INTERNATIONAL STANDARD

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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

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 1: Définitions, symboles et généralités

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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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 13232-1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 22, *Motorcycles*.

This second edition cancels and replaces the first version (ISO 13232-1:1996), 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 1: Definitions, symbols and general considerations

1 Scope

This part of ISO 13232 provides the definitions, abbreviations, symbols and other general considerations used in all parts of ISO 13232, which 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 13232-2, *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*

AIS-90:1990, Association for the Advancement of Automotive Medicine (AAAM) Des Plaines, IL, USA *The abbreviated injury scale, 1990 revision*

UN/ECE/TRANS/WP.29/78/Rev 1/Amend.2: 1999, *The consolidated resolution on the construction of vehicles (R E 3), Rev 1*

3 Terms and definitions

3.1 General terms

3.1.1
motorcycle
MC
two-wheeled vehicle with an engine cylinder capacity in the case of a thermic engine exceeding 50 cm^3 or whatever the means of propulsion a maximum design speed exceeding 50 km/h

[Adapted from UN/ECE/TRANS/WP.29/78/Rev 1/Amend.2: 1999]

3.1.2
opposing vehicle
OV
saloon type passenger car, into which the MC is impacted

3.1.3
leg protective device
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

EXAMPLE forks, brake assembly, frame

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

3.1.6
fitted to the motorcycle
attached in a permanent manner to a structural element of the motorcycle

3.1.7
crash protection
reduction of the frequency or severity of rider injuries during impacts

3.1.8
rider
operator of a motorcycle

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

3.1.10
modified MC
MC 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

3.1.11.1
single paired comparison
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
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

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
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
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
magnitude of the OV velocity relative to the ground, immediately prior to first MC/OV contact

3.1.12.3
MC impact speed
MCS
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
target or measured point on the periphery of the OV, when viewed from above

[see ISO 13232-2]

3.1.12.5
OV contact point
for accident analysis, point representing the region of main and presumably initial structural damage to the OV in a given accident with an MC

3.1.12.6
MC contact point
MCCP
for full-scale tests or computer simulations, 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, 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
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)
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, 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
first frame on the high speed film which shows contact between the helmet and the OV

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

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

3.1.19
entire impact sequence
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
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
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

3.1.20.3
inertial axis system
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

3.1.20.4
head axis system
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, and with the origin located at the Hybrid III head centre of gravity

3.1.20.5
dummy axis system
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
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

[see ISO 13232-5]

3.1.22
failure mode and effects analysis
FMEA
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
objective calculation of the effects of a protective device, in comparison to a baseline MC 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
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 Definition of impact conditions in relation to accident data (see ISO 13232-2)

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
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 Motorcyclist anthropometric impact dummy (see ISO 13232-3)

3.3.1
certification
compliance
achievement and documentation of 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

3.3.3
knee compliance element
small, triangular, deformable plastic element which, when mounted in series with a brass shear pin, simulates the flexibility of knee ligaments, four of which are mounted in each injury indicating knee.

NOTE Two compiance 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
dummy component fabricated from crushable foam which exhibits specified force/deflection properties and very limited spring back, which is installed in the test dummy abdomen, and 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
non-instrumented structural replacement for a dummy-mounted load cell, having the same structural attachment configurations as a load cell, and 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

NOTE Such critical characteristics may include: mass, dimensions, strength, dynamic response, accuracy, range, etc., depending on the nature of the device, and for wich depends on the nature of the product or 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 ISO 13232.

