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

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

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

Partie 4: Variables à mesurer, instrumentation et méthodes de mesure



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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

ISO 13232-4 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 22, *Motorcycles*.

This second edition cancels and replaces the first version (ISO 13232-4:1996), which has been technically revised.

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: Motorcyclist 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*

Introduction

ISO 13232 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 motorcycles 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 all of the methods and recommendations contained in ISO 13232 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 ISO 13232, a clear explanation of how the used procedures differ from the basic methodology should be provided.

ISO 13232 was prepared by ISO/TC 22/SC 22 at the request of the United Nations Economic Commission for Europe Group for Road Vehicle General Safety (UN/ECE/TRANS/SCI/WP29/GRSG), based on original working documents submitted by the International Motorcycle Manufacturers Association (IMMA), and comprising eight interrelated parts.

This revision of ISO 13232 incorporates extensive technical amendments throughout all the parts, resulting from extensive experience with the standard and the development of improved research methods.

In order to apply ISO 13232 properly, it is strongly recommended that all eight parts be used together, particularly if the results are to be published.

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

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

1 Scope

This part of ISO 13232 specifies requirements for the:

- repeatability and reproducibility of the dynamic measurement procedures for the motorcycle, the opposing vehicle, and the dummy; and
- dummy instrumentation.

ISO 13232 specifies the minimum requirements for research into the feasibility of protective devices fitted to motorcycles, which are intended to protect the rider in the event of a collision.

ISO 13232 is applicable to impact tests involving:

- two-wheeled motorcycles;
- 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 motorcycle;
- 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 motorcycles fitted and not fitted with the proposed devices).

ISO 13232 does not apply to testing for regulatory or legislative purposes.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13232-1, *Motorcycles — Test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles — Part 1: Definitions, symbols and general considerations*

ISO 13232-3, *Motorcycles — Test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles — Part 3: Motorcyclist anthropometric impact dummy*

ISO 13232-6, *Motorcycles — Test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles — Part 6: Full-scale impact test procedures*

ISO 13232-7, *Motorcycles — Test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles — Part 7: Standardized procedures for performing computer simulations of motorcycle impact tests*

ISO 13232-8, *Motorcycles — Test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles — Part 8: Documentation and reports*

ISO 6487, *Road vehicles — Measurement techniques in impact tests — Instrumentation*

SAE 1733, Sign convention for vehicle crash testing, Warrendale, Pennsylvania, USA

3 Definitions, symbols, and abbreviations

The following terms are defined in ISO 13232-1. For the purposes of this part of ISO 13232, those definitions apply. Additional definitions which could apply to this part of ISO 13232 are also listed in ISO 13232-1:

- aim point;
- blur;
- cursor;
- detachable external cables;
- digitizing surface;
- film analysis frame;
- frame width;
- helmet centroid point;
- high speed photography;
- leading edge;
- magnification;
- motion analyser grid;
- oblique camera;
- off axis;
- output signal voltage;
- overall accuracy of the film analysis;

- primary axis;
- signal gain;
- trailing edge;
- visual resolution.

4 Requirements

4.1 Electronically recorded variables

4.1.1 Required

The variables listed below shall be recorded in all full-scale impact tests from at least 0,100 s before first MC/OV contact until at least 3,000 s after first MC/OV contact, using the sensors described in 4.4.1:

- a) first MC/OV contact occurrence;
- b) head (nine linear accelerations):
 - 1) bottom centre acceleration in three axes (a_1, a_4, a_7),
 - 2) top centre acceleration in two axes (a_3, a_6),
 - 3) bottom left acceleration in two axes (a_5, a_9),
 - 4) bottom right acceleration in two axes (a_2, a_8);
- c) chest:
 - 1) sternum upper left displacement (l_{uL}),
 - 2) sternum upper right displacement (l_{uR}),
 - 3) sternum lower left displacement (l_{lL}),
 - 4) sternum lower right displacement (l_{lR}).
- d) upper neck
 - 1) upper neck antero - posterior shear force ($F_{x,n}$),
 - 2) upper neck lateral shear force ($F_{y,n}$),
 - 3) upper neck tension/compression forces ($F_{z,n}$),
 - 4) upper neck lateral bending moment ($M_{x,n}$),
 - 5) upper neck flexion/extension moment ($M_{y,n}$),
 - 6) upper neck torsional moment ($M_{z,n}$).

4.1.1.1 Additionally required for leg protective device evaluation

a) left and right upper femur:

- 1) axial force ($F_{z,uF}$),
- 2) lateral bending moment ($M_{x,uF}$),
- 3) antero-posterior bending moment ($M_{y,uF}$);

b) left and right upper tibia:

- 1) lateral bending moment ($M_{x,uT}$),
- 2) antero-posterior bending moment ($M_{y,uT}$).

4.1.2 Not recommended

The variables listed below should not be recorded because of motorcyclist anthropometric impact dummy biofidelity limitations:

- chest accelerations;
- pelvic accelerations.

