Safe through the winter

Heat transfer fluids with frost protection are an important component in solar power systems and geothermal heat pump systems. Temperature resistance plays a major role for solar power systems, and for heat pumps the potential water hazard from leaks is just as important.

The technician should check the status of the heat transfer fluid once per year during maintenance of the solar power system.
PHOTO: SENTINEL

While solar power systems and heat pumps complement each other very well, both technologies also require a heat transfer fluid that is protected against freezing. In the case of solar power systems, there is the additional challenge of ensuring that the heat transfer fluid can withstand high temperatures. For most products, manufacturers use monopropylene glycol (MPG) as a component for frost protection in the aqueous solutions (see table on page 32). The substance, which boils at just under 190 °C, is considered to be stable at a constant temperature of 170° C, and can briefly be subjected to higher temperatures. Glycols that boil at higher temperatures are an alternative for solar power systems that are subjected to particularly high stagnation temperatures, such as systems with vacuum tube collectors. Some manufacturers use the substance di-propylene glycol, which boils at about 230 °C, others, like Climalife, use 1,3-propanediol, which boils at 213 °C. With these frost protection solutions, solar power systems are expected to withstand short-term temperatures of up to 260 °C, as the manufacturer Aqua-Concept states for its Coracon Sol 5 HF. None of these glycols are considered harmful to health, and are grouped in water hazard class 1. Di-propylene glycol is also added to cosmetic products. The 1,3-propanediol that Climalife uses in its products is obtained from renewable raw materials. Other manufacturers also offer this particularly environmentally friendly option.

Even though modern products are designed for high temperatures, heat transfer fluids should generally undergo thermal stress as briefly as possible in order to achieve a long service life. This is the only way to prevent so-called glycol cracking, which in extreme cases can lead to lumpy residues that clog the system. For this reason, solar power systems should be designed to empty well. With these systems, evaporation of the heat transfer fluid as stagnation sets in causes the fluid to be quickly pressed out of the collectors and then protected. It is not just the temperature resistance of glycol that is important. Also important are the additives to the heat transfer fluid for preventing corrosion of the pipes and for neutralising the acidic degradation products of glycol. If these additives remain as solid residues in the collectors during evaporation, they will be exposed to the full force of the solar energy. Additives that evaporate together with the other constituents are better protected. Independent tests carried out by the SPF Institute of Solar Technology provide the best substantiation of these products' properties. For example, Clariant has had its new product Antifrogen Solar intensively tested by the SPF with regard to the requirements of solar power systems. Antifrogen Solar is a heat transfer fluid based on monopropylene glycol and is available as a prepared mixture or as a concentrate.

Hot heat transfer fluids also have a different effect on solar circulation system seals than hot water does. For example, the manufacturer Tyforop Chemie states in the Tyfocor LS data sheet that the seals made of EPDM 281, AFM 34, or Centellen 3820, which are often used in solar power systems, are resistant. The suitability of the pressure equalization vessel membrane should always be checked, because the properties of the membrane not only depend on the outlet rubber, but also on the respective production conditions.

