Choosing a bath fluid

Written by
Steve Iman
Fluke's Hart Scientific Division

Presented by
Norman Willgress
Fluke's Hart Scientific Division

“Ideal” bath fluid

- Wide temperature range
- Low viscosity
- High heat capacity
- Very low vapor pressure
- High flash point

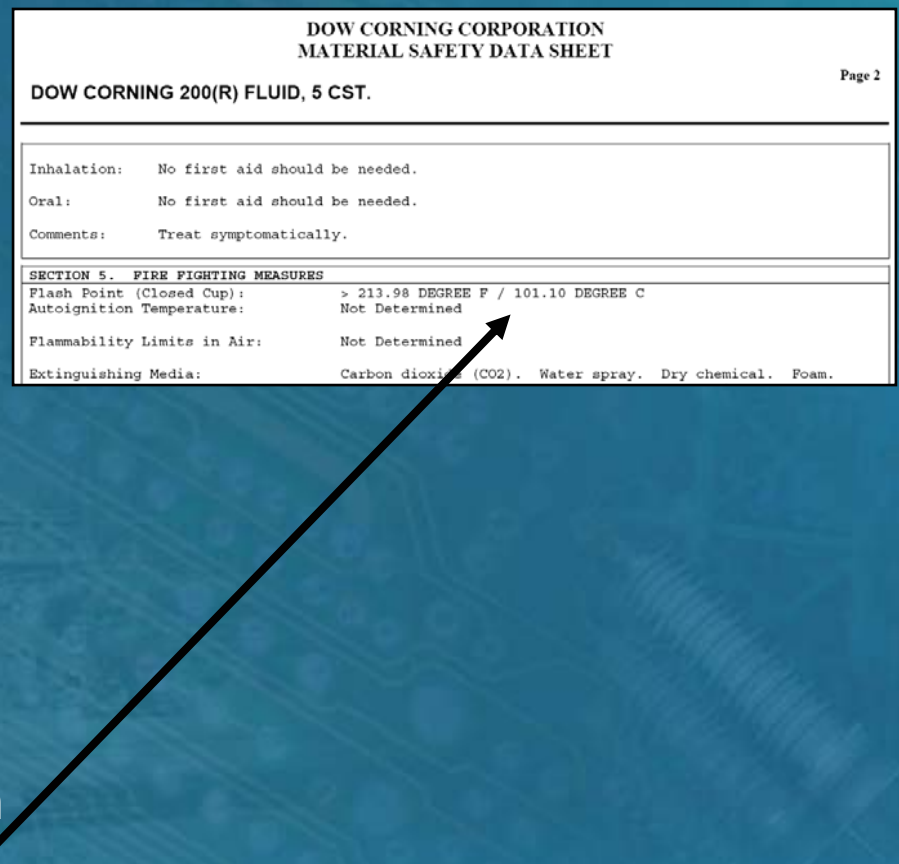
No single fluid has all of these properties!

Operational considerations

- Safety precautions
- Flash points
- Viscosity
- Head capacity
- Thermal conductivity
- Fluid expansion
- Specific gravity
- Vapor pressure
- Gel time (or time to polymerization)
- Useable life
- Storage

Flash point

- Temperature at which fluid vapor mixed with air will ignite
- Two units of measure for flash point
  - Open cup; vapor is not enclosed and there is a larger concentration of air
  - Closed cup; vapor is enclosed with air and there is a larger concentration of vapor
- Fluid manufacturers typically use flash point classifications instead of actual flash point values
  - The Material Safety Data Sheet (MSDS) might say Flash point greater than 101.1°C when the Flash point is actually 132.4°C



DOW CORNING CORPORATION
MATERIAL SAFETY DATA SHEET

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DOW CORNING 200(R) FLUID, 5 CST.

Inhalation:	No first aid should be needed.
Oral:	No first aid should be needed.
Comments:	Treat symptomatically.

SECTION 5. FIRE FIGHTING MEASURES

Flash Point (Closed Cup):	> 213.98 DEGREE F / 101.10 DEGREE C
Autoignition Temperature:	Not Determined
Flammability Limits in Air:	Not Determined
Extinguishing Media:	Carbon dioxide (CO2). Water spray. Dry chemical. Foam.

Kinematic viscosity

- For bath fluids we use kinematic viscosity
  - This differs from standard viscosity
    - Kinematic viscosity is a measure of volume flow of a liquid
  - Defined as a stoke
    - 1 stoke = 1 cm^2/sec
    - Convert to standard viscosity by multiplying by fluid density
- Viscosity changes with temperature
  - High viscosity will place too much load on the stirring and pumping motors
  - High viscosities also affect stability and uniformity
  - Hart baths are optimized for 10 centistokes
    - But will work satisfactorily up to 50 cst

Specific heat capacity

- Specific heat capacity of a liquid is defined as the heat required to raise a unit of mass by 1 degree of temperature

$$\Delta Q = mc\Delta T$$

Where:

