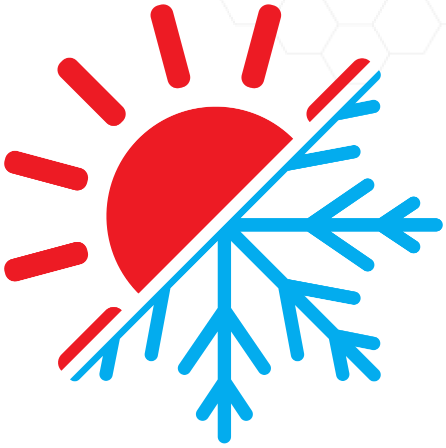
PRODUCT SERIES
- HEAT TRANSFER FLUIDS

Heat transfer fluids are used within process cooling to remove unwanted heat from associated applications. With several types of fluid available to choose from, it is important to take multiple factors into consideration. This article will discuss each of these factors to support you in choosing an appropriate heat transfer fluid for your application.



Choosing a Heat Transfer Fluid

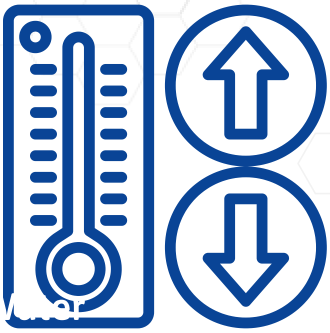
When choosing a heat transfer fluid, there are many things to consider to ensure optimum performance. There are four main categories of heat transfer fluid:

- Water (including deionised water)
- Glycol/water combinations (ethylene glycol/water or propylene glycol combination)
- Oils
- PFPEs

Water is one of the most efficient and highest quality products available for heat transfer by theory, but freezes and boils, providing a limited temperature range within which water alone can be used as a heat transfer medium. Glycol and water combinations are able to offer very high stability at higher temperatures and often require a lower start up temperature than oils. Oils are often non-toxic, efficient, and cost-effective, performing well at moderate to high temperatures. The benefits and drawbacks of each of these heat transfer fluids will be discussed in a later section of this article.

PFPE, or Perfluoropolyether, is a type of fluorinated fluid that can operate at both temperature extremes, with typical operating temperatures ranging from -70°C to 290°C. PFPE is able to offer high thermal stability, has good dielectric properties and is chemically inert, compatible with metals, plastics and elastomers. However, PFPEs are expensive and have seeking properties.

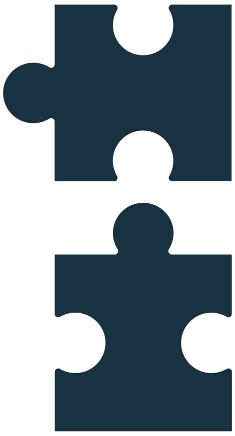
Choosing a Heat Transfer Fluid



To select an efficient heat transfer fluid, you must first know the minimum and maximum operating temperatures of your equipment. Fluid with a lower operating temperature will offer protection from premature degradation of your equipment when turning on. It is important to consider the thermal stability, heat transfer efficiency, and expansion rate of heat transfer fluids, and ensure that the fluid will meet the requirements of both the process and chiller.

Several questions must be asked regarding the operating conditions of the heat transfer fluid to ensure maximum compatibility.

- Is the fluid able to operate efficiently throughout the entire process cycle, transitioning between temperatures quickly?
- What is the local climate?
- Will the chiller be located outside and so open to the atmosphere?
- Is this a continuous process?
- Does this process require heat transfer fluids with a food-grade rating?



To ensure that phase separation does not occur, it is essential to consider fluid compatibility when replacing existing heat transfer fluids. As it is incredibly challenging to completely drain fluid from a system, any remnants of expired fluid that do not effectively mix with replacement fluid could cause pump cavitation and unnecessary wear and tear on other parts throughout the system. It is also important to ensure that there is no contamination of heat transfer fluids during maintenance, as contaminants are incompatible with most heat transfer fluids and will immediately degrade their efficiency. When considering compatibility, it is also essential to ensure that the heat transfer fluid is compatible with the construction materials of your equipment to prevent leeching of particles into the fluid.

