Bath fluids

The bad news is there's a lot to know about selecting a proper bath fluid—and there's a lot to understand about how to correctly use it. The good news is we're in our fourth decade of working with a very wide variety of fluids and we've already done a lot of the homework for you!

On the following pages you'll find a list of fluids (including granular bath salt) offered by Hart Scientific. We offer most of them in a variety of different container sizes, so please select the packaging you prefer. (If you order 100 liters in a one-liter size, you'll get 100 separately packaged liters.) You'll also find a chart, which graphically indicates usable ranges and some other important facts about each fluid.

First, though, let's get you acquainted with some of the important things to know about selecting and using various bath fluids.

Usable range

Hart Scientific defines the "usable range" of a bath fluid as the range of temperatures over which a fluid can safely provide a good environment in which to compare thermometers. The ranges we define for each fluid may be different than what the manufacturers of those fluids specify. That's simply because we're taking the application (thermometer testing in baths) into account.

Range can be limited by viscosity, flash points, freeze points, boiling points, evaporation rates, propensity to gel (or polymerize), etc. Safety-related issues should never be discounted.

Unfortunately, no magic fluid exists to cover extremely wide temperature ranges. We wish one did! Most fluids cover smaller ranges than we'd like. Ideally, you have a separate bath for every common temperature point you use – to eliminate fluid changes and time for baths to change temperature and to maximize throughput.

Viscosity

Viscosity is a measure of a fluid's resistance to flow—we often think of it simply as "thickness." Kinematic viscosity is the ratio of absolute viscosity to density and is measured in "stokes" (at a specific temperature), which are commonly divided by 100 to give us more helpful "centistokes." The higher the number of centistokes, the more viscous (or thick) a fluid is. Viscosity is always stated at a specific temperature (often at 25 °C) and increases as the fluid's temperature decreases (and vice versa).

Bath fluids which are too viscous create strain on stirring and pumping mechanisms and don't adequately transfer heat uniformly from temperature sources to thermometers.

Hart recommends using fluids with less than 50 centistokes viscosity, which is reflected in the usable ranges we state for each fluid. Less than 10 centistokes viscosity, however, is ideal. Low-uncertainty calibrations require a homogeneous temperature within the "calibration zone" of a bath. High-viscosity fluids promote unwanted temperature gradients.

Flash points

This is the temperature at which an adequate mixture of fluid vapor and air will ignite if in the presence of a spark or flame. (The vapor may even stop burning if the flame is removed.)

There are two ways to measure flash points. With the "open cup" method, neither the fluid nor the air around it is enclosed, so there is a higher ratio of air to fluid vapor. With the "closed cup" method, the fluid, fluid vapor, and air are enclosed. Closed cup flash points are typically lower than open cup flash points.

Also, fluid manufacturers list flash points in various places. On MSDS, the flash point is often given non-specifically to fit into a classification scheme used for hazard control. Actual product specification sheets usually give more specific information. For example, the flash point of one silicone oil is listed on its MSDS as "> 101.1 °C," whereas a more specific "211 °C cc" is listed on its specification sheet.

For Hart fluids that have flash points, we list the closed cup method and limit the upper end of the fluid's range to slightly below the flash point.

Heat capacity

Specific heat is the amount of heat required to raise the temperature of a unit of a substance by 1 °C. The higher the heat capacity, the more difficult it is to raise a fluid's temperature, therefore it is both slower and more stable.

Thermal conductivity

Thermal conductivity is a fluid's ability to transfer heat from one molecule to another. The better the heat transfer, the quicker the fluid will heat or cool. Better thermal conduction improves bath uniformity.

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Expansion

All fluids have a coefficient of thermal expansion. This coefficient tells how much a fluid's volume will change (expand or contract) with changes in temperature. Fluid expansion has important ramifications for safety, cleanliness, and care of equipment. If baths are filled too high with a fluid at a low temperature and then heated without regard to volume increase, they can obviously spill. Also, if the fluid in a bath is allowed to run too low, it can leave bath heaters exposed, which can damage them.

Specific gravity

The specific gravity is the ratio of a fluid's density to that of water. The higher the specific gravity, the more dense (and heavy) a fluid is. If the fluid is too heavy, it may not work well in a bath equipped with a pump mechanism or circulator.

Vapor pressure

Vapor pressure is (at least for our purposes here) the temperature at which the rate of evaporation of that fluid equals the rate at which the fluid's vapor is condensing back into the fluid—i.e. the two are at equilibrium. Raising the temperature increases a fluid's vapor pressure over ambient pressure, thereby driving vapor into the air.

