

Antifrogen® – The Heat Transfer Fluid **FROST AND CORROSION PROTECTION**

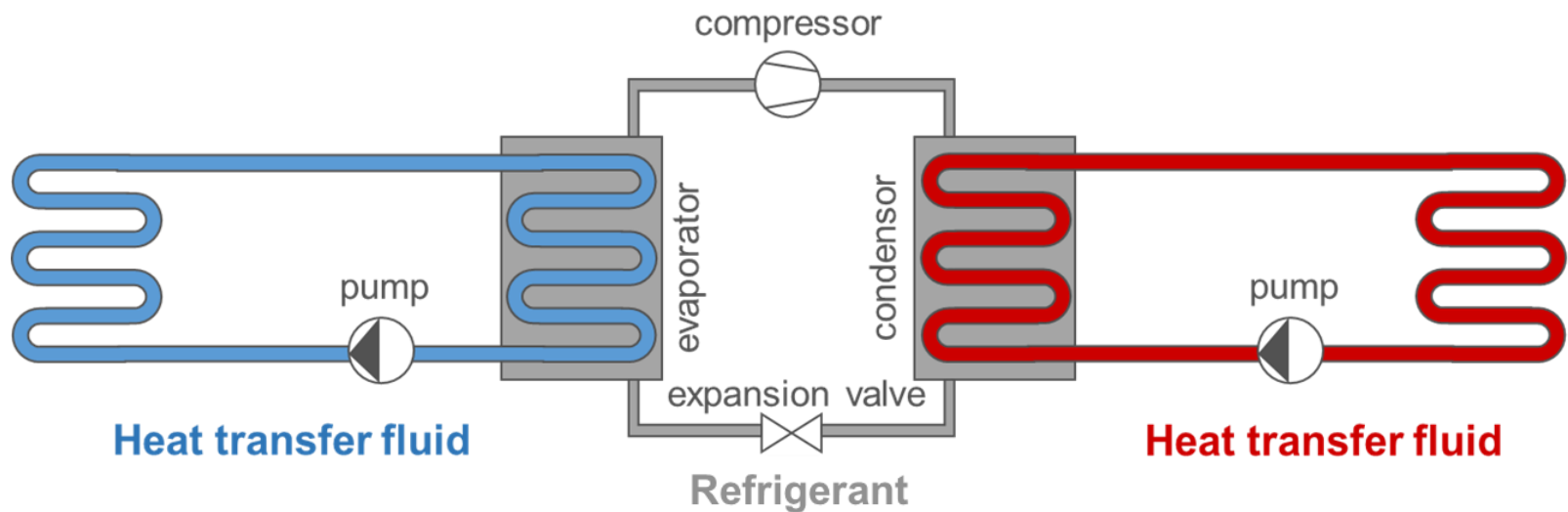
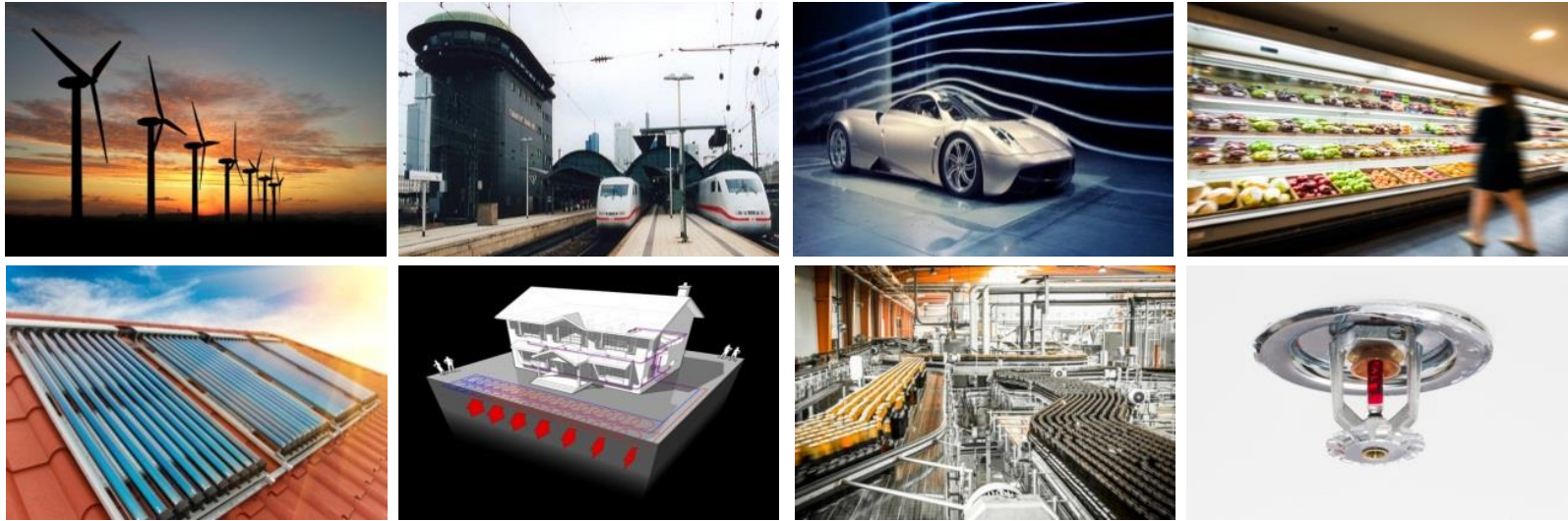


Public

Clariant Heat Transfer Fluids

what is precious to you?

Heat transfer fluids – General aspects



Heat transfer fluids – General aspects

Required to provide:



Heat Transfer



Frost Protection



Corrosion Protection



Compatibility with Sealings



Be relatively non-flammable
and non-toxic

Heat transfer fluids – General aspects

Water is by far the best heat transfer fluid:

specific heat capacity of water: **4.2 kJ/(kgK)**

.....but has some significant disadvantages as well!

Burst effect



Corrosion



Antifrogen[®] products reliably compensate those disadvantages!

Heat transfer fluids – Composition

Clariant heat transfer fluids contain:

