Designation: F2837 – 11

Standard Test Method for Hot Compression Properties of Gasket Materials[1]

This standard is issued under the fixed designation F2837; 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 means of measuring the hot compression properties of a gasket material by measuring its creep under a constant load at both room temperature and while increasing the temperature. Short term creep properties including both cold and hot creep, total creep and compression set of a gasket material can be determined.

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

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]

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

F104 Classification System for Nonmetallic Gasket Materials

3. Terminology

3.1 *Symbols:*

T_0 = original specimen thickness

T_1 = cold thickness under load (specimen thickness after a 5-min hold under load at room temperature)

T_2 = hot thickness under load (specimen thickness at maximum test temperature under load)

T_3 = final specimen thickness (after specimen has been removed from the machine and cooled)

T_{s0} = original calibration ring thickness

T_{s1} = calibration ring thickness (after a 5-min hold under load at room temperature)

T_{s2} = calibration ring thickness (at maximum test temperature under load)

T_{s3} = final calibration ring thickness (after specimen has been removed from the machine and cooled)

4. Summary of Test Method

4.1 Specimens cut from gasket material are subjected to a stress perpendicular to the flat surface of the specimen for a specified time at room temperature, and then the temperature is increased at a defined rate while the stress remains constant. The recommended maximum temperature limit for the test is 300°C (572°F). The desired gasket load for the test is 25.5 MPa (3700 psi). Dimensional changes to the thickness are determined while the gasket is under stress and after the stress has been removed. Tests may be performed on a gasket material at various temperatures or stresses as agreed upon between the producer and the user, to determine the relationship between temperatures at a constant stress.

5. Significance and Use

5.1 The hot compression properties of a gasket material, including creep resistance and compression set, are a major factor with regard to the selection of a given material for use in a particular sealing application. The significance of the test method is based, in part; on the assumption that if a material exhibits too much creep at elevated temperature that it will no longer function as effectively as a seal. This assumption can only be used as a guide; however, since exact yield or failure points are difficult to define for gasket materials (which are usually viscoelastic in nature). Two or more materials can be compared to determine differences in their hot compression properties. A sample of material can be compared to an established standard or previously determined characteristics on original lots of the same material, for quality assurance purposes.

5.2 Samples are to be tested with a raised profile insert or calibration ring described in 6.3 and Fig. 1 so that the area (2042 mm^2 (3.17 $in.^2$)) remains constant during the test.

[1] This test method is under the jurisdiction of ASTM Committee F03 on Gaskets and is the direct responsibility of Subcommittee F03.40 on Chemical Test Methods.

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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.