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

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

3.4 Variables to be measured, instrumentation, and measurement procedures (see ISO 13232-4)

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
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
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
point which falls on the horizontal and vertical centre of the image seen in a camera view finder

3.4.5
digitizing surface
surface of a film analysis machine on which a photographic image is projected, and which might 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 and only where typically every nth frame is considered a film analysis frame

3.4.7
frame width
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
centre of a circle, on the digitizing surface, which is centred about or within the outline of the helmet

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

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

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

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

3.4.13
magnification
ratio of the size of the projected image to the size of the film image

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

3.4.15
cursor
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
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
any load which is not along the primary axis of a sensor

3.5 Injury indices and risk/benefit analysis (see ISO 13232-5)

3.5.1
injury assessment variable
specific value of a kinematic response or force from a specific region of the anthropometric impact dummy, used to establish the probability of injury to that specific region of the body

EXAMPLE the maximum value of upper sternum deflection

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

3.5.1.2
upper (or lower) sternum maximum normalized compression
$C_{\text{us,max,norm}}$ ($C_{\text{ls,max,norm}}$)
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})
upper (or lower) sternum rate of compression

3.5.1.4
upper (or lower) sternum maximum velocity-compression
$VC_{us,max}$ ($VC_{ls,max}$)
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
$p_{A,max}$
maximum depth of the permanent deformation observed in the abdominal foam insert

3.5.2
lower extremities
IE
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
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

[AIS-90: 1990]

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
maximum PAIS among those calculated for the head, neck, chest, abdomen, and lower extremities

3.5.3.4
total PAIS
sum of the head, neck, 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
percentage of incapacity resulting from injury to the lower extremities

NOTE PPI serves to further define and prescribe injury costs.

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

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

3.5.5
injury potential variable
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
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

EXAMPLE 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
cost of dying, based on medical and ancillary costs calculated over an average lifetime

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

3.6 Full-scale impact test procedures (see ISO 13232-6)

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
turn a part about its longitudinal axis

3.6.3
pivot
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
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
point on the outboard surface of the dummy shoulder, on the effective forward flexion axis of the shoulder joint

3.6.6
motorcycle K point
point measured relative to the motorcycle axis system corresponding to the dummy K index when the dummy is properly positioned on the MC

3.6.7
motorcycle S point
point measured relative to the motorcycle axis system corresponding to the dummy S index when the dummy is properly positioned on the MC

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

3.6.9
knee centre line index
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
six-sided driver required to adjust the bolts of the Hybrid III joints

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

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

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

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 motorcycle, and wherever the dummy is at rest prior to impact, and for moving motorcycle tests, the area in which the motorcycle is accelerated toward the impact is excluded

3.6.15
suppression
complete prohibition of inflatable/triggered protective device deployment

3.6.16
kerb mass
mass of a vehicle with body, fitted with all electrical equipment and auxiliary equipment necessary for normal operation of the vehicle, plus the mass of the elements which the vehicle manufacturer provides as standard or optional equipment and which shall be specified in a list, plus the mass of the following elements:

— lubricants;

— coolant (if needed);

— washer fluid;

— fuel (tank filled to at least 90% of the capacity specified by the manufacturer);

— spare wheel(s);

— fire extinguisher(s), if so equipped by the vehicle manufacturer;

— standard spare parts, if so equipped by the vehicle manufacturer;

— chocks, if so equipped by the vehicle manufacturer;

— standard tool kit, if so equipped by the vehicle manufacturer.

[Adapted from UN/ECE/TRANS/WP.29/78/Rev 1/Amend.2: 1999]

3.6.17
overall height
maximum height of an original equipment vehicle, as found in any publication by the manufacturer of the vehicle, which lists this information

3.7 Standardized procedures for performing computer simulations of motorcycle impact tests (see ISO 13232-7)

3.7.1
system
interconnected set of components

EXAMPLE the dummy, the MC, 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
portion of a system which has one or more physical degrees of freedom relative to other portions of the system, as determined by a joint

3.7.4
maximum thickness
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 Symbols and abbreviations

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.