Heat transfer fluids for solar heating systems

Manufacturer	Product	Antifreeze	Delivery form	Suitable collector types	Suitable materials	Minimum temperature [°C]	Density [g/cm³] [1]	Refraction index
Aqua-Concept	Coracon Sol 5	MPG	concentrate	FPC, ETC (HP)	Al/Cu/VA	-	1.045	n/a
	Coracon Sol 5F	MPG	ready mixed	FPC, ETC, (HP)	Al/Cu/VA	-28 [5]	1.036	n/a
	Coracon Sol 5 HF	diropylene glycol	ready mixed	FPC, ETC, (HP, DF)	Al/Cu/VA	-24 [5]	1.03	n/a
	Coracon Sol EKO	MPG (RRM)	concentrate	FPC, ETC, (HP, DF)	Al/Cu/VA	-	1.055	n/a
	Coracon Sol EKO F	MPG (RRM)	ready mixed	FPC, ETC, (HP, DF)	Al/Cu/VA	-23 [5]	1.05	n/a
Clariant	Antifrogen Sol HT	high boiling glycols	ready mixed	FPC, ETC, (HP, DF)	Al/Cu/VA	-23	approx. 1.082	approx. 1.401
	Antifrogen Sol HT Conc.	high boiling glycols	concentrate	FPC, ETC, (HP, DF)	Al/Cu/VA	-	approx. 1.13	approx. 1.46
	Antifrogen Solar Conc.	MPG	concentrate	FPC, (HP)	n/a	-	1.043	1.432
	Antifrogen Solar	MPG	ready mixed	FPC, (HP)	n/a	-28	1.038	1.386
Climalife	Solufluid Solar -25 °C	MPG	ready mixed	FPC, ETC, (HP)	Al/Cu/VA	-25	n/a	1.382
	Greenway Neo Solar -30 °C	1,3-propanediol (RRM)	ready mixed	FPC, ETC, (HP, DF)	Al/Cu/VA	-30	n/a	1.389
	Greenway Neo Solar -25 °C	1,3-propanediol (RRM)	ready mixed	FPC, ETC, (HP, DF)	Al/Cu/VA	-25	n/a	n/a
	Greenway Neo	1,3-propanediol (RRM)	concentrate	FPC, ETC, (HP, DF)	Al/Cu/VA	-	1.06	n/a
Fragol	Zitrec LC	MPG	concentrate	FPC	Al/Cu/VA	-50	1.05	1.389
	Zitrec L-25	MPG	ready mixed	FPC	Al/Cu/VA	-25	1.036	1.378
	Fragoltherm W-PGA	MPG	concentrate	FPC	Al/Cu/VA	-50	1.05	1.378
	Fragoltherm W-VR	MPG	ready mixed	ETC	Cu/VA	-28	1.034	1.382
GHC Gerling, Holz & Co.	Coolex L	MPG	concentrate/ ready mixed [7]	FPC, ETC	Al/Cu/VA	-28	1.038	1.388
Pro Kühlsole	Pekasolar 100	MPG	concentrate	FPC, ETC	Al/Cu/VA	-50	1.046	1.431
	Pekasolar 50	MPG	ready mixed	FPC, ETC	Al/Cu/VA	-28	1.04	1.384
Sentinel	R100	MPG	ready mixed	FPC, ETC	Al/Cu/VA	-25	1.04	1.380 up to 1.384
Staub & Co. – Silbermann	Solarliquid L	MPG	concentrate	FPC, ETC	Al/Cu/VA	-	approx. 1.045	approx. 1.435
	Solarliquid L -28 °C	MPG	ready mixed	FPC, ETC	Al/Cu/VA	-28	approx. 1.04	approx. 1.445
	Solarliquid L -22 °C	MPG	ready mixed	FPC, ETC	Al/Cu/VA	-22	approx. 1.037	approx. 1.383
	Solarliquid HT	high boiling glycols	ready mixed	FPC, ETC	Cu/VA	-24	approx. 1.03	approx. 1.400
Thermochema	Powercool DC924-PXL	MPG	concentrate	FPC, ETC (HP)	Al/Cu/VA	-50	1.05	1.378 [8]
	HT-Solar fluid DC923-H	MPG	ready mixed	ETC, FPC	Cu/VA	-28	1.034	1,38
Tyforop	Tyfocor L	MPG	concentrate [2]	FPC	Al/Cu/VA	-50	1.039 [8]	1.3792 [8]
	Tyfocor L-eco	MPG (RRM)	concentrate [2]	FPC	Al/Cu/VA	-50	1.039 [8]	1.3792 [8]
	Tyfocor HTL	MPG, high boiling glycols	ready mixed	ETC, (FPC) [4]	Al/Cu/VA	-35	1.054	1.394
	Tyfocor LS	MPG	ready mixed	ETC, (FPC) [4]	Cu/VA	-28	1.034	1.382
	Tyfocor LS Arctic	MPG	ready mixed	ETC, (FPC) [4]	Cu/VA	-47	1.039	1.393
	Tyfocor LS Mediterraneo	MPG	ready mixed	ETC, (FPC) [4]	Cu/VA	-12	1.02	1.361
	Tyfocor G-LS	MPG	ready mixed	ETC, (FPC) [4]	Cu/VA	-28	1.034	1.382
Wittig Umweltchemie	Glysofor Solar	MPG, high boiling glycols	concentrate (20) [2]	FPC, ETC	Al/Cu/VA	-50	1.04	1.433
	Glysofor Solar AF	MPG, high boiling glycols	ready mixed	FPC, ETC	Al/Cu/VA	-28	1.02	1.389
	Glysofor Solar HT	MPG, high boiling glycols	ready mixed	FPC, ETC	Al/Cu/VA	-28	1.02	1.386

