Temper

Temper technology

This manual contains important information of how to use Temper. Always consult it before....

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Enter this Manual

Temper®

Glycol-free heat transfer fluid

The intelligent solution

Temper technology

1. Temper – the product

Glycol-free heat transfer fluid, non-toxic and environmentally compatible

THE BENEFITS

- **Non-toxic, non-flammable, non-explosive**
- **Free from phosphates, amines, nitrites and benzoates**
- **Approved for use in the food industry and supermarkets**
- **Can be used down to –55° C**
- **Pre-mixed, i.e ready for use**
- **Outstanding flow, even at low temperatures**
- **No bursting effect on freezing**
- **Novel corrosion protection, giving better thermal transfer**
- **High heat transport performance**
- **Readily biodegradable**
- **Safe to handle (pH 8–9)**

What is Temper?

Temper was developed by Aspen Petroleum AB, a Swedish manufacturer of special fuels and heat transfer fluids. Temper is a synthetic and homogenised glycol-free solution based on salts. It is colourless to yellowish and contains no amines or nitrites, although it does contain additives, which give it anti-corrosion and lubricating properties.

Temper is supplied ready for use and must not be diluted. Different versions (blends) are available, each with a designation that indicates its freezing point:

- Temper –10° C
- Temper –20° C
- Temper –30° C
- Temper –40° C
- Temper –55° C

What can Temper do?

Temper has a high specific heat capacity (eg 3.3 kJ/kg for Temper –20° C in the temperature range +20 to +30° C). It also has outstanding thermal conductivity, especially compared with propylene glycol.

Special additives in Temper provide optimal corrosion protection and lubricating properties.

Because its viscosity is relatively low compared with glycol, pumps and pipe work can be smaller for the same performance. This cuts the cost of purchasing, installing and running the system.

How safe is Temper?

Unlike glycols, Temper is non-toxic and ecologically sound as well as readily biodegradable. In addition, Temper is neither flammable nor explosive. Its WGK rating (Wassergefährdungsklasse, German water hazard class) is 1.

In unopened packs and in sealed systems, Temper is stable and will keep practically indefinitely.

On reaching its freezing point, Temper becomes grainy, but its volume does not increase significantly, so that there is no bursting effect.

2. Temper – applications

Secondary refrigerant systems in new and existing plants

How can Temper be used?

Temper can be used wherever a liquid heat transfer medium is required in stationary or mobile installations. Temper offers particular advantages as an alternative to glycol mixtures in the area of indirect cooling (secondary refrigeration) at low temperatures.

- Secondary refrigeration and freezing plants
- The food industry
- Supermarkets
- Ice rinks/artificial ski slopes
- The pharmaceutical industry
- Ships

Further applications as a heat transfer fluid at higher temperatures:

- Air conditioning systems
- Heat recovery
- Solar heat installations
- Heat pumps

Temper in new installations

Before filling, new installations should be well cleaned, preferable section by section, to avoid contaminants. The system is then pressure tested with nitrogen or air. The installation is then filled from the lowest point and all air is carefully vented off.

Temper in existing installations

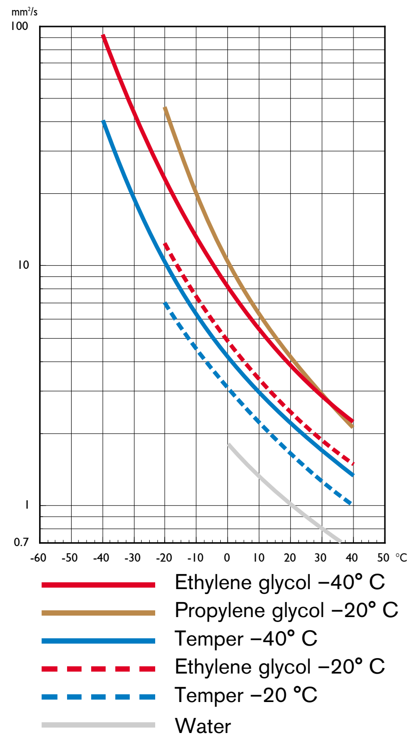
Existing installations with other heat transfer fluid can usually be converted without problems. In most cases there is a marked increase in performance because of the improved heat transfer. Before the changeover, the pumps, fittings, materials and seals used in the installation must be tested for compatibility with Temper (please request the relevant detailed information) and adapted if necessary.

The system must then be cleaned with a suitable agent to remove the old corrosion inhibitors and then flushed out with clear water until it is pH-neutral. Strainers and filters must be cleaned or changed.

The installation can then be filled with Temper and returned to service.

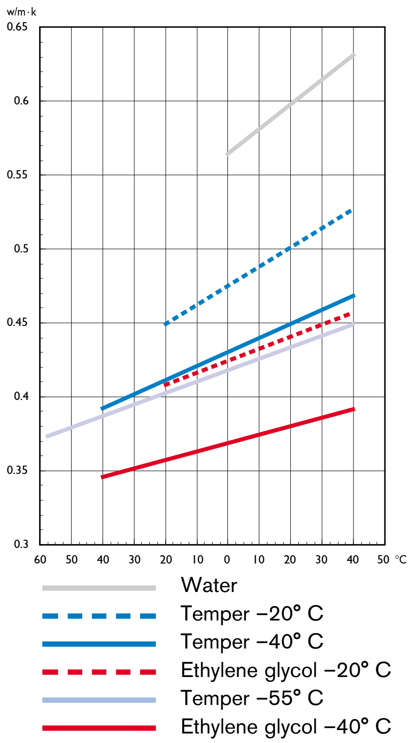
3. Using Temper properly

Planning, installation and operation



Kinematic viscosity

When a fixed body is transported through a fluid it is not only the dynamic viscosity that determines the resistance it meets. More energy is used to push a heavy fluid away than a light fluid. The concept of kinematic viscosity takes this factor in consideration.



Heat conduction capacity

Good heat conducting capacity is desirable for the medium in cooling or heating equipment, among other things because it reduces the temperature difference between the fluid and the wall of the pipe.

Correct installation for safe use

To make the best possible use of Temper and to ensure problem-free operation of the system for a long time, a number of important points must be borne in mind during planning, installation and operation. Detailed technical data sheets can be requested directly from us or obtained over the Internet **www.temper.se**.

Fundamentals

Secondary refrigeration systems

Temper should only be used in sealed systems, since oxygen from the air increases the tendency of metal parts in the system to oxidise. In addition, the water evaporates from open systems. This inevitably alters the composition/concentration of Temper and might lead to a thickening of the solution and to the formation of crystals. Air purger equipment must be installed in the system.

Pipe work and valves

Commonly used materials such as copper, brass, steel, stainless steel, cast iron and plastics (ABS, PE), approved for the planned temperature, may be used for pipe work and valves. Galvanised steel, zinc and soft solder are not suitable.

Filters

We recommend the use of filters with a mesh size of 0.6 to 0.8 mm, so that any corrosion products picked up by the heat transfer fluid are trapped.

Pumps

When choosing pumps, you should inform the manufacturer that Temper will be used. Make sure that the correct material is used for the seals. Because of the way Temper works, small amounts of Temper will appear at the shaft seal. Traces of salt crystals must be regularly washed off the seal surfaces with water. Alternatively, pumps without seals may be used.

Seal materials/gaskets

We recommend EPDM rubber, provided that they can withstand the temperatures of the application. Traditional sealing with flax/paste (such as Uni-Pack, Locher) may also be used, check with your supplier.

Our specialist advisors are at your service for further technical support relating to the use of Temper.

4. Temper corrosion protection

An innovative concept using novel inhibitors

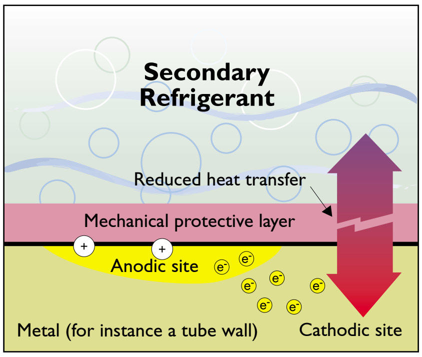


Figure 1

Conventional corrosion protection

Corrosion arises because of differences of electric potential between different metals (galvanic corrosion, compare the galvanic series).

Normally, corrosion inhibitors are added to the heat transfer fluid (glycol for example) to give protection against corrosion of pipes and valves etc. These inhibitors form a uniform mechanical protective film on the inside of all components. This protective film prevents corrosion by preventing the transport of electrons (see figure 1).

However, there are various drawbacks with this method:

- The protective film prevents optimal heat transfer.
- The protective film can easily be damaged by mechanical action, making it ineffective.
- If the inhibitors that form a protective film are degraded or damaged at some sites, new heat transfer fluid must be added. This creates a new, additional protective film throughout the entire system, even where the existing film is intact. This further reduces heat transfer.
- To assess the condition of the corrosion protection in the system, it would be necessary to check the adequacy of the mechanical protective film in every part of the system. This is to some extent impossible and would in any case be time-consuming and costly.

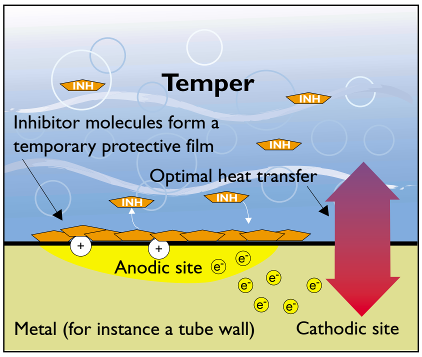


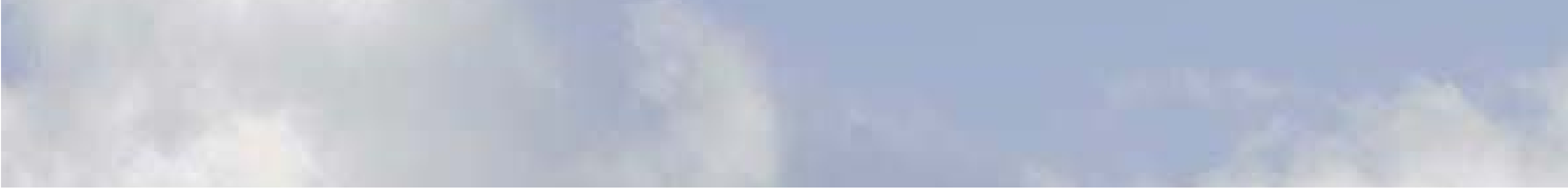
Figure 2

Temper corrosion protection

In the initial phase of corrosion, electronic potential displacements occur, without metal atoms being dissolved from the surface.

Temper contains special corrosion inhibitors which do not form a general mechanical protective film, but which instead act only where electronic potential differences arise. The molecules of the inhibitor accumulate at the corrosion-prone site, where they form an extremely thin local layer. This layer locally eliminates the risk of corrosion, with practically no effect on heat transfer. The Temper corrosion inhibitor is not consumed: Once the electric potential difference is equalized, the inhibitor molecules are released and are free to accumulate at any other site where there is an electric potential displacement (see figure 2).

With Temper, it is very easy to assess the corrosion condition of a system by determining the number of "free" inhibitor molecules. If the number of free inhibitor molecules falls below a given value (which might even happen when filling a system with Temper for the first time, for example because corrosion products are already present) optimal corrosion protection can be restored by adding pure inhibitor. If necessary the density (freezing point) can also be adjusted.



Health and environmental consideration as a business concept

Temper Technology's business idea is to develop and market fuels and chemical products with a minimum of negative effects on man and the environment. We have seen that petro-chemical products can be manufactured with a focus on health and the environment, which also have better technical performance than conventional products.

Temper Technology – a niche company

The world market is dominated by a small number of multinational corporations. Temper Technology is a niche company and is maintaining a firm position thanks to its unique innovations and strong commitment to the environment.

Temper Technology is certified in accordance with ISO 9001:2000 for quality and ISO 14001:1996 for environment.

