Designation: F3248 – 17

Standard Test Method for Determining Vertical Deformation and Area Deflection of Area Elastic, Point Elastic, Combined Elastic and Mixed Elastic Sport and Dance Surfaces[1]

This standard is issued under the fixed designation F3248; 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.

INTRODUCTION

This standard provides the methods to measure the deflective properties of a sports surface. These deflective properties provide estimates on the stability and comfort from a sport surface. Vertical deformation is a property that provides a quick and cost-effective means of estimating the stability that a sport surface provides during lower extremity loading. Area deflection is a property that provides a quick and cost-effective estimate of the vibration properties of a sports surface. Area deflection testing is limited to area elastic, combination elastic, and mixed elastic flooring systems. It is not applicable to natural turf, synthetic turf, or playground surfaces.

1. Scope

1.1 This method covers the quantitative measurement and normalization of deflections generated within a sports surface as an indication of the stability and comfort provided by the system.

1.2 Vertical deformation provides a measure for the vertical motion generated within the sports surface system directly below the point of impact which has been normalized to a standard impact force.

1.3 Area deflection provides a measure of the vibrations generated during an impact and their strength at a predetermined distance from the point of impact.

1.4 This method is not applicable to natural turf, synthetic turf or playground safety surfaces.

1.5 This method is applicable to indoor and outdoor surfaces including but not limited to: wood and synthetic courts, walk/jog/run tracks, tennis courts, dance surfaces, aerobics and general fitness surfaces.

1.6 The methods described are applicable in both laboratory and field settings.

1.7 Area deflection testing is optional, and only applicable to area-elastic, combined elastic and mixed elastic sport surfaces. These include wood surfaces, synthetic surfaces on a sprung wood subfloor, and point elastic surfaces with an internal area elastic component.

1.8 The values stated in SI units are to be regarded as standard. Units provided in parenthesis are informational only.

1.9 *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.*

1.10 *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:*[2]

F2569 Test Method for Evaluating the Force Reduction Properties of Surfaces for Athletic Use

2.2 *Other Standards:*

EN 14809 Surfaces for sports areas – Determination of vertical deformation

DIN 18032-2 Halls for Gymnastics, Games and Multipurpose Use, Part 2: Sports Floors Requirements, Testing

[1] This test method is under the jurisdiction of ASTM Committee F08 on Sports Equipment, Playing Surfaces, and Facilities and is the direct responsibility of Subcommittee F08.52 on Miscellaneous Playing Surfaces.

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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.

MFMA PUR™ Standard Performance and Uniformity Rating: Maple Flooring Manufacturer's Association, Inc.
FIBA Official Basketball Rules 20155 International Basketball Federation

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *area deflection, n*—downward vertical displacement a given distance (100 mm or 500 mm) from the center point of an impacted area expressed as a percent of the displacement produced at the center of the impacted area.

3.1.2 *area elastic sport surface, n*—sports surface of which a relatively large area around the point of an applied force is deflected (such as a wood floor).

3.1.3 *combination elastic sports surface, n*—sport surface with a point-elastic top layer over an area elastic subfloor which responds with both point and area elastic deflections under a point load (such as a padded urethane system over a wood subfloor system).

3.1.4 *mixed elastic sport surface, n*—point elastic system with an area-stiffening component (such as a vinyl surface over a thin steel sheet over a foam underlayment).

3.1.5 *point elastic sports surface, n*—sports surface of which only the area directly beneath, or very near, the point of an applied force is deflected (such as a pad and pour, poured urethane or vinyl).

3.1.6 *vertical deformation, n*—normalized displacement at the center of an impact point representing the downward displacement produced by a 1500 N vertical load.

4. Significance and Use

4.1 The dynamic interaction between the athlete and the surface is significant to the performance and comfort of the athlete. Therefore, the ability of the surface to deform under load is important. Too high a vertical deformation can affect the athlete through instability of the foot. Area elastic and combination elastic floors may be further characterized by evaluating the area deflection properties of the surface. Floors with low area deflection levels prevent or remove vibrations through damping mechanisms or design components.

4.2 Vertical deformation is a widely used and recognized property of sports surfaces. Governing bodies, trade associations, and a number of international standards recognize the significance of vertical deformation. A partial list of these organizations includes: FIBA, MFMA, ASTM, EN. Even FIFA utilizes a variation of this property. Area deflection is still commonly specified within North America and one governing body (FIBA) and one trade association (MFMA) currently use this property to certify systems within the required testing for their performance programs.