4.1.3 Permissible

In addition to the required variables listed in 4.1.1, the variables listed below may be recorded:

a) lumbar spine:

- 1) antero-posterior shear force ($F_{x,l}$),
- 2) lateral shear force ($F_{y,l}$),
- 3) axial force ($F_{z,l}$),
- 4) lateral bending moment ($M_{x,l}$),
- 5) antero-posterior bending moment ($M_{y,l}$),
- 6) torsional moment ($M_{z,l}$);

b) left and right upper femur:

- 1) axial force ($F_{z,uF}$),
- 2) lateral bending moment ($M_{x,uF}$),
- 3) antero-posterior bending moment ($M_{y,uF}$),
- 4) torsional moment ($M_{z,uF}$);

c) left and right lower femur:

- 1) axial force ($F_{z,lF}$),
 - 2) lateral bending moment ($M_{x,lF}$),
 - 3) antero-posterior bending moment ($M_{y,lF}$),
 - 4) torsional moment ($M_{z,lF}$);
- d) left and right upper tibia:
- 1) lateral bending moment ($M_{x,uT}$),
 - 2) antero-posterior bending moment ($M_{y,uT}$),
 - 3) torsional moment ($M_{z,uT}$);
- e) left and right lower tibia:
- 1) axial force ($F_{z,lT}$),
 - 2) lateral bending moment ($M_{x,lT}$),
 - 3) antero-posterior bending moment ($M_{y,lT}$).
- f) left and right femur and tibia: frangible bone continuity sensor

4.2 Mechanically recorded variables

The variables listed below shall be recorded in all full-scale impact tests using the sensors described in 4.4.2 and the procedures described in 5.2.3:

- abdomen maximum residual penetration ($p_{A,max}$);
- left and right femur fracture occurrence;
- left and right knee varus valgus dislocation occurrence;
- left and right knee torsional dislocation occurrence;
- left and right tibia fracture occurrence.

4.3 Photographic targets to be digitized

The targets listed below shall be digitized at first MC/OV contact, unless otherwise stated.

The high speed photographic data shall be analysed using a motion analyser for which the ratio of the overall accuracy to the magnification is 0,007 or less¹⁾.

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 ISO 13232 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.

4.3.1 Helmet centroid point

The following helmet centroid point variables shall be determined for the time frame and using the procedures defined in 5.2.4 and Annex A:

- inertial longitudinal position (x_h);
- inertial lateral position (y_h);
- inertial vertical position (z_h).

4.3.2 Motorcycle

Motorcycle targets which shall be digitized include the following:

- upper and lower targets on the top to bottom centre line, visible from the rear view, or front view if only the front camera is used;
- front and rear targets on the front to rear centre line, visible from the MC top view;
- main frame front and rear reference, visible from the MC side view, from at least 10 film analysis frames before first MC/OV contact until at least first MC/OV contact.

4.3.3 Opposing vehicle

The opposing vehicle targets which shall be digitized and their locations are given in Table 1.

Table 1 — Opposing vehicle targets

Target	Locations
Bonnet centre line	100 mm rearward from the bonnet leading edge 100 mm forward from the bonnet trailing edge
Roof centre line	100 mm rearward from the roof leading edge 100 mm forward from the roof trailing edge
Boot lid centre line	100 mm forward from the boot lid trailing edge 100 mm rearward from the boot lid leading edge
Body side reference ^a	Visible from OV side view camera
^a From at least 10 film analysis frames before first MC/OV contact until at least first MC/OV contact.	

4.3.4 Ground

At least two targets shall be fixed on the ground and shall be visible in each camera prior to and at first MC/OV contact. They shall be at least 2 m apart. The z locations of all target centres shall be equal. At least one of the ground fixed targets shall be visible and undisturbed in each camera from at least 10 film analysis frames before first MC/OV contact until at least first MC/OV contact. Multiple targets should be used to increase the likelihood that at least one is visible and undisturbed during the entire film analysis sequence.

4.3.4.1 MC side view and MC top view

The ground fixed targets which are visible in the MC side view and MC top view cameras shall be aligned such that a line connecting the targets is parallel to the pre-impact centre line or path of the MC.

4.3.4.2 MC rear or MC front view

The ground fixed targets which are visible in the MC rear view or MC front view camera shall be aligned such that a line connecting the targets is perpendicular to the pre-impact centre line of the MC. A third ground fixed target shall be visible and be aligned such that it is at least 1 m above and along the z inertial axis of either of the other two ground fixed targets.

4.3.4.3 OV side view

The ground fixed targets which are visible in the OV side view camera shall be aligned such that a line connecting them is parallel to the pre-impact centre line or path of the OV.

4.3.5 Dummy

The dummy joint target locations, as defined in 5.3.6 of ISO 13232-6, shall be digitized in the film frame immediately preceding first MC/OV contact, according to 5.3.5 of this part of ISO 13232.

If the test data are to be used for simulation comparison, according to 4.5.4 of ISO 13232-7, then these target locations shall also be digitized according to the procedures defined in 5.2.4 of this part of ISO 13232.

4.4 Sensor specifications

4.4.1 Electrical

4.4.1.1 Head accelerometers

The head linear accelerations listed in 4.1.1 shall be measured using Endevco accelerometers, model 7264-2000²⁾, mounted using an accelerometer block³⁾ as shown in Figure 1a and 1b. The mounting block shall be attached to the Hybrid III head using a mounting base³⁾ as shown in Figure 2.

4.4.1.2 Upper neck load cell

The neck variables listed in 4.1.1 shall be measured using a Denton load cell, model 1716⁴⁾.

-
- 2) Accelerometer model 7264-2000 is a product supplied by Endevco Corp, San Juan Capistrano, California, USA. This information is given for the convenience of users of ISO 13232 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.
 - 3) 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 ISO 13232 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) 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 ISO 13232 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.

