



Designation: D7690 – 11 (Reapproved 2021)

Standard Practice for Microscopic Characterization of Particles from In-Service Lubricants by Analytical Ferrography¹

This standard is issued under the fixed designation D7690; 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 the identification by optical microscopy of wear and contaminant particles commonly found in used lubricant and hydraulic oil samples that have been deposited on ferrograms. This practice relates to the identification of particles, but not to methods of determining particle concentration.

1.2 This practice interfaces with but generally excludes particles generated in the absence of lubrication, such as may be generated by erosion, impaction, gouging, or polishing.

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

[D4057 Practice for Manual Sampling of Petroleum and Petroleum Products](#)

[D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants](#)

[D7684 Guide for Microscopic Characterization of Particles from In-Service Lubricants](#)

[G40 Terminology Relating to Wear and Erosion](#)

3. Terminology

3.1 Definitions:

3.1.1 *abrasion, n*—wear by displacement of material caused by hard particles or hard protuberances. **D4175**

3.1.2 *abrasive wear, n*—wear due to hard particles or hard protuberances forced against and moving along a solid surface. **G40**

3.1.3 *adhesive wear, n*—wear due to localized bonding between contacting solid surfaces leading to material transfer between the two surfaces or loss from either surface. **G40**

3.1.4 *break-in, n*—See *run-in*. **D4175, G40**

3.1.5 *break in, v*—See *run in*. **G40**

3.1.6 *catastrophic wear, n*—rapidly occurring or accelerating surface damage, deterioration, or change of shape caused by wear to such a degree that the service life of a part is appreciably shortened or its function is destroyed. **G40**

3.1.7 *corrosion, n*—chemical or electrochemical reaction between a material, usually a metal surface, and its environment that can produce a deterioration of the material and its properties. **D4175**

3.1.8 *corrosive wear, n*—wear in which chemical or electrochemical reaction with the environment is significant. **G40**

3.1.9 *debris, n—in tribology*, particles that have become detached in a wear or erosion process. **G40**

3.1.10 *debris, n—in internal combustion engines*, solid contaminant materials unintentionally introduced in to the engine or resulting from wear. **D4175**

3.1.11 *fatigue wear, n*—wear of a solid surface caused by fracture arising from material fatigue. **G40**

3.1.12 *fretting, n—in tribology*, small amplitude oscillatory motion, usually tangential, between two solid surfaces in contact.

3.1.12.1 *Discussion*—Here the term *fretting* refers only to the nature of the motion without reference to the wear, corrosion, or other damage that may ensue. The term *fretting* is often used to denote fretting corrosion and other forms of

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 D02.96.06 on Practices and Techniques for Prediction and Determination of Microscopic Wear and Wear-related Properties.

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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.

fretting wear. Usage in this sense is discouraged due to the ambiguity that may arise. **G40**

3.1.13 *fretting wear*, *n*—wear arising as a result of fretting. (See *fretting*.) **G40**

3.1.14 *friction*, *n*—resistance to sliding exhibited by two surfaces in contact with each other. Basically there are two frictional properties exhibited by any surface; static friction and kinetic friction. **D4175**

3.1.15 *impact wear*, *n*—wear due to collisions between two solid bodies where some component of the motion is perpendicular to the tangential plane of contact. **G40**

3.1.16 *lubricant*, *n*—any material interposed between two surfaces that reduces the friction or wear between them. **D4175**

3.1.17 *lubricating oil*, *n*—liquid lubricant, usually comprising several ingredients, including a major portion of base oil and minor portions of various additives. **D4175**

3.1.18 *pitting*, *n*—*in tribology*, form of wear characterized by the presence of surface cavities the formation of which is attributed to processes such as fatigue, local adhesion, or cavitation. **G40**

3.1.19 *rolling*, *v*—*in tribology*, motion in a direction parallel to the plane of a revolute body (ball, cylinder, wheel, and so forth) on a surface without relative slip between the surfaces in all or part of the contact area. **G40**

3.1.20 *rolling contact fatigue*, *n*—damage process in a triboelement subjected to repeated rolling contact loads, involving the initiation and propagation of fatigue cracks in or under the contact surface, eventually culminating in surface pits or spalls. **G40**