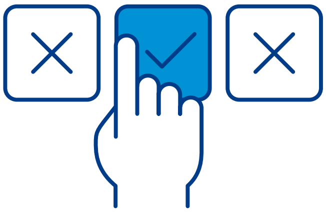
There are four crucial factors that should be compared when choosing a heat transfer fluid:

- Heat transfer efficiency
- Temperature range
- Material compatibility
- Thermal stability

Choosing a Heat Transfer Fluid

The heat transfer efficiency of a heat transfer fluid is determined by several characteristics. An ideal heat transfer fluid will have:

- ·Low viscosity
- ·High density
- ·High thermal conductivity
- ·High specific heat capacity



With the right balance of these characteristics, a heat transfer fluid will provide better heat transfer efficiency at a range of operating temperatures and flow conditions.

Any impurities should be removed from the heat transfer fluid to prevent fluid degradation and fouling on surfaces within the system. This extends the life of heat transfer fluids and reduces the amount of maintenance required.

When comparing the thermal stability of heat transfer fluids, it is important to remember that a product with higher thermal stability will provide higher heat transfer efficiency for a longer period and poses a lower risk of system damage or safety hazards when used in accordance with instructions.

Consider how frequently heat transfer fluids need to be replaced and whether a specialist waste removal service will be required to safely dispose of expired fluids. Ensure that the cost of this has been factored into the budget. It is also worth noting that although selecting a heat transfer fluid with an extended temperature range will provide a safety cushion, it can come at an enhanced cost, so discuss specific system requirements with the supplier.

Take time to discuss the requirements of your chiller with the manufacturer and take note of their heat transfer fluid recommendations. Working with a heat transfer fluid supplier who can provide technical support through the lifecycle of the product is beneficial, as fluid degradation will naturally occur.

In summary, choosing the right heat transfer fluid is essential in protecting against accelerated degradation, machine failure, increased maintenance, and decreased efficiency. Ensuring that fluids work in synchronisation with the specifications of the chiller and that regular preventative maintenance is undertaken will protect both the chiller and the fluid from damage. Expert advice should be sought from the heat transfer fluid supplier or chiller manufacturer to ensure that the right fluid is selected, and a proper maintenance plan formed. This will ensure that the operation runs with increased safety, efficiency, and reliability, with decreased downtime.

Choosing a Heat Transfer Fluid

There are four main categories of coolant used with ATC chillers:

- Water (or Deionised Water)
- Hexid – propylene glycol/water combination
- Coolflow – ethylene glycol/water combination
- Oils

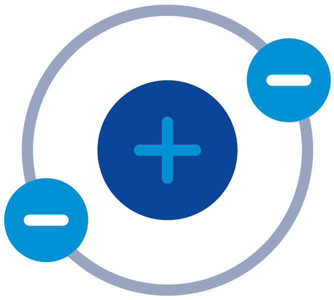
Water

Water can be used as a heat transfer fluid, meeting the needs of most liquid-cooling applications. Tap or facility water is cheaply and readily available, non-toxic and has a high thermal capacity. Due to the low viscosity of water, it is easy to pump. Using good quality water is recommended to minimise the potential for corrosion and to optimise thermal performance. The qualities of ‘good water’ can be seen in the table below:

Mineral	Recommended Limit
Calcium	<50ppm
Magnesium	<50ppm
Total Hardness	<100ppm
Chlorine	<25ppm
Sulphate	25ppm

If tap or facility water contains high levels of minerals, salts, or other impurities, it is important to either filter the water prior to use, or purchase filtered or deionised water. More sensitive applications may require deionised water.

Deionised water is made by running source water through one or more separate electrically charged resins, removing all, or most, of the ions. Ions removed include sodium, calcium, iron, copper, chlorine, and bromide. Removal of harmful minerals, salts, and other impurities can protect the system from corrosion or scale formation, damaging machine health.