4.3 Vertical deformation and area deflection testing are performed with a Stuttgart Artificial Athlete (SAA) which can be created by slightly modifying the BAA (Berlin Artificial Athlete) from Test Method F2569. Laboratory experiments are to be conducted at the standard 23 ± 2°C (72 ± 4°F), but tests at additional temperatures may be performed at the request of the client. When evaluating the deflective properties of sports surfaces in the field, testing is to be conducted at the ambient temperature. Deviations from the standard temperature may cause significantly different performance levels.

5. Apparatus

5.1 This standard utilizes the SAA (Stuttgart Artificial Athlete). The SAA can be created by making the following modifications to the BAA (Berlin Artificial Athlete) described within Section 6 of Test Method F2569. The modified SAA is shown in Fig. 1.

5.2 *Modifications to BAA described in Test Method F2569:*

5.2.1 The spring in subsection 6.1.1.3 of Test Method F2569 shall be replaced with one with a spring rate 40 ± 1.5 kN/m (228 ± 8.6 lb/in.), an outside diameter of 70.0 ± 0.1 mm (2.75 ± 0.004 in.), a free length of 75 ± 10 mm (3.95 ± 0.39 in.).

5.2.2 The test foot described in subsection 6.1.1.6 of Test Method F2569 must include horizontal projections that extend a minimum of 135 mm (5.3 in.) out from the central fall axis of the drop mass.

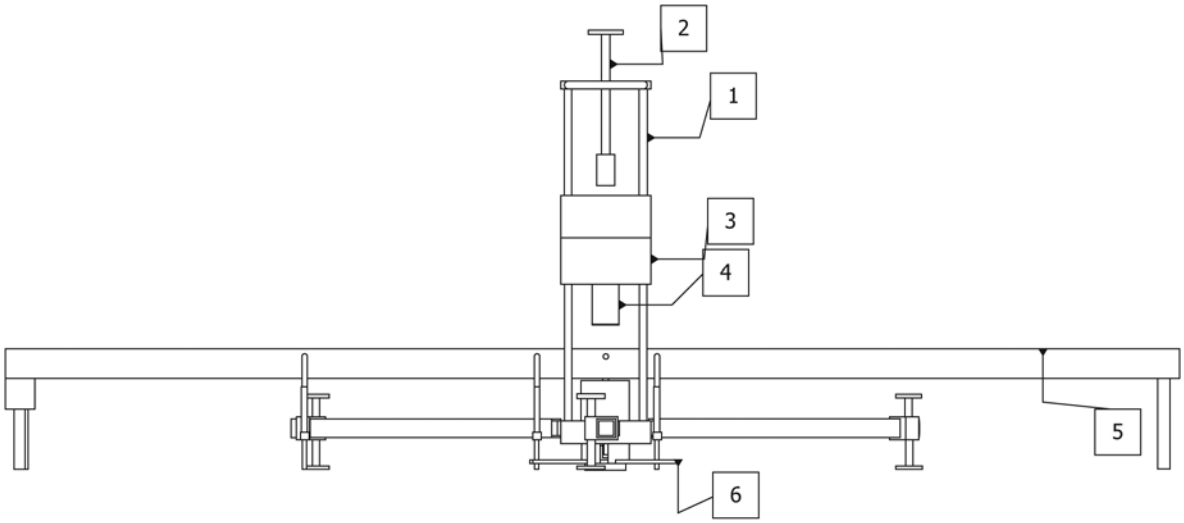
5.2.3 The mass of the test foot assembly, which includes force sensor, the spring, both spring end caps, shall be 3.5 ± 0.35 kg (7.72 ± 0.77 lb). It is possible to design one test foot that meets the requirements of Test Method F2569 and this standard.

5.3 *Additional Requirements:*

5.3.1 A separate stand that holds the linear position sensors used to measure the deflection of the sports surface must be utilized. This stand shall have a length of 2.25 ± 0.1 m (7.4 ± 0.33 ft) and each end of the stand shall be positioned a minimum of 1.0 m (39 in.) from the falling weight axis. The stand can be made such that it breaks down into shorter pieces for transport. Segments shall be constructed so that they form a rigid beam when re-assembled. The beam shall be made such that area deformation can be measured at 2 different distances from the point of impact, 500 and 100 mm away from the impact point.

