eurammon

refrigerants delivered by mother nature

Heat transfer Fluids
an Overview

Roger Rosander, Temper Technology AB

Schaffhausen, 29th of June 2018.

Indirect refrigeration systems vs. DX

Restrictions and limitation of refrigerant range, indirect refrigeration systems are still in focus.

Pros

- “Regular" pipes and low pressure levels
- Plastic pipes can be used (diffusion tight)
- Does not require certified welders
- Not directly sensitive to water (as refrig.)
- Cheaper installation - cost efficient
- Broad range of installation components

Cons

- In some cases corrosive fluids
- High pressure drop
- High pump power
- Bigger pipes
- One “extra” heat exchange

Heat transfer fluids - HTF

- All HTF have pros and cons
- Water may have “no” disadvantages at least at > 0°C
- Choose a HTF suitable for the actual application and plant

Properties to consider when choosing HTF

Health and Environment Hazards

Fire Hazards

Energy efficiency – Thermophysical properties

Corrosivity – electrical conductivity mS/cm

Corrosion protection

Installation – restriction on materials

Lifespan

Cost or rather life cycle cost

Types of HTF

Common used water based HTFs and organic fluids

Properties of fluids

Later comparisons consider food stuff applications

Types of HTF

• Alcohols	Ethanol	
• Glycols	MEG	
	MPG including PDO	
• NH_3 / Water		
• Hydrocarbons		
• Salts or brines	Inorganic	Calcium chloride, $CaCl_2$
	Organic	Potassium Acetate / Formate

eurammon
refrigerants delivered by mother nature

Ethanol – Regular alcohol

High viscosity also at high temperature

Compatible with most materials

Normally no need for corrosion inhibitors

Inflammable – therefore normally used down to -10/-15°C

Risk of explosion above 30%

Permission from the authorities to use alcohol

Mono propylene glycol – 1,2 -Propanediol - MPG

Propylene glycol has high viscosity at low temperatures and increases sharply already at -5° / -7°C

Compatible with most materials

The high viscosity leads to high energy consumption in pumps

Propylene glycol is less toxic than ethylene glycol

3-5 times the viscosity that of ammonia/water or brines already at -10ºC

Ammonia in water - Ammonium hydroxide NH_4OH

Good thermal properties

Tough odour even at very low concentration

Very high pH value (13-14)