ΔQ = heat applied to fluid
m = fluid mass
c = specific heat capacity
ΔT = rise in temperature

Thermal conductivity

- This is the fluids 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 will help improve bath uniformity

Coefficient of volume expansion

- All fluids will expand or contract as temperature changes
- Unless the bath has an overflow device care must be taken when filling the bath that it will not overflow during operation

Specific gravity

- This specifies the density or weight of the fluid as compared to water
  - Specific gravity of water = 1
- Fluids with higher specific gravity weigh more
  - If the fluid is too heavy pumping or circulators may not work or will wear out too soon
  - At the extreme, it may also cause warping of the tank or other support components in a bath

Vapor pressure/volatility

- Vapor pressure is the temperature at which the fluid will evaporate
  - At lower temperatures the vapor will condense into liquid
- Fluids with high volatility (alcohol) require a fume extraction system
- Fluids with high volatility (alcohol) will evaporate more quickly and require frequent refilling of the bath
- Rapid evaporation at the fluid surface has a cooling effect, making temperature control more difficult

Gel (polymerization) time

- Gel time is the time it takes oil to gel or polymerize
  - This is associated with silicon oils used at elevated temperatures
- Polymerization occurs due to oxidation
  - Can occur very quickly!
  - Fluid volume can double
  - Can destroy the bath and all of the contents
- Clean up is extremely difficult
  - Dow Corning has a solvent called OS-2 that can be used to assist in removing polymerized oil

Prolonging oil life – or avoiding Polymerization

- Keep the time of the bath at high temperature to a minimum
- Turn off the bath when not at use; or reduce to an idling temperature
- Avoid cross-contamination of oils
- Keep oxidizers out of the bath
  - For example bath salts
- Change bath oil when it becomes too dark or there is a notable difference in bath stability
  - This is a good reason to monitor bath stability with new oil and then periodically check as the oil gets older

Fluid life and storage

- The useable life of a fluid depends upon how it is used
  - What temperature
  - How long at temperature
  - Contamination
- Unused liquids should be stored in their original un-opened containers
  - Consult with the fluid manufacturer if storage life is a significant concern

Common calibration fluids

- Bath fluids determine the operating range of the bath – not the bath itself!
- Fluids that are commonly used for calibration are:
  - Water
  - Silicone oils
  - Cooking oils
  - White mineral oil
  - Perfluorocarbons
  - Alcohols
  - Bath salts

Water

- One of the most commonly used fluids over the range of 5°C to 60°C
  - Upper temperature range is determined by elevation and atmospheric pressure
- The temperature range can be extended by using ethylene glycol (car radiator fluid)
- Use distilled water to reduce hard water deposits
- Use an algaecide to reduce algae growth

Silicone oil

- Advantages
  - Wide temperature range -40°C to 300°C
    - Different formulations – not a single oil!
  - Varying viscosities
  - Good thermal characteristics
  - Low flammability
- Disadvantages
  - Toxic fumes
  - Difficult cleaning
  - Oxidation which leads to Polymerization
  - Icing when cold

Cooking oil

- Advantages
  - Non-toxic
  - Good viscosities
  - Good thermal characteristics
- Disadvantages
  - Limited temperature range
  - Greater fuming than silicone oil
  - Subject to gelling like silicone oil

White mineral oil

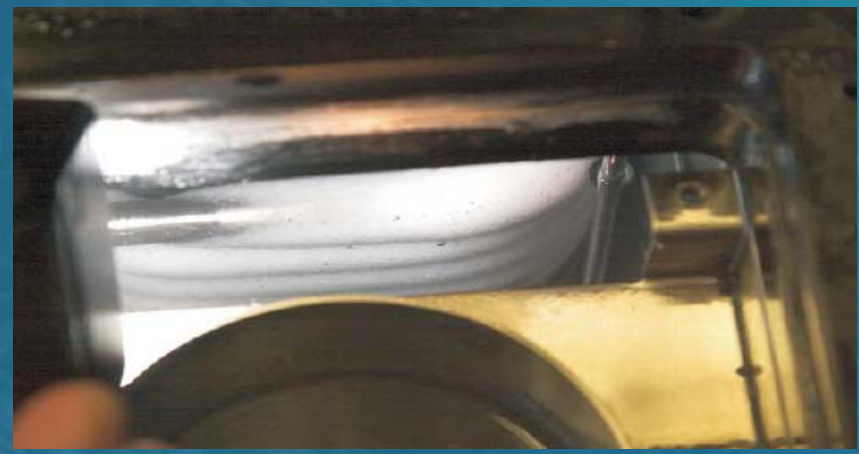
- Advantages
  - Inexpensive
  - Good thermal and electrical properties
- Disadvantages
  - Fuming
  - Difficult to clean
  - Decline in resistivity over time

Perfluorocarbons

- Advantages
  - Excellent low temperature performance
  - Good thermal and chemical stability
  - Non-flammable and low toxicity
  - Good electrical properties
  - Easy clean-up
- Disadvantages
  - Evaporation
  - Cost

Alcohols

- Ethanol and Methanol or most common
- Advantages
  - Good low temperature fluid (below 0°C)
  - Absorbs moisture – allows cooling coils to remain efficient
  - Inexpensive
- Disadvantages
  - Volatility, low flash point
  - Toxic
  - Evaporation



Silicone oil at low temperature. Condensing moisture drops into fluid then freezes to coils insulating them from the remaining fluid.

