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Motorcycles — Test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles —

Part 3:
Anthropometric impact dummy

Motocycles — Méthodes d'essai et d'analyse de l'évaluation par la recherche des dispositifs, montés sur les motocycles, visant à la protection des motocyclistes contre les collisions —

Partie 3: Mannequin anthropométrique

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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

This part of ISO 13232 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 22, *Motorcycles*.

At the request of the United Nations Economic Commission for Europe, Group for Road Vehicle General Safety (UN/ECE/TRANS/SCI/WP29/GRSG), this International Standard has been prepared by ISO/TC 22/SC 22, *Motorcycles*, as eight interrelated parts, on the basis of original working documents submitted by the International Motorcycle Manufacturers Association (IMMA).

This is the first version of the standard.

ISO 13232 consists of the following parts, under the general title *Motorcycles — Test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles*:

— *Part 1: Definitions, symbols and general considerations*

— *Part 2: Definition of impact conditions in relation to accident data*

— *Part 3: Anthropometric impact dummy*

— *Part 4: Variables to be measured, instrumentation and measurement procedures*

— *Part 5: Injury indices and risk/benefit analysis*

— *Part 6: Full-scale impact-test procedures*

— *Part 7: Standardized procedures for performing computer simulations of motorcycle impact tests*

— *Part 8: Documentation and reports*

Annex A forms an integral part of this part of ISO 13232. Annex B is for information only.

Introduction

This International Standard has been prepared on the basis of existing technology. Its purpose is to define common research methods and a means for making an overall evaluation of the effect that devices which are fitted to motor cycles and intended for the crash protection of riders, have on injuries, when assessed over a range of impact conditions which are based on accident data.

It is intended that the methods and recommendations contained in this International Standard should be used in all basic feasibility research. However, researchers should also consider variations in the specified conditions (for example, rider size) when evaluating the overall feasibility of any protective device. In addition, researchers may wish to vary or extend elements of the methodology in order to research issues which are of particular interest to them. In all such cases which go beyond the basic research, if reference is to be made to this International Standard, a clear explanation of how the procedures used differ from the basic methodology should be provided.

In order to apply this International Standard properly, it is strongly recommended that all eight parts be used together, particularly if the results are to be published.

To the extent, if any, that any products identified in this International Standard may be subject to patent rights, and to the extent, if any, that licenses may be available relative to such patents, potential manufacturers of such products are advised that individual patent inquiries should be made and alternative products considered. A record of patent holders' statements, if any, regarding their willingness to negotiate licenses under patent and like rights with applicants throughout the world under reasonable terms and conditions, is on file with the ISO Central Secretariat.

Motorcycles — Test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles —

Part 3:
Anthropometric impact dummy

1 Scope

This International Standard specifies minimum requirements for research into the feasibility of protective devices fitted to motor cycles, which are intended to protect the rider in the event of a collision.

This International Standard is applicable to impact tests involving

- two wheeled motor cycles;
- the specified type of opposing vehicle;
- either a stationary and a moving vehicle or two moving vehicles;
- for any moving vehicle, a steady speed and straight line motion immediately prior to impact;
- one helmeted dummy in a normal seating position on an upright motor cycle;
- the measurement of the potential for specified types of injury, by body region;
- evaluation of the results of paired impact tests (i.e., comparisons between motor cycles fitted and not fitted with the proposed devices).

This part of ISO 13232 specifies the minimum requirements for the

- biofidelity of the motor cyclist anthropometric impact dummy;
- compatibility of the dummy with motor cycles, helmets, multi-directional impacts, and the instrumentation;
- repeatability and reproducibility of the dummy properties and responses.

This International Standard does not apply to testing for regulatory or legislative purposes.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 13232 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 13232-1: 1996, Motor cycles - Test and analysis procedures for research evaluation of rider crash protective devices fitted to motor cycles - Part 1 - Definitions, symbols and general considerations.

ISO 13232-4: 1996, Motor cycles - Test and analysis procedures for research evaluation of rider crash protective devices fitted to motor cycles - Part 4 - Variables to be measured, instrumentation and measurement procedures.

ISO 13232-6: 1996, Motor cycles - Test and analysis procedures for research evaluation of rider crash protective devices fitted to motor cycles - Part 6 - Full-scale impact test procedures.

