Contenu:

Le chapitre suivant contient les descriptions détaillées et techniques des méthodes d'essai pour les agrès gymnastiques pour lesquelles l'essai par une laboratoire de test officielle de la FIG est obligatoire. Concernant la codification des agrès, les mêmes abréviations comme dans chapitre II sont utilisées.
Comme ces explications s'adressent surtout aux autorités de la FIG, aux techniciens/-iennes, ingénieurs (femme), scientifiques de sport et aux laboratoires de test et départements de développement des firmes, elles sont formulées qu'en anglais.

IV-1 Sommaire des agrès avec abréviations, date de publication et équivalences éventuelles concernant les méthodes d'essai
IV-2 Spécifications de standard pour les agrès individuels

Contents:

Chapter IV comprises the detailed technical descriptions of the test procedures for those gymnastics apparatus for which a test at an official FIG test laboratory is obligatory. For identification of apparatus the same abbreviations as in chapter II are used.
Since the following explanations are primarily intended for FIG authorities, technicians, engineers and sports scientists, as well as for test laboratories and research departments of companies, they are published in English exclusively.

IV-1 Overview of the gymnastics apparatus, with abbreviations, date of publication and possible common test features
IV-2 Standard specifications for individual gymnastics apparatus

Inhalt:

Das folgende Kapitel IV umfasst die detaillierten, technischen Beschreibungen der Prüfverfahren für diejenigen Turngeräte, für die eine Prüfung an den offiziellen Prüfinstituten der FIG vorgeschrieben sind. Bei der Kennzeichnung der Turngeräte werden die gleichen Abkürzungen wie in Kapitel II verwendet.
Da sich die Ausführungen ausschließlich an FIG-Behörden, Testinstitute, Techniker, Ingenieure, Sportwissenschaftler und Entwicklungsabteilungen in Firmen richten, sind sie nur in Englisch abgefasst.

IV-1 Übersicht über die Turngeräte mit Abkürzungen, Erscheinungsdatum und eventuellen Äquivalenzen bezüglich der Prüfverfahren.
IV-2 Normspezifikationen für die einzelnen Turngeräte

FIG International Gymnastics Federation
Overview of the gymnastic apparatus with obligatory Tests
at FIG Test - Institutes

MAG	Apparatus	Code	Date of Issue	Equivalence
	Floor	MAG1	01.01.06	WAG4; ACRO1
	Pommel Horse	MAG2	01.12.94	
	Rings	MAG3	1989	
	Vaulting Table	MAG4	01.02.01	WAG1
	Parallel Bars	MAG5	01.01.97	
	High Bar	MAG6	29.03.96	
	Landing Mat 20cm	MAG11	01.08.96	WAG11; ACRO11
	Landing Mat 10cm	MAG12	12.07.89	
	Vaulting Board	MAG14	01.01.06	WAG14; TRA15

WAG	Apparatus	Code	Date of Issue	Equivalence
	Vaulting Table	WAG1	01.02.01	MAG4
	Uneven Bars	WAG2	01.05.93	
	Balance Beam	WAG3	01.12.94	
	Floor	WAG4	01.01.06	MAG1; ACRO1
	Landing Mat 20cm	WAG11	01.08.96	MAG11; ACRO11
	Vaulting Board	WAG14	01.01.06	MAG14; TRA15

RG	Apparatus	Code	Date of Issue	Equivalence
	Floor	RG1	01.12.92	

AER	Apparatus	Code	Date of Issue	Equivalence
	Floor	AER1	01.07.2000	

FIG International Gymnastics Federation
Overview of the gymnastic apparatus with obligatory Tests at FIG Test - Institutes

TRA	Apparatus	Code	Date of Issue	Equivalence
	Trampoline	TRA1	01.02.1995	
	Tumbling Track	TRA3	01.07.1996	
	Vaulting Board	TRA14	01.01.2006	MAG14; WAG14

ACRO	Apparatus	Code	Date of Issue	Equivalence
	Floor	ACRO1	01.01.2006	MAG1; WAG4
	Landing Mat 20cm	ACRO11	01.01.2000	MAG11; WAG11

IV
4

Standard Specification: Floors for Men Artistic Gymnastics

This standard is issued under the fixed designation FIG: IV-MAG1-01.01.1997; the numbers immediately following the designation indicate the date of original adoption by the FIG, or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories. This standard was originally published in English only.

Introduction

The objective of this FIG standard is to provide equal opportunities for all athletes in FIG competitions by controlling the functional properties of floors and to minimize any differences between competition and training equipment.

1 Scope

1.1 This specification covers the measurement of certain shock-absorbing characteristics, the impact force - time relationships, and the rebound properties of gymnastic floors. This standard specification is applicable to all gymnastic floors that are to be used at any FIG-sanctioned event.

1.2 This specification does not imply that an injury cannot be incurred while using a gymnastic floor which complies with this specification.

1.3 The test procedures associated with this standard may involve hazardous operations and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2 Normative References

2.1 Society of Automotive Engineers: SAE J211 Recommended Practice for Instrumentation for Impact Tests – Requirements for Channel Class 1000, October 1988.

2.2 International Gymnastics Federation (FIG): Apparatus Rules: II-MAG1.

3 Terminology

3.1 *Description of terms specific to this standard:*

3.1.1 *Acceleration:* The instantaneous time rate of change of velocity, expressed in m/s^2, which may be positive or negative.

3.1.2 *Base plane:* The starting reference plane of the gymnastic floor from which the total deflection and total height of rebound is determined. It is taken as the top plane of the gymnastic floor.

3.1.3 *Deflection:* The measured distance (in mm) between the base plane and the maximum displacement of the impactor below the base plane.

3.1.4 *Force (F):* The product of the mass of the impactor, expressed in kg, and the acceleration of the impactor, expressed in m/s^2.

3.1.5 *Maximum Force (F_{max}):* The maximum value of force measured during the impact and expressed in Newtons.

3.1.6 *Height of rebound:* The measured distance (in mm) between the base plane and the maximum displacement of the impactor above the base plane.

3.1.7 *Impactor:* The striking part of the test apparatus.

3.1.8 *Impact velocity:* The velocity of the impactor, expressed in m/s, immediately prior to crossing the base plane on impact.

3.1.9 *Theoretical drop height:* A calculated drop height which equates the measured velocity of the impactor at the moment of impact to a height that would generate the same velocity if the test were performed at sea level and there was no friction to retard the impactor during a drop from that height.

4 Principle of Measurement

4.1 A test specimen is impacted at a specified velocity with an impactor of given mass and geometry. A transducer mounted in the impactor monitors the acceleration – time history of the impactor which is recorded with the aid of a data acquisition system. An additional transducer may be used to monitor the displacement – time history of the impactor.

4.2 Dynamic data obtained during these procedures are indicative of the cushioning and rebound properties of the gymnastic floor and materials used in training and FIG-sanctioned competitions.

5 Performance Requirements

5.1 When tested according to the procedures described in Section 9, the overall mean values of the measured variables across all impact sites shall be within the figures of Table 1.

Table 1: Figures for Gymnastic Floors
x represents the mean value of the measured variable

Deflection (mm)	***Height of rebound (mm)***	***F_{max} (N)***
$69.5 \le x \le 75$	$245 \le x \le 335$	$x \le 4500$

6 Test Apparatus

6.1 *Impact test machine:* Any type of dynamic testing apparatus that is capable of impacting a test specimen at a prescribed impact velocity and monitoring and recording the acceleration - time history of the impactor is acceptable. The impact test machine and the impactor shall have sufficient rigidity to eliminate undesirable vibrations in the apparatus which might be recorded on the acceleration - time curve. The impact test machine shall also be designed in such a manner that only the impact face contacts the test specimen at any time during the test procedures.

6.2 *Impactor:* The impactor shall be 20 kg ± 0.2 kg and shall have a flat impact face with a 10 cm ± 0.5 cm diameter. The edge of the impactor face should be relieved to eliminate sharp edges. Provision shall be made so that the accelerometer can be securely fastened parallel to the vertical axis of the impactor with a maximum deviation of ± 5°.

6.3 *Recording equipment - The recording equipment shall meet the following criteria:*

6.3.1 *Acceleration - time:* The selection of the specific acceleration - time recording equipment, including transducers and recorders, is at the discretion of the test laboratory. However, the recording system shall have a frequency response adequate to measure the peak acceleration value to an accuracy of ± 5% of the true value. The total system, detection and recording, shall be capable of measuring impact accelerations of up to 200 g at frequencies from 2 to 1000 Hz to an accuracy of ± 5%. The minimum sampling rate of the data acquisition system shall be 5000 Hz.

6.3.2 *Displacement - time:* It is optional, but desirable, that the displacement - time history is recorded by a separate transducer. Any transducer that provides a linear signal proportional to the displacement of the impactor along the impact axis which can be monitored simultaneously with the acceleration - time trace is acceptable. If displacement is recorded, the test equipment shall have means to determine and record the top plane (base plane) of the test specimen from which the total deformation and rebound height are determined.

6.3.3 *Filtering:* The signal from all transducers shall be conditioned with a low pass filter which complies with Channel Class 1000 of SAE Recommended Practice J211. A fourth-order Butterworth low pass filter with a cut-off frequency of 1000 Hz meets this requirement.

7 Test Specimen

7.1 The test specimen submitted for testing shall represent the gymnastic floor as it is intended to be used during training and/or competition.

7.2 The test specimen shall comply with FIG Apparatus Rules: II-MAG1. Exception: See 7.3.

7.3 The minimum horizontal dimensions (length * width) for any test specimen shall be 200 cm * 120 cm.

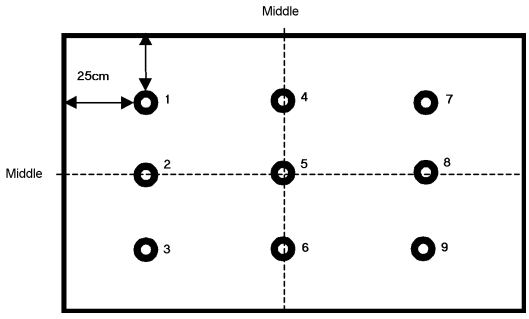
8 Conditioning and Test Temperature

8.1 Test specimens shall be preconditioned at 50% ± 10% relative humidity and 21° C ± 3° C for a minimum of 24 hours prior to the test. All testing shall be carried out under the same conditions.

9 Laboratory Procedure (Test Method)

9.1 *Impact locations:* A total of nine impact sites shall be designated on the test specimen. See Figure 1 for an illustration of the impact sites.

Figure 1: Impact Locations for Gymnastic Floors



9.2 *Impact test procedures:*

9.2.1 Place the test specimen under the impact test machine on a smooth, solid floor (concrete or metal plate) and orient the impactor such that the centre of the impact face will contact one of the designated impact test sites.

9.2.2 Raise the impactor to an appropriate drop height such that it will contact the test specimen with an impact velocity of 3.96 m/s ± 3%. This corresponds to a theoretical drop height of 0.8 m.

9.2.3 Release the impactor and capture the acceleration - time history and displacement - time history (if applicable) using recording equipment described in Section 6.3.

9.2.4 Upon completion of a given impact test, raise the impactor off the surface of the test specimen.

9.2.5 The duration between tests at a given impact site shall not be less than 120 seconds.

9.2.6 Each test specimen shall receive a total of 90 impacts. Impact each of the nine impact sites ten times.

9.3 *Calculations:*

9.3.1 Immediately following each test, record the following measurements: F_{max} (N), Deflection (mm) and Height of rebound (mm).

9.3.2 The last eight tests for each impact site shall be used to determine the arithmetic mean value of a measured variable for each impact site and for the overall mean value of a measured variable across all impact sites.

9.3.3 Calculate the mean values of Deflection, Height of rebound and F_{max} across all impact sites rounded to zero decimal places.

10 Report

10.1 *The test report shall include the following information:*

10.1.1 Complete identification of the tested gymnastic floor, including type, source, manufacturer's model number (if appropriate), dimensions of test specimen, and any other pertinent information. Photographs may be included in the test report for sample documentation purposes.

10.1.2 Test identification number according to the internal regulations between the FIG Test Institutes.

10.1.3 Complete identification of the testing laboratory including test technician and test laboratory manager (if appropriate).

10.1.4 Conditions of test, including test date, temperature and humidity.

10.1.5 Description of the impactor mass and the drop height conditions.

10.1.6 Description of the test results relative to the performance requirements identified in Section 5.

10.1.7 Mean values of Deflection, Height of rebound and F_{max} across all impact sites.

10.1.8 Maximum value, minimum value and standard deviation of Deflection, Height of rebound and F_{max} variables.

10.1.9 Mean values of Deflection, Height of rebound and F_{max} for the last eight tests at each impact site.

10.1.10 Deflection, Height of rebound and F_{max} values for all tests.

IV
4

Standard Specification: Pommel Horses for Men Artistic Gymnastics

This standard is issued under the fixed designation FIG: IV-MAG2-01.12.1994; the numbers immediately following the designation indicate the date of original adoption by the FIG, or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories. This standard was originally published in English only.

Introduction

The objective of this FIG standard is to provide equal opportunities for all athletes in FIG competitions by controlling the functional properties of pommel horses and to minimize any differences between competition and training equipment.

1 Scope

1.1 This specification covers the measurement of certain shock-absorbing and frictional characteristics of pommel horse bodies, as well as positional stability and frictional characteristics of pommels. This standard specification is applicable to all pommel horses that are to be used at any FIG-sanctioned event.

1.2 This specification does not imply that an injury cannot be incurred while using a pommel horse which complies with this specification.

1.3 The test procedures associated with this standard may involve hazardous operations and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2 Normative References

2.1 Society of Automotive Engineers: SAE J211 Recommended Practice for Instrumentation for Impact Tests – Requirements for Channel Class 1000, October 1988.

2.2 International Gymnastics Federation (FIG): Apparatus Rules: II-MAG2.

3 Terminology

3.1 *Description of terms specific to this standard:*

3.1.1 *Acceleration:* The instantaneous time rate of change of velocity, expressed in m/s^2, which may be positive or negative.

3.1.2 *Base plane:* The starting reference plane of the horse body from which the total deflection and total height of rebound is determined. It is taken as the top plane of the horse body.

3.1.3 *Deflection:* The measured distance (in mm) between the base plane and the maximum displacement of the impactor below the base plane.

3.1.4 *Force (F):* The product of the mass of the impactor, expressed in kg, and the acceleration of the impactor, expressed in m/s^2.

3.1.5 *Maximum Force (F_{max}):* The maximum value of force measured during the impact and expressed in Newtons.

3.1.6 *Height of rebound:* The measured distance (in mm) between the base plane and the maximum displacement of the impactor above the base plane.

3.1.7 *Impactor:* The striking part of the test apparatus.

3.1.8 *Impact velocity:* The velocity of the impactor, expressed in m/s, immediately prior to crossing the base plane on impact.

3.1.9 *Theoretical drop height:* A calculated drop height which equates the measured velocity of the impactor at the moment of impact to a height that would generate the same velocity if the test were performed at sea level and there was no friction to retard the impactor during a drop from that height.

3.1.10 *Slider:* A test body of given mass and geometry for measuring frictional characteristics of the horse body. The slider includes a test sole which is bonded to the bottom of the slider and is made of synthetic material with defined friction properties.

3.1.11 *Maximum traction force:* Maximum force, expressed in Newtons, applied during the pulling movement of the slider.

3.1.12 *Friction coefficient of horse body:* Quotient of the maximum traction force (in N) and the weight of the slider (in N).

3.1.13 *Displacement of pommels:* Relative and horizontal displacement (in mm) between a pair of pommels at a defined horizontal stretching force.

3.1.14 *Residual displacement of pommels:* Residual displacement (in mm) between the pommels after the removal of the stretching force.

3.1.15 *Testing belt:* A belt for measuring frictional properties of the pommels. The surface of the belt is made of synthetic material of defined frictional properties.

3.1.16 *Friction force of pommel:* The friction force, expressed in Newtons, generated by the contact of the testing belt and the specimen pommel.

3.1.17 *Friction coefficient of pommel:* Quotient of the friction force (in N) and the pulling-down weight of the testing belt (in N).

4 Principle of Measurement

4.1 *The complete test procedures include 4 parts:* Determination of shock absorption of horse body, determination of top friction of horse body, determination of positional stability of pommels, and determination of friction of pommels.

4.1.1 *Test A - Shock absorption of horse body:* A specimen horse body is impacted with an impactor of given mass and geometry at a specified velocity. A transducer mounted in the impactor monitors the acceleration – time history of the impactor which is recorded with the aid of a data acquisition system. An additional transducer may be used to monitor the displacement – time history of the impactor.

4.1.2 *Test B - Top friction of horse body:* A slider is pulled horizontally upon the surface of a specimen horse body at a defined loading rate. A transducer connected to the pulling cable monitors the maximum traction force generated during the pulling movement.

4.1.2.1 *Test C - Positional stability of pommels:* A pair of specimen pommels is stretched outward in the horizontal direction at a defined stretching force. The incremental displacement between the pommels during the time of force application is monitored. Residual displacement between the pommels is also monitored after the removal of the stretching force.

4.1.3 *Test D - Friction of pommels:* A testing belt is hung on a specimen pommel and pulled down at a defined weight. The frictional resistance force of the pommel is monitored.

4.2 Data obtained during these procedures are indicative of the cushioning properties and the top friction characteristics of the horse body and the positional stability and frictional properties of the pommels used in training and FIG-sanctioned competitions.

5 Performance Requirements

5.1 *Test A – Shock absorption of the horse body:* When tested according to the procedures described in Section 9.1, the values of the measured variables shall meet the performance requirements specified in Table 1.

5.2 *Test B – Top friction of the horse body:* When tested according to the procedures described in Section 9.2, the mean values of the measured variables shall meet the performance requirements specified in Table 2.

5.3 *Test C – Positional stability of the pommels:* When tested according to the procedures described in Section 9.3, the mean values of the measured variables shall be within the figures of Table 3.

Table 1: Figures for Test A – Shock absorption of the horse body
See Figure 1 for an illustration of the impact sites.
x represents the mean values of the measured variables

	Deflection (mm)	***Height of rebound*** (mm)	F_{max} (N)
Mean values across impact sites 1 to 5	$16 \le x \le 42$	$80 \le x \le 205$	$x \le 12000$
Difference between highest and lowest mean values on impact sites 1 to 5	≤ 16	≤ 130	≤ 2500

Table 2: Figures for Test B – Top friction of the horse body
x represents the mean value of the measured variable

	Friction coefficient of horse body
Mean value across test sites 1 to 3	$0.35 \le x \le 0.60$
Difference between highest and lowest mean value on test sites 1 to 3	≤ 0.05
Difference between mean values of orthogonal test directions	≤ 0.05

Table 3: Figures for Test C – Positional stability of the pommels
x represents the mean values of the measured variables

Displacement of pommels (mm)	$x \le 15.0$
Residual displacement of pommels (mm)	$x \le 1.0$

Table 4: Figures for Test D – Friction of the pommels
x represents the mean value of the measured variable

	Friction coefficient of pommel
Mean value of both pommels	$0.45 \le x \le 0.80$
Difference between two pommels	≤ 0.05

5.4 *Test D – Friction of the pommels:* When tested according to the procedures described in Section 9.4, the mean values of the measured variable shall be within the figures of Table 4.

6 Test Apparatus

6.1 *Test A – Shock absorption of horse body:*

6.1.1 *Impact test machine:* Any type of dynamic testing apparatus that is capable of impacting a test specimen at a prescribed impact velocity and monitoring and recording the acceleration - time history of the impactor is acceptable. The impact test machine and the impactor shall have sufficient rigidity to eliminate undesirable vibrations in the apparatus which might be recorded on the acceleration - time curve. The impact test machine shall also be designed in such a manner that only the impact face contacts the test specimen at any time during the test procedures.

6.1.2 *Impactor:* The impactor shall be 10 kg ± 0.1 kg and shall have a flat impact face with a 10 cm ± 0.5 cm diameter. The edge of the impactor face should be relieved to eliminate sharp edges. Provision shall be made so that the accelerometer can be securely fastened parallel to the vertical axis of the impactor with a maximum deviation of ± 5°.

6.1.3 *Recording equipment - The recording equipment shall meet the following criteria:*

6.1.3.1 *Acceleration - time:* The selection of the specific acceleration - time recording equipment, including transducers and recorders, is at the discretion of the test laboratory. However, the recording system shall have a frequency response adequate to measure the peak acceleration value to an accuracy of ± 5% of the true value. The total system, detection and recording, shall be capable of measuring impact accelerations of up to 200 g at frequencies from 2 to 1000 Hz to an accuracy of ± 5%. The minimum sampling rate of the data acquisition system shall be 5000 Hz.

6.1.3.2 *Displacement - time:* It is optional, but desirable, that the displacement - time history is recorded by a separate transducer. Any transducer that provides a linear signal proportional to the displacement of the impactor along the impact axis which can be monitored simultaneously with the acceleration - time trace is acceptable. If displacement is recorded, the test equipment shall have means to determine and record the top plane (base plane) of the test specimen from which the total deformation and rebound height are determined.

6.1.3.3 *Filtering:* The signal from all transducers shall be conditioned with a low pass filter which complies with Channel Class 1000 of SAE Recommended Practice J211. A fourth-order Butterworth low pass filter with a cut-off frequency of 1000 Hz meets this requirement.

6.2 *Test B - Top friction of the horse body:*

6.2.1 *Measurement device:* Any type of friction testing apparatus that is capable of pulling a slider on the surface of a specimen horse body at a given loading velocity is acceptable. During the test, the traction force – time history of the slider shall be monitored and recorded.

6.2.2 *Slider:* The slider shall have a mass of 5 kg ± 0.2 kg. A square-shaped test sole with a thickness of 10mm ± 0.5 mm and a size of 40 mm ± 1 mm shall be bonded to the bottom of the slider. The thickness of the test sole shall be decreased to 75% ± 5% of the original thickness at a pressure of 5 N/cm^2. The coefficient of static friction of the test sole shall be 0.25 ± 0.03.

6.2.3 The slider shall be pulled at a constant loading rate of 5 N/s ± 0.5 N/s.

6.2.4 *Recording equipment - The recording equipment shall meet the following criteria:*

6.2.4.1 *Force - time:* The selection of the specific force - time recording equipment, including transducer and recorder, is at the discretion of the test laboratory. The total system, detection and recording, shall be capable of measuring traction forces up to 100 N at frequencies from 2 to 100 Hz to an accuracy of ± 3%. The minimum sampling rate of the data acquisition system shall be 200 Hz.

6.3 *Test C - Positional stability of the pommels:*

6.3.1 *Measurement device:* Any type of static testing apparatus that is capable of stretching a pair of pommels outward in the horizontal direction with a given force, and monitors and records the static displacement between the pommels is acceptable.

6.3.2 *Static stretching force:* The static stretching force shall be 600 N ± 20 N, horizontally applied between the pommels.

6.3.3 *Recording equipment for the static displacement:* The selection of the specific measurement equipment is at the discretion of the test laboratory. However, the accuracy of the measurement shall be ± 0.1 mm.

6.4 *Test D - Friction of the pommels:*

6.4.1 *Measurement device:* Any type of friction testing apparatus that is capable of measuring the static friction force of a pommel is acceptable. A pommel shall be set like a pulley with a testing belt hung on it. One end of the testing belt shall be pulled by the weight of 5 kg ± 0.2 kg The traction force of the other end shall be measured. See Figure 4 for an illustration.

6.4.2 *Testing belt:* The width of the testing belt

shall be 20 mm ± 1 mm. The contacting side of the testing belt shall have a layer with a thickness of 10 mm ± 0.5 mm. .The thickness of the layer shall be decreased to 75% ± 5% of the original thickness at a pressure of 5 N/cm^2. The coefficient of static friction of the layer shall be 0.25 ± 0.03.

6.4.3 *Recording equipment for the static displacement:* The selection of the specific measurement equipment is at the discretion of the test laboratory. However, the system shall be capable of measuring traction force up to 100 N to an accuracy of ± 3%.

7 Test Specimen

7.1 The test specimen submitted for testing shall consist of a complete pommel horse as it is intended to be used during training and/or competition.

7.2 The test specimen shall comply with FIG Apparatus Rules: II-MAG2.

8 Conditioning and Test Temperature

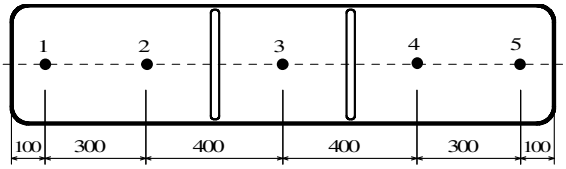
8.1 The test specimen shall be preconditioned at 50% ± 10% relative humidity and 21° C ± 3° C for a minimum of 24 hours prior to the test. All testing shall be carried out under the same conditions.

9 Laboratory Procedure (Test Method)

9.1 *Test A – Shock absorption of the horse body:*

9.1.1 *Impact sites:* A total of five impact sites shall be designated on the test specimen. See Figure 1 for an illustration of the impact sites.

Figure 1: Impact sites on the horse body (distances in mm)



9.1.2 *Impact test procedures:*

9.1.2.1 Place the test specimen under the impact test machine on a smooth, solid and horizontal floor (concrete or metal plate) and orient the impactor such that the centre of the impact face will contact one of the designated impact test sites.

9.1.2.2 Raise the impactor to an appropriate drop height such that it will contact the test specimen with an impact velocity of 2.80 m/s ± 3%. This corresponds to a theoretical drop height of 0.4 m.

9.1.2.3 Release the impactor and capture the acceleration - time history and displacement - time history (if applicable) using recording equipment described in Section 6.1.3.