5.3.2 Two electronic displacement sensors are required to measure the vertical deformation. Area deflection may be measured using only two displacement sensors but it requires rotating the sensors through the three different positions needed to calculate area deflection in all 4 directions around the impact point. The preferred method of measuring involves the use of 4 displacement sensors and allows all of the data needed to computer area deflection to be computed using data from the same impact. All displacement sensors shall have range of at least ±12 mm (0.39 to 0.5 in.) and an accuracy no larger than 0.05 mm (0.002 in.). Position Sensors are mounted on the stand described in 5.3.1. Sensors should interface with a data acquisition system with at least 12 bits of resolution, creating a resolution of 0.001 mm (0.0004 in.) or smaller. All displacement sensors shall be recorded at 2 kHz or twice the upper frequency response of the amplifier/filter system preceding the digital system, whichever is greater.

5.3.2.1 When measuring vertical deformation, the displacement sensors shall be mounted such that they contact the horizontal projections from 5.2.2, and must be mounted less than 125 mm from the falling weight vertical axis, as shown in Fig. 2.



1	=	Guide/rods
2	=	Lifting/release
3	=	Drop Weight
4	=	Striker
5	=	LVDT Support Beam
6	=	Test Foot (includes load cell, spring, tube, deflection plate)

FIG. 1 Vertical Deformation Test Apparatus – Front View

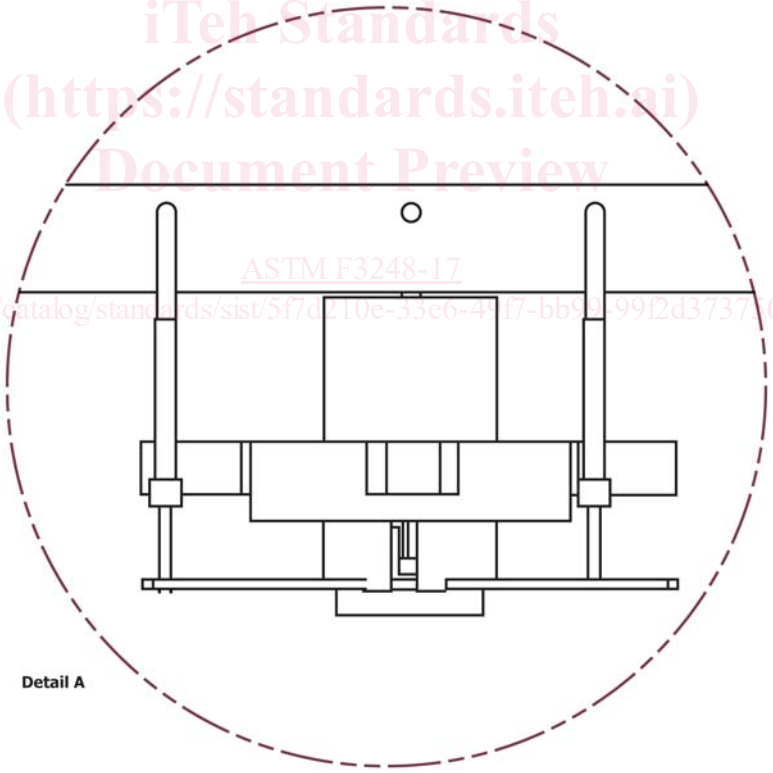


FIG. 2 Position of Linear Displacement Sensors on Horizontal Projections

5.3.2.2 When measuring area deflection, the displacement sensors shall be mounted with the appropriate distance of 100 mm for ^{w}100 and 500 mm for ^{w}500 to the falling weight axis depending on the surface being tested and the instructions from the client. They shall be mounted such that they contact the sports surface and that the two contact points form a 90° angle with each other through the vertical axis of the falling weight.

5.3.3 One force sensor with a full scale of 6000 N (1348 lb) and a resolution of greater than 12 bits, or any combination that results in a resolution of 1.46 N (0.33 lb) or less.

5.3.4 The SAA must be designed to generate a release height of at least 120 ± 0.25 mm (4.72 ± 0.0098 in.). Recording equipment shall be capable of storing data from all sensors for at least 0.15 s and to calculate data or display readings.

5.3.5 All position sensors (pick-ups) should be zeroed with the weight suspended from the electromagnet.

5.3.6 All sensors shall be recorded at 2 kHz or twice the upper frequency response of the amplifier/filter system preceding the digital system, whichever is greater. The signal from all sensors shall be filtered with a low-pass filter having a 2nd order Butterworth characteristic with a –3 dB frequency of 120 Hz. Filtration may be implemented in hardware or software. The response of the system at any given frequency shall be within ± 0.5 dB of the expected response, calculated on the basis of the Butterworth function. All sensors must have an uncertainty no greater than ±2 %.