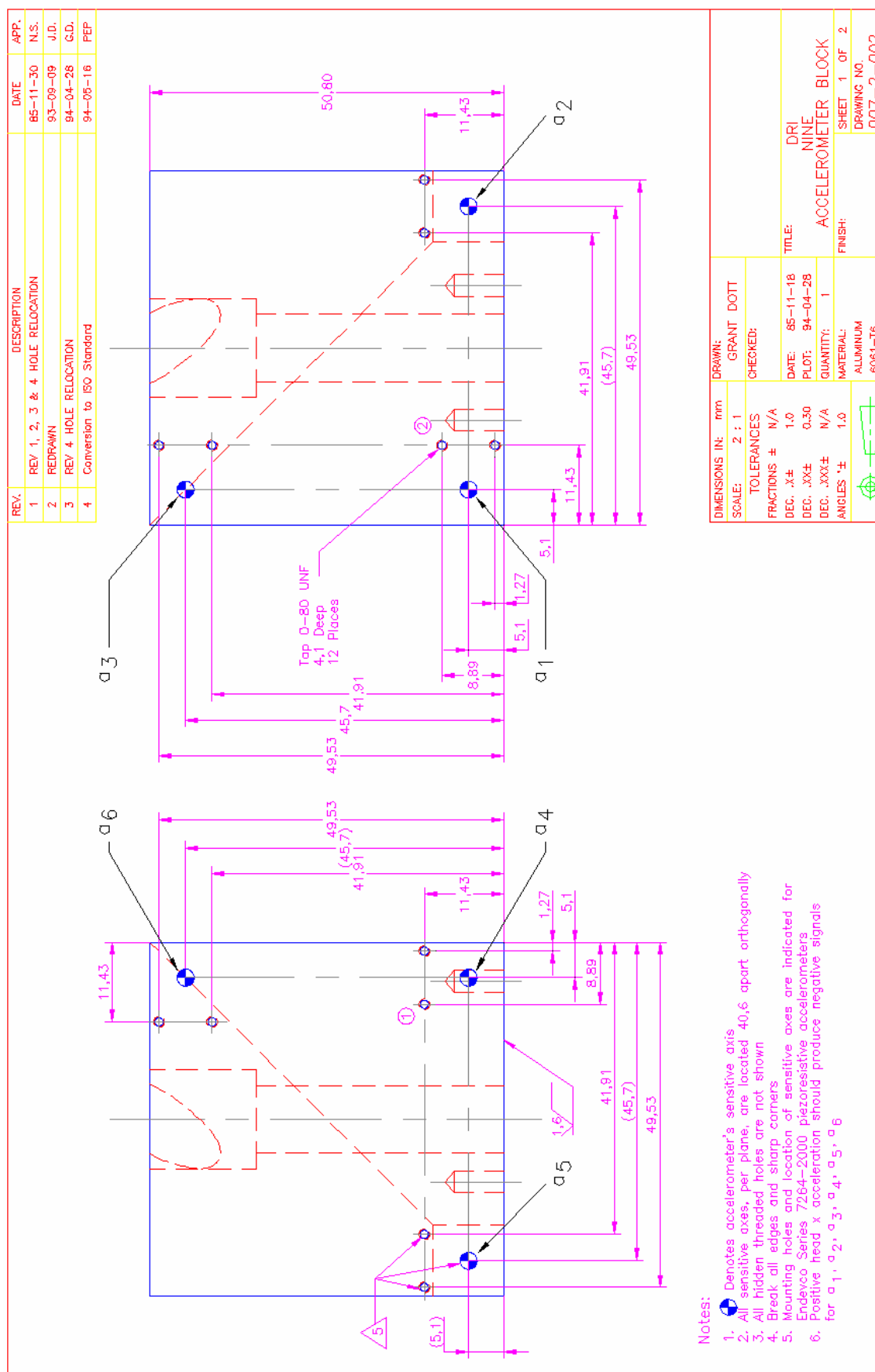


Figure 1a — Nine accelerometer block with accelerometer mounting locations and orientations

