Designation: D8288 – 19

Standard Test Method for Comparison of Metalworking Fluids Using a Tapping Torque Test Machine[1]

This standard is issued under the fixed designation D8288; 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 test method describes a laboratory technique to evaluate the relative performance of metal removal fluids using an instrumented tapping machine that measures and records torque.

1.1.1 The method is applicable to all tap types, machining speeds, and alloys that can be fabricated into a test piece. Comparison can be made between different operating conditions or various types of fluids including straight and emulsifiable oils, semi-synthetics and synthetic fluids (see Classification D2881).

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

1.2.1 *Exception*—The units for the threads of the tap, M6, are in metric thread units.

1.3 *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.*

1.4 *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]

D2881 Classification for Metalworking Fluids and Related Materials

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

D5619 Test Method for Comparing Metal Removal Fluids Using the Tapping Torque Test Machine (Withdrawn 2016)[3]

D6300 Practice for Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products and Lubricants

D7778 Guide for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E1488 Guide for Statistical Procedures to Use in Developing and Applying Test Methods

3. Terminology

3.1 For definitions of terms used in this test method, refer to Terminology D4175.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *built up edge, n*—an accumulation of the material being tapped which seizes or bonds to the cutting surface of the tap.

3.2.2 *cutting tap, n*—in metal removal, a machine tool which forms a thread by cutting and removing test piece material.

3.2.2.1 *Discussion*—Cutting taps form threads by removing material as chips; less force is typically required and they are more effective than forming taps for hard materials.

3.2.3 *datum mark (D), n*—an etched indication on the corner of a machined test piece indicating that the adjoining sides are square or perpendicular.

3.2.4 *forming tap, n—in metal removal*, a machine tool that forms a thread by displacing or deforming the test piece material.

3.2.4.1 *Discussion*—A form tap is most effective in ductile materials where metal can flow; no chips are removed.

3.2.5 *tool feed rate, n*—the distance traveled by the tool at a uniform rate divided by the number of spindle revolutions during which this travel occurs.

3.2.5.1 *Discussion*—In this method the tool feed rate is the distance (mm) per second a cutting or forming tap (8.9) passes through a hole in a test piece (8.10).

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.L0.01 on Metal Removal Fluids and Lubricants.

Current edition approved Dec. 1, 2019. Published January 2020. DOI: 10.1520/D8288-19.

[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. Summary of Test Method

4.1 The torque required to tap threads is measured for a number of holes in a test piece lubricated with a metal removal fluid. These values are compared with the comparable torques using another fluid such as a reference fluid. The relative tapping efficiency is then calculated.

5. Significance and Use

5.1 This test method can be used to predict the comparative lubricating properties of a metalworking fluid (MWF).

5.1.1 Fluids that produce lower torques or higher efficiencies are predicted to have better machining characteristics.

5.2 The method is applicable to all tap types, machining speeds, alloys and coatings that can be fabricated into a test piece.

5.3 Comparison between different operating conditions or various types of fluids can be made.

5.4 The reportable quantity is the efficiency or mean average torque of a reference fluid divided by the mean average torque of the fluid of interest.

6. Interferences and Primary Sources of Test Method Variation

6.1 The tapping torque is a function of multiple factors, including, but not limited to:

6.1.1 *MWF Chemistry,* formulation and concentration for water miscible fluids

6.1.2 Metal alloy being tested and test piece variation.

6.1.3 Tap rotational speed as well as tap to tap variation.

6.1.4 Ambient temperature.

6.2 The precision statistics provided in Section 16 apply only to the instrument used and the test conditions included in the repeatability study.

6.2.1 Users of this method should determine the precision of the method when using instruments, MWF, test piece alloys, tool feed rates, tapping torque instruments or combinations thereof other than those included in the repeatability study.

6.2.2 For information on determining the precision of testing performed under specific conditions, refer to Guides D7778 and E1488.

7. Apparatus

7.1 *Tapping Torque Machine*—Capable of providing a lower limit not to exceed 300 r/min and an upper limit of at least 2400 r/min with a maximum torque of at least 7 Nm and digital output of tap vertical position precise to at least 0.04 mm and torque precise to at least 0.01 Nm.[4]

7.1.1 The machine's tap position shall be stationary.

7.1.2 The machine's test piece holder shall be a movable X-Y table or fixture that provides the means for positioning the test holes beneath the tap.