ISO 13232-8: 1996, Motor cycles - Test and analysis procedures for research evaluation of rider crash protective devices fitted to motor cycles - Part 8 - Documentation and reports.

ISO 6487: 1987, Road vehicles - Measurement techniques in impact-tests - Instrumentation.

49 CFR Part 572, subpart E: 1993, Anthropomorphic test dummies, United States of America Code of Federal Regulations issued by the National Highway Traffic Safety Administration (NHTSA). Washington, D.C.

3 Definitions

For the purposes of this part of ISO 13232, the definitions given in ISO 13232-1 apply, of which the following are of particular relevance to this part of ISO 13232.

- abdominal foam insert;
- alternative products;
- certification, compliance;
- knee compliance element;
- load cell simulator;
- lot;
- specimen.

4 Mechanical requirements for the motor cyclist anthropometric impact dummy

The manufacturers of dummies or dummy components which are intended to meet this International Standard, shall provide with the supplied dummies or dummy components, certification that the dummies or dummy components meet the requirements specified below.

4.1 Basis dummy

The basis dummy shall be the Hybrid III 50th percentile male dummy[1]. The dummy shall be equipped with

- the sit/stand construction[2];
- the head/neck assembly which is compatible with the six axis upper neck load cell which is specified in 4.4.1.2 of ISO 13232-4[2];
- standard, non-sliding knees[2].

1) Basis dummy as specified in 49 CFR Part 572, subpart E, or equivalent.

2) A list describing one or more example products which meet these requirements is maintained by the ISO Central Secretariat and the Secretariat of ISO/TC 22/SC 22. The list is maintained for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the products listed. Alternative products may be used if they can be shown to lead to the same results.

The basis dummy specified components shall be modified or replaced as described below.

4.2 Motor cyclist dummy head skins

The head skin components shall include the two basis Hybrid III head skins, plus two extensions which provide helmet compatibility. The geometries of the head skins and extensions are shown in figure A.1, where 1 and 2 are the basis Hybrid III head and rear skull cap skins and 3 and 4 are the jaw and nape extensions which provide helmet compatibility. The masses of the jaw and nape skin extensions shall be 0,27 kg ± 0,05 kg and 0,15 kg ± 0,05 kg, respectively[1]. The head-neck skin modifications to the Hybrid III head shall be attached by means of any suitable adhesive. Such an adhesive shall be shown to provide a bond between the mating parts in which the parent material will fail under tensile loading before the bond itself. Cyanoacrylate is an example of a suitable adhesive.

4.3 Motor cyclist dummy neck components

4.3.1 Neck shroud

The neck shroud shall be as specified in figure A.2[1].

4.3.2 Lower neck mount

The basis Hybrid III lower neck mount shall be modified as shown in figure A.3 to increase head position adjustability.[1]

4.3.3 Motor cyclist neck

The standard Hybrid III neck and its interfaces with the head and upper torso assembly shall be modified as shown in figure A.4[1] and shall incorporate the neck torsion element, an example of which is illustrated in figure A.5.[1]

When dynamically tested according to the procedures described in 6.8, the neck torque relative to the head angle of rotation shall be within the corridors shown in figure 1.

4.3.4 Replacement nodding blocks

The standard Hybrid III nodding blocks shall be replaced with one of the three pairs of nodding blocks shown in figure A.6[1], using the procedure described in annex D of ISO 13232-6.

4.4 Motor cyclist dummy upper torso components

4.4.1 Replacement thoracic spine

Either a standard Hybrid III thoracic spine, or a replacement thoracic spine[1] shall be used. If a replacement spine is used, then the replacement thoracic spine shall be compatible with the internal data acquisition system described in ISO 13232-4. When combined with the internal data acquisition system, the replacement thoracic spine shall

- maintain the same interface geometry and overall height as the standard Hybrid III spine box, including the shoulder, rib, lower neck mount, and lumbar spine attachment points;

- not interfere with the motion of the shoulders;

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1) A list describing one or more example products which meet these requirements is maintained by the ISO Central Secretariat and the Secretariat of ISO/TC 22/SC 22. The list is maintained for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the products listed. Alternative products may be used if they can be shown to lead to the same results.