Abbreviations: FPC = flate plate collector; ETC = evacuated tube collector; HP = heat pipe; DF = direct flow; Al = aluminium; Cu = copper; VA = stainless steel; MPG = monopropylene glycol; n/r = not recommended; RRM = gained from renewable raw materials; IBC = Intermediate Bulk Container

Footnotes: 1) at 20 °C; 2) minimum concentration 40 %; 3) for concentration 50 %; 4) developed for ETC; 5) for flocculation point; 6) first flocculation point, second solidifying point; 7) for concentration 47 %; 8) for concentration 40 %

SOURCE: COMPANY DATA

	pH-value [1]	Buffer alkalinity [ml 0.1 N HCl]	Mixable
	approx. 8	approx. 9 [7]	MPG (n/r)
	approx. 8	approx. 9	MPG (n/r)
	approx. 8	approx. 9	n/a
	approx. 8	approx. 9 [7]	n/a
	approx. 8	approx. 9	n/a
	approx. 9	≥ 4	n/a
	approx. 9	≥ 8.5	n/a
	8.0 up to 9.5	≥ 4	n/a
	8.0 up to 9.5	≥ 2.1	n/a
	7.5 up to 9	≥ 3	no
	8 up to 8.4	≥ 4	no
	8 up to 8.4	≥ 4	no
	8.3 up to 8.8 [3]	≥ 4	yes
	7.5 up to 8.5	n/a	MPG (n/r)
	approx. 8	n/a	MPG (n/r)
	7.5 up to 9.5	n/a	n.e.
	9	> 20	n.e.
	approx. 8	approx. 2.2	MPG
	9	4	yes
	9	2	yes
	8.35	7.7	yes
	7.5 up to 8.5	approx. 19	MPG
	approx. 8	approx. 9.5	MPG
	approx. 8	approx. 9.5	MPG
	7.5 up to 8.5	approx. 9.5	n/a
	8.6	> 6	Gelbin DC924-L
	approx. 9	> 20	Powercool DC924-PXL
	7.5 up to 8.5 [8]	> 5 [8]	Tyfocor L-eco, others n/r
	7.5 up to 8.5 [8]	> 4 [8]	Tyfocor L, others n/r
	7.5 up to 8.5	> 9	no
	9.0 up to 10.5	> 20	LS Arctic, LS Mediterraneo, Tyfocor G-LS
	9.0 up to 10.5	> 25	TyfocorLS, LS Mediterraneo, Tyfocor G-LS
	9.0 up to 10.5	> 12	Tyfocor LS, LS Arctic, Tyfocor G-LS
	9.0 up to 10.5	> 20	Tyfocor LS, LS Arctic, LS Mediterraneo
	7 up to 8	3	MPG
	7 up to 8	3	MPG
	7 up to 8	3	no

Alternatives to glycol

The temperature resistance is not important for the heat transfer fluids of geothermal heat pumps, because the ground collector circuit does not become warmer than 30 °C. Thus, glycols that boil at higher temperatures are not necessary for this application. The manufacturers often use monopropylene glycol for heat pumps. Monoethylene glycol (MEG) is the alternative in this case. Although MEG is harmful to humans, there is no difference to MPG because it is also a water hazard class 1 substance. In addition to glycol-containing fluids, manufacturers also offer heat transfer fluids based on ethanol, alkali carbonates, and alkali formates. The German Working Group on water issues of the Federal States and the Federal Government (LAWA) has formulated water management recommendations for geothermal probes and geothermal heat collectors, and publishes a table of water hazard class 1 products that can be used in geothermal heating circuits. LAWA does not list potassium carbonate because it is "very easily soluble in water and has a strongly alkaline reaction." Furthermore, the soil's natural potassium content is quite low. Ethanol also does not fulfil the LAWA recommendation criteria. However, it is comparable to the LAWA recommendations with regard to water hazard potential, which is why there are two fluids based on ethanol in the LAWA list.