7.1.2.1 Test piece holder fixture shall be capable of holding test piece (8.10) firmly in place for the duration of all tapping operations performed on the test piece

7.1.3 The machine's software shall be capable of:

7.1.3.1 Recording torque and vertical positioning data during tapping events.

7.1.3.2 Capturing and transmitting 7.1.3.1 data to the analysis program.

7.2 *Computer*—Attached computer with installed control and analysis software

7.2.1 The computer's software shall be capable of recording the tapping machine operating conditions and analyzing and displaying data for multiple test runs.

8. Reagents and Materials

8.1 *Air-line,* pressurized, filtered.

8.1.1 The downward travel of the tap from rest to its contact with the test piece is initiated by compressed air to ensure repeatability.

8.2 *Alignment Tool*—Tap plug gauge.

8.2.1 Alignment tool shall be mounted in the tap chuck to verify alignment of the tap with the test hole.

8.3 *Fluid, Reference*—MWF with known tapping torque test performance properties.

8.3.1 Reference fluid should be similar in type to the fluids being tested (for example, straight or emulsifiable oil, semi-synthetic or synthetic fluid (per Classification D2881).

8.3.2 Tapping torque test repeatability and precision shall be known for the reference fluid used under the test conditions to be used to evaluate test fluid (8.4) performance.

NOTE 1—Preferably, the reference fluid will not contain active extreme pressure agents such as sulfur, chlorine, or phosphorus as these could react with the tap and potentially bias the results for the test fluid(s). The reference fluid should have a known composition that can be properly defined and replicated.

8.4 *Test Fluid*—MWF to be tested per this method.

8.4.1 The volume of test fluid should be sufficient for all operations.

8.5 *Magnifier,* 3× to 5× (handheld or bench mounted).

8.6 *Pipettes, Disposable Plastic Dropper Type:*

8.6.1 A clean or previously unused pipette shall be used for reference fluid (8.3) and each test fluid (8.4).

8.7 *Solvent,* easily evaporated, non-filming and non-chlorinated.

8.7.1 Select a solvent in which test fluid (8.4) is soluble.

NOTE 2—Mineral spirits has been found to be suitable for water-immiscible fluids such as straight oils; distilled or reverse osmosis water has been found to be suitable for water-miscible fluids such as emulsifiable oils, semi-synthetics and synthetics.

8.8 *Tape:*

8.8.1 The tape shall be resistant to the reference and test fluids. Polyamide tape has been found to be suitable.

8.9 *Taps, Cutting or Forming:*

8.9.1 The tap size used for determining the precision of this method is M6x1. The repeatability statistics reported in Section 16 may not apply for testing performed using other sized taps.

NOTE 3—Uncoated taps have been found to be effective in evaluating metal working fluids since there is no coating to provide an ameliorative effect on lubrication.

[4] This test method was conducted using apparatus and materials available from Microtap USA, Inc, 1854 Star Batt Drive, Rochester Hills, MI 48309.

NOTE 4—Depending on the test piece (8.10) alloy, either a cutting tap or forming tap may be used. The use of cut or form taps is application specific. The method of form tapping is preferred as it requires more force and provides greater torque definition than cut tapping to create a thread. Cut tapping is typically used for hard or difficult to deform alloys such as stainless steels, titanium or nickel-based alloys.

8.10 *Test Piece*—Metal alloy or composite blocks of a suitable size to fit and be fixtured on the table.

NOTE 5—Most commonly 1018 steel or 6061-T6 aluminum are used to fabricate test pieces; they may have blind or through holes.

8.10.1 Test piece shall be pre-drilled and reamed with suitable holes for the tap used. 5.55 mm holes are recommended for M6 forming taps or 5.00 mm holes for M6 cutting taps. The distance between pre-drilled holes should be sufficient to prevent interactions between the holes.

NOTE 6—For an M6 test piece for 1018 steel, 6061-T6 aluminum and other non-ferrous alloys up to four rows of holes spaced no closer than 10 mm (0.4 in.) from the center of one hole to the center of the next; for harder or work hardened materials such as stainless steel up to three rows of properly sized holes spaced no closer than 12 mm (0.5 in.) from the center of one hole to the center of the next.