9.1.2.4 Upon completion of a given impact test, raise the impactor off the surface of the test specimen.

9.1.2.5 The duration between tests at a given impact site shall not be less than 120 seconds.

9.1.2.6 Each test specimen shall receive a total of 50 impacts. Impact each of the five impact sites ten times.

9.1.3 *Calculations:*

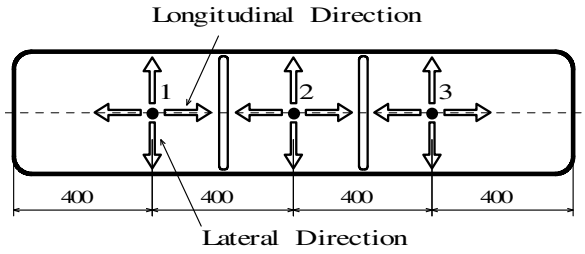
9.1.3.1 Immediately following each test, record the following measurements: Deflection (mm), Height of rebound (mm) and F_{max} (N).

9.1.3.2 The last eight tests for each impact site shall be used to determine the arithmetic mean value of a measured variable for each impact site and for the overall mean value of a measured variable across all impact sites.

9.2 Test B – Top friction of the horse body:

9.2.1 *Test sites and directions:* A total of three test sites shall be designated on the test specimen as illustrated in Figure 2. Four orthogonal test directions for the traction of the slider shall be also designated on each test site as illustrated in Figure 2.

Figure 2: Top friction test sites and directions on the horse body (distances in mm)



9.2.2 *Friction test procedures:*

9.2.2.1 Place the complete test specimen on a smooth, solid and horizontal floor.

9.2.2.2 Put the slider on the pommel horse in such a manner that the centre of its sole will contact one of the designated test sites, and also in such a manner that the pulling direction of the slider will conform to one of the designated test directions. Immediately prior to placing the slider, magnesium carbonate powder of 1g shall be spread on the surface of the test site. This shall be repeated prior to each test.

9.2.2.3 Pull the slider horizontally at a constant loading rate of 5 N/s ± 0.5 N/s and capture the traction force – time history using the recording equipment described in Section 6.2.4.

9.2.2.4 Repeat the procedure given in 9.2.2.2 and 9.2.2.3 five times at each test site and in each test direction.

9.2.2.5 Each test specimen shall receive a total of

60 friction test procedures.

9.2.3 *Calculations:*

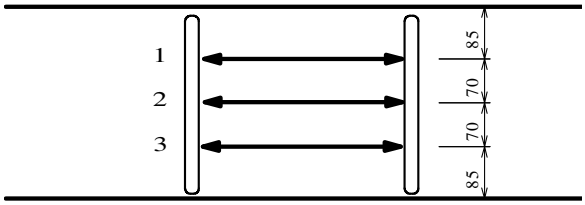
9.2.3.1 Immediately following each test, calculate and record the friction coefficient.

9.2.3.2 Determine the overall mean value of the friction coefficients across the test sites 1 to 3. Determine also the difference between the highest and the lowest mean value of the friction coefficient between all test sites, and the difference between mean values of the friction coefficients of orthogonal test directions between all test sites.

9.3 *Test C – Positional stability of the pommels:*

9.3.1 *Loading and measuring points:* A total of three pairs of loading points shall be designated on the test specimen as illustrated in Figure 3. The displacement shall be measured at these points.

Figure 3: Loading and measuring points of the pommels (distances in mm)



1, 2, 3 : Loading and measuring points

9.3.2 *Stretching test procedures:*

9.3.2.1 Place the complete test specimen on a smooth, solid and horizontal floor.

9.3.2.2 Set the loading device between the specimen pommels such that the loading axis will pass through one of the pairs of the loading points illustrated in Figure 3.

9.3.2.3 Stretch the specimen pommels horizontally up to the stretching force of 600 N ± 20 N and measure the incremental displacement between the specimen pommels using recording equipment described in Section 6.3.3. Measurement shall be done within 10 seconds after reaching the prescribed stretching force.

9.3.2.4 Measure the residual displacement between the specimen pommels 60 seconds after the removal of the stretching force.

9.3.2.5 Repeat the procedures given in 9.3.2.2, 9.3.2.3 and 9.3.2.4 at each of the specified loading points.

9.3.3 *Calculations:*

9.3.3.1 Immediately following each test, record the displacement of the pommels and the residual displacement of the pommels.

9.3.3.2 Determine the overall mean values of the measured variables for all loading points.

9.4 *Test D – Friction of the pommels:*

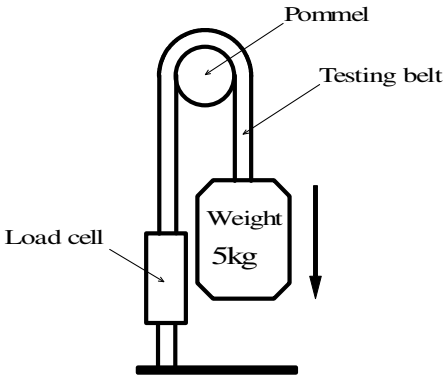
9.4.1 *Friction test procedures:*

9.4.1.1 Remove the specimen pommels from the horse body and fasten each pommel to the testing position such that the testing belt shall be hung on at the middle point of the specimen pommel.

9.4.1.2 Hang the testing belt on the pommel and connect one end of the testing belt to a transducer that can measure the traction force as illustrated in Figure 4. Immediately prior to hanging the testing belt, magnesium carbonate powder of 1 g shall be spread on the surface of the specimen pommel each time.

9.4.1.3 Pull the other end of the testing belt by the weight of 5 kg ± 0.2 kg and measure the traction force 10 seconds after weighting.

Figure 4: Setup of friction test of the pommels



9.4.1.4 Repeat the procedure given in 9.4.1.2 and 9.4.1.3 ten times for each pommel. Repeat the same procedure in the opposite frictional direction. A pair of specimen pommels shall receive a total of 40 friction test procedures.

9.4.2 *Calculations:*

9.4.2.1 Immediately following each test, record the traction force. The frictional force of the pommel is defined as the pulling weight minus the traction force. Use this value to calculate the friction coefficient of the pommel.

9.4.2.2 Determine the overall mean value of the friction coefficient for both pommels. Determine also the difference of the mean values of the friction coefficients between the two pommels.

9.5 Calculate the values of all required variables rounded to the decimal places of the corresponding

figures identified in Section 5.

10 Report

10.1 *The test report shall include the following information:*

10.1.1 Complete identification of the tested pommel horse, including type, source, manufacturer's model number (if appropriate), dimensions of test specimen, and any other pertinent information. Photographs may be included in the test report for sample documentation purposes.

10.1.2 Test identification number according to the internal regulations between the FIG Test Institutes.

10.1.3 Complete identification of the testing laboratory including test technician and test laboratory manager (if appropriate).

10.1.4 Conditions under which the tests were made, including test date, temperature and humidity.

10.1.5 Identification of performed parts of the test – Test A, Test B, Test C and Test D.

10.1.6 Description of the impactor mass and the drop height conditions (Test A), mass, loading rate of the slider (Test B), static load (Test C) and the weight of the testing belt (Test D).

10.1.7 Description of all test results related to the performance requirements identified in Section 5.

10.1.8 Supplemental description of the test results:

10.1.8.1 Maximum value, minimum value and standard deviation of deflection, height of rebound and F_{max} variables according to Test A.

10.1.8.2 Mean values of deflection, height of rebound and F_{max} for the last eight tests at each impact site according to Test A.

10.1.8.3 Deflection, height of rebound and F_{max} values for all tests according to Test A.

10.1.8.4 Mean values and standard deviations of the friction coefficient at each test site and direction according to Test B.

10.1.8.5 Friction coefficient values for all tests according to Test B.

10.1.8.6 Displacement of the pommels and residual displacement of the pommels for all loading points according to Test C.

10.1.8.7 Mean values and standard deviations of friction coefficient of each pommel and frictional direction according to Test D.

10.1.8.8 Friction coefficient values for all tests according to Test D.

Standard Specification: Rings for Men Artistic Gymnastics

This standard is issued under the fixed designation FIG: IV-MAG3-1989; the numbers immediately following the designation indicate the date of original adoption by the FIG, or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories. This standard was originally published in English only.

Introduction

The objective of this FIG standard is to provide equal opportunities for all athletes in FIG competitions by controlling the functional properties of rings and to minimize any differences between competition and training equipment.

1 Scope

1.1 This specification covers the inspection of stability for rings. This standard specification is applicable to all ring frames that are to be used at any FIG-sanctioned event.

1.2 This specification does not imply that an injury cannot be incurred while using a ring frame which complies with this specification.

1.3 The test procedures associated with this standard may involve hazardous operations and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2 Normative References

2.1 International Gymnastics Federation (FIG): Apparatus Rules: II-MAG3

3 Terminology

3.1 *Description of terms specific to this standard:*

3.1.1 *Static tractive force*: The predetermined value of force exerted on one ring while pulling the ring vertically downwards.

3.1.2 *Starting position:* The vertical position of the unloaded ring within the mounted ring frame before loading it with a defined static tractive force. The lower inner side of the ring shall serve as the point of reference.

4 Principle of Measurement

4.1 The rings of a mounted ring frame are pulled vertically downwards with a predetermined static tractive force. After the release of the static tractive force the rings must return into the starting position.

5 Performance Requirements

When tested according to the procedures described in Section 9, the rings shall return into the starting position within a tolerance of 5mm and no damage or residual deflection shall be observable.

6 Test Set-up and Apparatus

6.1 Any type of test set-up is acceptable that is capable to stress the test specimen under prescribed conditions.

6.2 The device which applies the test load to the ring shall have a width of 35mm ± 1mm.

7 Test Specimen

7.1 The test specimen submitted for testing shall consist of a complete ring frame as it is intended to be used during training and/or competition.

7.2 The test specimen shall comply with FIG Apparatus Rules: II-MAG3.

8 Conditioning and Test Temperature

8.1 The ring frame, mounted and assembled for use, shall be preconditioned at 50% ± 10% relative humidity and 21° C ± 3° C for a minimum of 24 hours prior to the test. All testing shall be carried out under the same conditions.

9 Laboratory Procedure (Test Method)

9.1 Mount the ring frame with the rings at a height as prescribed for competitions (Part II).

9.2 Install the traction device on one ring and determine the starting position.

9.3 Pull the ring vertically downwards with a static tractive force of 4000 N ± 40 N.

9.4 After the release of the static tractive force verify whether the ring returns into the starting position. Report any fraction or observed permanent deflection in any part of the test specimen.

9.5 Repeat the procedure given in 9.3 to 9.5 for the other ring.

10 Report

10.1 *The test report shall include the following information:*

10.1.1 Complete identification of the tested ring frame, including type, source, manufacturer's model number (if appropriate), dimensions of test specimen,

and any other pertinent information. Photographs may be included in the test report for sample documentation purposes.

10.1.2 Test identification number according to the internal regulations between the FIG Test Institutes.

10.1.3 Complete identification of the testing laboratory including test technician and test laboratory manager (if appropriate).

10.1.4 Conditions of test, including test date, temperature and humidity.

10.1.5 Test height of the rings and cable tension of the mounted and unloaded ring frame.

10.1.6 Description of the static tractive force.

10.1.7 Description whether fracture or other damage has occurred or if any permanent deformation has been observed after the test.

Standard Specification: Vaulting Tables for Men Artistic Gymnastics

This standard is issued under the fixed designation FIG: IV-MAG4new-01.02.2001; the numbers immediately following the designation indicate the date of original adoption by the FIG, or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories. This standard was originally published in English only.

Introduction

The objective of this FIG standard is to provide equal opportunities for all athletes in FIG competitions by controlling the functional properties of vaulting tables and to minimize any differences between competition and training equipment.

1 Scope

1.1 This specification covers the measurement of the profile dimensions, certain shock-absorbing characteristics, the impact force - time relationships, and the rebound properties of vaulting tables. This standard specification is applicable to all vaulting tables that are to be used at any FIG-sanctioned event.

1.2 This specification does not imply that an injury cannot be incurred while using a vaulting table which complies with this specification.

1.3 The test procedures associated with this standard may involve hazardous operations and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2 Normative References

2.1 Society of Automotive Engineers: SAE J211 Recommended Practice for Instrumentation for Impact Tests – Requirements for Channel Class 1000, October 1988.

2.2 International Gymnastics Federation (FIG): Apparatus Rules: II-MAG4new.

3 Terminology

3.1 *Description of terms specific to this standard:*

3.1.1 *Acceleration:* The instantaneous time rate of change of velocity, expressed in m/s^2, which may be positive or negative.

3.1.2 *Starting position of an impact site:* The vertical position of an impact site at the surface of an unloaded vaulting table from which the total deflection and total height of rebound is determined.

3.1.3 *Deflection:* The measured distance (in mm) between the starting position of an impact site and the maximum displacement of the impactor below the starting position of an impact site.

3.1.4 *Force (F):* The product of the mass of the impactor, expressed in kg, and the acceleration of the impactor, expressed in m/s^2.

3.1.5 *Maximum Force (F_{max}):* The maximum value of force measured during the impact and expressed in Newtons.

3.1.6 *Height of rebound:* The measured distance (in mm) between the starting position of an impact site and the maximum displacement of the impactor above the starting position of an impact site.

3.1.7 *Impactor:* The striking part of the test apparatus.

3.1.8 *Impact velocity:* The velocity of the impactor, expressed in m/s, immediately prior to crossing the starting position of an impact site on impact.

3.1.9 *Theoretical drop height:* A calculated drop height which equates the measured velocity of the impactor at the moment of impact to a height that would generate the same velocity if the test were performed at sea level and there was no friction to retard the impactor during a drop from that height.

4 Principle of Measurement

4.1 A test specimen is impacted at a specified velocity with an impactor of given mass and geometry. A transducer mounted in the impactor monitors the acceleration – time history of the impactor which is recorded with the aid of a data acquisition system. An additional transducer may be used to monitor the displacement – time history of the impactor.

4.2 Dynamic data obtained during these procedures are indicative of the cushioning and rebound properties of vaulting tables used in training and FIG-sanctioned competitions.

5 Performance Requirements

5.1 When tested according to the procedures described in Section 9, the overall mean values and maximum ranges of the measured variables across all impact sites shall be within the figures of Table 1.

Table 1: Figures for Vaulting Tables
x represents the mean value of the measured variable

	Deflection (mm)	*Height of rebound (mm)*	F_{max} *(N)*
Mean value	$34 \le x \le 44$	$120 \le x \le 180$	$x \le 2500$
Max. range	≤ 10	≤ 75	≤ 550

6 Test Apparatus

6.1 *Profile dimension test device:* The selection of the specific profile dimension test device, including transducers and recorders, is at the discretion of the test laboratory. However, the recording system shall be capable of measuring profile dimensions at specific measurement points orthogonal to the given standard profile line to an accuracy of ± 0.5 mm. The total system, detection and recording, shall be capable of measuring proportional profile dimensions at specific measurement lines (see Section 9.1).

6.2 *Impact test machine:* Any type of dynamic testing apparatus that is capable of impacting a test specimen at a prescribed impact velocity monitoring and recording the acceleration - time history of the impactor is acceptable. The impact test machine and the impactor shall have sufficient rigidity to eliminate undesirable vibrations in the apparatus which might be recorded on the acceleration - time curve. The impact test machine shall also be designed in such a manner that only the impact face contacts the test specimen at any time during the test procedures.

6.3 *Impactor:* The impactor shall be 10 kg ± 0.1 kg and shall have a flat impact face with a 10 cm ± 0.5 cm diameter. The edge of the impactor face should be relieved to eliminate sharp edges. Provision shall be made so that the accelerometer can be securely fastened parallel to the vertical axis of the impactor with a maximum deviation of ± 5°.

6.4 *Recording equipment - The recording equipment shall meet the following criteria:*

6.4.1 *Acceleration - time:* The selection of the specific acceleration - time recording equipment, including transducers and recorders, is at the discretion of the test laboratory. However, the recording system shall have a frequency response adequate to measure the peak acceleration value to an accuracy of ± 5% of the true value. The total system, detection and recording, shall be capable of measuring impact accelerations of up to 200 g at frequencies from 2 to 1000 Hz to an accuracy of ± 5%. The minimum sampling rate of the data acquisition system shall be 5000 Hz.

6.4.2 *Displacement - time:* It is optional, but desirable, that the displacement - time history is recorded by a separate transducer. Any transducer that provides a linear signal proportional to the displacement of the impactor along the impact axis which can be monitored simultaneously with the acceleration - time trace is acceptable. If displacement is recorded, the test equipment shall have means to determine and record the starting position of an impact site from which the total deformation and rebound height are determined.

6.4.3 *Filtering:* The signal from all transducers shall be conditioned with a low pass filter which complies with Channel Class 1000 of SAE Recommended Practice J211. A fourth-order Butterworth low pass filter with a cut-off frequency of 1000 Hz meets this requirement.

7 Test Specimen

7.1 The test specimen submitted for testing shall consist of a complete vaulting table as it is intended to be used during training and/or competition.

7.2 The test specimen shall comply with FIG Apparatus Rules: II-MAG4new.

7.3 The profile dimensions of the test specimen shall be inspected according to the procedures described in Section 9.1.

8 Conditioning and Test Temperature

8.1 Test specimens shall be preconditioned at 50% ± 10% relative humidity and 21° C ± 3° C for a minimum of 24 hours prior to the test. All testing shall be carried out under the same conditions.

9 Laboratory Procedure (Test Method)

9.1 *Profile dimension measurement:*

9.1.1 *Measurement locations:* A total of 42 measurement points (MP) on five measurement lines are used to inspect the profile dimensions. In longitudinal direction there are 14 measurement points on the center measurement line of the test specimen (MP1 and MP16 are not required for standardization). In transversal direction there are 28 measurement points, seven at each measurement line (four transversal lines, orthogonal crossing the center measurement line at MP4, MP5, MP7 and MP9). See Figures 1-3 for illustrations of the measurement points.

9.1.2 *Profile dimension measurement procedures:*

9.1.2.1 Place the test specimen under the profile dimension test device on a horizontal, smooth and solid floor.

9.1.2.2 Determine the proportional profile dimensions for each measurement line (four transversal profiles and one longitudinal profile).

9.1.3 *Determination of the orthogonal deviations to*

the standard profile (in orientation of the designated arrows in Figures 1 and 3):

9.1.3.1 *Longitudinal direction:* Compare the actual profile to the standard profile by crossing (overlaying) the profiles in MP5 and MP14 (i.e. the deviation in these measurement points is set to zero by shifting the profiles in horizontal and vertical direction without rotation). Calculate the deviations at the remaining measurement points.

9.1.3.2 *Transversal direction:* Compare the actual profile to the standard profile for each transversal measurement line by crossing (overlaying) the profiles in the center measurement point N4 (i.e. the deviation in this measurement points is set to zero by shifting the profiles in horizontal and vertical direction without rotation). Calculate the deviations at the remaining measurement points.

Figure 1: Dimension Measurement Locations for Vaulting Tables – Measurement Points on Center Line in Longitudinal Direction (MP1 – MP16)
(Side view - distances in cm)

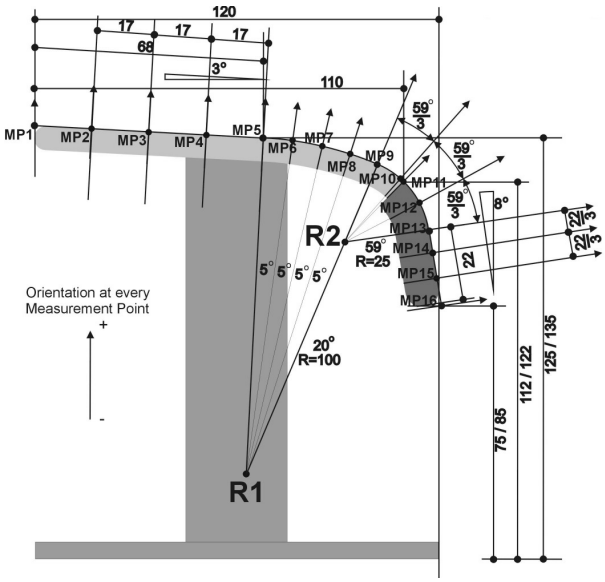


Figure 2: Dimension Measurement Locations for Vaulting Tables – Measurement Lines in Transversal Direction (Line MP4 / MP5 / MP7 / MP9)
(Frontal view - distances in cm)

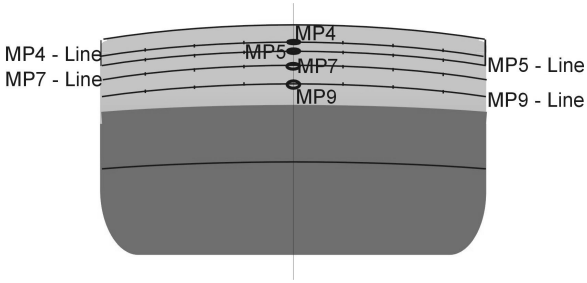
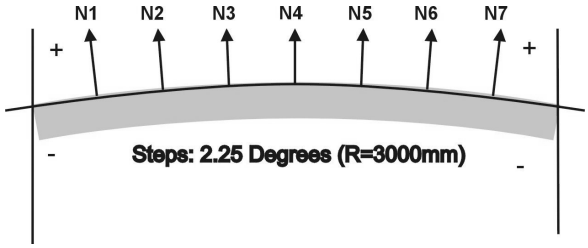
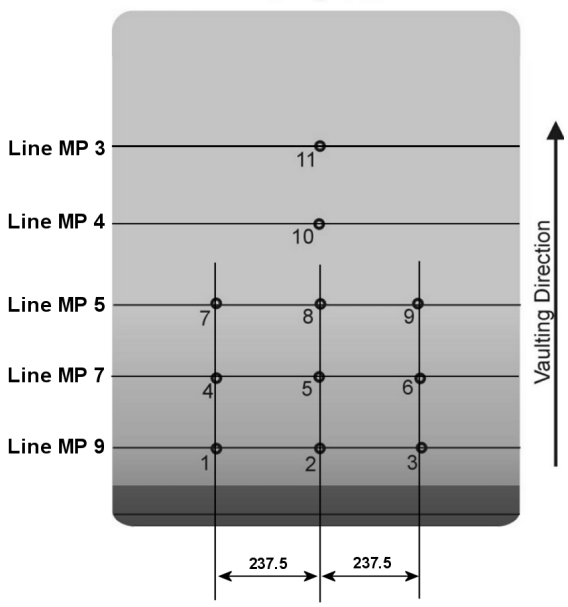


Figure 3: Dimension Measurement Locations for Vaulting Tables – Measurement Points on Measurement Lines in Transversal Direction (N1 – N7)
(Transverse section)



9.2 *Impact locations:* A total of eleven impact sites shall be designated on the test specimen. See Figure 4 for an illustration of the impact sites.

Figure 4: Impact Locations for Vaulting Tables
(Oversight view - distances in mm)



9.3 *Impact test procedures:*

9.3.1 Place and tilt the test specimen under the impact test machine such that the centre of the impact face of the impactor will contact one of the designated impact test sites perpendicular to the surface of the vaulting table. See Figures 5-7 for illustrations of the tilted test positions. It is optional, but desirable, to enable the necessary tilt angles of the test specimen by attaching the test specimen to a smooth, solid metal plate with the same inclination.

Figure 5: Impact Test Setup for Test Points 1,2,3

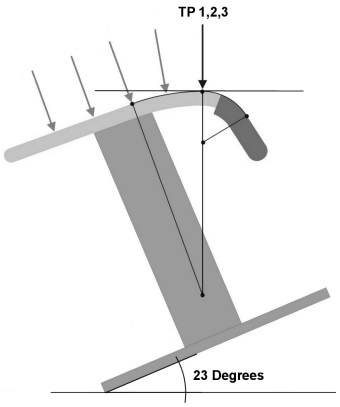


Figure 6: Impact Test Setup for Test Points 4,5,6

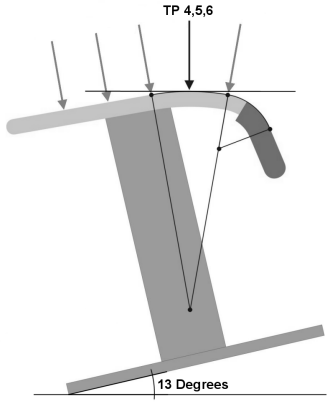
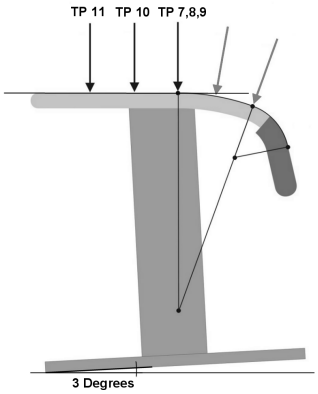


Figure 7: Impact Test Setup for Test Points 7 – 11



9.3.2 Raise the impactor to an appropriate drop height such that it will contact the test specimen with an impact velocity of 2.80 m/s ± 3 %. This corresponds to a theoretical drop height of 0.4 m.

9.3.3 Release the impactor and capture the acceleration - time history and displacement - time history (if applicable) using recording equipment described in Section 6.4.

9.3.4 Upon completion of a given impact test, raise the impactor off the surface of the test specimen.

9.3.5 The duration between tests at a given impact site shall not be less than 120 seconds.

9.3.6 Each test specimen shall receive a total of 110 impacts. Impact each of the eleven impact sites ten times.

9.4 *Calculations:*

9.4.1 Immediately following each test, record the following measurements: F_{max} (N), Deflection (mm) and Height of rebound (mm).

9.4.2 The last eight tests for each impact site shall be used to determine the arithmetic mean value of a

measured variable for each impact site and for the overall mean value of a measured variable across all impact sites.

9.4.3 Calculate the mean values of Deflection, Height of rebound and F_{max} across all impact sites rounded to zero decimal places.

10 Report

10.1 *The test report shall include the following information:*

10.1.1 Complete identification of the tested vaulting table, including type, source, manufacturer's apparatus denomination, manufacturer's model number (if appropriate), dimensions of test specimen, and any other pertinent information. Photographs may be included in the test report for sample documentation purposes.