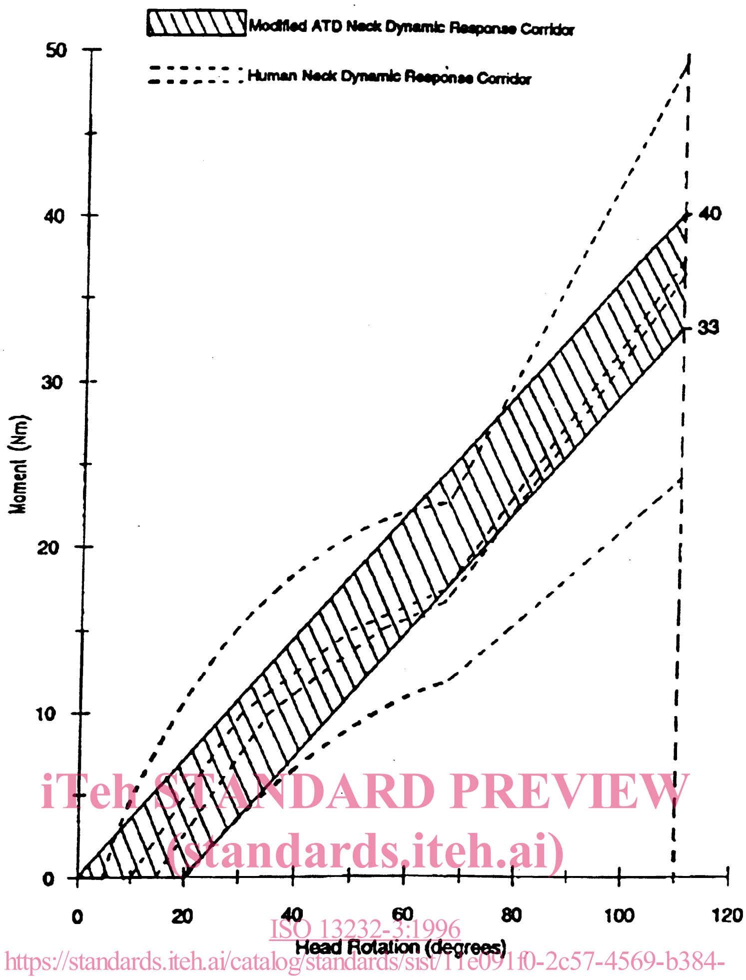

Figure 1 - Motor cyclist neck torsional response corridor

- provide at least 75 mm of sternum deflection in the sagittal plane, measured perpendicularly, relative to the front surface of the spine box;
- not exceed 125 mm in lateral width;
- result in the same upper torso mass and centre of gravity as specified for a standard Hybrid III upper torso[1].

4.4.2 Modified chest skin

With the chest skin properly installed on the upper torso, the back of the chest skin shall be modified with four holes which expose the two upper and two lower rib attachment screws in order to enable measurement of the upper torso angle, using a torso inclinometer such as the example shown in ISO 13232-6, figure C.1.

4.5 Motor cyclist dummy lower torso components

When fully assembled, the lower torso assembly shall result in the same lower torso mass and centre of gravity as specified for the standard Hybrid III lower torso[2].

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1) Refer to General Motors Hybrid III drawing numbers 78051-89 and 78051-338 in 49 CFR Part 572.

2) Refer to General Motors Hybrid III drawing numbers 78051-70 and 78051-338 in 49 CFR Part 572.

4.5.1 Modified straight lumbar spine

For use with either the six-axis or three-axis lumbar load cell, the straight lumbar spine and cable shall be FTSS part numbers 1260004 and 1260005[1]. The lower lumbar spine transducer mount and ballast block shall be replaced with the part shown in figure A.7 for a six-axis load cell[2] and in figure A.8 for a three-axis load cell[2]. An abdomen reaction plate, as shown in figure A.9 for the six-axis load[2] cell or figure A.10 for the three-axis load cell[2], shall be mounted to the lower lumbar spine transducer mount and ballast block.

When using the dummy without either of the permissible lumbar load cells described in 4.4.1.4 of ISO 13232-4, the load cell shall be replaced with a lumbar load cell simulator[2].

4.5.2 Motor cyclist dummy abdominal insert

The basis Hybrid III abdominal insert shall be replaced with a frangible solid abdominal insert, as shown in figure A.11. The replacement insert shall have a mass of 53 g ± 3 g.

When tested according to the method described in 6.7, the specified values of force shall be as given in table 1[2].

