INTERNATIONAL STANDARD

ISO 13232-1

First edition
1996-12-15

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

Part 1: Definitions, symbols and general considerations

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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 —

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Partie 1: Définitions, symboles et généralités

Reference number
ISO 13232-1:1996(E)

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X.400 c=ch; a=400net; p=iso; o=isocs; s=central

Printed in Switzerland

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).

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This is the first version of the standard.

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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*

Annexes A and B of this part of ISO 13232 are 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 all of 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 reseach, if reference is to be made to this International Standard, a clear explanation of how the used procedures 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.

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

Part 1:
Definitions, symbols and general considerations

1 Scope

This International Standard specifies the 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 positionon 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).

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This part of ISO 13232 provides the definitions, abbreviations, symbols, and other general considerations used in all parts of this International Standard.

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 3833: 1977, Road vehicles - Types - Terms and definitions

ISO 13232-2: 1996, Motor cycles - Test and analysis procedures for research evaluation of rider crash protective devices fitted to motor cycles - Part 2 - Definition of impact conditions in relation to accident data

AIS-90: 1990, American Association of Automotive Medicine (AAAM) The abbreviated injury scale. 1990 revision. Des Plaines, Il.

3 Definitions of terms and abbreviations

For the purposes of all parts of ISO 13232, the following definitions apply. The terms and abbreviations are presented by part. The symbols and subscripts are presented after the terms.

3.1 General terms

3.1.1 motor cycle; MC: See ISO 3833: 1977, def. 3.5.

3.1.2 opposing vehicle; OV: A saloon type passenger car, into which the MC is impacted.

3.1.3 leg protective device: A device which is intended to reduce the frequency of leg bone fractures.

3.1.4 structural element of the MC: Any substantially rigid component of the MC (examples: forks, brake assembly, frame).

3.1.5 head protective device: A device which is intended to reduce the frequency or severity of head concussive injuries.

3.1.6 fitted to the motor cycle: Attached in a permanent manner to a structural element of the motor cycle.

3.1.7 crash protection: Reduction of the frequency or severity of rider injuries during impacts.

3.1.8 rider: Operator of a motor cycle.

3.1.9 baseline MC: A MC which has not been fitted with a protective device.

3.1.10 modified MC: One which has been fitted with a protective device.

3.1.11 paired comparison: Testing and comparing results between two or more identical MCs with the only experimental variable between or among them being the presence of the proposed protective device.

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3.1.11.1 single paired comparison: A paired comparison which includes only one test with a modified MC and only one test with a baseline MC.

3.1.11.2 multiple paired comparison: A paired comparison which includes more than one test with modified MCs, all with the same modification, and an equal number of tests with baseline MCs.

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3.1.11.3 group of tests: All of the tests with the baseline MC and with the modified MC, in a paired comparison which involves more than two tests.

3.1.12 impact conditions; impact variables: The five variables which characterize and define the positions, orientations, and velocities of the MC and OV immediately prior to impact in a full-scale impact test, a computer simulation of an impact, or in MC/OV accident data.

3.1.12.1 relative heading angle; rha: The angle between the MC x axis and the OV x axis measured in a clockwise direction from the MC x axis as viewed from above, immediately prior to first MC/OV contact.

3.1.12.2 OV impact speed; OVS: The magnitude of the OV velocity relative to the ground, immediately prior to first MC/OV contact.

3.1.12.3 MC impact speed; MCS: The magnitude of the MC velocity relative to the ground, immediately prior to first MC/OV contact.

3.1.12.4 OV contact point (for full-scale tests or computer simulations); OVCP: The target or measured point on the periphery of the OV, when viewed from above, as shown in figure 1 of ISO 13232-2.

3.1.12.5 OV contact point (for accident analysis): A point representing the region of main and presumably initial structural damage to the OV in a given accident with a MC.

3.1.12.6 MC contact point (for full-scale tests or computer simulations); MCCP: The target point on the MC for the main impact with the OV, being the foremost point, the rearmost point or the midpoint along the MC overall length.

