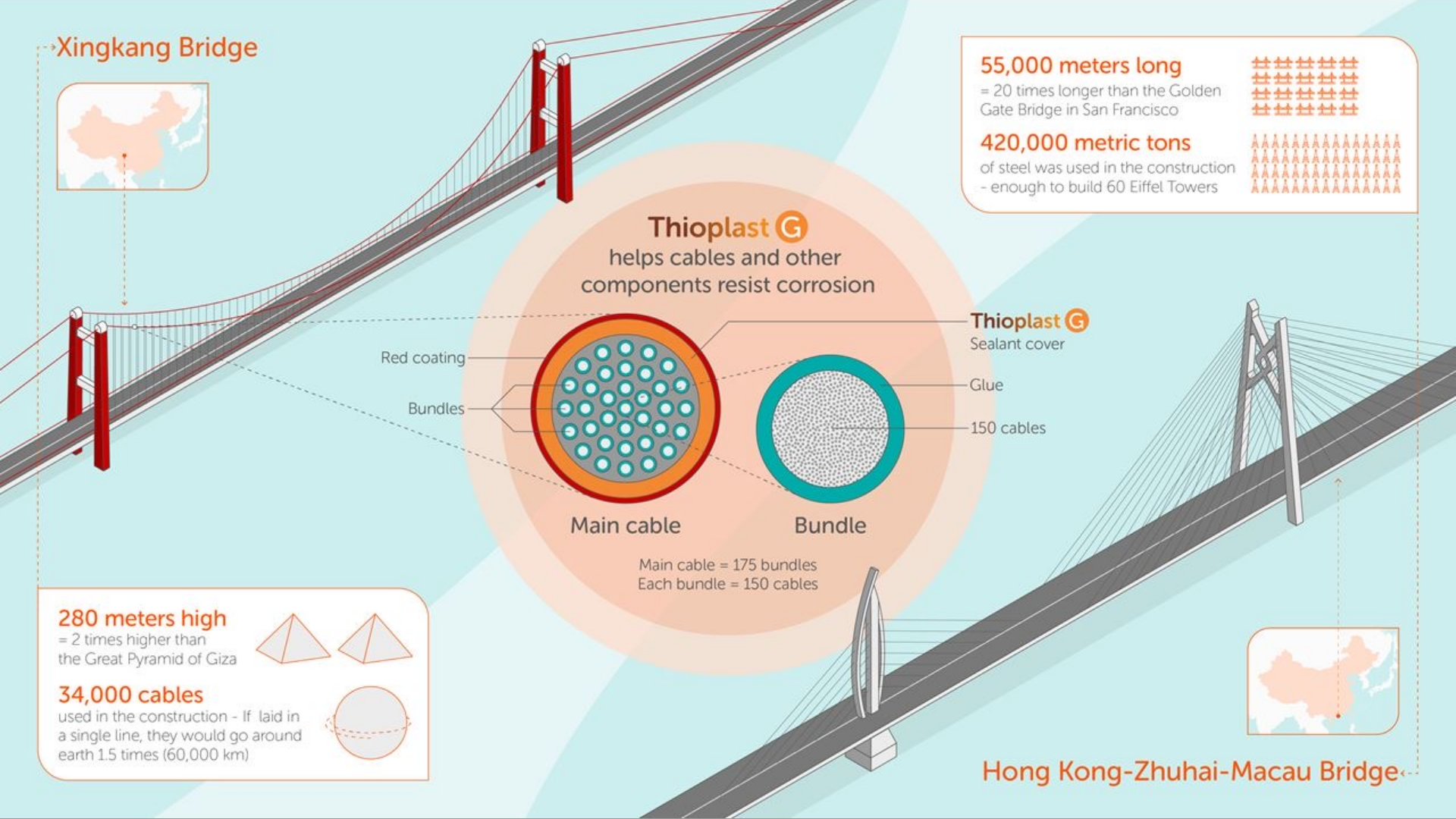
Thioplast™ Polysulfides in coatings – How Thioplast™ G helps to protect

