INTERNATIONAL STANDARD

ISO 13232-6

Second edition
2005-12-15

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

Part 6:
Full-scale impact-test procedures

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 6: Méthodes d'essai de choc en vraie grandeur

Reference number
ISO 13232-6:2005(E)

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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 13232-6 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 22, *Motorcycles*.

This second edition cancels and replaces the first version (ISO 13232-6:1996), 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 6:
Full-scale impact-test procedures

1 Scope

This part of ISO 13232 specifies minimum requirements for:

- paired comparison tests;
- the preparation of the dummy, motorcycle and opposing vehicle;
- the repeatability and reproducibility of impact test conditions within and between test sites;
- the minimization of variation in secondary test variables;
- realistic and representative impact conditions for full-scale impact tests;
- a means to verify analytical evaluations of proposed rider crash protective devices fitted to motorcycles, such as computer simulation.

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);
- evaluation of inflatable/triggered protective device.

ISO 13232-6 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 13232-2, *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 13232-7, *Motorcycles — Test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles — Part 7: Standard 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*

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

SAE Engineering aid 23: 1986, User's manual for the 50th percentile Hybrid III test dummy, Disassembly and assembly, p. 5-20. Warrendale, Pennsylvania, USA

E/ECE/TRANS/505 Rev. 1/Add. 21/Reg. 22/Rev. 3: 1992, Uniform provisions concerning the approval of protective helmets and of their visors for drivers and passengers of motorcycles and mopeds, Genève, Switzerland

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 also listed in ISO 13232-1:

- baseline MC;
- kerb mass;
- dummy K index;
- dummy preparation areas;
- dummy S index;
- group of tests;
- head hook;

- hexagonal key tool;
- knee centre line index;
- lower arm clamping fixture;
- modified MC;
- motorcycle K point;
- motorcycle S point;
- multiple paired comparison;
- overall height;
- overall length of the MC;
- pivot;
- rotate;
- secondary test variables;
- single paired comparison;
- structural element of the MC;
- suppression
- upper torso reference line;
- weight hanger.

4 Requirements

4.1 Opposing vehicle

For all test series except those intended for international comparison purposes, the opposing vehicle (OV) for all tests in a given test series shall be a single make, model, year and version of any four door saloon having a kerb mass not less than 1238 kg and not greater than 1450 kg, and having an overall height not less than 137 cm and not greater than 147 cm.

For all test series which are intended for international comparison purposes, the involved research organizations shall together select a single make, model, year and version of a four door saloon, which meets the aforementioned kerb mass and overall height specifications. The involved research organizations may also select, for tests in other regions, local versions that are similar to the selected version, which are or shall be made to be structurally equivalent to the selected version, with full explanation given in the test report. The involved research organizations shall also together select the OV ride height values for the selected version, as described in 5.2.1, to be used in all tests for international comparison purposes.

The OV shall be in sound, unmodified mechanical condition, except for modifications to the local versions of the selected OV for international comparison tests, as may be required by this clause. The allowable test mass for all OV’s shall be 80 kg ± 20 kg more than the kerb mass of the selected vehicle.

NOTE The specified OV's are to be used until ISO 13232 is amended to incorporate updated OV alternatives, and/or a moving deformable barrier.

The OV shall be set up following the procedures described in 5.2.1.

4.2 Motorcycle

The motorcycle (MC) shall be set up following the procedures described in 5.2.2.

4.3 Dummy and instrumentation

4.3.1 Motorcyclist anthropometric impact dummy

The motorcyclist impact dummy used shall meet all of the requirements described in ISO 13232-3.

Prior to use in impact testing the dummy head, thorax, and knees shall be tested to conform to the calibration requirements and procedures as described in paragraphs 572.32, 572.34, and 572.35 of U.S. 49 CFR Part 572, using the test conditions and instrumentation described in paragraphs 572.36 of U.S. 49 CFR Part 572. The neck shall be tested to conform to the requirements of 3-4.3.6. The number of full-scale tests between calibrations shall not exceed ten. The number of full-scale tests since the last calibration shall be documented according to ISO 13232-8.

All frangible components shall be new and not previously used either in full-scale or component testing.

4.3.2 Instrumentation

The dummy shall be equipped with the instrumentation described in ISO 13232-4.

4.3.3 Sensor, data acquisition, and post processing systems verification

Prior to each impact test, the operation of the head sensors and data acquisition and post processing systems shall be verified by applying an impact to the unhelmeted head of the dummy, as described in 5.3.1. The resulting time histories shall be included in the documentation of test results. Between the time of such verification test and the full-scale impact test, none of the sensors, data acquisition or post processing hardware, or gains, scale factors or ranges shall be changed in any way.

4.3.4 Joint tensions

The dummy joint tensions shall be adjusted, as described in 5.3.2, according to the procedures described in Annex A.

4.3.5 Clothing

The dummy shall be fitted with long sleeved close fitting thermal knit underwear. The underwear shall have holes cut in it to accommodate the lower arm pre-mount positioning procedure, described in Table B.1, and the upper torso angle measurement procedure, if performed as described in C.2.4.2. The dummy feet shall be fitted with leather racing type boots which shall have the following dimensions:

2,0 cm ± 0,5 cm heel height;

1,0 kg ± 0,3 kg mass per boot.

The same boot make, model, and size shall be used for all tests within a paired comparison, as described in 4.5.4.4.

Gloves may also be used to protect the hands if the gloves do not affect the flexibility of the hands and fingers.

4.3.6 Position on motorcycle

The dummy shall be positioned on the motorcycle, as described in 5.3.4 and 5.3.5.

4.3.7 Helmet

The dummy shall be fitted with a Bieffe model B12R[1)] helmet according to the procedures described in Annex D. The helmet shall be new (i.e., the helmet shall not be used for more than one test) and shall meet the following specifications:

- size designation, either small (56 cm) or medium (58 cm);
- certified to ECE Reg 22-03 on a 57 cm headform.

The same helmet make, model, and specifications shall be used for all tests within a paired comparison, as described in 4.5.4.4. Helmets from the same production lot should be used for all tests within a paired comparison[2)].

4.4 Photographic equipment

High speed cameras having the capabilities given in ISO 13232-4 shall be used. The cameras used for pre-test and pre-impact photographs may be remotely triggered.

Photographic targets shall be placed on the MC, OV, and ground at the locations described in 4.3 of ISO 13232-4, and on the dummy at the locations described in 5.3.6 of this part of ISO 13232.

4.5 Impact conditions

In order to do an overall evaluation of the feasibility of a given protective device according to ISO 13232, paired comparison tests using at least the seven full-scale impact configurations defined in 4.3.1 of ISO 13232-2 shall be done. The protective device shall also be evaluated in the remaining 193 impact configurations defined in Table B.1 of ISO 13232-2, and this evaluation should be done by computer simulation according to ISO 13232-7.

The impact condition shall be selected as described in 5.1.

The impact test shall be performed such that it meets the following requirements.

4.5.1 Pre-test measurement

The static measurements which are required to determine impact conditions shall be performed as defined in 5.6 of this part of ISO 13232.

4.5.2 Post-test measurement

Measurements of impact conditions at the time immediately preceding first MC/OV contact shall be performed as described in 5.3 of ISO 13232-4. The measurements shall be used to determine accuracy of impact conditions, as described in 4.5.4 of this part of ISO 13232.

When comparing the pre-test set up photographs with the pre-impact photographs, the positions of the dummy helmet centroid point and of the dummy joint locations, with respect to the motorcycle, shall agree to within ± 3 cm.

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1) Bieffe, model B12R is a product supplied by Bieffe Helmets S.r.l., Lucca, Italy. This information is given for the convenience of users of ISO 13232 and does not constitute an endorsement by ISO of the product named.

2) Helmets purchased in EU countries are marked with a serial number related to the production lot number. Users who choose to use such helmets should contact Bieffe to determine the relationship between serial numbers and lot numbers.

4.5.3 Vehicle speed control

The MC and OV shall be free wheeling at the time of impact, and thereafter, except:

- if the OV impact speed is zero, then the OV parking brake, adjusted to the manufacturer's specification, shall be fully applied during the entire impact test;
- if the OV impact speed is non-zero, then between 0,5 s and 1,0 s after impact, the OV shall be decelerated to a stop with braking equivalent to a brake pedal force of at least 400 N.

4.5.4 Paired comparisons

4.5.4.1 Required relative tolerances

The difference between two tests in a single paired comparison or among all members of a group of tests in a multiple paired comparison shall not be greater than the following values:

- relative heading angle: 3°;
- OV impact speed: 5% of the target speed;
- MC impact speed: 5% of the target speed;
- MC roll angle: 5°;
- OV contact point: see Table 1 for the seven required impact configurations described in ISO 13232-2.

Table 1 — OV contact point relative tolerances for the seven required impact configurations described in ISO 13232-2

OV contact location	Relative heading angle deg	OV/MC speeds m/s	OV contact point relative tolerance cm
Front	90	9,8/0	5
Front	135	6,7/13,4	10
Front corner	180	0/13,4	3
Side	90	0/13,4	5
Side	135	6,7/13,4	15
Side	90	6,7/13,4	15
Side	45	6,7/13,4	15

4.5.4.2 Recommended OV contact point relative tolerances for other impact configurations

For the other 193 impact configurations described in ISO 13232-2, the OV contact point relative tolerance should be as described in Table 2.

Table 2 — OV contact point tolerances for other impact configurations

OV contact location	Relative heading angle deg	OV contact point relative tolerance cm	
		For zero OV or MC speed	All other speed combinations
Front or rear	all	5	10
Front corner or rear corner	all	3	6
Side front, side middle, or side rear	90	5	15
Side front, side middle, or side rear	45, or 135	5	15

4.5.4.3 Required absolute tolerances

For a given impact condition and for each impact condition variable, the difference between the target condition and each of the tests in a single or multiple paired comparison, shall be less than or equal to the values specified in 4.5.4.1 and 4.5.4.2.

4.5.4.4 Number of tests

For paired comparison impact tests, at least one test with the protective device fitted to the MC and at least one test without the protective device fitted to the MC shall be done.

Multiple runs may be performed provided that the same number of multiple runs are performed and documented for both the baseline MC and the modified MC.

4.5.5 Ambient conditions

The air temperature of the area used for long term storage of the dummy should be between 13° C and 30° C. Beginning at least 3 hours before the planned time of impact, the air temperature in each of the dummy preparation areas shall be measured and documented while the dummy is in each area.

If the temperature measured in each of the dummy preparation areas is between 13° C and 30° C, then no additional temperature soaking procedures shall be used.

If the temperature in any of the dummy preparation areas is outside this range, and the total exposure time to the out of range temperature exceeds the time given by the equation below, where first area is the soak area and the second area is the out of range area, then the dummy shall be soaked following the temperature soaking procedure given in 5.7.

$$t = \tau \ln \left[(T_2 - T_1)/(T_2 - T_0) \right]$$

where

t is the total exposure time required to reach the limit of the temperature range, in hours;

T_1 is the air temperature in the first area, in degrees Celsius;

T_2 is the air temperature in the second area, in degrees Celsius;

T_0 is the critical temperature, in degrees Celsius: 13° C for moving to or from temperatures colder than the required range; 30° C for moving to or from temperatures warmer than the required range;

τ is 2.9, the dummy thorax thermal time constant, in hours.

Any further exposure to out of range temperatures shall be treated as described in 5.7.

The wind velocity at the point and time of impact shall be no greater than 4,2 m/s. The test surface shall be substantially level with a maximum gradient of 2%.

4.6 Additional test and analysis procedures for inflatable/triggered protective device

If an inflatable/triggered protective device (i.e., airbag) is being evaluated, additional test and analysis methods should be used that are consistent with those outlined in Annex F.

4.7 Test safety

When performing tests using ISO 13232 procedures, specifications, and requirements, safety must always be a primary goal. At no time should safety practices and procedures be compromised in order to comply with the requirements of this Standard.

Users of this Standard are requested to report to the relevant ISO working group any test personnel injuries or near injuries encountered during the implementation of ISO 13232 so that the incident may be analysed and ISO 13232 modified as required, in order to prevent future accidents and possible injuries.

5 Impact test methods

5.1 Impact conditions

From the list of required and other, permissible impact configurations given in 4.3 of ISO 13232-2, select the impact configuration to be tested and specify the impact conditions using the variables described in ISO 13232-2.

5.2 Vehicle set up

5.2.1 Opposing vehicle

Remove the battery cable and fuel. Weigh the vehicle. Weigh the brake actuator system and the portion of the guidance system mounted on the OV. Add this mass to the measured OV mass and compare the total mass to the allowable test mass given in 4.1. Add or remove ballast or components as necessary to attain the allowable test mass. Install the brake actuator and guidance systems in the OV.

Leave the steering wheel and steering system free to steer. Put the transmission in neutral gear. Completely close all doors, windows, the bonnet, and the boot lid.

For the first OV in a test series, measure and adjust the ride height as specified in Table 3. For subsequent OV's in a test series, measure and adjust the ride height to be within the tolerances as specified in Table 3. Adjust the ride height by adjusting any of the tyre pressures to between 138 kPa and 276 kPa, or by adding spring spacers and/or compressors.

Table 3 — OV ride heights

OV contact location	OV ride height measurement location	Height above ground cm	Tolerance compared to first OV in test series cm
Front and front corner	Lowest point of bonnet at forward end of bonnet centreline	Measure for first OV in test series[a]	1
Side	Highest point of front door	Measure for first OV in test series[a]	1
Rear	Lowest point of boot lid at rearward end of boot lid centreline	Measure for first OV in test series[a]	1
[a] To be measured for first OV in a test series, after vehicle’s x and y body axes have been levelled to be 90 degrees ± 5 degrees from the gravitational vertical axis.			

5.2.2 Motorcycle

Remove the fuel. If the MC is equipped with a rear wheel adjuster to accommodate a chain or belt, adjust the rear wheel to the most forward position. Remove the chain or belt, if present. Set the tyre pressures to the vehicle manufacturer's recommendations. Set the suspension ride height and damping settings to the vehicle manufacturer's recommendations, or to the mid-range point, in the absence of a recommendation. Weigh the MC. Put the MC in neutral gear.

For impact configurations in which the overall MC length measurement is required (e.g., 143-9,8/0 in ISO 13232-2), place the dummy on the motorcycle in a riding position which approximates that to be used in the full-scale impact tests, with the hands on the hand grips and the feet on the foot rests. Ballast the motorcycle to simulate the mass of any additional equipment related to the conduct of the test. Place a bump, like the one shown in Figure 1, approximately 1,5 m in front of the MC, such that the bump is perpendicular to the MC longitudinal centre line. Roll the laden MC a total distance of at least 3 m, perpendicularly across the bump. Place a target on the intended MC contact point and document the MC overall length as specified in clause 6. Remove the dummy from the MC.

