HARTGARD® FOR FREEZE PROTECTION

All solar water heaters must have some means of protecting the solar collectors against freeze damage during cold weather. For systems installed in mild climatic regions, the protection need not be very elaborate. In colder climates, freeze-protection may be a major element of system design. This Fact File describes how Solahart J and Kf Series solar water heaters use Hartgard to provide freeze protection.

What Happens When a Solar Collector Freezes?

The absorber tubes of a solar collector can rupture when the water they carry freezes. To know why this occurs, it is necessary to understand what happens when water freezes.

All substances are made up of molecules that are separated by space. The distance between molecules is what gives a substance its 'volume' and this varies according to the temperature of the substance. For most substances, volume decreases (separation space reduces) as temperature falls and increases (separation space grows) as temperature rises. But water is different. Initially a temperature fall produces the normal reduction in volume until 4°C. At this temperature, ten kilograms water has reduced in volume to ten litres. As temperature falls further, volume increases. At 0°C, the volume of ten kilograms of water has increased to nearly eleven litres and the liquid freezes to a solid. This property explains why ice cubes float in a glass of water. Unlike most other substances, frozen water is less dense than liquid.

If the water contained in the absorber tubes of a solar collector freezes, it expands. Because different parts of the collector cool at different rates, ice forms in some parts sooner than in others. This ice 'plugs' the tubes in which it forms. Any liquid water trapped within the plugged sections continues to expand as the collector cools. If it cannot be relieved, the expanding water ruptures the tubes and the collector subsequently leaks when the ice thaws.

When Will a Solar Collector Freeze?

A solar collector containing water will freeze if the collector tubes experience a temperature of 0°C or lower. But this does not necessarily mean that the surrounding air temperature needs to be as low as 0°C. A collector can experience 0°C during the night even if the air temperature is as high as 3 or 4°C! Two aspects of the design of solar collectors contribute to this. First, for solar collectors to be effective as absorbers of solar radiation the absorber surface must be black in colour. But a black surface is also a good radiator. This means that it will quickly cool if it is hotter than the space it is facing. Second, to present the maximum surface area to absorb solar radiation, solar collectors must face the sky.

On clear nights, the black surface of the absorber 'looks' at deep space. To the absorber, the temperature of the night sky 'appears' to be far lower than 0°C. It radiates heat to the cold space and its temperature falls. The absorber temperature can fall to below 0°C, and the collector water can freeze, even if the surrounding air temperature is above the freezing point.

How Does Hartgard Protect Against Freeze Damage?

It is possible to lower the temperature at which water freezes by mixing in other substances. For example, the salt in seawater lowers the freezing point by nearly 3°C. This is why salt is sometimes spread on roads to prevent the build-up of ice.

There are many anti-freeze substances. Amongst the most common is ethylene glycol, an additive used in automobile cooling systems. But most of these substances are not suitable for use with solar water heaters. Some are toxic.

The unique design of the Solahart J and Kf Series solar water heaters features a closed collector circuit that is filled with a non-replacing charge of fluid. Hartgard is

an anti-freeze additive developed specifically for use in Solahart solar water heaters.

Its major component is propylene glycol. Introducing 4 litres of Hartgard into the closed circuit depresses the freezing point of the mixture by 10˚C. But three characteristics of the mixture provide freeze protection at temperatures lower than minus 10˚C. First, as the mixture freezes ice crystals begin to form at minus 10˚C but it continues to flow freely down to minus 15˚C. Second, through to minus 15˚C the density the mixture does not decrease.

Third, down to minus 40˚C, the mixture remains fluid and therefore does not form ice plugs in the collector tubes.

What Else Does Hartgard Do?

Hartgard also works to protect the closed circuit against corrosion. It contains a small amount of a substance known as a 'buffer' which inhibits its corrosion. The buffer or inhibitor prevents the circuit from becoming 'acidic'. Even when the Hartgard is initially mixed with the water to charge the closed circuit, the inhibitor provides enough 'reserve' alkalinity to offset any mild alkalinity in the water.

Does Hartgard Need to be Regularly Replaced?

Once the closed circuit is sealed, the fluid becomes stable. Because oxygen and other substances are excluded from the closed circuit, there is no need for any servicing or recharging of the Hartgard.

Although the closed circuit of a Solahart solar water heater is fitted with a pressure relief valve, this does not result in any ongoing loss of the closed circuit fluid. The purpose of the relief valve is to relieve any over filling that may have occurred during initial charging. Once the first full heating cycle is complete, the relief valve becomes redundant. It does not 'breathe' to allow air ingress.

Does Hartgard Deteriorate from Over Heating?

The major component of Hartgard, propylene glycol has a boiling point of 188˚C. At high temperatures, in the presence of oxygen, it can oxidise. But in the closed circuit of a Solahart solar water heater, two factors ensure this does not occur. First, any oxygen that is in the initial water Hartgard charge is quickly 'consumed' by the inhibitor. Second, because the closed circuit is sealed, there is no ongoing supply of oxygen to "feed" the oxidisation reaction. This means that even under very high temperatures, Hartgard remains stable.

Is Hartgard Toxic?

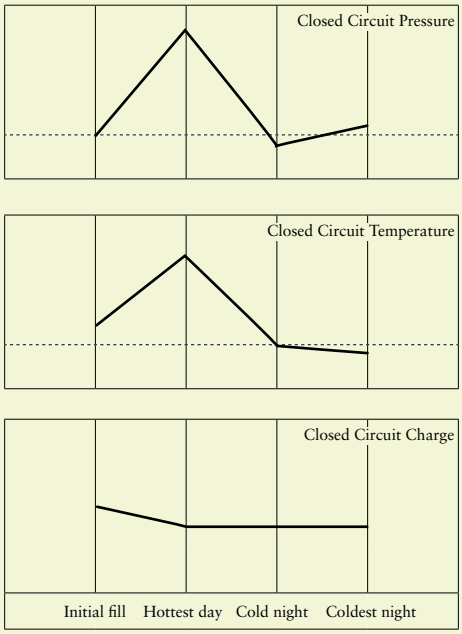
Hartgard is non-toxic. The major component, propylene glycol is actually a USP food grade product. The non-toxic properties of inhibited propylene glycol permit its use as a coolant in the refrigeration systems of dairies, breweries and food processing plants where a leak in the system could cause the refrigerant to come into contact with the products. The blue colour of Hartgard is derived from a food dye.

Chemical Composition

Propylene glycol, USP Grade	90%
Di-potassium mono-hydrogen phosphate	4%
Edicol blue colouring dye	0.008%
Distilled water	6%

A Year in the Life of the Closed Circuit

The diagrams show how the pressure, temperature and mass of the closed circuit fluid in a Solahart solar water heater may change over the first year of service. The closed circuit is initially filled with a charge of about 22 kg of a water / Hartgard mixture at a temperature of about 20˚C and at atmospheric pressure. On the hottest day of the year, the temperature rises to about 100˚C and the pressure increases to 80 kPa at which point the relief valve operates. This causes a slight reduction in the mass of the charge as some fluid is relieved to waste. On a subsequent cold night, the temperature of the charge is 0˚C the pressure is slightly negative (as the volume of the charge decreased with falling temperature), but the charge mass is unchanged. On the coldest night, the temperature of the charge is minus 20˚C, the pressure is slightly positive (as the volume of the charge increased as the mixture froze), but the charge mass is constant.



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