Ronald Klukas, Manager at Aqua-Concept, definitely sees advantages to ethanol and salt solutions: "These fluids have good heat transfer values and low viscosities." On the other hand, Markus Hafner, Branch Manager of GHC Gerling, Holz & Co. Handels GmbH, has a more critical view of ethanol: "It often makes no sense to use ethanol-based heat transfer fluids, because it generally entails high investments for explosion protection. Some breweries are currently using these fluids. Other applications are rare." Aqueous salt solutions are not the preferred choice for geothermal probes or geothermal heat collectors. They are generally used when there is a requirement for temperatures below -30 °C. A further advantage of the salt solutions is that they are not combustible. "However, care must be taken to ensure that the installation does not undergo continuous oxygenation, and that the fluid has good corrosion inhibitors," said Hafner.

Heat transfer fluids for geothermal energy

Manufacturer	Product	Antifreeze	Delivery form	Minimum concentration [Vol %] [1]	Tmin [°C] [2]	Classification according GHS [2]	Density [g/cm³] [2,3]
Aqua-Concept	Coracon KS 6	MEG	concentrate	25	-13	GHS08	1.045
	Coracon KS 6 F-13	MEG	ready mixed	-	-13	GHS07, GHS08	1.055
	Coracon WT 6N	MEG	concentrate	25	-11	GHS07, GHS08	1.044
	Coracon WT 6N F-20	MEG	ready mixed	-	-20	GHS07, GHS08	1.068
	Coracon WT 6P	MPG	concentrate	25	-13	none	1.026
	Coracon WT 6P F-20	MPG	ready mixed	-	-20	none	1.038
	Coracon GEKO N	MEG	concentrate	10	-5	GHS07, GHS08	1.018
	Coracon GEKO EF-10	MPG (RRM)	ready mixed	-	-10	none	1.037
	Coracon GEKO AF-8	ethanol	ready mixed	-	-8	none	0.98
	Coracon Geko W	none	ready mixed		0	none	1
Carl Dicke	CD-Geotherm N	MEG	concentrate	25	n/a	GHS07, GHS08	1.11
Clariant	Antifrogen N	MEG	concentrate/ ready mixed	20	-10	n/a	1.033
	Antifrogen L	MPG	concentrate/ ready mixed	25	-10	none	1.028
	Protectogen N ECO	MEG	concentrate/ ready mixed	20	-8	n/a	1.024
	Protectogen L ECO	MPG	concentrate/ ready mixed	25	-9	none	1.018
	Antifrogen GEO Blue	MEG	concentrate/ ready mixed	25	-10	n/a	1.029
Climalife	Solufluid Heat Pump -25 °C	MPG	ready mixed	-	-25	none	1.04
	Greenway Neo Heat pump -30 °C	1,3-propanediol (RRM)	ready mixed	-	-30	none	1.05
	Greenway Neo Heat pump -25 °C	1,3-propanediol (RRM)	ready mixed	-	-25	n/a	1.047
	Greenway Neo	1,3-propanediol (RRM)	concentrate	n/a	n/a	n/a	n/a
Fragol	Zitrec MC	MEG	concentrate	n/a	-	GHS07, GHS08	n/a
	Zitrec M-05	MEG	ready mixed	-	-5	GHS07, GHS08	1.017
	Zitrec M-10	MEG	ready mixed	-	-10	GHS07, GHS08	1.027
	Zitrec M-15	MEG	ready mixed	-	-15	GHS07, GHS08	1.04
	Zitrec M-20	MEG	ready mixed	-	-20	GHS07, GHS08	1.049
	Zitrec M-25	MEG	ready mixed	-	-25	GHS07, GHS08	1.054
	Zitrec M-35	MEG	ready mixed	-	-35	GHS07, GHS08	1.066
	Fragoltherm W-ECO	MEG	concentrate	-	-15	GHS07, GHS08	1.04
	Fragoltherm W-ECO-20	MEG	ready mixed	-	-20	GHS07, GHS08	1.049
	Zitrec LC	MPG	concentrate	-	-15	none	1.028
	Zitrec L-20	MPG	ready mixed	-	-20	none	1.034
GHC Gerling, Holz & Co.	Coolex N	MEG	concentrate/ready mixed	20	-10	GHS07, GHS08	1.033
	Coolex L	MPG	concentrate/ready mixed	25	-10	none	1.028
Pro Kühlsole	Glykosol N	MEG	concentrate/ready mixed	-	-8	GHS07	1.036
	Pekasol L	MPG	concentrate/ready mixed	-	-6	none	1.017 [4]
	Pekasol 2000	organic salt solution	concentrate/ready mixed	32	-10	none	1.111
Staub & Co. - Silbermann	Kühlsolekonzentrat N	MEG	concentrate	20	-9	GHS07, GHS08	approx. 1.037
	Kühlsolekonzentrat Spezial VA	MPG	concentrate	20	-6	none	approx. 1.022
	Kühlsolekonzentrat N-GEO	MEG	concentrate	20	-8	GHS07, GHS08	approx. 1.109
	Kühlsolekonzentrat Spezial-GEO	MPG	concentrate	20	-7	none	approx. 1.042
	Staubcosol BE -10 °C	ethanol	ready mixed	-	-10	none	approx. 0.970
	Staubcosol BE -8 °C	ethanol	ready mixed	-	-8	none	approx. 0.975
Tyforop	Tyfocor	MEG	concentrate	20	-9	GHS07, GHS08	1.035
	Tyfocor GE	MEG	concentrate	20	-8	GHS07, GHS08	1.034
	Tyfo Spezial	potassium carbonate	ready mixed	100	-13	GHS07	1.274
Wittig Umweltchemie	Glysofor N	MEG	concentrate	20	-10	GHS08	1.037
	Glysofor L	MPG	concentrate	25	-10	none	1.035
	Glysofor TERRA	MEG	concentrate	20	-10	GHS08	1.037
	Glysofor EVO N	MEG	concentrate	20	-10	GHS08	1.037
	Glysofor EVO L	MPG	concentrate	25	-10	none	1.035
	Glysofor CARBO	alkali carbonate	ready mixed	-	-12	GHS05, GHS07	1.25