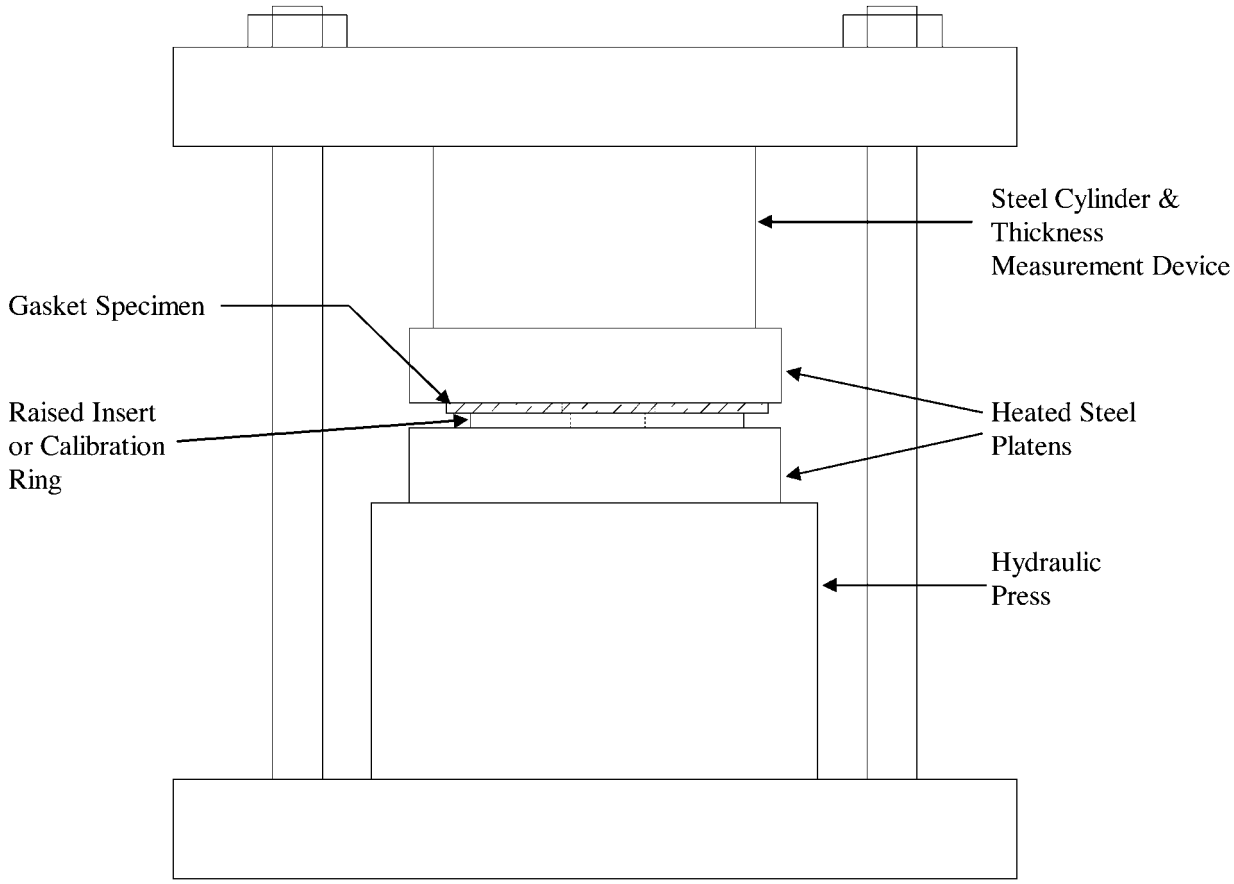

FIG. 1 Test Assembly for Determining Hot Compression

6. Apparatus

6.1 *Testing Machine,* for applying a known value of compressive stresses to specimens. The machine should be capable of applying a stress of up to 51.7 MPa (7500 psi) (tolerance of ±5 %), depending on the indent resistance of the steel platens and the means of reading the applied load.

6.2 *Hardened Steel Platens, Two* (Rockwell of C35 to 40 or equivalent), circular shape, larger than the specimen diameter. A suitable size is a diameter of approximately 152 mm (6 in.). The faces of the platens shall be plane parallel with a surface finish of 0.25 to 0.50 µm Ra (10 to 20 µin Ra). Fig. 1 shows a suitable arrangement of steel platens and test specimen.

6.3 *Insert or Calibration Ring*—A raised profile insert or calibration ring with a minimum raised height of 1.6 mm (0.063 in.) having a 75 ± 0.5 mm (2.953 ± 0.02 in.) outside diameter by 55 ± 0.5 mm (2.165 ± 0.02 in.) inside diameter made of the same material as the platens (Rockwell of C 35 to 40 or equivalent) is required. The faces of the insert shall be plane parallel and have a surface finish of 0.25 to 0.50 µm Ra (10 to 20 µin Ra).

6.4 *Device for Applying Heat to Platens,* sufficient to achieve a desired temperature at interface with gasket material specimens. In some cases, the loading device itself may be heated, such as with a hot press. Any appropriate means is acceptable. The device shall be capable of increasing the temperature at a constant rate of 8°C (14°F) per minute. The temperature difference between the two platens shall not exceed 5°C (9°F) at any time. The recommended elevated temperature is 300°C (572°F). Other temperatures may be employed as desired, or as agreed upon between the producer and the user.

6.5 *Temperature Measuring Device,* for use at interface, such as a thermocouple assembly and a means for recording the voltage.

6.6 *Dial or Thickness Measuring Device*—An indicating dial, or dials, graduated in 0.025 mm (0.001 in.), or a digital device, to show or record the thickness of the specimen during the test. Readings shall be estimated to the nearest 0.002 mm (0.0001 in.).

6.7 *Shield*—A safety shield for protection from severe outgassing that may occur during the test.

6.8 *Dies*—Cutting dies for specimens of desired size and shape. The inside faces of the dies shall be polished and be perpendicular to the plane formed by the cutting edges for a depth sufficient to prevent any bevel on the edge. The die shall be sharp and free of nicks in order to prevent ragged edges on the specimen. The bore and outside diameter shall be concentric.

6.9 *Micrometer,* for making specimen thickness measurements in accordance with Classification F104.

6.10 *Water-Cooled Disc*—A metal disc cooled by water that acts as a heat exchanger that can be placed between the platens to lower the temperature between tests, is recommended to shorten the cycle time between tests. Water-cooled platens may be used as well.