For impact configurations in which the MC is moving, install the MC in the guidance system, such that:

— the steering system is free to steer after release from the guidance system and prior to impact, except for interaction with the dummy's hands;

— the front wheel is pointed in the straight ahead direction;

— the front and rear facing MC upper and lower centre line targets form a vertical line with respect to gravity.

For impact configurations where the MC is stationary, construct two wooden support stands with a nominally square cross section; a maximum length and width of 50 mm; and of suitable height to support the MC in a vertical position. Use metal shims having a maximum outside diameter of 25 mm and a maximum thickness of 2 mm, on top of each support stand to level the MC on the stands.

5.3 Dummy set up

5.3.1 Sensor, data acquisition, and post processing systems verification

Mark the dummy head skin with the impactor target point and line-of-motion centre as indicated in Figure 2. Seat the dummy on a rigid, flat, horizontal surface with the thoracic spine box, upper arms, and lower legs in a vertical orientation. Adjust the neck adjustment joint so that with the helmet alignment tool (shown in Figure D.1) fitted to the front of the head, the helmet alignment tool upper edge is horizontal, ± 2° with respect to gravity. Pitch the dummy torso/head assembly forward about the hip joints by adjusting the lateral separation of the legs, if necessary, so that the helmet alignment tool upper edge is inclined 45° ± 2° from horizontal.

Impact the dummy head by moving the impactor centre line along the line of motion indicated in Figure 2 with a pendulum impactor as described in Table 4. Record the head and neck load cell responses with the data acquisition system, as described in 4.5 of ISO 13232-4.

Review the recorded time history data. Before proceeding with the full-scale test, check for proper system functioning and approximate scaling, by examining the data. Include the time histories in the documentation as specified in clause 6.

Table 4 — Impactor characteristics for systems verification

Characteristic	Value
Mass of impactor head	5,0 kg ± 0,5 kg
Mass of pendulum arm	1,0 kg ± 0,1 kg
Impactor surface	Spherical, radius 50 mm ± 5 mm
Length of pendulum arm	500 mm ± 50 mm
Pendulum drop height	500 mm ± 50 mm
Impactor motion at impact	Horizontal, ± 2° with respect to gravity

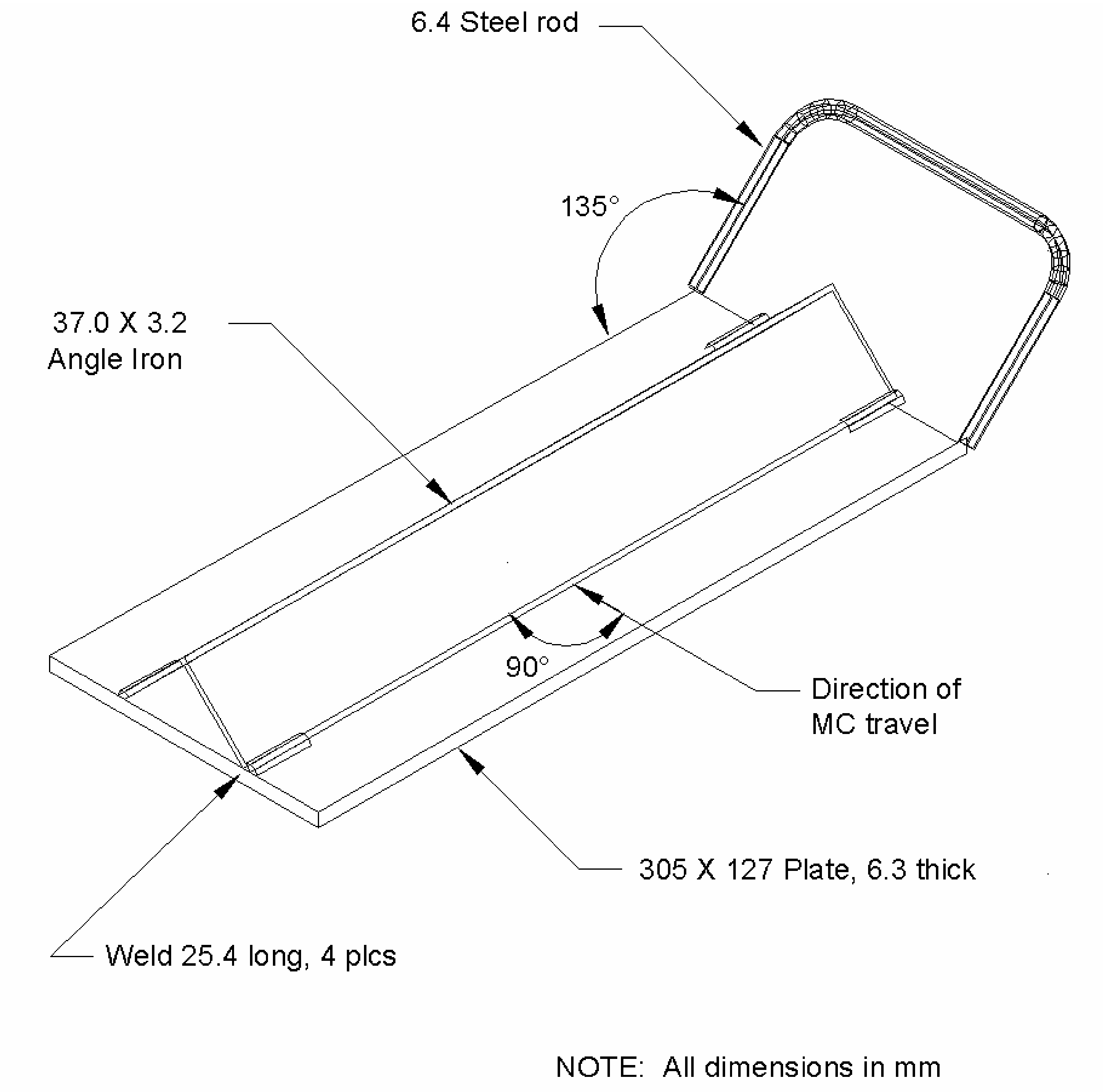


Figure 1 — Motorcycle overall length measurement bump

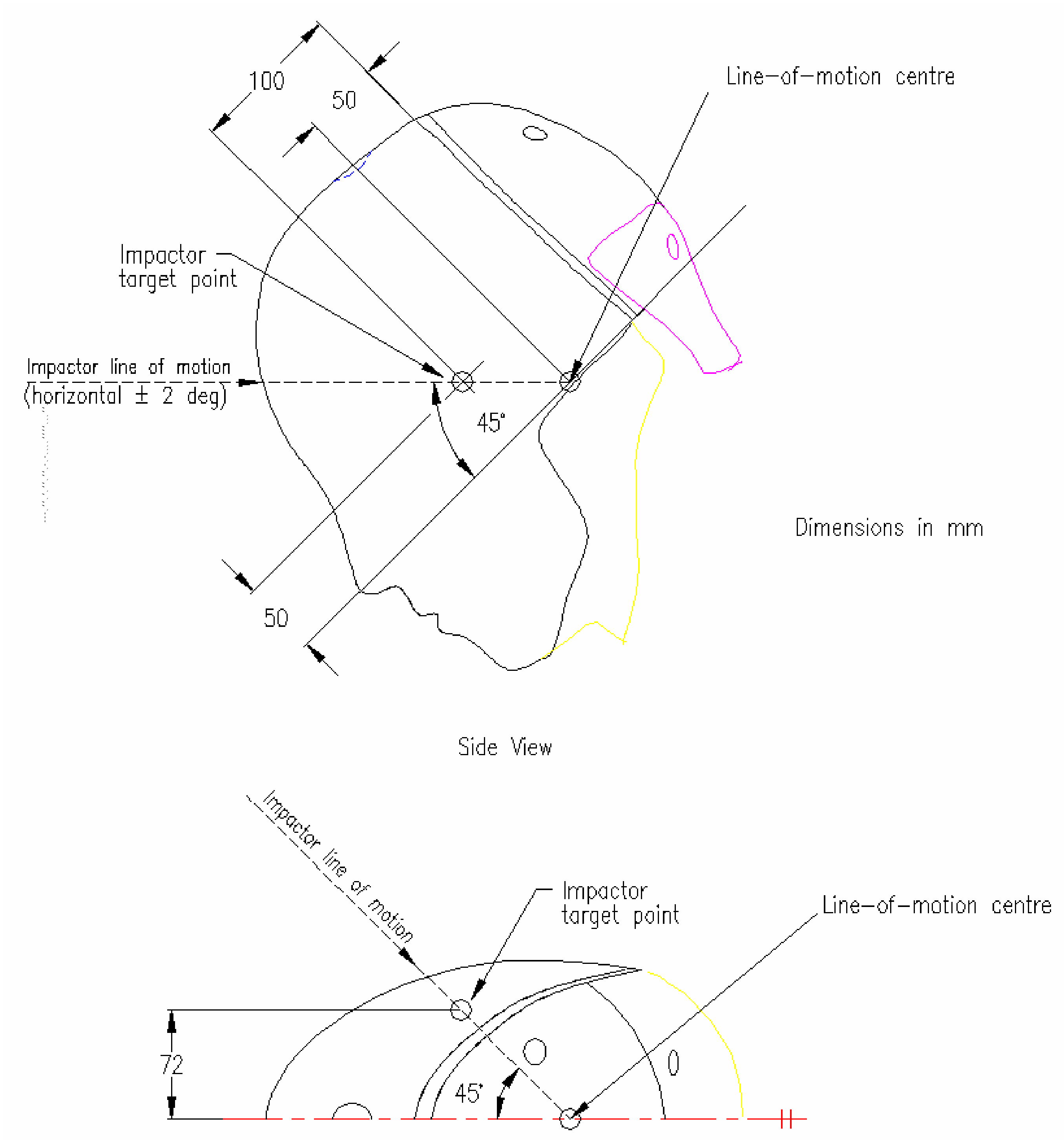


Figure 2 — Head impactor target point and line-of-motion centre for sensor, data acquisition, and post processing verification

5.3.2 Joint tensions

Set the joint tensions before each impact, following the procedures described in Annex A.

5.3.3 Clothing

Clothe the dummy as described in 4.3.5.

5.3.4 Pre-mount preparation

Prepare the dummy for mounting on the motorcycle, following the procedure described in Annex B.

5.3.5 Mount on motorcycle

Position the dummy on the motorcycle, following the procedure described in Annex C. Position the helmet on the dummy, following the procedure described in Annex D.

Measure the heights above the ground of the centre of the headlamp lens and of the taillamp lens. Adjust the heights by adjusting the tire inflation pressures within the range recommended by the vehicle manufacturer or suspension spring settings provided by the manufacturer for the user, if present, such that for any paired comparison, the maximum difference between the two tests is ± 1 cm, if possible. If not possible, minimize the difference between the two tests, and provide a full explanation in the test documentation. Include the measurements in the test documentation.

5.3.6 Film analysis targeting

Place targets on the dummy clothing, at the shoulder, hip, knee, and ankle joints, on the side of the dummy nearest to the MC side view high speed camera. Place each target such that it will be centred on the centre of rotation of the joint and as close as possible to parallel to the plane of the camera lens.

5.4 Stationary MC support

For impact configurations in which the MC is stationary, support the MC with two separate support stands, such that:

- the steering system is free to steer except for interaction with dummy's hands;
- the front wheel is pointed in the straight ahead direction;
- the front and rear facing MC upper and lower centre line targets form a vertical line with respect to gravity.

Support the MC vertically with stands, as described in 5.2.2, on both the left and right sides such that they contact some structural element of the MC. Use up to five metal shims, as described in 5.2.2, to adjust the vertical position of the MC.

An alternative procedure may be used which produces the equivalent result.

5.5 Camera set up

While the vehicles are positioned in the expected first MC/OV contact locations, set up and adjust the required high speed cameras, the pre-impact dummy position verification imaging systems, and any other cameras, according to the specifications given in 4.6 and 4.7 of ISO 13232-4. If required, set the triggers for the pre-impact still cameras or other image reading systems such that the images are recorded before first contact, but not sooner than 0,100 s before first contact.

Before the impact test, if necessary for lens distortion correction, film a grid pattern with each required camera as described in 5.1 of ISO 13232-4.

5.6 Pre-test measurements

Measure the parameters as described in 5.1 of ISO 13232-4.

5.7 Temperature soaking

Place the dummy in an area which has an air temperature in the required range, for a period of time given by the equation in 4.5.5, where the first area is the out of range area, and the second area is the soak area.

6 Documentation and reporting

All test conditions (including ambient, OV, MC, and dummy), recorded verification data, impact conditions, and measurements described in this part of ISO 13232 shall be documented in accordance with ISO 13232-8.

Annex A
(normative)

Procedure to set dummy joint tensions

A.1 New component preparation and dummy assembly

For instruction on fitting new components and assembling the dummy use the USA SAE Engineering aid 23. In addition, check and, if necessary, lap the hip and ankle ball and socket joints, such that with each set screw fully loosened and all flange bolts fully tightened, each joint rotates freely under the weight of the attached limb, throughout its full range of motion.

A.2 Apparatus

The apparatus required for this procedure includes the:

— overhead hoist;

— weight hanger, an example of which is shown in Figure A.1;

— weight set, shown in Figure A.2;

— lower arm clamping fixture, an example of which is shown in Figure A.3.

A.3 Procedure

A.3.1 Whole dummy preparation

Remove the chest skin components and using a harness placed under the clavicles near the spine box, suspend the dummy in a straight standing position with the hands and arms at the dummy sides.

A.3.2 Arm joint initial adjustments

Adjust the left and right arm joints in the sequence and following the procedures given in Table A.1.