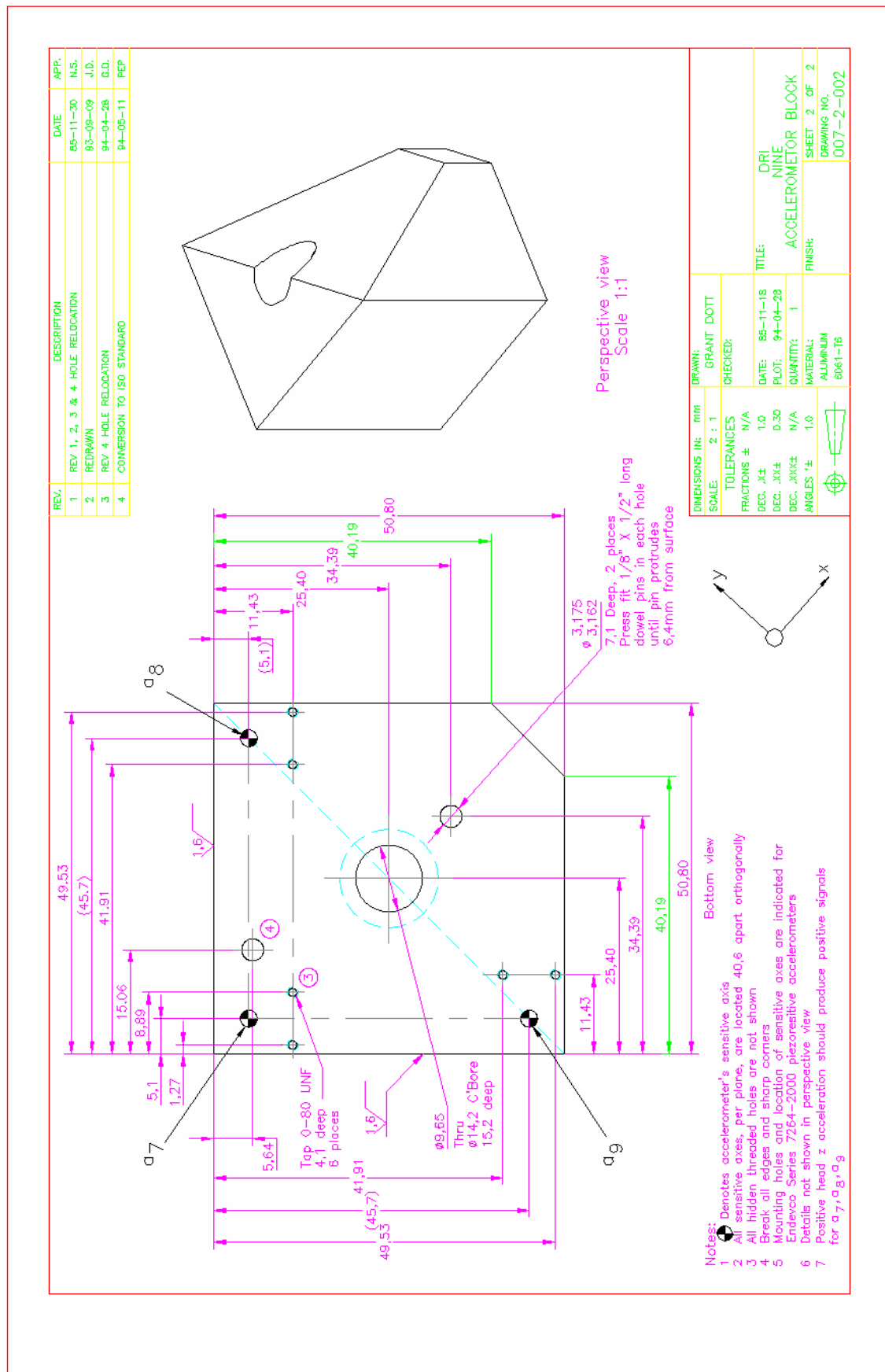


Figure 1b — Nine accelerometer block with accelerometer mounting locations and orientations



4.4.1.3 Chest potentiometers

The chest displacements listed in 4.1.1 shall be measured using Space Age Control string potentiometers, models 160-321VL and 160-321VR⁵⁾, mounted as shown in Figure 3⁶⁾.

Alternative mounting configurations for the chest potentiometers may be used as long as the cable positions shown in Figure 3 are maintained. For example the lower right hand spooling potentiometer shown in Figure 3 could be replaced by a left hand spooling unit mounted below the cable location.

4.4.1.4 Lumbar load cell

The lumbar spine forces and moments listed in 4.1.3 shall be measured using a Denton load cell, model 1708⁷⁾ for six axes or model 1891⁷⁾ for three axes.

4.4.1.5 Upper femur load cells

The upper femur forces and moments listed in 4.1.1.2 and 4.1.3 shall be measured using Denton load cells, model 2693⁷⁾.

4.4.1.6 Frangible leg bone strain gauges

The strain gauges used to measure the lower femur and upper and lower tibia forces and moments listed in 4.1.1.2 and 4.1.3 shall conform to the specifications listed in Table 2. They shall be mounted on the bones at the locations shown in Figure 4.

Table 2 — Frangible leg bone strain gauge specifications

Parameter	Specification
Configuration	Half or full bridge
Resistance	350 ohms
Excitation	2,05 V - 0,05 V to 2,50 V + 0,05 V
Maximum cross axis sensitivity	5%
Gauge factor	2

Each frangible bone strain gauged variable recorded in each full-scale test shall be calibrated according to 5.2.2.

NOTE Frangible bone strain gauges which have been properly mounted and calibrated can provide useful additional information in crash tests regarding the general magnitude, direction and timing of bone forces, prior to or in the absence of bone fracture. However, because they are exposed to damage from various sources, and because of possible installation variations, they might not be reliable in all cases, in particular for the time period during and after a bone fractures. In addition,

-
- 5) String potentiometer models 160-321VL and 160-321VR are products supplied by Space Age Controls, Inc., Palmdale, California, USA. This information is given for the convenience of users of ISO 13232 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.
- 6) 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 ISO 13232 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.
- 7) Load cell models 1708, 1891, and 2693 are products supplied by Robert A. Denton, Inc., Rochester Hills, Michigan, USA. This information is given for the convenience of users of ISO 13232 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.

like load cells, they sense force in only one location, whereas the force components elsewhere in the bone can be much larger. For these and other reasons, they are not considered appropriate for injury evaluation or frangible bone conformity of production tests.