6.11 *Metal Foil* (for example, Inconel, nickel, stainless steel), capable of low creep at the desired maximum test temperature may be used to prevent the sample from sticking to the platens. Recommended thickness is 0.025 mm (0.001 in.).

7. Test Specimen

7.1 *Sheet-Type Gasketing* (see Classification F104)—The gasket shall be die cut in the shape of an annulus with clean smooth edges. The bore and outside diameter shall be concentric.

7.1.1 The recommended annular specimen size is 90 ± 0.5 mm (3.55 ± 0.02 in.) outside diameter by 50 ± 0.5 mm (1.97 ± 0.02 in.) inside diameter. Three specimens should be prepared for each material that is to be evaluated.

7.1.2 The recommended test specimen thickness may vary depending on the type of testing machine employed, type of material being evaluated, and the application to which the results are directed. The exact effect of specimen thickness on the test results is not being addressed in this test method, other than to acknowledge it will most likely influence the results and should be a part of the report as specified in Section 12. See Table 3 in Classification F104 for recommended thicknesses for different types of materials.

7.2 *Solid Form-in-Place Gasketing* (see Classification F104):

7.2.1 A 211-mm (8.30-in.) long piece of standard size material between 3.18 and 4.76 mm (0.125 and 0.1875 in.) nominal size or width, shall be formed into a circle of 65 mm (2.56 in.) mean diameter. The ends of the Type 4 material shall be so laid as to have a 6.35 ± 1.59 mm (0.25 ± 0.0625 in.) overlap to complete the specimen. The Type 5 material shall have an overlap of 1.59 ± 0.79 mm (0.0625 ± 0.0313 in.) to complete the specimen. Three specimens should be prepared for each material that is to be evaluated.

8. Calibration and Standardization

8.1 Since accurate thickness measurements depend on the effects of thermal and mechanical characteristics on the fixture, in addition to the effect produced by the test gasket, it is necessary that the fixture be calibrated in accordance with Section 10 using only the raised profile insert or calibration ring to obtain the values T_{s0}, T_{s1}, T_{s2}, and T_{s3}, (which correspond to T_0, T_1, T_2, and T_3 in 10.1-10.10).

8.2 If a test machine performs calibration automatically as a part of its program, the procedures in this section are not necessary and inclusion of the values T_{s0}, T_{s1}, T_{s2}, and T_{s3} in Section 10 are not required.

8.3 It is recommended that the test machine be calibrated approximately every 100 cycles and between these periods the calibration results from the previous test be used in Section 10.

9. Conditioning

9.1 Condition the cut specimens in accordance with the appropriate procedure specified in Classification F104 with respect to the type of gasket material from which the specimens are cut.

10. Procedure

10.1 *Original Thickness Measurement, T_0*—Measure the thickness of the conditioned gasket specimen according to Classification F104, section 9.1. The specimen thickness is measured with the micrometer at three equally spaced places approximately 120° apart, the result is averaged and recorded as the thickness T_0.

10.2 The test shall begin with the platens and specimen at room temperature. For subsequent tests the platens shall be cooled to room temperature.

10.3 If sticking is a problem the specimen may be placed between new pieces of metal foil. Center the specimen or the specimen and foil combination if used, between the platens with the raised profile insert or calibration ring. Place the assembled platens in the test fixture described in Fig. 1.

10.4 Close the testing device with the upper platen in position over the specimen and lower the platen, using minimal contact force. Some testing machines automatically record the initial thickness, while some testing machines only record the difference in thickness. Depending on equipment capability, some materials will compress significantly at the lowest stress setting of the stand. If this happens, or if the test machine only records the difference in thickness, the thickness data collected during the test can be adjusted using T_0 from 10.1 after the test is completed.

10.5 Increase the pressure on the platens to the desired gasket load (typical 25.5 MPa or 3700 psi, ±5 %). This constant load is to be maintained throughout the test period. After a 5-min hold at the desired gasket load, record the specimen cold thickness under load as T_1.

10.6 Start the temperature program to increase the platen temperature by 8°C (14°F) per minute to the desired maximum test temperature, typically 300 ± 5°C (572 ± 9°F), while maintaining a constant load on the gasket throughout the duration of the test (tolerance ±5°C). Record the change in thickness every 8°C (14°F). If desired this data can be used to provide a thickness versus temperature plot for the specimen.

10.7 At the test maximum temperature, record the specimen hot thickness under load as T_2.

10.8 *Upon Completion of the Test:*

10.8.1 *Sheet-Type Gasketing*—Remove the load, separate the platens and remove the specimen from the fixture and allow the fixture to cool to room temperature. A water cooled disc or water cooled platens described in 6.10 may be used.