1. Freezing point depressants

- Glycols, organic salts

2. Corrosion inhibitor package

- Several inhibitors (OAT technology) – dedicated to each metal

3. Additives to ensure a sufficient reserve alkalinity

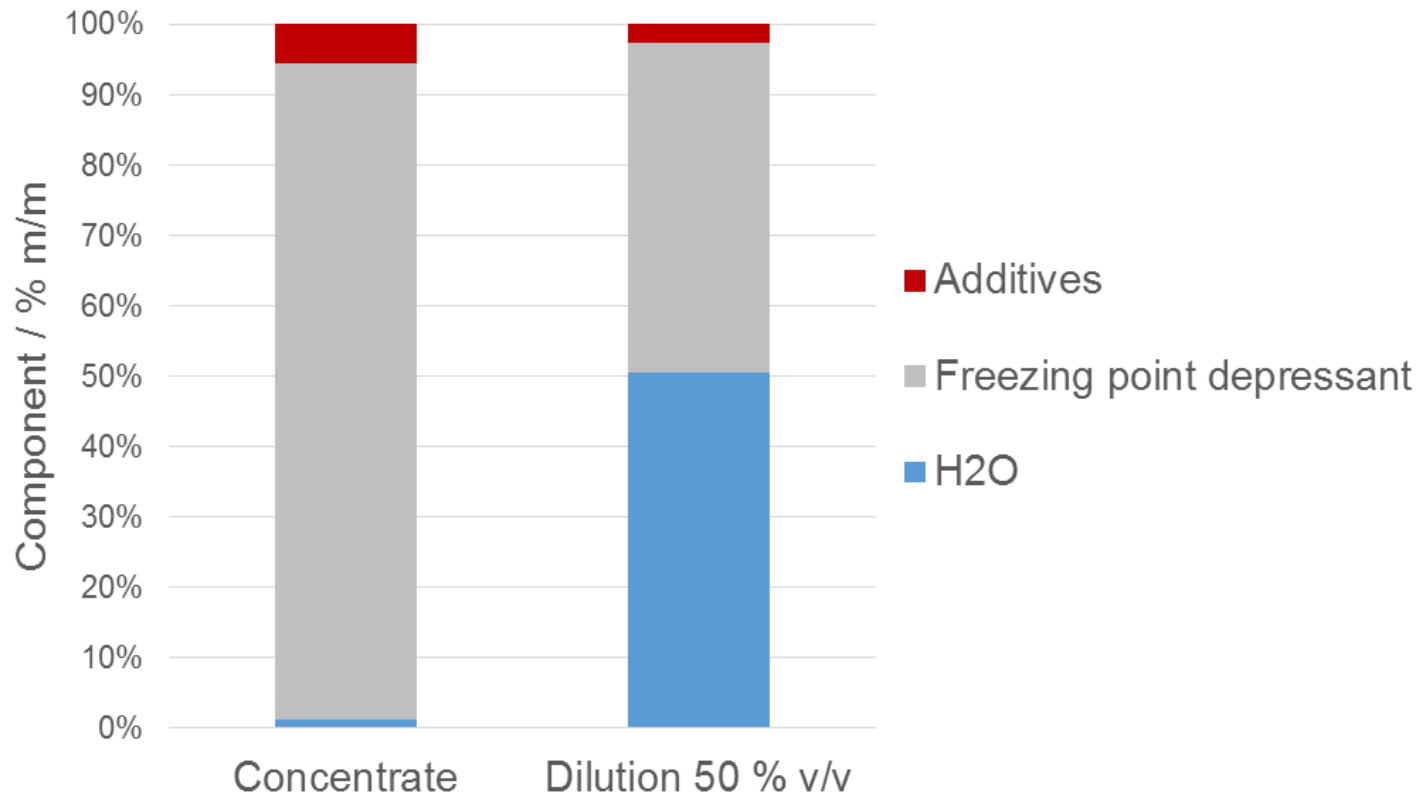
- Ensure that pH stays in basic range (buffer)

4. Defoamers

5. Dyes

Heat transfer fluids – Composition

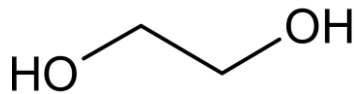
Composition of glycol based fluids (example)



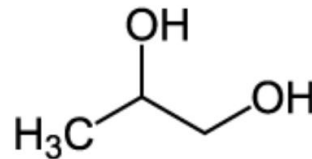
Heat transfer fluids – Physical properties

- The *physical properties* of water-based heat transfer fluids, e.g.
 - Frost resistance
 - Specific heat capacity
 - Kinematic viscosity

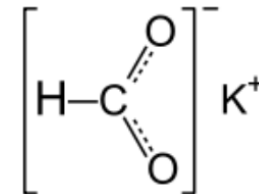
are mainly a result of which kind and amount of glycols / organic salt is used!



Monoethylene glycol
(MEG)



Monopropylene glycol
(MPG)



Potassium formate
(KF)

Heat transfer fluids – Corrosion inhibition

- Remarkable differences between heat transfer fluids on the market are observed regarding their material compatibilities!

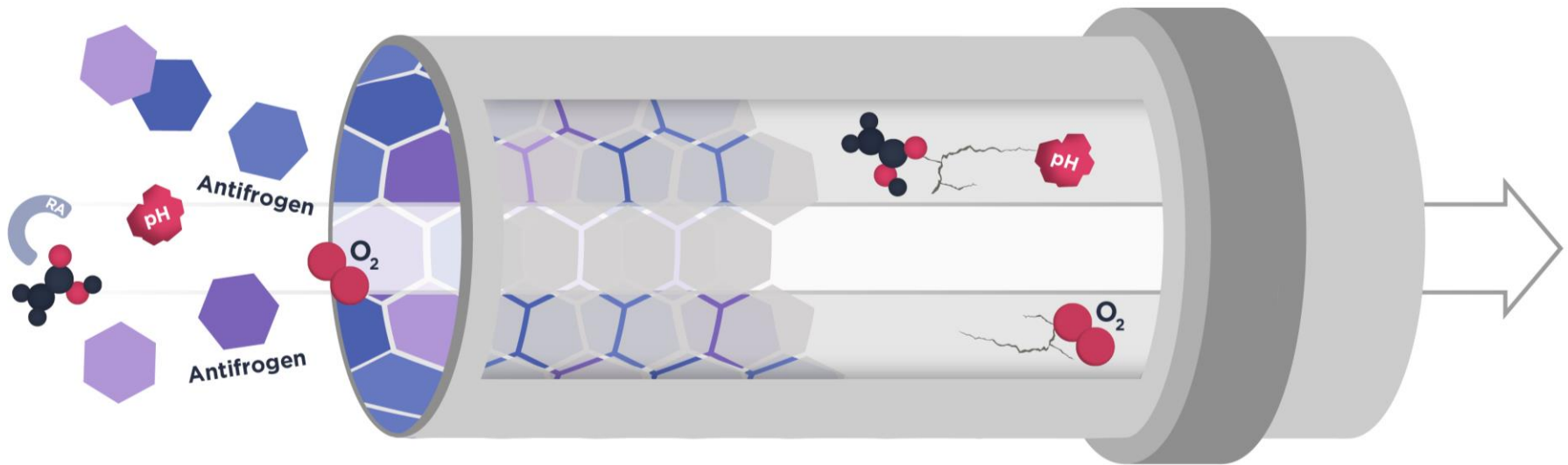


Especially regarding the **corrosion inhibition**



Principles of corrosion protection

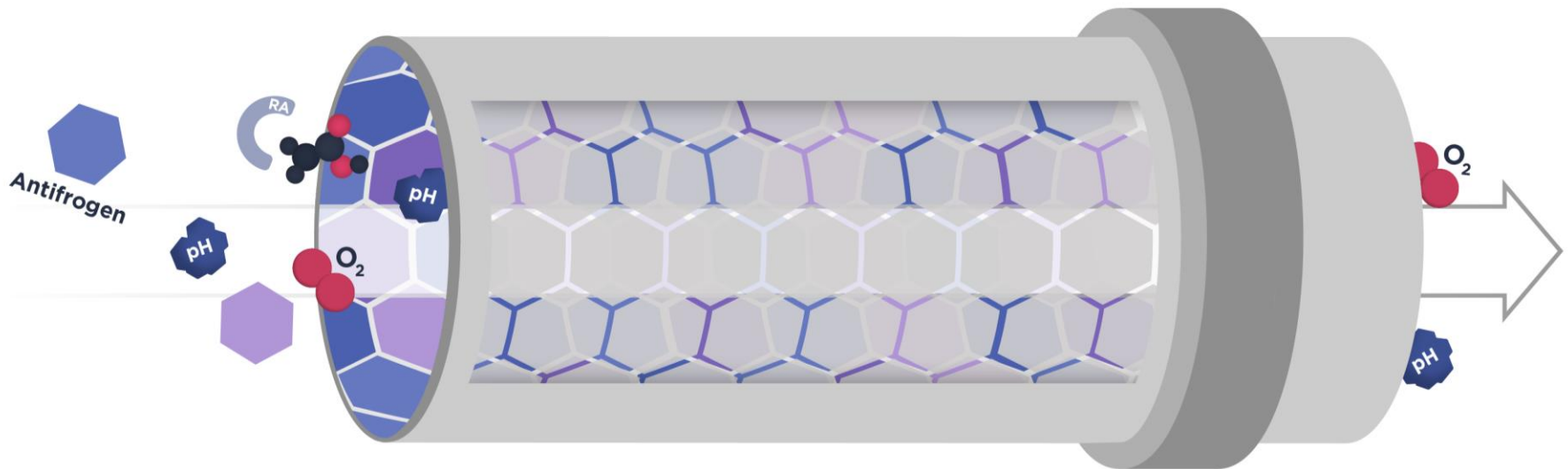
Antifrogen®: Outstanding corrosion protection



Oxygen and **acids** are dangerously corrosive, especially for metallic linings inside pipe systems. They can **attack surfaces** and lead to uncontrolled rusting. Massive damages to systems can result, often within a short time.