Deionised water has a higher resistivity than tap water. Resistivity provides a measure of waters ionic content. It is worth noting that as resistivity rises, as does corrosivity. Stainless steel or ABS piping is required when using deionised water as a heat transfer fluid to ensure that particles from plumbing materials are not leeched into the water circuit, potentially causing fouling and blockages.

Water

Conductivity provides a measurement of a fluid's ability to conduct electrical current. If resistivity is high, conductivity will be low. As it is an excellent insulator, with very low conductivity, deionised water is often used in the manufacturing of electrical components where parts must be electrically isolated.

The relationship between conductivity and resistivity can be seen in below.

Conductivity (microsiemens/cm^2)	Resistivity (megaohm/cm^2)
0.056	18
0.063	16
0.071	14
0.083	12
0.100	10
0.133	7.5
0.200	5
0.500	2
1.000	1
1.333	0.75
2.00	0.5
4.00	0.25
10.00	0.1
20.00	0.05
40.00	0.025
80.00	0.013
100.00	0.01
200.00	0.005
500.00	0.002
1000.00	0.001
2000.00	0.0005
5000.00	0.0002
10000.00	0.0001

Water

There are three grades of deionised water.

Grade 1 water, or ultrapure water, is the purest form of water available. This type of water should be used for advanced analytical procedures and critical applications. It can also be used in applications that require grade 2 water. Applications using grade 1 water include liquid chromatography, gas chromatography, inductively coupled plasma mass spectrometry (ICP-MS) and molecular biology.

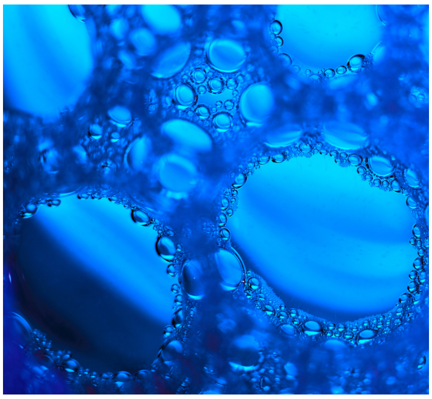
Grade 2 water does not have the same level of pureness as grade 1 water, but still maintains high levels of purity. Although grade 2 water cannot be used for applications requiring type 1 water, it can be used as a feed water in the production of grade 1 water. Applications using grade 2 water include general lab practices, electrochemistry, and general spectrophotometry.

Grade 3 water, or RO water, is water produced through reverse osmosis. It has the lowest level of purity and is used for many basic lab applications such as heating baths and media preparation. RO water can also be used as feed water in the production of grade 1 water.

Please see the table below for the International Organisation for Standardisation (ISO) requirements for the grading of deionised water under ISO 3639:1987.

Perameter	Grade 1 Water	Grade 2 Water	Grade 3 (RO) Water
pH value at 25°C	-	-	5.0-7.0
Conductivity (µS/cm) at 25°C	0.1	1.0	5.0
Oxidisable matter Oxygen content (mg/l), max	-	0.08	0.4
Absorbance at 254nm and 1cm optical path length, absorbance units, max.	0.0001	0.01	-
Residue after evaporation on heating at 110°C (mg/kg), max	-	1	2
Silica (SiO_2), content (mg/l), max	0.01	0.02	-

Water



As water, and deionised water, alone have no antimicrobial properties, they are vulnerable to contamination. Microbial contamination can be a difficult problem to remedy once it enters a system, as it causes growth, leading to internal fouling and blockages. To minimise this risk, in-line UV decontamination packs allow any growth to be prevented by passing the water through a steel tube which contains a UV lamp.When water passes under the ultraviolet light, the genetic code of microorganisms is attacked, rearranging the DNA/RNA, meaning that the microorganism is unable to reproduce or function.

However, water has a low boiling point and freezes easy, which makes it unstable and difficult to manage under extreme temperature conditions.

