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Standard Guide for Pumpability of Heat Transfer Fluids[1]

This standard is issued under the fixed designation D8046; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This guide covers general information, without specific limits, for selecting and evaluating pumpability characteristics of heat transfer fluids at both low and high temperature. This guide is a compendium of information and does not recommend a specific course of action. This guide provides additional information on pumpability topics found in companion guides for evaluating heat transfer fluids, Guides D5372 and D7665.

1.2 Pumpability of heat transfer fluids is dependent on both fluid properties and the design of the fluid handling system that stores and transports the fluid, and therefore presents a number of pumping options. This guide is considered particularly useful for identifying pumpability options. The listing of test standards and guides is not all-inclusive and additional standards and guides may be useful.

1.3 The values stated in SI units are to be regarded as standard.

1.3.1 *Exception*—Other units are provided for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Users of heat transfer fluids should be especially mindful of potential fire and explosion hazards.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D92 Test Method for Flash and Fire Points by Cleveland Open Cup Tester
D93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
D97 Test Method for Pour Point of Petroleum Products
D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
D891 Test Methods for Specific Gravity, Apparent, of Liquid Industrial Chemicals
D2161 Practice for Conversion of Kinematic Viscosity to Saybolt Universal Viscosity or to Saybolt Furol Viscosity
D2270 Practice for Calculating Viscosity Index from Kinematic Viscosity at 40 °C and 100 °C
D2879 Test Method for Vapor Pressure-Temperature Relationship and Initial Decomposition Temperature of Liquids by Isoteniscope
D2887 Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography
D2983 Test Method for Low-Temperature Viscosity of Lubricants Measured by Brookfield Viscometer
D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter
D5372 Guide for Evaluation of Hydrocarbon Heat Transfer Fluids
D6304 Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration
D7042 Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)
D7665 Guide for Evaluation of Biodegradable Heat Transfer Fluids
E794 Test Method for Melting And Crystallization Temperatures By Thermal Analysis

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *cavitation, n*—a process of dropping the local liquid pressure below its vapor pressure due to flow phenomenon and is characterized by the formation of vapor bubbles within the liquid.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

3.1.1.1 *Discussion*—Implosion of vapor bubbles on pump components can cause eroding of surfaces, which may lead to decreased pumping performance and mechanical failures.

3.1.2 *heat transfer fluid, n*—a fluid that remains essentially a liquid while transferring heat to or from an apparatus or process, although this guide does not preclude the evaluation of a heat transfer fluid that may be used in its vapor state.

3.1.2.1 *Discussion*—Heat transfer fluids may be hydrocarbon- or petroleum-based such as polyglycols, esters, hydrogenated terphenyls, alkylated aromatics, diphenyl-oxide/biphenyl blends, mixtures of di- and triaryl-ethers. Small percentages of functional components such as antioxidants, anti-wear and anti-corrosion agents, TBN, acid scavengers ,and/or dispersants can be present.

3.1.3 *pumpability, n*—a fluid characteristic related to its ability to deform (shear stress-shear rate relationship) or ability to flow.

3.1.3.1 *Discussion*—There is no specific value associated with pumpability, although as a practical matter, the term is associated with the ability of pumps to flow a fluid at a specific temperature. Some producers of heat transfer fluids provide the temperature at which the fluid attains a specific viscosity value that may be associated with pumping limits. For example, it is common to find temperature values of heat transfer fluids for viscosities of 300 cSt (300 mm^2/s) and 2000 cSt (2000 mm^2/s). The pump design and its installation will determine the viscosity limit for pumpability of a heat transfer fluid.

4. Significance and Use

4.1 Pumpability of heat transfer fluids depends upon the configuration of the system in use, pumps and their installation, and the physical properties of the fluids being transported. The fluid's ability to pump efficiently is key to the economy of the system operation and heat transfer fluid life. The test methods listed in Section 5 may be considered as guides for determining the pumpability of heat transfer fluids under specific operating conditions. Information gained from use of this guide will aid in the selection of pumping equipment and its installation.

5. Relevant Tests for Characterization of Fluid Pumpability

5.1 *Flash Point, open cup or closed cup* (Test Method D92, D93)—This test method will detect low flash ends which are one cause of cavitation during pumping. In closed systems, especially when fluids are exposed to temperatures of 225 °C (approximately 400 °F) or higher, the formation of volatile hydrocarbons by breakdown of the fluid may require venting through a pressure relief system to prevent dangerous pressure build-up.

5.2 *Pour Point* (Test Method D97)—The pour point may be used as an approximate guide to what is known as the "borderline pumpability temperature," or bpt, and is a general indication of the lowest temperature a fluid can be pumped. If a heat transfer system is subjected to low temperatures when not in use, a heat trace system should be employed to warm the fluid above minimum pumping temperature before start-up.

5.3 *Crystallization Temperature* (Test Method E794)—Crystallization or freezing is a condition of solid formation and no liquid pump will work in this region.

5.4 *Viscosity* (Test Method D445, D2983, D7042)—Fluid viscosity is important for determining Reynolds and Prandtl numbers for heat transfer systems, to estimate fluid turbulence, heat transfer coefficient, and heat flow. Fluids become more difficult to pump as their viscosity becomes higher. See 6.1 for pumping of viscous fluids.