You will need high grade quality material and of course no copper

Follow local regulations using ammonia

Hydrocarbons - for instance Marlotherm XC - Ethylmetylbenzene

Very low freezing point lower than -90 °C

Industrial cooling

Very low viscosity

Low specific heat and thermal conductivity

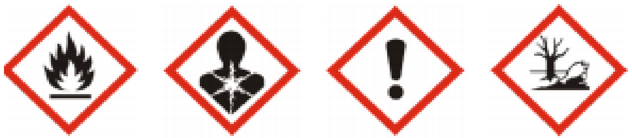
Compatible with most materials

Inflammable

Fatal when swallowed

Respiratory irritation

Toxic to aquatics



Calcium Chloride $CaCl_2$

Good thermal properties

Freezing point > -45°C

High pH value: 10-11

No use of stainless steel – titanium heat exchangers

Very corrosive, dichromate inhibitors needed

Potassium Acetate / Formate brines and mixtures

Good thermal properties

Very low freezing point

Compatible with most materials

Not hazardous. Acetate is a preservative E261

pH: Acetate: 8-9 Formate 10-11

Electrical conductivity: Acetate: 135 mS/cm, Formate 250 mS/cm

Comparison between different HTF

- *Pressure drop*
- *Heat transfer coefficient*
- *Pumping energy demand*

HTF – medium and low temperature applications

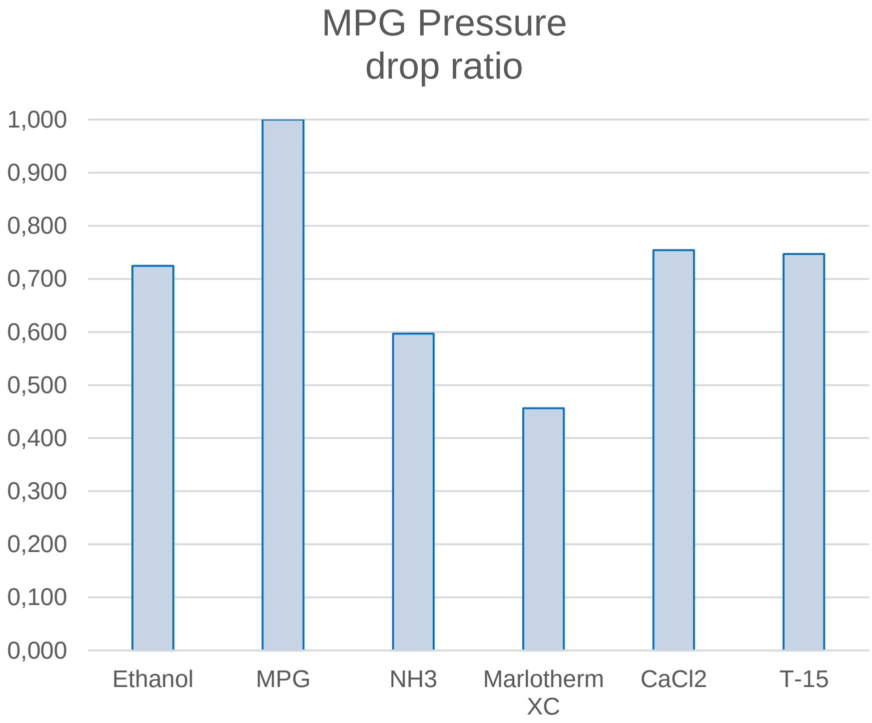
- Typical inlet temperature to cabinets or rooms is approximately -8°C for fridges

- Suitable freezing point for HTF, is then -15°C

Freezing point -15°C @ -8°C

HTF	Ethanol	MPG	NH_3/Water	Marlotherm XC	$CaCl_2$	Temper-15
Conc. %	24,4	32,9	10,8	100	18	-
Density, kg/m_3	974	1037	961	885	1168	1121
Dyn Visc. cP	9,38	12,95	2,51	0,91	3,70	4,16
Kin Visc. cSt	9,63	12,49	2,61	1,03	3,17	3,71
Spec. heat J/kg K	4284	3855	4235	1790	3122	3381
Therm. Cond. W/m K	0,419	0,411	0,477	0,135	0,535	0,486

Pressure drop ratio with MPG. -15°C / -8°C

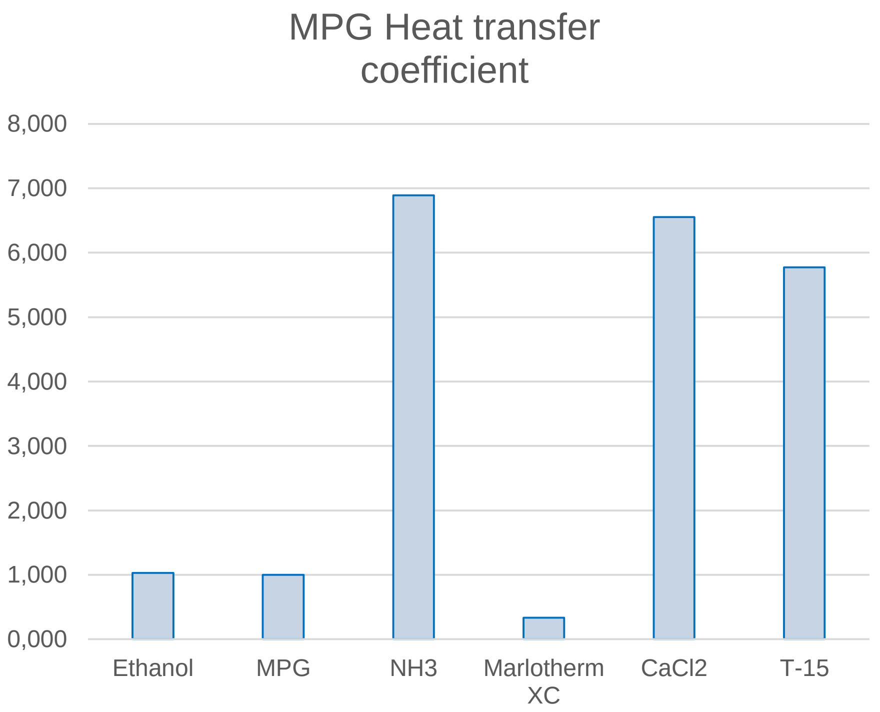


Re number

Ethanol	*1661*
MPG	*1282*
NH3	*6134*
Marlotherm XC	*15504*
$CaCl_2$	*5044*
Temper-15	*4306*