10.1.2 Description of the profile dimensions relative to the requirements in FIG Apparatus Rules: II-MAG4new.

10.1.3 Test identification number according to the internal regulations between the FIG Test Institutes.

10.1.4 Complete identification of the testing laboratory including test technician and test laboratory manager (if appropriate).

10.1.5 Conditions of test, including test date, temperature and humidity.

10.1.6 Description of the impactor mass and the drop height conditions.

10.1.7 Description of the test results relative to the performance requirements identified in Section 5.

10.1.8 Mean values of Deflection, Height of rebound and F_{max} across all impact sites.

10.1.9 Maximum value, minimum value and standard deviation of Deflection, Height of rebound and F_{max} variables.

10.1.10 Mean values of Deflection, Height of rebound and F_{max} for the last eight tests at each impact site.

10.1.11 Deflection, Height of rebound and F_{max} values for all tests.

Standard Specification: Parallel Bars for Men Artistic Gymnastics

This standard is issued under the fixed designation FIG: IV-MAG5-01.01.1997; the numbers immediately following the designation indicate the date of original adoption by the FIG, or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories. This standard was originally published in English only.

Introduction

The objective of this FIG standard is to provide equal opportunities for all athletes in FIG competitions by controlling the functional properties of parallel bars and to minimize any differences between competition and training equipment.

1 Scope

1.1 This specification covers the measurement of certain static stiffness properties, dynamic force - time and displacement - time relationships as well as oscillation and stability characteristics of parallel bars. This standard specification is applicable to all parallel bars that are to be used at any FIG-sanctioned event.

1.2 This specification does not imply that an injury cannot be incurred while using parallel bars which comply with this specification.

1.3 The test procedures associated with this standard may involve hazardous operations and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2 Normative References

2.1 International Gymnastics Federation (FIG): Apparatus Rules: II-MAG5.

2.2 International Gymnastics Federation (FIG): Apparatus Rules: IV-MAG6.

3 Terminology

3.1 *Description of terms specific to this standard:*

3.1.1 *Bar linkage:* A rigid mechanical linkage between both bars of a parallel bars to exert equal forces simultaneously on both bars.

3.1.2 *Static tractive force*: The predetermined value of force (in N) exerted on the midpoint of the bar, pulling the bar vertically downwards.

3.1.3 *Starting position:* The position of an unloaded bar or an unloaded bar linkage from which the total deflection in vertical direction is determined. The midpoint of the bar or the bar linkage shall serve as the point of reference for the measurements.

3.1.4 *Deflection:* The measured distance (in mm) between the starting position and the maximum displacement of the midpoint of the bar or the bar linkage in vertical direction.

3.1.5 *Definition of spatial dimensions and test directions*: For the determination of the vertical deflection of the midpoint of the bar or the bar linkage the spatial dimensions are defined as illustrated in Figure 1 to 3. The test directions are defined as illustrated in Figure 4.

3.1.6 *Pendulum:* Tubular test body of given dimensions and mass with an additional low-friction falling weight inside. The test body is attached to a bar or a bar linkage with the help of two inflexible grasping arms, each of which is at the same distance from the midpoint of the bar or the bar linkage, guaranteeing a low-friction rotation of the test body about the longitudinal axis of the bar or the bar linkage.

Figure 1: Definition of Spatial Dimensions
Test position: Middle of bars (lateral)
(Pendulum in horizontal position before release)

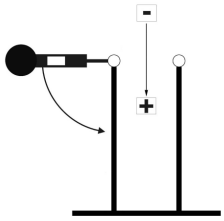


Figure 2: Definition of Spatial Dimensions
Test position: Middle of bars (transversal)
(Pendulum in horizontal position before release)

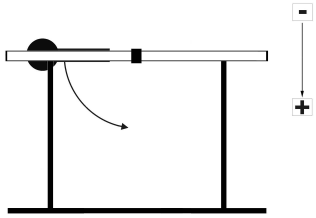


Figure 3: Definition of Spatial Dimensions
Test position: End of bars (transversal)
(Pendulum in horizontal position before release)

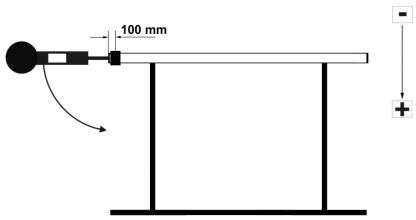
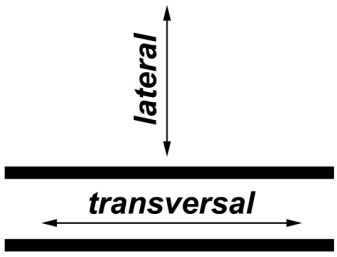


Figure 4: Definition of Test Directions



3.1.7 *Maximum Force (F_{max}):* The maximum value of the reaction force in the direction of the pendulum's centre of gravity measured as the sum of the forces exerted on both grasping arms during the pendulum swing, expressed in Newtons.

3.1.8 *Hanging position:* Stable equilibrium position of the hanging pendulum under gravity conditions only.

3.1.9 *Horizontal position:* Position of the attached pendulum rectangular to the hanging position.

3.1.10 *Additional falling weight:* Cylindrical test body of given dimensions and mass inside the pendulum producing an additional impact stress on the gymnastic apparatus during pendulum swing.

3.1.11 *Internal drop height:* Predetermined sliding distance of the additional falling weight inside the pendulum.

3.1.12 *Initial tension:* Predetermined value of the force (in N) exerted on the bar or the bar linkage, composed of the gravity of the attached pendulum and an additional tractive force pulling the bar-pendulum system vertically downwards.

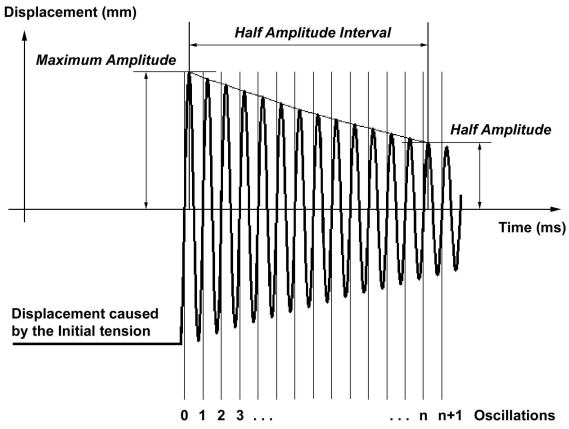
3.1.13 *Frequency of oscillation:* Reciprocal of the value determined by the duration of the half amplitude interval divided by the number of oscillations of the bar-pendulum system within the half amplitude interval. The frequency is expressed in Hertz. See Figure 5 for illustration of the frequency determination.

3.1.14 *Maximum amplitude:* Value of the amplitude (in mm) of the first oscillation of the bar-pendulum system after the release of the initial tension.

3.1.15 *Half amplitude:* Value of the amplitude (in mm) of the first oscillation which is equal to or less than half the maximum amplitude.

3.1.16 *Half amplitude interval:* Duration of oscillation (in ms) between the passage of the maximum amplitude and the reaching of the half amplitude. See Figure 5 for illustration.

Figure 5: Oscillation Damping Parameters



4 Principle of Measurement

4.1 *The complete measurement is composed of four specific test procedures:*

4.1.1 *Test A - Static traction stress:* A bar of a mounted apparatus is pulled vertically downwards with a predetermined static tractive force. A measuring device mounted on the bar monitors the displacement - time history of the midpoint of the bar caused by this force. The maximum deflection is recorded with the aid of a data acquisition system. After the release of the static tractive force the bar must return into the starting position.

4.1.2 *Test B - Stress by pendulum swing:* A pendulum which is attached to a bar or a bar linkage of a mounted apparatus is rotated from hanging position into horizontal position and then released. While it swings down, an additional falling weight inside the tubular pendulum slides down from a predetermined internal drop height until the weight strikes against the inside bottom of the pendulum, producing an additional impact stress on the gymnastic apparatus. A measuring device monitors the displacement - time history of the midpoint of the bar or the bar linkage. Load cells inside both pendulum grasping arms moni-

tor the reaction force - time history of the pendulum. Both are recorded with the aid of a data acquisition system. The test measures the maximum reaction force in the direction of the pendulum's centre of gravity and the positive deflection of the bar or the bar linkage in vertical direction.

4.1.3 *Test C - Oscillation damping:* A pendulum which is attached to a bar or a bar linkage of a mounted apparatus is pulled vertically downwards until a predetermined initial tension is reached. The abrupt release causes a damped oscillation of the bar-pendulum system. A measuring device monitors the displacement - time history of the midpoint of the bar or the bar linkage which is recorded with the aid of a data acquisition system. The test measures the frequency as well as the half amplitude interval of the oscillation.

4.1.4 *Test D - Lateral stability:* One bar of a parallel bars which is ensured against sideward slipping is pulled horizontally in lateral direction until a predetermined inclination of the parallel bars is reached. A load cell inside the towing cable monitors the tractive force - time history which is recorded with the aid of a data acquisition system. The test measures the tractive force in the predetermined inclination position of the parallel bars.

4.2 Static and dynamic data obtained during these procedures are indicative of the static stiffness, elastic, damping, oscillation and stability properties of parallel bars used in training and FIG-sanctioned competitions.

5 Performance Requirements

5.1 *Test A - Static traction stress:* When tested according to the procedures described in Section 9.2, the value of the measured variable shall be within the figures of Table 1.

Table 1: Figure for Test A – Static traction stress
x represents the measured variable

Test A: Static traction stress	
Deflection (mm)	$50 \le x \le 70$

5.2 *Test B - Stress by pendulum swing:* When tested according to the procedures described in Section 9.3, the mean values of the measured variables shall be within the figures of Table 2.

Table 2: Figures for Test B – Stress by pendulum swing
x represents the mean value of the measured variable

Test B: Stress by pendulum swing	
Middle of bars (lateral)	
F_{max} (N)	$x \le 2300$
Positive vertical deflection (mm)	$85 \le x \le 115$
Middle of bars (transversal)	
F_{max} (N)	$x \le 2750$
Positive vertical deflection (mm)	$62 \le x \le 77$
End of bars (transversal)	
F_{max} (N)	$x \le 3000$
Positive vertical deflection (mm)	$63 \le x \le 73$

5.3 *Test C - Oscillation damping:* When tested according to the procedures described in Section 9.4, the mean values of the measured variables shall be within the figures of Table 3.

Table 3: Figures for Test C – Oscillation damping
x represents the mean value of the measured variable

Test C: Oscillation damping	
Middle of bars (lateral)	
Frequency of oscillation (Hz)	$3.00 \le x \le 3.60$
Half amplitude interval (ms)	$400 \le x \le 2750$
Middle of bars (transversal)	
Frequency of oscillation (Hz)	$4.00 \le x \le 4.80$
Half amplitude interval (ms)	$400 \le x \le 2500$
End of bars (transversal)	
Frequency of oscillation (Hz)	$3.80 \le x \le 5.00$
Half amplitude interval (ms)	$400 \le x \le 1200$

5.4 *Test D - Lateral stability:* When tested according to the procedures described in Section 9.5., the value of the measured variable shall be within the figure of Table 4. If the parallel bars do not meet this requirement the manufacturer and the appropriate FIG authorities will be informed that at all FIG sanctioned competitions and events, the parallel bars must be fixed to the floor.

Table 4: Figure for Test D – Lateral Stability
x represents the measured variable

Test D: Lateral stability	
Tractive force (N)	$x \ge 900$

6 Test Set-up and Apparatus

6.1 *Set-up for Test A - Static traction stress*: Any type of test set-up is acceptable that is capable to stress the test specimen under prescribed conditions

and monitoring and recording the displacement - time history of the midpoint of the bar.

6.2 *Set-up for Test B - Stress by pendulum swing:* Any type of test set-up is acceptable that is capable of stressing the test specimen with a pendulum swing under prescribed conditions and monitoring and recording the displacement - time history of the midpoint of the bar or the bar linkage and the reaction force - time history of the pendulum. It is optional, but desirable, that the pendulum is released from a magnet in the horizontal position.

6.3 *Set-up for Test C - Oscillation damping*: Any type of test set-up is acceptable that is capable of stressing a bar-pendulum system under prescribed conditions and monitoring and recording the displacement - time history of the midpoint of the bar or the bar linkage. It is optional, but desirable, that the bar-pendulum system is released from a magnet at the prescribed initial tension.

6.4 *Set-up for Test D - Lateral stability:* Any type of test set-up is acceptable that is capable to stress the test specimen under prescribed conditions and monitoring and recording the tractive force - time history of the towing cable.

6.5 *Bar linkage:* Any type of rigid mechanical linkage between the bars is acceptable which enables an attachment of the pendulum for all tests in transversal test direction. The bar linkage shall enable a distance between the bars of 52 cm ± 1 cm. The weight of the bar linkage shall be 3.0 kg ± 0.3 kg.

6.6 *Pendulum* - The pendulum shall meet the following criteria:

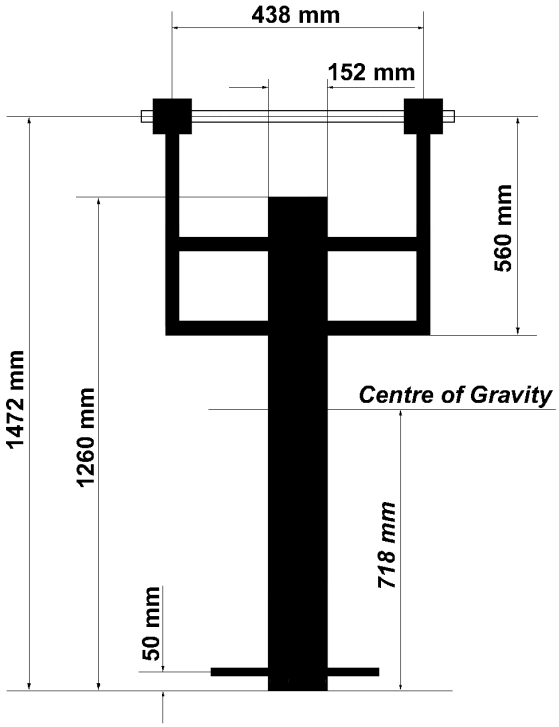
6.6.1 *Mass and geometry:* The tubular test body shall have a mass of 40.0 kg ± 3% (including load cells, grasping arms and appliances for additional weights) and a geometry as specified in Figure 6. The load cells shall be located between the test body and the grasping arms. The weight of each grasping arm shall be 1.0 kg ± 3%.

6.6.2 *Pendulum fixation* - The pendulum fixation to the bar shall meet the following criteria:

6.6.2.1 *Functional properties:* The fixation shall allow an immediate transfer of forces between pendulum and bar or bar linkage and guarantee a low-friction rotation of the pendulum about the longitudinal axis of a bar or a bar linkage (the use of roll bearings is recommended).

6.6.2.2 *Friction of the bar-pendulum fixation* - The frictional properties of the fixation shall meet the criteria as specified in *FIG Apparatus Rules: IV-MAG6 Standard Specification for Horizontal Bars for Men Artistic Gymnastics.*

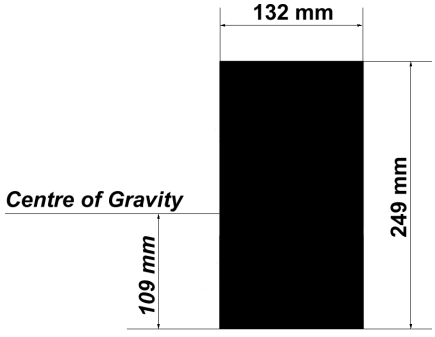
Figure 6: Geometry of Tubular Test Body
(All dimensions with an accuracy of 3%)



6.6.3 *Additional falling weight* - The additional falling weight shall meet the following criteria:

6.6.3.1 *Mass and geometry:* The cylindrical falling weight shall have a mass of 20.0 kg ± 0.2 kg and a geometry as specified in Figure 7.

Figure 7: Geometry of Additional Falling Load
(All dimensions with an accuracy of 3%)



6.6.3.2 *Friction within the tube of the test body* - The frictional properties of the additional falling weight shall meet the criteria as specified in *FIG Apparatus Rules: IV-MAG6 Standard Specification for*

Horizontal Bars for Men Artistic Gymnastics.

6.6.3.3 *Damping of the additional falling weight at the inside bottom of the tubular test body:* The damping properties of the additional falling weight shall meet the criteria as specified in *FIG Apparatus Rules: IV-MAG6 Standard Specification for Horizontal Bars for Men Artistic Gymnastics.*

6.7 *Recording equipment* - The recording equipment shall meet the following criteria:

6.7.1 *Displacement - time:* The selection of the specific displacement - time recording equipment, including transducers and recorders, is at the discretion of the test laboratory. However, the transducers shall provide linear signals proportional to the displacement of the midpoint of the bar or the bar linkage. If displacement is recorded, the test equipment shall have means to determine and record the starting position of the bar or the bar linkage from which the total deflection is determined. The total system, detection and recording, shall be capable of measuring displacements of up to 200 mm at frequencies from 2 to 200 Hz to an accuracy of ± 1%. The minimum sampling rate of the data acquisition system shall be 500 Hz.

6.7.2 *Reaction force - time:* Any reaction force - time recording equipment, including load cells and recorders, which can monitor the reaction force exerted on the pendulum simultaneously with the displacement - time trace is acceptable. The total system, detection and recording, shall be capable of measuring reaction forces of up to 5000 N at frequencies from 2 to 200 Hz to an accuracy of ± 1%. The minimum sampling rate of the data acquisition system shall be 500 Hz.

6.7.3 *Tractive force:* Any tractive force recording equipment, including load cells and recorders, which can monitor the tractive force exerted on the parallel bars is acceptable. The total system, detection and recording, shall be capable of measuring tractive forces of up to 5000 N to an accuracy of ± 1%.

7 Test Specimen

7.1 The test specimen submitted for testing shall consist of complete parallel bars as it is intended to be used during training and/or competition.

7.2 The test specimen shall comply with FIG Apparatus Rules: II-MAG5.

8 Conditioning and Test Temperature

8.1 The parallel bars, mounted and assembled for use, shall be preconditioned at 50% ± 10% relative humidity and 21° C ± 3° C for a minimum of 24 hours prior to the test. All testing shall be carried out under the same conditions.

9 Laboratory Procedure (Test Method)

9.1 *General set-up:*

9.1.1 Mount the parallel bars to a height as prescribed for competitions (Part II).

9.1.2 For Test A, B and C the parallel bars shall have a fixation to the floor to eliminate undesirable vibrations and movements of the apparatus.

9.2 *Test A - Static traction stress:*

9.2.1 Install the displacement measuring device on an unloaded bar and determine the starting position.

9.2.2 Pull the midpoint of one bar vertically downwards with a static tractive force of 1350 N ± 20 N and capture, then record the resulting maximum deflection (mm) using recording equipment described in Section 6.7.

9.2.3 After the release of the static tractive force verify whether the bar returns into the starting position.

9.3 *Test B - Stress by pendulum swing:*

9.3.1 Install the displacement measuring device on an unloaded bar (tests in lateral test direction) or the unloaded bar linkage (tests in transversal test direction) and determine the starting position.

9.3.2 Attach the pendulum (60 kg: 40 kg pendulum with additional 20 kg falling weight) to a bar or the bar linkage in hanging position.

9.3.3 Move the pendulum from hanging position into horizontal position and move the additional falling weight inside the pendulum to the 50 cm ± 1 cm internal drop height position. For the direction of the pendulum swing at the different test positions see Figure 1 to 3.

9.3.4 Release the pendulum and capture the displacement - time history of the midpoint of the bar or the bar linkage and the reaction force - time history of the pendulum, using recording equipment described in Section 6.7.

9.3.5 The parallel bars shall be stressed at each of the following test positions by repeating the pendulum swing five times: End of bars (transversal), Middle of bars (transversal), Middle of bars (lateral). See Figure 1 to 4 for illustration of the locations and the directions of the test positions.

9.3.6 Immediately following each test, record the following measurements: F_{max} (N) and positive vertical deflection (mm).

9.3.7 All five tests per test position shall be used to determine the arithmetic mean values of the measured variables.

9.4 *Test C - Oscillation damping:*

9.4.1 Attach the pendulum (60 kg: 40 kg pendulum with additional 20 kg falling weight at the inside bottom of the pendulum) to a bar (tests in lateral test di-

rection) or the bar linkage (tests in transversal test direction) in hanging position.

9.4.2 Pull down the pendulum vertically until the initial tension of 1000 N ± 30 N is reached.

9.4.3 Release the pendulum and capture the displacement - time history of the midpoint of the bar or the bar linkage using recording equipment described in Section 6.7.

9.4.4 Repeat the above process for each test position (see 9.3.5) five times.

9.4.5 Immediately following each test, record the following measurements: Frequency (Hz) and half amplitude interval (ms) of the oscillation.

9.4.6 All five tests per test position shall be used to determine the arithmetic mean values of the measured variables.

9.5 *Test D - Lateral stability:*

9.5.1 Ensure the parallel bars against sideward slipping with a barrier at the base frame.

9.5.2 Mount the towing cables to one bar at the top of the uprights and pull horizontally in lateral direction until the test specimen tilts to an inclination of 10°. Capture, then record the tractive force (N) using recording equipment described in Section 6.7.

9.6 Calculate the values of all required variables rounded to the decimal places of the corresponding figures identified in Section 5.

10 Report

10.1 *The test report shall include the following information:*

10.1.1 Complete identification of the tested parallel bars, including type, source, manufacturer's model number (if appropriate), dimensions of test specimen, and any other pertinent information. Photographs may be included in the test report for sample documentation purposes.

10.1.2 Test identification number according to the internal regulations between the FIG Test Institutes.

10.1.3 Complete identification of the testing laboratory including test technician and test laboratory manager (if appropriate).

10.1.4 Conditions of test, including test date, temperature and humidity.

10.1.5 Test height of the parallel bars.

10.1.6 *Test A - Static traction stress:* Description of the static tractive force.

10.1.7 *Test B - Stress by pendulum swing:* Description of the pendulum mass, the additional falling weight and the internal drop height.

10.1.8 *Test C - Oscillation damping:* Description of the pendulum mass (including the additional falling weight at the inside bottom of the pendulum) and the initial tension.

10.1.9 *Test D - Lateral stability:* Description of the inclination of the parallel bars.

10.1.10 Description of the test results relative to the performance requirements identified in Section 5.

Standard Specification: Horizontal Bars for Men Artistic Gymnastics

This standard is issued under the fixed designation FIG: IV-MAG6-29.03.1996; the numbers immediately following the designation indicate the date of original adoption by the FIG, or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories. This standard was originally published in English only.

Introduction

The objective of this FIG standard is to provide equal opportunities for all athletes in FIG competitions by controlling the functional properties of horizontal bars and to minimize any differences between competition and training equipment.

1 Scope

1.1 This specification covers the measurement of certain static stiffness properties, dynamic force - time and displacement - time relationships and the oscillation characteristics of horizontal bars. This standard specification is applicable to all horizontal bars that are to be used at any FIG-sanctioned event.

1.2 The test procedures associated with this specification does not imply that an injury cannot be incurred while using a horizontal bar which complies with this specification.

1.3 This standard may involve hazardous operations and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2 Normative References

2.1 International Gymnastics Federation (FIG): Apparatus Rules: II-MAG6.

3 Terminology

3.1 *Description of terms specific to this standard:*

3.1.1 *Cable tension*: The predetermined value of force (in N) exerted on the mounting cables of the completely-mounted unloaded horizontal bar.

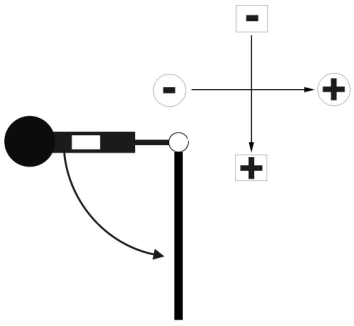
3.1.2 *Static tractive force*: The predetermined value of force (in N) exerted on the midpoint of the bar, pulling the bar vertically downwards.

3.1.3 *Starting position:* The position of the unloaded bar from which the total deflection in vertical and horizontal direction is determined. The midpoint of the bar shall serve as the point of reference for the measurements.

3.1.4 *Deflection:* The measured distance (in mm) between the starting position and the maximum displacement of the midpoint of the bar in vertical and horizontal direction respectively.

3.1.5 *Definition of spatial dimensions:* For the determination of the vertical and horizontal deflection of the midpoint of the bar the spatial dimensions are defined as illustrated in Figure 1.

Figure 1: Definition of Spatial Dimensions
(Pendulum in horizontal position before release)



3.1.6 *Pendulum:* Tubular test body of given dimensions and mass with an additional low-friction falling weight inside. The test body is attached to the bar with the help of two inflexible grasping arms, each of which is at the same distance from the midpoint of the bar, guaranteeing a low-friction rotation of the test body about the longitudinal axis of the bar.

3.1.7 *Maximum Force (F_{max}):* The maximum value of the reaction force in the direction of the pendulum's centre of gravity measured as the sum of the forces exerted on both grasping arms during the pendulum swing, expressed in Newtons.

3.1.8 *Hanging position:* Stable equilibrium position of the hanging pendulum under gravity conditions only.

3.1.9 *Horizontal position:* Position of the attached pendulum rectangular to the hanging position.

3.1.10 *Additional falling weight:* Cylindrical test body of given dimensions and mass inside the pendulum producing an additional impact stress on the gymnastic apparatus during pendulum swing.

3.1.11 *Internal drop height:* Predetermined sliding distance of the additional falling weight inside the pendulum.

3.1.12 *Initial tension:* Predetermined value of the force exerted on the bar, composed of the gravity of the attached pendulum and an additional tractive force

pulling the bar-pendulum system vertically downwards.