For further information and details, please contact Temper Technology or visit us at **www.temper.se**

temper technology

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Thermal properties

Freezing point °C	Temperature, °C	Density, kg/m^3	Spec. Heat Capacity, kJ/kg.K	Thermal Conductivity, W/m.K	Dynamic Viscosity, mPa.s	Kinematic Viscosity., mm^2/s
0 Water	30	996	4,178	0,614	0,80	0,80
	20	998	4,182	0,598	1,00	1,00
	10	1000	4,192	0,580	1,31	1,31
	0	1000	4,217	0,562	1,79	1,79
-10	30	1084	3,590	0,559	1,16	1,07
	20	1086	3,577	0,544	1,45	1,33
	10	1088	3,561	0,529	1,95	1,80
	0	1090	3,542	0,514	2,80	2,57
	-10	1092	3,520	0,499	4,12	3,77
-20	30	1139	3,337	0,521	1,46	1,28
	20	1142	3,315	0,508	1,80	1,58
	10	1145	3,290	0,494	2,40	2,09
	0	1147	3,263	0,481	3,41	2,97
	-10	1149	3,233	0,467	5,14	4,48
	-20	1151	3,200	0,454	8,11	7,05
-30	30	1174	3,140	0,498	1,74	1,48
	20	1177	3,124	0,486	2,10	1,79
	10	1181	3,102	0,473	2,76	2,34
	0	1184	3,075	0,460	3,96	3,34
	-10	1187	3,042	0,448	6,14	5,17
	-20	1190	3,004	0,435	10,10	8,49
	-30	1192	2,961	0,423	17,32	14,53
-40	30	1203	3,011	0,476	2,05	1,70
	20	1207	3,008	0,465	2,71	2,24
	10	1211	2,997	0,454	3,65	3,01
	0	1215	2,978	0,443	5,10	4,20
	-10	1218	2,951	0,432	7,64	6,27
	-20	1222	2,917	0,421	12,67	10,37
	-30	1225	2,875	0,410	23,96	19,56
	-40	1227	2,825	0,399	51,53	41,99
-55	30	1235	2,886	0,456	2,02	1,64
	20	1240	2,876	0,445	2,96	2,39
	10	1245	2,860	0,435	4,36	3,50
	0	1250	2,840	0,426	6,48	5,18
	-10	1254	2,814	0,417	9,88	7,87
	-20	1259	2,784	0,408	16,05	12,75
	-30	1262	2,749	0,400	29,84	23,63
	-40	1266	2,708	0,392	68,94	54,47
	-50	1268	2,663	0,385	201,47	158,87
	-55	1269	2,639	0,381	368,63	290,47

Thermal expansion for Temper

There are a lot of different ways of calculating thermal expansion.

In some cases the concept of coefficient of expansion is used. Instead of just one unambiguous way, unfortunately there are several of ways, different reference temperatures among other things, to calculate the coefficient of expansion.

Usually you want to know how much a certain fluid expands in volume with increased temperature. Fluids always expand with higher temperatures and consequently decrease in density.

Below is a method described for calculating the relation between temperature and volume for a certain temperature interval.

Note! Chose the density for the correct Temper version.

The density values may be read out of the table "Thermal properties.pdf" or " Thermal Properties - Temper.xls" or from our web page www.temper.se and click further to "Thermal calculator".

D(T0) = The density of the fluid at the lower temperature, T0.

D(T1) = The density of the fluid at the higher temperature, T1.

V = The total volume of the system.

ΔV = The expansion of the fluid, in volume.

$\Delta V = V \times [D(T0) - D(T1)] / D(T1)$ Litres or

$\Delta V = 100 \times [D(T0) - D(T1)] / D(T1)$ %

Example:

How much will a fluid expand if the volume of the system is 600 litres of Temper-40 and the temperatures increases from –30°C to +20°C?

D(T0) = D(-30) = 1225 kg/m3

D(T1) = D(+20) = 1207 kg/m3

V = 600 Litres

$\Delta V = 600 \times [1225-1207] / 1207$ litres = 8,95 Litres or 1,49%.

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Technical Specifications

Temper -10	
Appearance:	Pale yellowish liquid
Boiling point:	≈ +109 °C
Freezing point:	< -10 °C
Density (+20 °C):	1079 - 1092 kg/m^3
pH (+20 °C):	8,5 ± 0,5
Dynamic viscosity (+20 °C):	Ca. 1,45 mPa·s (cP)
Kinematic viscosity (+20 °C):	Ca. 1,33 mm^2/s (cSt)
Specific heat capacity (+20 °C)	Ca. 3,577 kJ/kg·K
Thermal conductivity (+20 °C)	Ca. 0,544 W/m·K

Temper –20	
Appearance:	Pale yellowish liquid
Boiling point:	≈ +109 °C
Freezing point:	< -20 °C
Density (+20 °C):	1138-1146 kg/m^3
pH (+20 °C):	8,5 ± 0,5
Dynamic viscosity (+20 °C):	ca. 1,80 mPa·s (cP)
Kinematic viscosity (+20 °C):	ca. 1,58 mm^2/s (cSt)
Specific heat capacity (+20 °C)	ca. 3,315 kJ/kg·K
Thermal conductivity (+20 °C)	ca. 0,508 W/m·K

Temper –25	
Appearance:	Pale yellowish liquid
Boiling point:	≈ +109 °C
Freezing point:	< -25 °C
Density (+20 °C):	1159 - 1163 kg/m^3
pH (+20 °C):	8,5 ± 0,5
Dynamic viscosity (+20 °C):	ca. 1,90 mPa·s (cP)
Kinematic viscosity (+20 °C):	ca. 1,64 mm^2/s (cSt)
Specific heat capacity (+20 °C)	ca. 3,20 kJ/kg·K
Thermal conductivity (+20 °C)	ca. 0,497 W/m·K

Temper –30	
Appearance:	Pale yellowish liquid
Boiling point:	≈ +109 °C
Freezing point:	< -30 °C
Density (+20 °C):	1173 - 1183 kg/m^3
pH (+20 °C):	8,5 ± 0,5
Dynamic viscosity (+20 °C):	ca. 2,10 mPa·s (cP)
Kinematic viscosity (+20 °C):	ca. 1,79 mm^2/s (cSt)
Specific heat capacity (+20 °C)	ca. 3,12 kJ/kg·K
Thermal conductivity (+20 °C)	ca. 0,486 W/m·K

Temper –40	
Appearance:	Pale yellowish liquid
Boiling point:	≈ +109 °C
Freezing point:	< -40 °C
Density (+20 °C):	1204 - 1213 kg/m^3
pH (+20 °C):	8,5 ± 0,5
Dynamic viscosity (+20 °C):	ca. 2,71 mPa·s (cP)
Kinematic viscosity (+20 °C):	ca. 2,24 mm^2/s (cSt)
Specific heat capacity (+20 °C)	ca. 3,01 kJ/kg·K
Thermal conductivity (+20 °C)	ca. 0,465 W/m·K

Temper –55	
Appearance:	Pale yellowish liquid
Boiling point:	≈ +109 °C
Freezing point:	< -55 °C
Density (+20 °C):	1239 - 1242 kg/m^3
pH (+20 °C):	8,5 ± 0,5
Dynamic viscosity (+20 °C):	ca. 2,96 mPa·s (cP)
Kinematic viscosity (+20 °C):	ca. 2,39 mm^2/s (cSt)
Specific heat capacity (+20 °C)	ca. 2,88 kJ/kg·K
Thermal conductivity (+20 °C)	ca. 0,445 W/m·K

Temper technology

Temper

Safety Data Sheet

1. IDENTIFICATION OF THE SUBSTANCE AND OF THE COMPANY

Identification of Substance/preparation:	**Temper -10, -20, -30, -40, -55**
Application:	Heat transfer fluid
Company Identification:	**Temper Technology AB** Iberovägen 2 SE-430 63 Hindås Sweden Phone: +46(0)301-23 00 00 Fax: +46(0)301-23 00 99 web address: www.temper.info e-mail: temper@aspen.se
Contact person:	Roger Rosander tel. +46(0)708 - 23 50 32
Emergency telephone number:	Jan Lindblad +46(0)707-10 39 80 Roger Rosander +46(0)708-23 50 32

2. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical Composition	CAS-nr	Content	Symbol	R-phrases
Brine of carboxylic acids	127-08-2 590-29-4	15-80%		
Water		20-85%		
Different inhibitors		<1,5%		

3. HAZARDS IDENTIFICATION

The product is not restricted by any hazards identification.

4. FIRST-AID MEASURES

Inhalation:	In case of excessive exposure, get fresh air.
Skin:	Wash with water and soap.
Eyes:	Wash eye thoroughly with water. If irritation persists, obtain medical advise.

Safety Data Sheet

Ingestion: Drink much water, seek medical attention.

5. FIRE-FIGHTING MEASURES

Extinction suitable: Not flammable, non-burning liquid. Possesses extinguishing properties.

6. ACCIDENTAL RELEASE MEASURES

Flush with much water, accidental release can be flushed in sink with excess hygiene.

7. HANDLING AND STORAGE

Sink and water should be available close to working place.

8. EXPOSURE CONTROLS/ PERSONAL PROTECTION

Protection: Normal ventilation, wear plastic gloves. Protect eyes with goggles when contact may occur

9. PHYSICAL AND CHEMICAL PROPERTIES

pH 8-9
Boiling point (°C): ca. 109°C
Melting point (°C): Temper-10 < -10, Temper-20 < -20, Temper-30< -30, Temper-40< -40, Temper-55< -55
Flash point (°C): Not flammable
Density (kg/m^3): 1086-1240
Solubility (% of the weight): Unlimited in water, glycol, alcohol and glycerine.

10. STABILITY AND REACTIVITY

Stability: Stable at normal conditions, does not react with other water-based heat transfer fluids.

Condition to avoid: Not suitable materials galvanised steel, zinc and soft solder.

Safety Data Sheet

11. TOXICOLOGICAL INFORMATION

LD50 oral rat: The product is not toxic. LD50, oral rat: > 2 000 mg/kg.

Skin contact: A prolonged contact with the skin may give redness or skin chaps.

Eye contakt: Unlikely to cause other than temporary redness on accidental contact.

Ingestion: The product has a bitter taste, which gives a warning if the product is digested by mistake.

12. ECOLOGICAL INFORMATION

Ekotoxicity: LC50 96h, OECD TG203 (Rainbow Trout, Oncorhynchus mykiss) 13900 mg/l and is not classified as acute aquatic toxic.

Persistence/Degradability: The product is not regarded as being toxic to the environment. The components are easily biodegradable, DOC (OECD 301A)> 90% already after 7 days.

Bio-accumulation: Not bioaccumulating. Most of the components act as fertilisers and enter in to the biological circulation and do not accumulate in any micro organisms, plants or other living species..

13. DISPOSAL CONSIDERATIONS

Product disposal: Dispose in accordance with local regulations

14. TRANSPORT INFORMATION

Not regulated.

15. REGULATORY INFORMATION

The product does not fall under any EC labelling regulation.

The safety data sheet is prepared according EC-directive.

Safety Data Sheet

16. Other information

Product information See Aspen Temper recommendations and guidelines.

Emptying: Turn the barrel upside down to drip-dry (< 1 drop/min).

The information in this Safety Data Sheet is to the best of today's knowledge and believed accurate and reliable as of the date indicated.

However, no representation, warranty or guarantee is made as to it's accuracy, reliability or completeness. It is the user's responsibility to satisfy himself as to the suitability and completeness of such information for his own particular use.

Temper – installation Guidelines

Temper – Installation Guidelines

1. System design - summary

Temper is a ready-mixed freeze protection product based on an aqueous solution of potassium acetate and potassium formate. The mixture includes corrosion protection at an optimal concentration (one of the reasons why Temper is only available ready-mixed).

The operational life and reliability of a refrigeration system depend to a large extent on how it is installed, the system's cleanliness before first use, and how the system's components are handled and mounted in relation to each other.

The instructions below are for the benefit of the installer / design engineer, and should be regarded as providing assistance in their work. However, the installation firm must possess the necessary skills to implement a fully functional indirect system.

- To prevent air from entering, Temper should only be used in closed systems. Oxygen always means an increased risk of corrosion.
- Most materials can be used, such as copper, brass (dezincified), steel, stainless steel, cast iron and certain types of plastic pipes. Selection of materials must therefore take into account the operational temperatures in the system. The higher the temperature, the better the quality of the materials. (see chapter 2)
- Unsuitable materials are; galvanised steel, zinc and soft solder.
- Joining of heat transfer fluid systems must be done by:
    1. Welding
    2. Brazing (copper or silver brazing solder)
    3. Flange joints (avoid fibre packing as Temper has low surface tension; use EPDM rubber).