Basic conditions:
Tube diameter: 16 mm
Flow velocity: 1 m/s
Length: 10 m

Heat transfer coeff. ratio with MPG. -15°C / -8°C



Re number

Ethanol	*1661*
MPG	*1282*
NH3	*6134*
Marlotherm XC	*15504*
$CaCl_2$	*5044*
Temper-15	*4306*

Basic conditions:
Tube diameter: 16 mm
Flow velocity: 1 m/s
Length: 10 m

Pumping energy demand

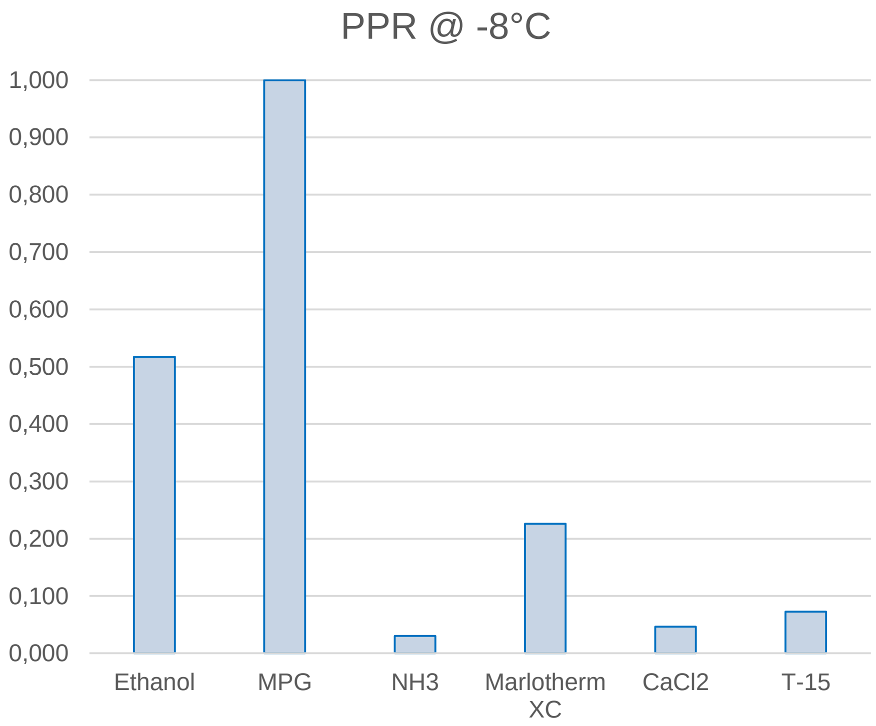
$$PPR_{12}=(\nu_1/\nu_2)^{1,95}*(\rho_1/\rho_2)^{-0,05}*(k_1/k_2)^{-2,3}*(Cp_1/Cp_2)^{-1,05}$$

- PPR_{12} using the thermophysical properties from the different products, describes the amount of energy needed to pump a fluid 1 relative to fluid 2 in order to get the same heat transfer performance.

- v = Kinematic viscosity
- ρ = Density
- k = Thermal conductivity
- Cp = Specific heat capacity

- This PPR_{12} equation comes from substituting appropriate values in Equation 9 of the following paper: Sherwood, G, "Secondary Heat Transfer Systems and the Application of a New Hydroflouroether", 1195 International CFC and Halon Conference

