Designation: D7933 – 15

Standard Test Method for Engine Coolant Stagnation in Flux-Brazed Aluminum Heat Exchangers[1]

This standard is issued under the fixed designation D7933; 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 covers a laboratory screening procedure for evaluating engine coolant compatibility and corrosion protection after aging two weeks at 90°C in an aluminum heat exchanger brazed using flux.

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

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1176 Practice for Sampling and Preparing Aqueous Solutions of Engine Coolants or Antirusts for Testing Purposes
D1193 Specification for Reagent Water
D4340 Test Method for Corrosion of Cast Aluminum Alloys in Engine Coolants Under Heat-Rejecting Conditions
E230/E230M Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples

3. Summary of Test Method

3.1 An aluminum heat exchanger that was brazed using flux via any application method or as part of the material cladding is filled with engine coolant, plugged, and placed in an oven for two weeks (336 h) at 90°C. Engine coolant compatibility is assessed based on changes in coolant physical and compositional properties, and engine coolant aluminum corrosion protection is based on performance in the Test Method D4340 test.

4. Significance and Use

4.1 Automobile and truck radiators and heater cores are now predominantly made with aluminum alloys using various manufacturing processes including brazing with a flux (See Appendix X1 for additional information). The presence of residual internal brazing flux in heat exchangers along with the high ratio of internal aluminum surface area to coolant volume may affect certain physical and chemical properties and corrosion protection of the coolant. This test method provides a screening test to assess engine coolant physical and chemical properties and corrosion protection after aging it in a heat exchanger brazed with flux at elevated temperature under stagnant conditions. This method cannot stand alone as evidence of satisfactory coolant performance in flux-brazed aluminum heat exchangers. The actual service of an engine coolant formulation can be determined only by more comprehensive bench, dynamometer, and field tests.

5. Apparatus

5.1 *Aluminum Heat Exchanger Brazed with Flux*—The heat exchanger may be a radiator, heater core, or other, liquid cooled heat exchanger.

NOTE 1—The aluminum brazed heat exchangers used in this test method may be commercially produced or experimentally prepared by the heat exchanger supplier. The aluminum grade, alloying, flux loading during brazing, and residual flux remaining in the heat exchanger after brazing may vary from part to part. The heat exchanger type, manufacturer, size, and other design parameters are decided by mutual agreement of the parties involved.

5.2 *Coolant Hoses, Clamps, Hose Adapters, and Caps or Plugs*—Rubber engine coolant hoses (approximately 15 cm length) of appropriate diameter shall be fitted onto heat exchanger inlet/outlets to allow for coolant expansion. EPDM is one type hose material suitable for the test. Metal clamps, hose adapters, and threaded caps or plugs (stainless steel, or steel) shall be used to seal the heat exchanger during the

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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.

stagnation test. All materials used in the preparation and plumbing of the test specimen shall not be galvanic to the aluminum heat exchanger.

5.3 *Temperature-Measuring Instrument (Thermocouple)*—An ASTM partial immersion temperature-measuring instrument having a range from -20 to 150°C and conforming to the requirements for thermocouple as summarized in Specification E230/E230M.

6. Reagents and Materials

6.1 *Reagent Grade Water*—Specification D1193 Grade are available.

7. Test Solution

7.1 *Engine Coolant Test Fluid*—The engine coolant test fluid shall be a 50 vol % engine coolant prepared using Specification D1193 Type IV reagent water and prepared per Practice D1176 directions.

7.2 The engine coolant test fluid shall be tested before and after the stagnation period for physical and chemical properties along with performance testing in the Test Method D4340. The specific physical and chemical property tests (appearance, water and glycol content, pH, coolant composition and contamination, glycol degradation and oxidation products, corrosion and brazing flux components) as well as test conditions (temperature, pressure, duration, and test fluid dilution) in the Test Method D4340 are decided by mutual agreement of parties using the test.

8. Test Conditions

8.1 *Engine Coolant Test Fluid*—The amount of engine coolant required for the test is dependent on the size of the heat exchanger and shall be 80 % of the volume of the heat exchanger.

8.2 *Test Temperature*—The test shall be conducted at 90°C. The temperature shall be maintained at ±2°C throughout the test.

8.3 *Test Duration*—The test shall be run continuously for two weeks (336 h).

9. Procedure

9.1 *Aluminum Heat Exchanger Brazed with Flux*—The aluminum heat exchanger shall be used in the test as received. There shall be no internal washing, rinsing, flushing of the heat exchanger before the test (Note 2). New heat exchangers shall be used for each test. Attach engine coolant hoses to inlet and outlet tubes of heat exchanger with metal clamps. Install hose adapter and clamp on the other end of the hose.