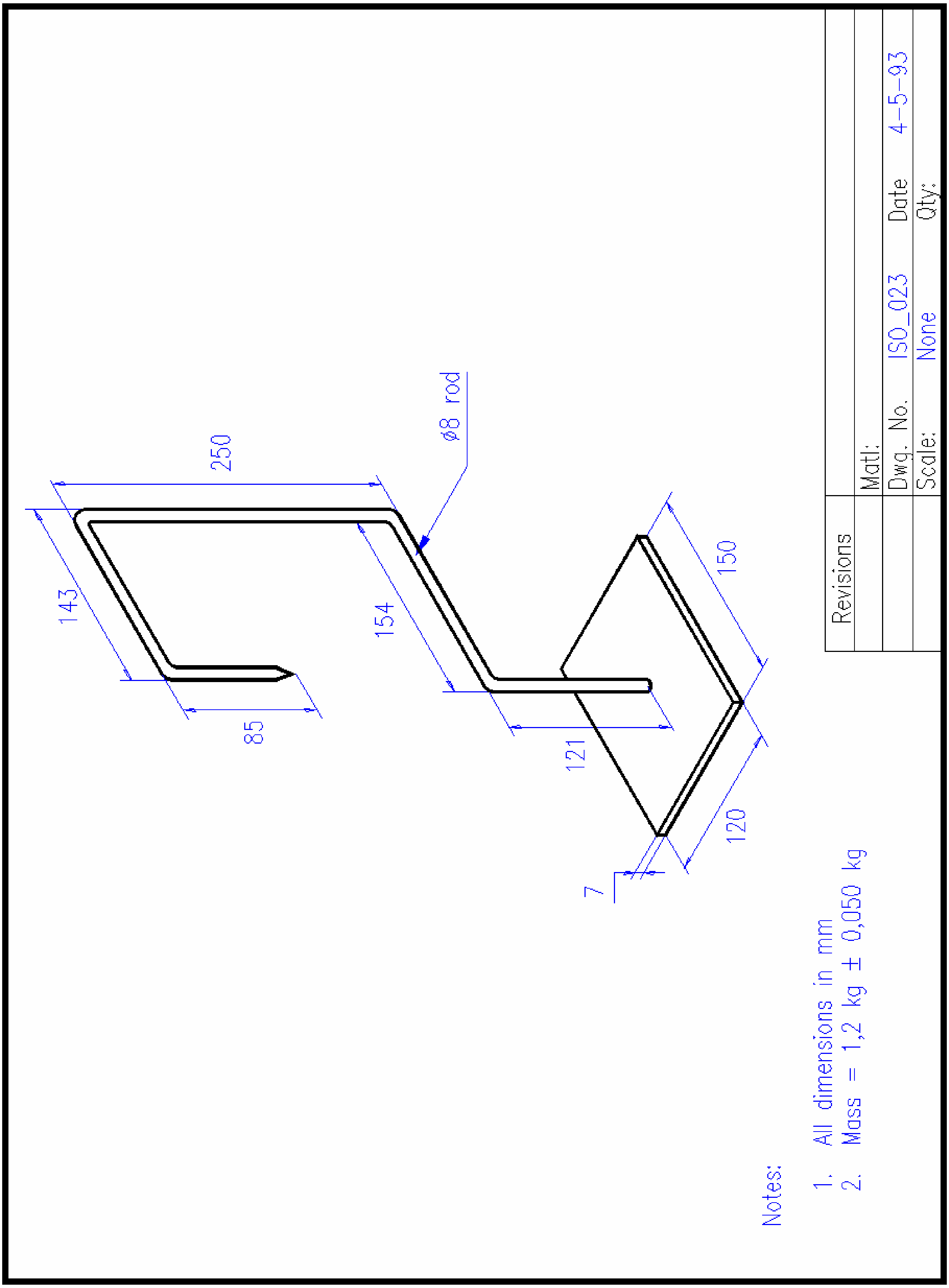
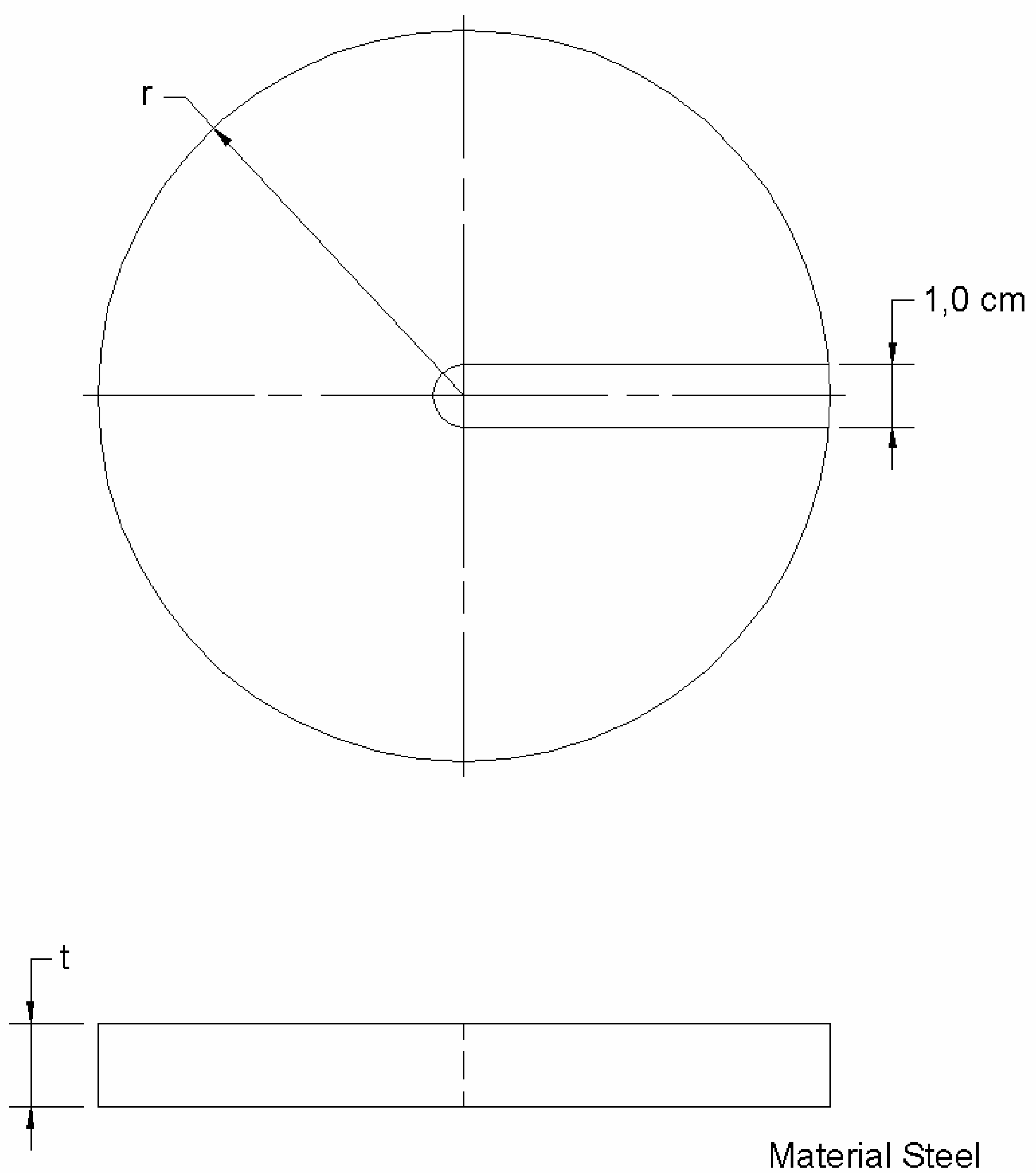


Figure A.1 — Typical weight hanger



Mass	Quantity	r cm	t cm
6 Kg ± 300g	1	11,8	1,8
4 Kg ± 200g	1	11,8	1,2
2 Kg ± 100g	1	9,2	1,0
1 Kg ± 50g	2	9,2	0,5
0,2 Kg ± 10g	1	4,2	0,5
0,1 Kg ± 5g	2	3,0	0,5

Dimensions and shape may be adjusted to facilitate fabrication and to comply with the mass tolerance.

Figure A.2 — Weight set

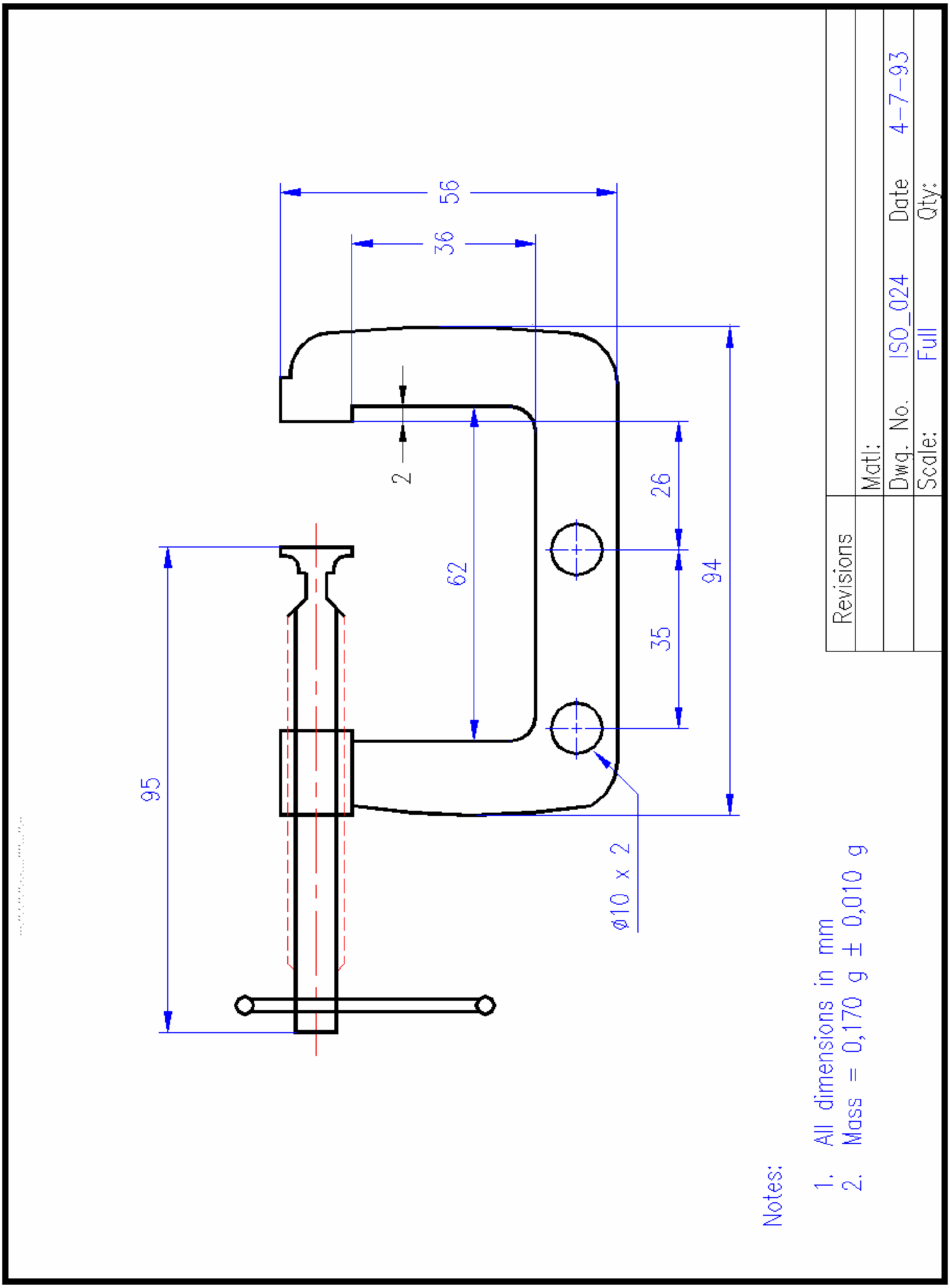


Figure A.3 — Typical lower arm clamping fixture

Table A.1 — Arm joint initial adjustments

Sequence	Procedure
1	Rotate the shoulder joint so the shoulder pivot axis is vertical (side elevation), arm is forward.
2	Tighten the shoulder rotation bolt.
3	Pivot the upper arm to a horizontal position, laterally outward from the torso.
4	Tighten the shoulder yoke clevis bolt (1/4)[a].
5	Rotate the elbow until the elbow pivot axis is vertical.
6	Tighten the elbow rotation bolt (3/16).
7	Pivot the lower arm until it is perpendicular to the upper arm (lower arm points forward).
8	Tighten the elbow pivot bolt (1/4).
9	Rotate the wrist until the wrist pivot axis is horizontal (palm down).
10	Tighten the wrist rotation bolt (3/16).
11	Pivot the hand until the back of the hand is horizontal (palm down).
12	Straighten the fingers.
13	Tighten the wrist pivot bolt (3/8).

[a] Fractions in parentheses refer to the size, in inches, of the hexagonal key tool needed to adjust the referenced Hybrid III dummy bolt.

A.3.3 Arm joint tension adjustments

— Adjust the left and right arm joint tensions in the sequence and following the procedures given in Table A.2.

Table A.2 — Arm joint tension adjustments

Sequence	Procedure
1	Place the weight hanger plus 4,0 kg such that the pointer contacts the head of the screw in the back of the hand.
2	Adjust the wrist pivot bolt (3/8)[a] such that the wrist will pivot due to the load of the weight hanger plus 4,0 kg but will not pivot with the weight hanger plus the 4,0 kg removed
3	Attach the lower arm clamping fixture to the wrist pivot bolt with the off-centre hole oriented away from the dummy centreline.
4	Place the weight hanger plus 1,2 kg in the off-centre hole of the clamping fixture.
5	Adjust the wrist rotation bolt (3/16) such that the wrist will rotate under the load of the weight hanger plus the 1,2 kg, but will not rotate with the 1,2 kg removed from the weight hanger
6	Place the empty weight hanger in the centre hole of the lower arm clamping fixture.
7	Adjust the elbow rotation bolt (3/16) such that the lower arm will rotate under the load of the empty weight hanger but will not rotate with the weight hanger removed.
8	Remove the lower arm clamping fixture.
9	Rotate the elbow such that the elbow pivot bolt is horizontal (forearm is pointing down).
10	Loosen the elbow pivot bolt (1/4) and pivot the elbow until the axis of the wrist rotation bolt is vertical.
11	Place the pointer of the empty weight hanger in the head of the wrist rotation bolt and add 4,0 kg.
12	Adjust the elbow pivot bolt (1/4) such that the elbow will pivot under the load of the weight hanger plus the 4,0 kg, but will not pivot with the weight hanger plus 2,2 kg (instead of 4,0 kg).
13	Reposition the arm such that the upper arm, lower arm, and hand are aligned in a straight line; the axis of the shoulder pivot bolt is horizontal; the arm is horizontal, laterally outward from the torso; and the head of the elbow rotation bolt is facing upward.
14	Place the pointer of the empty weight hanger in the head of the elbow rotation bolt and add 6 kg.
15	Adjust the shoulder pivot bolt (1/4)[a] such that the shoulder will pivot under the load of the weight hanger plus the 6 kg, but will not pivot with the weight hanger plus the 6 kg removed.
16	Pivot the shoulder to the vertical position (arm down).
17	Rotate the shoulder to the horizontal position (hand forward).
18	Rotate the elbow such that the axis of the elbow pivot bolt is vertical.
19	Rotate the wrist such that the wrist pivot bolt is vertical, with the bolt head facing upward.
20	Place the pointer of the empty weight hanger in the head of the wrist pivot bolt and add 1,1 kg.
21	Adjust the shoulder rotation hex head bolt such that the shoulder will rotate under the load of the weight hanger plus the 1,1 kg, but will not rotate with the weight hanger plus the 1,1 kg removed.
22	Replace the chest skin.