Pump energy demand -15°C / -8°C



HTF – medium and low temperature applications

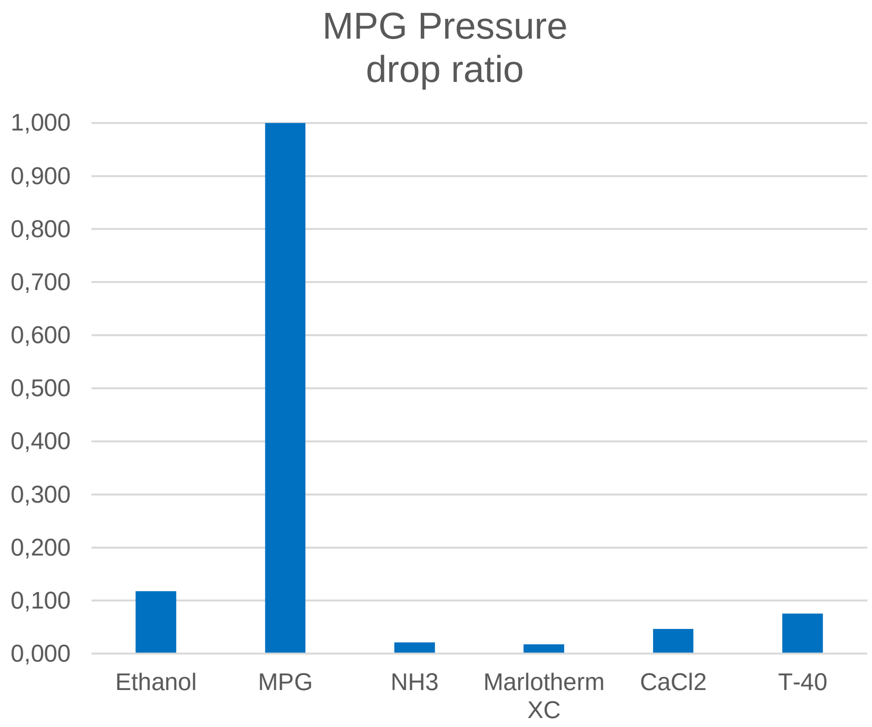
- Typical inlet temperature to cabinets or rooms is approximately -32°C for freezers

- Suitable freezing point for HTF, is then -40°C

Freezing point -40°C @ -32°C

HTF	Ethanol	MPG	NH_3/Water	Marlotherm XC	$CaCl_2$	Temper-40
Conc. %	53,1	54,0	21,0	100	28,3	-
Density, kg/m_3	949	1068	939	904	1285	1225
Dyn Visc. cP	42,90	364,75	7,85	1,41	17,02	27,65
Kin Visc. cSt	45,22	341,53	8,33	1,56	13,24	22,57
Spec. heat J/kg K	3367	3359	4296	1750	2682	2865
Therm. Cond. W/m K	0,294	0,321	0,385	0,140	0,490	0,408

Pressure drop ratio with MPG. -40°C / -32°C

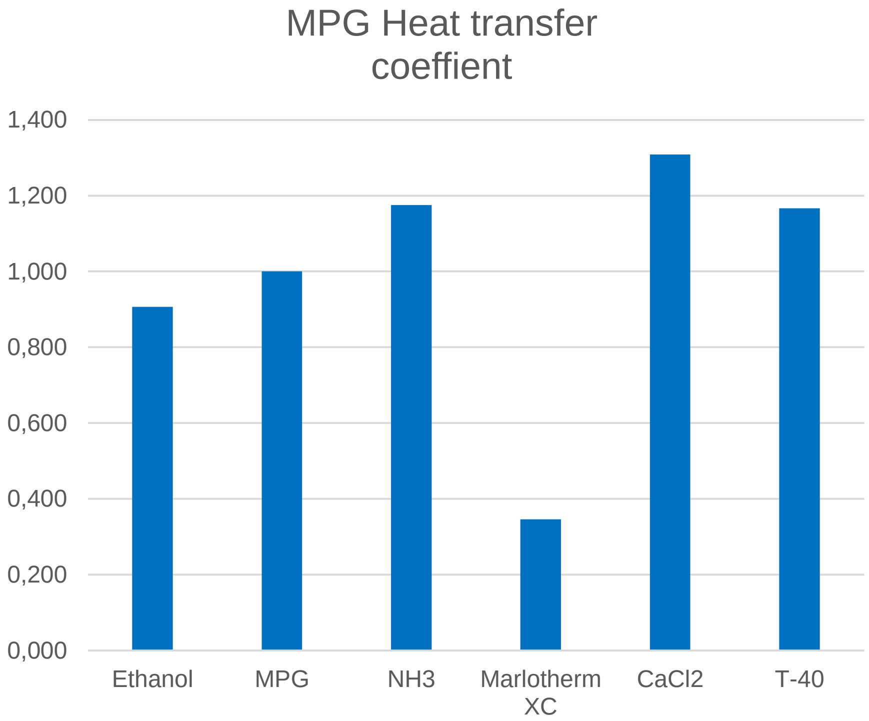


Re number

Ethanol	*354*
MPG	*47*
NH3	*1921*
Marlotherm XC	*10286*
$CaCl_2$	*1208*
Temper-40	*709*

