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- HYCOOL Technical Information details the product specification and also gives general information about the application of the product.
- HYCOOL is manufactured and supplied by Hydro Chemicals. If the product is used incorrectly in systems, Hydro Chemicals will not accept responsibility for any damage that may occur.

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Introduction

HYCOOL is based on potassium formate with the chemical formula HCOOK, which is the potassium salt of formic acid. Formic acid is the simplest organic acid, followed by acetic acid.

Potassium formate as an anti-freeze liquid in circulating systems was patented in the USA in 1941, due to potassium formate's excellent thermodynamic properties at low temperatures and its low corrosivity on the metals commonly used in cooling and heating systems. This discovery did not become commercially viable until many years later.

As focus on the environment and its related aspects increased around the world, in the early 1990s Norsk Hydro began to look more closely at potassium formate and formates in general.

Different applications for formates were studied, based on its different properties and, in particular, its excellent environmental profile:

- Oil-field chemical, where high density and good environmental profile are important factors.
- De-icing fluids, where a low freezing point and good environmental profile are important factors.
- Ensilage fluid and feed additive, where preserving properties are important.
- Secondary refrigerant, where a low freezing point, good thermodynamic properties, a high environmental profile and good material compatibility are important factors.

These new areas of focus within Hydro have led to the development of several commercial products such as HYCOOL, which is a secondary refrigerant for indirect refrigeration systems.

HYCOOL is used today for:

- Air conditioning
- Process cooling
- Chilling applications
- Freezing applications
- Heat recovery systems

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Product specification

Composition:	Potassium formate 30-50% Deionised water Corrosion inhibitor
Appearance:	Clear fluid Insignificant smell
Freezing point:	-20 to -50°C
Density*:	1194 – 1348 kg/m^3
Dynamic viscosity*:	1,8 – 2,6 mPas (cP)
Thermal conductivity*:	0,50 – 0,56 W/mK
Specific heat capacity*:	2,5 – 3,0 kJ/kgK
Boiling point:	105 – 115°C at atmospheric pressure
pH:	10,6 – 11,4

* At 20°C

Refractive index*:	1,364 – 1,385
Surface tension*:	78,5 mN/m for HYCOOL 20 (water: 72,4 mN/m)
Thermal expansion coefficient:	3-4 • 10^{-4} 1/K E.g.: approx.1% thermal volume expansion between –10 and 20°C
Vapour pressure*:	1,3 – 2,0 kPa (water: approx. 2,3 kPa)
Electrical conductivity*:	210 – 240 mS/cm
Flashpoint:	Non-flammable
Miscibility with water:	Complete

Handling

- HYCOOL is delivered ready-mixed as 5 grades: HYCOOL 20, 30, 40, 45, 50. The number represents the freezing point. Example: HYCOOL 20 has a freezing point of –20°C.
- HYCOOL must not be mixed with water or other chemicals.
- See Safety Data Sheet for more information about handling.
- See HYCOOL Environmental Information for more information about HYCOOL's environmental aspects.

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Physical properties

HYCOOL 20

Temp. (°C)	Density (kg/m^3)	Specific heat-capacity (kJ/kgK)	Thermal-conductivity (W/mK)	Dynamic viskosity (mPas (cP))	Kinematic viskosity (mm^2/s)
50	1181	3,07	0,59	1,1	0,9
45	1183	3,06	0,58	1,1	1,0
40	1185	3,05	0,58	1,2	1,0
35	1187	3,04	0,57	1,3	1,1
30	1189	3,02	0,57	1,5	1,2
25	1191	3,01	0,56	1,6	1,4
20	1194	3,00	0,56	1,8	1,5
15	1196	2,99	0,55	2,0	1,7
10	1198	2,98	0,54	2,3	1,9
5	1200	2,97	0,53	2,5	2,1
0	1202	2,96	0,52	2,9	2,4
-5	1204	2,94	0,51	3,3	2,7
-10	1206	2,93	0,50	3,8	3,2
-15	1209	2,92	0,49	4,5	3,7
-20	1211	2,91	0,48	5,3	4,4

