Designation: D7559/D7559M – 09 (Reapproved 2014)

Standard Test Method for Determining Pressure Decay of Inflatable Restraint Cushions[1]

This standard is issued under the fixed designation D7559/D7559M; 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 determine the ability of an inflatable restraint cushion to retain air pressure at elevated pressures for a specified time interval.

1.2 Procedures and apparatus other than those stated in this test method may be used by agreement of purchaser and supplier, provided the specific deviations from the standard acknowledged in the report.

1.3 The results of this test method should not be used to predict the actual internal pressure decay of a cushion during a deployment.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 *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]

D123 Terminology Relating to Textiles

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

D6799 Terminology Relating to Inflatable Restraints

3. Terminology

3.1 For all terminology relating to D13.20, Inflatable restraints, refer to Terminology D6799.

3.1.1 The following terms are relevant to this standard: deployment; inflatable restraint.

3.2 For all other terms related to textiles, see Terminology D123.

4. Summary of Test Method

4.1 After inflation with air to a specific initial internal pressure, an inflatable restraint cushion is tested to for its ability to retain a specified residual pressure (allowing for some pressure loss) over a specified time period.

4.2 An inflatable restraint cushion is mounted onto a test stand that allows for the inflation of the cushion to a specified initial internal pressure. After the air supply is discontinued, instrumentation measures and records internal pressure drop over time.

4.3 Cushion internal pressure versus time data is recorded and compared to allowable limits agreed upon by the purchaser and supplier.

5. Significance and Use

5.1 This test method may be used for product development and design, production validation, manufacturing process control, lot acceptance, or for a combination thereof.

5.2 The rate of inflation in this method does not attempt to mimic that of an actual cushion deployment, nor is it intended to subject the cushion to the dynamic loads, stress, and temperatures during such an event. It is also recognized that the compressed air used for this tests may not leak through the cushion at the same rate as the gas or mixture of gasses typically used in cushion inflators. Rather this method is intended to give a relative indication of the pressure holding ability of the cushion.

5.3 The internal volume and internal design of cushions varies greatly. This test method is most useful when comparing data from cushions of the same design and volume. This test method does not provide any data concerning the volume of gas leaking from the bag. At certain higher levels of the initial internal pressure, this test method will irreversibly damage the cushion and change its leakage properties for future testing or for commercial use. The damage to the bag is dependent on the design or shape of a specific bag and the type of coating

[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and are the direct responsibility of Subcommittee D13.20 on Inflatable Restraints.

Current edition approved July 1, 2014. Published August 2014. Originally approved as D7559/D7559M-09. Last previous edition approved in 2009 as D7559/D7559M-09. DOI: 10.1520/D7559_D7559M-09R14.

[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.

applied. It is the responsibility of the supplier and / or purchaser to determine if the parameters under which a cushion is tested will be destructive and render the cushion unfit for future use

5.4 Within the limits of variance expressed in Section 12, this test method is useful for design and production validation and may be suitable for incorporation in a cushion specification or for lot acceptance testing of commercial shipments.

6. Apparatus

6.1 *Air Supply Source,* capable of filling the cushion to the specified pressure, with a flow rate capable of maintaining the specified pressure at equilibrium. Typically the pressure used for testing the cushion will not exceed 200 kPa [29 psi], nor will the flow exceed 1500 L/min [53 CFM]. The air source should be equipped with an inline filter, shut off valve, and flow regulator. Care should be taken to trap out excess moisture or oil from the compressed air source.

6.2 *Shut Off Valve,* capable of being actuated either manually or remotely by an electrical signal.

6.3 *Mounting Fixture,* capable of allowing a sealed attachment of the cushion to the air supply source, the shut off valve, and instrumentation to monitor the pressure decay during the test. It should contain a pressure pickup tube. It shall be in an orientation that allows free expansion of the cushion geometry. It should have sufficient safety shielding and isolation for operator protection during the test. The clamping device that attaches the opening of the cushion to the filling tube fixture should be designed to properly fit the opening of the cushion, provide a secure mechanical attachment, and prevent gas leakage.

6.4 *Pickup Tube,* mounted coaxially inside filling tube of the mounting fixture. One end should extend inside the cushion at minimum of 25 mm [1 in.] beyond the clamping device. The other end should extend through the wall of the filling tube of the mounting fixture through a sealed joint, and be connected to a pressure transducer or gauge. The end that extends into the cushion should be oriented such that it allows free expansion of the cushion geometry.