[a] Fractions in parentheses refer to the size, in inches, of the hexagonal key tool needed to adjust the referenced Hybrid III dummy bolt.

A.3.4 Leg joint initial adjustments

Before adjusting the leg joint tension for each leg, adjust the leg, such that:

- the knee is fully extended;
- the axis of the knee rotation is parallel to the ground;
- the foot is perpendicular to the lower leg;
- the upper leg is horizontal;
- the z axis of the leg is pointing forward.

Tighten the femur ball set screw (3/8), knee adjustment bolt (9/16), and ankle ball set screw (5/32) to hold this position. Use hexagonal key tools of the sizes indicated in parentheses.

A.3.5 Leg joint tension adjustments

Adjust the left and right leg joint tensions in the sequence and following the procedures given in Table A.3.

Table A.3 — Leg joint tension adjustments

Sequence	Procedure
1	Attach the empty weight hanger plus 2,2 kg to the ankle such that the pointer of the weight hanger rests in the notch between the top of the foot and the lower leg skin.
2	Adjust the knee adjustment bolt (3/16)[a] *) such that the knee will pivot under the load of the weight hanger plus the 2,2 kg, but will not pivot with the weight hanger plus the 2,2 kg removed.
3	Straighten the leg, so that the lower leg is aligned with the upper leg and the upper leg is horizontal and pointing forward, parallel with the dummy torso x axis. Attach the empty weight hanger plus 14,4 kg such that the pointer is recessed in the head of the socket head screw on the front side of the leg just above the knee.
4	Adjust the femur ball set screw (3/8) such that the hip will rotate under the load of the weight hanger plus the 14,4 kg, but will not rotate with the weight hanger plus the 14,4 kg removed (with the lower leg aligned with the upper leg).
5	Adjust the leg to a vertical position with the upper and lower leg aligned and the foot perpendicular to the lower leg.
6	Place the empty weight hanger on the foot such that the pointer contacts the foot at a point 145 mm from its forward extremity, along the axis of the foot.
7	Adjust the ankle ball set screw (5/32) such that the ankle will rotate under the load of the empty weight hanger but will not rotate with the weight hanger removed.

[a] Fractions in parentheses refer to the size, in inches, of the hexagonal key tool needed to adjust the referenced Hybrid III dummy bolt.

Annex B
(normative)

Procedure for dummy pre-mount preparation

Suspend the dummy using a harness placed under the clavicles. Adjust the left and right limbs in the sequence and to the positions given in Table B.1.

Table B.1 — Dummy limb pre-mount positions

Sequence	Joint	Limb	Position
1	Shoulder rotation	Upper arm	Horizontal
2	Shoulder pivot	Upper arm	Approximately 15° abducted from straight ahead
3	Elbow rotation	Lower arm	Inside of the elbow joint facing toward the dummy centre line
4	Elbow pivot	Lower arm	Pivoted 10° with respect to the upper arm, by aligning the scribe mark on the upper arm elbow lug with the scribe mark on the Delrin bushing, Hybrid III part number 78051-199[a] (shown in Figure A.12 of ISO 13232-3)
5	Wrist rotation	Hand	Wrist pivot bolt horizontal, the bolt head toward the dummy centre line
6	Wrist pivot	Hand	Palm facing downward
7	Fingers	Fingers	Straight
8	Femur	Upper leg	Approximately 20° below horizontal; approximately 30° abducted from straight ahead
9	Knee	Lower leg	Perpendicular to the upper leg
10	Ankle ball	Foot	Perpendicular to the lower leg

[a] 49 CFR Part 572, subpart E.

Annex C
(normative)

Procedure for positioning the dummy on the motorcycle

C.1 Preparation

Adjust the MC handlebars to a baseline, initial position. Mark the MC longitudinal centre line along the top surface of the MC. Verify that the handlebars are adjusted to the same position for all tests within a paired comparison, by measuring the height above the ground of the centres of the outboard ends of the hand grips. Document the results as specified in C.3.

C.2 Positioning

NOTE The following procedures may result in different dummy positions on the baseline MC versus the modified MC in a paired comparison. This is considered to be part of the effect of the protective device.

C.2.1 Whole body

Lower the dummy pelvis onto the motorcycle seat so that the pelvis centre line lies on the seat centre line, and the dummy K indices lie near the known or expected motorcycle K points (see C.2.4.1 and C.2.4.2).

C.2.2 Foot adjustments

C.2.2.1 Motorcycles with peg foot rests

Place the heels and soles of the boots in contact with the upper surface of the foot rests so that the inner edges of the soles of the boots are even with the inner edges of the foot rests at the heel, and the forward edges of the heels of the boots are in contact with the trailing edges of the foot rests. Adjust the feet so they are perpendicular to the lower legs.

C.2.2.2 Motorcycles with attached platform foot rests

Place the heels and soles of the boots in contact with the top surface of the platforms so that the outer edges of the soles of the boots are even with the outer edges of the platforms, and the forward edges of the boots are even with the forward edges of the platforms. If any part of the boot lies below a brake or gear shift pedal, position the boot such that the forward edge of the boot is even with the rearward edge of the pedal. Measure and document the position of the left and right boots.

C.2.2.3 Motorcycles with integral platform foot rests

Place the heels and soles of the boots in contact with the top surface of the platforms such that the outer edges of the soles of the boots are even with the outer edges of the platforms, and the forward edges of the boots are even with the most forward parts of the platforms which are substantially horizontal. If any part of the boot lies below a brake or gear shift pedal, position the boot such that the forward edge of the boot is even with the rearward edge of the pedal. Measure and document the position of the left and right boots.

C.2.3 Knee adjustments

Press the knees toward each other until the legs are in contact with some surface of the motorcycle, or until the knee centre line indices are 30 cm ± 1 cm apart, whichever results in a greater distance between the knee centre line indices. Measure and document the distance between the knee centre line indices.

C.2.4 Pelvis and torso

Place the hands on the hand grips with:

- the first finger in contact with the inner edge of the hand grip;
- all fingers wrapped over and in contact with the hand grip;
- the thumb wrapped under and in contact with the hand grip;
- the palm in contact with the hand grip;
- the back of the hand parallel to the surface connecting the hand grip and hand lever;
- the lower arm pivoted 10° with respect to the upper arm, as described in Annex B.

To accomplish this, minimal adjustments to the following may be made, in the following order of preference:

- rotate the shoulder;
- pivot the shoulder;
- rotate the wrist;
- pivot the wrist;
- adjust the handlebar.

C.2.4.1 If MC K and S points are known

Position the pelvis and torso so that the dummy K and S indices are aligned with the MC K and S points, respectively.

C.2.4.2 If MC K and S points are not known

While maintaining the hand, wrist, arm, shoulder and foot positions move the pelvis forward or rearward, so that the upper torso reference line is 10° forward of vertical. Measure and document the upper torso angle using a torso inclinometer like the one shown in Figure C.1. Insert the four dowels of the inclinometer into the holes previously cut in the back of the dummy chest skin such that the dowels contact the dummy upper and lower rib posterior attachment bolts. The torso angle may also be measured by partially unzipping the rear of the chest skin and placing an inclinometer directly on the rib attachment plane.

Exceptions to the upper torso angle requirement are:

- if the pelvis cannot be moved sufficiently rearward due to the presence of an operator seat back or passenger seat cushion, position the pelvis such that the pelvis contacts the operator seat back or passenger seat cushion;
- if the pelvis cannot be moved sufficiently forward due to the presence of a pelvis, knee, or leg obstruction such as a seat lip, fuel tank, or mechanical or structural device, position the pelvis forward until the pelvis, knee, or leg obstruction is reached.

In case of either of the above exceptions, measure the actual upper torso inclination angle forward of vertical.

Measure and document the resulting K and S points relative to the point which is vertically below the rear axle, at ground level, along the MC longitudinal centre line.

C.2.4.3 Motorcycle roll balance

Mount an inclinometer to the front disc brake rotor or any suitable surface, such that it measures the MC roll angle with respect to vertical, at the front wheel when the wheel is in the straight ahead position. Stand astride of the front wheel, facing the dummy. Support the MC and dummy by holding the handlebars. Adjust the steering head to a straight ahead position by visually aligning the front and rear wheels, with the aid of a straight edge. Find the angle at which the MC is balanced. Maintain this roll angle for the remainder of the pre-test setup and while the MC and dummy are accelerated up to speed during moving motorcycle tests. Measure and document the pre-test roll angle and the heights above the ground of the centres of the outboard ends of the hand grips.

C.3 Documentation

Document all measurements made in Annex C in accordance with ISO 13232-8.

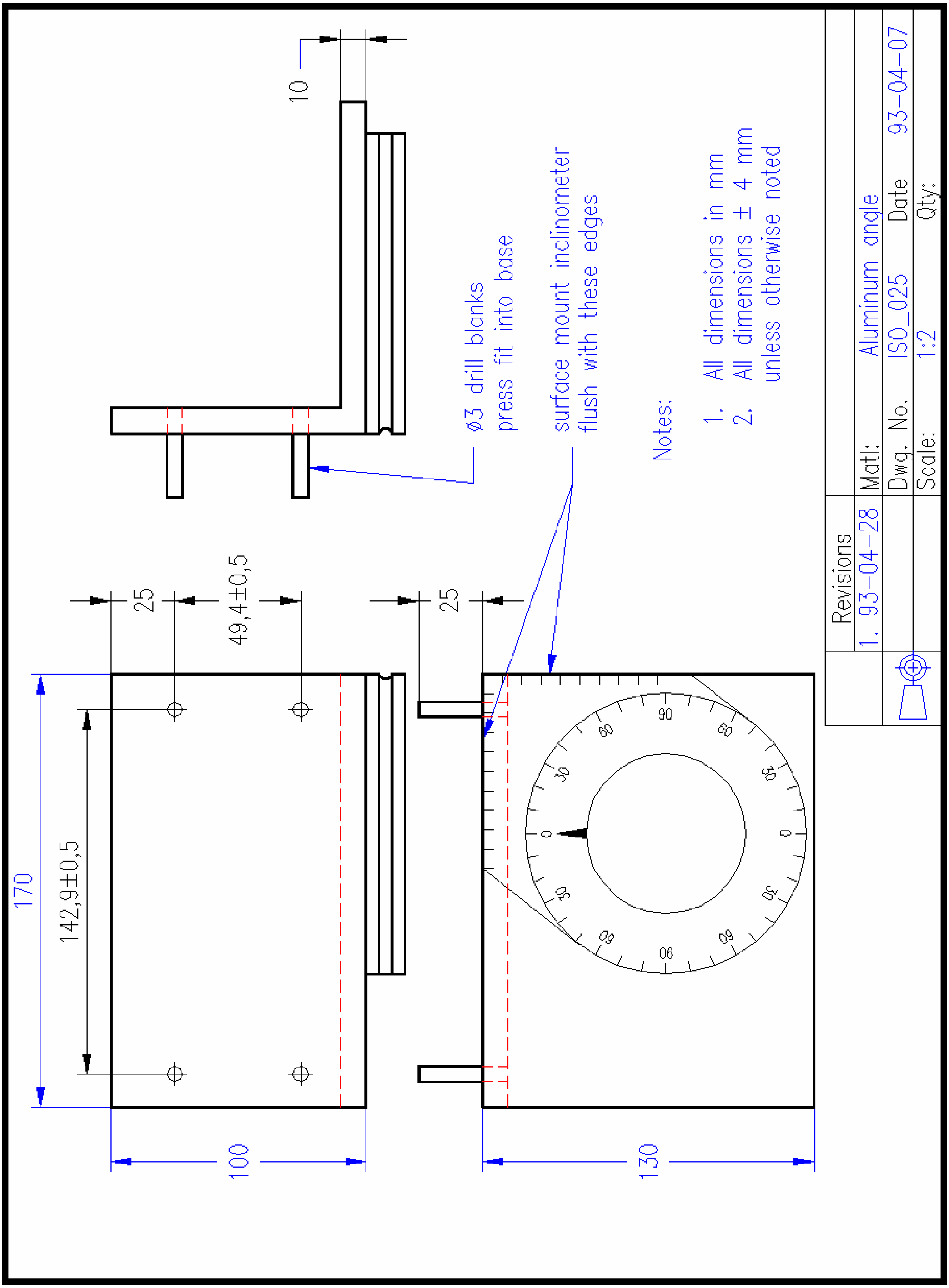


Figure C.1 — An example torso inclinometer

Annex D
(normative)

Procedure to install the helmet on the dummy and position the dummy head

D.1 Remove the head hook from the dummy head

D.2 Helmet fitment

Mark the helmet centre line above and below the visor. Place the helmet on the dummy head. Push the helmet down on the dummy head until the helmet is fully seated. Open the helmet visor. Rotate the helmet about the x_H and z_H axes until the helmet centre line marks above and below the visor align with the centre line of the dummy face. Place the helmet alignment tool, as shown in Figure D.1[3], on the centre line of the dummy face. Rotate the helmet about the y_H axis until the top of the alignment tool contacts the helmet.

If helmets other than the specified Bieffe are used, the alignment tool may require modification. The modified tool shall match the Hybrid III nose profile and provide a measure of the angle between the Hybrid III head instrumentation plane and horizontal. If the tool is modified, dimension A in Figure D.1 should remain 69,1 mm, if possible. If not possible, the new dimension shall be noted in the test documentation.

Tighten the helmet retention strap, so that a weight of 4 kg, hung from the strap centre line, will displace the strap vertically by 10 mm ± 5 mm, relative to the lower edge of the helmet alignment tool.

D.3 Position dummy head

With the dummy torso angle positioned according to C.2.4, set the lower neck angle adjustment joint to zero degrees. Select the pair of nodding blocks (See 4.3.4 of ISO 13232-3) that position the top of the helmet alignment tool as near to horizontal as possible. Re-adjust the lower neck angle adjustment joint such that the top of the helmet alignment tool is horizontal, or as near to horizontal as possible. Measure the deviation from horizontal of the helmet alignment tool upper edge. Document the angle and nodding blocks selected, as specified in clause 6.