8.10.2 Each hole shall be drilled, reamed with a chamfer at the top of the hole as shown in Fig. 1.

8.10.3 The top of each test piece shall be identified with a datum mark in the top, far right corner.

9. Apparatus and Test Piece Preparation

9.1 Power on the tapping machine (7.1) and its software in accordance with the manufacturer's operating manual.

9.2 Turn on the compressed air supply (8.1).

9.3 If required, set the apparatus's auto-indexing table to match the hole to hole distance of the test piece (8.10).

9.4 Clean the test piece using an appropriate solvent (8.7) and blow dry using clean compressed air (8.1).

9.5 If lubricant application (12.3) will be filling through holes use tape (8.8) to cover the bottom of through hole test pieces.

9.5.1 Score the tape between the holes with a knife or razor blade so the tap does not pull on the tape covering adjacent holes

9.6 Securely place the test piece (8.10) in the test fixture (7.1.2.1) with the datum mark (8.10.3) on the test piece facing up and to the far right.

9.6.1 Firmly push the test piece into the upper right corner and secure it using the clamps on either end.

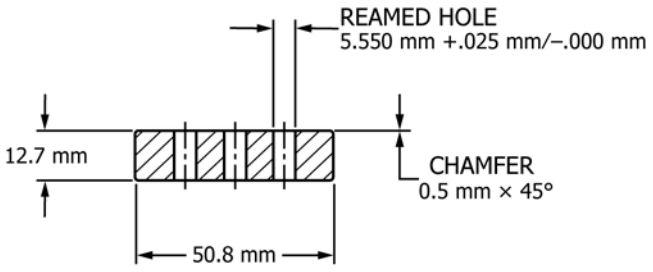

FIG. 1 Side View of a Through Hole Test Piece for an M6 Forming Tap

9.7 Set the test parameters of the tapping machine (7.1) including speed, torque limit, tapping depth and other parameters according to the manufacturer's directions.

NOTE 7—The same test bar should be used for all comparative tests; if this is not possible then one of more fluids should be run on each test bar used to verify equivalence. Minimum depth of tap should be 6 mm.

10. Tap Inspection and Preparation

10.1 Clean taps using an appropriate solvent (8.7) and blow dry using clean compressed air (8.1).

10.2 Check the taps carefully under magnification if necessary (8.5).

10.2.1 If any built up edge or nicks are detected, discard the tap.

10.2.2 If contamination is evident, re-clean as described above.

NOTE 8—The same tap is used for all fluids being tested provided it is not worn or damaged during the evaluation session. Use a bristle or brass wire brush to assist removal of chips from the tap.

11. New Tap or New Test Condition Validation

11.1 Break in new tap.

11.1.1 Apply reference fluid (8.3) and tap (Section 12) three to six holes on the appropriate test piece (8.10).

11.1.2 Determine if the tapping torque meets the expectations for these test conditions per 8.3.2.

11.1.3 If the tap does not meet these expectations, repeat 11.1.1 and 11.1.2 or replace the tap.

11.2 Determine optimal tap speed for new test conditions.

11.2.1 Set the appropriate speed for the test piece material. Tap a hole (Section 12). Observe maximum torque.

11.2.2 If torque is higher than desired, decrease speed by ~20 % and tap another hole.

11.2.3 If torque lower than desired, increase speed by ~20 % and tap another hole.

11.2.4 Repeat 11.2.2 and 11.2.3 if necessary, until maximum torque is in desired range.

NOTE 9—Speeds of 500 r/min for 1018 steel and 1000 r/min for 6061-T6 aluminum have been found to be suitable for M6 taps.

NOTE 10—It has been found that a maximum torque in the range of 3 Nm to 6 Nm provides good fluid differentiation and minimum tap wear.

12. Tapping Equipment Operation

12.1 Prepare apparatus and test piece per Section 9.

12.2 Align test bar and set height.

12.2.1 Position the tap above the first hole to be tested. Fig. 2 shows the test piece and tap positioned for testing.

12.2.1.1 Use alignment tool to confirm alignment of the test bar. Adjust the X-Y table position if necessary. If appropriate alignment tool is not available a tap may be used for confirming alignment

12.2.1.2 The subsequent table indexing steps shall follow test bar holes.

12.2.1.3 Insert tap in the test apparatus.

12.2.1.4 Set the distance from the top of the test piece to the tip of the tap while in the rest position according to the manufacturer's directions.