ATC offer frost protection to protect chillers using water as a heat transfer fluid, allowing the chiller to function in freezing temperatures by altering the wiring and thermostat to prompt the pump to run should the machine drop below +6°C.

To support chillers located in lower temperatures, Applied Thermal Control offer a low temperature pack, allowing the chiller to operate below 4°C. Addition of a low temperature pack will allow chillers to be operated down to -15°C, although heat transfer fluids containing glycol are recommended at temperatures.

ATC also offer a heater pack, making it possible to raise the operating temperature of the chiller above 35°C.

Glycol

Although water alone is better at retaining and conducting heat from the associated process, glycol has antifreeze properties, and is more suited to chillers that are expected to function in low-temperature environments, where water alone would freeze and cause obstructions within the chiller.

There are two types of glycol heat transfer fluid, ethylene glycol/water combinations and propylene glycol/water combinations.

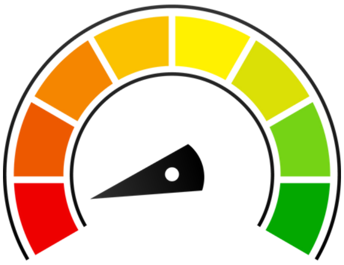
Ethylene Glycol

Ethylene glycol is the chemical used in antifreeze. Although similar, it is important to never use automotive glycol as a heat transfer fluid in chillers due to the presence of inhibitors specific to automotive processes that will cause fouling within the chiller system, reducing the lifespan of pump seals and overall efficiency of the chiller. Use of the correct inhibitors within chiller-specific heat transfer fluids will prevent corrosion and prolong the life of the chiller.

Ethylene glycol and water combinations as a heat transfer fluid has several desirable thermal qualities:

- High boiling point
- Low freezing point
- Stability over a wide temperature range
- Low viscosity, reducing pump requirements

When preparing or selecting an ethylene glycol/water combination, it is important to use the lowest concentration of glycol possible to meet the needs of the process. The higher the glycol concentration, the lower the performance of the heat transfer fluid. At a minimum combination of 25-30% ethylene glycol to water, the ethylene glycol will also serve as a bactericide and fungicide, protecting the chiller from microbial contamination.



A recirculating chiller using a 30% ethylene glycol/water combination will result in approximately a 3% reduction in performance. Although the thermal conductivity of ethylene glycol/water combinations is not as great as water alone, the added freeze protection, down to -15°C/5°F, can provide benefit both during use and shipping.

Ethylene Glycol

The quality of water used when preparing an ethylene glycol/water combination is important, as the presence of ions within the water may cause the inhibitor to fall out of the solution, leaving the system vulnerable to fouling and corrosion. The minimum requirements for good quality water can be seen below:

Mineral	Recommended Limit
Calcium	<50ppm
Magnesium	<50ppm
Total Hardness	<100ppm
Chlorine	<25ppm
Sulphate	25ppm

Applied Thermal Control stock CoolFlow, an industrial grade refrigerant antifreeze based on ethylene glycol. CoolFlow is sold by ATC in three variations:

Coolflow EG

CoolFlow EG Concentrate is blended with BS6580 proven corrosion, scale, and biological inhibitors. A dilution of 20% CoolFlow to 80% ultrapure water is recommended, providing protection against freezing down to -10°C. CoolFlow EG Concentrate is dark blue in colour and available in 5L and 25L containers. Coolflow EG is suitable for industrial process cooling where toxic classification is of no concern. It is classed as harmful, but usually considered to be toxic. Coolflow EG has high thermal conductivity and low viscosity at sub-zero temperatures, resulting in increased heat transfer efficiency and reduced thermal demands.

Antifreeze protection is provided down to -50°C, with a lower concentration (% volume) of Coolflow EG required to achieve the same freeze-point protection when compared with other ethylene glycol heat transfer fluids.

