Designation: D 2872 – 97

Standard Test Method for Effect of Heat and Air on a Moving Film of Asphalt (Rolling Thin-Film Oven Test)[1]

This standard is issued under the fixed designation D 2872; 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 is intended to measure the effect of heat and air on a moving film of semi-solid asphaltic materials. The effects of this treatment are determined from measurements of the selected properties of the asphalt before and after the test.

1.2 The values stated in inch-pound units are to be regarded as the 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:*

D 113 Test Method for Ductility of Bituminous Materials[2]

D 2171 Test Method for Viscosity of Asphalts by Vacuum Capillary Viscometer[2]

E 1 Specification for ASTM Thermometers[3]

3. Summary of Test Method

3.1 A moving film of asphaltic material is heated in an oven for 85 min at 325°F (163°C). The effects of heat and air are determined from changes in physical test values as measured before and after the oven treatment. An optional procedure is provided for determining the change in sample mass.

3.2 Precision values for this test method have been developed for viscosity at 140°F (60°C); and ductility at 60° (15.6°C).

4. Significance and Use

4.1 This test method indicates approximate change in properties of asphalt during conventional hot-mixing at about 302°F (150°C) as indicated by viscosity and other rheological measurements. It yields a residue which approximates the asphalt condition as incorporated in the pavement. If the mixing temperature differs appreciably from the 302°F (150°C) level, more or less effect on properties will occur. This test method also can be used to determine mass change, which is a measure of asphalt volatility.

5. Apparatus [4]

5.1 *Oven*—This shall be a double-walled electrically heated convection-type oven. Its inside dimensions shall be 15 in. (381 mm) high, 19 in. (483 mm) wide, and 17½ ± ½ in. (445 ± 13 mm) deep (with the door closed). The door shall contain a symmetrically located window with dimensions of 12 to 13 in. (305 to 330 mm) wide by 8 to 9 in. (203 to 229 mm) high. The window shall contain two sheets of heat-resistant glass separated by an air space. The window should permit an unobstructed view of the interior of the oven. The top of the upper heating element shall be 1 ± ⅛ in. (25 ± 3 mm) below the oven floor.

5.1.1 The oven shall be vented at the top and bottom. The bottom vents shall be located symmetrically to supply incoming air around the heating elements. They shall have an open area of 2.31 ± 0.11 in.^{2}(15.0 ± 0.7 cm^2). The top vents shall be symmetrically arranged in the upper part of the oven and have an open area of 1.45 ± 0.07 in.^{2}(9.3 ± 0.45 cm^2).

5.1.2 The oven shall have an air plenum covering the side walls and ceiling. The air space shall be 1½ in. (38.1 mm) deep from the walls and ceiling. At a midpoint in the width of the oven, and 6 in. (152.4 mm) from the face of the circular metal carriage to its axis, a squirrel cage-type fan 5¼ in. (133 mm) OD by 2⅞ in. (73 mm) wide shall be turned at 1725 rpm by an externally mounted motor. The squirrel cage fan shall be set so that the fan turns in an opposite direction to its vanes. The air flow characteristics of the fan-plenum system shall be suction from the floor of the oven through the wall plenums and exhaust of the air through the fan. Fig. 1 and Fig. 2 show details of this plenum system.

5.1.3 The oven shall be equipped with a proportional control thermostat capable of maintaining 325°F (163°C) temperature within ± 1.0°F (±0.5°C). The sensing element of the thermostat shall be placed 1 in. (25.4 mm) from the left side and approximately 1½ in. (38.1 mm) from the ceiling of the interior of the plenum-enclosed oven so that the end of the

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[1] This test method is under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.46 on Durability and Distillation Tests.

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[2] *Annual Book of ASTM Standards*, Vol 04.03.

[3] *Annual Book of ASTM Standards*, Vol 14.03.

[4] Complete equipment may be obtained from James Cox and Sons Inc., P.O. Box 674, Colfax, CA 95713.