Thioplast™ in specialty coatings

Application example: protective coatings

- Thioplast™ Polysulfides are used in high-performance coatings in demanding environments
- Here: protective cable coating for steel girder bridges
- Key benefits from Thioplast™ in this application: **Durability increased and maintenance costs lowered** by improved corrosion resistance, flexibility, weathering resistance (water, UV light) and crack-bridging-ability

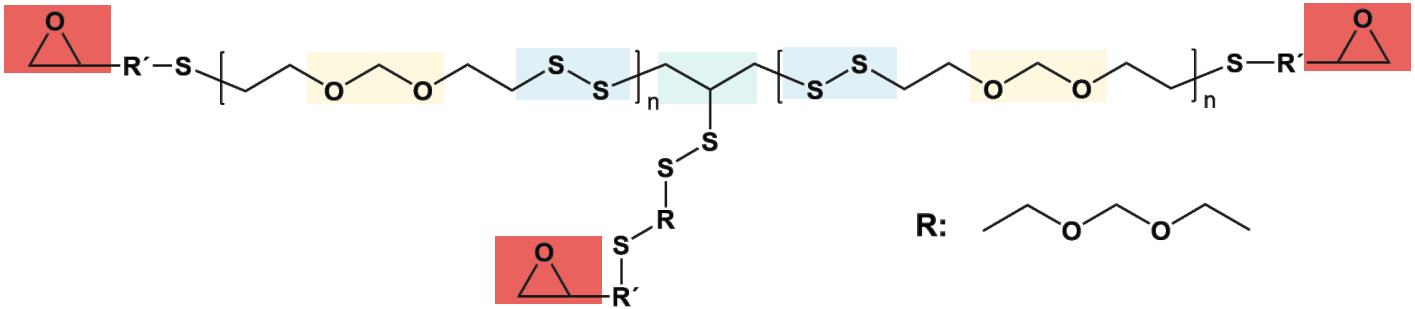
Hong Kong-Zhuhai-Macao Bridge. Cables protected with **Thioplast™** polysulfides.


Xingkang Bridge
55,000 meters long
= 20 times longer than the Golden Gate Bridge in San Francisco
420,000 metric tons
of steel was used in the construction - enough to build 60 Eiffel Towers
Thioplast G
helps cables and other components resist corrosion
Red coating
Bundles
Thioplast G
Sealant cover
Glue
150 cables
Main cable
Bundle
Main cable = 175 bundles
Each bundle = 150 cables
280 meters high
= 2 times higher than the Great Pyramid of Giza
34,000 cables
used in the construction - If laid in a single line, they would go around earth 1.5 times (60,000 km)
Hong Kong-Zhuhai-Macau Bridge

Thioplast™ EPS –
Introducing the all new „Thioplast™ EPS35“

Thioplast™ Polysulfide Polymers

Thioplast™ EPS product family



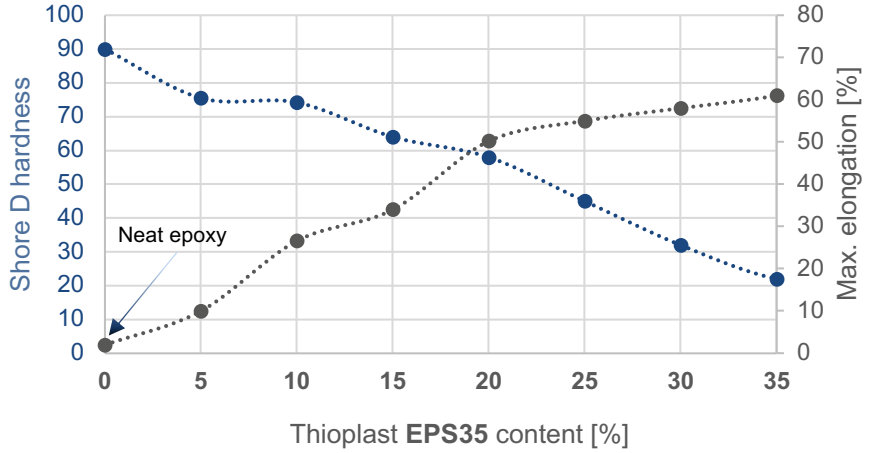
- **Epoxy end groups** — No mercaptan odor; Amine- or anhydride curable; Miscible with all standard epoxy resins
- **Hybrid polymer** — Epoxy-terminated Thioplast™ EPS polymers are hybrids that ideally combine chemical and physical performance of polysulfides with the strengths of epoxy resins
- **Aromatic / aliphatic** — Aromatic grade - EPS70 - for quick curing indoor applications; aliphatic grades - EPS25 & EPS35 - for outdoor applications
- **New & better** — The recently commercialized, best performing EPS grade, **“Thioplast™ EPS35”** is now available in China, Europe & USA!