Principles of corrosion protection

Antifrogen®: Outstanding corrosion protection



Antifrogen® corrosion inhibitors cover the inside of the pipe surface and form a very **thin film** that provides effective protection against corrosion. Unprotected sites are quickly closed again using new corrosion inhibitors and the **protection** is maintained **over long periods of time**.

Standard corrosion test for heat transfer fluids

Static corrosion test according to ASTM D 1384

- Test Metals: Copper
Soft solder (WL 30)
Brass (MS 63)
Steel (C15)
Gray cast iron (CG 22)
Cast aluminum (AlSi6Cu3)
- Fluid: Glycol + Aggressive water
(100 ppm Cl^- , 100 ppm SO_4^{2-} ,
100 ppm HCO_3^-)
Air flow through fluid (6 NI/h)
- Temperature: 88 °C / 190 F
- Test duration: 2 weeks (**336 h**)



Antifrogen[®] – What makes the difference?

Antifrogen[®] N, 34 % v/v



Tap water



MEG, 34 % v/v



Fluids / Metal plates after ASTM D 1384 Test (336 h)

Antifrogen® – What makes the difference?

	Antifrogen® N 34 % v/v	Tap water	MEG 34 % v/v	Limits
Copper	0	-1	-3	3,6
Soft solder	-1	-11	-135	11,2
Brass	-1	-1	-8	3,6
Steel	0	-76	-152	3,6
Gray cast iron	0	-192	-273	3,5
Cast aluminum	-2	-32	-16	10,4

Given values show the **weight loss/gain of the metals in g/m²** (acc. to ASTM D 1384, at 88°C, 6 l/h of air, 336 h); Limits acc. to ASTM D 3306-05 (Specification for Glycol Base Engine Coolant for Automobile and Light-Duty Service)

Antifrogen® – What makes the difference?

	Antifrogen® L 34% v/v	Tap water	MPG 34 % v/v	Limits
Copper	0	-1	-1	3,6
Soft solder	-3	-11	-136	11,2
Brass	-1	-1	-3	3,6
Steel	0	-76	-225	3,6
Gray cast iron	0	-192	-92	3,5
Cast aluminum	-2	-32	-68	10,4

Given values show the **weight loss/gain of the metals in g/m²** (acc. to ASTM D 1384, at 88°C, 6 l/h of air, 336 h); Limits acc. to ASTM D 3306-05 (Specification for Glycol Base Engine Coolant for Automobile and Light-Duty Service)

Antifrogen[®] – What makes the difference?

Antifrogen[®]: Long-lasting corrosion protection
... **even at aggravated conditions** (beyond ASTM D 1384)

- **Extension of test duration** from 336 h to 1000 h and 3000 h

Antifrogen [®] N 34 % v/v	336 h	1000 h	3000 h	Limits
Copper	0	-1	-2	3,6
Soft solder	-1	-2	-2	11,2
Brass	-1	-1	-2	3,6
Steel	0	0	0	3,6
Gray cast iron	0	0	0	3,5
Cast aluminum	-2	-2	-1	10,4

Given values show the weight loss/gain of the metals in g/m² (acc. to ASTM D 1384, at 88°C, 6 l/h of air); Limits acc. to ASTM D 3306-05

Antifrogen® – What makes the difference?

Antifrogen®: Long-lasting corrosion protection
... **even at aggravated conditions** (beyond ASTM D 1384)

- **Thermal pretreatment** of fluid (180 °C / 3 days / air)

Antifrogen® N 34 % v/v	No Pretreatment	Pretreatment	Limits
Copper	0	0	3,6
Soft solder	-1	-1	11,2
Brass	-1	-1	3,6
Steel	0	0	3,6
Gray cast iron	0	-1	3,5
Cast aluminum	-2	0	10,4



Given values show the weight loss/gain of the metals in g/m² (acc. to ASTM D 1384, at 88°C, 6 l/h of air, 336 h); Limits acc. to ASTM D 3306-05

Antifrogen® – What makes the difference?

Competitor product based on monoethylene glycol (20 % v/v)

Test duration: 336 h



Test duration: 1000 h



Fluids / Metal plates after ASTM D 1384-Test



Competitor product: No corrosion protection after extended test conditions!

Antifrogen® – What makes the difference?

Competitor product based on monoethylene glycol (20 % v/v)

Competitor product (MEG based, 20 % v/v)	336 h	1000 h	Limits
Copper	-1	-117	3,6
Solt solder	-7	-108	11,2
Brass	-3	-108	3,6
Steel	0	-3045	3,6
Gray cast iron	-1	-2321	3,5
Cast aluminium	-13	-55	10,4

Given values show the weight loss/increase of the metals in g/m² (acc. to ASTM D 1384, at 88°C, 6 l/h of air); Limits acc. to ASTM D 3306-05 (Specification for Glycol Base Engine Coolant for Automobile and Light-Duty Service)



Competitor product: No corrosion protection after extended test conditions!

Product portfolio – The Antifrogen[®] family



Antifrogen[®] N
Monoethylene glycol (MEG)



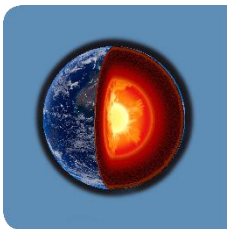
Antifrogen[®] L
Monopropylene glycol (MPG)



Antifrogen[®] SOL HT
Higher boiling glycols



Antifrogen[®] SOLAR
Monopropylene glycol (MPG)



Antifrogen[®] GEO
Monoethylene glycol (MEG)



Antifrogen[®] KF
Potassium formate

Antifrogen[®] N – Facts



- **Universal** heat transfer fluid
- Outstanding corrosion protection
- Based on monoethylene glycol (**MEG**)
- Appearance: yellow
- Minimum usage concentration: **20 % v/v**
- Permanent application temperature:
- 50 °C to + 150 °C

Why is concentration control important?

Concentration too low

(< 20 % v/v for MEG based fluid)

- Decreasing frost protection
- System is not completely protected against corrosion
- **Growing of microorganism**
 - ➔ organic deposits
 - ➔ microbial corrosion

Concentration too high

(> 60 % v/v for MEG based fluid)

- Poorer heat transfer
- Higher energy consumption (pump!)
- **Decreasing frost protection!**
 - ➔ MEG based fluids

Why is concentration control important?

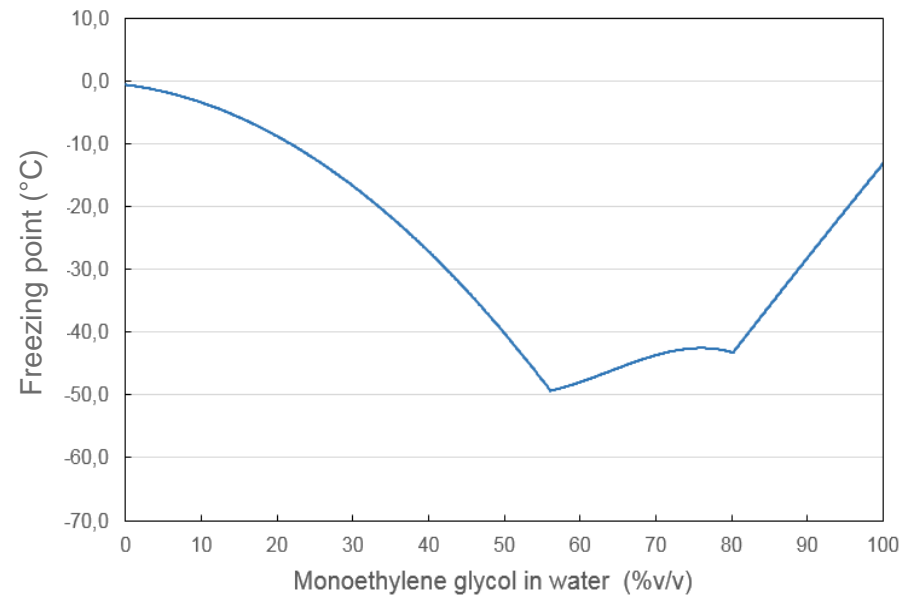
Concentration too low

(< 20 % v/v for MEG based fluid)