Fluids that have low vapor pressures (such as alcohols and water) evaporate quickly and require frequent replenishment. Furthermore, rapid evaporation at the fluid surface has a cooling effect on the fluid, making temperature control more difficult, especially with an uncovered bath. Such fluids generally are only suitable for low temperature use. In some cases, vapors in the air can provide a health hazard and should be carefully vented.

Gelling (polymerization)

Here's an area that can get people into trouble! Given enough time, temperature, and catalysts, silicone oils will eventually polymerize. That is, they'll suddenly turn into a molasses-like "goop," doubling in volume and making an unpleasant mess.

Oxidation is the root cause. While silicone oils may be used safely to near their flash points, susceptibility to polymerization increases with use above their oxidation points, which we list for each silicone oil.

To delay polymerization, limit a bath's time above a fluid's oxidation point, have it idle below its vapor point when not being used, keep contaminants out of the oil (including salts, other oils, and oxidizers), and change your oil if it becomes too dark, too viscous, or too unstable in temperature.

Water

There are a few things to understand about water in non-water baths. First, never introduce water into a salt or hot oil bath as this can be extremely dangerous.

Second, water may condense in an oil bath being used at low temperatures, particularly where there is high ambient humidity. The water can freeze to cooling surfaces and cause bad stirring conditions. Occasionally the water needs to be boiled off.

Lastly, alcohols absorb water. This isn't all bad. In fact 5 % water in methanol will allow methanol to be used at –100 °C. Also, water that is absorbed will not freeze onto cooling surfaces. However, when too much water is absorbed, the alcohol becomes saturated and a slurry forms, impeding stability and uniformity. At that point, the fluid needs to be changed.

Ventilation

Always use good ventilation with baths that will prevent bath users from breathing fumes from bath fluids. Suction devices that open near the bath's access opening and exit out of doors are best. Oil vapor can settle on the surfaces of the eyes which causes some discomfort. Silicone oils can create benzine and formaldehyde as they break down at high temperatures—i.e. at about the flash point or above. Keep baths sealed up as much as possible to prevent fumes from coming into the work space. This will help with safety but will also increase the lifetime of the oil and improve performance of the bath.

Safety

Nothing is more important when working around a bath than to follow good safety practices. Here are some important recommendations:

- Always wear appropriate personal protective equipment. This may include gloves, aprons, and face shields of adequate covering and material for the temperatures being worked with.
- Understand the fluids you're using. MSDS sheets from manufacturers can be very helpful. Product specification sheets from manufacturers often include helpful information not in the MSDS.
- Ventilate appropriately, as mentioned above.
- Never mix fluids or put any chemicals into the fluid.
- Never put anything into bath fluid which could potentially cause a physical or chemical reaction.
- Never allow water to come into contact with hot salts or oils. (If a fire-

Specifications

Model #	Fluid	Usable Range§	FlashPoint†
5019	Halocarbon 0.8 Cold Bath Fluid	–100 °C to 70 °C	n/a
5022	Dynalene HF/LO*	–65 °C to 58 °C	60 °C
5023	HFE Cold Bath Fluid	–75 °C to 100 °C	n/a
5020	Ethylene Glycol (Mix 1:1 with water)	–30 °C to 90 °C	n/a
5010	Silicone Oil Type 200.05	–40 °C to 130 °C	133 °C
5012	Silicone Oil Type 200.10	–30 °C to 209 °C	211 °C
5013	Silicone Oil Type 200.20	10 °C to 230 °C	232 °C
5014	Silicone Oil Type 200.50	30 °C to 278 °C	280 °C
5017	Silicone Oil Type 710	80 °C to 300 °C	302 °C
5011	Mineral Oil	10 °C to 175 °C	177 °C
5001	Bath Salt, 125 lb‡ Potassium Nitrate 53 % Sodium Nitrite 40 % Sodium Nitrate 7 %	180 °C to 550 °C	n/a

§Atmospheric pressure affects the usable ranges of some fluids. The temperatures quoted are at sea level.
†Flash point is the temperature at which a vapor (not the fluid) will ignite if exposed to an open flame. When the flame is removed, the vapor will stop burning. (Open cup method.)
*Electrical resistivity is greater than 20 MΩ-cm.
‡125 lb bath salt fills a 30-liter (7.9-gallon) tank.

Material Safety Data Sheets available at www.hartscientific.com

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extinguishing sprinkler system is triggered and sends water into salt and hot oil baths, the situation can become literally explosive.)