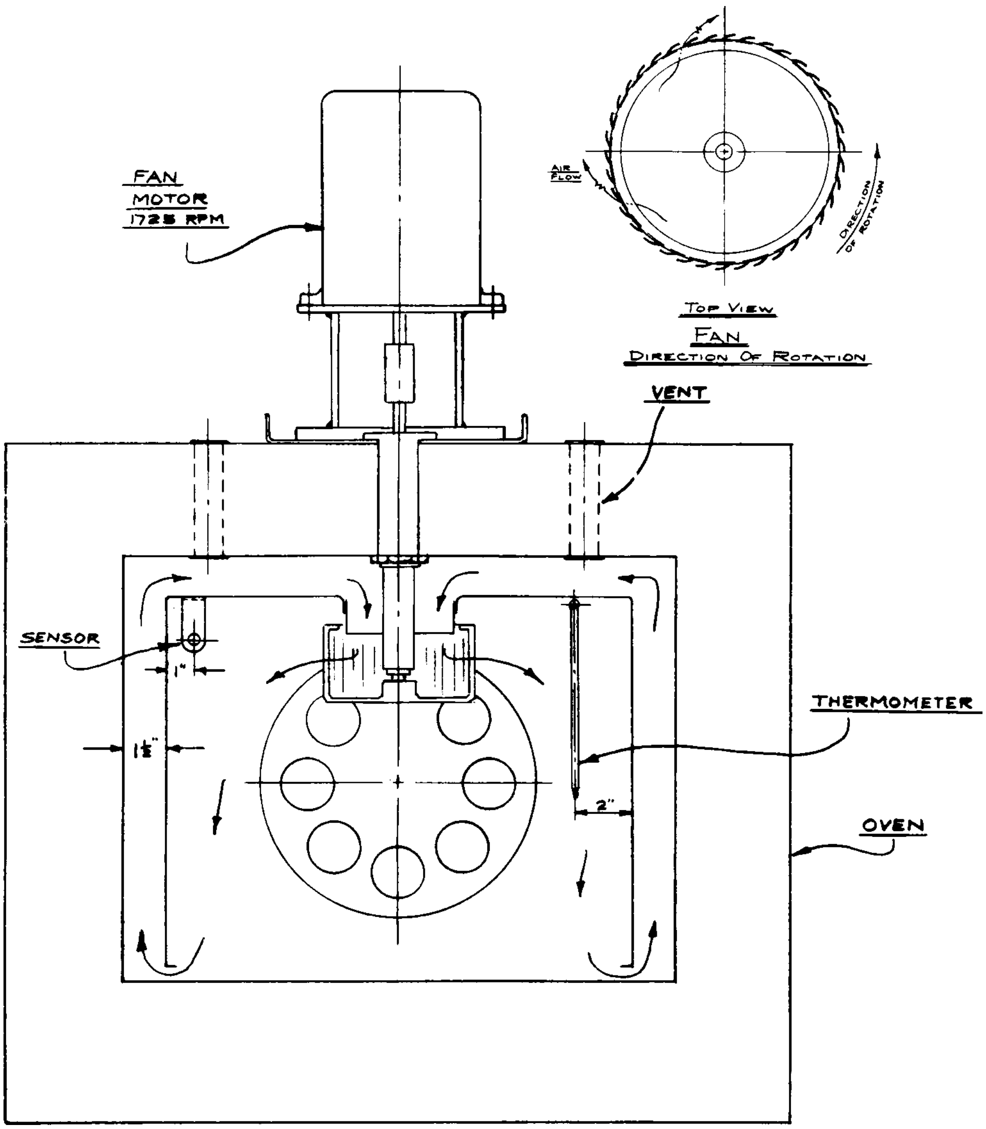

FIG. 1 Schematic of Air Flow Front View

sensing element is at a point approximately 8 in. (203.2 mm) from the rear interior wall of the oven. The thermometer shall be hung or affixed to a mounting in the ceiling which is 2 in. (50.8 mm) from the right side of the oven at a midpoint in the depth of the oven. The thermometer shall hang down into the oven so that the bulb of the thermometer is within 1 in. of an imaginary line level with the shaft of the circular metal carriage. The heating controls shall be capable of bringing the fully loaded oven back to the test temperature within a 10-min period after insertion of the samples in a preheated oven.

5.1.4 The oven shall be provided within a 12-in. (304.8-mm) diameter, vertical circular carriage (see Fig. 2 for details). This carriage shall be provided with suitable openings and clips for firmly holding eight glass containers in a horizontal position (see Fig. 3). The vertical carriage shall be mechanically driven through a ¾-in. (19-mm) diameter shaft at a speed of 15 ± 0.2 r/min.