Abbreviations: MPG = mono propylenglycol; MEG = mono ethylenglycol; GHS = globally harmonized system of classification and labelling of chemiclas; GHS 08 = health risks; GHS 07 = acute toxicity; GHS 05 = corrosive; RRM = gained from renewable raw materials

	Refraction index [2]	pH-value [2,3]	Specific thermal capacity [kJ/kgK] [2,3]	Buffer alkalinity [ml 0,1 N HCl]	Mixable	Dynamic viscosity [mPa*s] [3]
	n/a	8.0 up to 8.5	3.73	n/a	n/a	n/a
	n/a	8.0 up to 8.5	3.62	n/a	n/a	n/a
	n/a	8.0 up to 8.5	3.74	n/a	n/a	n/a
	n/a	8.0 up to 8.5	3.48	n/a	n/a	n/a
	n/a	8.0 up to 8.5	3.92	n/a	n/a	n/a
	n/a	8.0 up to 8.5	3.75	n/a	n/a	n/a
	n/a	8.0 up to 8.5	4.03	n/a	n/a	n/a
	n/a	8.0 up to 8.5	3.87	n/a	n/a	n/a
	n/a	8.0 up to 8.5	3.83	n/a	n/a	n/a
	n/a	n/a	n/a	n/a	n/a	n/a
	n/a	8	n/a	n/a	water	n/a
	1.357	7.4 up to 8.0	3.9	≥ 4	n/a	3.59
	1.362	8.0 up to 9.0	3.9	≥ 4	n/a	5.95
	1.352	7.0 up to 8.5	3.9	≥ 1.6	n/a	n/a
	1.359	7.5 up to 9.5	3.9	≥ 2.3	n/a	n/a
	1.356	7.0 up to 8.5	3.9	≥ 1.5	n/a	n/a
	1.382	7.5 up to 9	3.59	≥ 3	n/a	15.7
	1.389	8 up to 8.4	3.16	≥ 4	n/a	14.175
	n/a	8 up to 8.4	3.23	≥ 4	n/a	12.18
	n/a	8.3 up to 8.8 [6]	n/a	≥ 4	yes	n/a
	n/a	8.8 up to 9.0	n/a	n/a	MEG (conditional)	
	1.347	8.3 up to 8.6	4.01	n/a	MEG (conditional)	2.77
	1.368	8.3 up to 8.6	3.98	n/a	MEG (conditional)	3.51
	1.361	8.3 up to 8.6	3.87	n/a	MEG (conditional)	4.41
	1.368	8.3 up to 8.6	3.74	n/a	MEG (conditional)	5.72
	1.373	8.3 up to 8.6	3.6	n/a	MEG (conditional)	7.04
	1.382	8.3 up to 8.6	3.36	n/a	MEG (conditional)	9.66
	1.361	8.7 up to 8.8	3.85	n/a	MEG (conditional)	n/a
	1.368	8.3 up to 8.6	3.72	n/a	MEG (conditional)	5.79
	1.349	8.8 up to 9.0	4.05	n/a	MEG (conditional)	n/a
	1.378	8.4 up to 8.6	3.73	n/a	MEG (conditional)	12.84
	1.354	7.5 up to 8.5	3.8	approx. 4.5	n/a	3.5
	1.363	7.5 up to 8.5	3.7	approx. 4.5	n/a	6
	1.433 up to 1.435	8 up to 10	3.88	> 20	n/a	n/a
	1.435 up to 1.436	8 up to 10	3.39 [5]	n/a	n/a	n/a
	-	8 up to 9	3.41	-	Pekasol 50 (conditional)	n/a
	n/a	7.5 up to 8.5	approx. 3.88	n/a	MEG	n/a
	n/a	7.5 up to 8.5	approx. 4.00	n/a	MPG	n/a
	n/a	7.5 up to 8.5	n/a	n/a	MEG	n/a
	n/a	7.5 up to 8.5	n/a	n/a	MPG	n/a
	1.342 up to 1.350	7.5 up to 8.5	n/a	approx. 0.4	no	n/a
	1.340 up to 1.348	7.5 up to 8.5	n/a	approx. 0.4	no	n/a
	1.3545	> 8	3.91	> 10	Tyfocor GE	3.47
	1.3545	> 8	3.92	> 5.5	Tyfocor	3.4
	n/a	> 10	3.02	n/a	no	3.69
	n/a	7 up to 8	3.85	> 3	MEG	n/a
	n/a	7 up to 8	3.95	> 3	MPG	n/a
	n/a	7 up to 8	3.85	> 3	MEG	n/a
	n/a	7 up to 8	3.85	> 3	MEG	n/a
	n/a	7 up to 8	3.95	> 3	MPG	n/a
	-	11	n/a	n/a	water	n/a