3.1.12.7 MC contact point (for accident analysis): A point representing the region of main and presumably initial structural damage to the MC in a given accident with a passenger car.

3.1.13 first MC/OV contact: The first instant in time when a part of the MC or the dummy contacts the OV.

3.1.14 time of first MC/OV contact; time zero (for film analysis): The first frame on the high speed film which shows contact between a part of the MC or the dummy and the OV, or the frame immediately before where the first light emission from a contact sensing system occurs, whichever is sooner.

3.1.15 time of first MC/OV contact (for electronic data): The instant of initial contact between a part of the MC or the dummy and the OV, sensed by a contact switch and indicated by an electronic pulse on one of the data channels.

3.1.16 first helmet/OV contact: The first frame on the high speed film which shows contact between the helmet and the OV.

3.1.17 primary impact period: The time period from 0,050 s before first MC/OV contact until 0,500 s after.

3.1.18 secondary impact period: The time period from 0,500 s until 3,000 s after first MC/OV contact.

3.1.19 entire impact sequence: The time period from 0,050 s before until 3,000 s after first MC/OV contact.

3.1.20 axis systems:

3.1.20.1 vehicle axis system: A mutually perpendicular set of three axes fixed in the plane of symmetry of the vehicle, with the x axis in the direction of forward straight line motion, the z axis downward parallel to gravity, and the y axis directed toward the right side of the vehicle.

3.1.20.2 specimen axis system: A mutually perpendicular set of three axes fixed in the specimen, with the axial axis parallel to the axis of symmetry or longest dimension of the specimen.

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3.1.20.3 inertial axis system: A mutually perpendicular set of three axes fixed to the ground, with the x axis parallel to the pre-impact path of the MC, the z axis downward parallel to gravity, and the y axis to the right of the pre-impact path of the MC.

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3.1.20.4 head axis system: A mutually perpendicular set of three axes fixed to the head, with x axis forward and horizontal in the mid-sagittal plane, the z axis downward in the mid-sagittal plane, and the y axis toward the right side of the head. The origin is located at the Hybrid III head centre of gravity.

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3.1.20.5 dummy axis system: A mutually perpendicular set of three axes fixed in each component of the dummy, with the x axis in the forward (anterior) direction, the y axis toward the right side of the dummy, and the z axis in the downward direction, and, in general, passing through any joint axes present in the component, when the dummy is in a standing position, with hands and arms at the dummy sides, elbow pivot axes in the forward direction, palms toward the rear (posterior) of the dummy, knee pivot axes in the lateral direction, and toes in the forward direction.

3.1.21 feasibility: The capacity of a proposed protective device to reduce injuries to a given body region, and to reduce injury costs, in a significant percentage of the accident population, without increasing injury costs in more than a very small percentage of the accident population, where "significant" and "very small" may be defined by the users of this International Standard.

3.1.22 failure mode and effects analysis; FMEA: An objective identification of those impact configurations from the accident population in which a given protective device is predicted to cause increased injuries, for purposes of identifying possible additional full-scale test configurations.

3.1.23 risk/benefit analysis; overall evaluation: An objective calculation of the effects of a protective device, in comparison to a baseline motor cycle in terms of the percentage of the population of impact configurations in which the device is beneficial versus the percentage in which it is harmful or in which it has no effect, for various injury indices.

3.1.24 normal seating position: The position in which an operator would generally ride on the specified MC.

3.1.25 optional accessories: Original equipment accessories as provided by the vehicle manufacturer.

3.2 Part 2 - Definition of impact conditions in relation to accident data

3.2.1 cell: Region of five-dimensional space in which the dimensions are relative heading angle, OV impact speed, MC impact speed, OV contact point, and MC contact point (for accident analysis).

3.2.2 cell range: For each cell, the range of values for each of the five impact variables used to define the cell.