Bath salts

- Advantages
  - Excellent high temperature fluid
    - Useable from 200°C to 550°C
  - Excellent heat transfer
  - Easy to clean
  - Inexpensive
  - Long life
    - If used below 454°C, above this temperature some thermal decomposition occurs gradually increasing the melting temperature
- Disadvantages
  - Electrically conductive
  - Oxidizer
  - Initial melting process must be done with care
  - Never allow water to contact molten salt

Bath Fluid Selection Chart

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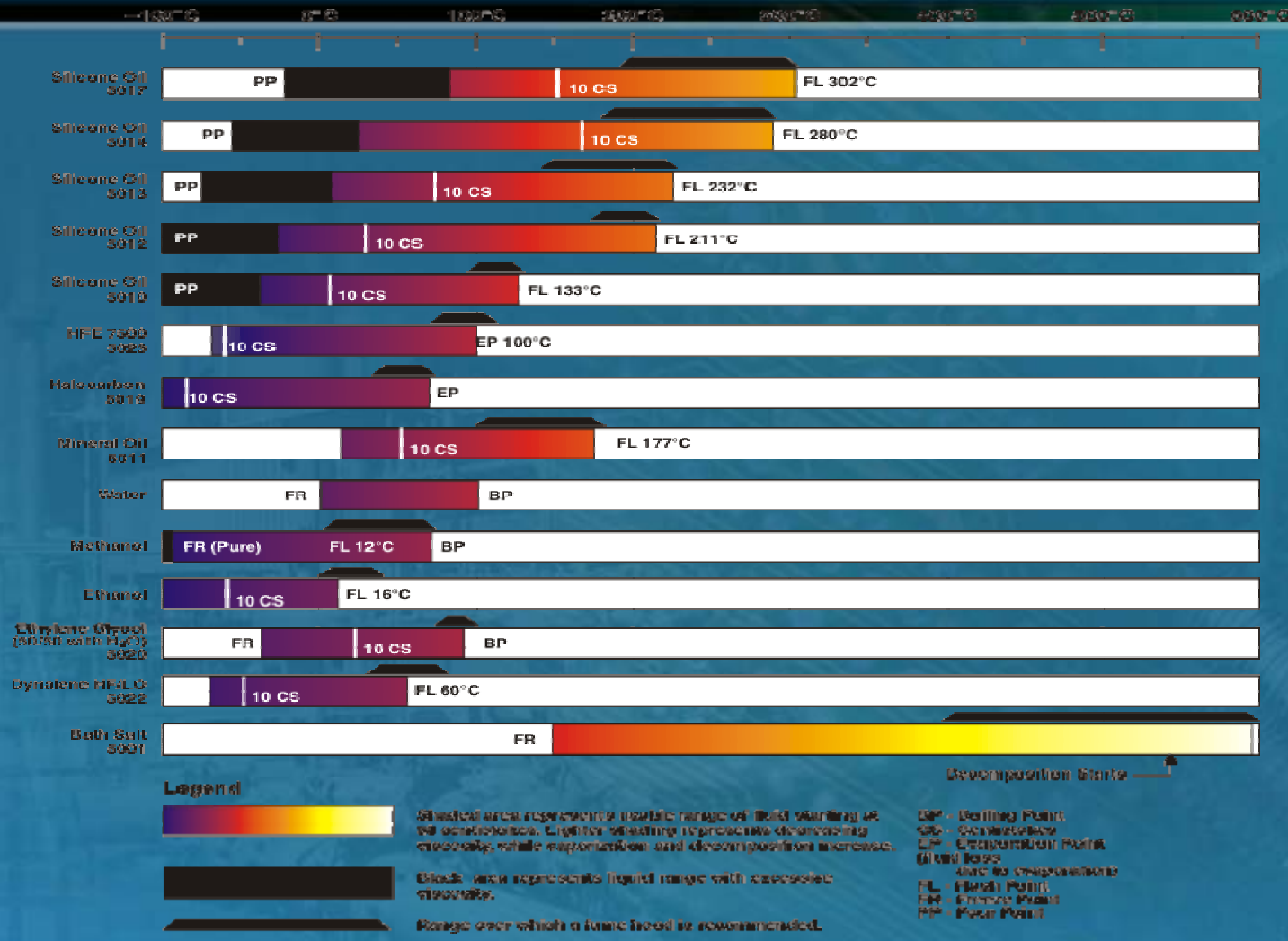
Hart Scientific



Conclusion

- Fluids are an integral part of a calibration bath
- Fluids define the useable temperature range
- Proper fluid choice requires careful consideration of the advantages and limitations