Designation: F3291 – 17

Standard Test Method for Measuring the Force-Resistance of a Membrane Force Sensor[1]

This standard is issued under the fixed designation F3291; 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 the force versus resistance measurement of a membrane force sensor (MFS) where the electrical resistance decreases as the force on the sensor is increased.

1.2 An MFS may or may not be electrically open in its static state. This depends on the attributes required for the application. If the MFS has a measureable resistance in static state, it was most likely designed to be used as a variable resistor, not as a normally open switch. A high but measurable resistance, in static state, may still be considered an open switch if the resistance is above the closed resistance threshold recognized by the interface electronics.

1.3 Special printed conductive polymer inks or characteristics, or both, of the sensor design are used in MFS to achieve variable resistance when compressed. As force is applied to the MFS the resistance continues to decrease, but not linearly, until a point where additional force does not change the resistance appreciably. Ideally, when force is removed from the MFS the resistance will return to, or close to, its original value.

1.4 Materials other than conductive polymers can be used in an MFS and also exhibit reduced resistance with increasing force.

1.5 This test method should not be confused with Test Method F2592 for measuring the force-displacement characteristics of a membrane switch (MS) that is designed for momentary closure. Although the resistance of a MS does change during contact closure the change from high resistance to contact resistance is very sudden and additional force does not have a significant effect on the resistance; that is, an MS is not designed to be used as a variable resistor.

1.6 *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.*

1.7 *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:*

F2592 Test Method for Measuring the Force-Displacement of a Membrane Switch

F1578 Test Method for Contact Closure Cycling of a Membrane Switch

3. Terminology

3.1 *Definitions:*

3.1.1 *force at initial measurable resistance (Fim), n*—force at *Rim*. If there is a measurable resistance *Rim* at *Fss* then both *Fss* = *Fim* = 0.

3.1.2 *initial measurable resistance (Rim), n*—resistance of MFS without force applied (if measurable) or the first measurable resistance when test probe begins applying force.

3.1.3 *maximum sensor force (Fmaxs), n*—a special maximum force to be applied to MFS during test or the force at which no appreciable change in resistance is noted, also known as saturation resistance.

3.1.4 *maximum sensor pressure (Pmaxs), n*—Fmaxs/surface area of test probe in contact with MFS.

3.1.5 *membrane force sensor (MFS), n*—similar in construction to a non-tactile membrane switch (MS) but the measured resistance is designed to decrease as force applied is increased. Also sometimes referred to in the industry as a force sensing resistor.

3.1.6 *membrane switch (MS), n*—a momentary switching device in which at least one contact is on, or made of, a flexible substsrate.

3.1.7 *pressure at initial measurable resistance (Pim), n*—*Fim*/surface area of test probe in contact with MFS.

3.1.8 *Rmaxs, n*—resistance at Fmax.

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3.1.9 *test probe tip diameter (Dtp), n*—diameter of the test probe tip (or actuator) that is in contact with MFS during test.

3.1.10 *zero force steady state (Fss), n*—steady state condition before test begins, no probe force applied, $Fss = 0$. If there is a measurable resistance *Rim* at *Fss* then *Fim* is also 0.

4. Significance and Use

4.1 An MFS has similar properties to a load cell or strain gauge. However, an MFS is not suitable for precision measurements.

4.2 MFS pressure versus resistance data can be calculated if the force probe is providing uniform pressure over a distributed area or if the sensor is exposed to measurable air or hydraulic pressure.

4.3 MFS force-resistance plotted results are not linear and results may change when exposed to repeated force cycles – Test Method F1578. It is useful to note that the force-resistance curve models closely to mathematical form of $y = 1/x$.

4.4 Static forces may contribute to drifting test results (also known as creep).

5. Interferences

5.1 The switch samples should be mounted on a rigid support in order to get a more accurate representation of the force and resistance.

6. Apparatus

6.1 *Test Probe,* made of non-elastic material with a flat tip sized 50 - 80 % of the minimum spacer area opening or as specified. Apply to the flat tip a silicone rubber pad (recommended 65 Shore A Hardness 0.020 in. thick).

6.2 *Test Surface,* to be flat, smooth, unyielding and larger than MFS under test.

6.3 *Force Application Device,* suitable to hold test probe securely and provide perpendicular movement into and away from MFS under test, and to apply all force data points.

6.4 *Resistance Measure Device,* that is, ohm meter. The device should not apply a voltage outside the operating range of the MFS contacts.

7. Procedure

7.1 *Pre-test Setup:*

7.1.1 Ensure that the test specimen is mounted securely to a rigid substrate.

7.1.2 Connect sensor terminals to resistance measuring device.

7.1.3 Record test probe diameter and durometer.

7.1.4 Position test probe over designated test area of sensor.

7.1.4.1 Record position of test probe on sensor (normally would be center of sensor).

7.1.5 Position probe until tip is just above the top surface of the sensor without touching.

7.1.6 Precondition sensor at a specified force between 5 to 25 cycles, and it is recommended that the instrument and test probe be used when practical.

7.2 *In-Process Test:*

7.2.1 Record resistance if measurable at $F0$ – static state (if not measurable resistance – record as "open").

7.2.1.1 Example 1: at $F0$, Rim = open

7.2.1.2 Example 2: at $F0$, $Fim = 0$, $Rim = 50$ K ohms.

7.2.2 Begin applying force to sensor (at a speed not to exceed analog to digital conversion or introduce noise through mechanical inertia through test probe – if using an automated system) until first measurable resistance on the resistance measurement device is registered.

7.2.2.1 Record force as *Fim*, and record resistance as *Rim*.

7.2.3 Continue applying force at predetermined force intervals.

7.2.3.1 Record data at first interval after *Fim* as $F1$, and corresponding resistance as $R1$.

7.2.3.2 Continue recording data at each force interval as $R2$, $F2$… Rx, Fx.

7.2.4 Continue applying force until *Fmaxs* is achieved or when there is no longer any appreciable change in resistance.

7.2.4.1 Record resistance at *Fmaxs* as *Rmaxs*.

8. Calculations

8.1 For pressure versus resistance (if desired)

8.2 Calculate pressure at all resistance measurements = F/Area of test probe tip.

8.2.1 Record as $P1$, $P2$…. Px.

9. Precision and Bias

9.1 *Precision*—It is not possible to specify the precision of the procedure in Test Method F3291 for measuring the force versus resistance because inter-laboratory studies have proven inconclusive due to insufficient participating laboratories with the appropriate equipment.

9.2 *Bias*—No information can be presented on the bias of the procedure in Test Method F3291 for measuring the force versus resistance because no standard sample is available for this industry.

10. Report

10.1 Report the following information:

10.1.1 Temperature,

10.1.2 Humidity,

10.1.3 Barometric pressure,

10.1.4 Probe material, diameter, Shore A hardness,

10.1.5 Description of test apparatus,

10.1.6 Description of test specimen and the location of test probe contact location on sensor; normally test would be center of sensor,

10.1.7 Probe tip area,

10.1.8 *Rim*,

10.1.9 *Fim*,

10.1.10 *Fmaxs*,

10.1.11 *Rmaxs*,

10.1.12 Resistance versus force data and pressure data (if required) – in table form (example Fig. 1) or plotted curves, or both (example Fig. 2 and Fig. 3),

10.1.13 Velocity of test probe if automated system is used,

10.1.14 Preconditioning force and number of cycles.