HYCOOL 30

Temp. (°C)	Density (kg/m^3)	Specific heat-capacity (kJ/kgK)	Thermal conductivity (W/mK)	Dynamic viscosity (mPas (cP))	Kinematic viscosity (mm^2/s)
50	1234	2,90	0,56	1,2	1,0
45	1236	2,89	0,56	1,3	1,0
40	1238	2,88	0,55	1,4	1,1
35	1241	2,86	0,55	1,5	1,2
30	1243	2,85	0,54	1,6	1,3
25	1246	2,84	0,54	1,8	1,4
20	1248	2,83	0,53	1,9	1,5
15	1250	2,82	0,53	2,1	1,7
10	1253	2,81	0,52	2,4	1,9
5	1255	2,79	0,51	2,7	2,1
0	1258	2,78	0,50	3,1	2,4
-5	1260	2,77	0,49	3,5	2,8
-10	1262	2,76	0,48	4,1	3,2
-15	1265	2,75	0,47	4,8	3,8
-20	1267	2,74	0,46	5,8	4,6
-25	1269	2,73	0,45	7,1	5,6
-30	1272	2,71	0,44	8,9	7,0

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HYCOOL 40

Temp. (°C)	Density (kg/m^3)	Specific heat-capacity (kJ/kgK)	Thermal conductivity (W/mK)	Dynamic viscosity (mPas (cP))	Kinematic viscosity (mm^2/s)
20	1294	2,69	0,52	2,2	1,7
15	1297	2,68	0,51	2,4	1,9
10	1299	2,67	0,50	2,7	2,1
5	1302	2,66	0,49	3,1	2,4
0	1305	2,65	0,48	3,6	2,7
-5	1307	2,63	0,47	4,2	3,2
-10	1310	2,62	0,47	4,9	3,8
-15	1312	2,61	0,46	5,9	4,5
- 20	1315	2,60	0,45	7,2	5,5
- 25	1317	2,59	0,44	8,9	6,8
- 30	1320	2,58	0,43	11,3	8,5
- 35	1322	2,57	0,42	14,6	11,1
- 40	1325	2,55	0,41	19,5	14,7

HYCOOL 45

Temp. (°C)	Density (kg/m^3)	Specific heat-capacity (kJ/kgK)	Thermal conductivity (W/mK)	Dynamic viscosity (mPas (cP))	Kinematic viscosity (mm^2/s)
20	1318	2,62	0,51	2,4	1,8
15	1321	2,61	0,50	2,7	2,0
10	1323	2,60	0,49	3,0	2,3
5	1326	2,59	0,48	3,4	2,6
0	1329	2,58	0,48	4,0	3,0
-5	1331	2,57	0,47	4,6	3,5
-10	1334	2,56	0,46	5,5	4,1
-15	1337	2,54	0,45	6,6	4,9
- 20	1339	2,53	0,44	8,1	6,0
- 25	1342	2,52	0,43	10,1	7,5
- 30	1345	2,51	0,42	12,8	9,6
- 35	1347	2,50	0,42	16,8	12,5
- 40	1350	2,49	0,41	22,8	16,9
- 45	1353	2,47	0,40	32,0	23,7

HYCOOL 50

Temp. (°C)	Density (kg/m^3)	Specific heat-kapacity (kJ/kgK)	Thermal conductivity (W/mK)	Dynamic viscosity (mPas (cP))	Kinematic viscosity (mm^2/s)
20	1348	2,54	0,50	2,6	1,9
15	1351	2,53	0,49	3,0	2,2
10	1353	2,52	0,48	3,4	2,5
5	1356	2,51	0,47	3,9	2,9
0	1359	2,50	0,47	4,6	3,4
-5	1362	3,49	0,46	5,5	4,1
-10	1365	2,48	0,45	6,7	4,9
-15	1367	2,46	0,44	8,0	5,9
-20	1370	2,45	0,43	10,1	7,4
- 25	1373	2,44	0,43	13,1	9,5
- 30	1376	2,43	0,42	17,3	12,6
- 35	1378	2,42	0,41	23,7	17,2
- 40	1381	2,41	0,40	33,5	24,3
- 45	1384	2,39	0,39	49,4	35,7
- 50	1387	2,38	0,39	76,5	55,2