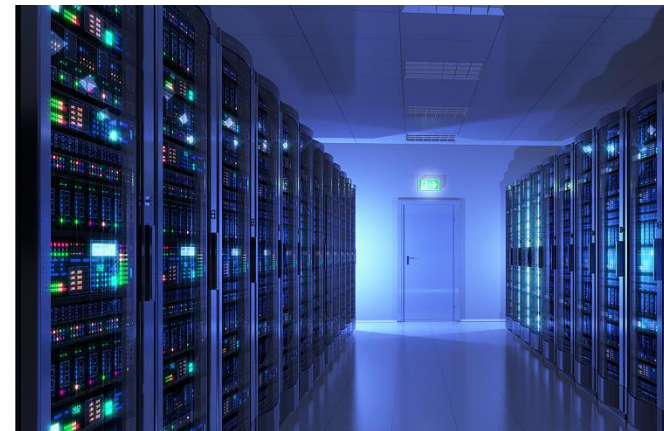
Concentration too high

(> 60 % v/v for MEG based fluid)



Antifrogen[®] N – Applications

The universal heat transfer fluid



Antifrogen[®] L – Facts

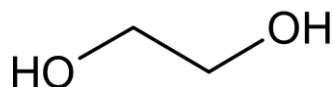


- For use in the **food** and **pharma industry**
- Certified as antifreeze additive for **sprinkler systems**
- Outstanding corrosion protection
- Based on monopropylene glycol (**MPG**)
- Appearance: blue
- Minimum usage concentration: **25 % v/v**
- Permanent application temperature:
- 25 °C* to + 150 °C

* lower temperatures are possible > increased kin. viscosity needs to be considered

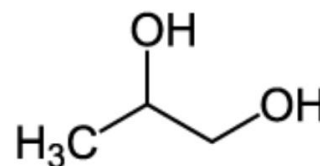
MEG – MPG: What is the difference?

Freezing point depressants



Monoethylene glycol (MEG)

- Toxic
- Lower price
- Effective freezing point depressant:
50 %m/m MEG = -30 °C FP
- Medium viscosity at low temperatures

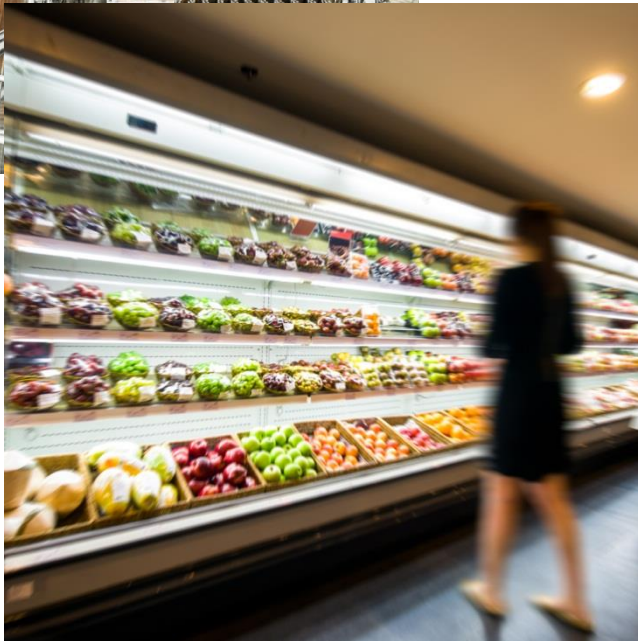


Monopropylene glycol (MPG)

- Non-toxic
- Higher price
- Less effective freezing point depressant:
50 %m/m MPG = -20 °C FP
- High viscosity at low temperatures

Antifrogen[®] L – Applications I

Heat transfer fluid for the food and pharma industry



Antifrogen[®] L – Applications II

Frost protection for sprinkler systems



The first heat transfer fluid which has been officially certified from VdS (*VdS Schadenverhütung GmbH*) as antifreeze additive in sprinkler systems

Antifrogen® L – Certificates



Conclusions from the toxicological risk evaluation

The toxicological risk evaluation which had been performed accordingly has shown that the safe use of the product ANTIFROGEN® L can be assured such that

ANTIFROGEN® L as a cooling brine for the food industry, antifreeze and corrosion inhibitor for refrigeration and heat pump systems has to be regarded as safe for the health of users when after unrecognized leakage a certain amount of foodstuff may have been contaminated with a certain amount of the ingredient substances of the product ANTIFROGEN® L

when taking into account the following elements of the toxicological risk evaluation:

- assessment of the relevant toxicity profiles of all ingredient substances considering the specific formulation (recipe) and
- assessment of the intended and reasonably foreseeable exposure conditions for users when additionally taking into account the specified use conditions of the product ANTIFROGEN® L.

Overall for the toxicological risk evaluation is very conservative with regard to its relevant input parameters, therefore the outcome is considered to be very robust.