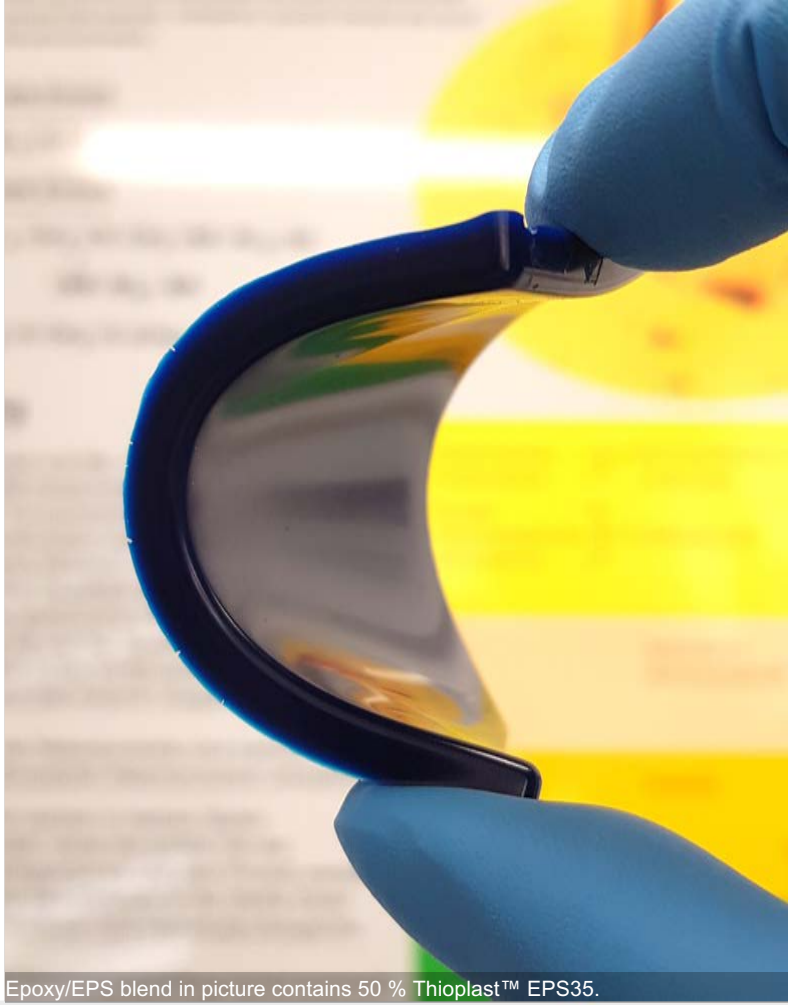
Thioplast™ EPS35 provides flexibility, low-temperature impact resistance, shear strength and chemical resistance for epoxy-based coatings and adhesives - in one product.

Thioplast™ EPS35
Flexibility

- Thioplast™ EPS35´s aliphatic polymer structure enables chain flexibility in the cured epoxy network
- Shore hardness and elongation become adjustable to coatings and adhesives applications