Table 1 - Specified values for certification of replacement abdominal insert

Deflection mm	Force N
20	1 040
40	1 875
60	2 810

4.5.3 Sit/stand pelvis

The internal data acquisition system may be contained within a sit/stand pelvis which has been suitably modified to accommodate it[2]. Whether modified or not, the sit/stand pelvis shall

- maintain the same interface geometry and external dimensions as the standard Hybrid III sit/stand pelvis;
- not interfere with the motion of the legs.

4.6 Modified elbow bushing

The Delrin elbow bushing, Hybrid III part number 78051-199[3], shall be modified with scribe marks, as shown in figure A.12.

1) Parts 1260004 and 1260005 are products supplied by First Technology Safety Systems, Plymouth, Michigan, USA. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Alternative products may be used if they can be shown to lead to the same results.

2) A list describing one or more example products which meet these requirements is maintained by the ISO Central Secretariat and the Secretariat of ISO/TC 22/SC 22. The list is maintained for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the products listed. Alternative products may be used if they can be shown to lead to the same results.

3) Refer to General Motors Hybrid III drawing number 78051-199 in 49 CFR Part 572.

4.7 Motor cyclist dummy hands

The basis Hybrid III hands shall be replaced with the Itoh-Seiki Co. part number 065-322048[1].

4.8 Motor cyclist dummy upper leg components

4.8.1 Frangible femur bone and mounting hardware

The frangible femur bone shall be mounted to the knee joint using the adaptor shown in figure A.13[2]. The frangible femur bone shall meet the interface and size requirements shown in figure A.14, and have a mass 85 g ± 10 g. The frangible bone materials and design shall remain constant in the axial direction along the minimum frangible length, as shown in figure A.14.

When statically tested according to the methods described in 6.1, 6.2, and 6.5, the specified values of the static deflection and strength of the bone shall be as given in table 2. When dynamically fractured according to the methods described in 6.3 and 6.4, the specified values of the peak strength of the bone shall be as given in table 2[2].

Table 2 - Specified values for certification of frangible femur components

	Static deflection	Dynamic peak strength	Static strength
Bending	5,1 mm	360 N · m	-
Torsion	5,8°	205 N · m	-
Axial loading	-	-	34 680 N

4.8.2 Femur load cell simulator

When using the dummy without the permissible femur load cells described in 4.4.1.5 of ISO 13232-4, the load cell shall be replaced with an upper femur load cell simulator, as shown in figure A.15[2].

4.9 Motor cyclist dummy frangible knee assembly

The frangible knee assembly and the interface with the knee clevis assembly shall be as shown in figure A.16. The knee assembly shall have a mass of 1,00 kg ± 0,05 kg.

When statically tested according to the methods described in 6.6, the specified values of the rotational angles for the defined moments shall be as given in table 3. The specified values of the rotational angles and moments which indicate peak strength at shear pin failure shall be as given in table 3.[2]

4.10 Leg retaining cables

Each frangible leg bone shall be installed together with a leg retaining cable to prevent the loss of portions of the

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1) Part number 065-322048 is a product supplied by Itoh-Seiki Co., Tokyo, Japan. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Alternative products may be used if they can be shown to lead to the same results.

2) A list describing one or more example products which meet these requirements is maintained by the ISO Central Secretariat and the Secretariat of ISO/TC 22/SC 22. The list is maintained for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the products listed. Alternative products may be used if they can be shown to lead to the same results.

Table 3 - Specified values for certification of frangible knee assembly components

Degree of Freedom	Condition	Specified value
Valgus	Rotation at 89 N · m (pre-failure)	20,0°
	Maximum torque	132 N · m
	Rotation at maximum torque	25,0°
Torsion	Rotation at 35 N · m (pre-failure)	20,0°
	Maximum torque	87 N · m
	Rotation at maximum torque	40,0°

dummy leg when the frangible bone fractures. The cable mass shall not exceed 200 g for each frangible bone. The cable shall be installed with at least 5 mm of slack[1].

4.11 Motor cyclist dummy lower leg components

4.11.1 Frangible tibia bone and mounting hardware

The frangible tibia bone shall be mounted to the ankle joint using the adaptor shown in figure A.17[1]. The bone shall meet the interface and size requirements shown in figure A.18 and have a mass of 120 g ± 10 g. The frangible bone materials and design shall remain constant in the axial direction along the minimum frangible length, as shown in figure A.18.