Basic conditions:
Tube diameter: 16 mm
Flow velocity: 1 m/s
Length: 10 m

Heat transfer coeff. ratio with MPG. -40°C / -32°C

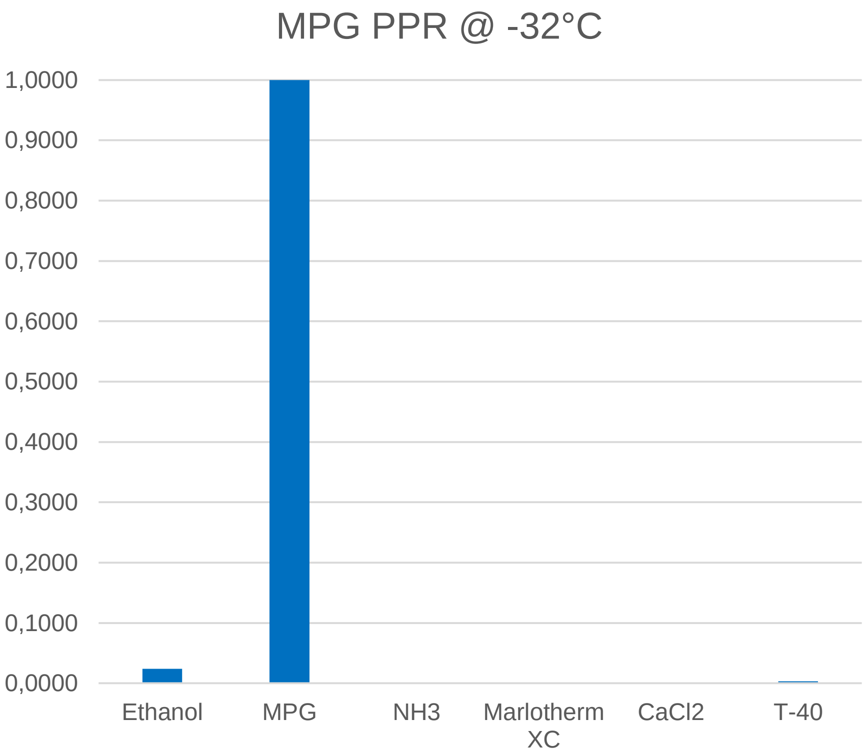


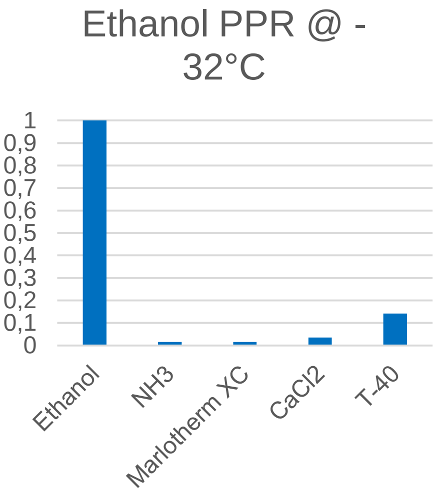
Re number

Ethanol	*354*
MPG	*47*
NH3	*1921*
Marlotherm XC	*10286*
$CaCl_2$	*1208*
Temper-40	*709*