10.8.2 *Solid Form-in-Place Gasketing*—Before removing the load and separating the platens allow the gasket to cool in the platens to prevent curling. After removing the specimen, a water cooled disc or water cooled platens described in 6.10 may be used.

TABLE 1 Thickness Decrease – Hot (%)

Material	Average[A]	Repeatability Standard Deviation	Repeatability Limit
	$\bar{x}$	s_r	r
A	4.53	0.42	1.18

[A] The average of the laboratories' calculated averages.

10.8.3 After each test, clean the platens appropriately to restore them to their original condition. Wipe the surfaces with a solvent, such as acetone, using a soft cotton cloth to ensure that the surface is clean.

10.9 Repeat the thickness measurement in accordance with 10.1 to obtain the final thickness and record as T_3.

10.10 If the data must be adjusted for T_0 as described in 10.4, do so and record the adjusted values for T_1, T_2, and T_3.

10.11 Repeat the test procedure on two additional specimens of the same material and the same thickness being evaluated.

11. Calculation

11.1 Thickness Decrease Cold, % =

$$\frac{T_0 - T_1}{T_0} \times 100$$

11.2 Thickness Decrease Hot, % =

$$\frac{(T_1 - T_2) - (T_{s1} - T_{s2})}{T_1} \times 100$$

11.3 Thickness Decrease Total, % =

$$\frac{(T_0 - T_2) - (T_{s0} - T_{s2})}{T_0} \times 100$$

11.4 Total Compression Set, % =

$$\frac{(T_0 - T_3) - (T_{s0} - T_{s3})}{T_0} \times 100$$

11.5 Record the results for each of the given calculations for the three specimens tested and determine the average values.

12. Report

12.1 Report the following information for each material tested:

12.1.1 Material identification,
12.1.2 Maximum temperature of test,
12.1.3 Gasket load used for test,
12.1.4 Original gasket thickness,
12.1.5 Cold thickness under load,
12.1.6 Hot thickness under load,
12.1.7 Final gasket thickness,
12.1.8 Thickness decrease cold results,
12.1.9 Thickness decrease hot results,
12.1.10 Thickness decrease total results, and
12.1.11 Total compression set results, and
12.1.12 Graphical display of results if desired.

12.1.12.1 A plot of thickness versus temperature results indicating original thickness of specimen at T_0, T_1, and each 8°C (14°F) interval, T_2, and T_3. Give specific thickness of the specimen and gasket stress.

13. Precision and Bias[3]

13.1 The precision of this test method is based on an intralaboratory study conducted in 2008. Nine laboratories tested a single type of gasketing material. Every "test result" represents an individual determination. Each laboratory was asked to submit triplicate test results, from a single operator, for the material. Except for the analysis of only a single material, Practice E691 was followed for the design and analysis of the data.

13.1.1 *Repeatability Limit (r)*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the "*r*" value for that material; "*r*" is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

13.1.1.1 Repeatability limits are listed in Tables Tables 1-4 below.

13.1.2 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177.

13.1.3 Any judgment in accordance with statement 9.1.1 and would have an approximate 95 % probability of being correct.

13.2 *Bias*—At the time of the study, no accepted reference material suitable for determining the bias for this test method was utilized, therefore, no statement on bias is being made.

13.3 The precision statement was determined through statistical examination of 107 results, from nine laboratories, on a single material. This material was described as follows: Material A: Sheet-Type Gasketing (see Classification F104), 1.5 mm (1/16 in.) thick, specimen size is 90 mm (3.55 in.) outside diameter by 50 mm (1.97 in.) inside diameter.

14. Keywords

14.1 cold creep; compression; compression set; creep; gasket; gasket compression; hot compression; hot creep; strain; stress; thickness change

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: F03-1018.

TABLE 2 Thickness Decrease – Cold (%)

Material	Average[A]	Repeatability Standard Deviation	Repeatability Limit
	$\bar{x}$	s_r	r
A	7.32	0.67	1.87

[A] The average of the laboratories' calculated averages.

TABLE 3 Thickness Decrease – Total (%)

Material	Average[A]	Repeatability Standard Deviation	Repeatability Limit
	$\bar{x}$	s_r	r
A	11.31	0.67	1.88

[A] The average of the laboratories' calculated averages.

TABLE 4 Total Compression (%)

Material	Average[A]	Repeatability Standard Deviation	Repeatability Limit
	$\bar{x}$	s_r	r
A	8.89	1.00	2.80

[A] The average of the laboratories' calculated averages.