6.5 *Pressure Transducer,* suitable for measuring pressures inside the cushion (via the pickup tube) from 0 to at least 200 kPa [0 to 29 psi] and maintained to an accuracy of a maximum of ±2 %.

6.6 *Pressure Gauge,* suitable for measuring pressures inside the cushion (via the pickup tube) from 0 to at least 200 kPa [0 to 29 psi] and maintained to an accuracy of a maximum of ±2 %.

6.7 *Data Acquisition System,* suitable for recording the output of the pressure transducer versus elapsed time. The input amplifier and the time interval at which the data is recorded must have an accuracy of ±1 %. It is optional that this system can initiate the filling of the bag and the closure of the shut-off valve.

6.8 *Manual Timer (stopwatch),* optional, suitable for manually observing elapsed time. This must have an accuracy of ±1 %.

6.9 Filter requirements, data sampling rate, transducer frequency response, and amplifier frequency response shall be such that the overall accuracy of the data acquisition system shall be within ±1 %. The significant figures of the recorded data of time and pressure, along with the timing increment should be agreed upon by the purchaser and supplier.

7. Sampling

7.1 The Cushion Pressure Decay Test at certain test parameters and pressures is a destructive test and therefore necessitates sampling procedures if used in conjunction with lot acceptance.

7.2 The determination of lot size and sampling plan shall be agreed to by purchaser and supplier.

7.3 One cushion assembly is a test specimen.

8. Equipment Calibration

8.1 For inflatable restraints, all test equipment used in accordance with this test method shall be certified for calibration annually using gages that are traceable to the National Institute of Science and Technology (NIST) or other national standards laboratory. The test parameters of the equipment shall be tested within the operating ranges covered in the cushion specification or equivalent document.

9. Conditioning

9.1 Conditioning of specimens and conducting of the testing in the standard atmosphere for testing textiles is desirable, but not required. It is recognized that conditions of the air from the compressed air source used to inflate the specimen will not be controlled, even though care should be taken to filter the air and trap out any excessive moisture or compressor oils.

9.2 Testing can be conducted in, or specimens conditioned in an environment other that of the standard atmosphere for testing textiles, such as in hot or cold conditions. These conditions will be agreed upon between the purchaser and supplier, or as specified in any relevant customer or supplier specifications.

10. Procedure

10.1 Select and condition specimens in accordance with Sections 7 and 9.

10.2 Ensure that the shut off valve is closed and the pressure reading is at 0.

10.3 Mount the specimen onto the mounting fixture, ensuring that it is securely attached and sealed, and that the pickup tube does not interfere with the inflation of the cushion. If the cushion contains an internal gas guide or heat shield, it is optional to remove this if it would otherwise interfere with the ability to mount the specimen, or the operation of the pick-up tube.

10.4 Record any necessary information, such as cushion serial number, lot number, and style, and ensure that the data acquisition system is ready.

10.5 Open the shut-off valve and adjust the flow regulator such that the specimen slowly inflates over a minimum of

typically 10 s. The specimen should then be inflated to a pressure slightly exceeding the specified starting point pressure, but not to exceed a level of 2 % above that of the starting point, or 1.5 kPa [0.22 psi], which ever is greater. This pressure should be held at equilibrium for a minimum of 0.5 s, but not to exceed a maximum 10 s.

10.6 Close the shut off valve. When the pressure drops to the specified starting pressure, data collection will begin, and this point will become time 0 of the specified time interval.

10.7 Data collection will continue until the specified time interval has elapsed. Fig. 1shows a graphic representation of the test scheme

10.8 Safely bleed any residual air pressure from the specimen. Remove the specimen from the test stand.

10.9 Review the recorded data to ensure that the necessary data was successfully acquired.

10.10 Optional procedure – In lieu of an electronic data collection system, data can be collected by observing a mechanical pressure gauge and stopwatch type timer and recording the data manually. This may be useful only in situations where the pressure drop is relatively slow. If this method is utilized, it must be mentioned on the test report. The Precision limits listed in Section 12 do not apply if this optional procedure is used.