Formulae

- **Density (kg/m³)**

HYCOOL; temp: formula

20; -20 to 50°C: -0,429180•t+1202,2
30; -30 to 50°C: -0,475350•t+1257,5
40; -40 to 20°C: -0,512290•t+1304,5
45; -45 to 20°C: -0,530754•t+1328,7
50; -50 to 20°C: -0,552300•t+1359,0

- **Specific heat capacity (kJ/kgK)**

HYCOOL; temp: formula

20; -20 to 50°C: 0,0023•t+2,955
30; -30 to 50°C: 0,0023•t+2,783
40; -40 to 20°C: 0,0023•t+2,646
45; -45 to 20°C: 0,0023•t+2,578
50; -50 to 20°C: 0,0023•t+2,498

- **Thermal conductivity (W/mK)**

HYCOOL; temp: formula

20; -20 to 20°C: 0,001978•t+0,5172
20; 20 to 50°C: 0,001005•t+0,5368
30; -30 to 20°C: 0,001840•t+0,4980
30; 20 to 50°C: 0,001000•t+0,514
40; -40 to 20°C: 0,001730•t+0,4826
45; -45 to 20°C: 0,001674•t+0,4750
50; -50 to 20°C: 0,001610•t+0,4660

- **Dynamic viscosity (mPas (cP))**

HYCOOL; temp: formula

20; -20 to 20°C: 0,07190•exp[524,75/(t+142,05)]
20; 20 to 50°C: 0,0005524•t²- 0,06281•t+2,8536
30; -30 to 20°C: 0,11100•exp[408,17/(t+123,15)]
30; 20 to 50°C: 0,000295•t²- 0,0441•t+2,6836
40; -40 to 20°C: 0,07830•exp[498,13/(t+130,25)]
45; -45 to 20°C: 0,08990•exp[479,09/(t+126,55)]
50; -50 to -10°C: 0,0491•exp[581,12/(t+129,05)]
50; -10 to 20°C: 0,0491•exp[581,12/(t+129,05)]+0,2

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Material compatibility

Metals

HYCOOL is compatible with the metals commonly used in indirect refrigeration systems in accordance to general corrosion tests. Brazing rod and silver solder have also been tested for galvanic corrosion.

Metals compatible with HYCOOL

- *Copper*
- *Brass*
- *Carbon steel*
- *Stainless steel*
- *Cast iron*
- *Aluminium*
- *Magnesium*
- *Brazing rod*
- *Silver solder*

Metals not compatible with HYCOOL

- *Galvanised steel*
- *Zinc*
- *Tin solder (soft solder)*

NB!

If HYCOOL is spilt on a metal surface it must be wiped up immediately with a wet cloth or rinsed off with water.

On galvanised steel, HYCOOL damages the surface and discolours the metal. A blue residue can appear if HYCOOL is spilt on copper.

Polymers

HYCOOL is chemically compatible with the polymers commonly used in indirect refrigeration systems. Check the temperature range compatibility for the material used.