Table 1 — Symbols used in ISO 13232

Symbol	Meaning
FO	Frequency of occurrence
N	Number of items defined by the subscript
d	Distance between two points, defined by the subscripts
x	Distance to or location of a point in the x direction
y	Distance to or location of a point in the y direction
z	Distance to or location of a point in the z direction
E	Voltage
L	Applied load
Gain	Amplifier gain
S/N	Signal-to-noise ratio
θ	Angular displacement
W	Width
l	Length
D	Deflection
C	Compression
p	Penetration
V	Velocity
VC	Velocity-compression[a]
a	Linear acceleration
α	Angular acceleration
F	Force
M	Moment
G	GAMBIT; see 3.5.1.1
HIC	Head injury criterion
P	Probability
MAIS	Maximum AIS
TAIS	Total AIS
MDC	Medical costs for the specified body region of the specified AIS severity level, as defined by the subscripts; see 3.5.7.1
AC	Ancillary cost for the specified body region of the specified AIS severity level, as defined by the subscripts; see 3.5.7.2
CS	Cost of survival

Symbol	Meaning
MR	Mortality rate
a see 3.5.1.4	

4.2 Subscripts

The subscripts used throughout all parts of ISO 13232 and their definitions are given in Tables 2 and 3.

Table 2 — Meanings of subscripts for body regions and parts

Subscript	Meaning
A	Abdomen
arm	Arm
C	Thoracic compression
F	Femur
H	Head
h	Helmet centroid point
hH	Helmeted head
K	Knee
l	Lumbar spine
larm	Lower arm
lE	Lower extremities, including the dummy femurs, knees, and tibia
lF	Lower femur
lleg	Lower leg
ls	Lower sternum
lT	Lower tibia
lTh	Lower thorax
n	Neck
P	Pelvis
T	Tibia
Th	Thorax
uarm	Upper arm
uF	Upper femur
uleg	Upper leg
us	Upper sternum
uT	Upper tibia
uTh	Upper thorax
VC	Thoracic velocity-compression

Table 3 — Meanings of subscripts other than those for body regions and parts

Subscript	Meaning
avg	Average
barrier	Barrier for MC barrier test
c	Camera
ci	Correct injuries
comp	Compression
cp	First MC/OV contact point
cs	Computer simulation
cyl	Cylinder, laboratory component test impactor
disc	Disc, laboratory component test impactor
e	Excitation
ext	Extension
f	Film frame
fatal	Fatality
fc	First contact
flex	Flexion
fork	MC front fork
fs	Full-scale impact test
g	Ground or ground target
i	Index for film frame, time, body region, or country
imp	Impactor, laboratory component test impactor
j	Index for AIS severity level
k	K point on MC, see 3.6.6
L	Left
lL, lR	Lower left, lower right
m	Mass
max	Maximum value of a variable, which is the most positive value of the respective variable, over the time interval of interest.
MC	Motorcycle, see 3.1.1
min	Minimum value of variable, which is the most negative value of the respective variable, over the time interval of interest.
mtr	Meter, as in voltage meter.
norm	Normalized
o	Output
OV	Opposing vehicle; see 3.1.2
p	Pre-impact
peak	Peak value of variable, which is the value which has the largest absolute value, retaining the appropriate sign, over the time interval of interest.

Subscript	Meaning
pend	Pendulum, laboratory component test impactor
R	Right
r	Resultant
rs	MC rear spring-damper
S	Distance between supports for the frangible component tests
s	S point on MC; def 3.6.7
seat	MC seat
shear	Shear
sphere	Sphere, laboratory component test impactor
tens	Tension
tors	Torsion
tot	Total
uL, uR	Upper left, upper right
v	Vehicle target, on either the OV or the MC
x, y, z	In the x, y, or z direction
xy, yz, zx, xyz	Resultant of two or three axes

Annex A
(informative)

Rationale for ISO 13232 - A common approach

NOTE All references cited in Annex A are listed in the bibliography.