When statically tested according to the methods described in 6.1 and 6.2, the specified values of the static deflection of the bone shall be as given in table 4. When dynamically fractured according to the methods described in 6.3 and 6.4, the specified values of the peak strength of the bone shall be as given in table 4[1].

Table 4 - Specified values for certification of frangible tibia components

	Static deflection	Dynamic peak strength
Bending	3,8 mm	280 N · m
Torsion	7,0°	171 N · m

1) A list describing one or more example products which meet these requirements is maintained by the ISO Central Secretariat and the Secretariat of ISO/TC 22/SC 22. The list is maintained for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the products listed. Alternative products may be used if they can be shown to lead to the same results.

4.11.2 Modified lower leg skin

The basis Hybrid III lower leg skins shall be modified according to figure A.19, to

- include a vertically aligned rear surface zipper to permit installation and removal of the skin from the leg;
- conform to the frangible knee structure.

The mass shall be 1,05 kg ± 0,10 kg.

5 Sampling of frangible components

Frangible components shall be sampled to certify conformity of production. In all cases, such sampling shall be performed using new, unused frangible components.

5.1 Initial conformity of production

For certification of any new design, material specification, or manufacturing process of any frangible component and for each of the test methods described in clause 6, ten unused components shall be tested to establish estimates of the sample's mean and standard deviation. For example, certification of three different test methods would require 30 components to be tested. The sample mean value shall be within ± 5% of the specified value for all strengths and abdominal insert static forces. The sample mean value shall be within ± 20% of the specified value for all static deflections. The sample standard deviation shall be less than 7% of the sample mean value for all strengths and abdominal insert static forces. The sample standard deviation shall be less than 10% of the sample mean value for all static deflections.

5.2 Subsequent conformity of production

Once a specific design, material specification, and manufacturing process have been certified, three components from each lot which is identically manufactured shall be tested to verify the applicable characteristics specified in table 5.

Table 5 - Frangible component subsequent conformity of production characteristics

Component	Characteristic
Frangible abdominal insert	Forces at 40 mm deflection
Frangible leg bone	Dynamic bending strength
Knee shear pin	Failure moments given in table 3
Knee compliance element	Pre-failure rotations given in table 3

If none of the components deviates by more than two standard deviations, as defined in 5.1, from the established mean value for the specified characteristic, the lot shall be considered acceptable for full-scale impact testing, according to ISO 13232-6. If one or more of the tested components deviate by more than two standard deviations, as defined in 5.1, from the established mean value for the specified characteristic, a different sample of three components from the same lot shall be tested. If more than two of the total sample of six components deviate by more than two standard deviations, as defined in 5.1, from the established mean values, the said lot shall not be used for full-scale impact testing.

6 Test methods

6.1 Frangible bone static bending deflection test

Using pins, attach rigid extensions of equal length, as shown in figure A.20, to each end of the frangible bone such that the minimum combined length of the bone and extensions is as given in table 6. Support the specimen radially at both ends, at the distances given in table 6. Place a 25 mm diameter solid rigid cylindrical bar at the mid-span location, perpendicular to the specimen axial axis with the curved surfaces of the bone and bar in contact with each other. Apply a radial load as given in table 6.

Table 6 - Frangible bone static bending deflection test specifications

	Minimum combined length mm	Distance between supports mm	Applied radial load N
Femur	355	341	1 350 ± 25
Tibia	300	286	1 450 ± 25

Measure the perpendicular linear deflection at the mid-span location of the specimen relative to the supported ends.

6.2 Frangible bone static torsional deflection test

Apply a torsional load of 69 N · m to the femur and 48 N · m to the tibia. Measure the torsional deflection of one end of the bone relative to the other end.

6.3 Frangible bone dynamic bending fracture test

Using pins, attach rigid extensions and support the specimen as described in 6.1, using the bone extensions shown in figure A.20 and the specimen supports shown in figure A.21. Align the specimen so that it is perpendicular to both the cylindrical bar and the direction of motion of the impactor head, shown in figure A.22. Attach the impactor head to the impactor device, which is shown in figures A.23 through A.26. Impact the specimen at 7,5 m/s ± 0,2 m/s at mid-span, using the impacting mass shown in figure A.23.