5.3.7 The test program, or software, must be able to store and record the maximum force and deflections generated during the first impact, or approximately 0.2 s of data.

6. Testing Conditions

6.1 *Laboratory Conditions:*

6.1.1 *Temperature*—Testing performed in the lab shall be conducted at 23 ± 2°C (72 ± 4°F). Testing at additional temperatures can be evaluated at the request of the client.

6.1.2 *Relative Humidity*—The relative humidity of the lab shall be between 35 and 55 %.

6.2 *Sample Conditioning:*

6.2.1 Synthetic samples shall be conditioned to the laboratory environment for a minimum of 24 h.

6.2.2 Wood samples, or the components themselves (such as strip flooring, plywood, and sleepers) shall be conditioned to the laboratory environment for a minimum of 48 h. Once constructed wood samples must be monitored to ensure that they have not expanded or contracted so as to form a hump in the system, or loose boards within the playing surface.

6.3 *Laboratory Sample Sizes*—Standards that reference this method shall ensure that the sample size is sufficiently large and that test points are sufficiently far from the edge of the sample that edge effects are prevented from altering the outcome of the results. General recommendations are at least 1 by 1 m (29 by 39 in.) for point elastic systems, and at least 3.5 by 3.5 m for area, mixed, and combination elastic systems.

6.4 *On Site Testing:*

6.4.1 Tests on site shall be carried out at the ambient temperature and humidity conditions present. These values shall be measured 0.8 ± 0.1 m (31 ± 4 in.) above the playing surface, and they shall be recorded and reported. Some materials produce significantly different results for seemingly minor temperature changes.

6.4.2 The temperature of the surface shall be recorded using a temperature sensor, such as an Infrared temperature sensor.

6.4.2.1 There may be times when it is appropriate to record the internal temperature. Most indoor systems will not allow this without damaging the surface. Some systems such as a resilient track will allow internal temperature measurements to be made without damaging the surfaces.

6.4.2.2 Record the ambient temperature, the temperature of the surface, the internal temperature (if recorded) and the location that the measurements were made, either surface or internal.

7. Test Method

7.1 *General Test Methods*—Locate, identify and document all test points.

7.1.1 Be no closer than 150 mm (6 in.) to another test point.

7.2 *Vertical Deformation:*

7.2.1 *Description:*

7.2.1.1 Vertical Deflection results are reported in units of millimeters, and represent the magnitude of the negative vertical deformation of the point of impact under a 1500 N (337 lb) impact.

7.2.1.2 This test is performed with a Stuttgart Artificial Athlete (SAA). A modified version of the Berlin Artificial Athlete described in Test Method F2569 is shown in Fig. 1. A mass of 20 kg is allowed to fall on a spring, which transmits the load to a test foot with a rounded base resting on the surface. The foot is fitted with a force transducer which enables the force generated during the impact event to be recorded. The deformation of point of impact is measured by means of the simultaneously sampling the signal from the deformation sensors mounted so that they read the deformation of the test foot on opposite sides of the impact point.

7.2.2 *Test Method:*

7.2.2.1 The apparatus is set vertically (±2°) with the test foot resting directly on the test surface. The distance between the bottom of the drop weight and the top end-cap of the spring is adjusted to 120 ± 0.25 mm. The force gauge is described in 5.3.3, and the position sensors are described in 5.3.2 of this standard. The zero position of all displacement transducers shall be determined with the impact mass suspended from the electromagnet, and with the test foot resting on the sports surface.

7.2.2.2 Activate the recording and release the drop weight. Record the force and deformation of the surface generated by the first impact of the falling mass. The data from 0.025 s prior to initiation of the 1st impact and 0.125 s after the initiation of the first impact shall be used to determine the maximum force (F_{max}) and maximum deformation (d_{max}) at the test point generated during the impact.

7.2.2.3 Return the drop weight to the holding device and adjust the drop height as necessary. Without moving the test device, repeat this for a total of 3 impacts with a resting time between impacts of 1 min ± 30 s.

7.2.3 *Calculations: Vertical Deformation:*

7.2.3.1 The portion of the force and deflection curves collected during the first impact of the drop mass and the spring, as defined in 7.2.2.2 is to be isolated.

7.2.3.2 The signal from the two position sensors placed on the horizontal projections 125 mm from the impact, shall be averaged in the time domain. These signals are then used to obtain the maximum downward deflection of the sport surface at the point of impact. Obtain the maximum deflection at the