INTERNATIONAL STANDARD

**ISO 13232-7**

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# 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



*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 7: Méthodes normalisées de simulation par ordinateur d'essais de choc sur motocycles*

Reference number
ISO 13232-7:2005(E)

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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
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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 13232-7 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 22, *Motorcycles*.

This second edition cancels and replaces the first version (ISO 13232-7:1996), 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 7:
## Standardized procedures for performing computer simulations of motorcycle impact tests

### 1 Scope

The purposes of this part of ISO 13232 are to provide:

— conventions for calibrating and documenting the important features of the simulation models;

— guidelines for definition and use of mathematical models for motorcycle impact simulations, which can be correlated against data for full-scale tests;



— a means for identifying possible additional impact conditions for full-scale testing; and

— a standardized tool, of optional use, for risk/benefit analysis of rider crash protective devices fitted to motorcycles, based upon the population of impact conditions identified in ISO 13232-2.



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

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 13232-2, *Motorcycles — Test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles — Part 2: Definition of impact conditions in relation to accident data*

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 13232-4, *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*

ISO 13232-5, *Motorcycles — Test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles — Part 5: Injury indices and risk/benefit analysis*

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



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

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 listed in ISO 13232-1:

- body;
- failure mode and effects analysis (FMEA);
- maximum thickness;
- motion;
- risk/benefit analysis; overall evaluation;
- system.

# 4 Requirements

## 4.1 Modelling

The simulation model shall be based upon accepted laws and principles of physics and mechanics. The model shall consist of portions describing a motorcycle (MC) and the opposing vehicle (OV), as described in ISO 13232-6, the dummy, as described in ISO 13232-3, the dummy mounting position, joint tensions, and helmet, as described in ISO 13232-6, the protective device, if present, and the road surface. In the model, the following impact conditions shall be able to be varied, across the range of conditions described in Annex B of ISO 13232-2:

- MC impact speed;
- OV impact speed;
- MC contact point;
- OV contact point;
- relative heading angle.

The model of the dummy should include the following bodies, at a minimum:

a) helmeted head;

b) neck;



c) upper torso;

d) lower torso;

e) left and right:

   1) upper legs;

   2) lower legs;

   3) feet;

   4) upper arms;

   5) lower arms;

   6) hands.

The model of the MC should include the following bodies at a minimum:

- front wheel;
- rear wheel;
- main frame;
- upper front fork assembly;
- lower front fork assembly.

The model of the OV should include the following bodies at a minimum:

— four unsprung assemblies;

— sprung body.

The upper leg, knee, and lower leg bodies shall be modelled so that the bone fracture/knee dislocation kinematics effects are simulated (e.g., resulting in reduced bending moment in the leg at the appropriate location after fracture).

If any of the bodies listed in Tables 1 and 2 can fracture, the masses of the bodies resulting from the fracture shall be modelled.

For a given MC/protective device combination, the same model formulation shall be used for all impact configurations. The only differences between a model of a MC with a protective device and a model of a MC without a protective device shall be in those portions directly related to the protective device.

## 4.2 Parameters

For each body listed in 4.1, the parameter values used should correspond to the actual measured:

— mass;

— centre of gravity location;

— moments of inertia;

— principal axes orientations;

— joint locations;

— joint physical degrees of freedom;

— joint orientations;

— maximum thickness of each undeformed body.



For a given MC/protective device combination, the same parameter values shall be used for all impact configurations. All of the parameter values for a given MC/protective device combination shall correspond to the parameter values used to calibrate the simulation, as described in 4.5. The only difference between a parameter set for a MC with a protective device and a parameter set for a MC without a protective device shall be in those parameters directly related to the protective device.

## 4.3 Outputs

Force, moment, and motion time histories which are compatible with the injury variables and injury indices listed in ISO 13232-5 shall be output to allow computation of the injury indices. The form shall be consistent with the full-scale test time histories documented as described in ISO 13232-8. The data shall be output and plotted at 0,001 s intervals for the time period up to but not including dummy to ground contact, or 0,500 s after the first MC/OV contact, whichever is sooner.

Indication of frangible damage shall be output for all of the frangible components defined in ISO 13232-3, along with the time at which the damage occurred, for the time period described above. The damage shall be expressed as occurrence of component failure for each frangible femur, knee (varus valgus or torsion), and tibia; and as maximum penetration for the frangible abdominal insert.

The linear and angular displacement and velocity time histories of the MC main frame and helmeted head centres of gravity and the shoulder, pelvis, knee, and ankle targets corresponding to those used in full-scale tests shall be output and plotted, at the intervals and for the time period described above.

 

For each simulation run and for each interaction which occurs between any of the MC bodies in Table 1 and any of the OV bodies in Table 2, the maximum force and maximum deflection of the MC body and of the OV body, along the directions indicated in Table 1 and Table 2, shall be output.

**Table 1 — MC laboratory component tests**

| Body | Impactor or impact surface[a] | Test type | Characteristics |
|---|---|---|---|
| MC fuel tank | 400 mm cylinder | Dynamic | $z_{cyl}$ force vs $z_{cyl}$ displacement<br>$z_{cyl}$ force vs time |
| MC seat | 400 mm cylinder | Static | $z_{cyl}$ force vs $i$ displacement |
| Protective device | (As required) | Dynamic | Force vs displacement<br>Force vs time |
| MC rear spring damper | None | Static | $x$ force vs $x$ displacement |
| MC rear spring damper | Flat | Dynamic | $x_{imp}$ force vs $x_{imp}$ velocity |
| MC front wheel | Barrier (as part of the MC laboratory test described in 4.5.2) | Dynamic | $x_{barrier}$ force vs $x_{MC}$ displacement |

[a] Refer to Figure 1.

**Table 2 — OV laboratory component tests**

| Body | Impactor or impact surface[a] | Test type | Characteristics |
|---|---|---|---|
| OV roof rail | 300 mm sphere | Dynamic | $x_{sphere}$ force vs $x_{sphere}$ displacement<br>$x_{sphere}$ force vs time |
| OV side | Disc (edge) | Static | $x_{disc}$ force vs $x_{disc}$ displacement |
| OV side | Disc (side) | Static | $y_{disc}$ force vs $y_{disc}$ displacement |
| OV front bumper | Disc (edge) | Static | $x_{disc}$ force vs $x_{disc}$ displacement |
| OV front bumper | Disc (side) | Static | $y_{disc}$ force vs $y_{disc}$ displacement |
| OV rear bumper | Disc (edge) | Static | $x_{disc}$ force vs $x_{disc}$ displacement |
| OV rear bumper | Disc (side) | Static | $y_{disc}$ force vs $y_{disc}$ displacement |
| OV bonnet | 300 mm sphere | Dynamic | $z_{sphere}$ force vs $z_{sphere}$ displacement<br>$z_{sphere}$ force vs time |
| OV front windscreen | 300 mm sphere | Dynamic | $x_{sphere}$ force vs $x_{sphere}$ displacement<br>$x_{sphere}$ force vs time |
| OV front suspension | Ground | Dynamic | $z_g$ force vs $z_{OV}$ displacement<br>$z_g$ force vs time |
| OV rear suspension | Ground | Dynamic | $z_g$ force vs $z_{OV}$ displacement<br>$z_g$ force vs time |

[a] Refer to Figure 1.