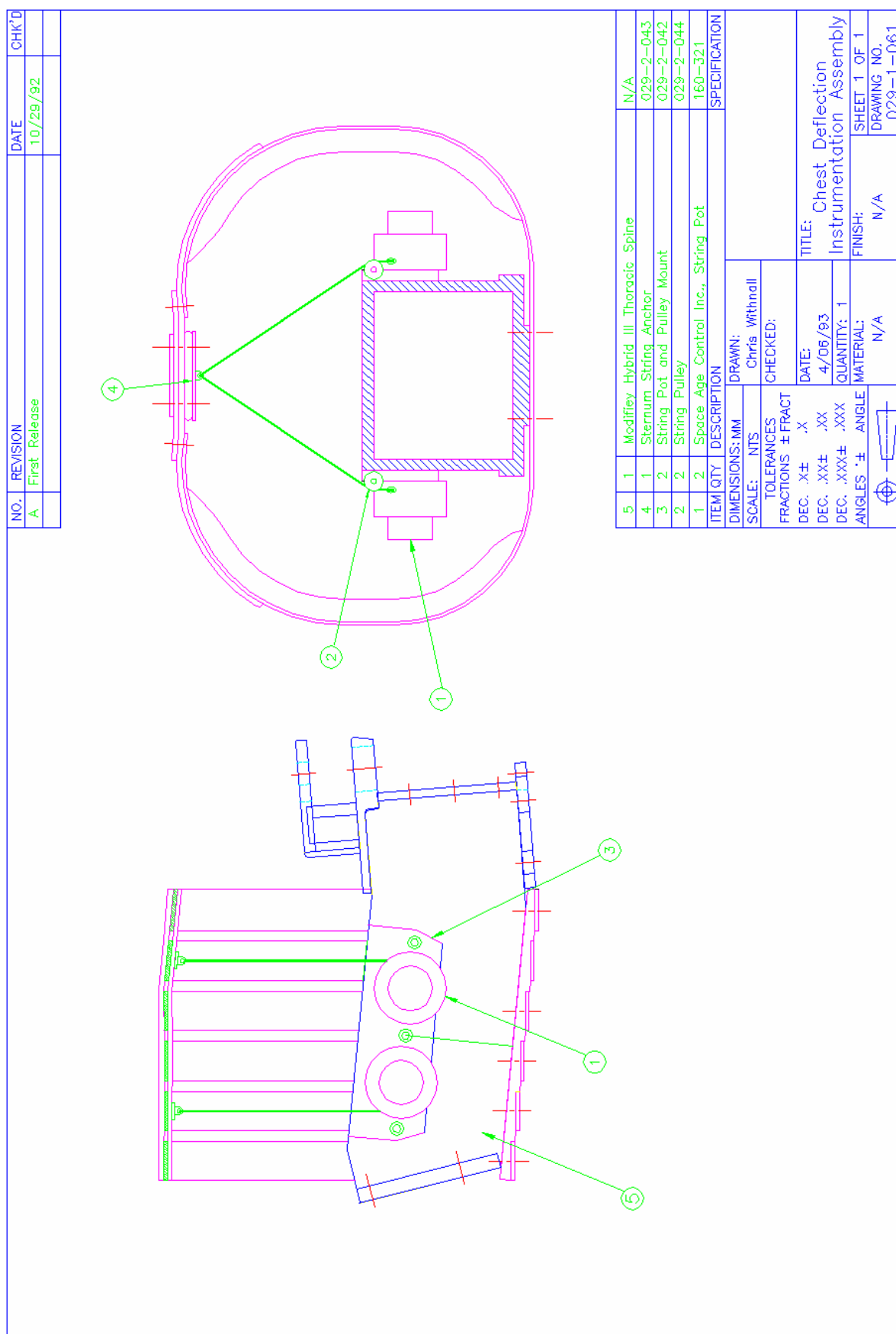


Figure 3 — Chest potentiometer installation

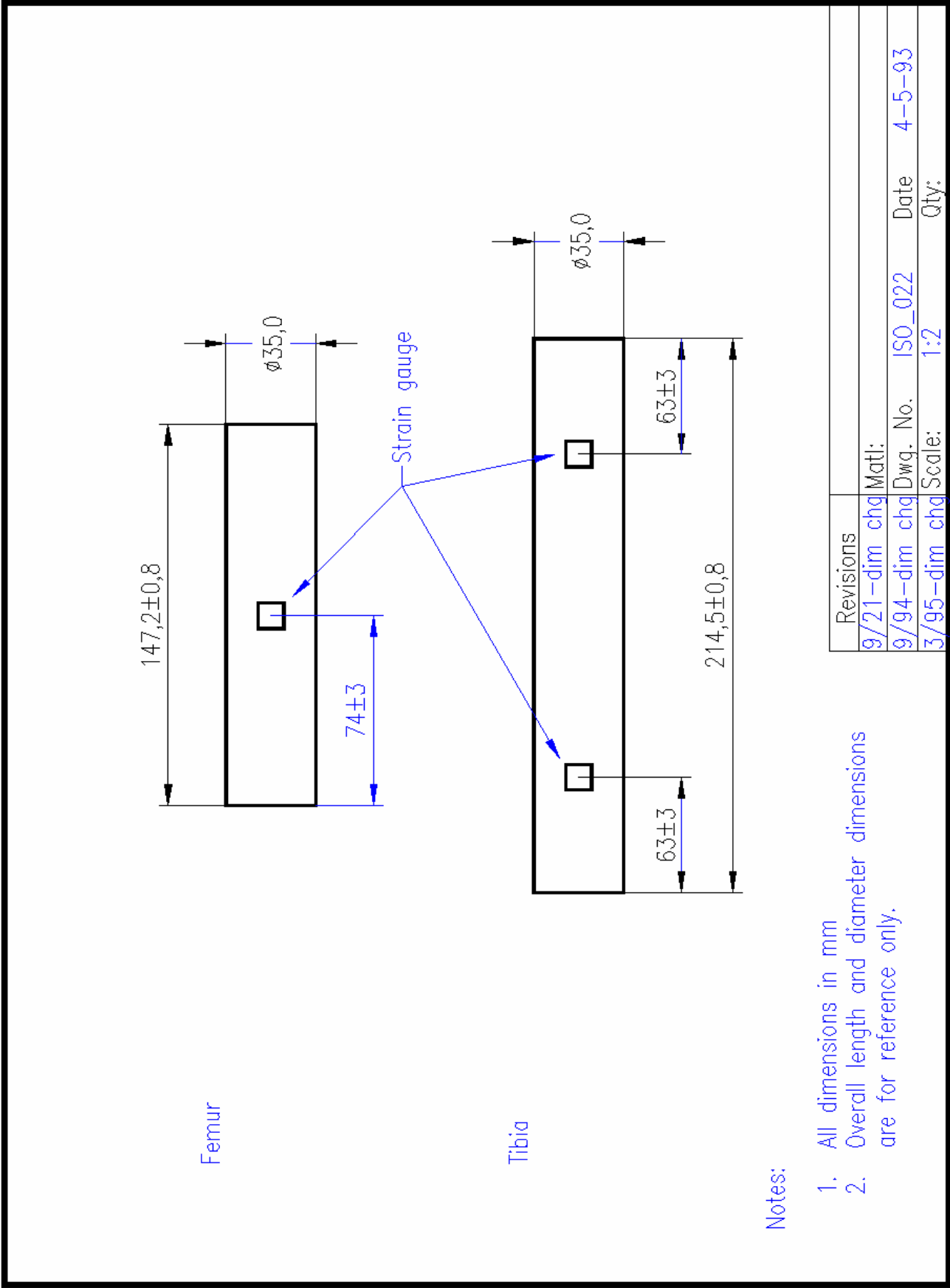


Figure 4 — Frangible bone strain gauge locations

4.4.1.7 Frangible bone continuity sensor

The frangible bone continuity sensor used to monitor frangible bone breakage shall be mounted on all four bones as shown in Figure 5, using the procedure described in 5.4.