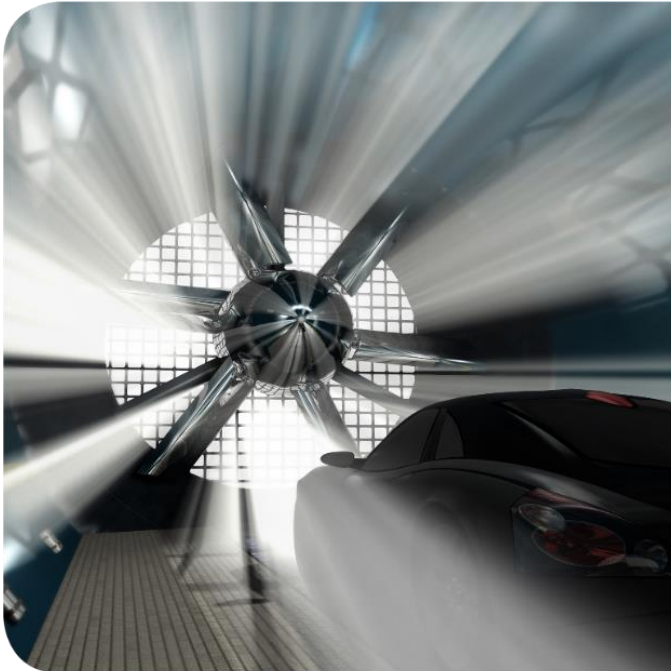
Krefeld, 2013-03-21

Dr. Joachim Haselbach
Expert Toxicologist DGPT
Eurotox Registered Toxicologist



Lothar Fruth
Specialist Pharmacist for
Toxicology and Ecology

Antifrogen[®] KF VP 1974 – Facts

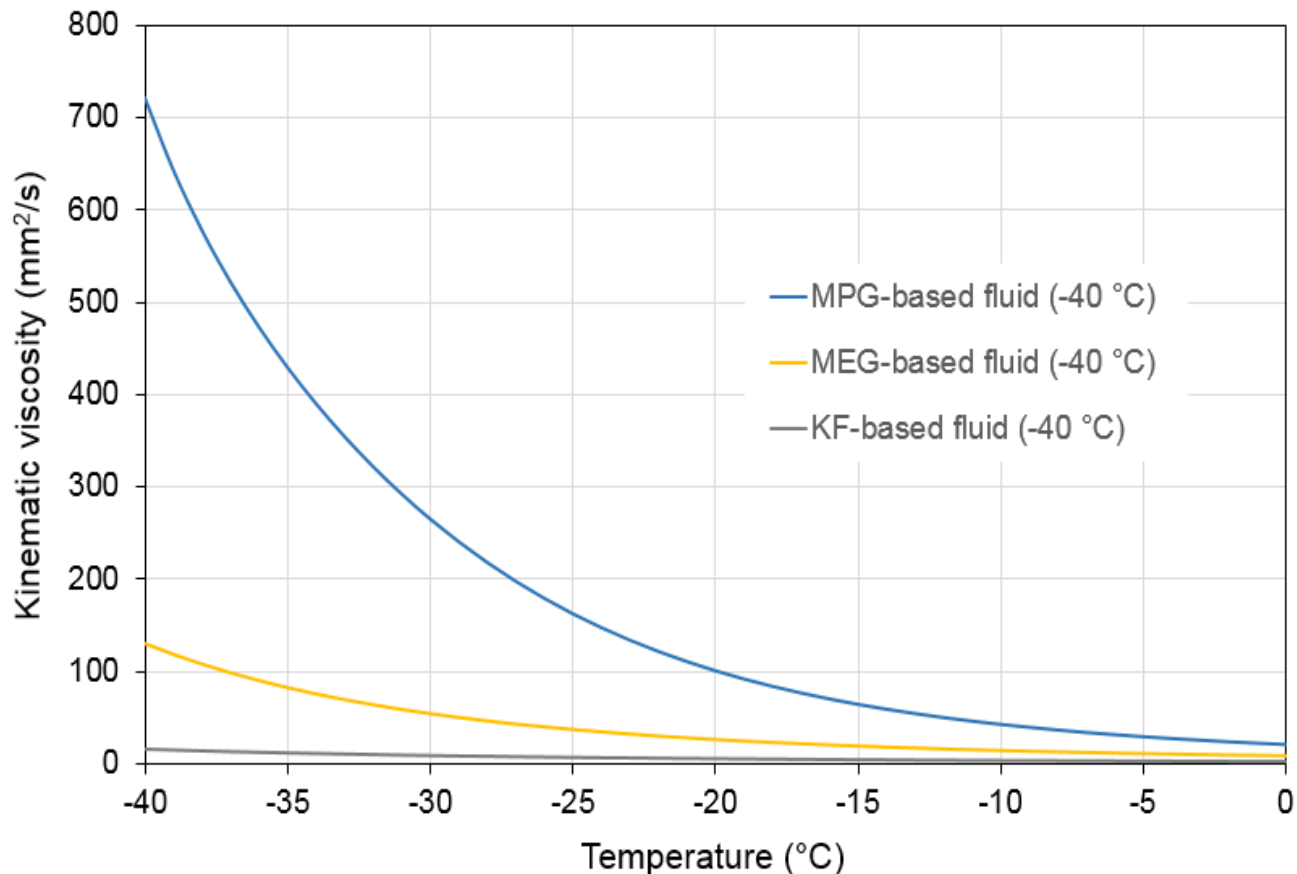


- **Energy-efficient deep temperature brine for food and industrial refrigeration systems**
- Superior corrosion protection
- Based on **potassium formate**
- Appearance: colorless
- Usage concentration: **50 – 100 % v/v**
(to be mixed with deionized/dest. water only)
- Permanent application temperature:
- 50 °C to + 80 °C

Antifrogen[®] KF VP 1974 – Facts

Low viscosity at low temperature

Kinematic viscosity vs. temperature for different freezing point depressants
(at given frost resistance of -40 °C)



Antifrogen[®] solar thermal products – Facts

Antifrogen[®] SOLAR



Antifrogen[®] SOL HT



Antifrogen[®] solar thermal products – Facts

Antifrogen[®] SOLAR

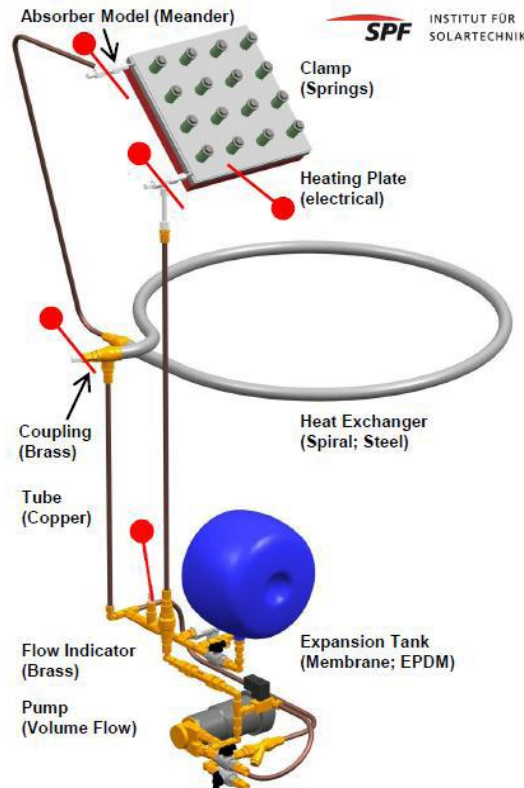
- Based on monopropylene glycol (**MPG**)
- Superior corrosion protection
- Permanent application temperature:
-28 °C to +150 °C
- For solar thermal applications (**flat plate collectors** and heat pipe systems)
- Appearance: red
- Ready-to-use mixture (-28 °C, 47 %v/v)
- Antifrogen[®] SOLAR Conc. for various frost resistances

Antifrogen[®] SOL HT

- Based on **higher boiling glycols**
- Superior corrosion protection
- Permanent application temperature:
-23 °C to +200 °C
- Stand still temperature: up to **+260 °C**
- For solar thermal applications exposed to high thermal loads (esp. **vacuum tube collectors**)
- Appearance: yellowish
- Ready-to-use mixture (-23 °C, 50 %v/v)
- Antifrogen[®] SOL HT Conc. for various frost resistances

Antifrogen[®] solar thermal products – Simulating the real application

Cowork with leading research institute: **SPF, Switzerland**



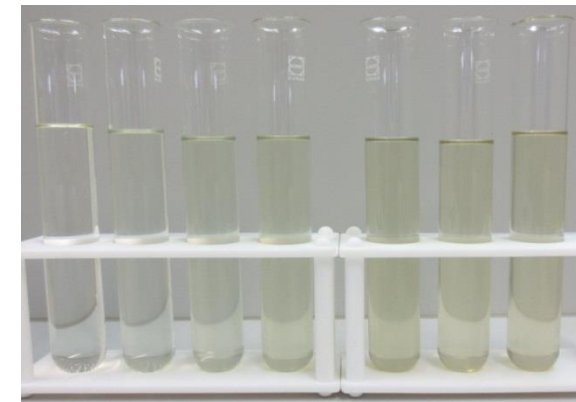
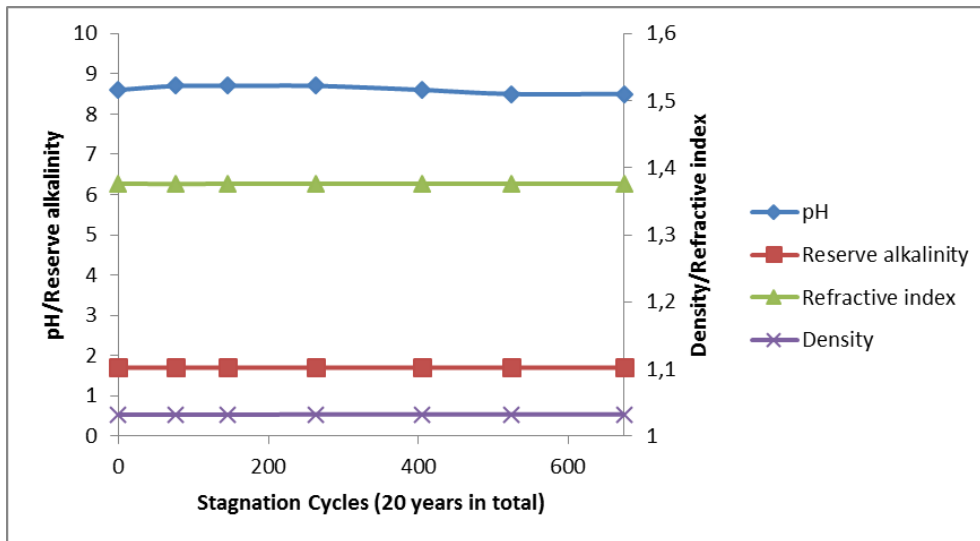
- Absorber Model: copper meander
- Stagnation system: steam back
- Stagnation Cycle:
 $T_{\min} = 60 \text{ }^{\circ}\text{C}$, $T_{\max} = 200 \text{ }^{\circ}\text{C}$, $t = 26 \text{ min}$,
 $p = 3 \text{ bar}$
- Fluid is exposed to 600 stagnations
(30 stagnations = 1 year)