5.1.5 The oven shall be equipped with an air jet positioned to blow heated air into each bottle at its lowest point of travel. The air jet shall have an outlet orifice 0.04 in. (1.016 mm) in diameter (No. 60 drill) connected to a 25-ft (7.6-m) length of 5⁄16-in. (8-mm) outside diameter refrigeration copper tubing. This tubing shall be coiled to lie flat on the bottom of the oven and lead to a source of fresh, dried, dust-free regulated air.

NOTE 1—Activated silica gel treated with an indicator is a satisfactory desiccant for the dried air.

5.2 *Flowmeter*—The flowmeter may be any suitable type capable of accurately measuring the airflow at a rate of 4000 mL/min. The flowmeter shall be located downstream of all regulating devices and upstream of the copper coil. The flowmeter shall be positioned so it is maintained at approximately room temperature. The airflow shall be calibrated periodically using a wet-test meter or other displacement method. This calibration shall be based on airflow exiting the air jet and shall be conducted with the oven off and at room temperature.

5.3 *Thermometer*—This shall be an ASTM Loss on Heat Thermometer conforming to the requirements for Thermometer 13C as prescribed in Specification E 1. This thermometer

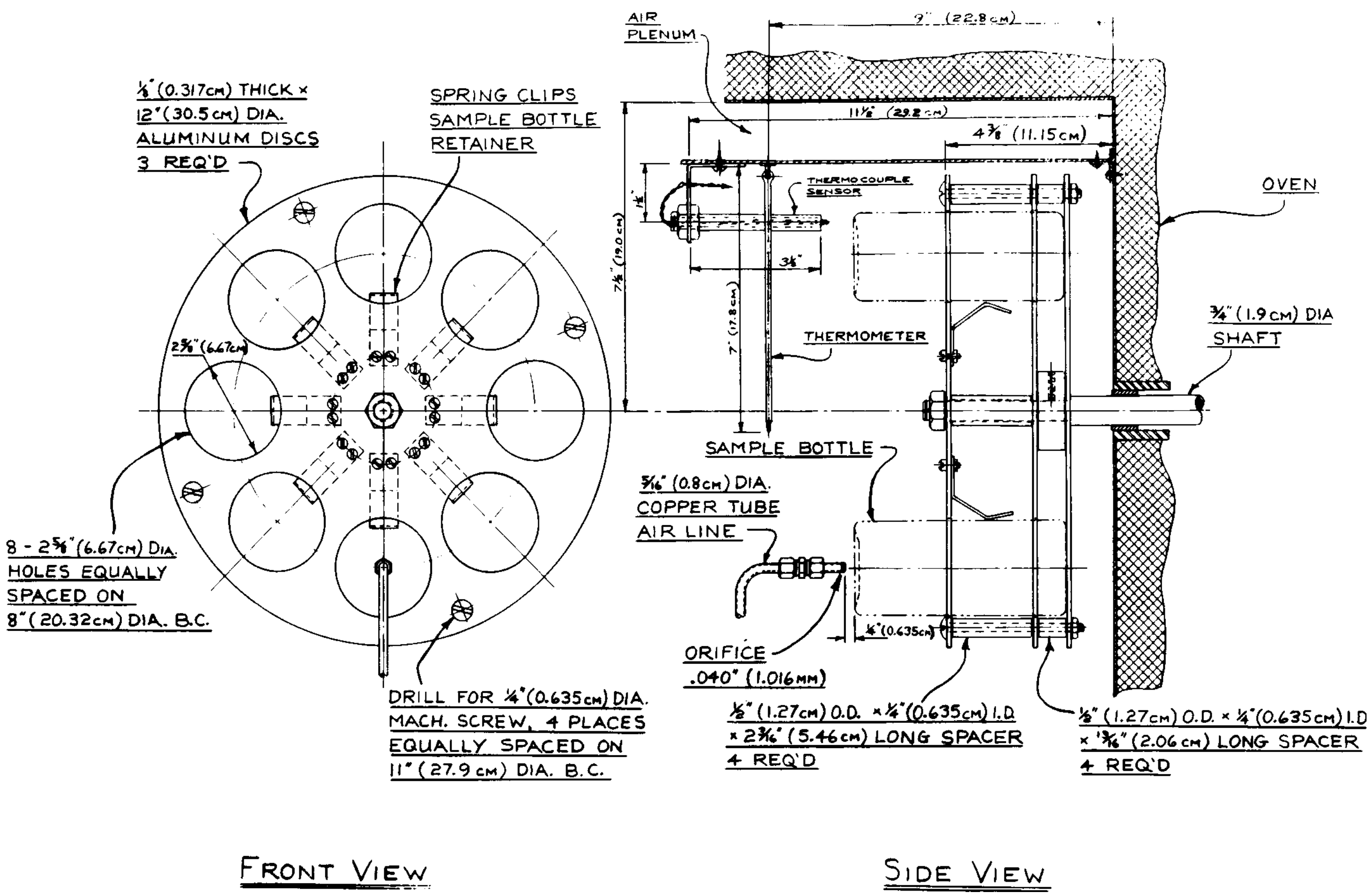

FIG. 2 Circular Metal Carriage

shall be used to make all temperature measurements required by this test method.