NOTE 2—Some manufacturers internally wash the heat exchangers to reduce the amount of internal manufacturing flux residues. If the heat exchanger is internally washed, it shall be recorded and reported that it was washed and there shall be no additional washing, rinsing, flushing of the heat exchanger prior to running the test.

9.2 *Charging*—Determine the volume capacity of the heat exchanger. Fill the heat exchanger to 80 % capacity with the engine coolant test solution. Place cap or plug on the ends of the coolant hoses and tighten firmly to seal the heat exchanger during aging in the oven. An example of an assembled heat exchanger with hoses, clamps, and caps is shown in the digital image in Fig. 1. The Test Method D4340 test requires a minimum of 500 mL of 50/50 engine coolant. If the heat exchanger is less than 500 mL, use additional heat exchangers to produce sufficient quantity of engine coolant to perform the Test Method D4340 test.

9.3 *Aging*—Place heat exchanger in a suitable convection oven for two weeks (336 h) at 90°C (Note 3). The oven test chamber shall be brought to test temperature prior to placing the heat exchanger in the oven. Maintain oven temperature within ±2°C during the test. (**Warning—**The heat exchanger and hoses may build up pressure during the test. Place heat exchanger in a tray to contain any coolant in the event of a leak. Avoid handling during the test. If handling is required, use protective safety glasses and gloves during handling the heat exchanger.)

NOTE 3—Maintaining the correct temperature within the specified limits of ±2°C during the entire test run is an important factor for assuring both repeatability and reproducibility of the test results. Care should be taken to maintain a constant airflow across the heat exchanger's external heat transfer surfaces (fin, tube). No direct radiant heating is permitted.

9.4 *Test Termination*—Remove the heat exchanger from the oven and cool to room temperature. Pick up the heat exchanger from the lay down position to a vertical orientation and gently rotate 180 degrees clockwise then counter-clockwise 180 degrees, repeat 4 times to mix coolant and pour engine coolant test solution into suitable containers. See Fig. 2.

9.5 *Post Stagnation Testing*—The engine coolant test fluid shall be tested before and after the stagnation period for physical and chemical properties along with performance testing in the Test Method D4340. The specific physical and chemical property tests (appearance, water and glycol content,