Simulation of **20 years solar thermal application!**

Antifrogen[®] solar thermal products – Simulating the real application

Cowork with leading research institute: SPF, Switzerland

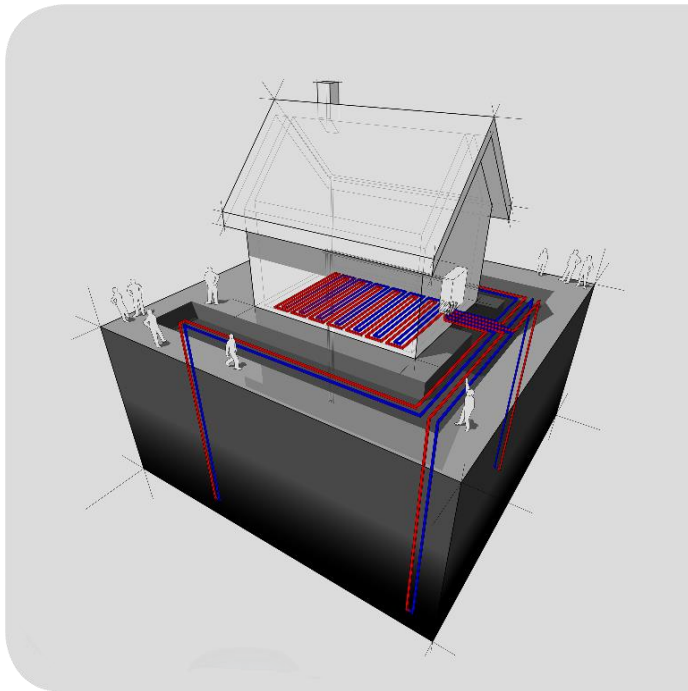


Fluid samples during test



No change of characteristics after simulation of **20 years solar thermal application!**

Antifrogen[®] GEO – Facts



- Economic heat transfer fluid tailor made for **near surface geothermics**
- Reliable corrosion protection
- Based on monoethylene glycol (**MEG**)
- Appearance: blue
- Usage concentration: **25 – 40 % v/v**
- Permanent application temperature: **-20 °C to + 40 °C**

Protectogen[®] C Aqua – Facts



- Glycol free **corrosion inhibition concentrate** for cold water systems **without frost protection**
- Superior corrosion protection
- Appearance: yellowish
- Usage concentration:
1.5 % v/v Protectogen[®] C Aqua in water
- Permanent application temperature:
+ 5 °C to + 95 °C

Which water quality can be used for dilution?



- ✓ Deionized water
- ✓ Distilled water
- ✓ Reverse osmosis water
- ✓ Tap water, if
Chloride content < 100 ppm
Water hardness 0 – 20 / 25 °GH

Any impurity in water will affect corrosion protection



The better the water, the better the performance!

Antifrogen[®] – What about material compatibility?



Example: Antifrogen[®] N

ABS	Acrylonitrile-butadiene-styrene	PA	Polyamide
CPE	Chlorinated polyethylene	PB	Polybutene
CR	Polychlorbutadiene elastomers	PC	Polycarbonate
EPDM	Olefin rubber	POM	Polyacetal
FKM	Fluorocarbon Elastomer	PP	Polypropylene
IIR	Butyl rubber	PTFE	Polytetrafluorethylene
LDPE/ HDPE	Polyethylene low/high density	RPVC	Polyvinyl chloride rigid
MFQ	Fluorosilicone rubber	SBR	Styrene-butadiene rubber up to 100 °C
NBR	Nitril rubber	SI	Silicone rubber
NR	Nature rubber up to 80 °C	UP	Polyester resins

Antifrogen® – What about material compatibility?



Question:

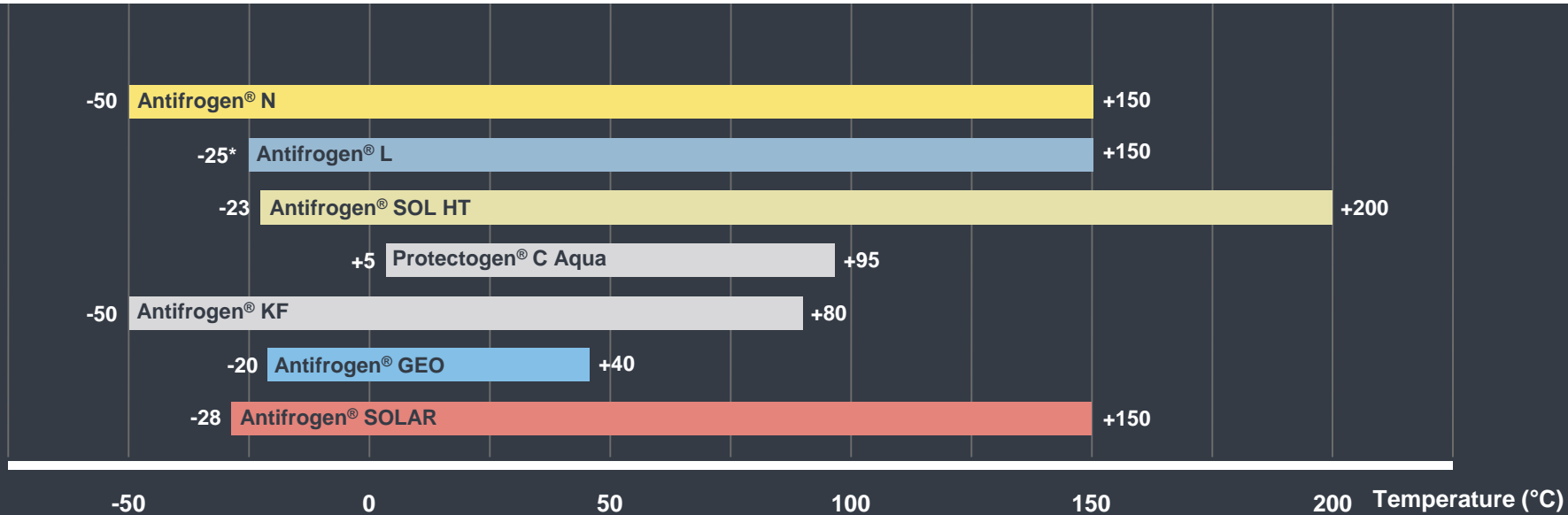
**FKM sealing compatible
with Antifrogen SOL HT?**



Solution:



Which Antifrogen[®] is needed?