5.5 *Relative Density* (Test Method D891, D4052)—Relative density of heat transfer fluids is a parameter needed for calculating fluid density which is used in performance calculations for heat transfer, fluid dynamics, and pumping power. Also, hydraulic shock during pumping is predicted via the use of a combination of density and compressibility data. Test methods such as those described in Test Method D4052 will provide direct measures of density where density is reported at a specific temperature or when reporting relative density, both test temperature and reference temperature are given (for example, relative density 20 °C/20 °C = 0.xxxx).

5.6 *Water Content* (Test Method D6304)—Use the water content of a heat transfer fluid to indicate when the heat transfer system has been dried out sufficiently. Consider raising the bulk fluid temperature through the 100 °C plus region, to allow venting of water vapor, before proceeding to operate the system at higher temperatures. The system expansion tank shall be full prior to startup to ensure that moisture is safely vented in the lowest pressure part of the system. Positive nitrogen pressure on the heat transfer fluid system will minimize entry of air or moisture. Heat transfer systems operating at temperatures of 120 °C or greater shall, for reasons of safety, contain little moisture, because destructive high pressures are generated when water enters the high temperature sections of the system. The fluid supplier should be consulted to determine how low the moisture level in the heat transfer fluid must be maintained for safe system operation. Heating the fluid before it is placed in service also removes most of the dissolved gasses in the fluid. If not removed, these gasses can cause pump cavitation. (**Warning—**Air and combustible gasses can accumulate in stagnant parts of a poorly designed system and form a region of high potential for explosion.)

5.7 *Vapor Pressure* (Test Method D2879)—Vapor pressure, which normally increases with increasing operating temperatures, is an important design parameter. Heat transfer fluids exhibiting high vapor pressures shall be used only in systems with sufficient structural integrity. Design and operation of vapor phase systems will require knowledge of the equilibrium vapor pressure. Vapor pressure is an important consideration when investigating cavitation potential of a pumping system. Vapor pressure and other fluid properties may change as the fluid ages.

5.8 *Viscosity Conversions and Calculations*—Viscosity information provided with heat transfer fluids may be either in units of absolute or kinematic viscosity or both for specific temperatures. Information is sometimes provided for pumpability characterization in terms of a specific viscosity at a given temperature. Practices D2161 and D2270 provide calculation methods for conversion of units.

5.9 *Boiling Range Distribution* (Test Method D2887)—The flow characteristics of heat transfer fluids, especially viscosity, can change due to changes in composition caused by thermal degradation, oxidation, venting of low boiling components, and other processes as the fluid ages. Boiling range distributions obtained by Test Method D2887 will give insight about fluid degradation and hence pumpability characteristics especially for ageing fluids.

6. Pumps and Installation (Informational Only)

6.1 *Pumps*—Centrifugal, gear, canned motor and magnetically coupled pumps are commonly used to pump heat transfer fluids. Selection of a pump type depends on numerous factors relating to cost of operation and fluid handling characteristics of the pump. Key fluid handling factors are fluid viscosity and net positive suction head required. Heavy duty centrifugal pumps are most common for pumping heat transfer fluids and are used with fluids with viscosity as high as 400 cP (400 mPa·s) (400 cSt with a specific gravity of 1.0) as a practical limit. For low temperature and high viscosities to approximately 2000 cP (2000 mPa·s), gear pumps are typically recommended. Use canned motor and magnetically coupled pumps to avoid leakage of heat transfer fluid. Because of viscous drag on rotating parts of a pump, horsepower requirements can be significantly increased when pumping highly viscous heat transfer fluids in the –80 °C to –10 °C temperature range. Typical seals used are packing glands, mechanical, and combinations of the two. For high temperature operation, provisions are needed for cooling of seals and bearings. The capacity of a rotary pump varies directly with relative speed, and is independent of pressure within its operating limits. Volumetric efficiency generally increases with increasing viscosity; however, overall mechanical efficiency will suffer at both high viscosities and very low viscosity. The approximate viscosity limit for rotary pumps is 4×10^5 cSt.

6.2 *Installation*—Excessive pressure loss in the inlet piping to a heat transfer fluid pump may lead to severe cavitation at the pump inlet. As inlet fluid velocity increases and the pressure at the inlet drops, the local pressure may approach the fluid vapor pressure resulting in cavitation issues. Ensure there is sufficient net positive suction head at the pump inlet to prevent cavitation. Net positive suction head available can be increased by increasing the blanket gas pressure at the expansion tank. The pump suction head requirement for a given inlet flow rate, known as the net positive suction head requirement (NPSHR) is dependent on the pump design and this data is supplied by the pump manufacturer. The user needs to determine the lowest possible heat transfer fluid temperature that can occur for the installation, determine the viscosity of new fluid at that temperature, consider how fluid changes due to degradation may increase fluid viscosity, and apply an appropriate safety factor to the maximum fluid viscosity. The user should select a pump and motor combination which can accommodate that maximum fluid viscosity. The motor should be large enough to handle the pump requirements when starting up and operating with the maximum fluid viscosity.

7. Keywords

7.1 characterization; heat transfer fluid; pumpability

SUMMARY OF CHANGES

Subcommittee D02.L0 has identified the location of selected changes to this standard since the last issue (D8046 – 16) that may impact the use of this standard. (Approved Oct. 1, 2016.)

(1) Added Test Method D7042 to Referenced Documents and to subsection 5.4.

(2) Revised subsections 5.5 and 5.6.