11. Report

11.1 State that the tests were conducted in accordance with this test method.

11.1.1 If deviation from this test method occurred, or if the optional procedure of 10.10 was used, any reference to this test method shall state: "Testing was performed in accordance with ASTM D7559, with the following changes:"

11.2 The purchaser and supplier shall determine the exact form of the report. Unless otherwise specified, report the following information:

11.2.1 Cushion designation.

11.2.2 Lot identification.

11.2.3 Date of report.

11.2.4 Name of person certifying report.

11.2.5 Relevant supplier or purchaser specification if any.

11.2.6 Parameters of the test and data obtained to include: initial starting pressure, specified time interval, and residual pressure after the specified time interval.

11.2.7 Laboratory conditions, if other than standard.

11.2.8 Deviations from standard procedures and apparatus.

12. Precision and Bias

12.1 The output data of this method are pressure and time. The tolerance of the data therefore is the verified accuracy of the Pressure Transducer (or gauge) and the time recording device. These should not exceed the limits shown in Sections 6.5 – 6.8.

12.2 The analysis of precision of test results using this test method is meaningful both within-laboratory and between-laboratory with multiple operators.

12.3 An inter-laboratory test was conducted to determine precision. Since this test method would be destructive to the specimen at some of the pressures used in this study, a simulated cushion surrogate was constructed. The test device consisted of a sealed steel tank of volume approximating that of a typical cushion, a hose of appropriate internal diameter to