3.2.3 nominal values: For each cell, the value of each of the five impact variables that represents that cell for the purpose of defining a unique impact condition for use in full-scale tests or computer simulations; typically, but not always, defined to be the centre of each cell.

3.2.4 corner of the OV: Point at which a vertical plane, set at 45° to the vertical longitudinal plane of the OV, contacts and is tangent to the surface of the bumper.

3.2.5 centre line of the OV or MC: Any line which is parallel to the ground and in the vertical plane which intersects the midpoints of the front wheel(s) and the rear wheel(s) of the OV or MC, at its test weight.

3.2.6 overall length of the OV or MC: The horizontal distance between the two vertical planes, each set at 90° to the plane of symmetry of the OV or MC, one contacting and tangent to the front extremity of the OV or MC, the other, to the rear extremity of the OV or MC, at its test weight.

3.2.7 MC front unsprung assembly: That portion of the front fork assembly which is not supported by the suspension; including the forks, front wheel and axle, and possibly including other structural elements which are attached.

3.3 Part 3 - Motor cyclist anthropometric impact dummy

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3.3.1 certification; compliance: To achieve and to document a specified level of performance.

3.3.2 frangible components: Components of the anthropometric dummy which are intended to fail mechanically at prescribed force/deflection values in order to simulate human injury mechanisms and to record predicted injuries.

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3.3.3 knee compliance element: A small, triangular, deformable plastic element which, when mounted in series with a brass shear pin, simulates the flexibility of knee ligaments. Four such elements are mounted in each injury indicating knee; two compliance elements simulate human knee flexibility for a standing dummy about the M_x axis, and two additional elements simulate human knee flexibility for a standing dummy about the M_z axis.

3.3.4 abdominal foam insert: A dummy component fabricated from crushable foam which exhibits specified force/deflection properties and very limited spring back. It is installed in the test dummy abdomen, and is used to measure the depth of abdominal penetrations to which the dummy is subjected during the course of the impact sequence.

3.3.5 load cell simulator: A non-instrumented structural replacement for a dummy-mounted load cell. The element has the same structural attachment configurations as a load cell, and is used during tests in which a particular load cell and its associated data channels are not required.

3.3.6 alternative products: Products or devices which have the same critical characteristics as those specified, within a certain tolerance. Such critical characteristics may include: mass, dimensions, strength, dynamic response, accuracy, range, etc., depending on the nature of the device. The tolerance also depends on the nature of the device. As a guideline, it is suggested that the manufacturers' specification for the specified product be the basis for the equivalence, with the tolerance being 0,2 mm on critical dimensions, and otherwise within ± 2% of the named manufacturer's specifications, unless otherwise specified in this International Standard.

3.3.7 lot: A number of components produced during a single run of a manufacturing process.

3.3.8 specimen: A frangible bone with one or two rigid extensions attached to the end(s).

3.4 Part 4 - Variables to be measured, instrumentation, and measurement procedures

3.4.1 detachable external cables: Cables which are able to detach from the dummy immediately following first MC/OV contact.

3.4.2 high speed photography: A photographic process incorporating cameras (typically 16 mm), which can produce film exposures at the rate of 400 frames per second or more.

3.4.3 oblique camera: A camera which is aligned in such a way that the angle between the viewing axis of the camera and the front, side, rear, or top of the OV, MC, or dummy is not 90°.

3.4.4 aim point: That point which falls on the horizontal and vertical centre of the image seen in a camera view finder.

3.4.5 digitizing surface: That surface of a film analysis machine on which a photographic image is projected. The surface may contain an electronic grid which, when used in conjunction with a moveable cursor, allows the operator to identify electronically the x and y coordinates of a given point on any exposed frame of film.

3.4.6 film analysis frame: Any frame from a high speed film which is used in a film analysis process to identify the locations of various objects at a given point in time. Typically, not all frames are used for the analysis process, and only every nth frame is considered a film analysis frame.