Coolflow EG contains synergistic corrosion inhibitors, exceeding BS6580 and ASTM D1384 standards. It also contains broad-spectrum biological inhibitors and polyacrylates to prevent scale precipitation.

Performance rating for CoolFlow EG	
Summary	B
Efficiency	B
Antifreeze	A
Corrosion Control	A
Toxicity	D

Ethylene Glycol - CoolFlow EG

When measuring the percentage concentration of Coolflow EG within solution, it is recommended that a recently calibrated refractometer is used.

Mixing guide for CoolFlow EG		
Frost Protection °C	**% v/v of CoolFlow EG in System**	**Refractive Index**
-10	20%	1.349
-15	27%	1.355
-20	32%	1.359
-25	37%	1.363
-30	41%	1.366
-35	45%	1.369

Ethylene Glycol - Coolflow EG Pre-Mix

CoolFlow EG Pre-Mix is available as a 20% pre-mixed solution with ultrapure water. It is able to achieve -10°C freeze protection. Coolflow EG Pre-Mix carries the same properties as CoolFlow EG and is light blue in colour.

Ethylene Glycol - Coolflow 1

CoolFlow 1 contains corrosion inhibitors tested in accordance with BS5117 and found to meet BS6580 and ASTM D1384 corrosion standards. CoolFlow 1 also contains scale and biological inhibitors. It is pre-mixed to a 20% solution, using ultrapure water, and achieves -10°C freeze protection, and is dark pink in colour.

CoolFlow 1 is classified as harmful, but is usually considered to be toxic, so is usually used in industrial cooling systems where toxicity is not an issue. It has high thermal conductivity and low viscosity at sub-zero temperatures, resulting in increased heat transfer efficiency and increased heat recovery.

Protection is provided down to -50°C, with less volume required to achieve the same freeze-point protection when compared to other ethylene glycol-based heat transfer fluids

CoolFlow 1 is a long-life, temperature rated formulation, with synergistic corrosion inhibitors exceeding ASTM D1384 standards. CoolFlow 1 contains broad-spectrum biological inhibitors and polyacrylates to prevent scale precipitation.

Coolflow 1 is available in 25L containers.

Ethylene Glycol - CoolFlow 1

Performance rating for CoolFlow 1	
Summary	B
Efficiency	B
Antifreeze	A
Corrosion Control	A
Toxicity	D

Ethylene Glycol - Coolflow B

CoolFlow B concentrate is a corrosion inhibitor and biocide and should be dosed to the system at a ratio of 1:50. It is light pink in colour and is available in 1L and 5L containers.

All CoolFlow products are classed as harmful if swallowed and may cause irritation to skin and eyes. It is important to wear appropriate personal protective equipment when handling chemicals, including goggles and rubber gloves.

Associated Safety Data Sheets are available for all products within the CoolFlow range.

Propylene Glycol

Propylene glycol/water combinations offer many of the same benefits as ethylene glycol/water combinations but are often selected in process that require a food grade heat transfer fluid.

Propylene Glycol - Hexid

Applied Thermal Control are an exclusive supplier of Hexid, a propylene glycol/water combination. Hexid heat transfer fluid is optimised for temperatures from -45°C to 90°C. This is beneficial for chillers situated outside or in non-heated rooms.

Hexid is fully compatible with system components, protecting even copper and aluminium systems, preventing any leeching of ions into the circuit. Hexid is also able to provide complete protection from freezing and algal growth. A trace biocide is included within the fluid to prevent microbial contamination within the system.