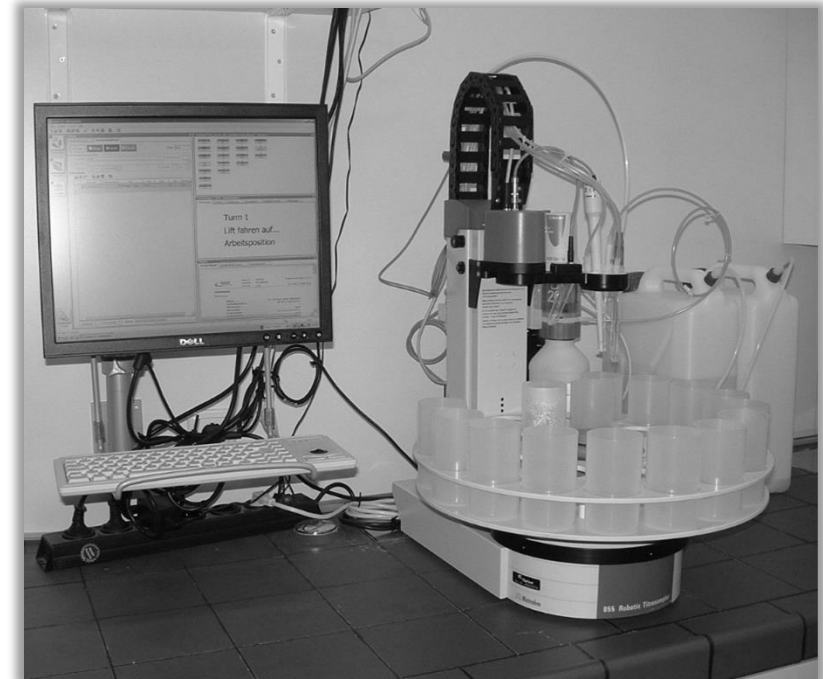
- | | |
|----------------------------------------------|---------------------------------------------------------------|
| No special requirements?..... | Antifrogen [®] N |
| Physiological harmless brine necessary?..... | Antifrogen [®] L, Antifrogen [®] KF |
| Solar thermal application?..... | Antifrogen [®] SOL HT, Antifrogen [®] SOLAR |
| Geo thermal application?..... | Antifrogen [®] GEO |
| No frost protection necessary?..... | Protectogen [®] C Aqua |
| Low viscosity at low temperature?..... | Antifrogen [®] KF |

Antifrogen® – What makes the difference?

Antifrogen® Service free of charge

Analysis:

- Frost protection
- pH
- Reserve alkalinity
- Inhibitor analysis
- Chloride content
- Optional:
electrochemical corrosion test



Antifrogen® – What makes the difference?

Antifrogen® Service free of charge

Dear Mr Smith,

Enclosed you can find the test results of the sample you submitted. If you have any further questions regarding those results please do not hesitate to contact your Antifrogen-Team.

For further information on our products please visit our website:
www.antifrogen.com.

Yours sincerely
Clariant Produkte (Deutschland) GmbH

Characteristics	System HST-250
<u>Appearance</u>	<u>yellow, clear</u>
<u>Refractive Index at +20 °C</u>	1.3693
<u>Density at +20 °C [g/cm³]</u>	1.0466
<u>Frost resistance [°C]</u>	-19
<u>Medium</u>	<u>Antifrogen® N/ water mixture</u>
<u>Share of [% v/v]</u>	34
<u>pH-value undiluted</u>	7.9
<u>Reserve alkalinity (pH 5.5) [mL 0,1 M HCl/10 mL]</u>	1.6
<u>Chlorid content [ppm]</u>	<100
<u>Assay on selected inhibitors</u>	<u>present</u>
<u>Judgement of the sample</u>	<input checked="" type="checkbox"/> still useable <input type="checkbox"/> limited useable * <input type="checkbox"/> not useable * <input type="checkbox"/> foreign product *

Featured Reviews (*) are provided with further observations.

Service report and official statement about further usability of the fluid is included!

Antifrogen® – What makes the difference?

Antifrogen® Calculator: www.antifrogen.com

Clariant Antifrogen® Online Calculator

A) Calculation method:

B) Select one of our Antifrogen® products:

C) Enter desired concentration (0 to 60% wV):

D) Enter temperature range (-55 - 150°C): -

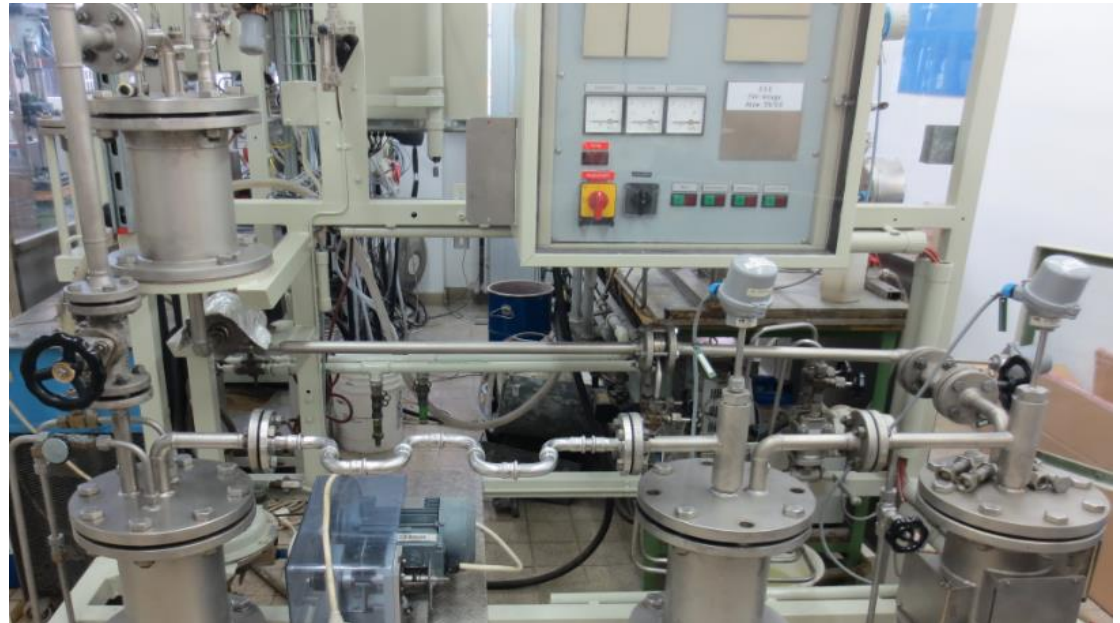
E) Enter increment in °C ein:

Table for Antifrogen® N with a fixed concentration of 34% wV. Frost resistance: -19°C

Temp. °C	Kinematic Viscosity v mm ² /s	Density d kg/m ³	Boiling point °C	Vapor pressure p bar	Coefficient of cubic expansion β 0.001/K	Specific heat cp kJ/kg·K	Thermal conductivity WL W/m·K	Relative heat transfer fa rel	Relative pressure drop fp rel
-19	12.70	1061	105		0.300	3.59	0.453	0.246	1.857
-18	11.96	1061	105		0.305	3.59	0.454	0.252	1.832
-17	11.27	1060	105		0.309	3.60	0.454	0.258	1.809
-16	10.64	1060	105		0.314	3.60	0.454	0.265	1.786
-15	10.06	1059	105		0.319	3.60	0.454	0.271	1.764
-14	9.53	1059	105		0.323	3.60	0.454	0.277	1.742
-13	9.03	1059	105		0.328	3.60	0.454	0.283	1.721
-12	8.57	1058	105		0.333	3.60	0.455	0.290	1.700
-11	8.15	1058	105		0.337	3.60	0.455	0.296	1.681
-10	7.75	1058	105		0.342	3.60	0.455	0.303	1.661
-9	7.38	1057	105		0.346	3.61	0.455	0.309	1.642
-8	7.03	1057	105		0.351	3.61	0.455	0.316	1.624
-7	6.71	1056	105		0.355	3.61	0.455	0.322	1.606
-6	6.41	1056	105		0.360	3.61	0.456	0.329	1.588
-5	6.13	1056	105		0.364	3.61	0.456	0.335	1.571
-4	5.86	1055	105		0.369	3.61	0.456	0.342	1.554
-3	5.62	1055	105		0.373	3.61	0.456	0.349	1.538
-2	5.38	1054	105		0.378	3.62	0.456	0.355	1.522
-1	5.16	1054	105		0.382	3.62	0.457	0.362	1.506
0	4.95	1053	105		0.387	3.62	0.457	0.369	1.491

Antifrogen[®] – What makes the difference?

Technical application experiments



Individual variation of test parameters depending on customer's requirements.

Antifrogen[®] contact

Clariant Produkte (Deutschland) GmbH
Site Gendorf



Technical support

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Questions?