4. Threaded joints (only in exceptional cases, when they can be made tight with sealing compounds such as Loctite, Omnifit, or flax and Locherpasta / Uni-Pack).
5. Avoid compression fittings of various types.

- It is very important to air purge the system. Always install high point air purgers (manual or automatic).
- Air purging becomes more effective at higher temperatures. Best results are obtained when the fluid is warm, around +35°C. If possible, use an immersion heater or similar. Be sure to air purge properly before operational use of the refrigeration system, particularly if prior warming has not been possible.
- Always install an easy-to-clean filter (0.6 – 0.8 mm filter mesh size) on the delivery side of the pump.
- When choosing the pump and/or shaft seal, consult your pump supplier about heat transfer medium used.
- For estimating pressure drops and heat transfer coefficient in the pipe system, see the calculation program “thermal calculator” at Temper Technology’s website www.temper.se
- Selection of the right flow rate depends on the dimensions, viscosity and the system design. Bear in mind that small dimensions in, for example, cooling coils will not tolerate flows of more than approx 0.7 m/s. In larger dimensions, the flow rate can be increased somewhat (approx 1.0 – 1.2 m/s).
- Do not allow the system to stand empty with no fluid, or only partly filled with fluid, as this can allow surface rust to form on the insides of the pipes.

2. Materials

Most of the common materials can be used such as copper, brass, steel, stainless steel, cast iron, as well as plastic pipes (ABS, PE). Plastic materials must be suitable for the system's minimum and maximum temperatures.

Unsuitable materials are; galvanised steel, zinc and soft solder. High temperatures involve an increased risk of corrosion. This applies particularly to certain types of materials (for example cast iron). Selection of materials must therefore take into account operational temperatures in the system. The higher the temperature, the better the quality of the materials.

Suitable materials are:	Unsuitable materials are:
• Steel	• Zinc
• Stainless steel	• Galvanised steel
• Copper	• Tin solder (soft solder)
• Cast iron	• Annealed components
• Brass (dezincified)	
• Aluminium	
• Copper brazing solder	
• Silver brazing solder	
• ABS (Plastic)	
• PE (Plastic)	

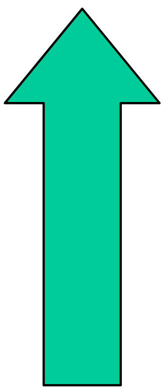
Suitable sealing and packing materials are:	Not suitable are:
• EPDM • Butyl rubber • Synthetic rubber • Nitrile rubber • Natural rubber • PE (LD and HD) • NBR (Nitrile Butadiene rubber) • Chloroprene rubber	• Fibre packings • PTFE, FEP (Teflon) • FKM (Viton)

Fibre and Teflon sealants have poor flexibility. This means that they do not adjust so well to temperature fluctuations in the system, and this increases the risk of leaks.

The galvanic series

When selecting materials, it is a good idea to select metals that are as close as possible to each other in the galvanic series. The best idea is to use the same material throughout the installation.

Most noble



Least noble

- Graphite
- Silver
- 18-8 Cr-Ni-Fe
- Nickel, passivated
- Silver brazing solder
- Copper-Nickel
- Bronze
- Copper
- Brass
- Tin
- Cast iron
- Steel, iron
- Galvanised steel
- Zinc

3. Pumps

- Dry running pumps should always be chosen in preference to wet running ones, as dry running pumps are considerably more efficient.
- The pump should be surface finished, with a non-rusting drip plate placed below it.
- Stainless steel bolts must be used.
- If possible, the pump should be surface finished inside. This applies particularly to "warm side" temperatures over +20°C.
- Consult the pump supplier, and inform the supplier about which heat transfer fluid is to be used.
- Experience shows that the selection of shaft sealing is important, and that "hard" shaft sealing materials should be selected (more information from the pump supplier).
- There should be a little "leakage" in order to provide a cooling effect between the stationary and the rotating sealing surface. When Temper gets outside the seal, the water will evaporate and the remaining crystals will become visible. These can be rinsed away with water at regular intervals. Alternatively, a sealingless pump can be used.
- Follow the pump supplier's operational and servicing instructions.

4. Valves

Valves must be of a type compatible with the list of materials – see chapter 2.

Bear in mind that most types of valve, for example adjustment valves, control valves and solenoid valves may contain fibre packing. This should be changed to rubber seals.

Consult the appropriate valve supplier about the choice of valves, and specify the type of transfer fluid and operational temperatures.

5. Expansion vessel

The purpose of the expansion vessel is to even out variations in volume and pressure that can arise from varying operational temperatures.

Calculation of the correct dimensions must be carried out so that the system functions properly in relation to the extent of expansion and suitable system pressures under different operating conditions.

- In order to monitor the vessels initial pressure, the expansion vessel must be provided with a shut-off valve and a drain valve.
- It is a good idea to locate the expansion vessel on the pump's suction side, where normally the lowest system pressure is to be found. The purpose of this is to ensure that the pump has enough static pressure to avoid cavitation.
- The expansion vessel must be compatible as regards temperatures and materials with the heat transfer fluid.
- When calculating dimensions for the expansion vessel, it is a good idea to use the instructions and calculation programs provided by the relevant supplier.

A common error in heat transfer systems is that the expansion vessel is under-dimensioned and with an initial pressure set too low in relation to the system's overall pressure. As a result, the system pressure fluctuates, with the consequence that there can be underpressure in the uppermost parts of the system. If automatic air purgers are installed, these may function in reverse, not as air purgers. For that reason, shut-off valves must be installed between the system and the air purgers. If the expansion vessel is too small, the result is that volume changes in the fluid cannot be counterbalanced by the expansion vessel.

6. Filter

Filters should be installed on the delivery side of the pump. This is because the corrosion inhibitor tends to agglomerate (bind) any corrosion products (for example in the event of high oxygen concentrations in the system). If there are filters in the system, then these corrosion products can be removed. These filters should be easy to clean, for example by thorough rinsing. The filter mesh size should be 0.6 - 0.8 mm. Filters with a small filter mesh size can be placed in a bypass flow. This is recommended if the fluid contains large amounts of small particles.

7. Connection methods and sealing materials

Recommended connection methods and sealing materials:

1. Welding
2. Brazing (copper or silver solder)
3. Flange joints (use rubber packing)
4. Threaded joints (only in exceptional cases, when they can be made tight with sealing compounds such as Loctite, Omnifit, or flax and paste/putty.

The manufacturers of the various products know which types can be used.

Brazing

- Brazing between copper parts must be done using copper phosphorus brazing solders (Cu 89%, P 6%, Ag 5%).
- Brazing between copper and brass must be done using silver brazing solders (Ag 44%, Cu 30%, Zn 26%) and flux.
- Brazing between copper and steel must be done using silver brazing solders (Ag 44%, Cu 30%, Zn 26%) and flux.

Miscellaneous

- Post-tightening of flanges and connectors must be done after installation and pressure tests, and at the correct operational temperature. Insulation work in these places must be carried out after these actions have been completed.
- When installing ABS or PE pipes or similar, it is important to use the glueing or jointing process recommended by the supplier. The plastic must also be suitable for the operational temperatures involved.
- Avoid using plastic flanges with plastic collar sockets. There is a great risk of sideways dragging and leakage. Instead, use steel-reinforced flanges.
- Avoid fibre and Teflon packing. Temper has low viscosity and low surface tension. This means there is a substantial risk of creep/leakage as a result of faulty installation etc.
- Packing maternal made of EPDM or nitrile rubber is recommended. Note that even small amounts of oil can destroy EPDM packing.

8. Storage

Temper should always be stored in tightly closed containers. This is to prevent evaporation and consequent changes in viscosity and density. In the long term, Temper is light-sensitive. Therefore always use non-translucent (dark) storage containers. This applies even to containers used for topping up. In a tightly closed container, Temper has practically unlimited storage stability.

9. Cleaning

Before being filled, the system must be thoroughly cleaned of dirt, welding remains, any remaining water from the pressure test and any other “foreign” particles.

During installation, cover the ends of pipes to prevent dirt and damp from penetrating in.

NOTE *Cleaning is important – otherwise loose particles can cause galvanic elements and lead to pitting corrosion in the system.*

10. Pressure testing

For pressure tests of the system, various methods can be used, such as air, nitrogen or water. Pressure tests using air or nitrogen are preferred. With pressure tests using water, there is no control over how much water comes out when the system is emptied. Water remaining in the system can cause dilution of the heat transfer fluid. This in turn can have a negative effect on the freezing point and the inhibitor content.

11. Charging the system

Temper is always supplied ready-mixed, and must not be diluted or mixed with other fluids.

The numbers on the label give the freeze protection temperature: Temper -20 = Freeze protection -20°C.

If possible, the system can be vacuum-pumped in order to make it easier to fill the system. This also minimises the risk of air pockets. However, containers and tanks must be kept separate to avoid damage to the materials (implosion). Check with the supplier whether installed components can be exposed to sub-pressure.

Charge the system from the lowest point, and fill it slowly to avoid air pockets.

Charging is done with a separate pump, or directly from a tank lorry. If it is possible to raise the temperature in the system to around +35°C, most of the "microbubbles" in the system will be eliminated.

Fluid drained from the system must be stored as described in *Chapter 8 Storage*. It must not be stored in open containers, as it will then become oxidised and will collect dirt.

Read more about this in Chapter 13 Air purging. Also see instructions from Köldbärarlaget (The Secondary Refrigerants Team) in Temper dossier, section 6.

12. Conversion

When changing from another type of transfer fluid to Temper, a thorough review and overhaul of the system is essential. This is required in order to ensure that the components to be incorporated are compatible with Temper and that the system is cleaned in the correct way. For more information about this, please contact Temper Technology.

13. Air purging

For properly functioning system, it is important to eliminate as much air as possible from the system.

Various problems can arise in badly air-purged systems, such as:

- reduced pump capacity
- reduced heat transfer
- corrosion, erosion
- sealing problems

How much air a fluid can bind to depends entirely on pressure and temperature. High temperature and low pressure binds less air than low temperature and high pressure. (If possible, warm up the system to around +35°C – this facilitates air purging).

Air purging is achieved mainly in the following ways:

- manual or automatic air purgers (high point air purger)
- air separator (micro-bubble separator)
- sub pressure air purgers (vacuum degasser)

Manual or automatic air purgers must be installed at all high points, and must be placed at the end of the pipe's direction of flow. If automatic air purgers are used, then shut-off valves must be installed between the system and the air purgers. Automatic air purgers must only be held open during filling and servicing, as with time there is a risk that they are set again and instead function as "reverse air purgers" into the system.

An air separator (micro-bubble separator) is installed where the cooling agent is at its warmest (return line). The micro-bubble separator only removes the "free air". To remove the bound air from the system, a sub pressure air purger is used. It does not need to be permanently connected to the system. Normally it is enough if it is connected at the start of operational running and for a time thereafter, depending on the volume of the system. Contact the supplier of the sub pressure air purger for more information.

NOTE *The views and recommendations given above are based on our experience to date, and may be revised in the future.*

Running and Attendance Recommendations

Temper is a ready-mixed anti-freezing solution that is based on potassium acetate and potassium formate dissolved in water. Corrosion inhibitors have also been added to the solution at a carefully balanced concentration where the anti-corrosive effects will be the best possible.

The following check-ups have to be done about 1 to 2 months after taking the plant into operation , and after that at regular intervals (about every 6 months – the inhibitor every 12 months):

- The density of the liquid – this will also tell you the anti-freeze effects of the solution.
- The pH of the liquid (nominal pH value: 8-9).
- The concentration of metal ions / corrosion products.
- The concentration of the anti-corrosive additive in the liquid

Sample that has been taken within 3 months after charging the system can be sent to Temper Technology for free analysis of density and pH.