Measure the impactor linear acceleration from just before bone contact until just after bone fracture, with an Endevco accelerometer, model 2262A-1000[1] rigidly mounted to the impactor at the location shown in figure A.23. Filter the data with an analog filter such that the data is attenuated by at least 40 dB at and above a frequency of 7 kHz. Sample the data at 10 kHz and filter the digital data such that the frequency response of the data output to the unfiltered analog input is in accordance with ISO 6487, CFC 600. Determine the peak linear acceleration related to the impact with the bone. Calculate the maximum bending moment as shown for this example:

$$M_{x,max} = (0,25)\ (9,807)\ d_s\ m\ a_{m,max}$$

where

$M_{x,max}$ is the maximum bending moment, in Newton-metres;

d_s is the distance between supports, in metres;

1) Model 2262A-1000 is a product supplied by Endevco Corp., San Juan Capistrano, California, USA. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Alternative products may be used if they can be shown to lead to the same results.

m is the mass of the impactor, in kilograms;

$a_{m,max}$ is the maximum linear acceleration of the impactor mass, in g units;

9,807 is a conversion factor from g units to newtons.

6.4 Frangible bone dynamic torsional fracture test

Attach a rigid extension to each end of the frangible bone and restrain one end of the resulting specimen with a Denton load cell, model B-2193[1)]. Attach a rigid moment arm to one of the rigid extensions, such that it extends perpendicularly from the axial axis of the specimen. Impact the moment arm at 7,5 m/s ± 0,2 m/s at a distance 0,150 m ± 0,005 m from the axial axis of the specimen. Impact with a solid rigid cylindrical bar with a diameter of 0,025 m ± 0,003 m and a total impacting mass greater than 50 kg. Orient the cylindrical bar to be perpendicular to the direction of travel and to the moment arm.

Measure the bone torque using the load cell and filtering and sampling according to the method described in 6.3. Determine the maximum torsional moment.

6.5 Frangible femur bone static axial load fracture test

Attach a rigid fixture to each end of the frangible bone such that any compressive load is transferred to the bone through the bone mounting bolt. Place the specimen in a hydraulic press, as shown in figure A.27, such that the centre line is aligned with the centre line of the hydraulic plunger and the lower end fixture is centred on a Denton load cell, model B-2193[1)]. Apply a continually increasing load at a rate of 6 500 N/s ± 2 000 N/s until failure occurs. Electronically record the applied load until the time of failure.

6.6 Frangible knee static strength and deflection test

6.6.1 Apparatus

Use either the apparatus shown in figure A.28, or the equivalent, including a

- lever arm with minimum length of 0,5 m;
- load cell located at the load application point;
- rotational potentiometer.

6.6.2 Procedure

Apply a continually increasing moment to the frangible knee valgus or torsional axis, at a rate of 30 N · m/s ± 5 N · m/s. Record the rotational angle and applied moment until shear pin failure occurs.

6.7 Frangible abdomen test

Use the apparatus shown in figure A.29, or the equivalent. Apply a continually increasing load to the center of an unused frangible abdominal insert at a rate of 450 N/s ± 150 N/s. Record the crush deflection and applied load up to a load greater than 3 300 N.

6.8 Motor cyclist neck dynamic axial torsion test

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1) Load cell model B-2193 is a product supplied by Robert A. Denton, Inc., Rochester Hills, Michigan, USA. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Alternative products may be used if they can be shown to lead to the same results.

Use either the pendulum fixture shown in figure A.30, or the equivalent. Release the pendulum so that its velocity at the bottom of the swing is 4,2 m/s ± 0,2 m/s. Measure the pendulum velocity in the last 10° before the vertical position. Measure the torque at the top of the neck, using a Denton load cell, model 1716[1]. Measure the rotation of the lower neck mount using a potentiometer. Plot the neck torque vs. the rotation angle of the lower neck mount.

7 Marking and documentation of frangible components

7.1 Marking

All frangible components shall be marked by their manufacturer with some designation of their lot number, in an area not likely to be damaged during testing.

7.2 Documentation

The manufacturer of each frangible part shall supply, with the frangible part, test data showing initial and subsequent conformity of production according to clauses 4, 5, and 6. The test data shall be included in the full-scale impact test documentation (see ISO 13232-8). The test data shall show the manufacturer and lot number designation of the part.

1) Load cell model 1716 is a product supplied by Robert A. Denton, Inc., Rochester Hills, Michigan, USA. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the product named. Alternative products may be used if they can be shown to lead to the same results.