Basic conditions:
Tube diameter: 16 mm
Flow velocity: 1 m/s
Length: 10 m

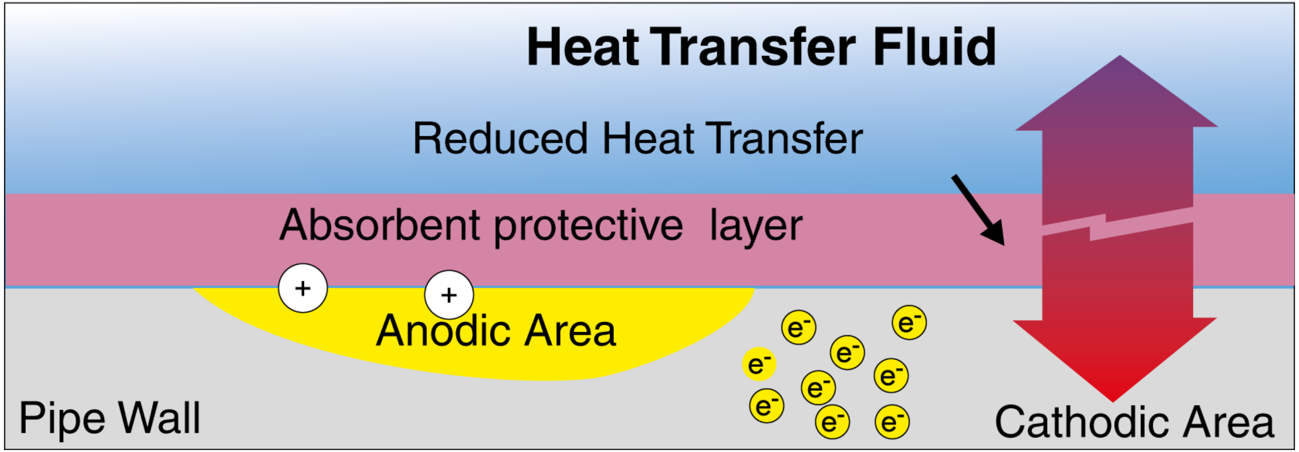
Pump energy demand -40°C / -32°C



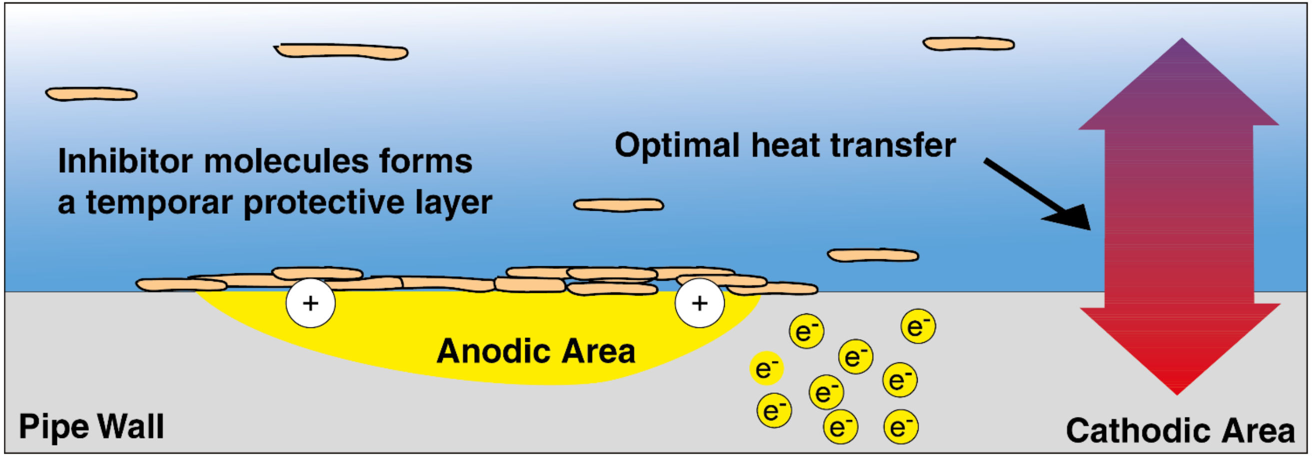


eurammon
refrigerants delivered by mother nature

Standard Corrosion Inhibitor Package

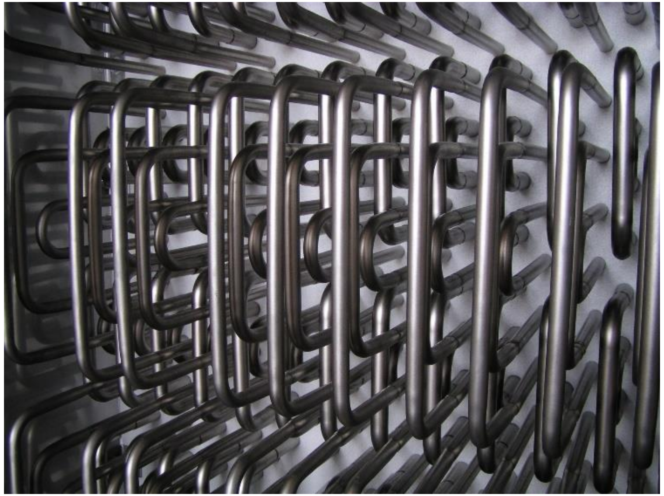


Advanced Corrosion Inhibitor Package



Areas of use

Areas of use



HTF may be used as waste heat defrost in CO_2 plants.

It takes a lot of electricity for electric defrosting.

At waste heat defrost, the heat is "free" and only the pump operation is operating cost.

Thank you very much for your attention!