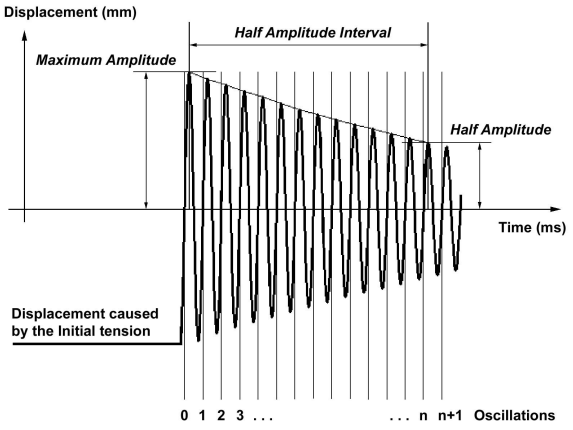
3.1.13 *Frequency of oscillation:* Reciprocal of the value determined by the duration of the half amplitude interval divided by the number of oscillations of the bar-pendulum system within the half amplitude interval. The frequency is expressed in Hertz. See Figure 2 for illustration of the frequency determination.

3.1.14 *Maximum amplitude:* Value of the amplitude (in mm) of the first oscillation of the bar-pendulum system after the release of the initial tension.

3.1.15 *Half amplitude:* Value of the amplitude (in mm) of the first oscillation which is equal to or less than half the maximum amplitude.

3.1.16 *Half amplitude interval:* Duration of oscillation (in ms) between the passage of the maximum amplitude and the reaching of the half amplitude. See Figure 2 for illustration.

Figure 2: Oscillation Damping Parameters



4 Principle of Measurement

4.1 *The complete measurement is composed of three specific test procedures:*

4.1.1 *Test A - Static traction stress:* The bar of a mounted apparatus is pulled vertically downwards with a predetermined static tractive force. A measuring device mounted on the bar monitors the displacement - time history of the midpoint of the bar caused by this force. The maximum deflection is recorded with the aid of a data acquisition system. After the release of the static tractive force the bar must return into the starting position.

4.1.2 *Test B - Stress by pendulum swing:* A pendulum which is attached to the bar of a mounted apparatus is rotated from hanging position into horizontal position and then released. While it swings down, an additional falling weight inside the tubular pendulum slides down from a predetermined internal drop height until the weight strikes against the inside bottom of the pendulum, producing an additional impact stress on the gymnastic apparatus. A measuring device monitors the two-dimensional displacement - time history of the midpoint of the bar. Load cells inside both pendulum grasping arms monitor the reaction force - time history of the pendulum. Both are recorded with the aid of a data acquisition system. The test measures the maximum reaction force in the direction of the pendulum's centre of gravity as well as the positive deflection of the bar in vertical direction and the positive and negative deflection of the bar in horizontal direction.

4.1.3 *Test C - Oscillation damping:* A pendulum which is attached to the bar of a mounted apparatus is pulled vertically downwards until a predetermined initial tension is reached. The abrupt release causes a damped oscillation of the bar-pendulum system. A measuring device monitors the displacement - time history of the midpoint of the bar which is recorded with the aid of a data acquisition system. The test measures the frequency as well as the half amplitude interval of the oscillation.

4.2 Static and dynamic data obtained during these procedures are indicative of the static stiffness, elastic, damping, and oscillation properties of the horizontal bar used in training and FIG-sanctioned competitions.

5 Performance Requirements

5.1 *Test A - Static traction stress:* When tested according to the procedures described in Section 9.2, the value of the measured variable shall be within the figures of Table 1.

Table 1: Figure for Test A – Static traction stress
x represents the measured variable

Test A: Static traction stress	
Deflection (mm)	$80 \leq x \leq 100$

5.2 *Test B - Stress by pendulum swing:* When tested according to the procedures described in Section 9.3, the mean values of the measured variables shall be within the figures of Table 2.

Table 2: Figures for Test B – Stress by pendulum swing
x represents the mean value of the measured variable

Test B: Stress by pendulum swing	
F_{max} (N)	$x \leq 3200$
Positive vertical deflection (mm)	$120 \leq x \leq 135$
Negative horizontal deflection (mm)	$-30 \leq x \leq -40$
Positive horizontal deflection (mm)	$60 \leq x \leq 75$

5.3 *Test C - Oscillation damping:* When tested according to the procedures described in Section 9.4, the mean values of the measured variables shall be within the figures of Table 3.

Table 3: Figures for Test C – Oscillation damping
x represents the mean value of the measured variable

Test C: Oscillation damping	
Frequency of oscillation (Hz)	$3.00 \leq x \leq 3.25$
Half amplitude interval (ms)	$1250 \leq x \leq 4900$

6 Test Set-up and Apparatus

6.1 *Set-up for Test A - Static traction stress*: Any type of test set-up is acceptable that is capable to stress the test specimen under prescribed conditions and monitoring and recording the displacement - time history of the midpoint of the bar.

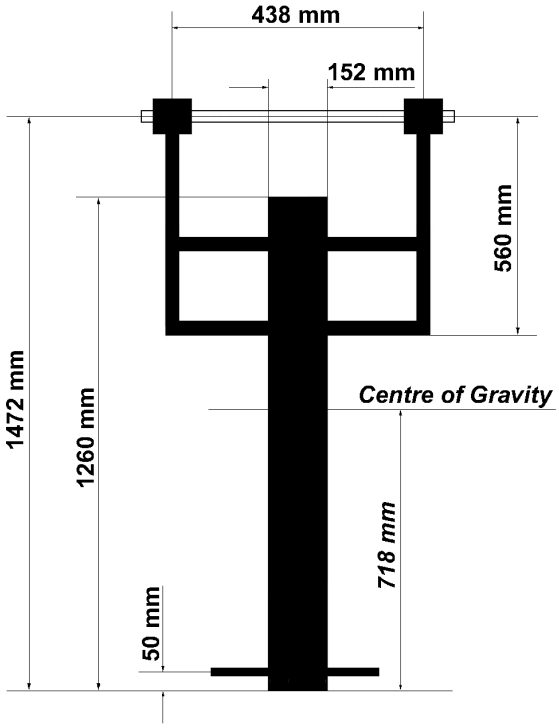
6.2 *Set-up for Test B - Stress by pendulum swing:* Any type of test set-up is acceptable that is capable of stressing the test specimen with a pendulum swing under prescribed conditions and monitoring and recording the displacement - time history of the midpoint of the bar and the reaction force - time history of the pendulum. It is optional, but desirable, that the pendulum is released from a magnet in the horizontal position.

6.3 *Set-up for Test C - Oscillation damping*: Any type of test set-up is acceptable that is capable of stressing the bar-pendulum system under prescribed conditions and monitoring and recording the displacement - time history of the midpoint of the bar. It is optional, but desirable, that the bar-pendulum system is released from a magnet at the prescribed initial tension.

6.4 *Pendulum* - The pendulum shall meet the following criteria:

6.4.1 *Mass and geometry:* The tubular test body shall have a mass of 40.0 kg ± 3% (including load cells, grasping arms and appliances for additional weights) and a geometry as specified in Figure 3. The load cells shall be located between the test body and the grasping arms. The weight of each grasping arm shall be 1.0 kg ± 3%.

Figure 3: Geometry of Tubular Test Body
(All dimensions with an accuracy of 3%)



6.4.2 *Added weights:* For Test B, two customary 10.0 kg ± 0.1 kg dumb-bell weights shall be added with the help of specific appliances to each side of the pendulum, for an additional weight on the pendulum of 20.0 kg ± 0.2 kg. See Figure 3 for the location of the specific appliances.

6.4.3 *Pendulum fixation* - The pendulum fixation to the bar shall meet the following criteria:

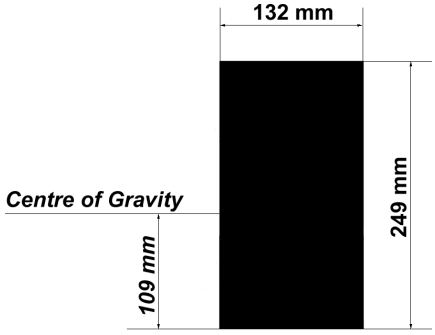
6.4.3.1 *Functional properties:* The fixation shall allow an immediate transfer of forces between pendulum and bar and guarantee a low-friction rotation of the pendulum about the longitudinal axis of the bar (the use of roll bearings is recommended).

6.4.3.2 *Friction of the bar-pendulum fixation* - The frictional properties of the fixation shall meet the following criteria: The time for the pendulum (80 kg: 40 kg pendulum with additional 20 kg falling weight at the inside bottom [no internal drop height] and 20 kg added weights) to swing from horizontal position (release) through hanging (vertical) position shall be 680 ms ± 15 ms.

6.4.4 *Additional falling weight* - The additional falling weight shall meet the following criteria:

6.4.4.1 *Mass and geometry:* The cylindrical falling weight shall have a mass of 20.0 kg ± 0.2 kg and a geometry as specified in Figure 4.

Figure 4: Geometry of Additional Falling Load
(All dimensions with an accuracy of 3%)



6.4.4.2 *Friction within the tube of the test body* - The frictional properties of the additional falling weight shall meet the following criteria: The time for the additional falling weight to cover the internal drop height of 90 cm by a pendulum swing (80 kg) down from horizontal position (release) shall be 640 ms ± 10 ms.

6.4.4.3 *Damping of the additional falling weight at the inside bottom of the tubular test body* - The damping properties of the additional falling weight shall meet the following criteria: The additional falling weight (20 kg) shall produce an average peak force of 5800 N ± 1500 N over 15 impact tests inside the tubular test body with a vertical drop height of 50 mm ± 1 mm. A chloroprene rubber at the bottom of the test body with a thickness of 8 mm, a density of 1.40 g/cm^3 and a tensile strength of 5,5 MPa is recommended.

6.5 *Recording equipment* - The recording equipment shall meet the following criteria:

6.5.1 *Displacement - time:* The selection of the specific displacement - time recording equipment, including transducers and recorders, is at the discretion of the test laboratory. However, the transducers shall provide linear signals proportional to the two-dimensional displacement of the midpoint of the bar. If displacement is recorded, the test equipment shall have means to determine and record the starting position of the bar from which the total deflections are determined. The total system, detection and recording, shall be capable of measuring displacements of up to 200 mm at frequencies from 2 to 200 Hz to an accuracy of ± 1%. The minimum sampling rate of the data acquisition system shall be 500 Hz.

6.5.2 *Reaction force - time:* Any reaction force - time recording equipment, including load cells and recorders, which can monitor the reaction force exerted on the pendulum simultaneously with the displacement - time trace is acceptable. The total system, detection and recording, shall be capable of measuring reaction forces of up to 5000 N at frequencies from 2 to 200 Hz to an accuracy of ± 1%. The minimum sampling rate of the data acquisition system shall be 500 Hz.

7 Test Specimen

7.1 The test specimen submitted for testing shall consist of a complete horizontal bar as it is intended to be used during training and/or competition.

7.2 The test specimen shall comply with FIG Apparatus Rules: II-MAG6.

8 Conditioning and Test Temperature

8.1 The horizontal bar, mounted and assembled for use, shall be preconditioned at 50% ± 10% relative humidity and 21° C ± 3° C for a minimum of 24 hours prior to the test. All testing shall be carried out under the same conditions.

9 Laboratory Procedure (Test Method)

9.1 *General set-up:*

9.1.1 Mount the horizontal bar to a height as prescribed for competitions (Part II).

9.1.2 The default cable tension shall be 1500 N ± 50 N provided that there is no other specific cable tension suggested by the manufacturer. If a specific cable tension is suggested by the manufacturer, then this suggested cable tension shall be used.

9.1.3 Install the displacement measuring device on the unloaded bar and determine the starting position.

9.2 *Test A - Static traction stress:*

9.2.1 Pull the midpoint of the bar vertically downwards with a static tractive force of 2200 N ± 20 N and capture, then record the resulting maximum deflection (mm) using recording equipment described in Section 6.5.

9.2.2 After the release of the static tractive force verify whether the bar returns into the starting position.

9.3 *Test B - Stress by pendulum swing:*

9.3.1 Attach the pendulum (80 kg: 40 kg pendulum with additional 20 kg falling weight and 20 kg added weights) to the bar in hanging position.

9.3.2 Move the pendulum from hanging position into horizontal position and move the additional falling weight inside the pendulum to the 90 cm ± 1 cm internal drop height position.

9.3.3 Release the pendulum and capture the two-dimensional displacement - time history of the midpoint of the bar and the reaction force - time history of the pendulum, using recording equipment de-

scribed in Section 6.5.

9.3.4 Stress the horizontal bar by repeating the pendulum swing five times.

9.3.5 Immediately following each test, record the following measurements: F_{max} (N), positive vertical deflection (mm), as well as positive and negative horizontal deflection (mm).

9.3.6 All five tests shall be used to determine the arithmetic mean value of each measured variable.

9.4 *Test C - Oscillation damping:*

9.4.1 Attach the pendulum (60 kg: 40 kg pendulum with additional 20 kg falling weight at the inside bottom of the pendulum) to the bar in hanging position.

9.4.2 Pull down the pendulum vertically until the initial tension of 1000 N ± 30 N is reached.

9.4.3 Release the pendulum and capture the displacement - time history of the midpoint of the bar using recording equipment described in Section 6.5.

9.4.4 Repeat the above process five times.

9.4.5 Immediately following each test, record the following measurements: Frequency (Hz) and half amplitude interval (ms) of the oscillation.

9.4.6 All five tests shall be used to determine the arithmetic mean value of each measured variable.

9.5 Calculate the values of all required variables rounded to the decimal places of the corresponding figures identified in Section 5.

10 Report

10.1 *The test report shall include the following information:*

10.1.1 Complete identification of the tested horizontal bar, including type, source, manufacturer's model number (if appropriate), dimensions of test specimen, and any other pertinent information. Photographs may be included in the test report for sample documentation purposes.

10.1.2 Test identification number according to the internal regulations between the FIG Test Institutes.

10.1.3 Complete identification of the testing laboratory including test technician and test laboratory manager (if appropriate).

10.1.4 Conditions of test, including test date, temperature and humidity.

10.1.5 Test height and cable tension of the unloaded horizontal bar.

10.1.6 *Test A - Static traction stress:* Description of the static tractive force.

10.1.7 *Test B - Stress by pendulum swing:* Description of the pendulum mass with added weights, the additional falling weight and the internal drop height.

10.1.8 *Test C - Oscillation damping:* Description of the pendulum mass (including the additional falling weight at the inside bottom of the pendulum) and the initial tension.

10.1.9 Description of the test results relative to the performance requirements identified in Section 5.

Standard Specification: 20 cm Landing Mats for Men Artistic Gymnastics

This standard is issued under the fixed designation FIG: IV-MAG11-01.08.1996; the numbers immediately following the designation indicate the date of original adoption by the FIG, or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories. This standard was originally published in English only.

Introduction

The objective of this FIG standard is to provide equal opportunities for all athletes in FIG competitions by controlling the functional properties of landing mats and to minimize any differences between competition and training equipment.

1 Scope

1.1 This specification covers the measurement of certain shock-absorbing characteristics, the impact force - time relationships, and the rebound properties of 20 cm landing mats. This standard specification is applicable to all landing mat systems that are to be used at any FIG-sanctioned event.

1.2 This specification does not imply that an injury cannot be incurred while using a landing mat system which complies with this specification.

1.3 The test procedures associated with this standard may involve hazardous operations and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2 Normative References

2.1 Society of Automotive Engineers: SAE J211 Recommended Practice for Instrumentation for Impact Tests – Requirements for Channel Class 1000, October 1988.

2.2 International Gymnastics Federation (FIG): Apparatus Rules: II-MAG11.

3 Terminology

3.1 *Description of terms specific to this standard:*

3.1.1 *Acceleration:* The instantaneous time rate of change of velocity, expressed in m/s^2, which may be positive or negative.

3.1.2 *Base plane:* The starting reference plane of the landing mat system from which the total deflection and total height of rebound is determined. It is taken as the top plane of the landing mat system.

3.1.3 *Deflection:* The measured distance (in mm) between the base plane and the maximum displacement of the impactor below the base plane.

3.1.4 *Force (F):* The product of the mass of the impactor, expressed in kg, and the acceleration of the impactor, expressed in m/s^2.

3.1.5 *Maximum Force (F_{max}):* The maximum value of force measured during the impact and expressed in Newtons.

3.1.6 *Height of rebound:* The measured distance (in mm) between the base plane and the maximum displacement of the impactor above the base plane.

3.1.7 *Impactor:* The striking part of the test apparatus.

3.1.8 *Impact velocity:* The velocity of the impactor, expressed in m/s, immediately prior to crossing the base plane on impact.

3.1.9 *Theoretical drop height:* A calculated drop height which equates the measured velocity of the impactor at the moment of impact to a height that would generate the same velocity if the test were performed at sea level and there was no friction to retard the impactor during a drop from that height.

4 Principle of Measurement

4.1 A test specimen is impacted at a specified velocity with an impactor of given mass and geometry. A transducer mounted in the impactor monitors the acceleration – time history of the impactor which is recorded with the aid of a data acquisition system. An additional transducer may be used to monitor the displacement – time history of the impactor.

4.2 Dynamic data obtained during these procedures are indicative of the cushioning and rebound properties of the landing mat systems and materials used in training and FIG-sanctioned competitions.

5 Performance Requirements

5.1 When tested according to the procedures described in Section 9, the overall mean values of the measured variables across all impact sites shall be within the figures of Table 1.

Table 1: Figures for 20 cm Landing Mats

Deflection (mm)	*Height of rebound (mm)*	F_{max} *(N)*
≤ 110	≤ 90	≤ 3000

6 Test Apparatus

6.1 *Impact test machine:* Any type of dynamic testing apparatus that is capable of impacting a test specimen at a prescribed impact velocity and monitors and records the acceleration - time history of the impactor is acceptable. The impact test machine and the impactor shall have sufficient rigidity to eliminate undesirable vibrations in the apparatus which might be recorded on the acceleration - time curve. The impact test machine shall also be designed in such a manner that only the impact face of the impactor contacts the test specimen at any time during the test procedures.

6.2 *Impactor:* The impactor shall be 20 kg ± 0.2 kg and shall have a flat impact face with a 10 cm ± 0.5 cm diameter. The edge of the impactor face should be relieved to eliminate sharp edges. Provision shall be made so that the accelerometer can be securely fastened parallel to the vertical axis of the impactor with a maximum deviation of ± 5°.

6.3 *Recording equipment - The recording equipment shall meet the following criteria:*

6.3.1 *Acceleration - time:* The selection of the specific acceleration - time recording equipment, including transducers and recorders, is at the discretion of the test laboratory. However, the recording system shall have a frequency response adequate to measure the peak acceleration value to an accuracy of ± 5% of the true value. The total system, detection and recording, shall be capable of measuring impact accelerations of up to 200 g at frequencies from 2 to 1000 Hz to an accuracy of ± 5%. The minimum sampling rate of the data acquisition system shall be 5000 Hz.

6.3.2 *Displacement - time:* It is optional, but desirable, that the displacement - time history is recorded by a separate transducer. Any transducer that provides a linear signal proportional to the displacement of the impactor along the impact axis which can be monitored simultaneously with the acceleration - time trace is acceptable. If displacement is recorded, the test equipment shall have means to determine and record the top plane (base plane) of the test specimen from which the total deformation and rebound height are determined.

6.3.3 *Filtering:* The signal from all transducers shall be conditioned with a low pass filter which complies with Channel Class 1000 of SAE Recommended Practice J211. A fourth-order Butterworth low pass filter with a cut-off frequency of 1000 Hz meets this requirement.

7 Test Specimen

7.1 The test specimen submitted for testing shall represent the landing mat as it is intended to be used during training and/or competition.

7.2 The test specimen shall comply with FIG Apparatus Rules: II-MAG11. Exception: See 7.3..

7.3 The minimum horizontal dimensions (length * width) for any test specimen shall be 200 cm * 120 cm.

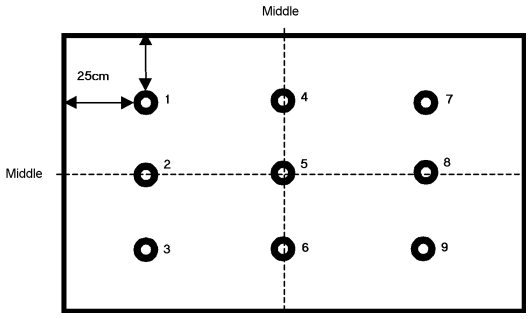
8 Conditioning and Test Temperature

8.1 Test specimens shall be preconditioned at 50% ± 10% relative humidity and 21° C ± 3° C for a minimum of 24 hours prior to the test. All testing shall be carried out under the same conditions.

9 Laboratory Procedure (Test Method)

9.1 *Impact locations:* A total of nine impact sites shall be designated on the test specimen. See Figure 1 for an illustration of the impact sites.

Figure 1: Impact Locations for Landing Mats



9.2 *Impact test procedures:*

9.2.1 Place the test specimen under the impact test machine on a smooth, solid floor (concrete or metal plate) and orient the impactor such that the centre of the impact face will contact one of the designated impact test sites.

9.2.2 Raise the impactor to an appropriate drop height such that it will contact the test specimen with an impact velocity of 3.96 m/s ± 3%. This corresponds to a theoretical drop height of 0.8 m.

9.2.3 Release the impactor and capture the acceleration - time history and displacement - time history (if applicable) using recording equipment described in Section 6.3.

9.2.4 Upon completion of a given impact test, raise the impactor off the surface of the test specimen.

9.2.5 The duration between tests at a given impact site shall not be less than 120 seconds.

9.2.6 Each test specimen shall receive a total of 90 impacts. Impact each of the nine impact sites ten times.

9.3 *Calculations:*

9.3.1 Immediately following each test, record the following measurements: F_{max} (N), Deflection (mm) and Height of rebound (mm).

9.3.2 The last eight tests for each impact site shall be used to determine the arithmetic mean value of a measured variable for each impact site and for the overall mean value of a measured variable across all impact sites.

9.3.3 Calculate the mean values of Deflection, Height of rebound and F_{max} across all impact sites rounded to zero decimal places.

10 Report

10.1 *The test report shall include the following information:*

10.1.1 Complete identification of the tested landing mat, including type, source, manufacturer's model number (if appropriate), dimensions of test specimen, and any other pertinent information. Photographs may be included in the test report for sample documentation purposes.

10.1.2 Test identification number according to the internal regulations between the FIG Test Institutes.

10.1.3 Complete identification of the testing laboratory including test technician and test laboratory manager (if appropriate).

10.1.4 Conditions of test, including test date, temperature and humidity.

10.1.5 Description of the impactor mass and the drop height conditions.

10.1.6 Description of the test results relative to the performance requirements identified in Section 5.

10.1.7 Mean values of Deflection, Height of rebound and F_{max} across all impact sites.

10.1.8 Maximum value, minimum value and standard deviation of Deflection, Height of rebound and F_{max} variables.

10.1.9 Mean values of Deflection, Height of rebound and F_{max} for the last eight tests at each impact site.

10.1.10 Deflection, Height of rebound and F_{max} values for all tests.

IV
4

Standard Specification: 10 cm Landing Mats for Men Artistic Gymnastics

This standard is issued under the fixed designation FIG: IV-MAG12-12.07.1989; the numbers immediately following the designation indicate the date of original adoption by the FIG, or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories. This standard was originally published in English only.

Introduction

The objective of this FIG standard is to provide equal opportunities for all athletes in FIG competitions by controlling the functional properties of landing mats and to minimize any differences between competition and training equipment.

1 Scope

1.1 This specification covers the measurement of certain shock-absorbing characteristics, the impact force - time relationships, and the rebound properties of 10 cm landing mats. This standard specification is applicable to all landing mat systems that are to be used at any FIG-sanctioned event.

1.2 This specification does not imply that an injury cannot be incurred while using a landing mat system which complies with this specification.

1.3 The test procedures associated with this standard may involve hazardous operations and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2 Normative References

2.1 Society of Automotive Engineers: SAE J211 Recommended Practice for Instrumentation for Impact Tests – Requirements for Channel Class 1000, October 1988.

2.2 International Gymnastics Federation (FIG): Apparatus Rules: II-MAG12.

3 Terminology

3.1 *Description of terms specific to this standard:*

3.1.1 *Acceleration:* The instantaneous time rate of change of velocity, expressed in m/s^2, which may be positive or negative.

3.1.2 *Base plane:* The starting reference plane of the landing mat system from which the total deflection and total height of rebound is determined. It is taken as the top plane of the landing mat system.

3.1.3 *Deflection:* The measured distance (in mm) between the Base plane and the maximum displacement of the impactor below the Base plane.

3.1.4 *Force (F):* The product of the mass of the impactor, expressed in kg, and the acceleration of the impactor, expressed in m/s^2.

3.1.5 *Maximum Force (F_{max}):* The maximum value of force measured during the impact and expressed in Newtons.

3.1.6 *Height of rebound:* The measured distance (in mm) between the Base plane and the maximum displacement of the impactor above the Base plane.

3.1.7 *Impactor:* The striking part of the test apparatus.

3.1.8 *Impact velocity:* The velocity of the impactor, expressed in m/s, immediately prior to crossing the base plane on impact.

3.1.9 *Theoretical drop height:* A calculated drop height which equates the measured velocity of the impactor at the moment of impact to a height that would generate the same velocity if the test were performed at sea level and there was no friction to retard the impactor during a drop from that height.

4 Principle of Measurement

4.1 A test specimen is impacted at a specified velocity with an impactor of given mass and geometry. A transducer mounted in the impactor monitors the acceleration – time history of the impactor which is recorded with the aid of a data acquisition system. An additional transducer may be used to monitor the displacement – time history of the impactor.

4.2 Dynamic data obtained during these procedures are indicative of the cushioning and rebound properties of the landing mat systems and materials used in training and FIG-sanctioned competitions.

5 Performance Requirements

5.1 When tested according to the procedures described in Section 9, the overall mean values of the measured variables across all impact sites shall be within the figures of Table 1.