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.

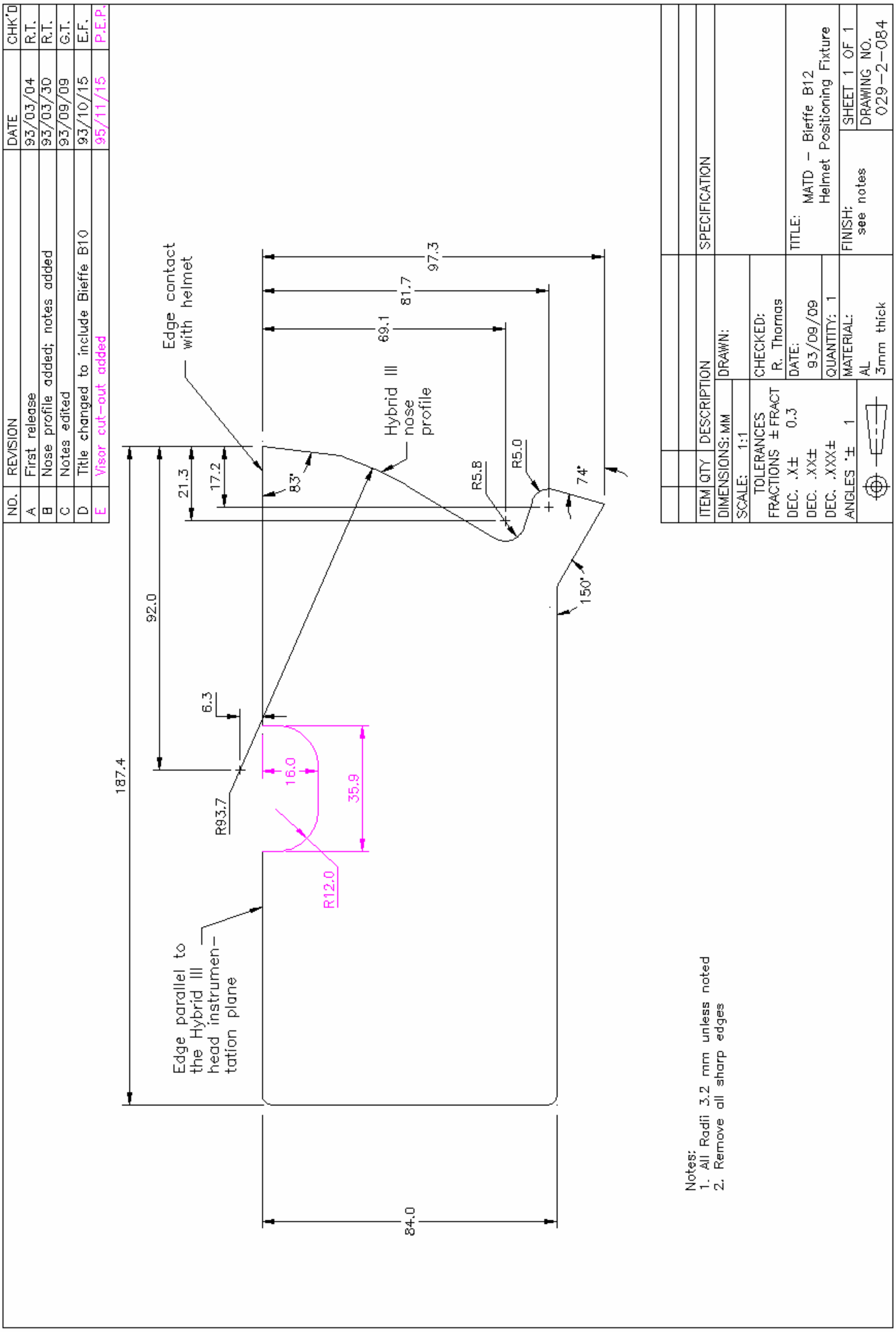


Figure D.1 — Template of the helmet alignment tool

Annex E
(informative)

Outline of additional general test and analysis procedures for inflatable/triggered protective devices

In addition to the impact configurations for full-scale test and for computer simulations of crash tests, defined in ISO 13232-2, evaluate the following additional conditions, based on tests or computer simulations, as indicated in the following.

NOTE 1 The following list is provided as a general outline only, and does not describe specific details of test procedures. They are provided with some level of detail because: less detail would be excessively vague, and would ignore factors that are understood to be important, based on past experience with car airbags and prototype motorcycle airbags; and more detail would be premature at the current stage of research. It is intended that in future revisions of ISO 13232 more specific procedures, or other procedures, would be added to those listed in this annex, based on on-going research.

NOTE 2 The following procedures are based on existing technology, for example, as adapted from the car airbag testing field, where they have been found to be necessary to verify basic safe operation of car airbags. They may not be suitable for all motorcycle types.

E.1 Impacts to OV's and OO's according to the impact configurations of ISO 13232-2, with other dummy sizes

— do by means of computer simulation.

— use Hybrid III dummy models with:

  — characteristics modified to reflect the 28 motorcyclist dummy modifications defined in ISO 13232-3,

  — with injury criteria scaled by dummy weight,

  — for:

    — 5th percentile adult female, if both feet are able to rest flat on the ground when dummy is seated,

    — 95th percentile adult male, if dummy is able to sit on motorcycle, with pelvis not over-hanging the rear of the seat, with the knees not contacting the fairing and in within gross vehicle weight rating.

— simulate impacts with all OV types and all OO types defined in ISO 13232-2.

— when doing injury risk/benefit analysis, weight the injury index results by the frequency of occurrence of each impact configuration, as listed in ISO 13232-2, Annex B.

NOTE The following types of procedures are intended to be analogous to procedures for car airbags as indicated in US/FMVSS 208, May 2000, and in various ISO car airbag test standards.

E.2 Out-of-position tests

E.2.1 Deployments of protective device if rider position sensing suppression system (RPSSS) is not present

— do with stationary deployment test.

— with maximum upper body forward lean, and:

  — with two other, equally spaced positions between "maximum upper body forward lean" and the normal seating position defined in ISO 13232-6.

E.2.1.1 With 50th percentile adult male MATD

— measure and analyze dummy injuries according to ISO 13232-4 and ISO 13232-5.

E.2.1.2 With 5th percentile adult female MATD

— do with computer simulation and evaluate injuries, as in F.1.

— first calibrate computer simulation for 50th percentile adult male MATD, according to ISO 13232-7.

— evaluate results with 5th percentile adult female dummy only if both feet of the 5th percentile adult female dummy are able to rest flat on the ground when dummy is seated.

E.2.2 Out-of-position sensing with RPSSS present

— use human volunteers.

— use sensor and suppression system only, with no ignitor, inflator or airbag.

— measure whether suppression signal occurs whenever rider leans into any portion of the "maximum airbag volume," as measured in the ISO 13232-2 full scale impact tests with normal dummy seating position.

E.2.2.1 With 50th percentile adult male volunteer

E.2.2.2 With 5th percentile adult female volunteer

— do only if both feet of volunteer are able to rest flat on the ground when volunteer is seated.

E.3 Low speed non-crash and crash deployments

— do with 50th percentile adult male MATD.

— full-scale moving motorcycle/stationary obstacle tests.

E.3.1 Barrier impacts, speed sweep

— rigid barrier.

— baseline motorcycle and motorcycle with protective device.

— series of impact tests at increasing speeds to evaluate non-deployment and deployment effects.

E.3.2 Ground impacts

— 50th percentile adult male MATD.

— normal seating position of ISO 13232-6.

E.3.2.1 Kerb impacts

- baseline motorcycle and motorcycle with protective device.
- series of 90 degree kerb or step encounters at increasing speeds and obstacle heights, until dummy hands separate from handlebars, or until 30 mi/h, whichever is lower.
- determine:
  - hand separation speed for baseline motorcycle.
  - speed for protective device deployment for motorcycle with protective device.

E.3.2.2 Dropped wheelie impact

- Motorcycle with protective device only.
- With motorcycle initially at 45 degrees nose-up pitch angle.
- Verify non-deployment of protective device.

E.4 Effect of pillion passenger

- By computer simulation only
- 50^{th} percentile adult male MATD rider.
- 50^{th} percentile adult male MATD passenger, if rear of pelvis does not over-hang rear of seat and if within motorcycle's gross vehicle weight rating, or else
- 5^{th} percentile adult female MATD, if rear of pelvis does not over-hang rear of seat and if within motorcycle's gross vehicle weight rating.
- Simulate all ISO 13232-2 impacts with OV's and OO's.
- Evaluate injuries of both rider and passenger.

E.5 Effect of helmet type

- full-scale stationary deployment test.
- 50^{th} percentile adult male MATD, maximum forward lean position as in F.2.
- five helmets with range of shapes and masses, and including open face and closed face.
- evaluate dummy injuries according to ISO 13232-5.

E.6 Extended risk/benefit analysis for inflatable/triggered protective devices

Extend and apply the injury risk/benefit methods of ISO 13232-5 to include intended use and foreseeable misuse of the motorcycle with and without protective device, as follows.

Consider the frequency of occurrence (FO) of each crash or non-crash event in the risk/benefit equations of ISO 13232-5 to be equal to n times the estimate of the probability of each event occurring during the usable life of the motorcycle (where n equals the total number of crash and non-crash events expected to occur during the usable life of all motorcycles of the same design), based on accident data of the frequency occurrence data in ISO 13232-2 and elsewhere, and other usage data (e.g., rider size and position, and over-the-road non-crash acceleration measurements), and including the probability of each of the various OV and OO impact configurations (e.g., from the frequency occurrence data in ISO 13232-2, Annex B) and non-crash events (p_i); the probability that the device is deployed in such an event (p_j); the probability of a given rider position (p_k); the probability of a given rider size (p_l); and the probability of a pillion passenger of a given size (p_m). In other words, set:

$$FO_{ijklm} = nx(p_i)\times(p_j)\times(p_k)\times(p_l)\times(p_m)$$

E.7 Future extensions to ISO 13232-4 measurement methods and ISO 13232-5 injury criteria for inflatable/triggered protective devices

Based on suitable physiological and biomechanical information and measurement technology, extend the ISO 13232-4 measurement methods and ISO 13232-5 injury criteria to monitor for the following types of injuries, and use such methods in the evaluation of the given protective device in the test and computer simulations defined in ISO 13232-2 and in F.1 to F.6 in this part of ISO 13232:

— arm/hand force or acceleration injuries,

— facial abrasions,

— chest and facial burns.

Annex F
(informative)

Rationale for ISO 13232-6

All references cited in Annex E are listed in Annex B of ISO 13232-1.

F.1 Specific portion of the Scope

"Paired comparison" testing is a widely used design for experiments, in which all variables are held constant except the variable of interest (in this case, the presence of a proposed protective device).

"Repeatability" and "reproducibility" refer to the procedures used in preparing and conducting an impact test, and not necessarily to the results, which are subject to experimental variability.

"Realistic" and "representative" refer to many of the detailed provisions in ISO 13232-6, for example, the use of impact configurations which represent frequent injuries or occurrence in real accident data, as described in ISO 13232-2; or, for example, to the means provided for positioning the dummy on the motorcycle (fingers around handgrips, seating posture, etc.).

Verification of "analytical evaluations" refers to the required use of full-scale impact data to validate the risk/benefit or failure mode and effects analyses described in ISO 13232-5 and ISO 13232-7, respectively.

F.2 Requirements (see 4)

F.2.1 Opposing vehicle (see 4.1)

This requirement provides two alternative opposing vehicle (OV) types, either of which is intended to represent "average" mass and height characteristics of 1998 to 2000 passenger cars in three market regions (EC, Japan, US).

One OV type, to be used in all tests intended for "international comparison", is a 4 door saloon model to be selected by the research organizations involved in the international comparison programme. A 4 door saloon model was specified because 4 door saloons were identified as the most frequent opposing vehicle in previous motorcycle accident research (Hurt, 1981). A single model of a 4 door saloon is necessary for "international comparison" purposes in order to eliminate many extraneous, secondary variables which may influence the results of tests done on the same motorcyclist protective device at different test facilities in different regions. This is a difficult goal to meet since, at the current time, there is no single passenger car that is structurally identical in all regions, due to differing crashworthiness regulations among the regions. As a consequence, a single model from one region is to be selected by the involved research organizations at the time of the international comparative research. Ideally this model would be one for which there were similar models in the other regions. Then, the involved research organizations could choose to import the selected model for test purposes; or to modify the locally available model to make it “structurally equivalent” to the selected model (e.g., by retrofitting doors and/or bumpers).

The other OV type, for any other research purpose, is any saloon model that has a kerb mass and an overall height lying within specified limits, which represent a range of vehicles about the sales-weighted average kerb mass and overall height of the 1998 to 2000 model year vehicles in the three regions.

In order to provide some level of comparability, the first OV type lies within the specified limits for the second OV type.

Data for approximately 350 saloon and other light passenger vehicle types from the EC, Japan and US markets, for the 1998 model year, were analyzed in order to identify the average, median and standard deviation of kerb mass and overall height in the three regions. The data (see Table F.1) indicate the following averages, standard deviations and medians of kerb masses and overall heights for the 350 vehicles:

Table F.1 — EC, Japan and US vehicle data

Region	By model			By sales		
	Average	Std. dev	Median	Average	Std. dev	Median
Height (cm)						
US	140	8	141	141	6	145
Japan	141	4	141	141	3	144
EC	143	3	143	143	3	146
Combined	141	7	141	142	5	145
Kerb mass (kg)						
US	1 443	232	1 439	1 414	207	1 674
Japan	1 335	238	1 300	1 284	202	1 460
EC	1 285	213	1 265	1 211	148	1 111
Combined	1 385	238	1 394	1 344	212	1 312

Note that median values may be of some interest in identifying height or mass of actual vehicles. However, median values are not so useful when considering the distribution of two independent variables (i.e., height and weight), and for this purpose, the average values are more useful, as they indicate the statistical centroid of the distribution.

F.2.1.1 Range selection criteria

In general, the standard deviation, or first statistical moment, can be a useful descriptor of the typical variability of a distribution. For a normal distribution, approximately two-thirds of the sample lies within ± 1 standard deviation of the average value.

For the OV height distribution in the three regions, the combined standard deviation of 5 cm is representative of the variability of this parameter within and among the regions, and indicates that there is a relatively tight range of overall heights about the average height[4]. A range of ± 5 cm seems reasonable from an inter-vehicle comparability viewpoint.