Density

Density / anti-freeze protecting qualities can be analysed in several ways, for example with the help of an aerometer. The density corresponds to a specific anti-freeze protection value. The density is measured at a liquid temperature of +20°C. The measured density value is compared to the anti-freeze protection value in the density table (s.5 'Temper – Density vs. Freezing point'.)
If the freezing point deviates more than 5°C from the nominal value the cooling medium has to be adjusted. Contact Temper Technology for advice. It is important to establish whether the plant might allow this temperature difference (i.e. if the temperature safety margin in e.g. the evaporator is sufficient).

pH

The pH value can be determined with a pH meter (ionometer or acid meter) or with a pH paper. If the pH value deviates with more than 0.5 (pH <7.5 or pH >9.5) from the nominal value (see above) The pH balance has to be adjusted. Contact Temper Technology for advice.

Metal ion and inhibitor concentration analysis

Concentration analysis of corrosion inhibitor and metal ions requires advanced equipment. Temper Technology may carry out this analysis for you. Take a sample and send it to Temper Technology as described above.

Charging

When charging Temper, take care to avoid air from getting into the system during the charging procedure, as this will only cause extra work with the air purging of the system. Heat, if possible, the liquid (to +35°C) before air purging at suitable spots.
Check air purge valves regularly and clean them with water if necessary, in order to ensure that nothing blocks the valves. Water also removes salts from evaporated Temper solution on pipe components. This is important since the remnants of spilled anti-corrosive agents might cause corrosion on the outside of components if not removed with water.

Other

Temper must always be handled in accordance with the instructions given in the material safety data sheet enclosed with the solution. Temper is maintained stable if transported in closed transportation vessels. Temper must never be mixed with other types of heat transfer fluids. Consult your pump supplier regarding advice about suitable shaft seals. See also the separate Installation Guidelines.

If you have any further questions, please do not hesitate to contact Temper Technology . We will be happy to assist you.

Temper Sampling

Density measurement equipment specially adapted to Temper can be ordered from Aspen for your own measurements. The equipment contains a density meter, a so-called aerometer, 1.000-1.300 g/ml, test cylinder 250 ml, thermometer –10 to +60° C and a density table valid for a liquid temperature at +20° C, i.e. a tempered liquid.

pH indicator sticks are also available from Temper Technology.
A set contains 100 dip in - read off sticks together with read off key.

If you intend to send the sample to Temper Technology to be analysed, be sure to use a vessel that is not fragile or could be damaged during transportation (use a plastic bottle for example).
Use a clean bottle or some other vessel (holding at least 150 ml) and fill it with the secondary refrigerant from a suitable spot in the plant, like for instance an overflow valve. To get rid of possible dirt and slag in the valve it is recommended to throw the first of the fluid down the sink and after that fill the vessel full.

Samples sent to Temper Technology have to be marked with:

- Sampling date
- Company name
- Secondary refrigerant version (for example Temper –20)
- The volume of the installation
- Date of charging

In the note that you attach to the sample you can also right down reason for analysis (for instance check-up) together with notes if and when problems have occurred. The more details you are able to give, the better are the chances that we can establish the exact cause of the problems.

Density Control Kit

Aerometer:	**1,000 – 1,300 g/ml at 20 °C**
Measuring cylinder:	**250 ml**
Thermometer:	**-10 – +60 °C**
Density vs. Freezing point:	**1,07– 1,24 g/ml**

Aerometres

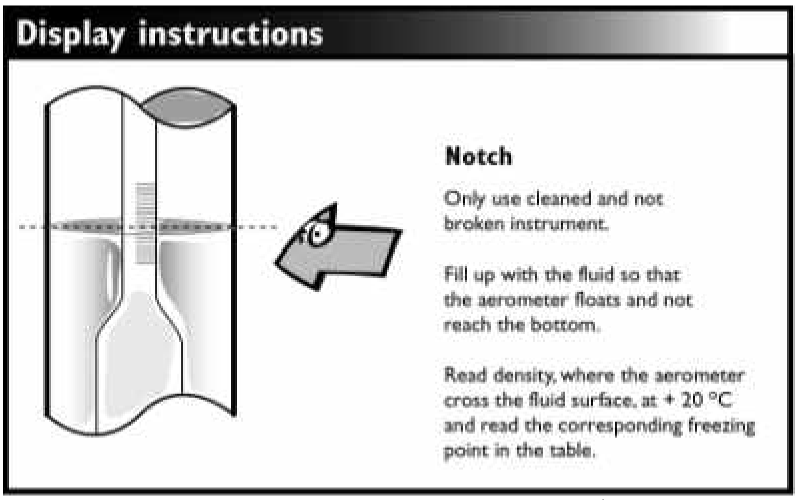
The aerometer (can be ordered from Temper Technology or your retailer) is an easy to use instrument for checking density in fluids, which corresponds to given freezing point. Archimedes principal says that the weight of a floating body is the same as the weight of the repressed fluid material mass. The floating body of the Scale-aerometer is weight balanced in the bottom end, usually with hailstone, which makes the aerometer to float in a vertically position. The aerometer ends in the top with a cylindrical tube where the scale is situated. Read the value on the aerometer where the scale crosses the fluid surface. See the picture below.

Normally aerometres are scaled in density (1 g/ml = 1000 kg/m3). Aerometres are also specially prepared to scale in percent, for instance alcohol-metres and sackaro-metres. Compare accumulator or glycol testers with applicable scales.

Since the density is varying with the temperature aerometres are normally calibrated at a certain temperature, usually + 20 °C.

Use the thermometer to ensure that the fluid temperature is approximately + 20 °C.

Always check the aerometer so it is clean and not damaged, if necessary clean with water.



Density vs. Freezing point

At +20 °C
(1000 kg/m³ = 1 g/ml)

Density, kg/m³	Freezing point, °C
1070	-7,8
1080	-8,9
1090	-10,7
1100	-12,4
1110	-14,1
1120	-16,0
1130	-17,8
1140	-19,6
1150	-22,2
1160	-25,2
1170	-27,8
1180	-31,0
1190	-34,1
1200	-37,5
1210	-40,9
1220	-43,6
1230	-46,8
1240	-55,0

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Aim

The use of heat transfer fluids within the refrigerating technology in so-called indirect systems has increased considerably, and we would therefore like to give some hints as to what has to be considered particularly when designing, installing, charging, starting up and running such a system to avoid problems. We will focus mainly on the problems connected with alcohol, glycol and organic salts used as anti-freezing solutions.

The aim of the SECONDARY REFRIGERANTS TEAM © is to provide information to increase the understanding of what might cause problems, so that these can be avoided.

Contents

Water-based anti-freezing solutions

The most common water-based anti-freezing solutions today are different types of alcohol, glycol and organic salts.

When using concentrates intended to be mixed with water, it is important to mix with the right water quality. Contact the supplier of the anti-freeze solution for exact information as to the water quality required for the product.

If using organic salts or propylene glycol with inhibitors for applications within the food sector, it is advisable either to use ready-mixed solutions from the supplier, or to mix with deionized water.

Motor radiator glycol must not be used in this type of system, because the inhibitor composition is not right and would cause pump damages.

Do not mix different types of anti-freezing solutions in the same system.

Information of the type of anti-freezing solution used and its concentration must always be available at the installation.

All types of heat transfer fluids should be treated as chemicals and should not be released into sewage disposal systems deliberately. Restrictions valid for the solution used may be obtained from the supplier. Before tapping a system of a heat transfer fluid and handling used products it is advisable to contact the local environmental and public health authorities. Used heat transfer fluids are to be classified as industrial waste.

Recommendations for heat transfer fluids:

- Use ready-mixed heat transfer fluids.
- When using concentrates – follow the suppliers recommendations as to water quality and concentration.
- Never mix different heat transfer fluids.
- Do not use motor radiator glycol.
- Before handling a heat transfer fluid, read the product information supplied with the fluids.
- Check the anti-freezing solution as advised by the supplier.

Design

When designing and installing a system it is important to know the requirements of the selected heat transfer fluid regarding material compatibility and thermodynamic properties.

Many types of corrosion and other problems are avoided by considering the following:

- Select and install components whose metal compositions are as homogeneous as possible to avoid galvanic corrosion. It is advisable to choose highquality steel or metals, because these are less sensitive to corrosion and may therefore last longer.
- Be sure to follow the material recommendations given both by the heat transfer fluid supplier and by the other suppliers. Don't forget that some types of material might not be suitable from the point of view of temperature.
- When designing and assembling the system, keep in mind that it has to be easy to charge, air purge and service.

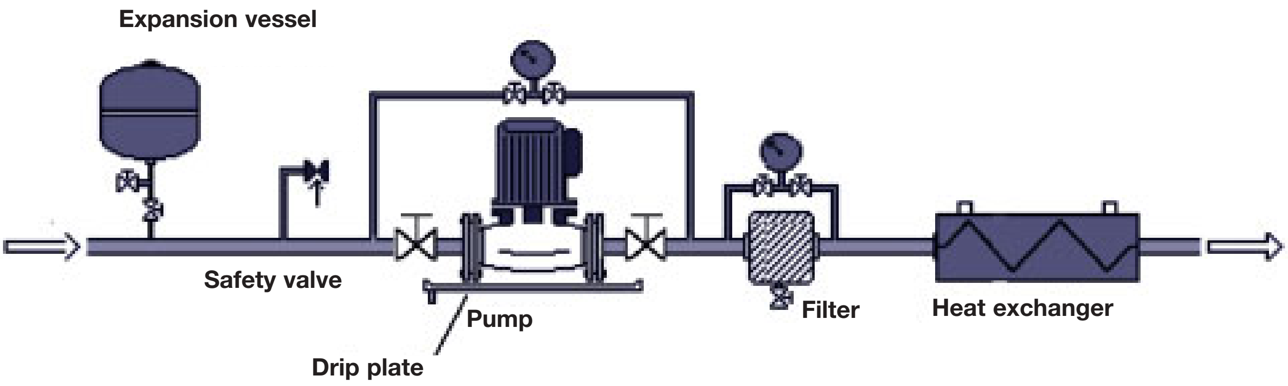
  Oxygen in the system always furthers corrosion processes. High and local pressure drops might induce air, and thereby oxygen, to penetrate into the system. This is avoided by selecting the right pipe dimensions.
- Erosion in the system (internal wear of pipe walls) is avoided with the right flow velocity. Contaminants in the liquid – metallic ions and corrosion deposits – might damage shaft seals in pumps.
- The air in the system is removed with the help of efficient air purgers placed where the static pressure of the system is low. Vacuum air purging is an excellent method.
  Automatic top air purgers have to be provided with a valve, so that they can be shut off from the system when necessary (see passage headed **Air purging**).

- A filter has to be installed at the delivery side of the pump. In systems with a plate heat exchanger a filter with a maximum mesh width of 1.0 mm has to be installed before the heat exchanger.

- An expansion vessel of sufficient size and pre-pressure has to be connected immediately before the suction side of the pump. A sufficiently high static pressure at the suction side has to be ensured to avoid cavitation in the pump.

- Systems with an operating temperature below 0°C should be welded or soldered. Be sure to consider the risk of frost burst when selecting connection pieces.

- Pumps should be provided with shut-off valves and cover-all drip plates.



Clean systems

Systems operating with water-based anti-freeze solutions – heat transfer fluids – have to be cleaned before being charged. Solid contaminants causes problems in systems by clogging and damaging pumps and by increasing the risk of corrosion.

Emptying the system completely after rinsing it is difficult, but this problem may be solved by cleaning the system section by section during the assembly work, instead of flushing the complete system when assembled.

Filters should be placed at the delivery side of the pump. If there is a plate heat exchanger in the system the mesh width of the filter should be maximum 1.0 mm.

Cleaning recommendations:

- Be careful when assembling the system. Provide the pipes with end covers.
- Clean the system section by section.
- When changing the heat transfer fluid, contact the supplier for information
- Test for leaks before charging the system.

Charging

The system has to be charged from its lowest point, because in that way the liquid will press out the air at the system's highest points.
Fig A.

Charge the system slowly to eliminate the risk of air pockets.
Fig B.

A correctly charged system without air pockets.
Fig C.

The system has to be completely air purged. The heat transfer fluid has to be mixed before charging it. Never charge concentrate and water separately.