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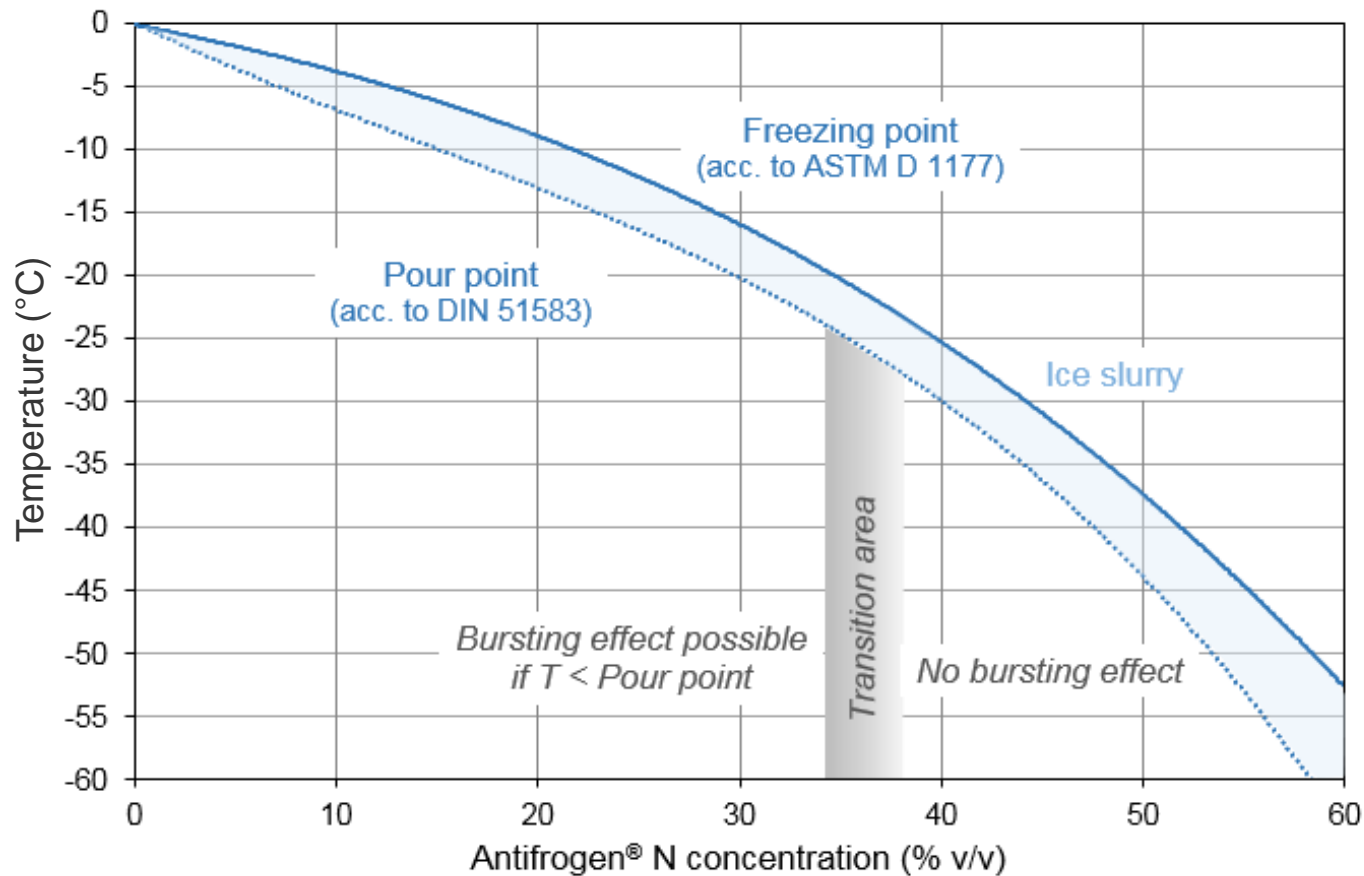
Public

Clariant Heat Transfer Fluids

what is precious to you?

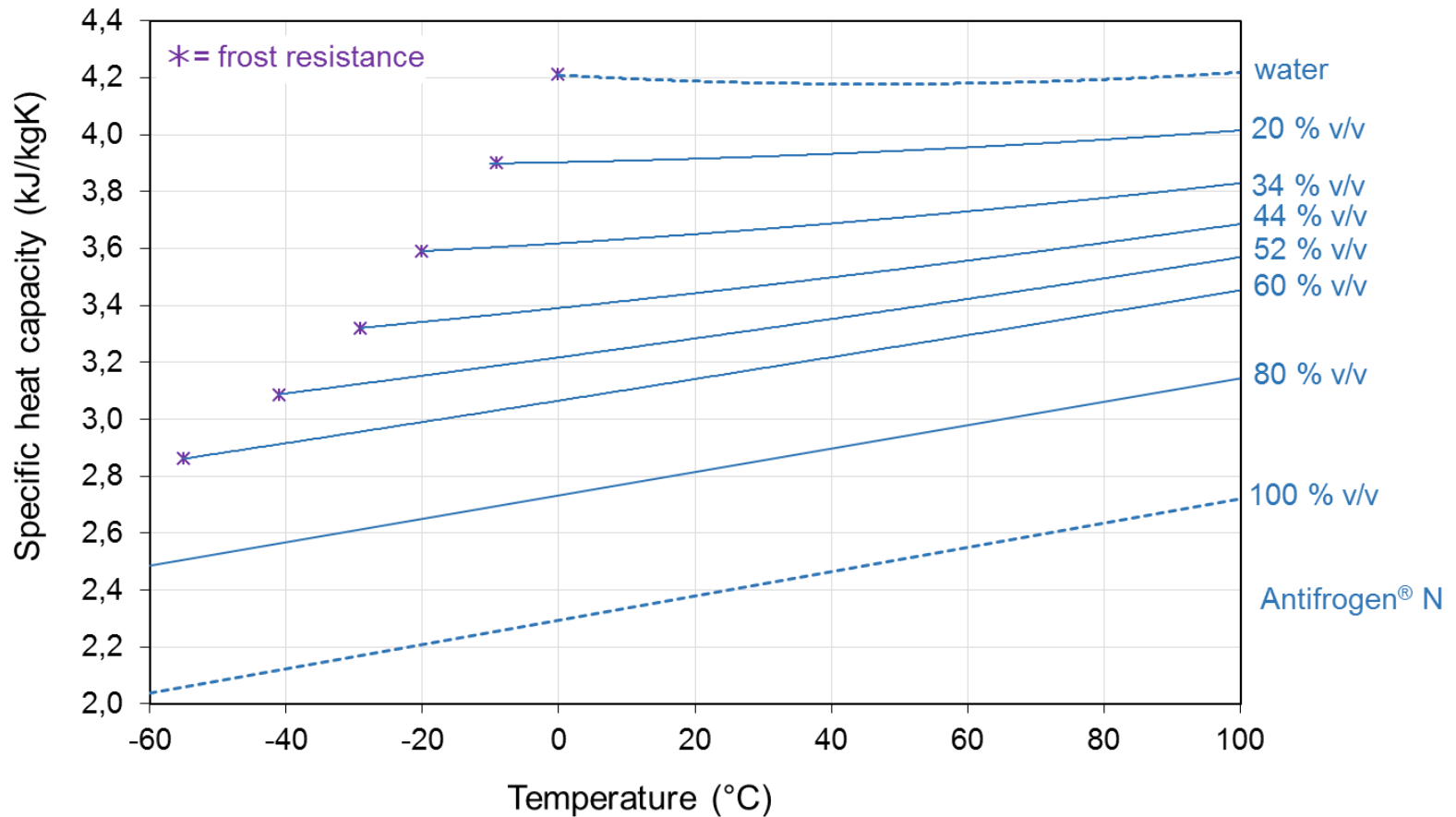
Heat Transfer Fluids – Physical properties

- Relationship **frost resistance** vs. **MEG-concentration**



Heat Transfer Fluids – Physical properties

- Relationship **specific heat capacity** vs. **MEG-concentration**



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