Designation: D4174 – 17

Standard Practice for Cleaning, Flushing, and Purification of Petroleum Fluid Hydraulic Systems[1]

This standard is issued under the fixed designation D4174; 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 aid for the equipment manufacturer, the installer, the oil supplier and the operator in coordinating their efforts towards obtaining and maintaining clean petroleum fluid hydraulic systems. Of necessity, this practice is generalized due to variations in the type of equipment, builder's practices, and operating conditions. Constant vigilance is required throughout all phases of design, fabrication, installation, flushing, testing, and operation of hydraulic systems to minimize and reduce the presence of contaminants and to obtain optimum system reliability.

1.2 This practice is presented in the following sequence:

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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

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

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

1.5 *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]

D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

D664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration

D974 Test Method for Acid and Base Number by Color-Indicator Titration

D1774 Test Method for Elastic Properties of Textile Fibers (Withdrawn 2000)[3]

D2709 Test Method for Water and Sediment in Middle Distillate Fuels by Centrifuge

D4006 Test Method for Water in Crude Oil by Distillation

D7042 Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)

D7546 Test Method for Determination of Moisture in New and In-Service Lubricating Oils and Additives by Relative Humidity Sensor

D7647 Test Method for Automatic Particle Counting of Lubricating and Hydraulic Fluids Using Dilution Techniques to Eliminate the Contribution of Water and Interfering Soft Particles by Light Extinction

F311 Practice for Processing Aerospace Liquid Samples for Particulate Contamination Analysis Using Membrane Filters

F312 Test Methods for Microscopical Sizing and Counting Particles from Aerospace Fluids on Membrane Filters

F313 Test Method for Insoluble Contamination of Hydraulic Fluids by Gravimetric Analysis (Withdrawn 1988)[3]

2.2 *ANSI Standards:*

B93.2 Glossary of Terms for Fluid Power[4]

B93.19 Method for Extracting Fluid Samples from the Lines of an Operating Hydraulic Fluid Power System (for Particulate Contamination Analysis)[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *nominal filtration rating*—an arbitrary micrometre value indicated by a filter manufacturer. Due to lack of reproducibility this rating is deprecated. (ANSI B93.2)

4. Significance and Use

4.1 Proper fluid condition is essential for the satisfactory performance and long life of the equipment. Prerequisites for proper lubrication and component performance are: (*1*) a well-designed hydraulic system, (*2*) the use of a suitable fluid, and (*3*) a maintenance program including proper filtration methods to ensure that the fluid is free of contaminants. These prerequisites are meaningless unless the hydraulic system is initially cleaned to a level that will prevent component damage on initial start up or when debris may be dislodged by any system upset.

4.2 The cleaning and flushing of both new and used systems are accomplished by essentially the same procedure. In new systems, the emphasis is on the removal of contaminants introduced during the manufacture, storage, field fabrication, and installation. In used systems, the emphasis is on the removal of contaminants that are generated during operations, from failures that occur during operation; or contaminants introduced during overhaul. Both new and used systems may benefit from high velocity flushing to remove materials that can collect in hard to drain pockets or normally non-wetted surfaces.

4.3 While the flushing and cleaning philosophies stated in this practice are applicable to all primary and servo hydraulic systems, the equipment specified herein does not apply to compact systems that use relatively small volumes of fluid unless they are servo systems where it is economically justified.

4.4 It should be emphasized that the established procedures to be followed for flushing and cleaning the hydraulic systems should be accomplished through the cooperative efforts and agreement of the equipment manufacturer, the installer, the flushing service vendor, the operator, and the fluid supplier. No phase of these procedures should be undertaken without a thorough understanding of the possible effects of improper system preparation. The installation and cleaning and flushing of the equipment should not be entrusted to persons lacking in experience.

5. Types of Contamination

5.1 *General*—Hydraulic systems can become contaminated from a variety of sources. Generally, there are five categories of contamination: (*1*) water, (*2*) fluid soluble material, (*3*) fluid insoluble material, (*4*) erroneous fluid additions, and (*5*) hydraulic fluid deterioration. Properly designed systems can normally control water and insoluble contaminants; however, when it is necessary to remove soluble contaminants, a fluid change and flush are required.

5.2 *Water*—Water is almost always present in hydraulic fluids. It may be present in solution or in a free or emulsified form. Water can exist in solution at varying concentrations depending on the nature of the fluid, the temperature, and so forth. For example, hydraulic fluid may hold 50 ppm of water

[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] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

at 21 °C (70 °F) and 250 ppm at 71 °C (160 °F). The water in solution has no adverse effect on lubricating properties of the fluid and causes no corrosion; however, when fluid passes through a cooler some water may come out of solution and become free water in the form of finely dispersed droplets. Many contaminants hinder the separation of this free water from the fluid by settling and may cause an emulsion. In hydraulic fluids, the emulsion impairs circulation, interfere with lubrication and adversely affect contamination control equipment.