4.4.2 Mechanical

All mechanical sensors shall conform to the specifications given in ISO 13232-3. The sensors shall include:

- an abdominal foam insert;
- frangible femur and tibia bones;
- knee compliance elements;
- knee shear pins.

4.5 Internal data acquisition and recording system specifications⁸⁾

There should be no external cables attached to the dummy, except during the pre-crash phase, detachable cables to supply power to the internal data acquisition system and the MC/OV contact sensor. A maximum force of 5 N shall be required to detach the cables.

4.5.1 Not recommended external cables

Non-detachable external cables should not be used, but if used, each cable shall have a mass not greater than 1/3 kg and a length not shorter than 12 m. The total mass of all of the cables, between the dummy and the point of attachment to the MC, shall not exceed 4 kg. The cables shall be arranged so that each is unrestrained. They shall not be attached to the MC, the dummy, or any other cable, except at the cable extremities. The cables shall be attached to the dummy by means of a connector attached to the rear portion of the pelvis.

4.5.2 Data acquisition

The data acquisition system shall be capable of recording a minimum of 32 channels, at a minimum bandwidth of 2.5 kHz for analog recording or a minimum sampling rate of 10 kHz for digital recording. The following system specifications shall apply.

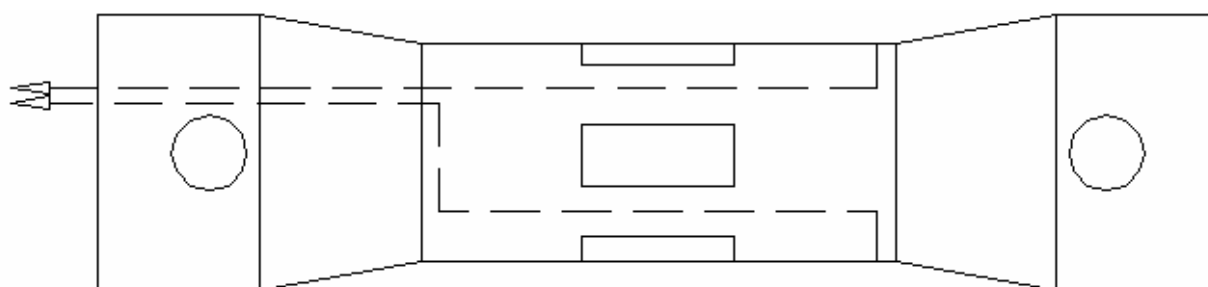
4.5.2.1 Sensor excitation

The load cells and accelerometers shall have a $10,0 \text{ V} \pm 0,2 \text{ V}$ excitation. The potentiometers and strain gauges shall have an excitation of $2,00 \text{ V} - 0,05 \text{ V}$ to $2,50 \text{ V} + 0,05 \text{ V}$.

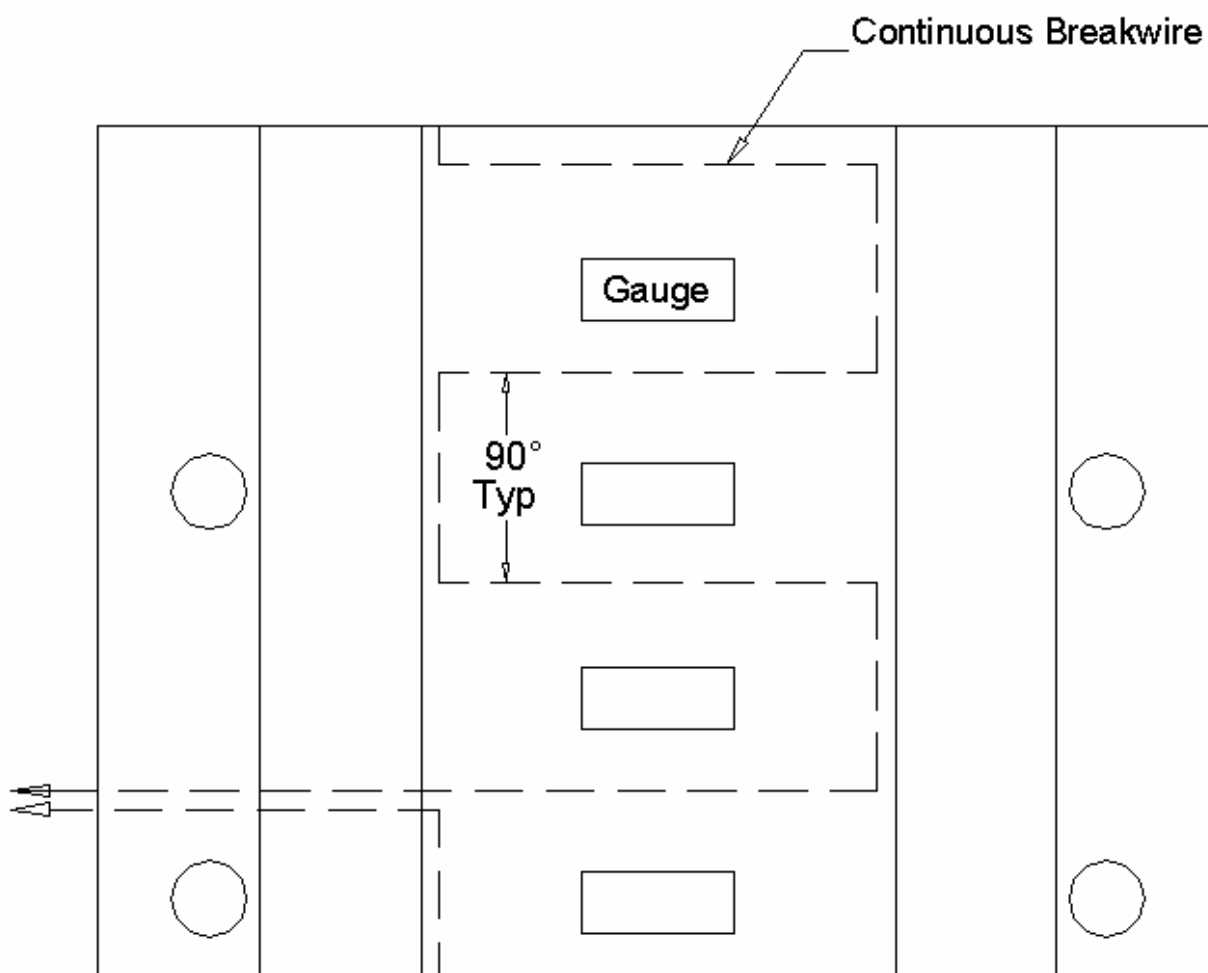
4.5.2.2 Anti alias filtering for digital systems