➢ <u>Epoxy coatings & adhesives become more flexible</u>





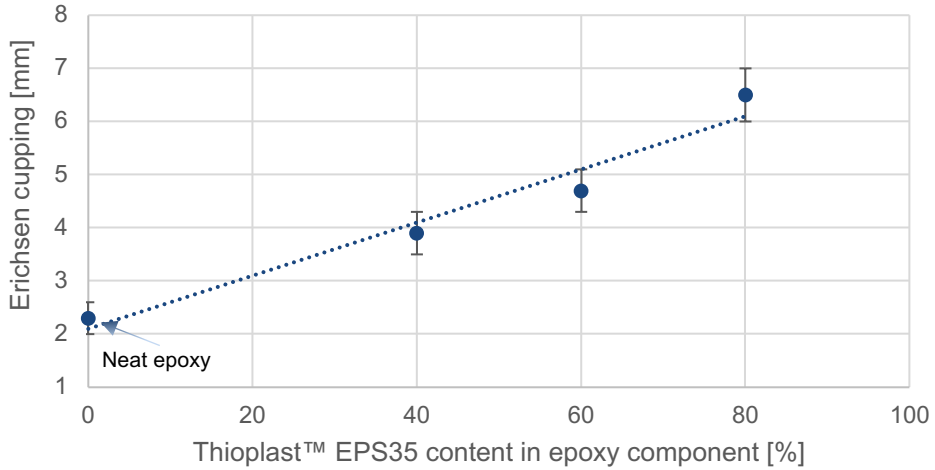
Epoxy/EPS blend in picture contains 50 % Thioplast™ EPS35.

 Tensile Strength Test performed acc. to DIN EN ISO 527

Thioplast™ EPS35
Crack resistance

- Thioplast™ EPS35´s flexible polymer backbone makes brittle epoxies softer
- Crack resistance can efficiently be improved

➢ <u>Epoxy coatings become tougher</u>




Pre-commercialization state: durable epoxy load bed coatings.

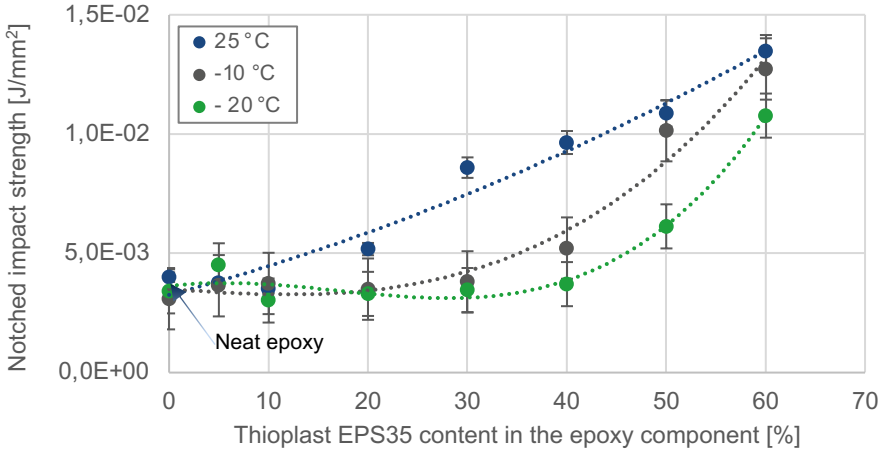
Erichsen cupping test performed by 3rd party institute „INNOVENT e. V.“ acc. to DIN EN 13523-6 test norm

Thioplast™ EPS35

Low-temperature impact resistance

- The flexible polymer structure of Thioplast™ EPS35 leads to a drastically improved impact resistivity of epoxy coatings
- Durability is improved and maintenance is lowered

➢ <u>Epoxy coatings become better in low-temperature conditions</u>




Potential application in low-temp. flexible and chemically resistive coatings.

12 Charpy impact resistance tests performed acc. to EN ISO 179 1 test norm

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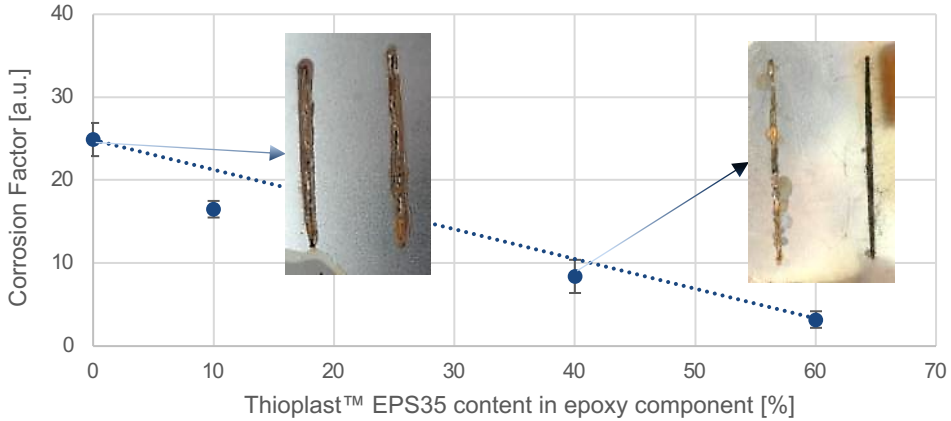
Thioplast™ EPS35
Anti-corrosion properties