FIG. 1 Aluminum Heat Exchanger with Hoses, Clamps, and Caps

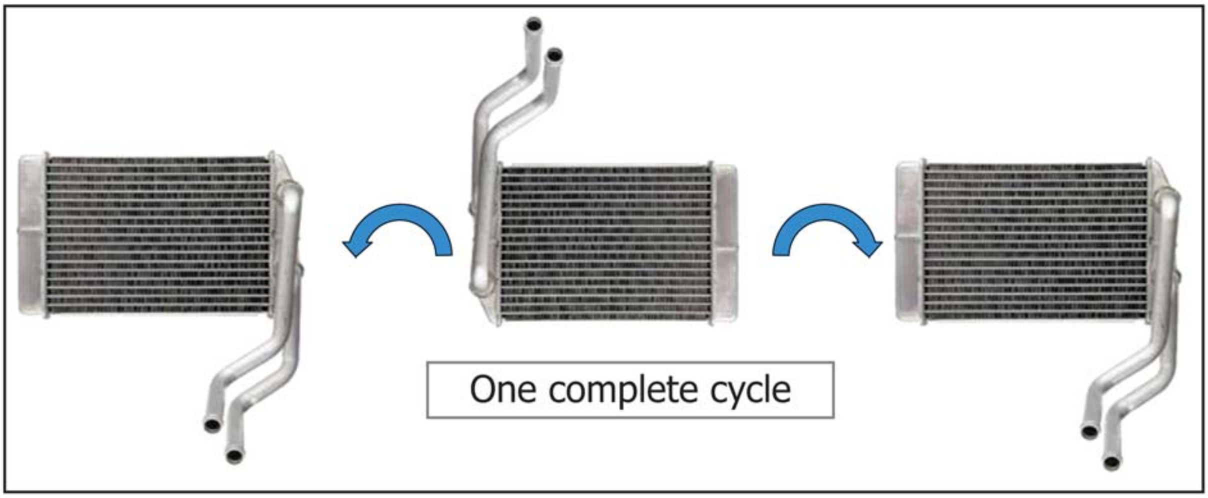

FIG. 2 One Rotation Cycle

pH, coolant composition and contamination, glycol degradation and oxidation products, corrosion and brazing flux components) as well as test conditions (temperature, pressure, duration, and test fluid dilution) in the Test Method D4340 are decided by mutual agreement of parties using the test. Test the engine coolant sample after Test Method D4340 test for physical and chemical properties (appearance, water and glycol content, pH, coolant composition and contamination, glycol degradation and oxidation products, corrosion and brazing flux components) as decided by users of the test. Compare test results and analyses to determine if there has been any change during fluid stagnation or if stagnation has any effect on fluid performance in Test Method D4340. If a loss of corrosion inhibitors or other adverse effect to the coolant is apparent, the heat exchanger(s) should be sectioned to look for build-up or plugging or any accumulation of residual solids or gels. If material is present, it should be analyzed.

9.6 *Heat Exchanger Reference Test*—Since commercially manufactured heat exchangers may contain varying amounts of manufacturing residues, a reference test shall be run on a separate heat exchanger from the same manufacturer and lot with Specification D1193 Type IV water to determine the typical amount of manufacturing residue that may be present from the heat exchanger. For the reference test, the heat exchanger shall be filled with Specification D1193 Type IV water and stored for 24 h at room temperature (22°C ± 2ºC). The post water solution shall then be tested for heat exchanger manufacturing residue as decided by the users of the test. (See Appendix X1 for additional information on the reference test and use of the test.)

10. Report

10.1 Report the following information:

10.1.1 Report the specifics on the heat exchanger used in the test (make, model, lot number, type of heat exchanger, flux and flux application method and volume of fluid tested.

10.1.2 Report the amount of flux residue components in the water solution after the control test, if agreed upon by the users (see Appendix X1).

10.1.3 Report coolant physical and chemical properties before and after stagnation and Test Method D4340 testing. The report summarizing the test results should include all the test information agreed to by the users.

10.1.4 Report the Test Method D4340 test result.

10.1.5 Report if the heat exchanger was sectioned and if any material deposits were observed.

10.1.6 Report analysis of any material deposits.

11. Precision and Bias

11.1 *Precision*—This test method is intended as a screening tool. Test results obtained on engine coolants after heat exchanger stagnation testing may inherently be lacking in precision and bias due to potential variability in quality and consistency of the heat exchanger used in the test. Repeatability and reproducibility limits currently do not exist.

11.2 *Bias*—Since there is no accepted reference heat exchanger or engine coolant for determining the bias for the procedure in this method, bias has not been determined.

12. Keywords

12.1 corrosion; engine coolants; heater core; heat exchanger; radiator

APPENDIX

(Nonmandatory Information)

X1. A BRIEF DISCUSSION OF CONTROLLED ATMOSPHERIC BRAZING OF ALUMINUM HEAT EXCHANGERS

X1.1 Significance

X1.1.1 Automobile and truck radiators and heater cores are now predominantly made with aluminum alloys via brazing with a flux. An example is the controlled atmosphere brazing (CAB) process, in which a fluxing agent (such as potassium fluoro-aluminate) is applied to the surfaces to be joined. The fluxing agent melts, dissolves, and displaces the aluminum oxide layer that naturally formed on the aluminum surface and frees up and allows the metal filler to flow and form brazed joints. The presence of residual internal brazing flux in heat exchangers along with the high ratio of internal aluminum surface area to coolant volume may affect certain physical and chemical properties and corrosion protection of the coolant.

X1.2 Heat Exchanger Reference Testing

X1.2.1 Since commercially manufactured CAB heat exchangers may contain an amount of post-braze flux, it is important to run a heat exchanger reference test to determine the amount that may be solubilized by water.

X1.2.2 The reference heat exchanger shall be from the same manufactuer and same lot. The reference heat exchanger shall be filled with Specification D1193 Type IV water and stored for 24 h at room temperature (22°C ± 2°C). The post water solution shall then be analyzed for residue components, as decided by users of the test.

X1.2.3 In cases where potassium fluoro-aluminate brazing flux is used as the brazing flux, the presence of potassium in the post water heat exchanger reference test may be used as a marker to reflect the amount of brazing residue solubilized by water. In addition, to ensure a minimum test severity to assess the coolant stability and performance, the post water solution from a reference heat exchanger test shall contain a minimum of 125 µg/mL potassium.

X1.2.4 In cases where another type of brazing flux (such as cesium, zinc, or silicon) is used, the parties shall establish a reference marker and a required amount of the marker to obtain a certain test severity.