- Only place clean thermometers into bath fluids.
- Never operate a bath on or around combustible materials. Keep the area around baths clean.
- Keep appropriate fire extinguishing equipment nearby.
- Ensure that all personnel who operate with or near baths understand the precautions that should be taken around them and how to deal with emergencies.
- Abide by federal, state, and local laws regarding the storage and disposal of hazardous or flammable bath fluids.
- Do not use or store bath salt in or around flammable materials. While Hart 5001 Bath Salt is not flammable, it supports combustion of other flammable materials such as wood or cardboard. Do not use bath salt for applications outside of thermometer calibrations.
- Avoid using fluids above their flash points. Special safety considerations should be used for alcohols since their flash points are typically below room temperatures.

Ordering Information

5001 Bath Salt	
5001	Bath Salt, 125 lb (fills a 30 liter [7.9 gal] tank)
5010 Silicone Oil	
5010-1L	Silicone Oil Type 200.05, –40 °C to 130 °C, 1 liter (0.26 gal)
5010-3.8L	Silicone Oil Type 200.05, –40 °C to 130 °C, 3.8 LITERS (1 GAL)
5010-18.9L	Silicone Oil Type 200.05, –40 °C to 130 °C, 18.9 liters (5 gal)
5011 Mineral Oil	
5011-1L	Mineral Oil, 10 °C to 175 °C, 1 liter (0.26 gal)
5011-3.8L	Mineral Oil, 10 °C to 175 °C, 3.8 liters (1 gal)
5011-18.9L	Mineral Oil, 10 °C to 175 °C, 18.9 liters (5 gal)
5012 Silicone Oil	
5012-1L	Silicone Oil Type 200.10, –30 °C to 209 °C, 1 liter (0.26 gal)
5012-3.8L	Silicone Oil Type 200.10, –30 °C to 209 °C, 3.8 liters (1 gal)
5012-18.9L	Silicone Oil Type 200.10, –30 °C to 209 °C, 18.9 liters (5 gal)
5013 Silicone Oil	
5013-1L	Silicone Oil Type 200.20, 10 °C to 230 °C, 1 liter (0.26 gal)
5013-3.8L	Silicone Oil Type 200.20, 10 °C to 230 °C, 3.8 liters (1 gal)
5013-18.9L	Silicone Oil Type 200.20, 10 °C to 230 °C, 18.9 liters (5 gal)
5014 Silicone Oil	
5014-1L	Silicone Oil Type 200.50, 30 °C to 278 °C, 1 liter (0.26 gal)
5014-3.8L	Silicone Oil Type 200.50, 30 °C to 278 °C, 3.8 liters (1 gal)
5014-18.9L	Silicone Oil Type 200.50, 30 °C to 278 °C, 18.9 liters (5 gal)
5017 Silicone Oil	
5017-1L	Silicone Oil Type 710, 80 °C to 300 °C, 1 liter (0.26 gal)
5017-3.8L	Silicone Oil Type 710, 80 °C to 300 °C, 3.8 liters (1 gal)
5017-18.9L	Silicone Oil Type 710, 80 °C to 300 °C, 18.9 liters (5 gal)
5019 Halocarbon Fluid	
5019-1L	Halocarbon 0.8 Cold Bath Fluid, –100 °C to 70 °C, 1 liter (0.26 gal)
5019-3.8L	Halocarbon 0.8 Cold Bath Fluid, –100 °C to 70 °C, 3.8 liters (1 gal)
5019-18.9L	Halocarbon 0.8 Cold Bath Fluid, –100 °C to 70 °C, 18.9 liters (5 gal)
5020 Ethylene Glycol	
5020-1L	Ethylene Glycol (Mix 1:1 with Water), –30 °C to 90 °C, 1 liter (0.26 gal)
5020-3.8L	Ethylene Glycol (Mix 1:1 with Water), –30 °C to 90 °C, 3.8 liters (1 gal)
5020-18.9L	Ethylene Glycol (Mix 1:1 with Water), –30 °C to 90 °C, 18.9 liters (5 gal)
5022 Dynalene HF/LO Fluid	
5022-1L	Dynalene HF/LO, –65 °C to 58 °C, 1 liter (0.26 gal)
5022-3.8L	Dynalene HF/LO, –65 °C to 58 °C, 3.8 liters (1 gal)
5022-18.9L	Dynalene HF/LO, –65 °C to 58 °C, 18.9 liters (5 gal)
5023 HFE Cold Bath Fluid	
5023-1L	HFE Cold Bath Fluid, –75 °C to 100 °C, 1 liter (0.26 gal)
5023-3.8L	HFE Cold Bath Fluid, –75 °C to 100 °C, 3 liters (1 gal)
5023-18.9L	HFE Cold Bath Fluid, –75 °C to 100 °C, 18.9 liters (5 gal)