5.2.1 Water contamination can be classified as either fresh or sea water, as encountered in land or marine systems. Fresh water enters the hydraulic system from moist air as condensation, through improperly located vents, leaks in coolers, and steam heaters, and because of improper operation. Sea water, in marine hydraulic systems, enters through leaks in coolers, faulty manhole gaskets, faulty sump tank seals and improperly located vents. Sea and brackish water can also present a problem when used as a coolant in land-based units. Water contamination in hydraulic fluids can:

5.2.1.1 Promote fluid oxidation.

5.2.1.2 Reduce fluid stability.

5.2.1.3 Promote sludge.

5.2.1.4 Promote foaming.

5.2.1.5 Form emulsions.

5.2.1.6 Promote rusting and corrosion.

5.2.1.7 Cause additive depletion and drop-out.

5.2.1.8 Adversely affect lubricating properties.

5.2.1.9 Promote bacteria growth.

5.2.1.10 Alter fluid viscosity.

5.2.1.11 Adversely affect fine filtration (that is, excessive back pressure).

5.2.1.12 Promote cavitation.

5.2.2 In the case of severe salt water contamination, it is necessary to remove the operating fluid and clean and flush the hydraulic systems.

5.3 *Soluble Contaminants:*

5.3.1 Soluble contaminants in hydraulic systems include cleaning chemicals, solvents, rust preventives, incompatible lubricants, flushing oils, extraneous oils, oxidation products, gasket sealants, and assembly lubricants. These contaminants cannot be removed by conventional fluid contamination control equipment. Normally, a new charge of fluid accompanied with a displacement flush oil is required to correct the problem. Fluid soluble contaminants can:

5.3.1.1 Change the fluid viscosity.

5.3.1.2 Alter the flash point.

5.3.1.3 Change the color.

5.3.1.4 Result in sludge deposits.

5.3.1.5 Attack elastomeric seals.

5.3.1.6 Initiate additive-water interaction that can cause emulsification, possible additive loss, instability, impaired purification equipment performance, foaming, and air entrainment.

5.3.1.7 Accelerate oxidation.

5.3.2 When a soluble contaminant is present, the fluid supplier and he equipment manufacturer should be consulted regarding the advisability of continued use of the fluid or replacing it with a new charge.

5.4 *Insoluble Contaminants:*

5.4.1 Insoluble contaminants normally encountered are metal particles (including rust) of all types and sizes, fibers, airborne solids, sand, and other nonmetallic particles. These contaminants are often the result of improper manufacturing techniques, improper shipping and storage practices, and careless installation of hydraulic systems. Some of the effects of solid contamination are:

5.4.1.1 Abrasive wear or sticking of components such as: control valve poppets, cylinders, piston rods, and seals.

5.4.1.2 Faulty control functioning, particularly plugged fluid lines/filter plugging.

5.4.1.3 Reduced fluid stability.

5.4.1.4 Sludge formation.

5.4.1.5 Increased foaming tendency.

5.4.1.6 Stabilized water-oil emulsions/accelerated oxidation by catalytic effect of metal particles.

5.4.2 Harmful contamination can exist in the hydraulic system in two forms:

5.4.2.1 *Lodged Contamination*—These contaminants may become dislodged by high fluid flows and temperature differentials or by induced vibration during flushing. Contamination can be lodged in unflushed pockets or settled on the bottom of tanks. Unless this contaminant is removed, it becomes dislodged during startup or during system upsets. Experience, good judgement, and careful inspection by the installation supervisor must be relied upon to determine when such dirt has been satisfactorily removed.

5.4.2.2 *Suspended or Loose Contamination:*

5.4.2.3 Contaminants suspended in the fluid can be generated by particles coming loose from pipe, hose, hydraulic components, tank walls generally caused by high fluid velocity, wear debris, and vibration. Suspended contaminant can be measured, as described in 11.3 and 11.4. To prevent the level of suspended contaminant from getting beyond acceptable limits, hydraulic system filtration can be augmented with a bypass contamination control system (fluid filter or centrifuge). Preferably a full flow filter or a full flow filter plus bypass purification is provided. When a full flow filter is used, a bypass purification system may not be required.

5.4.2.4 The bypass or full flow system, or both, can be in operation during the flush operation as well as on a continuous basis during hydraulic system operation. High-velocity flushes will require appropriately sized full flow filters. The rated flow capacity per hour of a bypass system should be 10 to 20 % of the total system fluid volume.

6. Contamination Control

6.1 *General*—Contamination control in a hydraulic system is the complete program of monitoring and maintaining a clean fluid. Contamination control must begin with the design, manufacture, and installation of the hydraulic system and continue throughout the life of the system. When making inspections or working in or around a unit, care must be taken to prevent contaminants from entering the system. When work that generates contaminants is being performed in the vicinity