- Thioplast™ EPS35 increases the adhesion to metal and concrete
- At the same time, flexibility and wettability are increased
- ➢ Anti-corrosion properties of epoxides are improved

- ➢ <u>Epoxy coatings become more resistive to offshore conditions</u>



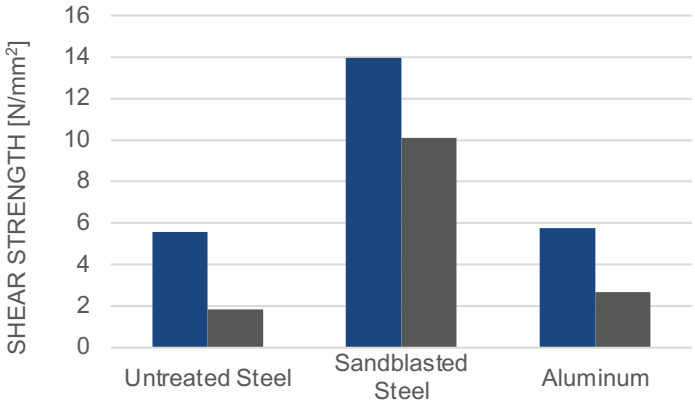

Potential application in corrosion resistant epoxy coatings.

Salt spray test performed by 3rd party institute „INNOVENT e. V.“ acc. to DIN EN ISO 9227:2006-10

Thioplast™ EPS35
Shear strength

- Even low amounts of Thioplast™ EPS35 improve the shear strength significantly and epoxy-based coatings and adhesive adhere better

➢ <u>Epoxy-based coatings become more reliable</u>



	Untreated Steel	Sandblasted Steel	Aluminum
24% Thioplast EPS 35	5,58	13,97	5,76
Neat Epoxide	1,85	10,11	2,68

Thioplast™ EPS is used in structural adhesives for the automotive industry.

14 Tensile Shear Test performed acc. to DIN EN 2830 Test Norm

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Thioplast™ EPS35
Chemical resistivity

- The sulfur in the polymer backbone increases the chemical resistivity of epoxides
- ➢ <u>Epoxy-based coatings become more resilient</u>

Days		1 2 3 4 5 6 7	8 9 10 11 12 13 14	15 16 17 18 19 20 21	22 23 24 25 26 27 28
Acetone	**EPS**				
	Epoxy				
Toluene	**EPS**				
	Epoxy				
Methanol	**EPS**	no alterations observed			
	Epoxy				
Diesel	**EPS**	no alterations observed			
	Epoxy	no alterations observed			
Benzene	**EPS**				
	Epoxy				
Acetic Acid (10%)	**EPS**				
	Epoxy				
Nitric Acid (20%)	**EPS**				
	Epoxy				
NaOH (50%)	**EPS**	no alterations observed			
	Epoxy	no alterations observed			
NH_3 (32%)	**EPS**	no alterations observed			
	Epoxy				

Thioplast™ EPS is used in oil and water tank coatings.

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Thioplast™ EPS35
Starting Formulation

	Formulation I	Formulation II	Formulation III	Formulation IV
Component A				
Thioplast™ EPS 35	10	20	30	40
Bisphenol A resin	65	55	45	35
Filler	20	20	20	20
Pigment	5	5	5	5
Total Component A	100	100	100	100
Component B				
Aradur 2964	31.4	26.7	23.3	20.6
Potting time @ 25°C [h]	>2	>2	>3	>3
Max. elongation [%]	27	50	59	66
Shore D after 21d @ r.t.	74	58	32	20
Strength @ break [N/mm2]	27	16	9	6

Softer & higher elongation

Picture of generic formulation. Thioplast™ EPS35 starting formulation visco.: 14-18 Pas.

Contact me for more information

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