3.4.7 frame width: The distance between the left and right edge of the field of view as seen through the camera view finder and measured in a plane containing the nearest visible target on the vehicle of interest.

3.4.8 helmet centroid point: The centre of a circle, on the digitizing surface, which is centred about or within the outline of the helmet.

3.4.9 leading edge: The foremost edge in the longitudinal direction of the specified component or vehicle.

3.4.10 trailing edge: The rearmost edge in the longitudinal direction of the specified component or vehicle.

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3.4.11 motion analyser grid: The working surface of a film analyser used to define the location of points in two dimensional space.

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3.4.12 visual resolution: The smallest linear dimension which can be differentiated by the film analyst.

3.4.13 magnification: The ratio of the size of the projected image to the size of the film image.

3.4.14 blur: The distance travelled by an image across the surface of a film during an exposure.

3.4.15 cursor: The movable index which identifies the location of points in two dimensional space, when used in conjunction with the motion analyser grid.

3.4.16 overall accuracy of the film analysis: The sum of the visual resolution of the motion analyser grid plus the visual resolution of the cursor.

3.4.17 primary axis: Force or moment axis corresponding to the sensitive or measurement axis of a sensor.

3.4.18 signal gain: Ratio of final amplifier output voltage to sensor output voltage for one data channel.

3.4.19 output signal voltage: Voltage at the output of the final amplifier associated with a data channel.

3.4.20 off axis: Referring to any load which is not along the primary axis of a sensor.

3.5 Part 5 - Injury indices and risk/benefit analysis

3.5.1 injury assessment variable: A specific value (e.g., the maximum value) of a kinematic response from a specific region of the anthropometric impact dummy, used to establish the probability of injury to that specific region of the body.

3.5.1.1 generalized acceleration model for brain injury tolerance; GAMBIT; G: A weighted function of translational and rotational acceleration of the head.

3.5.1.2 upper (or lower) sternum maximum normalized compression; $C_{us,max,norm}$ ($C_{ls,max,norm}$): The maximum value of the upper (or lower) sternal displacement measured in the x direction, normalized by a chest depth dimension.

3.5.1.3 upper (or lower) sternum velocity; V_{us} (V_{ls}): The upper (or lower) sternum rate of compression.

3.5.1.4 upper (or lower) sternum maximum velocity-compression; $VC_{us,max}$ ($VC_{ls,max}$): The time variant product of the upper (or lower) sternum compression and the upper (or lower) sternum velocity.

3.5.1.5 abdomen maximum residual penetration; $p_{A,max}$: The maximum depth of the permanent deformation observed in the abdominal foam insert.

3.5.2 lower extremities; LE: The body region of the anthropometric impact test dummy containing all frangible components of both legs; the femurs, knees, and tibias.

3.5.3 injury index: measure of the probability of a specific injury and/or injury cost, based upon the measured values of the injury assessment variables and/or frangible component damage.

3.5.3.1 abbreviated injury scale; AIS: The categorization of injury severity which ranks injury severity from 0 to 6; 0 being no injury to 6 being currently unsurvivable/untreatable, representing a subjective consensus measure of the probability of dying (see AIS-90).

3.5.3.2 probable AIS; PAIS: rounded to the nearest integer as a measure of the mean AIS.

3.5.3.3 maximum PAIS: The maximum PAIS among those calculated for the head, chest, abdomen, and lower extremities.

3.5.3.4 total PAIS: Sum of the head, chest, and abdomen PAIS, plus the total number of AIS 2 leg injuries times two plus the total number of AIS 3 leg injuries times three.

3.5.3.5 permanent partial incapacity; PPI: The percentage of incapacity resulting from injury to the lower extremities. It serves to further define and prescribe injury costs.

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3.5.3.6 probability of fatality; PF: The combined probability of obtaining an AIS 6 level injury and of dying from the combination of non-AIS 6 injuries.

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3.5.4 injury assessment function: A functional relationship between an injury assessment variable and the AIS of that same body region.