3.1.21 *run-in*, *n*—*in tribology*, initial transition process occurring in newly established wearing contacts, often accompanied by transients in coefficient of friction, or wear rate, or both, which are uncharacteristic of the given tribological system's long term behavior. (Synonym: *break-in*, *wear-in*.) **D4175, G40**

3.1.22 *run in*, *v*—*in tribology*, to apply a specified set of initial operating conditions to a tribological system to improve its long term frictional or wear behavior, or both. (Synonym: *break in*, *v*, and *wear in*, *v*.) See also *run-in*, *n*) **G40**

3.1.23 *rust*, *n*—*of ferrous alloys*, a corrosion product consisting primarily of hydrated iron oxides. **D4175**

3.1.24 *scoring*, *n*—*in tribology*, severe form of wear characterized by the formation of extensive grooves and scratches in the direction of sliding. **D4175, G40**

3.1.25 *sliding wear*, *n*—wear due to the relative motion in the tangential plane of contact between two solid bodies. **G40**

3.1.26 *soot*, *n*—*in internal combustion*, engines, sub-micron size particles, primarily carbon, created in the combustion chamber as products of incomplete combustion. **D4175**

3.1.27 *spalling*, *n*—*in tribology*, the separation of macroscopic particles from a surface in the form of flakes or chips, usually associated with rolling element bearings and gear teeth, but also resulting from impact events. **G40**

3.1.28 *three-body abrasive wear*, *n*—form of abrasive wear in which wear is produced by loose particles introduced or generated between the contacting surfaces.

3.1.28.1 *Discussion*—In tribology, loose particles are considered to be a “third body.” **G40**

3.1.29 *triboelement*, *n*—one of two or more solid bodies that comprise a sliding, rolling, or abrasive contact, or a body subjected to impingement or cavitation. (Each triboelement contains one or more tribosurfaces.)

3.1.29.1 *Discussion*—Contacting triboelements may be in direct contact or may be separated by an intervening lubricant, oxide, or other film that affects tribological interactions between them. **G40**

3.1.30 *two-body abrasive wear*, *n*—form of abrasive wear in which the hard particles or protuberances which produce the wear of one body are fixed on the surface of the opposing body. **G40**

3.1.31 *viscosity*, *n*—ratio between the applied shear stress and rate of shear. It is sometimes called the coefficient of dynamic viscosity. This value is thus a measure of the resistance to flow of the liquid. The SI unit of viscosity is the pascal second (Pa·s). The centipoise (cP) is one millipascal second (mPa·s) and is often used. **D4175**

3.1.32 *wear*, *n*—damage to a solid surface, usually involving progressive loss or displacement of material, due to relative motion between that surface and a contacting substance or substances. **G40, D4175**

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *abrasive wear particles*, *n*—long wire-like particles in the form of loops or spirals generated due to hard, abrasive particles present between wearing surfaces of unequal hardness.

3.2.1.1 *Discussion*—Sometimes called cutting wear particles.

3.2.2 *analytical ferrography*, *n*—technique whereby particles from an oil sample deposited by a ferrograph are identified to aid in establishing wear mode inside an oil-wetted path of a machine.

3.2.3 *bichromatic microscope*, *n*—optical microscope equipped with illumination sources both above and below the microscope stage such that objects may be viewed either with reflected light, or with transmitted light, or with both simultaneously.

3.2.4 *black oxides of iron*, *n*—generally small, black clusters with pebbled surfaces showing small dots of blue and orange color. These are nonstoichiometric compounds containing a mixture of Fe₃O₄, Fe₂O₃ and FeO.

3.2.5 *contaminant particles*, *n*—particles introduced from an extraneous source into the lubricant of a machine or engine.

3.2.6 *chunks*, *n*—free metal particles >5 μm with a shape factor (major dimension to thickness ratio) of <5:1.

3.2.7 *corrosive wear debris*, *n*—extremely fine partially oxidized particles caused by corrosive attack.

3.2.8 *dark metallo-oxide particles*, *n*—partially oxidized ferrous wear particles indicating high heat during generation most likely due to lubricant starvation.