Table 1: Figures for 10 cm Landing Mats

Deflection (mm)	*Height of rebound (mm)*	F_{max} *(N)*
≤ 65	≤ 80	≤ 3750

6 Test Apparatus

6.1 *Impact test machine:* Any type of dynamic testing apparatus that is capable of impacting a test specimen at a prescribed impact velocity and monitoring and recording the acceleration - time history of the impactor is acceptable. The impact test machine and the impactor shall have sufficient rigidity to eliminate undesirable vibrations in the apparatus which might be recorded on the acceleration - time curve. The impact test machine shall also be designed in such a manner that only the impact face of the impactor contacts the test specimen at any time during the test procedures.

6.2 *Impactor:* The impactor shall be 20 kg ± 0.2 kg and shall have a flat impact face with a 10 cm ± 0.5 cm diameter. The edge of the impactor face should be relieved to eliminate sharp edges. Provision shall be made so that the accelerometer can be securely fastened parallel to the vertical axis of the impactor with a maximum deviation of ± 5°.

6.3 *Recording equipment - The recording equipment shall meet the following criteria:*

6.3.1 *Acceleration - time:* The selection of the specific acceleration - time recording equipment, including transducers and recorders, is at the discretion of the test laboratory. However, the recording system shall have a frequency response adequate to measure the peak acceleration value to an accuracy of ± 5% of the true value. The total system, detection and recording, shall be capable of measuring impact accelerations of up to 200 g at frequencies from 2 to 1000 Hz to an accuracy of ± 5%. The minimum sampling rate of the data acquisition system shall be 5000 Hz.

6.3.2 *Displacement - time:* It is optional, but desirable, that the displacement - time history is recorded by a separate transducer. Any transducer that provides a linear signal proportional to the displacement of the impactor along the impact axis which can be monitored simultaneously with the acceleration - time trace is acceptable. If displacement is recorded, the test equipment shall have means to determine and record the top plane (base plane) of the test specimen from which the total deformation and rebound height are determined.

6.3.3 *Filtering:* The signal from all transducers shall be conditioned with a low pass filter which complies with Channel Class 1000 of SAE Recommended Practice J211. A fourth-order Butterworth low pass filter with a cut-off frequency of 1000 Hz meets this requirement.

7 Test Specimen

7.1 The test specimen submitted for testing shall represent the landing mat as it is intended to be used during training and/or competition.

7.2 The test specimen shall comply with FIG Apparatus Rules: II-MAG12. Exception: See 7.3.

7.3 The minimum horizontal dimensions (length * width) for any test specimen shall be 200 cm * 120 cm.

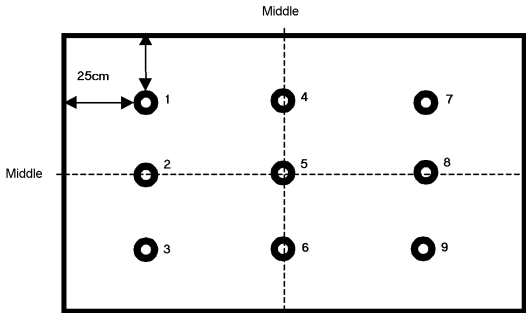
8 Conditioning and Test Temperature

8.1 Test specimens shall be preconditioned at 50% ± 10% relative humidity and 21° C ± 3° C for a minimum of 24 hours prior to the test. All testing shall be carried out under the same conditions.

9 Laboratory Procedure (Test Method)

9.1 *Impact locations:* A total of nine impact sites shall be designated on the test specimen. See Figure 1 for an illustration of the impact sites.

Figure 1: Impact Locations for Landing Mats



9.2 *Impact test procedures:*

9.2.1 Place the test specimen under the impact test machine on a smooth, solid floor (concrete or metal plate) and orient the impactor such that the centre of the impact face will contact one of the designated impact test sites.

9.2.2 Raise the impactor to an appropriate drop height such that it will contact the test specimen with an impact velocity of 2.80 m/s +/- 3%. This corresponds to a theoretical drop height of 0.4 m.

9.2.3 Release the impactor and capture the acceleration - time history and displacement - time history (if applicable) using recording equipment described in Section 6.3.

9.2.4 Upon completion of a given impact test, raise the impactor off the surface of the test specimen.

9.2.5 The duration between tests at a given impact site shall not be less than 120 seconds.

9.2.6 Each test specimen shall receive a total of 90 impacts. Impact each of the nine impact sites ten times.

9.3 *Calculations:*

9.3.1 Immediately following each test, record the following measurements: F_{max} (N), Deflection (mm) and Height of rebound (mm).

9.3.2 The last eight tests for each impact site shall be used to determine the arithmetic mean value of a measured variable for each impact site and for the overall mean value of a measured variable across all impact sites.

9.3.3 Calculate the mean values of Deflection, Height of rebound and F_{max} across all impact sites rounded to zero decimal places.

10 Report

10.1 *The test report shall include the following information:*

10.1.1 Complete identification of the tested landing mat, including type, source, manufacturer's model number (if appropriate), dimensions of test specimen, and any other pertinent information. Photographs may be included in the test report for sample documentation purposes.

10.1.2 Test identification number according to the internal regulations between the FIG Test Institutes.

10.1.3 Complete identification of the testing laboratory including test technician and test laboratory manager (if appropriate).

10.1.4 Conditions of test, including test date, temperature and humidity.

10.1.5 Description of the impactor mass and the drop height conditions.

10.1.6 Description of the test results relative to the performance requirements identified in Section 5.

10.1.7 Mean values of Deflection, Height of rebound and F_{max} across all impact sites.

10.1.8 Maximum value, minimum value and standard deviation of Deflection, Height of rebound and F_{max} variables.

10.1.9 Mean values of Deflection, Height of rebound and F_{max} for the last eight tests at each impact site.

10.1.10 Deflection, Height of rebound and F_{max} values for all tests.

IV
4

Standard Specification: Vaulting Boards for Men Artistic Gymnastics

This standard is issued under the fixed designation FIG: IV-MAG14-01.07.1985; the numbers immediately following the designation indicate the date of original adoption by the FIG, or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories. This standard was originally published in English only.

Introduction

The objective of this FIG standard is to provide equal opportunities for all athletes in FIG competitions by controlling the functional properties of vaulting boards and to minimize any differences between competition and training equipment.

1 Scope

1.1 This specification covers the measurement of certain shock-absorbing characteristics, the impact force - time relationships, and the rebound properties of vaulting boards. This standard specification is applicable to all vaulting boards that are to be used at any FIG-sanctioned event.

1.2 This specification does not imply that an injury cannot be incurred while using a vaulting board which complies with this specification.

1.3 The test procedures associated with this standard may involve hazardous operations and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2 Normative References

2.1 Society of Automotive Engineers: SAE J211 Recommended Practice for Instrumentation for Impact Tests – Requirements for Channel Class 1000, October 1988.

2.2 International Gymnastics Federation (FIG): Apparatus Rules: II-MAG14.

3 Terminology

3.1 *Description of terms specific to this standard:*

3.1.1 *Acceleration:* The instantaneous time rate of change of velocity, expressed in m/s^2, which may be positive or negative.

3.1.2 *Starting position of an impact site:* The vertical position of an impact site at the surface of an unloaded vaulting board from which the total deflection and total height of rebound is determined.

3.1.3 *Deflection:* The measured distance (in mm) between the starting position of an impact site and the maximum displacement of the impactor below the starting position of an impact site.

3.1.4 *Force (F):* The product of the mass of the impactor, expressed in kg, and the acceleration of the impactor, expressed in m/s^2.

3.1.5 *Maximum Force (F_{max}):* The maximum value of force measured during the impact and expressed in Newtons.

3.1.6 *Height of rebound:* The measured distance (in mm) between the starting position of an impact site and the maximum displacement of the impactor above the starting position of an impact site.

3.1.7 *Impactor:* The striking part of the test apparatus.

3.1.8 *Impact velocity:* The velocity of the impactor, expressed in m/s, immediately prior to crossing the starting position of an impact site on impact.

3.1.9 *Theoretical drop height:* A calculated drop height which equates the measured velocity of the impactor at the moment of impact to a height that would generate the same velocity if the test were performed at sea level and there was no friction to retard the impactor during a drop from that height.

4 Principle of Measurement

4.1 A test specimen is impacted at a specified velocity with an impactor of given mass and geometry. A transducer mounted in the impactor monitors the acceleration – time history of the impactor which is recorded with the aid of a data acquisition system. An additional transducer may be used to monitor the displacement – time history of the impactor.

4.2 Dynamic data obtained during these procedures are indicative of the cushioning and rebound properties of the vaulting board used in training and FIG-sanctioned competitions.

5 Performance Requirements

5.1 When tested according to the procedures described in Section 9, the overall mean values of the measured variables and the differences of the mean values at specified impact sites shall be within the figures of Table 1.

Table 1: Figures for the "hard" Vaulting Boards
See Figure 1 for an illustration of the impact sites. X represents the overall mean value of the measured variable.

	Deflection (mm)	*Height of rebound (mm)*	F_{max} *(N))*
Mean value across impact sites 1 to 5	55 ≤ x ≤ 68	340 ≤ x ≤ 400	x ≤ 4000
Difference between highest and lowest mean value on impact sites 1 to 5	≤ 15	≤ 100	
Difference between mean value on impact sites 6 and 7	≤ 4	≤ 25	≤ 150

Table 2: Figures for the "soft" Vaulting Boards
See Figure 1 for an illustration of the impact sites. X represents the overall mean value of the measured variable.

	Deflection (mm)	*Height of rebound (mm)*	F_{max} *(N))*
Mean value across impact sites 1 to 5	62 ≤ x ≤ 80	340 ≤ x ≤ 400	x ≤ 4000
Difference between highest and lowest mean value on impact sites 1 to 5	≤ 15	≤ 100	
Difference between mean value on impact sites 6 and 7	≤ 4	≤ 25	≤ 150

6 Test Apparatus

6.1 *Impact test machine:* Any type of dynamic testing apparatus that is capable of impacting a test specimen at a prescribed impact velocity and monitoring and recording the acceleration - time history of the impactor is acceptable. The impact test machine and the impactor shall have sufficient rigidity to eliminate undesirable vibrations in the apparatus which might be recorded on the acceleration - time curve. The impact test machine shall also be designed in such a manner that only the impact face contacts the test specimen at any time during the test procedures.

6.2 *Impactor:* The impactor shall be 20 kg ± 0.2 kg and shall have a flat impact face with a 10 cm ± 0.5 cm diameter. The edge of the impactor face should be relieved to eliminate sharp edges. Provision shall be made so that the accelerometer can be securely fastened parallel to the vertical axis of the impactor with a maximum deviation of ± 5°.

6.3 *Recording equipment - The recording equipment shall meet the following criteria:*

6.3.1 *Acceleration - time:* The selection of the specific acceleration - time recording equipment, including transducers and recorders, is at the discretion of the test laboratory. However, the recording system shall have a frequency response adequate to measure the peak acceleration value to an accuracy of ± 5% of the true value. The total system, detection and recording, shall be capable of measuring impact accelerations of up to 200 g at frequencies from 2 to 1000 Hz to an accuracy of ± 5%. The minimum sampling rate of the data acquisition system shall be 5000 Hz.

6.3.2 *Displacement - time:* It is optional, but desirable, that the displacement - time history is recorded by a separate transducer. Any transducer that provides a linear signal proportional to the displacement of the impactor along the impact axis which can be monitored simultaneously with the acceleration - time trace is acceptable. If displacement is recorded, the test equipment shall have means to determine and record the starting position of an impact site of the test specimen from which the total deformation and rebound height are determined.

6.3.3 *Filtering:* The signal from all transducers shall be conditioned with a low pass filter which complies with Channel Class 1000 of SAE Recommended Practice J211. A fourth-order Butterworth low pass filter with a cut-off frequency of 1000 Hz meets this requirement.

7 Test Specimen

7.1 The test specimen submitted for testing shall consist of a vaulting board as it is intended to be used during training and/or competition.

7.2 The test specimen shall comply with FIG Apparatus Rules: II-MAG14.

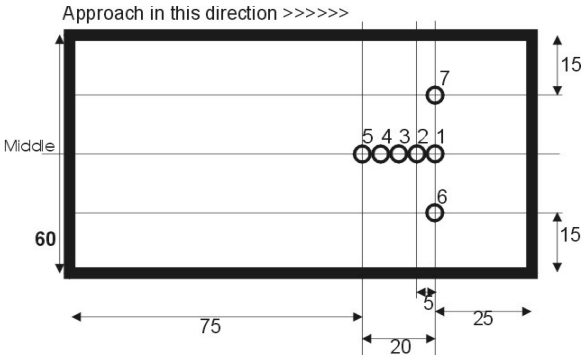
8 Conditioning and Test Temperature

8.1 The test specimen shall be preconditioned at 50% ± 10% relative humidity and 21° C ± 3° C for a minimum of 24 hours prior to the test. All testing shall be carried out under the same conditions.

9 Laboratory Procedure (Test Method)

9.1 *Impact locations:* A total of seven impact sites shall be designated on the test specimen. See Figure 1 for an illustration of the impact sites.

Figure 1: Impact Locations for Vaulting Boards
(Dimensions in cm)



9.2 *Impact test procedures:*

9.2.1 Place the test specimen under the impact test machine on a smooth, solid floor (concrete or metal plate) and orient the impactor such that the centre of the impact face will contact one of the designated impact test sites.

9.2.2 Raise the impactor to an appropriate drop height such that it will contact the test specimen with an impact velocity of 3.96 m/s ± 3%. This corresponds to a theoretical drop height of 0.8 m.

9.2.3 Release the impactor and capture the acceleration - time history and displacement - time history (if applicable) using recording equipment described in Section 6.3.

9.2.4 Upon completion of a given impact test, raise the impactor off the surface of the test specimen.

9.2.5 The duration between tests at a given impact site shall not be less than 30 seconds.

9.2.6 Each test specimen shall receive a total of 70 impacts. Impact each of the seven impact sites ten times.

9.3 *Calculations:*

9.3.1 Immediately following each test, record the following measurements: F_{max} (N), Deflection (mm) and Height of rebound (mm).

9.3.2 The last eight tests for each impact site shall be used to determine the arithmetic mean value of a measured variable for each measurement point.

9.3.3 Calculate the mean values of Deflection, Height of rebound and F_{max} across all impact sites rounded to zero decimal places.

10 Report

10.1 *The test report shall include the following information:*

10.1.1 Complete identification of the tested vaulting board, including type, source, manufacturer's model number (if appropriate), dimensions of test specimen, and any other pertinent information. Photographs may be included in the test report for sample documentation purposes.

10.1.2 Test identification number according to the internal regulations between the FIG Test Institutes.

10.1.3 Complete identification of the testing laboratory including test technician and test laboratory manager (if appropriate).

10.1.4 Conditions of test, including test date, temperature and humidity.

10.1.5 Description of the impactor mass and the drop height conditions.

10.1.6 Description of the test results relative to the performance requirements identified in Section 5.

10.1.7 Mean values of Deflection, Height of rebound and F_{max} across impact sites 1 to 5.

10.1.8 Maximum value, minimum value and standard deviation of Deflection, Height of rebound and F_{max} variables for impact sites 1 to 5.

10.1.9 Mean values of Deflection, Height of rebound and F_{max} for the last eight tests at each impact site.

10.1.10 Deflection, Height of rebound and F_{max} values for all tests.

IV
4

IV
WAG 1
01.02.2001
1

Standard Specification: Vaulting Table for Women Artistic Gymnastics

This standard is issued under the fixed designation FIG: IV-WAG1-18.04.1989; the numbers immediately following the designation indicate the date of original adoption by the FIG or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories. This standard was originally published in English only.

The standard specifications for vaulting tables for women artistic gymnastics are the same as for men artistic gymnastics, therefore, this standard refers to the FIG standard IV-MAG4.

See:

IV
MAG 4
01.02.2001
1-3

Standard Specification: Uneven Bars for Women Artistic Gymnastics

This standard is issued under the fixed designation FIG: IV-WAG2-01.05.1993; the numbers immediately following the designation indicate the date of original adoption by the FIG, or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories. This standard was originally published in English only.

Introduction

The objective of this FIG standard is to provide equal opportunities for all athletes in FIG competitions by controlling the functional properties of uneven bars and to minimize any differences between competition and training equipment.

1 Scope

1.1 This specification covers the measurement of certain static stiffness properties, dynamic force - time and displacement - time relationships and the oscillation characteristics of uneven bars. This standard specification is applicable to all uneven bars that are to be used at any FIG-sanctioned event.

1.2 This specification does not imply that an injury cannot be incurred while using uneven bars which comply with this specification.

1.3 The test procedures associated with this standard may involve hazardous operations and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2 Normative References

2.1 International Gymnastics Federation (FIG): Apparatus Rules: II-WAG2.

2.2 International Gymnastics Federation (FIG): Apparatus Rules: IV-MAG6.

3 Terminology

3.1 *Description of terms specific to this standard:*

3.1.1 *Cable tension*: The predetermined value of force (in N) exerted on the mounting cables of the completely-mounted unloaded uneven bars.

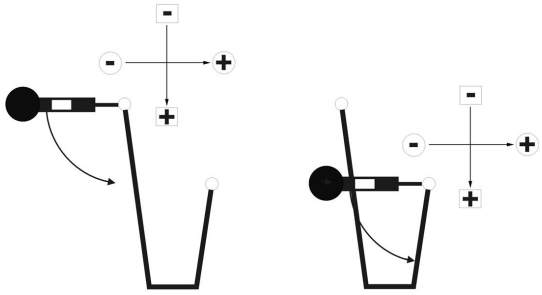
3.1.2 *Static tractive force*: The predetermined value of force (in N) exerted on the midpoint of a bar, pulling the bar vertically downwards.

3.1.3 *Starting position:* The position of an unloaded bar from which the total deflection in vertical and horizontal direction is determined. The midpoint of the bar shall serve as the point of reference for the measurements.

3.1.4 *Deflection:* The measured distance (in mm) between the starting position and the maximum displacement of the midpoint of a bar in vertical and horizontal direction respectively.

3.1.5 *Definition of spatial dimensions:* For the determination of the vertical and horizontal deflection of the midpoint of a bar the spatial dimensions are defined as illustrated in Figure 1.

Figure 1: Definition of Spatial Dimensions
(Pendulum in horizontal position before release)



3.1.6 *Pendulum:* Tubular test body of given dimensions and mass with an additional low-friction falling weight inside. The test body is attached to a bar with the help of two inflexible grasping arms, each of which is at the same distance from the midpoint of the bar, guaranteeing a low-friction rotation of the test body about the longitudinal axis of the bar.

3.1.7 *Maximum Force (F_{max}):* The maximum value of the reaction force in the direction of the pendulum's centre of gravity measured as the sum of the forces exerted on both grasping arms during the pendulum swing, expressed in Newtons.

3.1.8 *Hanging position:* Stable equilibrium position of the hanging pendulum under gravity conditions only.

3.1.9 *Horizontal position:* Position of the attached pendulum rectangular to the hanging position.

3.1.10 *Additional falling weight:* Cylindrical test body of given dimensions and mass inside the pendulum producing an additional impact stress on the gymnastic apparatus during pendulum swing.

3.1.11 *Internal drop height:* Predetermined sliding distance of the additional falling weight inside the pendulum.

3.1.12 *Initial tension:* Predetermined value of the force exerted on a bar, composed of the gravity of the

attached pendulum and an additional tractive force pulling the bar-pendulum system vertically downwards.

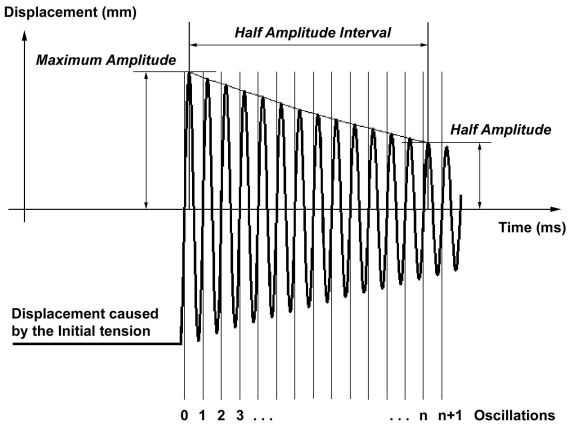
3.1.13 *Frequency of oscillation:* Reciprocal of the value determined by the duration of the half amplitude interval divided by the number of oscillations of a bar-pendulum system within the half amplitude interval. The frequency is expressed in Hertz. See Figure 2 for illustration of the frequency determination.

3.1.14 *Maximum amplitude:* Value of the amplitude (in mm) of the first oscillation of a bar-pendulum system after the release of the initial tension.

3.1.15 *Half amplitude:* Value of the amplitude (in mm) of the first oscillation which is equal to or less than half the maximum amplitude.

3.1.16 *Half amplitude interval:* Duration of oscillation (in ms) between the passage of the maximum amplitude and the reaching of the half amplitude. See Figure 2 for illustration.

Figure 2: Oscillation Damping Parameters



4 Principle of Measurement

4.1 *The complete measurement is composed of three specific test procedures:*

4.1.1 *Test A - Static traction stress:* A bar of a mounted apparatus is pulled vertically downwards with a predetermined static tractive force. A measuring device mounted on the bar monitors the displacement - time history of the midpoint of the bar caused by this force. The maximum deflection is recorded with the aid of a data acquisition system. After the release of the static tractive force the bar must return into the starting position.

4.1.2 *Test B - Stress by pendulum swing:* A pendulum which is attached to a bar of a mounted apparatus is rotated from hanging position into horizontal position and then released. While it swings down, an additional falling weight inside the tubular pendulum slides down from a predetermined internal drop height until the weight strikes against the inside bottom of the pendulum, producing an additional impact stress on the gymnastic apparatus. A measuring device monitors the two-dimensional displacement - time history of the midpoint of the bar. Load cells inside both pendulum grasping arms monitor the reaction force - time history of the pendulum. Both are recorded with the aid of a data acquisition system. The test measures the maximum reaction force in the direction of the pendulum's centre of gravity as well as the positive deflection of the bar in vertical direction and the positive and negative deflection of the bar in horizontal direction.

4.1.3 *Test C - Oscillation damping:* A pendulum which is attached to a bar of a mounted apparatus is pulled vertically downwards until a predetermined initial tension is reached. The abrupt release causes a damped oscillation of the bar-pendulum system. A measuring device monitors the displacement - time history of the midpoint of the bar which is recorded with the aid of a data acquisition system. The test measures the frequency as well as the half amplitude interval of the oscillation.

4.2 Static and dynamic data obtained during these procedures are indicative of the static stiffness, elastic, damping, and oscillation properties of the uneven bars used in training and FIG-sanctioned competitions.

5 Performance Requirements

5.1 *Test A - Static traction stress:* When tested according to the procedures described in Section 9.2, the values of the measured variables shall be within the figures of Table 1.

Table 1: Figures for Test A – Static traction stress
x represents the measured variable

Test A: Static traction stress	
Upper bar	
Deflection (mm)	$70 \leq x \leq 100$
Lower bar	
Deflection (mm)	$70 \leq x \leq 100$

5.2 *Test B - Stress by pendulum swing:* When tested according to the procedures described in Section 9.3, the mean values of the measured variables shall be within the figures of Table 2.

Table 2: Figures for Test B – Stress by pendulum swing
x represents the mean value of the measured variable

Test B: Stress by pendulum swing	
Upper bar	
F_{max} (N)	1500 ≤ x ≤ 1800
Positive vertical deflection (mm)	90 ≤ x ≤ 130
Negative horizontal deflection (mm)	-25 ≤ x ≤ -40
Positive horizontal deflection (mm)	50 ≤ x ≤ 75
Lower bar	
F_{max} (N)	1500 ≤ x ≤ 1800
Positive vertical deflection (mm)	90 ≤ x ≤ 130
Negative horizontal deflection (mm)	-25 ≤ x ≤ -40
Positive horizontal deflection (mm)	50 ≤ x ≤ 75

5.3 *Test C - Oscillation damping:* When tested according to the procedures described in Section 9.4, the mean values of the measured variables shall be within the figures of Table 3.

Table 3: Figures for Test C – Oscillation damping
x represents the mean value of the measured variable

Test C: Oscillation damping	
Upper bar	
Frequency of oscillation (Hz)	2.50 ≤ x ≤ 3.50
Half amplitude interval (ms)	350 ≤ x ≤ 5700
Lower bar	
Frequency of oscillation (Hz)	2.50 ≤ x ≤ 3.50
Half amplitude interval (ms)	350 ≤ x ≤ 5700

6 Test Set-up and Apparatus

6.1 *Set-up for Test A - Static traction stress*: Any type of test set-up is acceptable that is capable to stress the test specimen under prescribed conditions and monitoring and recording the displacement - time history of the midpoint of the bar.

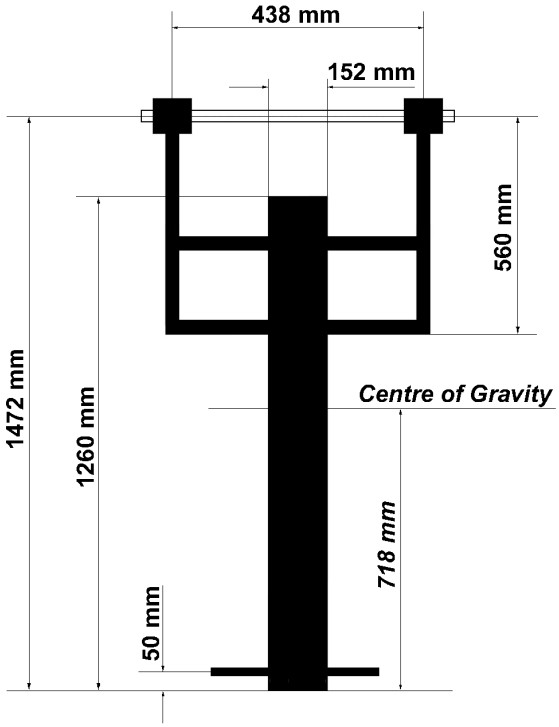
6.2 *Set-up for Test B - Stress by pendulum swing:* Any type of test set-up is acceptable that is capable of stressing the test specimen with a pendulum swing under prescribed conditions and monitoring and recording the displacement - time history of the midpoint of the bar and the reaction force - time history of the pendulum. It is optional, but desirable, that the pendulum is released from a magnet in the horizontal position.