Footnotes: 1) only for concentrates; 2) for minimum concentration; 3) at 0 °C; 4) at 20 °C, 5) for concentration 27 %; 6) for concentration 27 %

SOURCE: COMPANY DATA

The new fluid does not endanger groundwater

Klukas has identified another aspect of ethanol: it is possible to use bio-ethanols from renewable raw materials, "which are very favourable in terms of the overall CO_2 assessment due to the low CO_2 emissions during the manufacturing process." This also applies to organic glycols from renewable raw materials. Aqua-Concept is currently working to make their products and production CO_2-neutral. The company has also launched a new product this year, Coracon Geko W, which is not hazardous for water. "Coracon Geko W is of particular use if the authorities have prohibited products with a water hazard class of 1 or higher," Klukas stated. Gernot Krakat, responsible for the sale of heat transfer fluids at Fragol, confirms that there are "more frequent inquiries about fluids for use in water protection areas".

However, since Coracon Geko W does not contain frost protection, it must be ensured that the entire ground circuit and the system's supply lines will not freeze. This should not be a problem, given well designed probes and supply lines situated deep in the ground. Solar power systems can also be operated without frost protection, as is evident from the Aqua-System from Paradigma. However, during cold nights heat must be actively pumped through the solar circulation system in order to prevent freezing.

Many heat transfer fluids only contain additives classified as water hazard class 1, but some have constituents that are classified as water hazard class 2 or 3. And yet, Ronald Klukas observes that the water hazard class is not a factor in the sale, because the sale is only made based on the price. Nevertheless, he sees a trend towards products with very good biodegradability and the use of environmentally friendly glycols. Moreover, most current products only have frost protection of -8 °C to -10 °C. This is a great advantage for the environment, since the hazard potential is significantly lower due to the low glycol content. Since the viscosity is lower in comparison to higher frost protection solutions, a smaller circulating pump can also be used to save on electricity, depending on the system design.

The entire industry is now facing the price pressure. The assessment is that low-cost suppliers are drawing prices down with products of inferior quality. "Quality doesn't seem to have any meaning at this point. Unfortunately, the cheapest fluid wins," said Markus Hafner of GHC Gerling, Holz & Co.

Jens-Peter Meyer