For kerb mass, the standard deviation is observed to be large (i.e., generally more than 200 kg). This reflects a large diversity in vehicle functions, load capacities and market segments. For test purposes, one would expect test results to vary considerably for a ± 200 kg or more variation in kerb mass. For this reason, it is suggested that a smaller range be used. A range of half the combined standard deviation of 212 kg (i.e., ± 106 kg, or ± 7%) is considered to be a practical range, which provides a sufficient variety of candidate vehicles in the regions, with hopefully not excessive effects on the test results.

Therefore, the ranges of height and kerb mass are:

1 238 kg to 1 450 kg (i.e., 1 344 kg ± 106 kg)

137 cm to 147 cm (i.e., 142 cm ± 5 cm)

4) Note that it has been predicted by vehicle designers that the average overall height of light passenger vehicles will increase by about 5 cm in the next five years, due to worldwide changes in styling preferences. This will probably shift the average value and also increase the standard deviation of the overall height, worldwide, over the next decade.

If the foregoing ranges are used, then examination of the data for the 350 vehicles in the combined spreadsheet for the three regions indicates a substantial number (i.e., a total of about 100 models) of vehicles are available in the three regions.

In addition, each model year after 2000 should add additional models in each of the three regions that lie within this range.

The test mass for each selected OV is taken to be 80 kg greater than its kerb mass, in order to allow for added test equipment, as was specified in the 1996 version of the Standard.

The test heights are set at the reference point heights for the first OV in a given series of tests, after the vehicle has been levelled.

A four-door saloon model is specified, as these have B post structures, which a substantial fraction of the real vehicle population has, and which needs to be taken into account in MC rider protective device research. If coupes, convertibles and other vehicles without B pillars were used as a standard for research, it would tend to lead to misleading results, based on past test and accident investigation experience, which indicates that B pillar contact is important in MC accidents.

F.2.1.2 Attempt to select a single international comparison vehicle

An attempt was made to select a single make and model of vehicle from among the 350 candidate OV's from the 1998 to 2000 model years, for purposes of international comparison testing. This attempt, which was unsuccessful, and the related selection criteria are described herein in order to illustrate the difficulties of such selection, for the information of future users of this Standard.

With regard to the 350 candidate OV models, the following criteria for selection of one "international comparison vehicle" were defined:

1) A model that is close to the sales averaged values for kerb mass and overall height, identified in the foregoing table;

2) A model that is sold under the same make and model name in all three regions;[5)]

3) A model for which the kerb mass and overall height in all three regions is as uniform as possible;[6)]

4) A model which has relatively high sales (e.g., more than 200 000 vehicles per year) in each of the three regions, in order to provide sufficient availability in future years.

Application of only Criterion 2 to the 350 vehicles resulted in the following five models that are sold under the same name in the three regions:

— Toyota Corolla

— Toyota Camry

— Subaru Impreza

— Subaru Legacy

— Honda Accord

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5) Otherwise, it would be very difficult and complex to identify vehicles that have "similar designs" in all three regions, except by detailed interviews of knowledgeable persons among each car manufacturer's staff.

6) Some vehicles that are sold under the same model name in all three regions have very different kerb mass and height in the three regions (e.g., Honda Accord), or completely different body style (e.g., the 1998 Toyota Corolla is a "hatchback" or three door vehicle in Europe and a saloon in the US and Japan).

Application of Criterion 3 eliminated the Subaru Legacy and the Honda Accord, as the US models have much greater kerb mass than the Japan and EC models.

Application of Criterion 1 eliminated the Toyota Corolla, as it has much smaller kerb mass than the average value indicated above.

Application of Criterion 4 eliminated the remaining vehicles, the Toyota Camry and Subaru Impreza, which had sales of less than 25 000 vehicles per year in the Japan and EC markets.

However, for a given international comparison programme and a given time period, it may be possible in the future for the involved research organizations to select one make, model and version of OV, by relaxing one or more of these criteria.

F.2.2 Dummy and instrumentation (see 4.3)

F.2.2.1 Motorcyclist anthropometric impact dummy (see 4.3.1)

Calibration tests of the type applicable to the Hybrid III dummy are needed in order to verify that the head, neck, thorax, and knee components have not been mechanically degraded due to test usage, in order to maximize repeatability, reproducibility, and biofidelic response between tests and test facilities. The head, neck, thorax, and knee impact calibration tests are the applicable ones.

The number of full-scale tests between calibrations has been selected to be ten, which is a compromise between test quality control and test efficiency and cost. In particular, it is desirable to perform several full-scale tests during one test day, and this tends to preclude calibration tests with the same dummy. Based on experience and in general, the amount of physical degradation to the helmeted head, neck, mid-sternum region, and knee tends to be limited, over a series of ten or so tests (although damage to other dummy regions may be severe). Reporting of the calibration information is considered to be desirable from a quality control standpoint.

F.2.2.2 Sensor, data acquisition, and post processing systems verification (see 4.3.3)

Some means for verifying the proper functioning and scaling of the required dummy sensors and data acquisition system, prior to each test, is highly desirable. Past motorcycle impact tests have involved situations where, apparently: sensors have been noisy or broken; improper filtering has occurred; and improper scaling of sensor signals has occurred, in some cases, by an order of magnitude. These errors, in some cases, have affected the published data and conclusions which are based upon those data.

F.2.2.3 Joint tensions (see 4.3.4)

Dummy joint tensions, if not set to be within certain bounds, can tend to have an adverse effect on: the stability of the dummy on the free rolling motorcycle (MC) as it is subjected to shocks from the roadway and trolley release systems; and motions of the dummy limbs and body regions after impact.

F.2.2.4 Clothing (see 4.3.5)

It is desirable to provide clothing which provides some degree of protection to the exterior dummy surfaces, which can enhance the visibility of the dummy body regions, and which is sufficiently form fitting to enable mounting of adhesive photographic targets. Long sleeved, close fitting thermal knit underwear provides these functions. Some holes need to be cut in the clothing to allow access to dummy joint adjustments and position measurements.

It is desirable to fit the dummy with boots which provide: some protection of the dummy outer surfaces in order to enhance dummy durability; realistic motorcycle foot apparel; foot apparel which will tend to stay on the dummy during violent impact motions; a boot heel which will tend to stabilize the foot and lower leg on the motorcycle foot peg; and a standardized, relatively light weight (racing type) mass insofar that this may affect lower leg motions and forces. The specification of a relatively light weight also tends to preclude use of boots which may mechanically reinforce the lower leg region, thereby distorting leg injury assessment. Within a paired comparison the same make, model, and size boot is required so as to eliminate differences which may result from boot geometry, stiffness, strength, or fit.

F.2.2.5 Position on motorcycle (see 4.3.6)

A standardized dummy position is necessary as this may greatly affect the dummy motion and injuries after impact.

F.2.2.6 Helmet (see 4.3.7)

The Bieffe B12R helmet is a widely available full face motorcycle helmet. It is manufactured to very narrow performance specifications. When it is impacted at ambient conditions according to the procedures described in ECE Regulation 22-03, at a position 275 mm ± 50 mm above the brow, centred on the mid-sagittal plane, upon a flat steel surface, the test head form maximum resultant acceleration falls between 170 g and 190 g. It is injection moulded with polycarbonate. The liner is produced from expanded polystyrene bead foam with a density of 53 g/dm^3 to 57 g/dm^3.

A full face motorcycle helmet is used for two reasons. Firstly, this style of helmet represents approximately 85% of those manufactured worldwide. Secondly, the provision of protective coverage to the mouth and chin region of the Hybrid III head form eliminates concern that this part of the head form is not particularly biofidelic. The distributed loading to the dummy face that is induced by the helmet minimizes inappropriate contact phenomena.

The stipulation of the helmet according to ECE Regulation 22-03 insures that it will be generally available in the future. At the time of the drafting of this standard, ECE Regulation 22-03 was the most widely accepted international regulation for motorcycle helmets.

Both upper and lower performance requirements for the helmet are needed because, typically, commercial helmet quality control standards involve only upper tolerances. In this sense, the helmet required for ISO 13232 is a specialized test helmet having both upper and lower performance tolerances.

The helmet size is specified as that which fits a 57 cm head form in order to be compatible with the Hybrid III head form; and to ensure a proper fit, which affects the dynamic measurements made in a full-scale test.

A size small and a size medium Bieffe model B12R motorcycle helmet were both fitted to a Hybrid III using a helmet alignment tool as shown in Annex D. The small helmet is designed to fit on heads with circumferences of 56 cm and the medium helmet is designed to fit on heads with circumferences of 58 cm. Both helmets fit on the Hybrid III head form. The EC small helmet, however, fit more securely than the medium helmet.

The mass of the small helmet was 1,387 kg (a second small helmet was 1,388 kg). The mass of the medium helmet was 1,417 kg.

The helmet is specified as new because the helmet liner will tend to be damaged in an impact test, changing and degrading its dynamic properties.

The same make, model, and specification helmet is required for all tests to control the amount of variation in the dynamic measurements due to this variable.

F.2.3 Photographic equipment (see 4.4)

Photographic targets are needed on the dummy, MC, OV, and ground to enable high speed film digitization related to verifying proper impact configuration, and as a reference for dummy shifting and motions.

F.2.4 Pre-test measurement (see 4.5.1)

The pre-test measurements are mainly related to recording the camera position relative to the filmed objects in order to enable depth correction. Other measurements are related to determining the known distances and dimensions for initial vehicle speed and contact point determination.

F.2.5 Post-test measurement (see 4.5.2)

This refers to measurements derived from the pre-test and pre-impact images, which should be analyzed in a timely way in order to determine whether the impact conditions fell within specified tolerances.

Large differences (> ± 3 cm) in the dummy position on the motorcycle between pre-test and prior to first MC/OV contact affects the outcome of the full-scale test. Tests in which the dummy position changes more than ± 3 cm at the measured location are considered to be different from those which are set up.

F.2.6 Vehicle speed control (see 4.5.3)

"Free wheeling at the time of impact" is desirable in order to improve speed control and repeatability of impact conditions. If either vehicle is decelerating or accelerating at the time of impact, it would be very difficult to predict and to reproduce precisely the impact speeds of the vehicles.

It is desirable to apply "braking" to the OV after the impact, whether it is stationary or moving, in order to provide for the safety of the test personnel and equipment (e.g., high speed cameras); and to provide realism, in the sense that in real accidents the OV will probably undergo severe braking at or just after the time of the impact. Dummy and MC motions during the later phases of an accident (e.g., 0,500 s after first contact) can be influenced by whether the OV is continuing at nearly constant speed (which would seem to be unrealistic) or undergoing braking.

The parking brake is fully applied during impact tests with the stationary OV for simplicity and realism. In real accidents in which a MC strikes a stationary OV it seems likely that the latter could have been parked or delayed by traffic conditions. In such cases, either the parking brake or service brake would have been applied. The parking brake is first adjusted to the manufacturer's specifications in order to reduce variability between tests and test facilities.

"Braking equivalent to a brake pedal force of at least 400 N" is specified so that all facilities will use similar braking levels, corresponding to limit OV braking, and approximately to 5th percentile male foot pedal strength (U.S. DOT FMVSS 105, 1991a; Mortimer, et al., 1970), which may be representative of an emergency situation. "At least" is appropriate because 400 N is at or above the limit condition for most OVs, so that more brake pedal force will not result in more deceleration (because of wheel locking), and therefore, the result will be fairly repeatable. "Equivalent to a brake pedal force" means that many facilities will choose to apply the brakes with an "air-over-hydraulic" actuator, using a predetermined level of air pressure. This is one of the simplest methods of applying a constant brake force, and it does not require the use of complex sensing, instrumentation, and control systems in the OV. This method would typically involve a pre-test set up as follows: 1) apply 400 N pedal force; 2) measure the brake line pressure corresponding to the 400 N pedal effort; 3) install an air-over-hydraulic actuator which will produce a brake line pressure at least as high as that measured in 2); and 4) for moving OV tests, provide a triggering device which actuates the brakes between 0,5 s and 1,0 s after the first MC/OV contact.

In addition to maintaining test safety, another reason for applying brakes to a stationary OV is that the level of braking (or not braking at all) can affect the energy absorbed and the motions of the vehicles and the dummy, especially for impacts to the front or rear of a stationary OV.

A brake application time of 0,5 s to 1,0 s was selected: to represent typical driver reaction times, for example, if the driver did not see the MC and was responding to the impact itself; to be after and separated in time from the primary impact event; to be early enough to minimize hazard to test personnel and ground based equipment; and to be consistent with past practice at various facilities.

F.2.7 Required relative tolerances (see 4.5.4.1)

Differences in the relative heading angle, OV impact speed, MC impact speed, MC roll angle, and OV contact point affect the outcome of the full-scale impact tests. The requirement here is to ensure that all tests within a paired comparison have similar values for these variables within levels achievable with existing technology. Tests which fall outside the required relative tolerances are not considered to be "fair" comparisons.

F.2.8 Recommended OV contact point relative tolerances for other impact configurations (see 4.5.4.2)

The other 193 permissible impact configurations defined in ISO 13232-2 each need relative tolerance specifications, in order to define the conditions for a paired comparison. For relative heading angle, OV and MC impact speeds, MC roll angle, and dummy position, the same tolerances are used as for the seven baseline impact configurations. For OV contact point tolerance, the achievable (and therefore required) tolerance is a function of where the OV is struck and the relative heading angle (i.e., whether the MC is moving across or parallel to the path of the OV, and at what rate); and whether one of the vehicles is stationary (in which case, a tighter tolerance is achievable). The values in Table 2 are based on the values used in the seven baseline configurations, and are based on similar considerations. The tolerance for angled OV side impacts is greater than that for perpendicular or side impacts, because of the greater effect of uncertainty in the MC lateral path. The tolerance for moving/moving front, rear or corner impacts is twice that for moving/stationary impacts, and that for OV corner impacts is very tight, because of the very large effect of small contact point variations in these cases (i.e., hit or miss). The tolerance for moving/moving side impacts is three times that for moving/stationary impacts, to account for the "moving target" effects.

For both relative and absolute tolerances, for the other 193 configurations, the tolerances are "recommended" rather than "required", because, in general, relatively less test experience exists, worldwide, for most of these other cases.

F.2.9 Required absolute tolerances (see 4.5.4.3)

The recommendations for absolute tolerances are given in order to indicate how close to the target condition any test in a pair or group of tests should be; and to draw attention to this variable in the test report. For example, even if both tests in a paired comparison were within the required relative tolerances, the pair of tests could deviate to the left or to the right of the target impact point. This could lead to differences in results among different test facilities for the same nominal impact configuration.