6.3 *Set-up for Test C - Oscillation damping*: Any type of test set-up is acceptable that is capable of stressing a bar-pendulum system under prescribed conditions and monitoring and recording the displacement - time history of the midpoint of the bar. It is optional, but desirable, that the bar-pendulum system is released from a magnet at the prescribed initial tension.

6.4 *Pendulum* - The pendulum shall meet the following criteria:

6.4.1 *Mass and geometry:* The tubular test body shall have a mass of 40.0 kg ± 3% (including load cells, grasping arms and appliances for additional weights) and a geometry as specified in Figure 3. The load cells shall be located between the test body and the grasping arms. The weight of each grasping arm shall be 1.0 kg ± 3%.

Figure 3: Geometry of Tubular Test Body
(All dimensions with an accuracy of 3%)



6.4.2 *Pendulum fixation* - The pendulum fixation to a bar shall meet the following criteria:

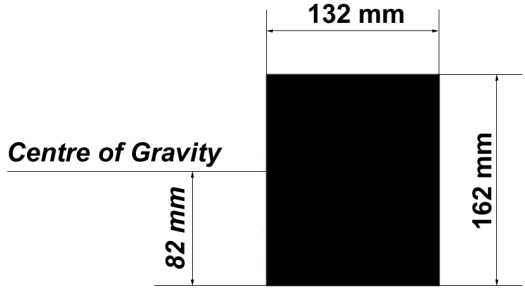
6.4.2.1 *Functional properties:* The fixation shall allow an immediate transfer of forces between pendulum and bar and guarantee a low-friction rotation of the pendulum about the longitudinal axis of the bar (the use of roll bearings is recommended).

6.4.2.2 *Friction of the bar-pendulum fixation* - The frictional properties of the fixation shall meet the criteria as specified in *FIG Apparatus Rules: IV-MAG6 Standard Specification for Horizontal Bars for Men Artistic Gymnastics.*

6.4.3 *Additional falling weight* - The additional falling weight shall meet the following criteria:

6.4.3.1 *Mass and geometry:* The cylindrical falling weight shall have a mass of 10.0 kg ± 0.1 kg and a geometry as specified in Figure 4.

Figure 4: Geometry of Additional Falling Load
(All dimensions with an accuracy of 3%)



6.4.3.2 *Friction within the tube of the test body* - The frictional properties of the additional falling weight shall meet the criteria as specified in *FIG Apparatus Rules: IV-MAG6 Standard Specification for Horizontal Bars for Men Artistic Gymnastics.*

6.4.3.3 *Damping of the additional falling weight at the inside bottom of the tubular test body* - The damping properties of the additional falling weight shall meet the criteria as specified in *FIG Apparatus Rules: IV-MAG6 Standard Specification for Horizontal Bars for Men Artistic Gymnastics.*

6.5 *Recording equipment* - The recording equipment shall meet the following criteria:

6.5.1 *Displacement - time:* The selection of the specific displacement - time recording equipment, including transducers and recorders, is at the discretion of the test laboratory. However, the transducers shall provide linear signals proportional to the two-dimensional displacement of the midpoint of a bar. If displacement is recorded, the test equipment shall have means to determine and record the starting position of the bar from which the total deflections are determined. The total system, detection and recording, shall be capable of measuring displacements of up to 200 mm at frequencies from 2 to 200 Hz to an accuracy of ± 1%. The minimum sampling rate of the data acquisition system shall be 500 Hz.

6.5.2 *Reaction force - time:* Any reaction force - time recording equipment, including load cells and recorders, which can monitor the reaction force exerted on the pendulum simultaneously with the displacement - time trace is acceptable. The total system, detection and recording, shall be capable of measuring reaction forces of up to 5000 N at frequencies from 2 to 200 Hz to an accuracy of ± 1%. The minimum sampling rate of the data acquisition system shall be 500 Hz.

7 Test Specimen

7.1 The test specimen submitted for testing shall consist of complete uneven bars as they are intended to be used during training and/or competition.

7.2 The test specimen shall comply with *FIG Apparatus Rules: II-WAG2*.

8 Conditioning and Test Temperature

8.1 The uneven parallel bars, mounted and assembled for use, shall be preconditioned at 50% ± 10% relative humidity and 21° C ± 3° C for a minimum of 24 hours prior to the test. All testing shall be carried out under the same conditions.

9 Laboratory Procedure (Test Method)

9.1 *General set-up:*

9.1.1 Mount the upper and lower bar to heights as prescribed for competitions (Part II). The inside width between the bars shall be 1.79 m.

9.1.2 The default cable tension shall be 2750 N ± 50 N provided that there is no other specific cable tension suggested by the manufacturer. If a specific cable tension is suggested by the manufacturer, then this suggested cable tension shall be used.

9.1.3 Install the displacement measuring device on the unloaded bars and determine the starting positions.

9.2 *Test A - Static traction stress:*

9.2.1 Pull the midpoints of the upper and lower bar individually vertically downwards with a static tractive force of 1350 N ± 20 N and capture, then record the resulting maximum deflections (mm) using recording equipment described in Section 6.5.

9.2.2 After the release of the static tractive force verify whether the bars return into the starting position.

9.3 *Test B - Stress by pendulum swing:*

9.3.1 Attach the pendulum (50 kg: 40 kg pendulum with additional 10 kg falling weight) to a bar in hanging position.

9.3.2 Move the pendulum from hanging position into horizontal position and move the additional falling weight inside the pendulum to the 50 cm ± 1 cm internal drop height position. For the direction of the pendulum swing at the upper and lower bar see Figure 1.

9.3.3 Release the pendulum and capture the two-dimensional displacement - time history of the midpoint of the bar and the reaction force - time history of the pendulum, using recording equipment de-

scribed in Section 6.5.

9.3.4 Stress each bar by repeating the pendulum swing five times.

9.3.5 Immediately following each test, record the following measurements: F_{max} (N), positive vertical deflection (mm), as well as positive and negative horizontal deflection (mm).

9.3.6 All five tests per bar shall be used to determine the arithmetic mean values of the measured variables for each bar

9.4 *Test C - Oscillation damping:*

9.4.1 Attach the pendulum (50 kg: 40 kg pendulum with additional 10 kg falling weight at the inside bottom of the pendulum) to a bar in hanging position.

9.4.2 Pull down the pendulum vertically until the initial tension of 1000 N ± 30 N is reached.

9.4.3 Release the pendulum and capture the displacement - time history of the midpoint of the bar using recording equipment described in Section 6.5.

9.4.4 Repeat the above process for each bar five times.

9.4.5 Immediately following each test, record the following measurements: Frequency (Hz) and half amplitude interval (ms) of the oscillation.

9.4.6 All five tests per bar shall be used to determine the arithmetic mean values of the measured variables for each bar.

9.5 Calculate the values of all required variables rounded to the decimal places of the corresponding figures identified in Section 5.

10 Report

10.1 *The test report shall include the following information:*

10.1.1 Complete identification of the tested uneven bars, including type, source, manufacturer's model number (if appropriate), dimensions of test specimen, and any other pertinent information. Photographs may be included in the test report for sample documentation purposes.

10.1.2 Test identification number according to the internal regulations between the FIG Test Institutes.

10.1.3 Complete identification of the testing laboratory including test technician and test laboratory manager (if appropriate).

10.1.4 Conditions of test, including test date, temperature and humidity.

10.1.5 Test height and cable tension of the unloaded horizontal bar.

10.1.6 *Test A - Static traction stress:* Description of the Static tractive force.

10.1.7 *Test B - Stress by pendulum swing:* Description of the pendulum mass, the additional falling weight and the internal drop height.

10.1.8 *Test C - Oscillation damping:* Description of the pendulum mass (including the additional falling weight at the inside bottom of the pendulum) and the initial tension.

10.1.9 Description of the test results relative to the performance requirements identified in Section 5.

Standard Specification: Balance Beams for Women Artistic Gymnastics

This standard is issued under the fixed designation FIG: IV-WAG3-01.12.1994; the numbers immediately following the designation indicate the date of original adoption by the FIG or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories. This standard was originally published in English only.

Introduction

The objective of this FIG standard is to provide equal opportunities for all athletes in FIG competitions by controlling the functional properties of balance beams and to minimize any differences between competition and training equipment.

1 Scope

1.1 This specification covers the measurement of certain elastic and shock absorbing characteristics, as well as frictional characteristics of balance beams. This standard specification is applicable to all balance beams that are to be used at any FIG-sanctioned event.

1.2 This specification does not imply that an injury cannot be incurred while using a balance beam which complies with this specification.

1.3 The test procedures associated with this standard may involve hazardous operations and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2 Normative References

2.1 Society of Automotive Engineers: SAE J211 Recommended Practice for Instrumentation for Impact Tests – Requirements for Channel Class 1000, October 1988.

2.2 International Gymnastics Federation (FIG): Apparatus Rules: II-WAG3.

3 Terminology

3.1 *Description of terms specific to this standard:*

3.1.1 *Base plane:* The starting reference plane of the balance beam from which deflection is determined. It is taken as the upper surface of the balance beam loaded by the loading disk prior to any impact.

3.1.2 *Deflection (D):* The measured distance (in mm) between the base plane and the bottom surface of the loading disk during the impact.

3.1.3 *Maximum deflection (D_{max}):* The maximum value of deflection (in mm) measured during the impact.

3.1.4 *Force (F):* The force applied to the balance beam during the impact, expressed in Newtons.

3.1.5 *Energy of deflection (E):* The integration value or calculated area under the force-deflection curve expressed in Nm (Newton*meter). The domain of integration is from the rising point to the maximum point of deflection on the curve.

3.1.6 *Rebound deflection (D_r):* The maximum rebounding displacement (in mm) of the bottom surface of the loading disk, measured from the plane of maximum deflection.

3.1.7 *Rebound time:* The difference in time (in s) between the point of maximum deflection and the point of rebound deflection.

3.1.8 *Rebound velocity (V_r):* The quotient of rebound deflection and rebound time expressed in mm/s.

3.1.9 *Intensity of rebound (D_rV_r):* The product of rebound deflection and rebound velocity expressed in mm^2/s.

3.1.10 *Loading disk:* The part of the test apparatus which applies the specified load to the test specimen.

3.1.11 *Slider:* A test body of given mass and geometry for measuring frictional characteristics of the balance beam. The slider includes a test sole which is bonded to the bottom of the slider and is made of synthetic material with defined friction properties.

3.1.12 *Maximum traction force:* The maximum statical friction force expressed in Newtons, observed at the beginning of the pulling movement of the slider.

3.1.13 *Friction coefficient of balance beam:* Quotient of the maximum traction force (in N) and the weight of the slider (in N).

4 Principle of Measurement

4.1 *The complete measurement procedure consists of two specific test procedures:*

4.1.1 *Test A - Elasticity and shock absorption:* A specimen balance beam is impacted by dropping an impactor from a predetermined height onto a set of rubber springs and a loading disk which are located on the top surface of the test specimen prior to the impact. Transducers mounted in the loading disk shall monitor the force – time history and displacement – time history of the loading disk. This data shall be recorded with the aid of a data acquisition system.

4.1.2 *Test B - Top friction:* A slider is pulled horizontally upon the surface of a specimen balance beam

at a defined loading rate. A transducer connected to the pulling string shall monitor the maximum traction force generated during the pulling movement.

4.2 Data obtained during these procedures are indicative of the elastic and shock absorbing properties and the top friction characteristics of balance beams used in training and FIG-sanctioned competitions.

5 Performance Requirements

5.1 *Test A – Elasticity and Shock absorption:* When tested according to the procedures described in Section 9.1, the values of the measured variables shall be within the figures of Table 1.

5.2 *Test B – Top friction:* When tested according to the procedures described in Section 9.2, the mean values of the measured variables shall be within the figures of Table 2.

Table 1: Figures for Test A – Elasticity and shock absorption of balance beams
See Figure 2 for an illustration of the impact sites.
x represents the mean values of the measured variables

Test A : Elasticity and shock absorption of balance beam				
	D_{max} (mm)	E (Nm)	D_r (mm)	D_rV_r (mm²/s)
Mean value across impact sites 1 to 7	3.5 ≤ x ≤14.0	2.5 ≤ x ≤ 9.5	3.0 ≤ x ≤ 20.0	300 ≤ x ≤ 4800
Difference between highest and lowest mean value on impact sites 1 to 7	≤ 5.0	≤ 3.0	≤ 5.0	≤ 2400

6 Test Apparatus

6.1 *Test A – Elasticity and Shock absorption of balance beam:*

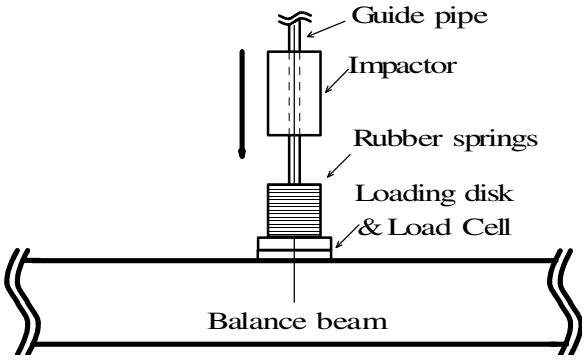
6.1.1 *Impact test machine:* Any type of dynamic testing apparatus that is capable of impacting a test specimen using the prescribed loading condition and monitoring and recording the force - time history and deflection - time history of the loading disk is acceptable. The impact test machine shall have sufficient rigidity to eliminate undesirable vibrations in the apparatus which might be recorded on the force - time curve and deflection - time curve. The impact test machine shall also be designed in such a manner that only the bottom surface of the loading disk contacts the test specimen at any time during the test procedures.

6.1.2 *Loading system - The loading system of the impact test machine shall meet the following requirements (see Figure 1).*

Table 2: Figures for Test B – Top friction of balance beam
See Figure 3 for an illustration of the test sites.
x represents the mean value of the measured variable

Test B : Top friction of balance beam	
	Friction coefficient of balance beam
Mean value across test sites 1 to 3	0.35 ≤ x ≤ 0.60
Difference between highest and lowest mean value on test sites 1 to 3	≤ 0.05
Difference between mean values of orthogonal test directions	≤ 0.05

Figure 1: Setup of the loading system



6.1.2.1 *Characteristics of the dynamic load:* The maximum dynamic force shall be 1300 N ± 2 % when this loading system is applied to the testing anvil. The time from the onset of force application to the time of maximum force shall be 50 ms ± 2 ms.

6.1.2.2 *Impactor:* The dropping impactor shall be 15 kg ± 0.1 kg and shall have a flat impact face. The impactor shall have the shape of a thick cylinder and shall be dropped along a guide pipe. The decision of the size of outside and inside diameters of the impactor is at the discretion of the test laboratory, but the clearance between the inside hole of the impactor and the guide pipe shall be 2 mm ± 0.2 mm. The dropping height of the impactor shall be 120 mm ± 1 mm to the upper surface of the rubber springs.

6.1.2.3 *Release mechanism:* The release mechanism shall be unattached to the loading disk and the guide pipe to prevent an additional load with the attached impactor on the loading disc and the test specimen

before the impact.

6.1.2.4 *Loading disk and guide pipe:* The loading disk shall have a diameter of 70 mm ± 0.5 mm. The total mass of the loading disk including the force transducer and the guide pipe shall be 5 kg ± 0.2 kg.

6.1.2.5 *Rubber springs:* A set of rubber springs shall be selected so as to meet the requirements described in 6.1.2.1.

6.1.3 *Recording equipment - The recording equipment shall meet the following criteria:*

6.1.3.1 *Force - time:* The selection of the specific force - time recording equipment, including transducers and recorders, is at the discretion of the test laboratory. However, the recording system shall have a frequency response adequate to measure the peak force value to an accuracy of ± 3% of the true value. The total system, detection and recording, shall be capable of measuring impact forces of up to 2000 N at frequencies from 2 to 1000 Hz to an accuracy of ± 3%. The minimum sampling rate of the data acquisition system shall be 5000 Hz.

6.1.3.2 *Displacement - time:* The selection of the specific displacement - time recording equipment, including transducers and recorders, is at the discretion of the test laboratory. However, the recording system shall have a frequency response adequate to measure the dynamic displacement value to an accuracy of ± 3% of the true value. The total system, detection and recording, shall be capable of measuring the displacement of ± 50 mm at frequencies from 2 to 1000 Hz to an accuracy of ± 3%. The minimum sampling rate of the data acquisition system shall be 5000 Hz.

6.1.3.3 *Filtering:* The signal from all transducers shall be conditioned with a low pass filter which complies with Channel Class 1000 of SAE Recommended Practice J211. A fourth-order Butterworth low pass filter with a cut-off frequency of 1000 Hz meets this requirement.

6.2 *Test B - Top friction of the balance beam:*

6.2.1 *Measurement device:* Any type of friction testing apparatus that is capable of pulling a slider on the surface of a specimen balance beam at a the required test velocity is acceptable. During the test, the traction force – time history of the slider shall be monitored and recorded.

6.2.2 *Slider:* The slider shall have a mass of 5 kg ± 0.2 kg. A square-shaped test sole with a thickness of 10mm ± 0.5 mm and a size of 40 mm ± 1 mm shall be bonded to the bottom of the slider. The thickness of the test sole shall be decreased to 75% ± 5% of the original thickness at a pressure of 5 N/cm^2. The coefficient of static friction of the test sole shall be 0.25 ± 0.03.

6.2.3 The slider shall be pulled at a constant loading rate of 5 N/s ± 0.5 N/s.

6.2.4 Recording equipment - The recording equipment shall meet the following criteria:

6.2.4.1 *Force - time:* The selection of the specific force - time recording equipment, including transducer and recorder, is at the discretion of the test laboratory. The total system, detection and recording, shall be capable of measuring traction forces up to 100 N at frequencies from 2 to 100 Hz to an accuracy of ± 3%. The minimum sampling rate of the data acquisition system shall be 200 Hz.

7 Test Specimen

7.1 The test specimen submitted for testing shall consist of a complete balance beam as it is intended to be used during training and/or competition.

7.2 The test specimen shall comply with FIG Apparatus Rules: II-WAG3.

8 Conditioning and Test Temperature

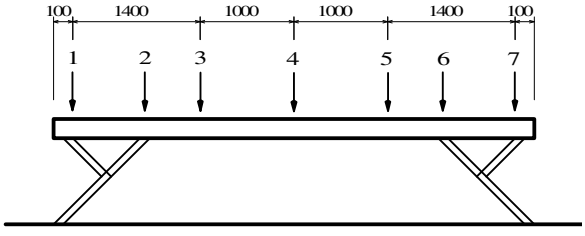
8.1 The test specimen shall be preconditioned at 50% ± 10% relative humidity and 21° C ± 3° C for a minimum of 24 hours prior to the test. All testing shall be carried out under the same conditions.

9 Laboratory Procedure (Test Method)

9.1 *Test A – Elasticity and Shock absorption of the balance beam:*

9.1.1 *Impact sites:* A total of seven impact sites shall be designated on the test specimen. See Figure 2 for an illustration of the impact sites.

Figure 2: Impact sites on the balance beam (distances in mm)



2, 6: intersections of beam and legs

9.1.2 *Impact test procedures:*

9.1.2.1 Place the test specimen under the impact test machine on a smooth, solid and horizontal floor (concrete or metal plate) and orient the loading disk such that the centre of the loading disk contacts one of the designated impact test sites.

9.1.2.2 Raise the impactor to an appropriate drop height such that it will impact on the rubber springs

and generate the proper dynamic load described in Section 6.1.2.

9.1.2.3 Release the impactor and capture the force - time history and displacement - time history using the recording equipment described in Section 6.1.3.

9.1.2.4 Upon completion of a given impact test, raise the impactor off the loading disk.

9.1.2.5 The duration between tests at a given impact site shall not be less than 120 seconds.

9.1.2.6 Impact each of the seven impact sites five times. Each test specimen shall receive a total of 35 impacts.

9.1.3 *Calculations:*

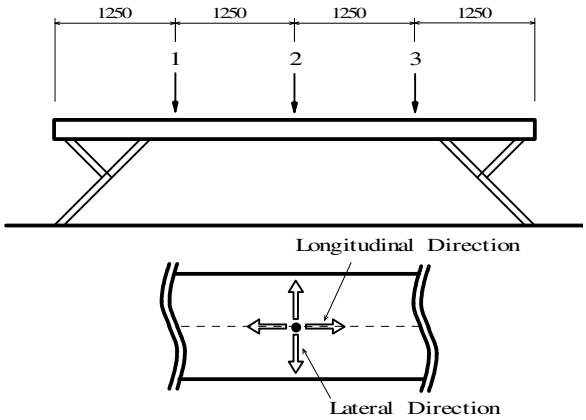
9.1.3.1 Immediately following each test, record the following measurements: D_{max} (mm), E (Nm), D_r (mm) and D_rV_r (mm^2/s).

9.1.3.2 Determine the arithmetic mean values of the measured variables for each impact site and for the overall mean values of the measured variables across all impact sites. Determine also the differences between the highest and lowest mean values of the measured variables for each test site and across all test sites.

9.2 Test B – Top friction of the balance beam:

9.2.1 *Test sites and directions:* A total of three test sites shall be designated on the test specimen as illustrated in Figure 3. Four orthogonal test directions for the traction of the slider shall be also designated on each test site as illustrated in Figure 3.

Figure 3: Top friction test sites and directions on the balance beam (distances in mm)



9.2.2 *Friction test procedures:*

9.2.2.1 Place the complete test specimen on a smooth, solid and horizontal floor.

9.2.2.2 Place the slider on the test specimen in such a manner that the centre of its sole will contact one of the designated test sites, and also in such a manner that the pulling direction of the slider will conform to one of the designated test directions. Just before putting the slider on the test specimen, magnesium carbonate powder of 1g shall be spread on the surface of the test site each time.

9.2.2.3 Pull the slider horizontally at a constant loading rate of 5 N/s ± 0.5 N/s and record the traction force – time history using recording equipment described in Section 6.2.4.

9.2.2.4 Repeat the procedure given in 9.2.2.2 and 9.2.2.3 five times at each test site and in each test direction.

9.2.2.5 Each test specimen shall receive a total of 60 friction test procedures.

9.2.3 *Calculations:*

9.2.3.1 Immediately following each test, record the friction coefficient.

9.2.3.2 Determine the overall mean value of the friction coefficient across the test sites 1 to 3. Determine also the difference between the highest and the lowest mean value of the friction coefficient between all test sites, and the difference between the mean values of the friction coefficients of the orthogonal test directions between all test sites.

9.3 Calculate the values of all required variables rounded to the decimal places of the corresponding figures identified in Section 5.

10 Report

10.1 *The test report shall include the following information:*

10.1.1 Complete identification of the tested balance beam, including type, source, manufacturer's model number (if appropriate), dimensions of test specimen, and any other pertinent information. Photographs may be included in the test report for sample documentation purposes.

10.1.2 Test identification number according to the internal regulations between the FIG Test Institutes.

10.1.3 Complete identification of the testing laboratory including test technician and test laboratory manager (if appropriate).

10.1.4 Conditions of test, including test date, temperature and humidity.

10.1.5 Identification of performed parts of the test – Test A and Test B.

10.1.6 Description of the impactor mass and the drop height conditions (Test A), mass and loading rate of the slider (Test B). A sample loading rate curve may be included in the test report to indicate compliance with the loading requirements of 6.1.2.1.

10.1.7 Description of all test results related to the performance requirements identified in Section 5.

10.1.8 *Supplemental description of the test results:*

10.1.8.1 Maximum value, minimum value and stan-

dard deviation of D_{max}, E, D_r and D_rV_r variables according to Test A.

10.1.8.2 Mean values of D_{max}, E, D_r and D_rV_r variables at each impact site according to Test A.

10.1.8.3 D_{max}, E, D_r and D_rV_r values for all tests according to Test A.

10.1.8.4 Mean values and standard deviations of the friction coefficients at each test site and in each direction according to Test B.

10.1.8.5 Friction coefficient values for all tests according to Test B.

Standard Specification: Floors for Women Artistic Gymnastics

This standard is issued under the fixed designation FIG: IV-WAG4-01.01.1997; the numbers immediately following the designation indicate the date of original adoption by the FIG or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories. This standard was originally published in English only.

The standard specifications for floors for women artistic gymnastics are the same as for men artistic gymnastics, therefore, this standard refers to the FIG standard IV-MAG1.

See:

IV
MAG 1
01.01.2006
1-3

This standard is subject to revision at any time by the FIG Apparatus Commission. Your are invited to comment on revision of this standard or on additional standards. Comments should be addressed to the FIG General Secretary.

Standard Specification: 20 cm Landing Mats for Women Artistic Gymnastics

The standard specifications for 20 cm landing mats for women artistic gymnastics are the same as for men artistic gymnastics, therefore, this standard refers to the FIG standard IV-MAG11.

See:

IV
MAG 11
01.08.1996
1-3

IV
WAG 14
01.01.2006
1

Standard Specification: Vaulting Boards for Women Artistic Gymnastics

The standard specifications for vaulting boards for women artistic gymnastics are the same as for men artistic gymnastics, therefore, this standard refers to the FIG standard IV-MAG14.

See:

IV
MAG 14
01.01.2006
1-3

Standard Specification: Rhythmic Gymnastic Floors

This standard is issued under the fixed designation FIG: IV-RG1-01.12.1992; the numbers immediately following the designation indicate the date of original adoption by the FIG, or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories. This standard was originally published in English only.

Introduction

The objective of this FIG standard is to provide equal opportunities for all athletes in FIG competitions by controlling the functional properties of rhythmic gymnastic floors and to minimize any differences between competition and training equipment.