Polymers compatible with HYCOOL

- *LDPE* *Polyethylene, low density*
- *HDPE* *Polyethylene, high density*
- *PP* *Polypropylene*
- *PTFE* *Polytetrafluorethylene*
- *PA** *Polyamide*
- *PVC* *Polyvinylchloride*
- *PPO* *Polyphenyleneoxide*
- *PMMA* *Polymethylmethacrylate*
- *PES* *Polyethersulphone*
- *Aramid* *Aromatic Polyamide*

- *ABS* *Acrylonitrilebutadienestyrene*
- *EP* *Epoxy resins*
- *UP* *Unsaturated polyester resins*
- *Acrylic plastic*
- *CR* *Chloroprene rubber*
- *NBR* *Nitrilebutadiene rubber*
- *EPDM* *Ethylenepropylene rubber*
- *SBR* *Styrenebutadiene rubber*
- *MVQ* *Silicone rubber*
- *IIR* *Butyl rubber*

* Compatible below 40°C

Polymers not compatible with HYCOOL

- *FPM* *Fluorocarbon rubber (Viton rubber)*

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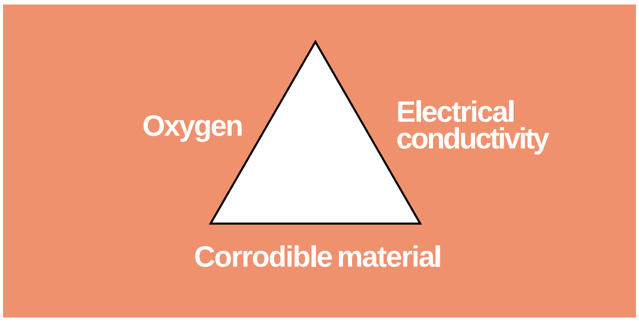
Wet corrosion

Problems with corrosion in indirect refrigeration systems are often solely attributed to the secondary refrigerant, but it has often been shown that lack of knowledge about the cause or type of corrosion has resulted in this conclusion.

The corrosion triangle

The corrosion triangle shows the three important conditions that must be present in order for corrosion to occur, see below:



Corrosion is a problem that causes damage and incurs large cost each year. Below is a simplified description of the types of corrosion problems that can arise in an indirect refrigeration system with a circulating water-based secondary refrigerant.

Some common types of corrosion:

- General corrosion
- Erosion corrosion (turbulence corrosion)
- Crevice corrosion
- Galvanic corrosion

General corrosion

This is the normal uniform decomposition of the entire metal area.

Erosion corrosion

Is the abrasive effect that arises when the fluid contains abrasive particles such as welding slag, sand/dirt or corrosion products. The oxide layer that is formed by the metal is worn away and the pure metal is exposed to oxygen. High fluid velocity can also contribute to this type of corrosion (also known as turbulence corrosion).

Crevice corrosion

Arises when the fluid stagnates in a small space or in a crevice. The fluid in the crevice changes and an electrochemical cell is created. If the environment outside the crevice is rich in oxygen, the risk of corrosion increases.

Galvanic corrosion

Arises when two different metals are in contact with each other.

T-M-S: three important points

The general rules for installing indirect refrigeration systems with HYCOOL are that material choice, system design and assembly are carried out in such a way that function and reliability of the system can be guaranteed. The three important areas that should be observed are: **T-M-S**

T = Temperature
M = Materials
S = System

Temperature

It is important to choose the right freezing point of the secondary refrigerant. The freezing point should be set approximately 5°C lower than the evaporating temperature or 10°C lower than the working temperature of the secondary refrigerant.

Materials

All materials used in the system must be checked to make sure that they are compatible with HYCOOL, and assembled so that the risk of corrosion is eliminated.

System

In general, the oxygen concentration in indirect refrigeration systems with water-based secondary refrigerants must be kept low (completely deaerated systems). It is also important to check that the fluid velocity is not too high and that the system is free from contaminants.

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System design

HYCOOL is a secondary refrigerant for indirect refrigeration systems and is used in the secondary circuit in the systems. HYCOOL complies with the demands of a high-quality secondary refrigerant because of its high environmental profile, compatibility with commonly used metals/polymers and good thermodynamic properties. In particular, its low viscosity allows large amounts of energy to be absorbed and transported cheaply and effectively.