F.2.10 Number of tests (see 4.5.4.4)

Multiple runs may be performed for a given modified MC and the results used to form an average, provided that the same number of runs are performed for the baseline MC being compared. The same number of tests is required for each average, to enable the averages to have the same statistical degrees of freedom.

F.2.11 Ambient conditions (see 4.5.5)

The dynamic response of the Hybrid III dummy is known to be temperature dependent, and as a result, very tight tolerances (21,4° C ± 0,8° C) have been placed on its use in car regulatory testing (U.S. DOT, 1991b). In general, it is also desirable to control temperature in motorcycle testing. However, for motorcycles, there are a number of factors which make very tight control less important and/or more difficult to achieve. These include:

- the research nature of ISO 13232;
- the prevalence of large scale, outdoor test facilities for motorcycle/car, moving/moving, angled impact tests;
- the desirability of all-season testing;
- the exposed position of the rider (in contrast to a car), which makes temperature control more difficult;
- the wide variations in climate and seasonal variations, internationally (e.g., motorcycle impact tests often occur in the range of 0° C to 45° C in various facilities in North America);
- the wide variety of facilities used for dummy storage and preparation before a test (heated or air conditioned tents, bags, sheds and buildings; blowers; and various areas for dummy assembly, calibration, joint adjustment, verification tests, etc.);
- the likelihood of test delays, where the dummy may be on the motorcycle, in an exposed area, waiting an unpredictable amount of time, for test readiness;
- the lower relative importance and magnitude of chest injuries and deflections (which is the most temperature sensitive factor in the Hybrid III dummy) in motorcycles as compared to cars;
- the limited time window generally available for testing at a given facility;

— the need for a simple procedure.

As a result, there are two main aspects of the temperature requirements for motorcycle testing:

— definition of an allowable temperature range;

— temperature soaking procedures, to keep the internal dummy temperature in the allowable range at the time of impact.

The tight temperature tolerance required in car testing with the Hybrid III is related to chest response properties; however, it is unknown at this time what the specific response error tolerance was which corresponds to the ± 0,8° C band selected by NHTSA (e.g., it might have been ± ½% on chest acceleration, which is not so relevant for motorcycle testing). In view of all of the above factors, a somewhat wider error tolerance for temperature is acceptable for a motorcycle research standard.

While data on the thermal response sensitivity of the Hybrid III was not obtained, data for the Hybrid II (Part 572), presented by Volkswagen (Seiffert and Leyer, 1976) may be representative, since the two dummies share many of the same components. Table F.2 summarizes the response sensitivity to temperature changes based on the Part 572 data. The temperature tolerance band corresponding to a ± 5% response error (selected as a target for motorcycle tests) is also shown. The tightest temperature bands (i.e., highest thermal sensitivity) are for the head form drop test, the abdominal insert, and the thorax. So, if a ± 5% error tolerance was desired for these variables, relatively tight temperature tolerances would be needed. However, it is suggested that these variables should not be the determining factors for motorcycle tests, because:

— the motorcyclist headform is helmeted, and does not strike rigid surfaces;

— thoracic and abdominal injuries are relatively infrequent in motorcycle accidents, and the typical deflections in motorcycle impact tests are very small (e.g., 10 mm, where 3% of 10 mm is only 0,3 mm, which is negligible).

Instead, the next tightest temperature band is for ± 5% HIC error, which corresponds to ± 8° C. That is for a whole dummy test, and for a response variable which is included in ISO 13232. This is proposed as the error criteria, given as:

range = 21,4° C ± 8° C = 13,4° C to 29,4° C

which has been rounded off in the text, for convenience of use.

It is conceivable that wind velocity can affect the motion of the dummy and, in particular, of inflatable air bag protective devices, and therefore, this is specified.

Table F.2 — Hybrid III dummy response sensitivity to temperature changes, based on Seiffert and Leyer, 1976

Response variable	Test	Response sensitivity to temperature change %/°C	Temperature band corresponding to ± 5% change in response sensitivity °C
Peak head acceleration	Head form drop	1,5	± 3
Peak head acceleration	Neck pendulum	0,5	± 10
Lumbar stiffness	Static bending	negligible	-
Abdominal insert	Static compression	2,7	± 2
Thorax	Pendulum impact	1,5	± 3
HIC	Whole dummy sled test, with restraint	0,6	± 8
Peak head acceleration	Whole dummy sled test, with restraint	0,3	± 17

F.3 Impact test methods

F.3.1 Impact conditions (see 5.1)

It is envisaged that the required impact configurations defined in ISO 13232-2 would be tested first. Then, the "permissible" impact configurations from failure mode and effects analysis could be tested, in order to verify and hopefully eventually eliminate such failure modes.

F.3.2 Opposing vehicle (see 5.2.1)

The OV ride height is specified because considerable variations in this may otherwise occur which could lead to differences in impact motions and forces of the MC and dummy and resulting dummy injuries. Adjustment means have been selected which will tend to have minimal effects on OV motion. The reference points have been selected for convenience of measurement. The measured heights for the first OV used in a given test series are to be used subsequently as standard values for all other OV's in the test series.

F.3.3 Motorcycle (see 5.2.2)

The fuel is removed from the vehicle in order to standardize the weight and to reduce the risk of damage to test apparatus and electronic equipment in the period after the impact test. The rear wheel is adjusted to the most forward position in order to standardize the reference point for the measurement of the dummy position. The chain or belt is removed in order to eliminate the possibility of entanglement when the rear wheel is in its most forward position. The MC steering system needs to be free to steer after release from the guidance system in order to allow for self stabilization of the MC, and improved accuracy of the impact point. Attachment of the dummy's hands is such that some steering compliance is maintained for self stabilization in the period prior to impact. The MC centre line targets are aligned to be vertical because it is desired to impact the OV in a vertical attitude with no leaning or turning, as a standard condition; and because leaning or turning can affect dummy motion. The MC length is measured after being rolled across a bump because many motorcycles have suspension systems which operate such that the overall length of the MC varies according to the load applied. The procedure which is used is intended to disturb the suspension of the laden MC so that it will settle to a correct position with consequent appropriate measurement of length.

F.3.4 Sensor, data acquisition, and post processing systems verification (see 5.3.1)

Prior to each test, a standard impact to the head can be used to generate response "signatures" for the nine head sensors. These signatures are to be included in the test documentation and, by comparison with signatures from previous verification tests, provide a means for verifying, approximately and retrospectively, the proper functioning of the entire data acquisition system (including sensors, gains, filtering, dummy response, recording, playback, scaling, and plotting). Such a procedure may also be of use at the time of the test set up, in order to detect hardware or procedural defects, and to enable appropriate countermeasures to be taken.

The defined impactor in Table 4 is intended to be one which is relatively simple to construct and use.

F.3.5 Mount on motorcycle (see 5.3.5)

The heights of the centre of the headlamp and taillamp lenses are measured and adjusted in order to ensure that within any paired comparison the ride height and pitch attitude of the motorcycle is the same within a tolerance of ± 1 cm. Just as with the OV, differing MC ride heights can influence the dummy motions and body part impacts with various vehicle structures.

F.3.6 Film analysis targeting (see 5.3.6)

Targets are placed at the dummy joints to facilitate dummy position verification during data analysis.

F.3.7 Stationary MC support (see 5.4)

Regarding the 143 configuration with 0 m/s MC speed, it is necessary to define a procedure to set the MC and the dummy in a stable but unrestraining position before the impact of the OV.

F.3.8 Camera set up (see 5.5)

Lens distortion correction is required if the lens focal lengths are shorter than those specified in order to preclude "fish eye" distortion of the data.

F.3.9 Temperature soaking (see 5.7)

The procedure is based on the principles described by U.S. DOT (1991b). This describes temperature variations with time, and the thermal time constants of various parts of the Hybrid III dummy. The temperature variations described by NHTSA correspond to:

$$T = T_1 + (T_2 - T_1)\left(1 - e^{\frac{-t}{\tau}}\right)$$

where T_1 and T_2 are the initial and final ambient temperatures. The general requirement expressed by NHTSA is that, starting at a certain soak temperature (T_1), and exposing the dummy to an ambient temperature (T_2) which is outside the ± 0,8° C tolerance band, the temperature (T) will stay within the tolerance band for a certain time (t), which is dependent on the thermal time constant (τ).

The thorax thermal time constant was selected by NHTSA as being most critical, and is also chosen here because it is representative of the group of dummy component time constants.

If all the dummy preparation areas are in the allowable range (13° C to 30° C), then no additional soaking is needed. However, if one or more of the dummy preparation areas (which in some cases are heated or air conditioned tents) is outside the allowable temperature range, a soaking procedure must be used, the soaking time of which is based on the above equation, and is intended to ensure that the thorax temperature remains within the allowable temperature range at the time of impact.

These temperature provisions are intended to provide a practical solution, given the extremely wide range of weather, climate, facilities and practices encountered.

Another possibility which was considered but not included was requiring an even tighter temperature range (e.g., ± 2° C) for all tests within a paired comparison. The difficulty encountered here is the variation among test facilities in the number of preparation areas; and how to account for a different soak time and temperature in each of these areas.

F.4 Annex A (normative) Procedure to set dummy joint tensions

F.4.1 New component preparation and dummy assembly (see A.1)

Any new dummy components are required to be fitted using the procedures of SAE Engineering aide 23 (SAE, 1986b). In addition, the ball of the hip and ankle joints, since they are not high precision parts, may need to be lapped, in order to preclude "binding" of the joints and to allow the joint tensions at those locations to be properly set. This is important, in view of the possibility that the hip joint, in particular, may influence the motion of the dummy during the impact test.

F.4.2 Procedure (see A.3)

In general, the dummy joint tensions are standardized in order to: provide for the stability of the dummy on the MC, during its release from the trolley, and run up to impact; and to standardize the influence of joint tension on dummy motion during the impact phase.

When used in car impact tests, the Hybrid III dummy requires setting the joint tensions at 1 g (SAE, 1986b). However, there are a number of differences between car impact tests and motorcycle impact tests, including:

— in car tests the dummy torso is supported by the seat back and the legs by a relatively wide seat cushion, whereas in motorcycle tests there are no such supports;

— in car tests the vehicle mass is relatively large so that transients due to road disturbances or towing cable release are relatively small, compared to what may occur with a motorcycle;

— for car tests the vehicle pitch and roll motions are inherently small, whereas for motorcycle tests there may be pitch and roll angle transients prior to impact;

— for motorcycle tests the arms of the dummy partly support the upper torso and the attachment of the hands on the handlebars provides the basis for this support. In this regard, the arms and hands are much more critical.

In addition, one problem with the SAE joint tension specification is that it provides no tolerances. Another problem is the fact that the designs of many of the Hybrid III joints are relatively crude. Also, it is obvious that if the joint is set at any value less than 1,0 g the joint will not support the adjacent body part weight and the body part will rotate even if the dummy is at rest. Under running conditions it is also obvious that even a joint set at something slightly more than 1,0 g will tend to rotate, due to the effect of vibration and transients. The question then becomes "how high should the joint tension be, in order to avoid rotation due to vibration and transients and yet not unduly affect dummy motion?" To investigate this question a multi rigid body three dimension simulation was performed using the articulated total body formulation (Obergefell, et al., 1988) using the U.S. Air Force Hybrid III dummy parameter set (Kaleps, et al., 1988). The simulation was of a dummy mounted on a medium conventional motorcycle running at 48 km/h into the mid-side of a stationary car. Several runs were made where the only variable from run to run was the amount of Coulomb friction moment (joint tension) in each of the movable joints in the dummy. Initially, all of the joints were set to 1 g Coulomb moment (i.e., the moment being set equal to the weight of the adjoining body part times the distance from the joint to the centre of gravity of the adjoining body part). The output was the motion time history of the dummy following impact up to the time of helmet to car roof impact. The output index was selected to be the maximum resultant head acceleration as being one of the more sensitive injury related variables in this impact configuration. Next, the impact was rerun with all dummy joint tensions reset to 0,5 g; and then subsequently to 2 g, 3 g, . . . 6 g. The results are shown in Figure F.1.

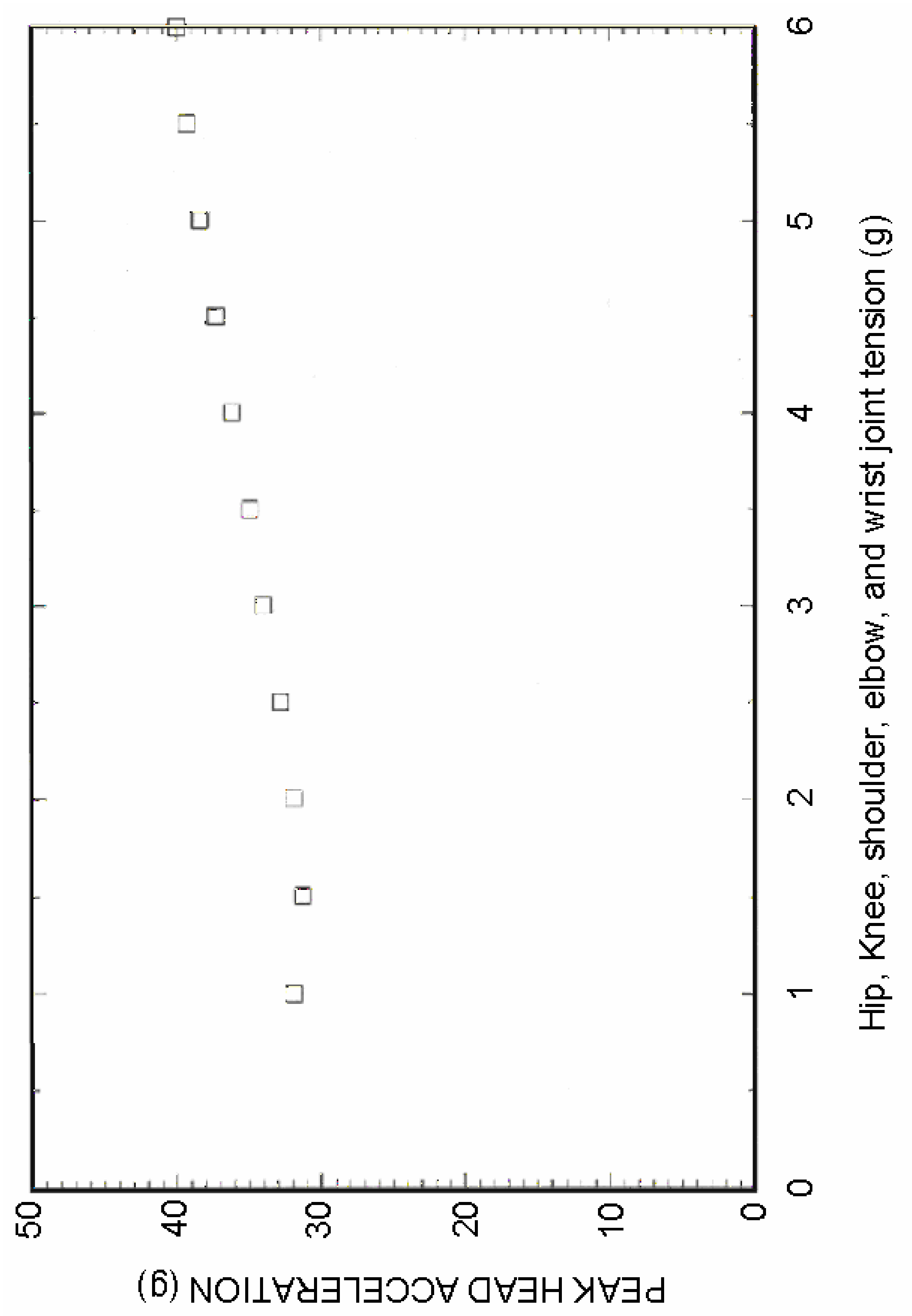

Figure F.1 — Effect of joint tension on maximum head acceleration in car side 90° impact

Results of the simulation show the maximum resultant head acceleration remains relatively constant when the joint tensions are between 1 g and 2 g.