Charging recommendations:

- Charge the system from its lowest point.
- Charge slowly to avoid air pockets.
- Keep in mind that if you use water for the leak tests, emptying the system completely will be difficult. The remaining water will dilute the solution, and its anti-freezing and/or anti-corrosion effect might be reduced. Furthermore the calculated solution quantity in the system will no longer be correct.
- Either charge the whole system at the same time or shut off charged sections, so that heat carrier and material cannot be exposed to air (oxygen).
- Mark the system visibly with:

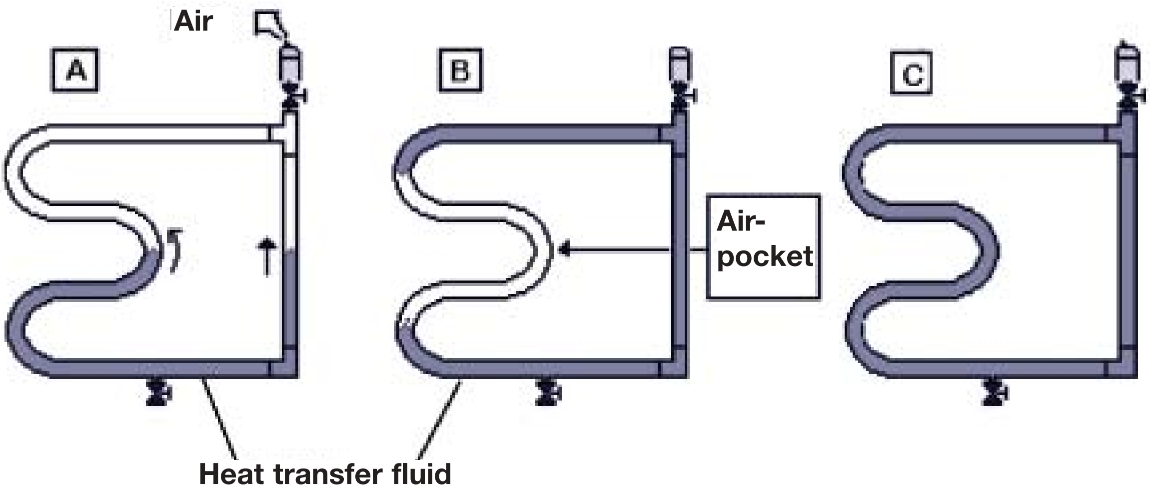
  -Name and concentration / freezing point of heat transfer fluid

  -Name and address of supplier

  -Charging date

  -The name of the person responsible for the charging.

Secondary refrigeration system



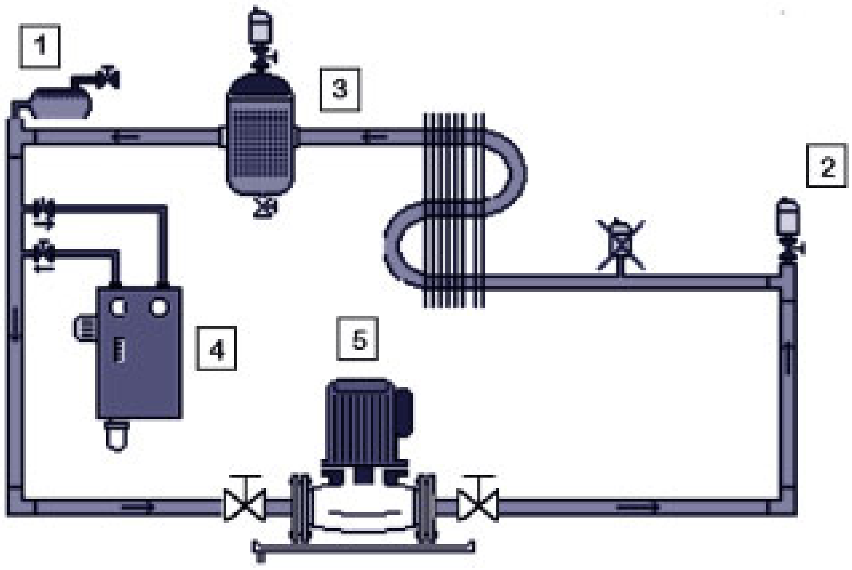
Air purging

The picture below illustrates some methods for air purging. In a system intended for water-based anti-freeze solutions it is extremely important to be able to remove all the air in the system. Air pockets, or oxygen in the system, increase the risk of corrosion and decomposition or deterioration of corrosion inhibitors. When using automatic air purgers, install a valve between this device and the system, so that it can be shut off when air purging is completed or when cleaning is required.

Air purging recommendations:

- Circulate the system at a high temperature (room temperature) some time after charging it. Air purging is accelerated when the temperature is increased.
- Be careful to remove all air from the system to avoid future operating disturbances.

1. Manual air purger
2. Automatic air purger
3. Active air purger
4. Sub-pressure air purger
5. Pump



Pump dimensioning

The pump diagrams found in manufacturers' catalogues refer to the pumping of water at a temperature of +20°C. When another medium than water is used the pump curve (operating point) has to be revised.

The operating point is based on the density and viscosity of the fluid used and on the operating temperature. The possible change in power consumption also needs to be considered.

State the following values when submitting an inquiry about a pump:

• Pressure height	kPa	Revise stated value with regard to selected medium and system resistance.
• Volume flow	kg/sec, l/sec or m^3/h	Revise stated value with regard to selected medium in the system.
• Heat transfer fluid type	% or freezing point, °C or °F	State freezing point or concentration of selected medium.
• Density	kg/m^3	State density at the operating temperature.
• Viscosity	mPas, cP or cSt	State viscosity at the operating temperature.
• Operating temperature	°C or °F	State minimum operating temperature
• Ambient temperature	°C or °F	State ambient temperature for pump motor.
• Surface treatment	Type	State desired surface treatment of the pump

The pump manufacturer will dimension pump and shaft seal based on these data.

Start-up

After the air purging it is time to start up cooling machinery and/or other types of equipment.
Keep the system under observation, checking particularly that there is no air in the system and that an overpressure is maintained during the whole cooling down period.

Operation

In order to avoid operating disturbances it is advisable to always contact the supplier before replacing the heat transfer fluid or changing it in any way. The supplier will assist you with analysis, advice about mixing, pump changes etc. The shaft seal of a dry pump must, for example, be selected with regard to the heat transfer fluid used. Due to its construction the shaft seal is always kept moist (lubricating film at sealing surfaces).

Water evaporates during operation, and additives might get deposited round the pump, either in solid form or as liquid droplets depending on the choice of heat transfer fluid. This is quite normal. Flush with water to cleanse out the deposits.

Mechanical shaft seals become worn. They have to be checked regularly and replaced when necessary.

Operating disturbances

Reduced capacity is normally caused by air in the system.

Air in the system reduces the heat transfer capacity of the exchanger. It also reduces the pump capacity with reduced flow velocity as a consequence. Furthermore there is an increased risk of decomposition of the corrosion inhibitors, and this might also cause operating disturbances.

Abnormal wear/leakage at the shaft seal might be caused by dry running or contamination. It might also be caused by the concentration of the inhibitor being wrong, and/or by the wrong water quality. These faults are not to be considered as material or manufacturing faults.

If the system is heavily contaminated, chemical cleaning, with weak and inhibited acids, for example, might be necessary. Engage well-known companies with references and be sure to give a detailed account of the components in the system. Take care that the contract also comprises after-rinsing and neutralisation.

Check the system:

- Check pumps using a differential pressure value which has been recalculated for the liquid used.
- Check that the system has been air purged properly.
- Check status of liquid; check for example pH, freezing point, appearance, or send a fluid sample to the supplier.
- Check system temperatures.

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We reserve the right to make alterations to the above instructions.

* THE SECONDARY REFRIGERANTS TEAM *

Part 2

Air purging technology and pumps in secondary refrigeration systems

Policy

The Secondary Refrigerants Team is a non-profit association with the following aims:

- to work for greater understanding of secondary refrigeration systems.
- to work for secondary refrigeration systems which are appropriate in terms of energy and the environment.
- to be independent of commercial interests.
- to promote optimal solutions (using LCC for instance) in collaboration with external expertise.

Content

This publication from * THE SECONDARY REFRIGERANTS TEAM* mainly covers air purging technology and air purging equipment, as well as circulating pumps in secondary refrigeration systems. Please read our 1999 publication as well.

So that the field of air purging could be covered factually and correctly, the following companies provided technical expertise and advice on the subject of air purging.

* THE SECONDARY REFRIGERANTS TEAM * wishes to thank:

- Armaturjonsson AB
- Beulco Armatur AB
- Flamco
- AB Frenco
- KAROB AB
- NICAB
- Nordicold / Valvab AB
- PREMA AB
- Recowa AB
- Retherm AB
- Ventim AB

Delivery

When heat transfer fluid is delivered it is important to check that it has not been contaminated via damaged packaging or in some other way (a tanker that has not been properly cleaned, for example).

Check that the packaging has not been damaged and if a tanker delivered the heat transfer fluid, check the tank-cleaning certificate.

Take a sample of the heat transfer fluid before charging. Check that the liquid is clear and not discoloured. Mark the sample and save it for 6-12 months for reference purposes.

Charging

The systems must be thoroughly cleaned before it is charged. Charge the entire system at one go or by sections, to avoid unnecessary exposure to oxygen, for example pumping via open vessels or similar. Any vessels used for charging must be sealed to prevent contamination. Empty the vessel after use.

Storage

Heat transfer fluids must be stored in sealed vessels to minimise the risk of contamination. Before using a heat transfer fluid that has been stored, check carefully that the liquid is not discoloured (rust-coloured). Half-filled metal drums rust internally due to condensation.

Air in secondary refrigeration systems

Air is made up of: 78% nitrogen N_2
21% oxygen O_2
1% noble gases

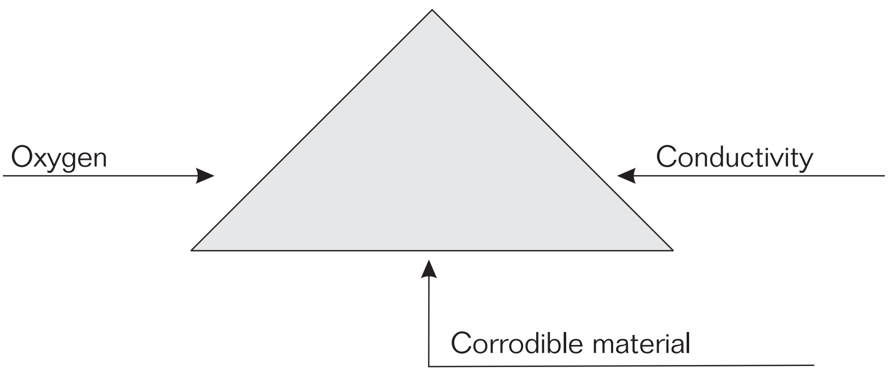
The term gas ought to be used instead of air, since air consists of various gases. For simplicity we shall use the term air in this document.

Various problems may occur in poorly air purged systems:

- Reduced pump capacity
- Reduced heat transfer
- Regulation problems
- Erosion and corrosion
- Leakage at seals

Oxygen in the air encourages corrosion in the systems. Since oxygen is one of the elements essential for the corrosion process, corrosion increases in poorly air purged systems.

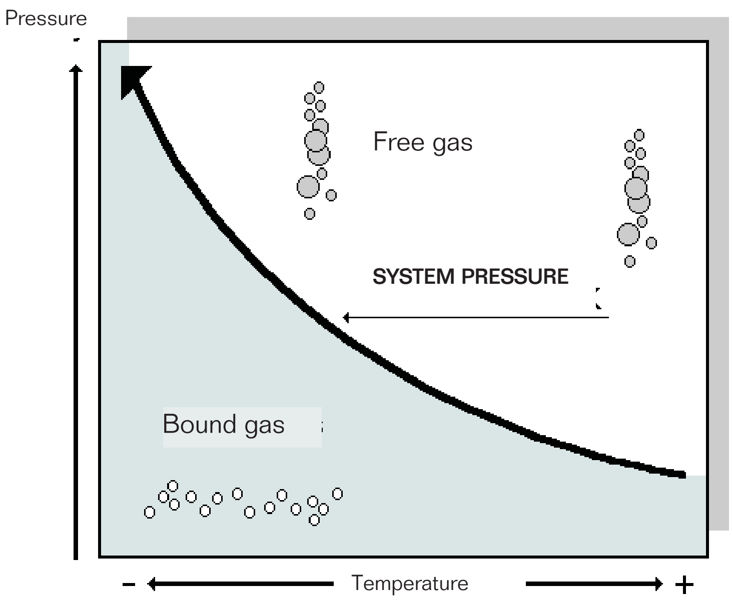
The corrosion triangle



Air may occur in different forms:

- Free air (air pockets, air bubbles)
- Bound air (dissolved in the liquid)

The amount of air that a liquid can bind depends mainly on pressure and temperature. The liquid can bind less air at high temperature and low pressure (A). The liquid can bind more air at low temperature and high pressure (B).