All analog data channels shall be filtered before digitizing such that the data is attenuated by at least 40 dB above a frequency of 7 kHz.

8) 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 ISO 13232 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.



Bone Side View



Bone Flat Pattern
Pattern

Figure 5 — Frangible bone break continuity sensor end-to-end wire pattern

4.5.2.3 Analog to digital conversion specifications for digital systems

The analog to digital conversion specifications shall be as given in Table 3.

Table 3 — A to D specifications for digital systems

Parameter	Specification
Minimum number of channels	32
Minimum sampling rate	10 000 per s per channel
Maximum inter-channel slew	$12,5 \times 10^{-6}$ s
Minimum number of bits	8
Gain sensitivity to temperature	$\pm 2\%$ over the range of 0° C to 70° C

4.5.2.4 Storage capacity

The minimum recording time capacity shall be 3,1 s.

4.5.2.5 Mechanical specifications for the internal data acquisition system

The system shall be dimensioned to fit inside the thoracic spine box and/or the modified sit/stand pelvis, described in ISO 13232-3. The upper torso and lower torso component masses and centres of gravity shall be as specified in ISO 13232-3. The system shall remain operational in all axes when subjected to a 60 g peak and 0,011 s duration haversine pulse.

4.5.2.6 Scaling of variables

For each recorded variable, the recorder channel gain shall be adjusted such that the minimum recording range corresponds to the value given in Table 4. The actual recording range may exceed that shown in Table 4 if the actual recorder resolution including noise (i.e., 10 bits) will result in the same or better signal resolution than that resulting from an 8 bit recorder and the minimum recording range shown in Table 4.

Table 4 — Full-scale recording ranges

Body region	Injury assessment variable	Range
Head	a_1, a_4, a_7 a_3, a_6 a_5, a_9 a_2, a_8	± 400 g
Upper neck	$F_{x,n}, F_{y,n}$ $F_{z,n}$ $M_{x,n}$ $M_{y,n}$ $M_{z,n}$	± 15 kN ± 30 kN ± 700 N·m ± 1000 N·m ± 700 N·m
Chest	l_{uL}, l_{uR} l_{lL}, l_{lR}	± 60 mm
Lumbar spine	$F_{x,l}, F_{y,l}$ $F_{z,l}$ $M_{x,l}, M_{y,l}$ $M_{z,l}$	± 5 kN ± 10 kN ± 500 N·m ± 250 N·m
Upper femur	$F_{z,uF}$ $M_{x,uF}, M_{y,uF}$ $M_{z,uF}$	± 12 kN ± 600 N·m ± 400 N·m
Lower femur	$F_{z,lF}$ $M_{x,lF}, M_{y,lF}$ $M_{z,lF}$	± 12 kN ± 500 N·m ± 300 N·m
Upper tibia	$M_{x,uT}, M_{y,uT}$ $M_{z,uT}$	± 400 N·m ± 200 N·m
Lower tibia	$F_{z,lT}$ $M_{x,lT}, M_{y,lT}$	± 40 kN ± 400 N·m

4.6 High speed photography

4.6.1 Camera specifications

The cameras, lenses, camera locations, lines of sight, and aim points shall be the same for all tests in a paired comparison.

The following shall be documented for each camera:

- the camera x, y, z locations relative to the targetted OV contact point, as defined in Figure 1 of ISO 13232-2, as expected at first MC/OV contact, projected to ground level and using the axis conventions defined in ISO 13232-8, A.6.5.1;
- the lens focal length;
- the approximate centre point of the field of view.

4.6.2 Required cameras

All cameras used for trajectory and velocity analysis shall have a 100 Hz minimum internal timing light visible in the field of view at all times.

The cameras shall have open shutter duration times which limit the blur of the dummy helmet to a maximum of 0,020 mm, at pre-impact velocity. For example, the required maximum open shutter duration time for a film image width of 10 mm, object width of 5 000 mm, and velocity of 15 000 mm/s is 0,00067 s.