A.1 Introduction to the philosophy behind ISO 13232

In 1992, the International Motorcycle Manufacturers Association (IMMA) proposed to the United Nations Economic Commission for Europe, Group for Road Vehicle General Safety (UN/ECE/TRANS/SC1/WP29/GRSG) that an international research methodology for motorcycle crash testing should be developed by ISO as an urgent project over a period of 18 months in order to provide a common basis for research into secondary safety devices. GRSG accepted the proposal and the short time scale because IMMA also offered to make available all of the industry's work on the research methodology. This commitment was fulfilled by the preparation and presentation of a full standard document and the preparation of explanatory presentations on the background research which had gone into the development of the methodology.

The aim of ISO 13232 is to provide a common basic research methodology for assessing the feasibility of crash protective devices fitted to motorcycles (MCs). ISO 13232 is based on existing proven technology and it is intended that it should be updated whenever necessary. ISO 13232 includes a number of recommended baseline tests and methods which are regarded as the minimum for internationally comparative purposes. ISO 13232 is not intended to be used for legislative or regulatory purposes because the criteria and procedures necessary for a legislative standard are different from those required for a research standard.

The purpose of ISO 13232 is to define "common research methods" for assessing the feasibility of rider crash protective devices fitted to MCs; and a means for making an overall evaluation of the effects of such devices on injuries, across a range of realistic impact conditions.

The structure of ISO 13232 reflects scientific research practice in which the research question is operationalized through the selection of indices, measurement criteria, instrumentation, etc., and then tested under specified conditions using a representative sample and, in this case, the method of paired comparisons.

Subsequently, inferences concerning the relevance of the sample results for the overall population can be made using statistical or simulation techniques. There are eight essential interrelated elements to ISO 13232, as shown in Figure A.1. Seven of these elements are primarily concerned with the requirements for testing a sample of devices (the definitions, dummy, the impact conditions in relation to accident data, test procedures, measurements, injury indices, and documentation and reports).

ISO 13232-7 is concerned with computer simulation. It is optional because it can be used for extending the sample results to the overall population of accidents. Computer simulation is regarded as a useful and powerful tool because it reduces the sample size needed to make results representative. It also enables potential failure modes and other additional test conditions to be identified and subsequently tested in full-scale impacts. (Potential failure modes are particularly important from a scientific viewpoint because they are possible 'counter examples' which might disprove the hypothesis, thereby requiring a modification of the theory from which the research question has been formulated.) Each individual part of the standard has its own specific objectives and these are contained in the scope of each part.