There are different ways of removing air from liquids.

Chemical air purging

Physical air purging

Thermal air purging

In *chemical* air purging, different substances are used to bind oxygen (for example hydrazine, sodium sulphite, etc). Some of these substances are harmful to health and some are banned. When using these binding agents it is important to check their concentration in the heat transfer fluid, to avoid the opposite effect or other problems.

I *physical* air purging, Henry's Law is applied. This states that the solubility of gases in liquids decreases with decreasing pressure. As a consequence of pressure reduction, bound air moves into the free gas zone, from which it can be released.

Thermal air purging only takes place at 30 °C and above, with bound air becoming free air.

Other

If the surface tension of the liquid is low, there is a greater risk of foaming.

In liquids with a high viscosity, the air rises more slowly.

The density of the liquid does not affect the solubility of the air in the liquid.

Pressure and temperature affect the solubility of air and therefore the air purging (Henry's Law).

Air purgers and how they work

The type of air purger to use and where to place it in the system depends on the design and size of the system. To choose the right type (method) and fit the de-aerator at the right place you need to know how the various methods work.

High-point air purgers

As the name implies, this type of air purger must be installed at high points in the system. Their operation is based on the fact that free air rises. During charging of the system, the air rises to the high points. When the system has been charged and is in use, it is difficult for the free air bubbles to leave the liquid naturally. The air bubbles circulate with the liquid until the circulation stops. Only then can the bubbles rise to the high points.

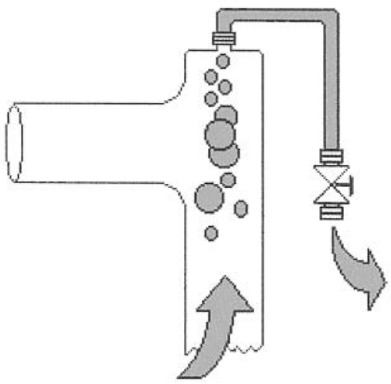
When choosing high point de-aerators you should choose the automatic type. In these there is a float which opens and closes the air purger automatically. This means that there is little work involved and good air purging is ensured.

After some time, automatic high point de-aerators (float valves) tend to leak because of various factors, such as dirt in the valve and deposits on the float. This leakage may cause major problems outside the system. In addition, leaky air purgers sometimes allow air to enter the system.

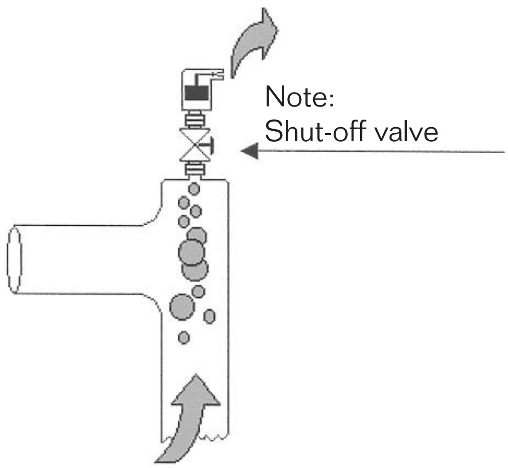
To overcome this problem, *a shut-off valve can be fitted between the system and the high point air purger*. (See picture of automatic high point de-aerator).

What is the use of a high-point de-aerator when it is isolated from the system? As already explained, it is difficult for air bubbles to leave a circulating liquid naturally. Consequently, a high point air purger (float valve) is not much use when the liquid is circulating, and should be isolated with the shut-off valve mentioned above.

When air purging is required, the circulation pump is stopped to allow the air to rise to the high points.



Manual highpoint air purger



Automatic high point air purger (Float valve)

Manual air purgers involve a lot of work, since they have to be opened and closed manually several times, and there is a considerable risk of poor air purging.

The shut-off valves are opened when there is a need for high point air purging, for instance during servicing.

We have now achieved two things: *good high point air purging* and *a non-leaking valve*.

Active air purger/ micro-bubble separator

This type of air purger must be installed where the pressure is lowest and the temperature highest in the system. A suitable location is in the return line from the refrigerated units/objects but before the expansion vessel.

If you choose to install a common air purger for the entire system, it must be positioned so that the entire flow of liquid circulates past the air purger.

Any remaining air bubbles which were not separated when the system was charged are now circulating in the liquid. These bubbles pass through the micro-bubble separator where they are trapped and discharged via a float air purger.

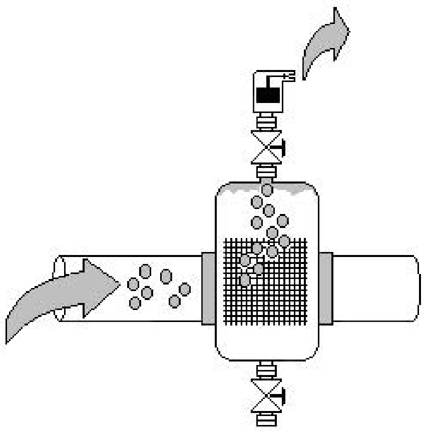
Sub-pressure air purger/ vacuum degasser

The methods above removed free air. To remove bound air it is advisable to use a sub-pressure air purger (pressure reduction).

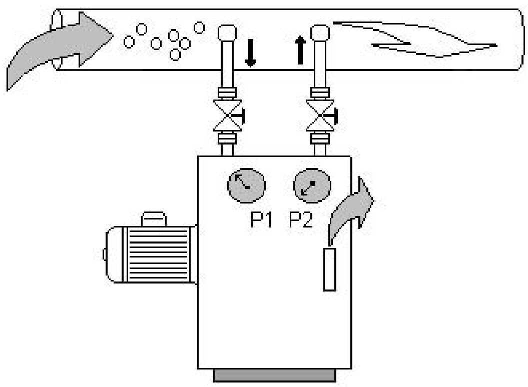
A partial flow of liquid from the system passes through the sub-pressure air purger, where the pressure on the liquid is reduced and the bound air is given off as free air and removed.

Other methods

Another way of removing air from the system is to apply a vacuum to all or parts of the system before and during charging with heat transfer fluid.



Active air purger, micro-bubble separator



Sub-pressure air purger, vacuum degasser

Summing-up

The following facts should be taken as a basis when designing and assembling secondary refrigeration systems:

It is easier to remove the free air that takes the form of air pockets and air bubbles in the system than to remove the air that is bound in the liquid.

It is therefore important as early as when charging the system with heat transfer fluid, to make sure that the free air can escape from the system via high points. When the system is charged from a low point, the air rises to the high points. Here, *high point de-aerators* are used.

When the system is full and pressurised, and the heat transfer fluid has begun to circulate, small amounts of free air will circulate with the liquid. This air comes from places in the system from which air was not displaced during charging (e.g. heat exchangers, fittings, etc.). These free air bubbles circulate with the liquid and are removed by installing a *active air purger* in the return pipe of the system.

To obtain a low air concentration in the liquid and so reduce the risks of corrosion or other problems, we recommend installing a *sub-pressure air purger* in the system.

The equipment and methods to be chosen in order to create an air-free system, depend on the design and size of the system.

However, high point air purgers should always be installed in systems, since it is important to get rid of as much air as possible at the initial charging. Air purging is most effective at higher temperatures. The refrigeration unit must not be running during air purging. Air purge the system thoroughly before putting it into service.

Consult the supplier of the air purging equipment about the location/installation requirements of each air purger and the compatibility of the air purger with the heat transfer fluid in question.

Circulating pumps in secondary refrigeration systems

The Secondary Refrigerants Team recommends circulation pumps with continuously variable speed control.

Pumps with a dry-running (fan-cooled) motor should be chosen. Canned-motor (wet-running) pumps should not be used in large installations. They have the disadvantage of transferring heat to the heat transfer fluid, leading to reduced efficiency.

Speed-controlled pumps improve the technical, operational and economic properties of the installation. Installation, operation and maintenance are simplified.

Valve arrangements in the system can be reduced and simplified at the design stage. The commissioning period is shortened because the pump can be continuously adapted to suit system data. Because the capacity of the pump is matched to the needs of the installation at all times and is monitored electronically, operation of the installation is safer and simpler.

Speed-controlled pumps also improve the system in terms of operating economic and environmental considerations. The extra cost of a speed-controlled pump is negligible compared to the operating cost savings. Savings in the valve arrangement rapidly outweigh the extra cost of this type of pump.

To obtain the highest possible static inlet pressure and more reliable air purging, we recommend installing the pumps at a low level in the installation.

If a standby pump is needed, the pumps in a secondary refrigeration system below 0 °C shall be single pumps. Dual pumps must not be used.

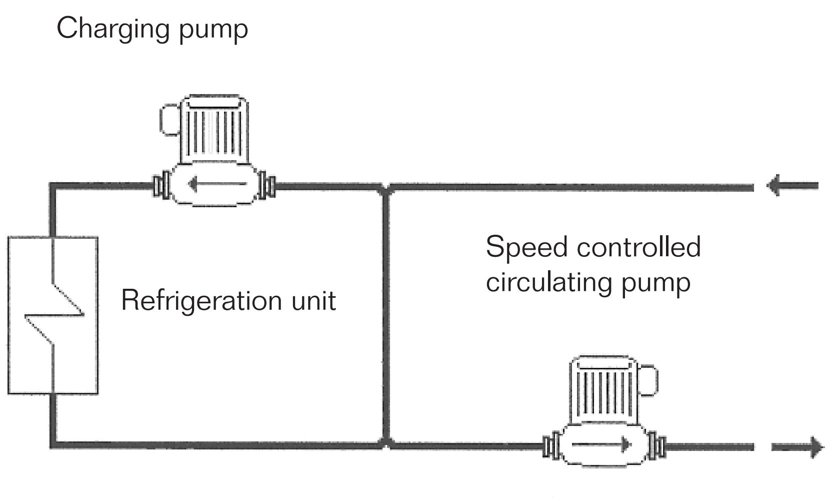
The circulation across a refrigeration unit (evaporator) should be constant. This requires the installation of a charging pump with the sole purpose of ensuring circulation across the evaporator.

The system is divided into two parts, the *charging* circuit and the *distribution* circuit.

When dimensioning circulation pumps for secondary refrigeration systems, bear in mind that the pump curves in manufacturers' catalogues are for pumping water at 20 °C. The pump curves must be revised for pumping other media.

Pump manufacturers will undertake pump dimensioning and fit the correct shaft seal if the following information is provided:

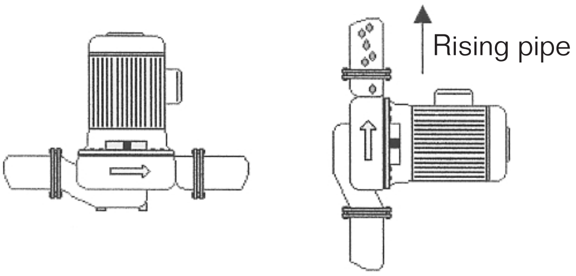
Head, volume flow, heat transfer fluid, concentration, operating temperature, ambient temperature and whether the pump should have surface treatment (recommended in secondary refrigeration systems).



Location of pumps

Circulation pumps in secondary refrigeration systems should be located so as to minimise the risk of air pockets forming in the pump. One way is to install the pump in a rising pipe, since there will be less likelihood of air bubbles collecting in the space around the shaft seal of the pump and possibly causing seal failure.

Circulation pump must not be installed at the high points of the system.