The required cameras and their specifications shall be as given in Table 5. The recommended fields of view and minimum focal lengths shall be as defined in Table B.1 of Annex B. If high speed photographic cameras are used, they should use 16 mm film. Larger film formats may be used, in which case the minimum focal lengths listed in Table B.1 shall be increased by the ratio of the larger film format to 16 mm.

4.6.3 Recommended cameras

The following cameras should be used to provide additional observation capabilities:

- MC oblique view (field of view as appropriate);
- MC front view, if applicable (see Table 5 for field of view);
- OV front or rear view (5 m wide field of view);
- OV side view (8 m wide field of view);
- MC side view, if MC front or rear is used for motion analysis for impact condition 143 (field of view as appropriate).

The fields of view for these cameras should be such that the dummy head is visible in the frame from at least 0,100 s before to 0,500 s after first MC/OV contact. A wider field of view may be used to evaluate overall dynamics of the impact sequence.

4.7 Still photography

Photographs or other high-resolution image recordings for use in dummy position verification shall be taken after the MC has been placed in its launch position and within 0,100 s before first MC/OV contact.

If a still photographic camera is used, the film size shall be at least 35 mm. The shutter speed setting shall be 1/500 s or faster. The minimum focal lengths and fields of view for 35 mm film shall be as given in Table 6. Larger film formats may be used, in which case the minimum focal lengths listed in Table 6 shall be increased by the ratio of the larger film format to 35 mm.

Table 5 — Required cameras and specifications

Camera view	Frame rate f/s	Camera field of view	Line of sight	Subjects at expected first MC/OV contact
MC top	400, minimum	Given in Annex B	Perpendicular to ground	Dummy helmet, first MC/OV contact point, OV, MC and ground targets
MC side, on side giving most unobstructed view of helmet trajectory (except for impact condition 143)	400, minimum	Given in Annex B	Perpendicular to pre-impact path of MC	Dummy helmet, first MC/OV contact point, OV, MC and ground targets
MC rear or front for impact condition 143	400 minimum	Given in Annex B	Perpendicular to pre-impact path of OV	Dummy helmet, first MC/OV contact point, OV, MC and ground targets
MC rear or front, as appropriate	400, minimum	Vertical, 30% $\pm$ 10% larger than overall MC/ dummy height at expected first MC/OV contact	Within 5° of parallel to pre-impact path of MC	MC and ground targets, dummy helmet
OV side, if OV speed is determined photographically	400, minimum	Given in Annex B	Perpendicular to pre-impact path of OV	OV and ground targets

Table 6 — Still photograph minimum focal lengths and field of view widths

View	Minimum focal length mm	Field of view width m
Side	100	4
Top	50	4

Alternative high resolution imaging systems, such as digital still or high speed video cameras, may be used if the user demonstrates that the system resolution, shutter speed, and field of view will enable the user to measure full-scale target locations, with a standard deviation of 0,25 cm or less (i.e., a total error of 0,50 cm when comparing the pre-test and pre-impact images). For a given test series, documentation of this demonstration shall be attached to the test reports that are specified in ISO 13232-8.

5 Measurement methods

5.1 Pre-test measurements related to data reduction

For each ground target, measure the x, y, z locations relative to the targetted OV contact point, as defined in Figure 1 of ISO 13232-2, as expected at first MC/OV contact, projected to ground level and using the axis conventions defined in ISO 13232-8, A.6.5.1.

Before the impact test, measure the following:

- distance between the photo-optic or electro-mechanical contact switches;
- OV overall width.

If the high speed camera lens focal length is less than that specified in Table B.1, record a grid pattern with each required high speed camera, prior to each impact test, on the same film as the impact test footage, using a grid of targets equally spaced throughout the camera field of view.

5.2 Data reduction

5.2.1 Electronic data

Define the time when first MC/OV contact is electronically sensed to be time zero, $t = 0,000$ s. Define data zero to be the average of the first 0,010 s of data, beginning 0,050 s before time zero. Convert the data to scaled data in physical units, using data zero and retaining three significant figures. Filter the data such that the overall frequency response of data output to unfiltered analog input is in accordance with ISO 6487 and the frequency response classes are as given in Table 7.

Table 7 — Motorcyclist anthropometric impact dummy frequency response classes

Typical test measurements	Frequency response class
Head linear accelerations	1000
Neck	
Forces	1000
Moments	600
Thorax	
Deflections	180
Lumbar	
Forces	1000
Moments	1000
Femur/tibia	
Forces	600
Moments	600

Separate the data into windows identified as primary or secondary impact periods.

Store the data in electronic files which are compatible with the latest version of ISO 13499.

Calculate the head linear accelerations, $a_{x,H}$, $a_{y,H}$, and $a_{z,H}$, and the head angular accelerations, $\alpha_{x,H}$, $\alpha_{y,H}$, and $\alpha_{z,H}$, over time, using the program which is included in Annex C.

Calculate neck occipital condyle moments using the procedures given in SAE J1733.

5.2.2 Calibration of frangible leg bone strain gauges

Calibrate each frangible bone strain gauged variable using the procedure described below.

5.2.2.1 Load application

Apply the following loads to the bone, one at a time, as shown in the corresponding figures:

- $F_z = 3\,000\text{ N}$, as shown in Figure 6;
- $M_x = 20\text{ N}\cdot\text{m}$, as shown in Figure 7;
- $M_y = 20\text{ N}\cdot\text{m}$, as shown in Figure 7;
- $M_z = 10\text{ N}\cdot\text{m}$, as shown in Figure 8.

5.2.2.2 Record data

For each of the four applied loads and each strain gauge data channel planned to be used during a crash test, record the following information in Table 8, 9, or 10:

- excitation voltage;