5.4 *Container*—The container in which the sample is to be tested shall be of heat-resistant glass conforming to the dimensions shown in Fig. 3.

5.5 *Cooling Rack*—A wire or sheet metal rack, constructed of stainless steel or aluminum, which allows the sample containers to cool in a horizontal position, with each container in the same horizontal plane. The rack shall be constructed in a way that allows air to flow freely around each container with at least 1 in. (2.5 cm) clearance between containers and at least 1 in. (2.5 cm) clearance between the containers and any solid surface.

6. Preparation of Oven

6.1 Position the air outlet orifice so that it is ¼ in. (6.35 mm) from the opening of the glass container. The orifice shall also be so positioned that the jet blows horizontally into the central arc of the opening of the circling glass container.

6.2 Position the thermometer specified in 5.3 so that the end of the bulb of the thermometer is within 1 in. (25.4 mm) of an imaginary line level with the center of the shaft holding the revolving carriage.

6.3 Level the oven so that the horizontal axes of the glass containers when in position in the carriage are level.

6.4 Preheat the oven for a minimum of 16 h prior to testing with the control thermostat adjusted to the setting that will be

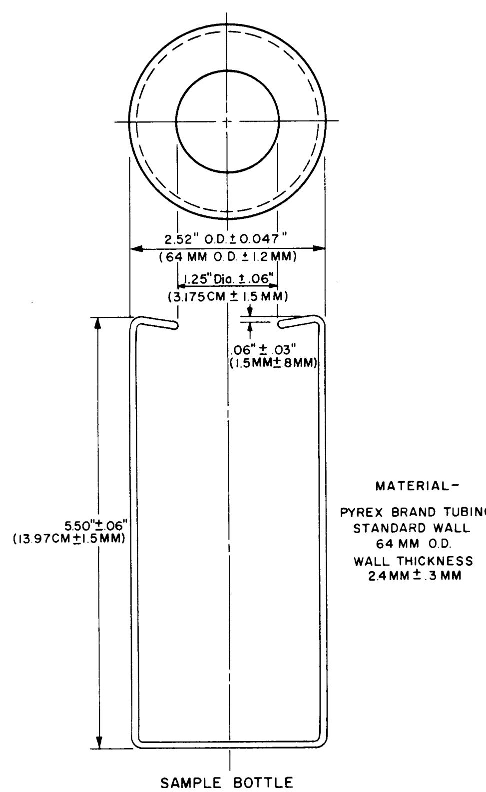

FIG. 3 Sample Bottle

used during the test. This setting shall be selected such that when the oven is fully loaded and the air is on, the oven will equilibrate at 325 ± 1°F (163 ± 0.5°C), as indicated by the test thermometer.

NOTE 2—Because the presence of sample containers affects the temperature distribution in the oven, containers must be present in the oven when the thermostat setting is determined. The use of empty containers is acceptable for this purpose.

7. Procedure

7.1 The sample as received shall be free of water. Heat the sample in its container with a loosely fitted cover in an oven not to exceed 302°F (150°C) for the minimum time necessary to ensure that the sample is completely fluid. Manually stir the sample but avoid incorporating air bubbles.

7.2 Pour 35 ± 0.5 g of the sample into each of the required glass containers, providing sufficient material for characterizing tests which are to be run on the residue.

7.3 Immediately after pouring the sample into a glass container, turn the container to a horizontal position, without rotating or twisting. Place the container in a clean cooling rack, which is maintained in a draft free, room temperature location, away from ovens or other sources of heat.

NOTE 3—For maximum precision in determining mass change, the cooling rack should be in a location that is the same temperature and humidity as the balance used for measuring the mass of the containers.

7.3.1 Allow the glass sample containers to cool in the cooling rack for a minimum of 60 min, and a maximum of 180 min.

7.3.2 When mass change is being determined, use two separate containers for this determination. After cooling, separately place each of these containers vertically on an analytical balance, and determine its mass to the nearest 0.001 g.