3.5.5 injury potential variable: A variable which suggests the possibility of potential head injury, based on helmet trajectory or velocity, in the proximity of an OV.

3.5.6 injury severity probability; ISP: Probability of obtaining or observing an injury of a specific minimum AIS injury severity level for a specific body region.

3.5.7 injury costs; IC: The expected costs of an observed or simulated injury, based on bio-economic data.

3.5.7.1 medical costs; MDC: Costs associated with initial and subsequent hospitalization; includes medical, rehabilitation, chronic care, and vocational rehabilitation costs.

3.5.7.2 ancillary costs; AC: Costs associated with lost wages and legal actions (excluding pain and suffering costs), in addition to the cost of replacing household and workplace contributions.

3.5.7.3 cost of fatality; CF: The cost of dying, based on medical and ancillary costs calculated over an average lifetime.

3.5.7.4 normalized injury cost; IC_{norm}: The costs associated with the predicted injuries if sustained by a live human being, normalized by the cost of a fatality.

3.6 Part 6 - Full-scale impact test procedures

3.6.1 secondary test variables: Extraneous, unidentified, and/or undesired variables which can introduce extraneous variations in the test results and which can lead to erroneous conclusions.

3.6.2 rotate: To turn a part about its longitudinal axis.

3.6.3 pivot: To turn a part in a circumferential direction about an axis which is perpendicular to the longitudinal axis and near one end of the part.

3.6.4 dummy K index: A point on the outboard external surface of the dummy knee, on the effective axis of flexion of the knee joint.

3.6.5 dummy S index: A point on the outboard surface of the dummy shoulder, on the effective forward flexion axis of the shoulder joint.

3.6.6 motor cycle K point: A point measured relative to the motor cycle axis system corresponding to the dummy K index when the dummy is properly positioned on the MC.

3.6.7 motor cycle S point: A point measured relative to the motor cycle axis system corresponding to the dummy S index when the dummy is properly positioned on the MC.

3.6.8 upper torso reference line: A line parallel to the dummy back rib attachment plane.

3.6.9 knee centre line index: The foremost point on the centre line of the knee flesh as viewed from the top, when the dummy is seated on the MC.

3.6.10 hexagonal key tool: The six-sided driver required to adjust the bolts of the Hybrid III joints.

3.6.11 weight hanger: The apparatus used to hold ballast weight during the dummy joint adjustment procedure.

3.6.12 lower arm clamping fixture: An apparatus used to hold the weight hanger during portions of the dummy joint adjustment procedure.

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3.6.13 head hook: An eye-bolt which screws into the top of the Hybrid III head, from which the dummy can be suspended.

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3.6.14 dummy preparation areas: All areas where the dummy is kept or prepared during the three hour period prior to the intended time of the impact test, including areas for storage, assembly, calibration, verification tests, joint position and tension adjustment, mounting on the motor cycle and wherever the dummy is at rest prior to impact. For moving motor cycle tests, the area in which the motor cycle is accelerated toward the impact is excluded.

3.7 Part 7 - Standardized procedures for performing computer simulations of motor cycle impact tests

3.7.1 system: An interconnected set of components, e.g., the dummy, the MC, or the OV.

3.7.2 motion: Pertinent variables which are functions of the linear or angular displacement, velocity, or acceleration of a system or body.

3.7.3 body: A portion of a system which has one or more physical degrees of freedom relative to other portions of the system, for example, as determined by a joint.

3.7.4 maximum thickness: The maximum x and also the maximum y dimension of a body, where the z axis of the body is vertical when the system is in a normal, standing position.

3.7.5 femur mid-span: Midway between the hip joint and the knee pivot joint.

3.7.6 tibia mid-span: Midway between the knee pivot joint and the ankle joint.

4 Definitions of symbols and subscripts

4.1 Symbols

The symbols which are not defined in clause 3, but are used throughout all parts of ISO 13232 are listed with their definitions in table 1.