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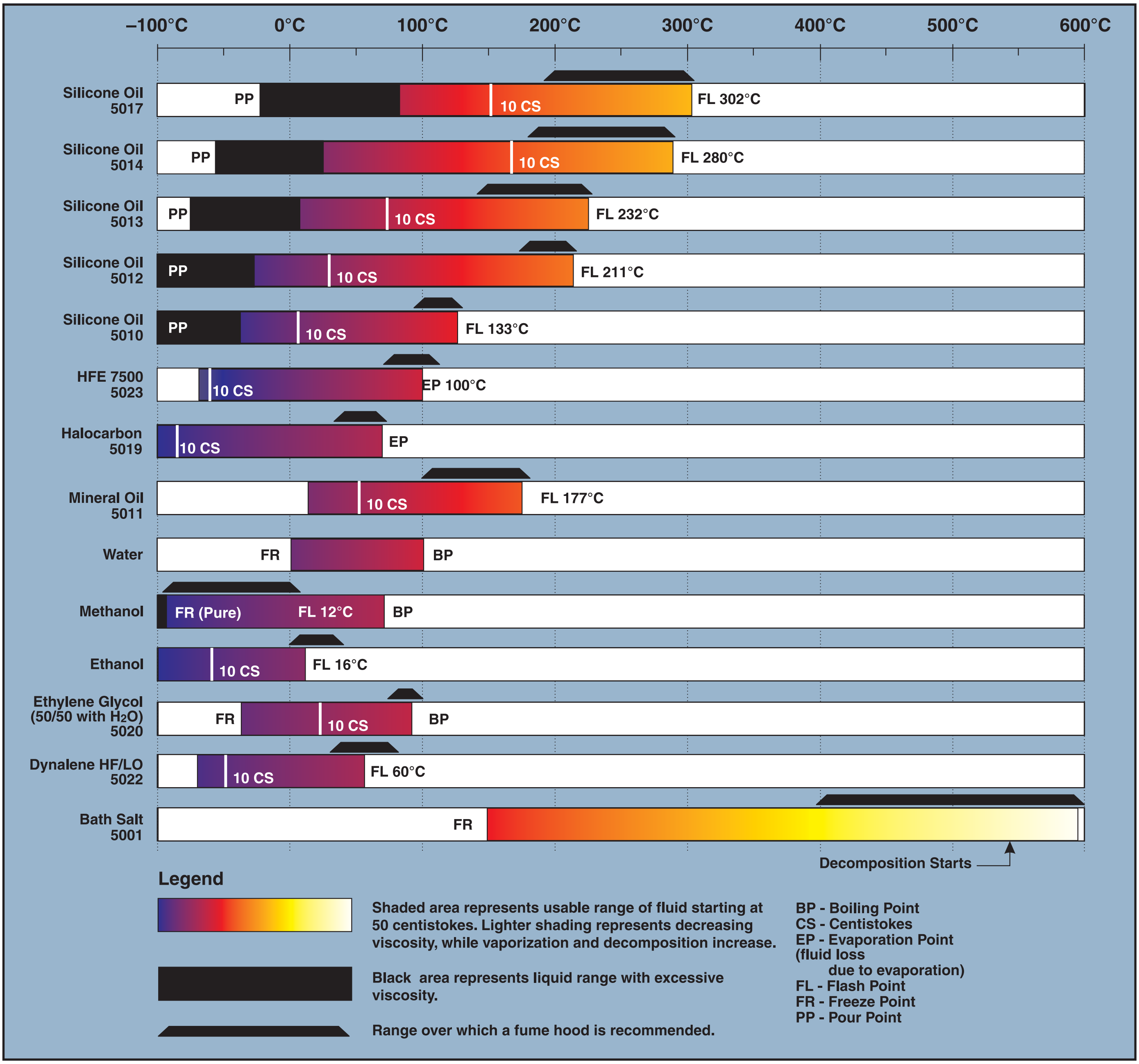

Can't a single fluid cover my bath's entire range?

So, you want to cover the entire temperature range of your bath with one fluid? That would be nice. Unfortunately for all of us, this is often not possible.

All fluids have temperature range limits for a variety of reasons. The properties of certain fluids just don't hold still over temperature. Not only do you have problems with freezing and boiling, but viscosity changes, evaporation, and flash points create limits for a fluid's useful temperature range.

The result is that one fluid may not cover the range you need within a single bath, leaving you with a choice between inconvenient fluid changes or multiple temperature-dedicated baths.