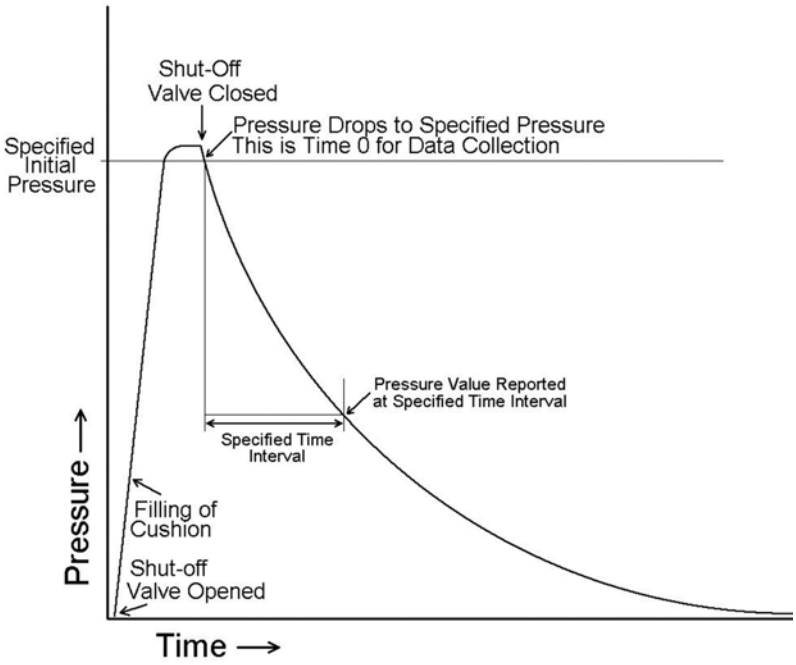

FIG. 1 Test Scheme

Test	1/16" (Good Performance) From 17.5 kPa Starting Pressure			1/16" (Good Performance) From 70 kPa Starting Pressure			1/16" (Good Performance) From 100 kPa Starting Pressure			3/32" (Moderate Performance) From 100 kPa Starting Pressure		
	kPa After 5 Sec	kPa after 6 Sec.	kPa After 10 Sec.	kPa After 5 Sec	kPa after 6 Sec.	kPa After 10 Sec.	kPa After 5 Sec	kPa after 6 Sec.	kPa After 10 Sec.	kPa After 5 Sec	kPa after 6 Sec.	kPa After 10 Sec.
Laboratory #1												
1	12.3	11.3	8.1	54.3	51.7	42.2	81.0	77.5	65.8	36.3	31.4	15.9
2	10.4	9.3	5.6	53.7	50.9	41.4	78.8	75.2	62.9	36.0	30.7	15.3
3	10.5	9.4	5.7	53.2	50.5	40.8	80.0	76.7	64.7	35.6	30.6	15.1
4	10.4	9.3	5.6	53.3	50.5	40.8	79.6	76.0	63.9	36.9	31.6	16.1
5	10.5	9.3	5.6	54.2	51.4	41.9	79.5	75.9	63.8	37.0	32.0	16.6
Laboratory #2												
1	11.1	10.1	6.6	55.5	52.8	43.8	82.5	79.3	68.0	38.4	33.3	18.1
2	11.0	9.9	6.4	54.9	52.2	43.0	80.9	77.5	65.8	37.7	32.8	17.4
3	10.7	9.6	6.0	54.9	52.2	43.0	81.6	78.2	66.7	36.9	31.7	16.2
4	10.8	9.6	6.1	54.8	52.1	42.7	82.0	78.7	67.2	36.5	31.6	16.0
5	10.7	9.6	5.9	54.3	51.7	42.3	81.1	77.7	65.8	37.7	32.5	17.3
Laboratory #3												
1	11.3	10.2	6.7	55.4	52.7	43.6	82.7	79.5	68.2	37.3	32.4	17.0
2	10.5	9.4	5.8	54.1	51.3	41.9	80.5	77.0	65.0	36.4	31.1	15.7
3	10.5	9.3	5.7	54.4	51.6	42.2	80.5	77.0	65.2	35.9	31.0	15.3
4	10.6	9.5	5.9	53.9	51.2	41.7	80.4	77.1	65.1	36.8	31.6	16.2
5	10.5	9.5	5.7	54.0	51.2	41.7	80.2	76.7	64.7	36.4	31.2	15.8
Laboratory #4												
1	10.8	9.9	6.5	53.5	51.1	42.6	84.1	80.8	69.4	37.6	33.1	18.4
2	11.0	9.8	6.3	53.3	51.0	42.2	83.7	80.7	69.2	37.6	32.7	18.1
3	11.0	9.7	6.3	53.3	51.2	42.2	83.9	80.8	69.3	37.6	33.0	18.4
4	11.0	9.8	6.4	53.4	50.9	42.3	84.2	81.0	69.4	37.3	32.7	18.2
5	11.0	9.9	6.4	53.2	51.2	42.4	84.0	80.9	69.3	37.1	32.5	17.9

FIG. 2 Data Table

act as the neck of the cushion and facilitate attachment to the test fixture, and an orifice plug to allow for leakage at a fixed rate. Two orifices sizes were used to simulate a range of leak down rates of the cushion. An orifice of 1.59 mm [1/16 in.] diameter was chosen to simulate a bag with reasonably good performance that would typically meet most common customer specification. An orifice of 2.38 mm [3/32 in.] diameter was chosen to simulate a bag with moderate to worse performance that would typically be marginal or not meet most common customer specifications. A variety of starting pressures and times were chosen to encompass the range of common specifications in the industry. Data was processed using ASTM E691 adjunct software package.

12.4 See Data Table (Fig. 2).

12.5 *Precision Statements*—The number of laboratories, materials, and determinations in this study DOES NOT meet the minimum requirements for determining precision prescribed in Practice E691:

	This Study	Practice E691 Minimum
Laboratories:	4	6
Materials	4	4
Determinations:	5	2

12.5.1 Precision, characterized by repeatability, S_r, r, and reproducibility, S_R, R, has been determined for the materials to be:

12.5.2 Precision Statement for Test Method: Residual kPa pressure after 5 s These precision statements are provisional. Within five years, additional data will be obtained and processed which does meet the requirements of E691.

Materials	Average	S_r	S_R	r	R
Good Performer from 17.5 kPa	10.83	0.461	0.461	1.291	1.291
Good Performer from 70 kPa	54.08	0.453	0.790	1.269	2.213
Good Performer from 100 kPa	81.56	0.740	1.900	2.071	5.320
Moderate Performer from 70 kPa	36.95	0.556	0.758	1.557	2.122

12.5.3 Precision Statement for Test Method: Residual kPa pressure after 6s

Materials	Average	S_r	S_R	r	R
Good Performer from 17.5 kPa	9.720	0.492	0.492	1.378	1.378
Good Performer from 70 kPa	51.47	0.4666	0.694	1.304	1.942
Good Performer from 100 kPa	78.21	0.813	2.071	2.275	5.710
Moderate Performer from 70 kPa	31.98	0.564	0.892	1.580	2.497

12.5.4 Precision Statement for Test Method: Residual kPa pressure after 10 s

Materials	Average	S_r	S_R	r	R
Good Performer from 17.5 kPa	6.165	0.612	0.612	1.713	1.713
Good Performer from 70 kPa	42.24	0.585	0.821	1.639	2.299
Good Performer from 100 kPa	66.47	1.021	2.340	2.858	6.552
Moderate Performer from 70 kPa	16.73	0.647	1.257	1.813	3.519

13. Keywords

13.1 airbag; inflatable restraint; pressure decay