Based upon these results and in consideration of the coarseness of the Hybrid III dummy friction joints, a minimum value of 1 g and a maximum value of 2 g were suggested as tolerance values for motorcycle dummy set up; or, in order words, the requirement that, statically, each joint would not move under the weight of the adjacent body part, but would move under twice the weight.

Subsequent experience indicated that it would be difficult to use a narrower tolerance than the above, in view of the coarseness of the Hybrid III friction joints.

Subsequent full-scale testing indicated that the 1 g to 2 g tolerance was workable, except that, in some cases, the dummy torso could become unstable in roll angle. That is, in the run up before impact, the upper torso could lean to the left or right. Subsequently, it was proposed that this be overcome by increasing the tolerance levels for the elbow joint to 3 g to 4 g and wrist to 5 g to 6 g levels of joint tension.

These tension levels were then confirmed in testing. Two tests on a H_yG_e sled were done with a test device based on a BMW K 100 RT. A Hybrid III 50th percentile male dummy with sit/stand construction was used. The standard hands were replaced with the Itoh-Seiki Co. part number 065-322048. The dummy was positioned following the procedures described in 5.3.4 and 5.3.5. The first test was conducted with arm joint tensions set between 1 g and 2 g. The second was with arm joint tensions set to conform to Table A.2.

Film analysis targets were placed on the dummy at the shoulder, elbow, and hand. These targets and the helmet centroid were analyzed following the procedures described in ISO 13232-4.

The results, given in Figure F.2, showed that there was no difference in the trajectories of the head and shoulder, and only a small change in the trajectories of the elbow and hand.

F.4.5 Other sled tests, performed at TRL, further demonstrated that the higher tensions at the elbow and wrist joints have little or no effect on dummy trajectory. The results of those tests are presented in ISO 13232-4, Figures D.15a through D.15d.

Table E.4 lists the dummy limb weights and moment arm distances used for the joint tension calculations. This includes the weight for the hanger and for the clamp as included in the joint tension procedure. As can be seen, in some cases, the total mass or the mass of the ballast has been rounded for convenience of specification.

F.4.6 Note that a joint setting of 4 g corresponds to holding a weight of 6,3 kg in the hand with the elbow supported. Such a load lies within the muscular strength capabilities of the young male rider population and may correspond to muscular tension occurring prior to impact. In any case, it is suggested that such load levels help ensure stability of the torso in the run up to impact.

The steps used to adjust the joint tensions roughly follow those specified in SAE Engineering aide 23 (SAE, 1986b).

The arm and leg joint "initial adjustments" are necessary in order to align the various joints (which may be 1, 2, or 3 axes) to be parallel or perpendicular to gravity, in order to enable the joint tensions to be set properly.

F.5 Annex B (normative) Procedure for dummy pre-mount preparation

This procedure is necessary in order to position the dummy limbs in a repeatable and appropriate way prior to mounting the dummy on the motorcycle. The goal is to position the limbs in such a way as to require only minimal adjustment after the dummy is mounted on the MC.

Without this procedure, the mounting of the dummy on the MC tends to be highly subjective, unwieldy, and non-repeatable.

The elbows are positioned such that the elbows will move outward if the dummy torso pitches forward in an impact. A slightly more realistic orientation would cause the elbows to move outward and downward during torso forward pitch, but this would require additional alignment procedures and has been neglected in the interest of simplicity.

Also, the elbow is flexed ("pivoted") 10° with respect to the upper arm. This is because the Hybrid III arm fully extends to an over centre position, such that upon compression the arm will not bend in flexion. The 10° alignment counteracts this tendency and provides a more realistic response.

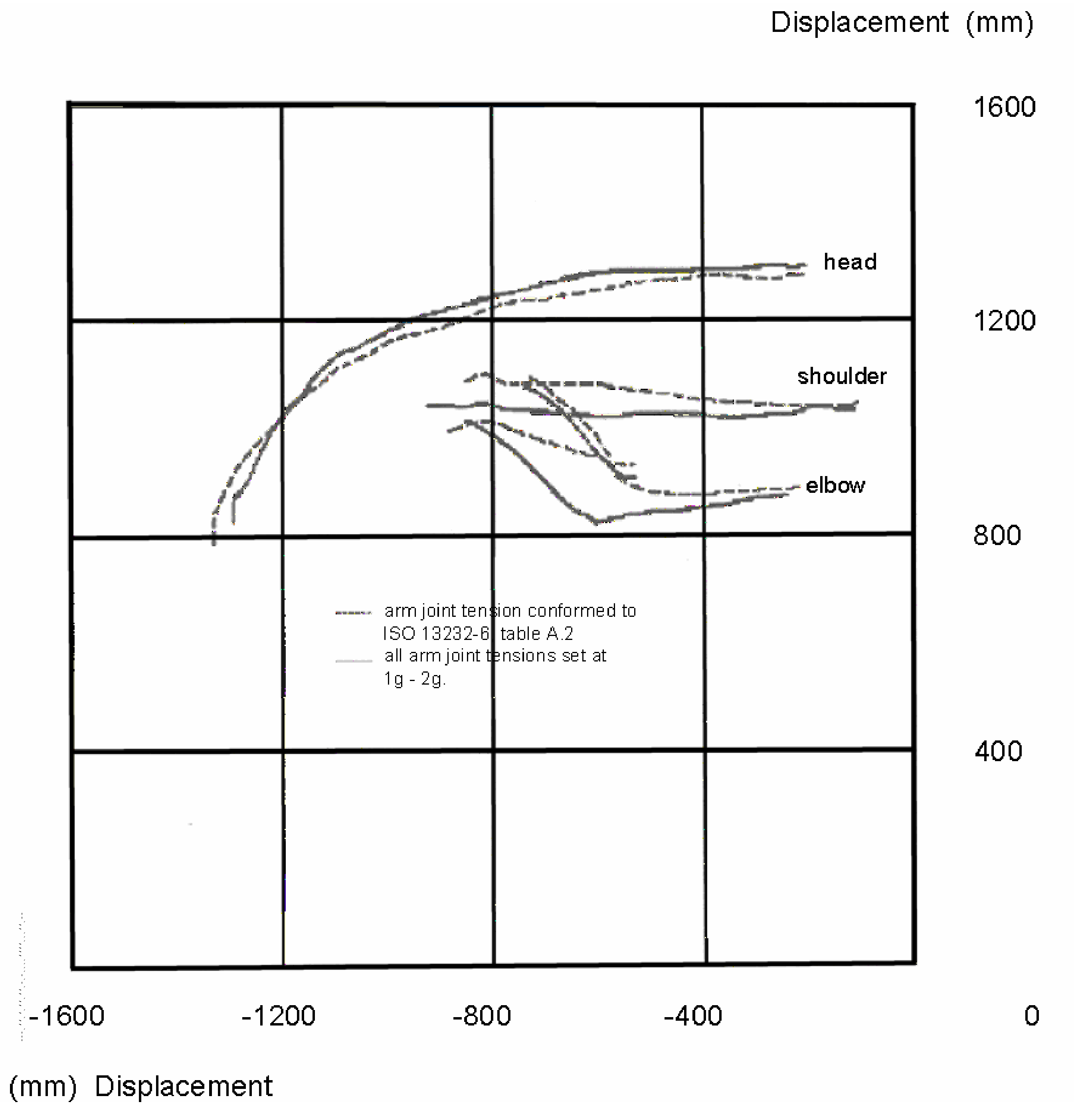

Figure F.2 — HyGe sled test results comparing arm joint tension effects on trajectory

Table F.3 — Dummy limb weights, distances used for joint tension calculations

( ) denotes rounded value

Object	Mass kg	Distance between pivot/point mm		Total mass for 2 g (hanger + ballast + clamp) kg	Mass of ballast kg	Total mass/ballast for 3 g kg	Total mass/ballast for 4 g kg
Hanger	1,200	-	-	-	-	-	-
Clamp	0,170	-	-	-	-	-	-
		Knee/cg	260	-	-	-	-
Lower leg plus foot	5,290	Knee/foot-leg crease	406	3,39	2,19 (2,2)	-	-
		Ankle/cg	32	-	-	-	-
Foot	1,355	Ankle/edge of foot	36	1,200	0,0	-	-
Whole leg		Hip/cg	375	-	-	-	-
	15,050	Hip/set screw above knee	362	15,6	14,4	-	-
		Wrist/cg	67	-	-	-	-
Hand	0,544	Wrist/screw head	30	1,215 (1,200)	(0,0)	-	-
		Elbow/cg	159	-	-	-	-
		Elbow/head of wrist rotation bolt	191	1,774	0,404 (0,400)	3,55/2,18	5,32/3,95
Lower arm plus hand	2,131	Elbow/head of wrist pivot bolt	248	1,366	-0,004 (0,400)	-	-
		Shoulder pivot/cg	273	-	-	-	-
		Shoulder pivot/ elbow rotation bolt	169	7,19	5,99 (6,0)	-	-
Whole arm	4,346	Shoulder pivot wrist/pivot bolt	514	2,308	1,108 (1,1)	-	-

F.6 Annex C (normative) Procedure for positioning the dummy on the motorcycle

For the MC, the handlebar position is generally adjustable and plays an important roll in determining the upper torso lean angle. Therefore, the handlebar should be set to a baseline position which should be the same for all tests within a paired comparison.

In general, the lateral alignment of the dummy is controlled by the positioning of the pelvis centre line relative to the seat centre line; and the fore/aft positioning is controlled by the position of the dummy K (knee) index in relation to the MC K point, if the K point has been previously determined; or in order to determine the K point, by setting the forward lean angle of the torso, with arms extended to the handlebar.

In general, the positioning of the feet on the foot rests has been specified so that the foot is in a natural position and is aligned with the surfaces of the foot rest and motorcycle, and to avoid catching the foot underneath a control pedal.

The knee adjustment takes into account both motorcycles with structures or fuel tanks between the knees and those with a step through layout (e.g., scooter), and provides for a natural riding position.

The hands are placed around the hand grips in a natural and realistic position. The metallic wires within the fingers providing the gripping force. Minimal adjustments to the shoulder and wrist joints are used in engaging the hand on the hand grip. These adjustments are performed in a specified order of preference beginning with the shoulder rotation joint, with the least desirable adjustment being to the handlebar itself.

The pelvis and torso are then positioned to align with the K and S points of the MC if these have been previously determined; or such that the upper torso forward lean is 10° if the K and S points are unknown. 10° represents a natural, realistic riding position for many motorcycles and provides for some minimal compression pre-load in the arms (for stability). Exceptions to the torso lean angle are defined, as may be affected by motorcycle design.

The reference point for the K and S points (vertically below the rear axle at ground level along the motorcycle centre line) was selected for universality among all motorcycle types.

The MC roll balance procedure is specified because there are many models of motorcycle which would have substantial lean after exiting the support fixture if the dummy position was determined purely by geometry rather than centre of gravity. In some cases the motorcycle centre of gravity may not be located on the longitudinal centre line of the motorcycle. 0,0° ± 0,5° is an achievable tolerance.

F.7 Annex D (normative) Procedure to install the helmet on the dummy and position the dummy head

In general, the positioning and pre-loading of the helmet on the dummy head form may affect the response properties of the head/helmet sub-system. For this reason, a standardized installation procedure is specified. The alignment procedure is designed to centre the helmet and orient the helmet on the head form in a reproducible manner. The helmet is centred on the head form by aligning defined reference indices on the head form with the centre line of the helmet. The attitude of the helmet relative to the head form is determined using the helmet alignment tool, which allows repeatable positioning of the top edge of the view port. The retention strap is tightened to a realistic pre-load.

The goal is to align the head in as realistic an orientation as possible using the modified lower neck angle adjustment joint. In some motorcycle designs, the exceptions in C.2.4.2 result in large torso forward or rearward lean angles. For these exceptional cases, the angle used is recorded in the test report.

F.8 Annex E (normative) Outline of additional general test and analysis procedures for inflatable/triggered protective devices

Additional general categories of test and analysis procedures for inflatable/trigged protective devices are considered in this research standard because:

— motorcycle airbag feasibility research has been an on-going research topic since the early 1970's, and standardized research methods are needed in order for the research to progress;

— such devices are deployed dynamically during crashes and therefore have special, additional safety-related issues, beyond those of fixed protective devices;

— the experience with and lately discovered critical importance of special test procedures in the car airbag field.

The outlined procedure checklist is currently not specific in content, and mentions only the main concepts and test variables. At the same time, the checklist is not overly vague, which could result in overlooking factors that are understood to be important from previous motorcycle and/or car airbag research.

The proposed text also notes that the outline is also intended to reflect existing evaluation technology (for example, 50th percentile male and 5th percentile female dummies); and that in the future, further definition of the detailed test procedures would be desirable.

"Triggerable" devices are mentioned in addition to "inflatable" devices in order to address other deployable mechanical devices which have been mentioned (e.g., sliding seats, pivoting tanks, ejection seats, etc.)

Further rationale for addition of this airbag checklist is given in Rogers and Zellner (2001).

ICS 43.140

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