Propylene Glycol - Hexid

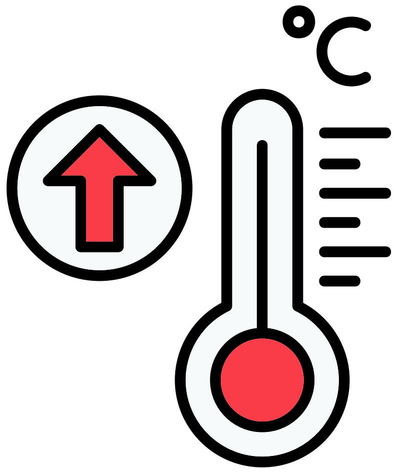
To ensure that the system is running at optimum and the inhibitors within Hexid remain effective, it should be replaced annually. Hexid is safe and easy to dispose of as it is:

- Non-toxic
- Non-flammable
- Environmentally safe
- VOC-free (ozone benign)

Hexid is a cost-effective heat transfer to protect the investments made in chillers at low costs per bottle. It is also easy to store and remains stable for at least two years when stored at ambient temperatures, in closed containers, away from direct sunlight and other sources of UV light.

Oils

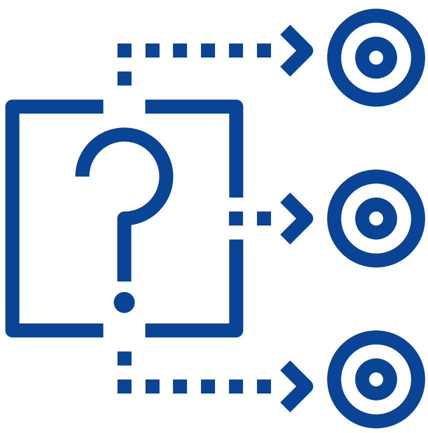
At higher temperatures, water ceases to become an effective heat transfer fluid. To continue to use water as a heat transfer fluid it may become necessary to pressurise the system, and substantial monitoring will be required to ensure safe operation. Water can also cause corrosion within the system.



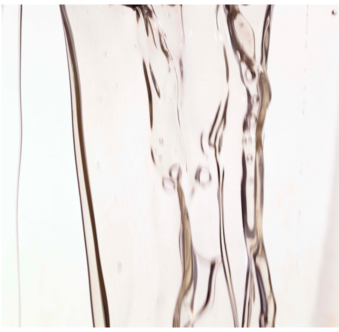
Mineral and synthetic oils are suited for use as a heat transfer fluid at much higher temperatures, and do not need to be pressurised until the top end of the range is reached.

Although no heat transfer oil is capable of meeting all of the below factors evenly, the following factors should be considered, alongside the specifics of the application:

- Low viscosity
- Good thermal stability
- High flash point
- Good heat transfer properties
- Ease of waste disposal
- Non-corrosive
- Non-toxic
- Non-flammable

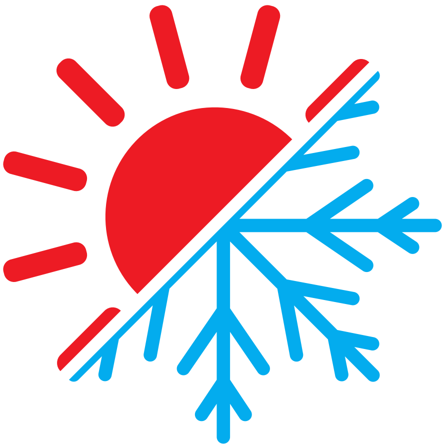


Oils



It is important that the viscosity of heat transfer oils is low, especially when operating at the lower end of the temperature range, as this will affect the operating conditions under which the chiller is able to function. If the oil becomes too viscous under lower temperatures, the system will not be able to start up, causing damage to the chiller. The operating viscosity of the heat transfer oil affects the flow properties within the pipes. The correct viscosity, combined with the associate optimum turbulent flow, enhances heat transmission.

When selecting a heat transfer oil, it is important to look at the heat transmission characteristics of the oil. The heat conductivity of the oil will give a good indication of how well heat will transfer from the film coating the pipe walls into the flowing heat transfer oil. The vapour pressure of the heat transfer oil will indicate whether the system will be able to be run without pressurisation. The thermal expansion-coefficient of the heat transfer oil will indicate whether the oil is compatible with the size of the expansion tank.



Giving careful consideration to the above factors prior to selecting a heat transfer medium will result in enhanced efficiency and increase the life of the heat transfer system.