1 Scope

1.1 This specification covers the measurement of certain shock-absorbing, static stiffness and top friction characteristics of rhythmic gymnastic floors. This standard specification is applicable to all rhythmic gymnastic floors that are to be used at any FIG-sanctioned event.

1.2 This specification does not imply that an injury cannot be incurred while using a rhythmic gymnastic floor which complies with this specification.

1.3 The test procedures associated with this standard may involve hazardous operations and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2 Normative References

2.1 International Gymnastics Federation (FIG): Apparatus Rules: II-RG1.

2.2 European Standard: CEN 12503-5: Sport Mats – Determination of the Base Friction. 2000.

3 Terminology

3.1 *Description of terms specific to this standard:*

3.1.1 *Acceleration:* The instantaneous time rate of change of velocity, expressed in m/s^2, which may be positive or negative.

3.1.2 *Base plane:* The starting reference plane of the rhythmic gymnastic floor from which the total deflection and total height of rebound is determined. It is taken as the top plane of the test specimen.

3.1.3 *Dynamic deflection:* The measured distance (in mm) between the base plane and the maximum displacement of the impactor below the base plane.

3.1.4 *Force (F):* The product of the mass of the impactor, expressed in kg and the acceleration of the impactor, expressed in m/s^2.

3.1.5 *Maximum Force (F_{max}):* The maximum value of force measured during the impact expressed in Newtons.

3.1.6 *Height of rebound:* The measured distance (in mm) between the base plane and the maximum displacement of the impactor above the base plane.

3.1.7 *Impactor*: The striking part of the test apparatus.

3.1.8 *Impact velocity:* The velocity of the impactor, expressed in m/s, immediately prior to crossing the base plane on impact.

3.1.9 *Theoretical drop height:* A calculated drop height which equates the measured velocity of the impactor at the moment of dynamic impact to a height that would generate the same velocity if the test were performed at sea level and there was no friction to retard the impactor during a drop from that height.

3.1.10 *Static deflection:* The measured distance between the base plane and the displacement of the floor's surface at a defined distance from the centre of static indentation. Values are expressed as a percentage of the maximum deflection at the centre of indentation.

3.1.11 *Slider:* A test body of given mass and geometry. The slider includes a test sole which is bonded to the bottom of the slider and is made of synthetic material with defined friction properties.

3.1.12 *Thrust - traction sequence:* A series of 5 successive thrust and traction movements of the slider which is pushed and pulled horizontally on the surface of the test specimen at a defined speed and distance.

3.1.13 *Sliding distance:* The horizontal distance between the two turning points of the movement of the slider in a thrust – traction sequence.

3.1.14 *Mean thrust - traction force:* Mean value of the absolute, average force, expressed in Newtons, as the slider moves during the fifth push and pull movement in a thrust - traction sequence.

3.1.15 *Friction coefficient:* Quotient of the mean thrust - traction force (in N) and the weight of the slider (in N) in a thrust - traction sequence.

3.1.16 *Base temperature:* The surface temperature (in ^{0} C) of the test specimen immediately before the beginning of a thrust - traction sequence.

3.1.17 *Mean thrust - traction temperature:* Mean value of the surface temperature (in ^{0} C) of the test

specimen at a defined distance to the slider during the fifth push and pull movement in a thrust - traction sequence.

3.1.18 *Temperature rise:* Difference (in ^{0}C) between the base temperature and the mean thrust - traction temperature in a thrust - traction sequence.

3.1.19 *Orthogonal difference of friction coefficients:* The absolute value of the difference between the mean value of the friction coefficients of 3 consecutive thrust - traction sequences in one measurement direction and the corresponding mean value of 3 additional consecutive thrust - traction sequences in a perpendicular measurement direction.

3.1.20 *Orthogonal difference of temperature rises:* The absolute value of the difference between the mean value of the temperature rises of 3 consecutive thrust - traction sequences in one measurement direction and the corresponding mean value of 3 additional consecutive thrust - traction sequences in a perpendicular measurement direction.

4 Principles of Measurement

4.1 *The complete test procedures include 3 parts:* Determination of shock absorption, determination of static stiffness and determination of top friction.

4.1.1 *Test A - Determination of shock absorption:* A test specimen is impacted with an impactor of given mass and geometry at a specified velocity. A transducer mounted in the impactor monitors the acceleration – time history of the impactor which is recorded with the aid of a data acquisition system. An additional transducer may be used to monitor the displacement – time history of the impactor.

4.1.2 *Test B - Determination of static stiffness:* A static load is applied to the rhythmic gymnastic floor to obtain an area of impression. The static deflection of the specimen's surface at defined distances from the centre of indentation is measured.

4.1.3 *Test C - Determination of top friction:* A slider of given mass and geometry traverses the test specimen which is fixed on a plane surface. The slider is pushed forward and pulled backwards for a specified number of times with a constant velocity over a given distance. Two transducers are mounted at the slider. One of them monitors the thrust and traction force - time history of the slider movement. The other captures the temperature - time history of the surface of the test piece in a defined distance to the slider.

4.2 Data obtained during these procedures are indicative of the cushioning and rebound properties, the static stiffness and the top friction characteristics of the rhythmic gymnastic floor used in training and FIG-sanctioned competitions.

5 Performance Requirements

5.1 *Test A - Determination of shock absorption:* When tested according to the procedures described in Section 9.1, the overall mean value of the measured variables across all impact sites shall be within the figures of Table 1.

Table 1: Figures for Test A - Determination of Shock Absorption

x represents the mean value of the measured variable

Dynamic deflection (mm)	*Height of rebound (mm)*	F_{max} *(N)*
21 <= x <= 27	120 <= x <= 180	≤ 3700

5.2 *Test B - Determination of static stiffness:* When tested according to the procedures described in Section 9.2, the measured variables shall be within the figures of Table 2.

Table 2: Figures for Test B - Determination of Static Stiffness

Distance to the centre of static indentation (cm)	0	5	6	8	10	12	14	16
Static deflection (%)	100	100	<57	<46	<38	<33	<28	<24
Distance to the centre of static indentation (cm)	18	20	22	24	26	28	30	32
Static deflection (%)	<20	<17	<14	<12	<11	<9	<8	<8

5.3 *Test C - Determination of top friction:* When tested according to the procedures described in Section 9.3, the measured variables shall be within the figures of Table 3.

Table 3: Figures for Test C - Determination of Top Friction

X represents the mean value of the measured variable

Friction coefficient	*Temperature rise (^{0}C)*	*Orthogonal difference of friction coefficients*	*Orthogonal difference of temperature rises (^{0}C)*
0.32≤ x ≤0.62	≤ 2.3	≤ 0.08	≤ 0.8

6 Test Set-up and Test Apparatus

6.1 *Test A - Determination of shock absorption:*

6.1.1 *Impact test machine:* Any type of dynamic testing apparatus that is capable of impacting a test specimen at a prescribed impact velocity and monitoring and recording the acceleration - time history of the impactor is acceptable. The impact test machine and the impactor shall have sufficient rigidity to eliminate undesirable vibrations in the apparatus which might be recorded on the acceleration - time

curve. The impact test machine shall also be designed in such a manner that only the impact face contacts the test specimen at any time during the test procedures.

6.1.2 *Impactor:* The impactor shall be 10 kg ± 0.1 kg and shall have a flat impact face with a 10 cm ± 0.5 cm diameter. The edge of the impactor face should be relieved to eliminate sharp edges. Provision shall be made so that the accelerometer can be securely fastened parallel to the vertical axis of the impactor with a maximum deviation of ± 5°.

6.1.3 *Recording equipment* - The recording equipment shall meet the following criteria:

6.1.3.1 6.1.3.1 *Acceleration - time:* The selection of the specific acceleration - time recording equipment, including transducers and recorders, is at the discretion of the test laboratory. However, the recording system shall have a frequency response adequate to measure the peak acceleration value to an accuracy of ± 5% of the true value. The total system, detection and recording, shall be capable of measuring impact accelerations of up to 100 g at frequencies from 2 to 1000 Hz to an accuracy of ± 5%. The minimum sampling rate of the data acquisition system shall be 5000 Hz.

6.1.3.2 6.1.3.2 *Displacement - time:* It is optional, but desirable, that the displacement - time history is recorded by a separate transducer. Any transducer that provides a linear signal proportional to the displacement of the impactor along the impact axis which can be monitored coincidentally with the acceleration - time trace is acceptable. If displacement is recorded, the test equipment shall have means to determine and record the top plane (base plane) of the test specimen from which the total dynamic deflection and rebound height are determined.

6.1.3.3 6.1.3.3 *Filtering:* The signal from all transducers shall be conditioned with a low pass filter which complies with Channel Class 1000 of SAE Recommended Practice J211. A fourth-order Butterworth low pass filter with a cut-off frequency of 1000 Hz meets this requirement.

6.2 *Test B – Determination of static stiffness:*

6.2.1 *Measurement device:* Any type of static testing apparatus that is capable of loading a test specimen with a given weight and monitoring and recording the static deflection at defined distances from the centre of static indentation is acceptable. The test apparatus, especially the part directly measuring the deflection, shall also be designed in such a manner that it does not contact the test specimen in a circular area of 0.8 m diameter around the centre of indentation at any time during the test procedures, except the impact face of the indentor.

6.2.2 *Static load:* The static load shall be 100 kg ± 1 kg, vertically applied by an indentor onto the test specimen. The indentor shall have a flat impact face with a 10 cm ± 0.5 cm diameter. The edge of the indentor face should be relieved to eliminate sharp edges.

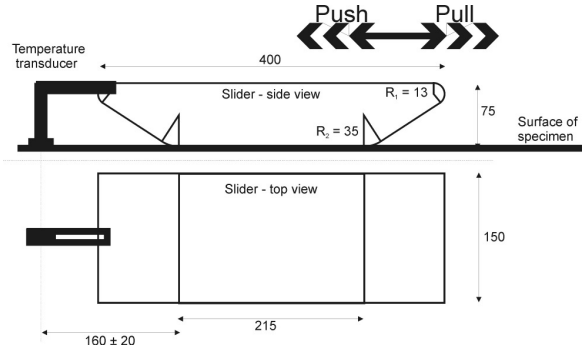
6.2.3 *Recording equipment for static deflection:* The selection of the specific measurement equipment is at the discretion of the test laboratory. However, the means of measuring the static deflection shall have a flat rectangular contact face of 47 mm * 31 mm ± 3%. The load on the surface of the test specimen by the weight of the measuring system shall be 2 N ± 3%. The accuracy of the system shall be ± 0.5 mm.

6.3 *Test C – Determination of top friction:*

6.3.1 *Measurement device:* Any type of friction testing apparatus that is capable of stressing a test specimen by pushing and pulling a slider on the specimen's surface at a given velocity and distance is acceptable. During the test the force – time history of the movement of the slider and the temperature – time history at the floor's surface shall be monitored and recorded. The friction test machine and the slider shall have sufficient rigidity to eliminate undesirable vibrations in the apparatus which might be recorded on the force - time curve. It is desirable to fix the test specimen for the friction tests with the help of an additional fastening system outside the sliding area.

6.3.2 *Slider:* The slider shall be made of wood with a mass of 9.5 kg ± 3% and shall have the geometrical dimensions specified in Figure 1. A test sole of synthetic material with a thickness of 2.6 mm ± 0.5 mm shall be bonded to the bottom of the slider, complying with the requirements of CEN 12503-5: $\alpha L := 47.5 \pm 0.5$. The temperature of the test specimen's surface shall be captured at a distance of 160 mm ± 20 mm to front edge of the flat part of the bottom of the slider (see Figure 1).

Figure 1: Slider Dimensions for Top Friction Tests of Rhythmic Gymnastic Floors.
(Dimensions in mm; Accuracy: ±1 mm)



6.3.3 The slider shall be pushed and pulled over a

determined sliding distance a specified number of times at a given constant velocity.

6.3.4 *Recording equipment* - The recording equipment shall meet the following criteria:

6.3.4.1 *Force – time:* The selection of the specific force - time recording equipment, including transducer and recorder, is at the discretion of the test laboratory. The total system, detection and recording, shall be capable of measuring thrust and traction forces up to ± 1000 N at frequencies from 2 to 100 Hz to an accuracy of ± 3%. The minimum sampling rate of the data acquisition system shall be 200 Hz.

6.3.4.2 *Temperature – time:* The selection of the specific temperature - time recording equipment, including transducer and recorder, is at the discretion of the test laboratory. The transducer should have means to provide temperature measurements during sliding movements up to 300 mm/s. The time constant of the temperature transducer shall be $T_{99} \leq 4$ s. The thermoelectric transducer ANRITSU/AIRFLOW C423 meets these requirements. The total system, detection and recording, shall be capable of measuring temperature differences up to $+10^0$ C at frequencies from 2 to 100 Hz to an accuracy of ± 1%. The minimum sampling rate of the data acquisition system shall be 200 Hz.

7 Test Specimen

7.1 The test specimen submitted for testing shall represent the rhythmic gymnastic floor as it is intended to be used during training and/or competition.

7.2 The test specimen shall comply with FIG Apparatus Rules: II-RG1. Exception: See 7.3.

7.3 The minimum horizontal dimensions (length * width) for any test specimen shall be 200 cm * 120 cm. For Test C (Determination of top friction) the minimum horizontal dimensions (length * width) for any test specimen shall be 100 cm * 120 cm.

8 Conditioning and Test Temperature

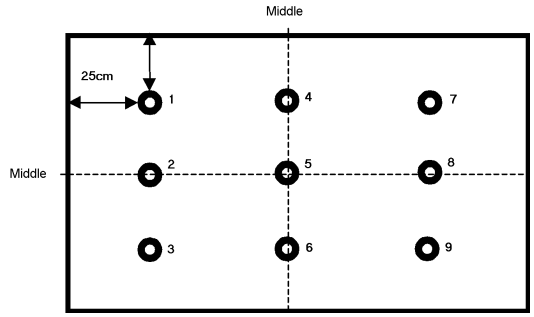
8.1 The test specimen shall be preconditioned at 50% ± 10% relative humidity and 21^o ± 3^o C for a minimum of 24 hours prior to the test. All testing shall be carried out under the same conditions.

9 Laboratory Procedures (Test Methods)

9.1 *Test A - Determination of shock absorption:*

9.1.1 Impact locations: A total of nine impact sites shall be designated on the test specimen. See Figure 2 for an illustration of the impact sites.

Figure 2: Impact Locations for Rhythmic Gymnastic Floors



9.1.2 *Impact test procedures:*

9.1.2.1 9.1.2.1 Place the test specimen under the impact test machine on a smooth, solid floor (concrete or metal plate) and orient the impactor such that the centre of the impact face will contact one of the designated impact test sites.

9.1.2.2 9.1.2.2 Raise the impactor to an appropriate drop height such that it will contact the test specimen with an impact velocity of 2.80 m/s ± 3 %. This corresponds to a theoretical drop height of 0.4 m.

9.1.2.3 9.1.2.3 Release the impactor and capture the acceleration - time history and displacement - time history (if applicable) using recording equipment described in Section 6.1.3.

9.1.2.4 9.1.2.4 Upon completion of a given impact test, raise the impactor off the surface of the test specimen.

9.1.2.5 9.1.2.5 The duration between tests at a given impact site shall not be less than 120 seconds.

9.1.2.6 9.1.2.6 Each test specimen shall receive a total of 90 impacts. Impact each of the nine impact sites ten times.

9.1.3 *Calculations:*

9.1.3.1 9.1.3.1 Immediately following each test, record the following measurements: F_{max} (N), Dynamic deflection (mm) and Height of rebound (mm).

9.1.3.2 9.1.3.2 The last eight tests for each impact site shall be used to determine the arithmetic mean value of a measured variable for each impact site and for the overall mean value of a measured variable across all impact sites.

9.2 *Test B - Determination of static stiffness:*

9.2.1 *Static impact test procedure:*

9.2.1.1 9.2.2.1 Place the test specimen under the impact test machine and orient the impactor such that it will contact the midpoint of the test specimen's surface. The test specimen shall lie on a smooth, solid floor (concrete or metal plate) for the test.

9.2.1.2 9.2.2.2 Apply the load on the test specimen's surface for 30 s. Measure and calculate the static deflection at the following distances from the centre of indentation: 0 cm; 5 cm; 6 cm; 8 cm; 10 cm;

12 cm; 14 cm; 16 cm; 18 cm; 20 cm; 22 cm; 24 cm; 26 cm; 28 cm; 30 cm and 32 cm.

9.2.1.3 9.2.2.3 Upon completion of the measurements unload the surface of the test specimen.

9.3 *Test C - Determination of top friction:*

9.3.1 Place the test specimen under the slider. Fix all components carefully with the fastening system to prevent horizontal movement of the test specimen during the friction test. The complete test specimen shall lie on a smooth and solid horizontal plate.

9.3.2 The slider shall be pushed and pulled with a constant velocity of 300 mm/s ± 3% over 90% of the total sliding distance of 600 mm ± 3%.

9.3.3 Perform a thrust – traction sequence with the slider (i.e. 5 pushing and pulling movements) within 30 sec. Capture the force – time history using recording equipment described in Section 6.3.4. Wait at least 300 seconds between trials. Repeat the whole thrust – traction sequence an additional two times with the pause between trials.

9.3.4 Repeat the procedure given in 9.3.3 to obtain readings in the perpendicular direction by rotating the test specimen through 90^0.

9.3.5 Upon completion of the measurements unload the surface of the test specimen.

9.3.6 Each test specimen shall receive a total of 6 thrust – traction sequences.

9.3.7 *Calculations:*

9.3.7.1 9.3.7.1 Immediately following the test, record and calculate the following measurements for every thrust – traction sequence: Friction coefficient and Temperature rise (^{0} C).

9.3.7.2 9.3.7.2 Determine the overall mean value of the measured variables for all thrust – traction sequences, the Orthogonal difference of friction coefficients and the Orthogonal difference of temperature rises.

9.4 Calculate the values of all required variables rounded to the decimal places of the corresponding figures identified in Section 5.

10 Report

10.1 The test report shall include the following information:

10.1.1 Complete identification of the tested rhythmic gymnastic floor, including type, source, manufacturer's model number (if appropriate), dimensions of test specimen, and any other pertinent information. Photographs may be included in the test report for sample documentation purposes.

10.1.2 Test identification number according to the internal regulations between the FIG Test Institutes.

10.1.3 Complete identification of the testing laboratory including test technician and test laboratory manager (if appropriate).

10.1.4 Conditions of test, including test date, temperature and humidity.

10.1.5 Identification of performed parts of the test – Test A; Test B; Test C.

10.1.6 Description of the impactor mass and the drop height conditions (Test A), static load (Test B), mass, velocity and sliding distance of the slider (Test C).

10.1.7 Description of the test results relative to the performance requirements identified in Section 5.

10.1.8 Mean values of Deflection, Height of rebound and F_{max} across all impact sites according to Test A.

10.1.9 Maximum value, minimum value and standard deviation of Deflection, Height of rebound and F_{max} variables according to Test A.

10.1.10 Mean values of Deflection, Height of rebound and F_{max} for the last eight tests at each impact site according to Test A.

10.1.11 Deflection, Height of rebound and F_{max} values for all tests according to Test A.

10.1.12 Friction coefficient, temperature rise, Orthogonal difference of friction coefficients and Orthogonal difference of temperature rises for all thrust – traction sequences according to test C.

Standard Specification: Floors for Sports Aerobics

This standard is issued under the fixed designation FIG: IV-AER1-01.07.2000; the numbers immediately following the designation indicate the date of original adoption the FIG or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories. This standard was originally published in English only.

Introduction

The objective of this FIG standard is to provide equal opportunities for all athletes in FIG competitions by controlling the functional properties of sports aerobic floors and to minimize any differences between competition and training equipment.

1 Scope

1.1 This specification covers the measurement of certain elastic and shock absorbing characteristics of sports aerobic floors. This standard specification is applicable to all sports aerobic floors that are to be used at any FIG-sanctioned event.

1.2 This specification does not imply that an injury cannot be incurred while using a sports aerobic floor which complies with this specification.

1.3 The test procedures associated with this standard may involve hazardous operations and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2 Normative References

2.1 Society of Automotive Engineers: SAE J211 Recommended Practice for Instrumentation for Impact Tests – Requirements for Channel Class 1000, October 1988.

2.2 International Gymnastics Federation (FIG): Apparatus Rules: II-AER1.

3 Terminology

3.1 *Description of terms specific to this standard:*

3.1.1 *Base plane:* The starting reference plane of the sports aerobic floor from which deflection is determined. It is taken as the upper surface of the floor loaded by the loading disk prior to any impact.

3.1.2 *Deflection (D):* The measured distance (in mm) between the base plane and the bottom surface of the loading disk during the impact.

3.1.3 *Maximum deflection (D_{max}):* The maximum value of deflection (in mm) measured during the impact.

3.1.4 *Force (F):* The force applied to the sports aerobic floor during the impact, expressed in Newtons.

3.1.5 *Energy of deflection (E):* The integration value or calculated area under the force-deflection curve expressed in Nm (Newton*meter). The domain of integration is from the rising point to the maximum point of deflection on the curve.

3.1.6 *Rebound deflection (D_r):* The maximum rebounding displacement (in mm) of the bottom surface of the loading disk, measured from the plane of maximum deflection.

3.1.7 *Rebound time:* The difference in time (in s) between the point of maximum deflection and the point of rebound deflection.

3.1.8 *Rebound velocity (V_r):* The quotient of rebound deflection and rebound time expressed in mm/s.

3.1.9 *Intensity of rebound (D_rV_r):* The product of rebound deflection and rebound velocity expressed in mm^2/s.

3.1.10 *Loading disk:* The part of the test apparatus which applies the specified load to the test specimen.

4 Principle of Measurement

4.1 A specimen sports aerobic floor is impacted by dropping an impactor from a predetermined height onto a set of rubber springs and a loading disk which are located on the top surface of the test specimen prior to the impact. Transducers mounted in the loading disk shall monitor the force – time history and displacement – time history of the loading disk. This data shall be recorded with the aid of a data acquisition system.

4.2 Data obtained during these procedures are indicative of the elastic and shock absorbing properties of sports aerobic floors used in training and FIG-sanctioned competitions.

5 Performance Requirements

5.1 When tested according to the procedures described in Section 9, the values of the measured variables shall be within the figures of Table 1.

Table 1: Figures for elasticity and shock absorption of sports aerobic floors
See Figure 2 for an illustration of the impact sites.
x represents the mean values of the measured variables

	D_{max} (mm)	E (Nm)	D_r (mm)	D_rV_r (mm²/s)
Mean value across impact sites 1 to 9	3.5 ≤ x ≤12.0	2.5 ≤ x ≤ 9.5	3.0 ≤ x ≤ 15.0	300 ≤ x ≤ 3600
Difference between highest and lowest mean values on impact sites 1 to 9	≤ 5.0	≤ 3.0	≤ 5.0	≤ 2400

Test Apparatus

5.2 *Impact test machine:* Any type of dynamic testing apparatus that is capable of impacting a test specimen at a prescribed loading condition and monitoring and recording the force - time history and deflection - time history of the loading disk is acceptable. The impact test machine shall have sufficient rigidity to eliminate undesirable vibrations in the apparatus which might be recorded on the force - time curve and deflection - time curve. The impact test machine shall also be designed in such a manner that only the bottom surface of the loading disk contacts the test specimen at any time during the test procedures.

5.3 *Loading system - The loading system of the impact test machine shall meet the following requirements (see Figure 1):*

5.3.1 *Characteristics of the dynamic load:* The maximum dynamic force shall be 1300N ± 2 % when this loading system is applied to the testing anvil. The time from the onset of force application to the time of maximum force shall be 50 ms ± 2 ms.

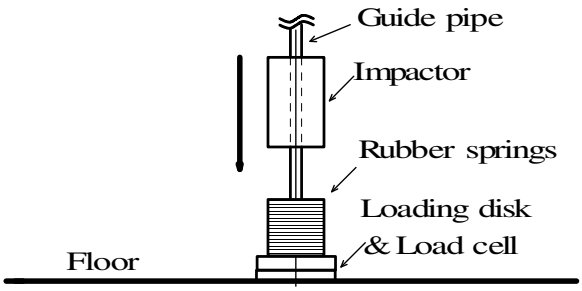
5.3.2 *Impactor:* The dropping impactor shall be 15 kg ± 0.1 kg and shall have a flat impact face. The impactor shall have the shape of a thick cylinder and shall be dropped along a guide pipe. The decision of the size of outside and inside diameters of the impactor is at the discretion of the test laboratory, but the clearance between the inside hole of the impactor and the guide pipe shall be 2 mm ± 0.2 mm. The dropping height of the impactor shall be 120 mm ± 1 mm to the upper surface of the rubber springs.

5.3.3 *Release mechanism:* The release mechanism shall be unattached to the loading disk and the guide pipe to prevent an additional load with the attached impactor on the loading disc and the test specimen before the impact.

5.3.4 *Loading disk and guide pipe:* The loading disk shall have a diameter of 70 mm ± 0.5 mm. The total mass of the loading disk including the force transducer and the guide pipe shall be 5 kg ± 0.2 kg.

5.3.5 *Rubber springs:* A set of rubber springs shall be selected so as to meet the requirements described in 6.2.1.

Figure 1: Setup of the loading system



5.4 *Recording equipment - The recording equipment shall meet the following criteria:*

5.4.1 *Force - time:* The selection of the specific force - time recording equipment, including transducers and recorders, is at the discretion of the test laboratory. However, the recording system shall have a frequency response adequate to measure the peak force value to an accuracy of ± 3% of the true value. The total system, detection and recording, shall be capable of measuring impact forces of up to 2000 N at frequencies from 2 to 1000 Hz to an accuracy of ± 3%. The minimum sampling rate of the data acquisition system shall be 5000 Hz.

5.4.2 *Displacement - time:* The selection of the specific displacement - time recording equipment, including transducers and recorders, is at the discretion of the test laboratory. However, the recording system shall have a frequency response adequate to measure the dynamic displacement value to an accuracy of ± 3% of the true value. The total system, detection and recording, shall be capable of measuring the displacement of ± 50 mm at frequencies from 2 to 1000 Hz to an accuracy of ± 3%. The minimum sampling rate of the data acquisition system shall be 5000 Hz.