● Temperature

The number after each HYCOOL grade, 20 to 50, represents the freezing point. The freezing point of the secondary refrigerant should be chosen based on the system's lowest temperature, not according to the working temperature of the secondary refrigerant. In the indirect refrigeration systems, the lowest temperature is in the primary circuit equal to the evaporating temperature. The freezing point should be set approximately 5°C lower than the evaporating temperature or 10°C lower than the working temperature of the secondary refrigerant.

Also check that the system's max/min temperature are within HYCOOL's temperature working range.

● Materials

All materials used in the system must be checked to ensure they are compatible with HYCOOL, and assembled so that the risk of corrosion is eliminated. Copper must be soldered with brazing rod or silver solder. Tin solder and solder containing chloride must not be used. Also check to ensure that the material to be used is suitable for the actual temperature range.

● System type

Closed systems are preferable to open systems, as these are easier to deaerate and the system pressure can be easily adapted to the system's functional requirements.

If an open system is used, these points must be carefully observed. An alarm or safeguard should be installed to prevent the system top-up vessel from running empty and entraining air, or to prevent a decrease in the calculated system pressure.

● Valves

The system must be constructed so that drainage and filling can take place. Mount the drain valves on low points and see that filling can take place at the system's lowest point.

Always mount isolation valves between the system and the automatic deaeraters located at the high points so that the deaerators can be isolated for servicing or shut off.

● Clean systems

Before filling with HYCOOL, all impurities, such as sand, dirt and welding slag, must be removed from the system (flush the system where necessary). Systems that are not cleaned before being filled are liable to develop problems because of blocked valves, leaking pumps and risk of corrosion.

Filling

The system must be filled at the lowest point so that the air can be expelled at the highest points. HYCOOL in contact with air in partially filled systems may cause crystal residues. In a copper pipe, this appears as a blue residue on the inside of the pipe.

When filling or servicing it is important that the partially filled or drained parts of the system is not exposed to the air for a long period of time.

HYCOOL is delivered ready to use and must not be mixed with water.

Retrofitting

When changing from another secondary refrigerant in an existing system to HYCOOL, it is important that the system is cleaned thoroughly, flushed and then drained before filling with HYCOOL.

HYCOOL must not be mixed with other chemicals as there is a risk that the original concentrations of the chemical components in HYCOOL will be altered and that the product specification will not be guaranteed.

Deaeration

When the system has been filled, it must be completely deaerated by, for example, automatic or manual deaerators located at the high points, active deaerators mounted in the system at the point that has the highest temperature, or degassing equipment that via a vacuum degasses the fluid so that it maintains a low oxygen level. Circulate the system before lowering to working temperature.

Deaeration of a secondary circuit is of major importance in all instances since oxygen contributes towards corrosion and other problems and affects inhibitors.

Control

After filling with HYCOOL ensure the density meets the specification.

Depending on the operating conditions, the inhibitors are expected to work effectively over a long period. They should however be checked regularly.

Pressure drop and flow velocity

When designing indirect refrigeration systems with HYCOOL, it is important to be familiar with the thermodynamic properties, which are also available in software format.

HYCOOL's pipe calculation program provides a simple overview of the pressure drop in the most commonly occuring pipe sizes for copper, steel, plastic and stainless steel. When calculating the pressure drop in other programs, be sure that the right thermodynamic data are used in the calculations.

HYCOOL has very good heat transfer performance because of its high thermal conductivity and low viscosity. When calculating heat exchangers and pipe systems, these factors should be taken into account, as HYCOOL even at low flow velocity shows turbulent flow (high Reynolds number) and good heat transfer performance. Calculate heat exchangers and pipe systems so that risks of turbulence problems are eliminated.

Backup

Hydro, the manufacturer and supplier of HYCOOL, offers technical backup and support as well as chemical analysis of HYCOOL samples.

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Notes

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