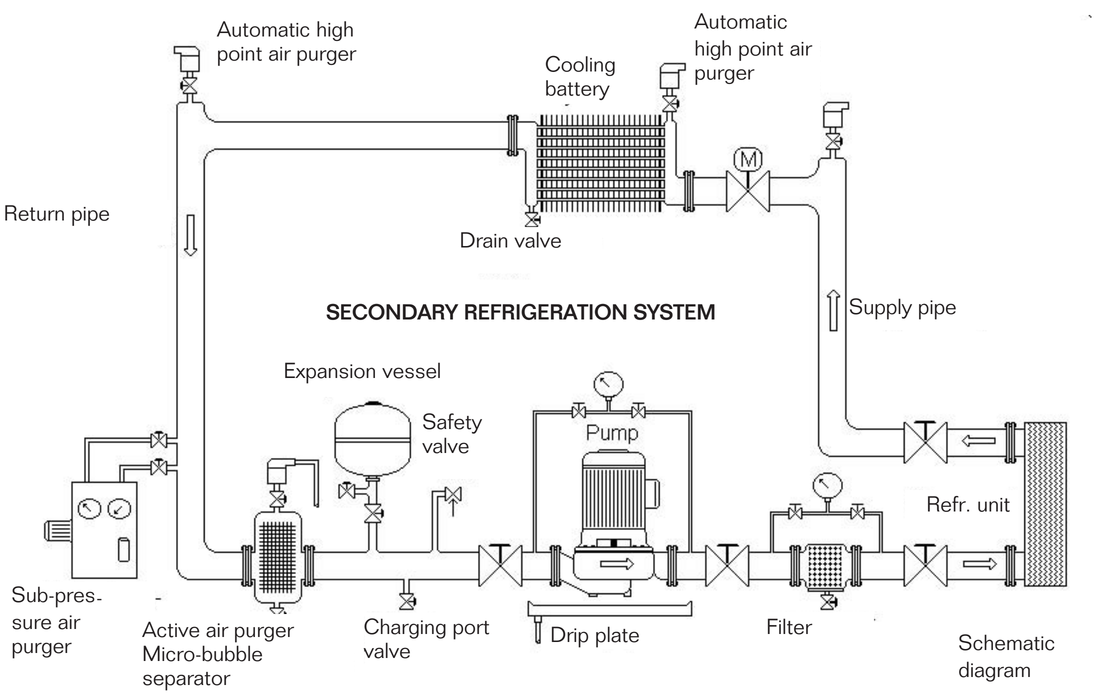


Location of system components

Expansion vessels must be installed on the suction side of the pump, and liquid filter on the delivery side. Pumps must be fitted with shut-off valves and a complete drip plate.

The pump must be provided with a sufficiently high static pressure on the suction side to prevent gas accumulation in the pump.

Active air purgers and sub-pressure air purgers must be fitted in the return pipes. High point air purgers must be installed at the high points of the system and fitted with a shut-off valve.



Notes

* THE SECONDARY REFRIGERANTS TEAM *

Publications from
* THE SECONDARY REFRIGERANTS TEAM *

Publication 1999	General advice and guidance for secondary refrigeration systems.
Publication 2000	Air purging technology and pumps in secondary refrigeration systems.

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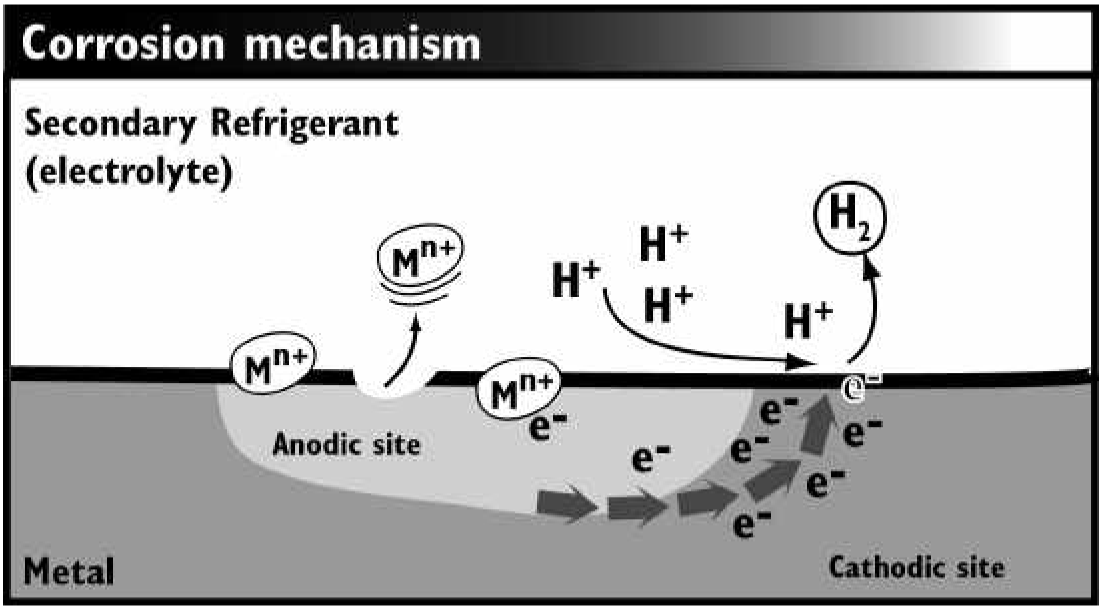
We reserve the right to make alterations to the above instructions.

Corrosion inhibitor

Corrosion

Corrosion needs electrical potential differences in a metal or between two different metals and an electrolyte, i.e. a liquid that can distribute electrical charge (electrons). See picture 1.



Picture 1

Corrosion through electrical potential differences between various noble metals is normally called galvanic corrosion. Corrosion may also be seen in material with only one metal owing to for instance concentration gradients in the electrolyte/fluid or impurities in the metal chemical structure etc.

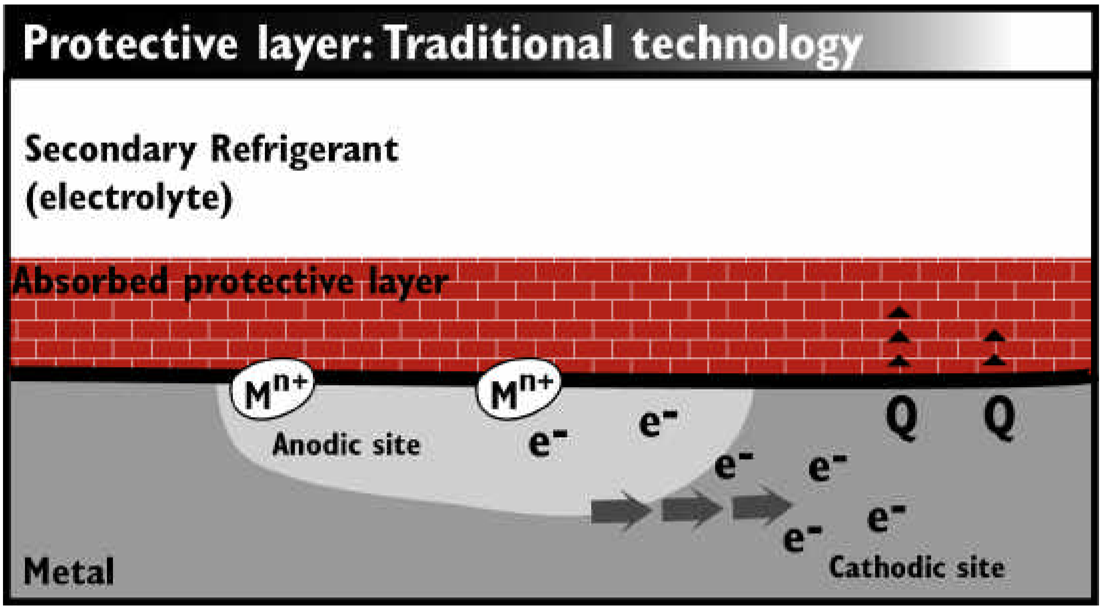
The pre-state of corrosion

You may call a condition a pre-state of corrosion when the electrons in the cathodic area or the metal atoms that have become positively charged not yet have left the metal surface. This electrical potential diversion is occurring all the time in electrical conductors such as metals. The diversions are created all the time to be, most of the times, reduced without any corrosion.

Corrosion protection

Traditionally you protect metals using sacrificial anode metals, i.e. zinc, or by adding a corrosion inhibitors.

Traditional corrosion inhibitors create a protective layer, that works mechanically, and prevent transport of electrons and metal ions to the electrolyte. This technology is good as long as the protective layer is intact. But through mechanical influence the layer can be damaged. The protective layer does not only prevent transport of electrons and metal ions but also it prevent heat transport.
Some of the traditional components will also be consumed or degraded. You have to fill up with fresh fluid to get the corrosion protection, which build up new protective films not only at the damaged areas but in the whole system and consequently reducing the heat transfer even more just to maintain the corrosion protection.
See picture 2.

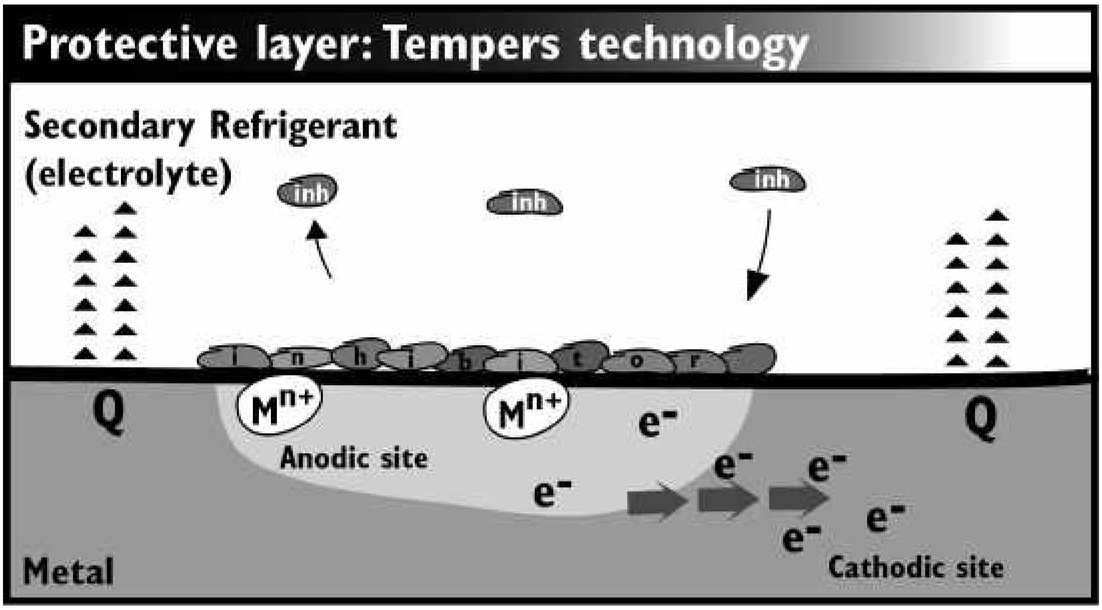


Picture 2

To analyse the status of the system in term of corrosion you have to inspect the entire parts of the system to be able to ensure that the protective layer is sufficient This is extremely difficult if not impossible and very time consuming and consequently very costly.

Temper corrosion inhibitor package is pulled together on the metal surfaces by electrical coupling already at the pre-state of corrosion (see above, " The pre-state of corrosion ") creating a local temporary and very thin protective layer. Temper corrosion inhibitor creates, and only when necessary, protective films with a minimal (monomolecular) thickness, which not noticeable reduces the heat transfer.
Later when the electrical diversion is reduced the Temper corrosion inhibitors are returned to the fluid without being consumed but ready to protect at the next diversion

(pre-state) that will occur. The Temper corrosion inhibitors are chemically selective to construction metals and are not interfered by other ions or non-construction metals such as for instance potassium. Temper corrosion inhibitor contains of course no environmentally hazardous components. See picture 3.