5.4.3 *Filtering:* The signal from all transducers shall be conditioned with a low pass filter which complies with Channel Class 1000 of SAE Recommended Practice J211. A fourth-order Butterworth low pass filter with a cut-off frequency of 1000 Hz meets this requirement.

6 Test Specimen

6.1 The test specimen submitted for testing shall

represent the sports aerobic floor as it is intended to be used during training and/or competition.

6.2 The test specimen shall comply with FIG Apparatus Rules: II-AER1. Exception: See 7.3.

6.3 The minimum horizontal dimensions (length * width) for any test specimen shall be 180 cm * 180 cm. The minimum dimensions shall be also larger than the dimensions of the basic module of the floor system.

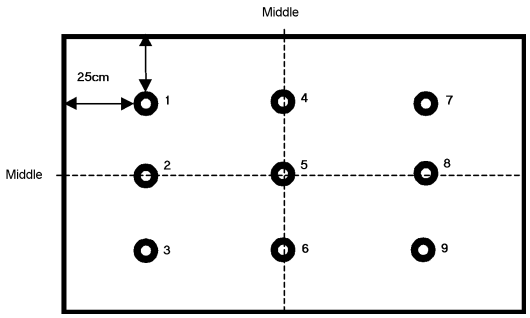
7 Conditioning and Test Temperature

7.1 The test specimen shall be preconditioned at 50% ± 10% relative humidity and 21° C ± 3° C for a minimum of 24 hours prior to the test. All testing shall be carried out under the same conditions.

8 Laboratory Procedure (Test Method)

8.1 *Impact sites:* A total of nine impact sites shall be designated on the test specimen. See Figure 2 for an illustration of the impact sites.

Figure 2: Impact sites on the sports aerobic floor



8.2 Impact test procedures:

8.2.1 Place the test specimen under the impact test machine on a smooth, solid and horizontal floor (concrete or metal plate) and orient the loading disk such that the centre of the loading disk contacts one of the designated impact test sites.

8.2.2 Raise the impactor to an appropriate drop height such that it will impact on the rubber springs and generate the proper dynamic load described in Section 6.2.

8.2.3 Release the impactor and capture the force - time history and displacement - time history using the recording equipment described in Section 6.3.

8.2.4 Upon completion of a given impact test, raise the impactor off the loading disk.

8.2.5 The duration between tests at a given impact site shall not be less than 120 seconds.

8.2.6 Impact each of the nine impact sites five times. Each test specimen shall receive a total of 45 impacts.

8.3 *Calculations:*

8.3.1 Immediately following each test, record the following measurements: D_{max} (mm), E (Nm), D_r (mm) and D_rV_r (mm^2/s).

8.3.2 Determine the arithmetic mean values of the measured variables for each impact site and for the overall mean values of the measured variables across all impact sites. Determine also the differences between the highest and lowest mean values of the measured variables for each test site and across all test sites.

8.4 Calculate the values of all required variables rounded to the decimal places of the corresponding figures identified in Section 5.

9 Report

9.1 *The test report shall include the following information:*

9.1.1 Complete identification of the tested sports aerobic floor, including type, source, manufacturer's model number (if appropriate), dimensions of test specimen, and any other pertinent information. Photographs may be included in the test report for sample documentation purposes.

9.1.2 Test identification number according to the internal regulations between the FIG Test Institutes.

9.1.3 Complete identification of the testing laboratory including test technician and test laboratory manager (if appropriate).

9.1.4 Conditions of test, including test date, temperature and humidity.

9.1.5 Description of the impactor mass and the drop height conditions. A sample loading rate curve may be included in the test report to indicate compliance with the loading requirements of 6.2.1.

9.1.6 Description of all test results related to the performance requirements identified in Section 5.

9.1.7 *Supplemental description of the test results:*

9.1.7.1 Maximum value, minimum value and standard deviation of D_{max}, E, D_r and D_rV_r variables.

9.1.7.2 Mean values of D_{max}, E, D_r and D_rV_r variables at each impact site.

9.1.7.3 D_{max}, E, D_r and D_rV_r values for all tests.

IV
4

Standard Specification: Trampolines

This standard is issued under the fixed designation FIG: IV-TRA1-01.02.1995; the numbers immediately following the designation indicate the date of original adoption by the FIG, or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories and was adapted from the former International Trampoline Federation (FIT) standard for Trampolines (FIT Handbook 1998). This standard was originally published in English only.

Introduction

The objective of this FIG standard is to provide equal opportunities for all athletes in FIG competitions by controlling the functional properties of trampolines and to minimize any differences between competition and training equipment.

1 Scope

1.1 This specification covers the measurement of certain elastic properties of trampolines. This standard specification is applicable to all competition trampolines that are to be used at any FIG-sanctioned event.

1.2 This specification does not imply that an injury cannot be incurred while using a trampoline which complies with this specification.

1.3 The test procedures associated with this standard may involve hazardous operations and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2 Normative References

2.1 International Gymnastics Federation (FIG): Apparatus Rules: II-TRA1.

3 Terminology

3.1 *Description of terms specific to this standard:*

3.1.1 *Base plane:* The reference plane of the trampoline from which the total deflection and total height of rebound is determined. It is taken as the plane of the trampoline bed.

3.1.2 *Vertical falling line*: The reference line in space, which corresponds to the vertical trajectory of a test sphere to the first impact on the trampoline.

3.1.3 *Reference point of the test sphere:* The bottom point of the test sphere in a defined spatial position.

3.1.4 *Deflection:* The vertically measured distance (in mm) from the base plane to the reference point of the test sphere at maximum displacement below the base plane caused by the first impact.

3.1.5 *Height of rebound:* The vertically measured distance (in mm) from the base plane to the reference point of the test sphere at maximum displacement above the base plane caused by the first rebound.

3.1.6 *Deviation to the side during rebound:* The measured horizontal distance (in mm) between the vertical falling line and the reference point of the test sphere at maximum displacement above the base plane.

4 Principle of Measurement

4.1 The trampoline is impacted from a specified height with a spherical impactor of given mass and diameter. The three-dimensional displacement – time history of the impactor is monitored during the impact onto the bed and the first rebound after impact.

4.2 Displacement data obtained during these procedures are indicative of the elastic properties of the trampoline used in training and FIG-sanctioned competitions.

5 Performance Requirements

5.1 When tested according to the procedures described in Section 9, the mean value of the measured variables for each impact site shall be within the figures of Table 1.

Table 1: Figures for Trampolines

(empty cells in table: no requirements;
x represents the mean value of the measured variable at an impact site)

Measurement point	Deflection (mm)	Height of rebound (mm)	Deviation to the side during rebound (mm)
1	$920 \le x \le 990$	$3100 \le x \le 3350$	
2		≤ 3350	
3		≤ 3350	
4		≤ 3350	$1550 \le x \le 1900$

6 Test Apparatus

6.1 *Impact test set-up:* Any type of test set-up that is capable of impacting a trampoline under the prescribed conditions and monitoring and recording the displacement - time history of the reference point of the test sphere is acceptable. It is optional, but desirable, that the test sphere is released magnetically at the prescribed drop height. In addition it is recommended to attach safety ropes in order to prevent uncontrolled movement of the test sphere after the first rebound from the bed of the trampoline. The use of overhead spotting rigs has been found to be useful for this purpose.

6.2 *Test sphere:* The test sphere shall be a metal sphere with a diameter of 40 cm ± 1 cm and a mass of 60 kg ± 0.5 kg. To attach a magnetic fixation to the sphere, a flat plated upper section (up to a diameter of 10 cm) is acceptable. To attach safety ropes, two suitable fixations at the upper side of the sphere are allowed.

6.3 *Recording equipment* - The recording equipment shall meet the following criteria:

6.3.1 *Displacement - time:* It is at the discretion of the test laboratory to select a specific instrumentation to monitor, record and calculate the three-dimensional displacement of the sphere during impact and first rebound. The total system shall be capable of measuring height of rebound and deviation to the side during rebound with an accuracy of ± 1 cm and deflection with an accuracy of ± 0.5 cm. The requirements can be met by using at least two video cameras (min. frequency 50 Hz; min. shutter speed 1/500) to capture the movements of the test sphere above the bed of the trampoline. The spatial motion of the test sphere can be calculated by three-dimensional cinematographic analysis utilizing the DLT - algorithm (Direct Linear Transformation) or a similar technique. The deflection may be determined by using one camera and two-dimensional cinematographic analysis.

7 Test Specimen

7.1 The test specimen submitted for testing shall consist of a trampoline as it is intended to be used during training and/or competition with safety padding and with at least one safety platform.

7.2 The trampoline shall comply with FIG Apparatus Rules: II-TRA1.

8 Conditioning and Test Temperature

8.1 The trampoline, mounted and assembled for use, shall be preconditioned at 50% ± 10% relative humidity and 21° C ± 3° C for a minimum of 24 hours prior to the test. All testing shall be carried out under the same conditions.

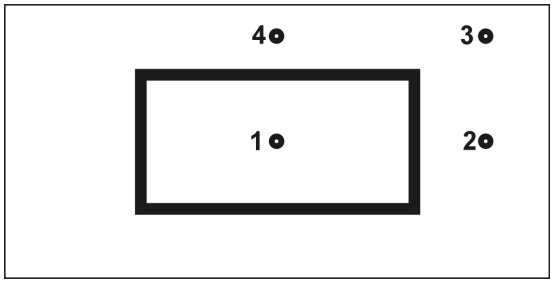
9 Laboratory Procedure (Test Method)

9.1 *Impact locations:* A total of four impact sites shall be designated on the trampoline. See Figure 1 for an illustration of the impact sites.

9.2 *Impact test procedures:*

9.2.1 Place the test specimen on a smooth and solid floor and orient the impact test sphere so that the contact will be at one of the designated impact test sites.

Figure 1: Impact Locations on the Bed for Trampolines with Marked Jumping Zone.
The locations 1 to 4 are the midpoints to related parts of the bed and the marked out jumping zone.



9.2.2 Raise the test sphere to an appropriate drop height such that the distance between the reference point of the test sphere and the unloaded bed of the trampoline is 400 cm ± 2 cm.

9.2.3 Release the test sphere and capture the displacement - time history using recording equipment described in Section 6.3.

9.2.4 Upon completion of a given impact test, raise the test sphere off the surface of the trampoline.

9.2.5 Check the displacement recordings after every test. If there is any deviation during the free fall of the test sphere (i.e. by pulling at the overhead safety rigs too early), the test shall be repeated.

9.2.6 Repeat the test procedures such that the trampoline to be tested shall receive three impacts at each of the four impact sites for a total of 12 impacts.

9.3 *Calculations:*

9.3.1 For each test, calculate the following measurements: Deflection (mm), Height of rebound (mm) and Deviation to the side during rebound (mm).

9.3.2 All three tests for each impact site shall be used to determine the arithmetic mean value of a measured variable for each impact site.

9.3.3 Calculate the mean values of Deflection, Height of rebound and Deviation to the side during

rebound across all impact sites rounded to zero decimal places.

10 Report

10.1 *The test report shall include the following information:*

10.1.1 Complete identification of the tested trampoline, including type, source, manufacturer's model number (if appropriate), dimensions of the trampoline, and any other pertinent information. Photographs may be included in the test report for sample documentation purposes.

10.1.2 Test identification number according to the internal regulations between the FIG Test Institutes.

10.1.3 Complete identification of the testing laboratory including test technician and test laboratory manager (if appropriate).

10.1.4 Conditions of test, including test date, temperature and humidity.

10.1.5 Description of the test sphere mass and the drop height conditions.

10.1.6 Description of the test results relative to the performance requirements identified in Section 5.

IV
4

Standard Specification: Tumbling Tracks

This standard is issued under the fixed designation FIG: IV-TRA3-01.07.1996; the numbers immediately following the designation indicate the date of original adoption by the FIG, or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories and was adapted from the former International Trampoline Federation (FIT) standard for Tumbling Tracks (FIT Handbook 1998). This standard was originally published in English only.

Introduction

The objective of this FIG standard is to provide equal opportunities for all athletes in FIG competitions by controlling the functional properties of tumbling tracks and to minimize any differences between competition and training equipment.

1 Scope

1.1 This specification covers the measurement of certain shock-absorbing, rebound, top friction and stability characteristics of tumbling tracks. This standard specification is applicable to all tumbling tracks that are to be used at any FIG-sanctioned event.

1.2 This specification does not imply that an injury cannot be incurred while using a tumbling track which complies with this specification.

1.3 The test procedures associated with this standard may involve hazardous operations and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2 Normative References

2.1 Society of Automotive Engineers: SAE J211 Recommended Practice for Instrumentation for Impact Tests – Requirements for Channel Class 1000, October 1988.

2.2 International Gymnastics Federation (FIG): Apparatus Rules: II-TRA3.

2.3 European Standard: CEN 12503-5: Sport Mats – Determination of the Base Friction. 2000.

3 Terminology

3.1 *Description of terms specific to this standard:*

3.1.1 *Acceleration:* The instantaneous time rate of change of velocity, expressed in m/s^2, which may be positive or negative.

3.1.2 *Base plane:* The starting reference plane of the tumbling track from which the total height of rebound is determined. It is taken as the top plane of the tumbling track.

3.1.3 *Force (F):* The product of the mass of the impactor, expressed in kg, and the acceleration of the impactor, expressed in m/s^2.

3.1.4 *Maximum Force (F_{max}):* The maximum value of force measured during the impact and expressed in Newtons.

3.1.5 *Height of rebound:* The calculated distance (in mm) between the base plane and the maximum vertical displacement of the impactor above the base plane under idealized frictionless conditions.

3.1.6 *Impactor:* The striking part of the test apparatus.

3.1.7 *Slider:* A test body of given mass and geometry. The slider includes a test sole which is bonded to the bottom of the slider and is made of synthetic material with defined friction properties.

3.1.8 *Thrust - traction sequence:* A series of 5 successive thrust and traction movements of the slider which is pushed and pulled horizontally on a surface of the test specimen at a defined speed and distance.

3.1.9 *Sliding distance:* The horizontal distance between the two turning points of the movement of the slider in a thrust – traction sequence.

3.1.10 *Mean thrust - traction force:* Mean value of the absolute, average force, expressed in Newtons, as the slider moves during the fifth push and pull movement in a thrust - traction sequence.

3.1.11 *Friction coefficient:* Quotient of the mean thrust - traction force (in N) and the weight of the slider (in N) in a thrust - traction sequence.

4 Principles of Measurement

4.1 *The complete measurement is composed of two specific test procedures:*

4.1.1 *Test A - Impact test:* A test specimen is impacted with an impactor of given mass and geometry from a specified drop height. A transducer mounted inside the impactor monitors the acceleration – time history of the impactor which is recorded with the aid of a data acquisition system.

4.1.2 *Test B - Determination of top friction:* A slider of given mass and geometry traverses the test specimen which is fixed on a plane surface. The slider is pushed forward and pulled backwards for a specified number of times with a constant velocity over a given distance. A transducer mounted at the slider monitors the thrust and traction force - time history of the slider movement.

4.2 Dynamic data obtained during these procedures are indicative of the cushioning and rebound (Test A) and top friction (Test B) properties of tumbling tracks used in training and FIG-sanctioned competitions.

5 Performance Requirements

5.1 *Test A - Impact test:* When tested according to the procedures described in Section 9.1, the overall mean values of the measured variables across all impact sites shall be within the figures of Table 1.

Table 1: Figures for Test A – Impact Test

Height of rebound (mm)	F_{max} *(N)*
≥ 550	≤ 6500

5.2 *Test B - Top friction:* When tested according to the procedures described in Section 9.2, the mean value of the measured variable shall be within the figure of Table 2.

Table 2: Figures for Test B – Top Friction

Friction coefficient
≥ 0.45

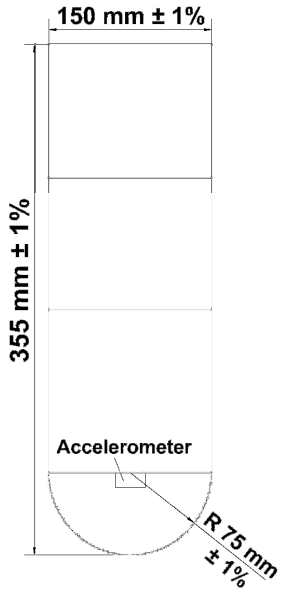
6 Test Apparatus

6.1 *Test A - Impact test procedures*:

6.1.1 *Impact test machine:* Any type of dynamic testing apparatus that is capable of impacting a test specimen with an impactor from a prescribed drop height and monitoring and recording the acceleration - time history of the impactor is acceptable. The impact test machine shall be designed in such a manner that only the impact face contacts the test specimen at any time during the test procedures. It is optional, but desirable, that the impactor is released from a magnet.

6.1.2 *Impactor:* The impactor shall consist of a cylindrical test body with a mass of 30 kg ± 0.3 kg and a geometry as specified in Figure 1. The accelerometer shall be rigidly mounted on the impactor as indicated in Figure 1.

Figure 1: Geometry of Impactor



6.1.3 *Recording equipment* - The recording equipment shall meet the following criteria:

6.1.3.1 *Acceleration - time:* The selection of the specific acceleration - time recording equipment, including transducer and recorder, is at the discretion of the test laboratory. However, the recording system shall have a frequency response adequate to measure the peak acceleration value to an accuracy of ± 5% of the true value. The total system, detection and recording, shall be capable of measuring impact accelerations of up to 100 g at frequencies from 2 to 1000 Hz to an accuracy of ± 5%. The minimum sampling rate of the data acquisition system shall be 5000 Hz.

6.1.3.2 *Filtering:* The signal from the transducer shall be conditioned with a low pass filter which complies with Channel Class 1000 of SAE Recommended Practice J211. A fourth-order Butterworth low pass filter with a cut-off frequency of 1000 Hz meets this requirement.

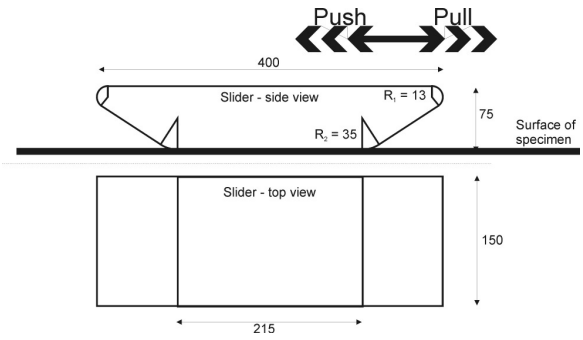
6.2 *Test B - Top friction:*

6.2.1 *Measurement device:* Any type of friction testing apparatus that is capable of stressing a test specimen by pushing and pulling a slider on the test specimen's surface at a given velocity and distance is acceptable. During the test the force – time history of the movement of the slider shall be monitored and recorded. The friction test machine and the slider shall have sufficient rigidity to eliminate undesirable vibrations in the apparatus which might be recorded on the force - time curve. It is desirable to fix the test specimen for the friction tests with the help of an addi-

tional fastening system outside the sliding area.

6.2.2 *Slider:* The slider shall be made of wood with a mass of 9.5 kg ± 3% and shall have the geometrical dimensions specified in Figure 2. A test sole of synthetic material with a thickness of 2.6mm ± 0.5 mm shall be bonded to the bottom of the slider, complying with the requirements of CEN 12503-5: aL := 47.5 ± 0.5.

Figure 2: Slider Dimensions for Top Friction Tests
(Dimensions in mm; Accuracy: ±1 mm)



6.2.3 The slider shall be pushed and pulled over a determined sliding distance a specified number of times at a given constant velocity.

6.2.4 *Recording equipment* - The recording equipment shall meet the following criteria:

6.2.4.1 *Force – time:* The selection of the specific force - time recording equipment, including transducer and recorder, is at the discretion of the test laboratory. The total system, detection and recording, shall be capable of measuring thrust and traction forces up to ± 1000 N at frequencies from 2 to 100 Hz to an accuracy of ± 3%. The minimum sampling rate of the data acquisition system shall be 200 Hz.

7 Test Specimen

7.1 The test specimen submitted for testing shall represent the tumbling track as it is intended to be used during training and/or competition.

7.2 The test specimen shall comply with FIG Apparatus Rules: II-TRA3. Exception: See 7.3.

7.3 The minimum horizontal dimensions (width * length) for any test specimen shall be 170 cm * 120 cm.

8 Conditioning and Test Temperature

8.1 The test specimen shall be preconditioned at 50% ± 10% relative humidity and 21° C ± 3° C for a minimum of 24 hours prior to the test. All testing shall be carried out under the same conditions.

9 Laboratory Procedure (Test Method)

9.1 *Test A - Impact test:*

9.1.1 *Impact locations:* A total of seven impact sites shall be designated on the test specimen. See Figure 3 for an illustration of the impact sites.

9.1.2 *Impact test procedures*:

9.1.2.1 Place the test specimen under the impact test machine on a smooth, solid floor (concrete or metal plate) and orient the impactor such that the centre of the impact face will contact one of the designated impact test sites.

9.1.2.2 Raise the impactor to the drop height of 1.20 m ± 3%.

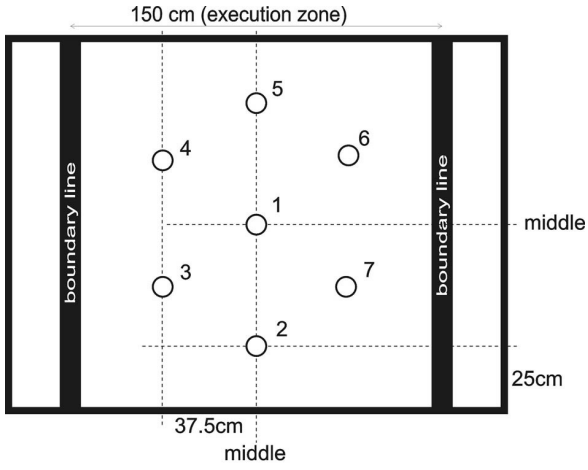
9.1.2.3 Release the impactor and capture the acceleration - time history using recording equipment described in Section 6.1.3.

9.1.2.4 Upon completion of a given impact test, raise the impactor off the surface of the test specimen.

9.1.2.5 The duration between tests at a given impact site shall not be less than 120 seconds.

9.1.2.6 Each test specimen shall receive a total of 70 impacts. Impact each of the seven impact sites ten times.

Figure 3: Impact Locations for Tumbling Tracks



9.1.3 *Calculations*:

9.1.3.1 Immediately following each test, calculate and record the following measurements: F_{max} (N) and Height of rebound (mm).

9.1.3.2 The last eight tests for each impact site shall be used to determine the arithmetic mean value of a measured variable for each impact site and for the overall mean value of a measured variable across all impact sites.

9.2 *Test B - Top Friction:*

9.2.1 Place the test specimen under the slider. Fix all components carefully with the fastening system to

prevent horizontal movement of the test specimen during the friction test. The complete test specimen shall lie on a smooth and solid horizontal plate.

9.2.2 The slider shall be pushed and pulled parallel to the boundary lines of the tumbling track with a constant velocity of 300 mm/s ± 3% over 90% of the total sliding distance of 600 mm ± 3%.

9.2.3 Perform a thrust – traction sequence with the slider (i.e. 5 pushing and pulling movements) within 30 sec. Capture the force – time history using recording equipment described in Section 6.2.4. Wait at least 300 seconds between trials. Repeat the whole thrust – traction sequence an additional two times with the pause between trials.

9.2.4 Calculations:

9.2.4.1 Immediately following the test, record and calculate the friction coefficient for every thrust – traction sequence.

10 Report

10.1 *The test report shall include the following information:*

10.1.1 Complete identification of the tested tumbling track, including type, source, manufacturer's model number (if appropriate), dimensions of test specimen, and any other pertinent information. Photographs may be included in the test report for sample documentation purposes.

10.1.2 Test identification number according to the internal regulations between the FIG Test Institutes.

10.1.3 Complete identification of the testing laboratory including test technician and test laboratory manager (if appropriate).

10.1.4 Conditions of test, including test date, temperature and humidity.

10.1.5 *Test A - Impact Test*:

10.1.5.1 Description of the impactor mass and the drop height conditions.

10.1.5.2 Description of the test results relative to the performance requirements identified in Section 5.1.

10.1.5.3 Mean values of height of rebound and F_{max} across all impact sites.

10.1.5.4 Maximum value, minimum value and standard deviation of height of rebound and F_{max} variables.

10.1.5.5 Mean values of height of rebound and F_{max} for the last eight tests at each impact site

10.1.5.6 Height of rebound and F_{max} for all tests.

10.1.6 *Test B - Top Friction:*

10.1.6.1 Description of the mass, velocity and sliding distance of the slider.

10.1.6.2 Friction coefficients for all thrust – traction sequences.

Standard Specification: Vaulting Boards for Tumbling

The standard specifications for vaulting boards for tumbling are the same as for men artistic gymnastics, therefore, this standard refers to the FIG standard IV-MAG14.

See:

IV
MAG 14
01.01.2006
1-3

Standard Specification: Floors for Acrobatics

This standard is issued under the fixed designation FIG: IV-ACRO1-01.01.00; the numbers immediately following the designation indicate the date of original adoption by the FIG or, in case of revision, the date of the last revision. This FIG standard was prepared by the Apparatus Commission of the FIG and participating FIG test laboratories. This standard was originally published in English only.

The standard specifications for floors for acrobatics are the same as for men artistic gymnastics, therefore, this standard refers to the FIG standard IV-MAG1.

See:

IV
MAG 1
01.01.2006
1-3

Standard Specification: 20 cm Landing Mats for Acrobatics

The standard specifications for 20 cm landing mats for acrobatics are the same as for men artistic gymnastics, therefore, this standard refers to the FIG standard IV-MAG11.

See:

IV
MAG 11
01.08.1996
1-3