7.4 With the oven at operating temperature and the airflow set at 4000 ± 200 mL/min, arrange the containers holding the asphalt in the carriage so that the carriage is balanced. Fill any unused spaces in the carriage with empty containers. Close the door and rotate the carriage assembly at a rate of 15 ± 0.2 r/min. Maintain the samples in the oven and the air flowing and the carriage rotating for 85 min. The test temperature 325 ± l°F (163 ± 0.5°C) shall be reached within the first 10 min; otherwise, discontinue the test.

7.5 At the conclusion of the testing period, remove any samples for mass change determination and place them horizontally in the cooling rack. Then, remove each remaining glass sample container, one at a time, and transfer its contents to a collection container having a capacity at least 30 % greater than the total expected volume of residue. This transfer shall be accomplished by first pouring out any residue that will flow freely from the glass sample container and then scraping out as much of the remaining residue as practical. While the residue is being removed from each sample container, the oven door shall remain closed, with the heater power on, the air on, and the remaining samples rotating in the carriage. The final container shall be removed from the oven within 5 min of removal of the initial container.

NOTE 4—Any scraping tool or technique may be used, as long as an average of 90 % or more of the residue is removed from the sample containers. It has been determined that circumferential scraping tends to be more effective than lengthwise scraping.

7.6 After removing the residue from each of the glass containers, gently stir the collection container to homogenize the residue without introducing air into it. Test the residue within 72 h of performing the RTFO test.

7.7 If the mass change is being determined, allow the designated residue sample containers to cool on the cooling rack for a minimum of 60 min and a maximum of 180 min. After cooling, place each container vertically on an analytical balance and determine its mass to the nearest 0.001 g. Discard the residue from mass change determination, and do not use it for other tests.

NOTE 5—To improve mass change precision, the containers used for determining mass change should be handled with clean gloves or tongs, and transfer to the balance should be done with tongs, to prevent temperature changes which could distort the mass measurement.

8. Report

8.1 Report the results from RTFO test in terms of the physical changes in the asphalt brought about by this method. These values are obtained by performing appropriate ASTM tests on the asphalt before and after the moving film oven cycle.

8.2 When determined, report the average mass change of the material in the two containers as a mass percent of the original material. Report this calculated result to the nearest 0.001 %. A mass loss shall be reported as a negative number while a mass gain shall be reported as a positive number.

NOTE 6—This test can result in either a mass loss or a mass gain. During the test, volatile components evaporate, causing a decrease in mass, while oxygen reacts with the sample, causing an increase in mass. The combined effect determines whether the sample has an overall mass gain or an overall mass loss. Samples with a very low percentage of volatile components usually will exhibit a mass gain, while samples with a high percentage of volatile components usually will exhibit a mass loss.

9. Precision and Bias

9.1 Criteria for judging the acceptability of the viscosity at 140°F (60°C) and the ductility at 60°F (15.6°C) test results on the residue after heating are given in Table 1. The values given in Column 2 are the standard deviations that have been found to be appropriate for the materials and conditions of test described in Column 1. The values given in Column 3 are the limits that should not be exceeded by the difference between the results of two properly conducted tests. The values given in Column 4 are the coefficients of variation that have been found to be appropriate for the materials and conditions of test described in Column 1. The values given in Column 5 are the limits that should not be exceeded by the difference between the results of two properly conducted tests expressed as a percent of their mean.

9.2 The precision of the loss of mass determinations have not been determined.

10. Keywords

10.1 aging; asphalt cement; rolling thin-film oven test (RTFOT)

TABLE 1 Precision of Test on Residue

Test Methods	Standard Deviation (1s)	Acceptable Range of Two Results (d2s)	Coefficient of Variation (percent of mean) (1s %)	Acceptable Range of Two Results (percent of mean) (d2s %)
Single-operator precision:				
Viscosity at 140°F (60°C)	...	...	2.3	6.5
Ductility at 60°F (15.6°C)[A]	3 cm	9 cm	...	...
Multilaboratory precision:				
Viscosity at 140°F (60°C)	...	...	4.2	11.9
Ductility at 60°F (15.6°C)[A]	6 cm	16 cm	...	...

[A] This is based on the analysis of data resulting from tests by 16 laboratories on two asphalts ranging from 13 to 30 cm.