Picture 3

To analyse the status of the system in term of corrosion is very easy when using Temper. Since the Temper corrosion inhibitors is dissolved in the fluid you may easily through analysing the inhibitor concentration decide whether the system is OK or not. If the inhibitor level is above the nominated minimal level the amount to protect the system is enough. Since the inhibitor is chemically-electrically selective no pre-state may "escape" but are detected and protected by the inhibitors.
Electrical dissimilarities are very fast to detect and also the fastest chemical reactions (protection).
If the inhibitor level decreases, which after all may happen initially when the system was not carefully cleaned or when the system contained corrosion elements from the beginning or by outer influence through in-leakage of foreign particles, you may very well top up with concentrated inhibitor solution to proper concentration.

National Food Administration Statement - Translation

Heat transfer medium for indirect systems in food stores/food industry

The National Food Administration has received a request from ASPEN PETROLEUM AB regarding the suitability of using a heat transfer medium named **Temper -60**. The Toxicology Unit has issued the following statement with regard to this matter.

The heat transfer medium, **Temper -60**, shall only be used in indirect cooling systems, i.e. sealed systems in cold-storage rooms. During normal operation, this heat transfer medium must not come in direct contact with foodstuffs. However, should an accident occur, for example leakage or release into the air from apparatus, then any packed or unpacked foodstuff can be contaminated.
Therefor, should leakage occur, all foodstuffs that have been in direct contact with the heat transfer medium must be destroyed.

On condition that product's chemical composition is not changed and that great care exercised when handling this heat transfer medium in sealed systems, the Toxicology Unit has, for the present, no objection to the above usage.

This is a translation into English from the original statement in Swedish dated 1995-11-02, Registration number: Dnr 3646/95, Saknr 322.

A copy of the Swedish original statement may be acquired from Aspen Petroleum AB.

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Ecological Information

Temper is an environmentally adapted heat transfer fluid. It passes great ecological requirements. The product is biodegradable, not toxic, not reactive and not inflammable.

Biodegradability

Aerobic biodegradability of Temper has been investigated at test laboratory Cenox AB in Sweden. (Report may be down loaded from Internet or required from Temper Technology.) Temper is biodegradable, according to method OECD 301A.

Biodegradability	OECD 301 A	97 % degradation after 7 days 99 % degradation after 28 days	Biological easy degradable

The test involves continually estimations of amount remaining DOC (Dissolved Organic Carbon). According to EOCD guidelines for testing chemicals a test compound is regarded as easily biodegradable if the loss of DOC is greater than 70% within 28 days. The pass value has to be reached in a 10-day window within the 28-day period of the test. For test compound Temper as much as 97% DOC is consumed after 7 days. Thus the criterion is reached and Temper Technology Temper can be regarded as readily biodegradable.

Toxicity, marine bacteria

Toxic effects on marine bacteria have been tested at test laboratory Toxicon AB in Sweden. (Report may be down loaded from Internet or required from Temper Technology.) Temper is not acute toxic for the bacteria Vibro fisheri, according to Microtox method.

Acute toxicity, marine bacteria	Microtox Method	Slightly toxic day 0 No toxic effects after 28 days	Not acute toxic

The Microtox method involves an analysis of the light emitting ability of bioluminescent bacteria in solution of the test compound. Two test solutions with the same start concentration are tested. One solution is tested day 0 and the other is tested after 28 days of aerobic biodegradability. The light emitting ability from exposed bacteria is estimated in series at exposure times of 5, 15 and 30 minutes. The relationship between concentration of test compound and response are calculated. Then the concentrations at a 20%-reduction of light emission (EC20) respectively 50%-reduction (EC50) are calculated. According to test results Temper (0,7 % v/v) is slightly toxic for the bacteria Vibro fisheri day 0. After 28 days of biodegradability no toxic effects are shown.

Toxicity, rainbow trout

Toxic effects on rainbow trout has been analysed at test laboratory Toxicon AB. (Report may be down loaded from Internet or required from Temper Technology.) Temper is not regarded as acute toxic, according to method OECD TG no 203, "Fish, Acute Test"

Acute toxicity, rainbow trout	OECD TG no 203	$LC_{50/96h}$ 13900 mg/l	Not acute toxic

The method involves exposure of rainbow trout in a solution of Temper in various concentrations. LC50 occurred at the concentration 1,2% v/v after 24 h respectively 1,1 % v/v after 96 h. (1,1% v/v=13900 mg /l).

Accumulation in living organisms

Temper does not contain components with the ability to accumulate in living organisms.

Fertilising effect

Temper contains positive potassium ion, that works as a naturally fertiliser.

Stability

Temper is stable, not flammable and not explosive.

Handling and safety

- Temper is regarded as not dangerous to environment and can diluted be poured in sewage system.
- Temper is stable, non-combustible and non-explosive. Thus the product is easy and safe to handle.
- Temper can, as well as any other salt solution, irritate in contact with the eyes. Use eye protection.
- Long skin contact can irritate. Protective gloves are recommended.
- Temper tastes bad.

Life cycle assessment of Temper

Life cycle assessment (LCA) is an international method to evaluate the environmental burdens associated with the life cycle of a product. A project has been performed to systematic describe and quantify the total environmental impact under different phases in the life cycle of Temper. The result from the analysis shows that Temper has very low environmental impact.

Temper - Benefits

Environment-friendly product:

Temper is composed of renewable raw products. Temper is biologically decomposable and non-toxic. Temper does not contain any amines, nitrites or phosphates.

Anti-corrosive product:

Temper contains unique inhibitors giving excellent protection against corrosion.

Many application possibilities:

Temper can be used in refrigerating plants within the food sector (Swedish National Food Administration do not put any restrictions in using Temper in cooling systems in food industry or food retailing), heat pumps, heat recovery systems, ice rinks, and for use as a cooling medium and cooling carrier within all the other industry sectors.

Low pH-value:

Temper has about the same pH value as an ordinary household soap (8.0-9.0).

Flexibility:

Temper can be used in freezing applications down to -55°C, and at the "hot side" – in for example solar collector plants – up to +180°C (pressurised).

Low energy consumption:

The viscosity of Temper is low even at low temperatures, and this means reduced energy consumption for the whole plant, if compared with the use of glycols etc as cooling media (see separate calculation, Flap 10).

Reduced installation costs:

The high heat capacity and heat transfer properties of Temper are high, which means reduced liquid flows and – as a consequence – smaller dimensions. The installation cists will in other word be lower than if glycol etc is used as heat carrier.

Product durability:

In closed packing or in a closed system the properties of Temper remain stable, and its durability is unlimited. It is, however, important to check the inhibitor content regularly during operation, in order to ensure the anti-corrosive protection of the plant. We recommend that a sample of the solution be taken and analysed every 6 months. Samples can be sent to Temper Technology AB for analyse (See 'Operating and maintenance instructions', Flap 5).

Safety:

Temper is neither inflammable nor explosive. Temper is less hazardous to the health than traditional cooling media and does not have to be degraded (in contrast to glycols). It can quite simply be diluted (50% water) and poured down the drainage. It is, however, advisable to consult the local sewage work before pouring out large volumes. Temper does not require any special handling or storage measures. The product is suitable to use as heat transfer medium according to Swedish National Food Administration (Livsmedelsverket).

References

Temper is used as a Heat Transfer Fluid in applications with an operating temperature from 180°C (6-8 bar) down to -55°C.
Temper is used in different applications such as supermarkets, food industry, ice hockey rinks, ski slopes, heat recovery, ships etc.
Temper has references in Europe, Australia and South Africa.
Temper is environmentally and commercially favourable in every application.
If you are you interested in receiving information from one of our reference installations please contact Temper Technology on tel. +46 (0)301 230 000 or via e-mail temper@aspen.se

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Comparison between different cooling media and their effect upon the operating costs of a shop refrigerating plant

Example: A shop refrigerating plant

Assumptions
In order to have an idea of the effects of different cooling media upon the operating costs of an ‘assumed’ shop refrigerating plant we are showing here below a calculation which is based mainly on components selected from different manufacturers. The total cooling requirement is assumed to be about 60 kW divided among 12 fan air coolers. The temperature level in the refrigerated storerooms has been set to +2°C.

Comparison limitations
Only Propylene glycol and **Temper** have been included in this comparison. We have not considered the difference in pump capacity for the cooling medium pump depending on the cooling medium used. Nor have considered differences in the investment costs of cooling medium pump and compressor, if any.

Thermophysical data for the cooling media
These are the thermophysical data used in the comparison:

Agent	**P Kg/m^3**	**Cp J/kg,K**	**P x Cp x10^8 J/m^3,K**	**λ W/m,K**	**ν x10^6 m^2/s**
Propylene glycol	1043	3738	3.89	0.388	15.3
Temper	1148	3245	3.73	0.473	3.78

This table is valid for a freezing point of -20   C and a medium temperature corresponding to –8°C

Fan air cooler
As fan air coolers we have selected 12 units type CBFC 9-5 from AIA in Aasarum.
Data as below:

- Cooling capacity (latent + noticeable): 5 kW
- Relative humidity in the air: 80%
- Room temperature: +2°C
- Temperature change, cooling medium: 5°C

Incoming cooling medium temperature has been established through ‘trial calculations’ with the view of covering the same cooling requirement. Data as below:

Medium	**ϑ_{in} °C**	**$\uparrow_{Kbin}$/$\uparrow_{kbout}$ °C**	**ϑ_{out} °C**	**ϑ_{in} °C**	**Number of coils**	**Δp kPa**
Propylene glycol	5.0	-8.0/-3.0	7.1	6.0	2	49
Temper	3.3	-6.3/-1.3	5.4	4.3	2	30

Evaporators
We have selected plate heat exchangers, make GEA (Tau), as evaporators.
Selected size: M55-60.
Data as follows:

Medium	**ϑ_{in} °C**	**Q_a/ϑ_{in} °C**	**ϑ_{out} °C**	**ϑ_{in} °C**	**t_2**	**Δp kPa**
Propylene glycol	12.6	4865	7.6	9.9	-15.6	31.9
Temper	10.7	5729	5.7	7.9	-12.0	23.8

Compressor capacity
The compressor capacity is estimated by using the equations here below. These equations are based on the capacity data for 'good-quality semi-hermetic piston compressors'. The equation for the calculation of the Carnot cycle (efficiency) of the cooling medium is valid for a condensing temperature of 30°C.

$$\eta_{ct} = 0.624 + 0.00293 t_2 + \frac{0.3827}{t_2}$$ where

η_{Ct} = the Carnot efficiency of the cooling medium
t_2 = the evaporating temperature (°C)

Capacity delivered to the compressor can be described in the following way:

$$E_{comp} = \frac{Q_2(30 - t_2)}{\eta_{ct}(273 + t_2)}$$ where

E_{comp} = Capacity supplied to the compressor (kW)
Q_2 = Cooling capacity (kW)

The coefficient of performance can now be calculated in the following way:

$$COP_{2t} = \frac{Q_2}{E_{comp}}$$ where

COP_{2t} = Total coefficient of performance for liquid cooling unit (excl of auxiliary power)

Medium	**T_1 °C**	**t_2 °C**	**η_{Ct}**	**Q_2 kW**	**E_{comp} kW**	**COP_{2t}**
Propylene glycol	30	-15.6	0.554	61.3	19.61	3.13
Temper	30	-12.0	0.557	61.3	17.71	3.46

Comparing operating costs, Temper – Propylene glycol

Example: Food storage

Assuming that the calculations of the temperature requirements and the dimensioning of the heat exchangers are based on the same criteria as above, it will be possible to determine the operating costs for a plant, independently if its size, in the following way:

Operating costs per year:

$K_D = 1.667 \times Q_2 \times K_{el} \times T_{year} \times K_{cool}$,

where

K_D = operating cost per year for the plant (SEK/year

Q_2 = cooling capacity (kW)

K_{el} = the price of electricity (SEK/kWh)

T_{year} = operating time per year (h)

K_{cool} = cooling energy cost (SEK/kWh)

Calculation example:

Q_2 =	650 kW
T_{year} =	6800 h
K_{el} =	0.65 SEK/kWh
K_{cool}, PG =	0.192 SEK/kWh (propylene glycol)
K_{cool}, TP =	0.173 SEK/kWh (**Temper**)
K_D, PG =	1.667 x 650 x 0.65 x 6800 x 0.192 = 919 544 SEK/year
K_D, TP =	1.667 x 650 x 0.65 x 6800 x 0.173 = 828 547 SEK/year

Thus, the savings in operating costs with **Temper** = 90 997 SEK/year