Designation: D7721 – 22

Standard Practice for Determining the Effect of Fluid Selection on Hydraulic System or Component Efficiency[1]

This standard is issued under the fixed designation D7721; 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 practice covers all types and grades of hydraulic fluids.

1.2 This practice is applicable to both laboratory and field evaluations.

1.3 This practice provides guidelines for conducting hydraulic fluid evaluations. It does not prescribe a specific efficiency test methodology.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4174 Practice for Cleaning, Flushing, and Purification of Petroleum Fluid Hydraulic Systems

D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants

2.2 *ISO Standards:*[3]

ISO 4391 Hydraulic fluid power—Pumps, motors and integral transmissions—Parameter definitions and letter symbols

ISO 4392–1 Hydraulic fluid power—Determination of characteristics of motors—Part 1: At constant low speed and constant pressure

ISO 4409 Hydraulic fluid power—Positive-displacement pumps, motors and integral transmissions—Methods of testing and presenting basic steady state performance

ISO 5598 Fluid power systems & components—Vocabulary

ISO 8426 Hydraulic fluid power—Positive displacement pumps and motors—Determination of derived capacity

3. Terminology

3.1 For additional definitions related to petroleum products and lubricants, see Terminology D4175. For additional definitions related to fluid power systems and components, see ISO 5598.

3.2 *Definitions:*

3.2.1 *baseline oil, n*—oil of known performance characteristics used as a basis for comparison.

3.2.1.1 *Discussion*—For purposes of this practice, the baseline oil may be a hydraulic fluid of any suitable composition.

3.2.2 *component, n—of a hydraulic system*, an individual unit, excluding piping, comprising one or more parts designed to be a functional part of a fluid power system, for example, cylinder, motor, valve, or filter.

3.2.3 *critical parts, n*—those components used in the test that are known to affect test severity.

3.2.4 *cycle time, n*—the amount of time it takes for a machine to perform a repetitive segment of an operation, typically measured as the time it takes a machine to return to the original position after completing a task.

3.2.5 *energy consumption, n*—the total energy content consumed during a test in kWh; determined from electric power meter readings or calculated from the mass of fuel consumed and the lower heating value of the fuel.

[1] This practice is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.N0 on Hydraulic Fluids.

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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.

[3] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

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

3.2.6 *energy efficiency, n*—the work output divided by the energy input; this ratio may be expressed as a percentage.

3.2.7 *fit for use, n*—product, system, or service that is suitable for its intended use.

3.2.8 *fuel rate, n*—the rate at which fuel is consumed in L/h, normalized to the fuel density at 15 °C.

3.2.9 *grade, n*—designation given a material by a manufacturer so that it is always reproduced to the same specifications established by standards organizations such as ASTM or ISO.

3.2.10 *hydraulic fluid, n*—liquid used in hydraulic systems for lubrication and transmission of power.

3.2.11 *hydraulic system, n*—fluid power system that is an arrangement of interconnected components which generates, transmits, controls, and converts fluid power energy.

3.2.12 *motor hydromechanical efficiency, n*—ratio of the actual torque output of the motor to the theoretical torque output of the motor.

3.2.13 *motor overall efficiency, n*—ratio of the mechanical output power to the power transferred from the liquid at its passage through the motor.

3.2.14 *motor volumetric efficiency, n*—ratio of the theoretical inlet flow rate to the effective inlet flow rate.

3.2.15 *outlier, n*—result far enough in magnitude from other results to be considered not part of the set.

3.2.15.1 *Discussion*—For purposes of this practice, classification of a result as an outlier shall be justified by statistical criteria in comparison with the valid data points.

3.2.16 *pump hydromechanical efficiency, n*—ratio of the theoretical input torque of the pump to the actual torque input of the pump.

3.2.17 *pump overall efficiency, n*—ratio of the power transferred to the liquid, at its passage through the pump, to the mechanical input power.

3.2.18 *pump volumetric efficiency, n*—ratio of the effective output flow rate to the theoretical output flow rate.

3.2.19 *test oil, n*—any oil subjected to evaluation in an established procedure.

3.2.19.1 *Discussion*—For purposes of this practice, the test oil may be a hydraulic fluid of any suitable composition.

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *design of experiment, DOE, n*—statistical arrangement in which an experimental program is to be conducted and the selection of the levels (versions) of one or more factors or factor combinations to be included in the experiment.

3.3.2 *duty cycle, n*—time interval devoted to starting, running, stopping, and idling when a device is in use and the time spent operating at different levels of speed, displacement volume, torque, and pressure.

3.3.3 *power factor, n—in AC electrical circuits*, the ratio of actual electric power dissipated by the circuit to the product of the root mean square values of current and voltage; *in DC electrical circuits*, it is the energy consumed (watts) versus the product of input voltage (volts) times input current (amps).

3.3.3.1 *Discussion*—The power factor is the dimensionless ratio of energy used compared to the energy flowing through the wires.

3.3.4 *system overall efficiency, n—in fluid power systems*, the ratio of the output power of the system to the input power of the system.

3.3.4.1 *Discussion*—For integral transmissions and open-loop hydraulic circuits that drive a hydraulic motor, system overall efficiency is the ratio of the output mechanical power at the hydraulic motor shaft to the input mechanical power at the pump shaft. Methods ISO 4391 and ISO 4409 provide additional details for determining system efficiency in circuits with boost pumps.

4. Summary of Practice

4.1 The purpose of this practice is to define minimum technical requirements for conducting energy efficiency performance comparisons of two or more hydraulic fluids in controlled laboratory or field evaluations. It is organized in three sections.

4.2 The first section describes guidelines for a dynamometer evaluation of fluids in a high-pressure positive displacement pump. Baseline and test fluids are evaluated under steady-state conditions of pump shaft speed, displacement, outlet pressure and fluid temperature. Input torque, outlet flow and case drain flow rates are measured.

4.3 The second section describes guidelines for dynamometer evaluation of fluids in low-speed hydraulic motor testing. Baseline and test fluids are evaluated under steady-state conditions of inlet pressure, motor shaft speed, and fluid temperature. Output torque, input flow, and case drain flow rates are measured.

4.4 The third section describes guidelines for field evaluations of hydraulic fluids. Baseline and test fluids are evaluated in hydraulically powered machines. Energy consumption and duty cycle times are measured to compare the effects of fluids on machine efficiency and productivity.

4.5 Differences between baseline and test fluid performance are statistically evaluated.

5. Significance and Use

5.1 The primary function of a hydraulic fluid is to transmit power. This practice provides uniform guidelines for comparing fluids in terms of their power-transmitting abilities as reflected in their effect on hydraulic system or component efficiency and productivity.

5.2 Practical advantages of enhanced hydraulic system efficiency may include increased productivity (faster machine cycle time), reduced power consumption (electricity or fuel), and reduced environmental impact (lower emissions).

5.3 Differences in fluid performance may be relatively small. Consequently, it is essential that the necessary experimental controls are implemented to ensure consistency in operating conditions and duty cycle when comparing the energy efficiency of different hydraulic fluid formulations.