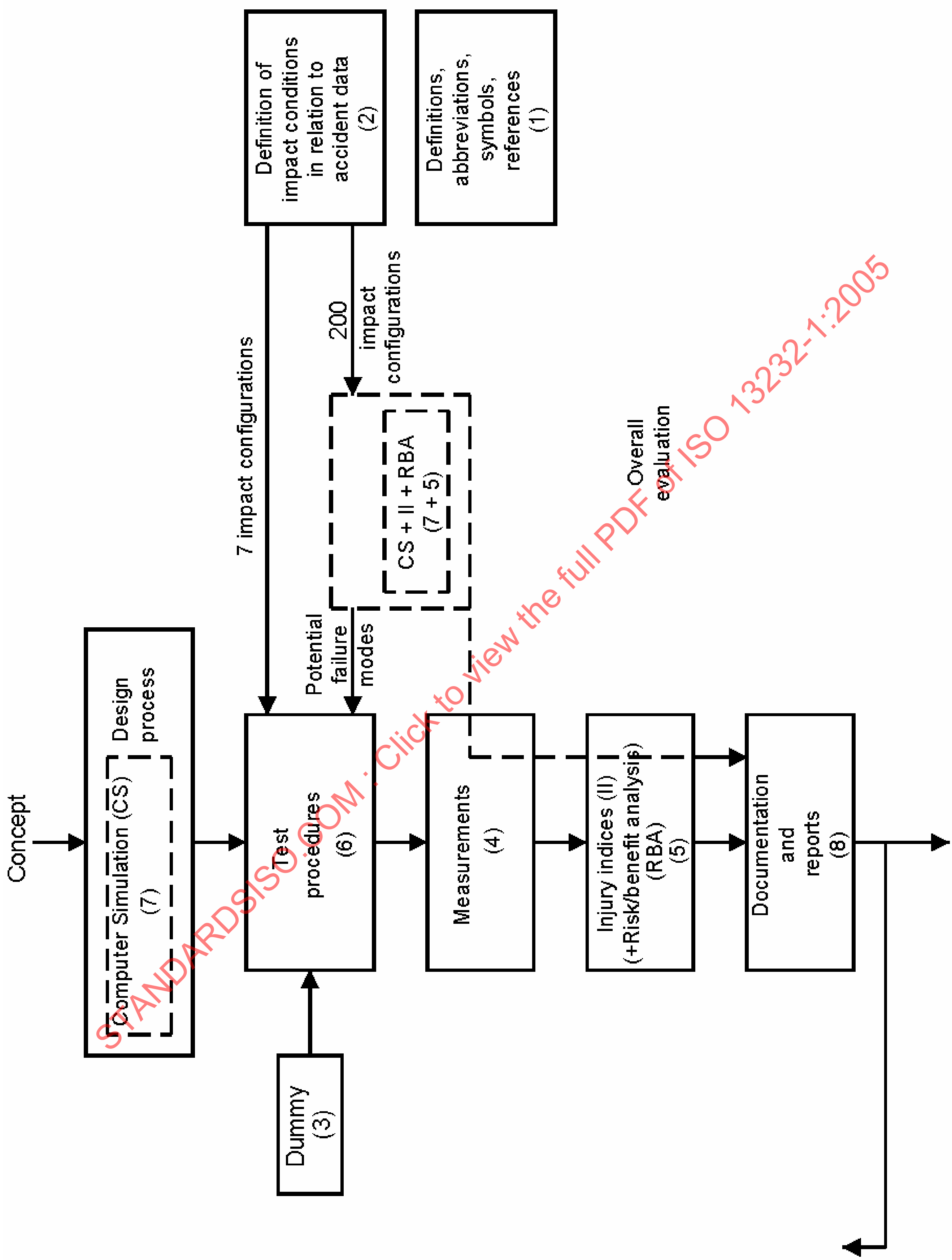

Figure A.1 — Functional relationships among the parts of ISO 13232

The technical approach used in preparing ISO 13232, in addition to being based upon existing technology, was to provide the simplest procedures which give standardized, repeatable, reproducible, realistic, and representative test conditions for paired comparison crash tests with and without proposed protective devices. These criteria were used throughout to determine specific provisions and content.

"Common research methods" are needed because prior to 1992, research by different groups, examining similar or identical protective devices, produced vastly different results using different test and analysis procedures (IMMA, 1992; TRRL, 1991). A device which one group found to be beneficial to the rider, another group found to be largely harmful. The two groups used different crash dummies, impact conditions, measurements, test procedures, indices, and computer simulation models. Exchange of data was impeded by different data formats and differences concerning what comprised a complete test report.

"Feasibility research" is the primary objective, because up until 1992, a motorcycle mounted device had yet to be found which researchers agreed gave some degree of protection and was not harmful to the rider in crash and non-crash situations.

Existing technology and information is the basis, so that ISO 13232 is practical; and so that ISO 13232 could be codified in a minimum amount of time (18 months to the CD stage), as requested by the mandating body (UN/ECE/TRANS/SCI/WP29/GRSG). In addition, the methodology had been documented previously in each of the key technical areas covered by ISO 13232, for example: accident data analysis (Pedder, et al., 1989); motorcycle impact dummy (Gibson, et al., 1992; Newman, et al., 1991; St-Laurent, et al., 1989, 1989a, 1989b); data acquisition and measurement (White and Gustin, 1989); injury indices (Newman, et al., 1992); test procedures (IMMA, 1992; Rogers, 1991a, 1991b); and computer simulation (Zellner, et al.,1991).

A.2 Explanation of scope (see 1)

ISO 13232 applies to "two wheeled motorcycles". ISO 13232 is applicable to the particular types of large angular motion, moving-moving impact conditions characteristic of motorcycle impacts, as well as the kinds of unrestrained, multi directional, whole body motions of riders during impacts. These motions and associated injuries are unlike those involved in either car occupant or pedestrian impacts. There has been no attempt in ISO 13232 to address three wheeled motorcycles, pedal cycles, or mopeds. On many points the procedures in ISO 13232 are not applicable to impact tests with these or other kinds of vehicles.

ISO 13232 applies to impacts with the "specified type of opposing vehicle". Further discussed under ISO 13232-6, the specified opposing vehicle is a saloon passenger car, which, along with coupe cars, is by far the most common opposing vehicle in motorcycle accidents (Hurt, et al., 1981a, 1981b; Otte, et al., 1981; Otte, 1980). The important features which characterize the motorcycle/rider interactions with this kind of vehicle include the front and rear bumpers, grille/bonnet, boot lid, roof structures (including A, B, C pillars and roof edge), and wheel arches. These features are characteristic of coupe and saloon cars. Interactions with other kinds of opposing objects (e.g., trucks, vans, estate cars, other motorcycles, fixed obstacles) would be expected to involve potentially other types of motions and injuries, and therefore, potentially different needs in terms of dummies, injury indices, measurements, test procedures, and proposed protective devices.

ISO 13232 applies to "steady speed, straight line, motion (of both vehicles) immediately prior to impact". This mainly relates to the capabilities of current impact test facilities. Current impact test facilities have been designed for steady, unaccelerated motion prior to impact. If one vehicle or both vehicles are accelerating prior to impact (e.g., non-steady speed, non-straight line, or non-upright), then it is probable that the test variability (e.g., contact point) would be much larger (i.e., poorer repeatability). Also, with regard to accident data, there is a general lack of quantitative information regarding the magnitude of such pre-impact "accelerations", although there is some indication that in a considerable fraction of accidents, vehicles are in some kind of accelerated state (e.g., Hurt, et al., 1981a, 1981b). Accident data are available which document the impact speed and cases with upright motorcycle attitude (Hurt, et al., 1981a, 1981b), and the focus is on these "known" conditions in the test procedures.

ISO 13232 applies to "one helmeted dummy in a normal seating position". The standard requires that the dummy be fitted with the specified "full face helmet". The Hybrid III basis dummy chin region, even as modified in ISO 13232, is not considered to be biofidelic for impacts because it has no moveable jaw. Impacts between the face/chin and rigid car structures may result in unrealistic head accelerations (and therefore, injury potential).

ISO 13232 applies to the "evaluation of results of paired impact tests". The evaluation and prediction of injury potential described in ISO 13232 are considered to be relative, not absolute, in nature. That is, the methodology is intended to describe the relative injury potential for specified body regions for vehicles fitted and not fitted with protective devices. This is in agreement with a general principle of engineering analysis and simulation, which is that, for models of systems, relative (or differential or small perturbation) effects tend to be more accurately predicted than absolute effects, due in part to the influence of modelling precision and unknown initial conditions and parameters. Since impact tests, dummies, and related methodologies are effectively models of physical processes, this concept of "relative" accuracy applies. "Paired comparison" refers to testing MCs with and without a proposed protective device under identical test conditions, i.e., with the only experimental variable being the presence of the proposed protective device.

The methodology is not suitable "for regulatory or legislative purposes" because up until 1992 a feasible protective device had yet to be found and, regulatory tests would typically involve pass/fail criteria, and limited and mandatory test conditions. Regulatory tests would not typically involve, for example, paired comparison tests involving both standard motorcycles and modified motorcycles, or impacts with an opposing production automobile.

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