EEVC/CEVE

European Experimental Vehicles Committee

Specification of the EEVC Side Impact Dummy EUROSID 1

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SPECIFICATION OF THE PRODUCTION EEVC SIDE IMPACT DUMMY EUROSID 1

1 INTRODUCTION

EUROSID is the name given to the dummy which has been produced by collaboration between various European institutes within the EEVC for use in the evaluation of the performance of vehicles in lateral impacts. The development was coordinated by the EEVC and took as the basis the best concepts from the three side impact dummies designed within the EEC Biomechanics Programme.(1)(2)(3)(4)

Individual Institutes developed different body areas with predefined common interfaces and four examples of the "First Prototype EUROSID" were produced by assembling these separate body parts (5). These four First Prototype EUROSIDs were evaluated, with the support of the European commission, by the five laboratories; APR, BASt, INRETS, TNO and TRRL, principally with regard to their suitability for a test device. The test programme concentrated on repeatability, reproducibility, durability and sensitivity (6).

The results of these evaluations led to the design of the "Production Prototype EUROSID" with the objective of studying the performance and behaviour of this prototype version before deciding on the final design (7)(8). The Production Prototype EUROSID was produced by a consortium of European manufacturers with some parts being purchased from USA manufacturers. At the request of vehicle manufacturers, legislative bodies and others, these Prototypes were released for further biofidelity and other evaluations (9)(10)(11)(12). As a result of the findings of these studies the design of the production dummy, EUROSID 1, has been agreed within EEVC.

This document describes the design of EUROSID 1, the basis for the design, the certification procedures for ensuring that the dummies continue to give consistent results, and the recommended handling procedures.

SECTION 2 BASIS FOR SPECIFICATION

This section describes a set of desirable requirements for a side impact dummy for regulatory testing that were used as the basis for the design and development of EUROSID 1 and for the current specification.

There are two main purposes for advanced side impact dummies:-

- firstly for use as part of a side impact test procedure in regulations for the assessment of the protection afforded to car occupants
- secondly for use in research testing to investigate the problems of side impacts into cars and the resulting injuries.

Although the following requirements are intended to suit testing for regulations, it is expected that most features would be suitable for a research dummy with, at the most, the substitution of a few components. EUROSID 1 is designed in this way being required to be the means of measuring impact test severity in a side impact test procedure for regulatory purposes in Europe. It incidentally will almost certainly be used for a much wider range of test investigations.

2.1 General design features.

These relate to a dummy which is to be used for side impact testing and which is primarily designed for use in full scale impacts which are perpendicular to the heading of the car under test. However, not all impacts into the dummy are likely to be exactly perpendicular and even in such tests the resultant loadings on the dummy are not always perpendicular. The dummy must therefore be designed accordingly and more generally should withstand 50 km/h impacts of a car front into a car side with full measurements and no failures of its components.

The objective of a side impact dummy is to evaluate the risk of injury in a lateral impact. Consequently, the design specification must ensure that the dummy can indicate injury risk in the body areas most likely to suffer serious or fatal injuries under these impact conditions. For lateral impacts these are the head, the chest, the abdomen and the pelvis.

2.2 Anthropomorphic features and Biofidelity.

- The dummy should reproduce the human being in terms of a selected size and corresponding mass and distribution.
- The stiffness of the dummy at the points at which it is struck, and where it is likely to strike the vehicle, should be similar to those of similar parts of the human body.
- The dummy should interact correctly with the vehicle seat and should sit in the seat in a lifelike manner. This is important for side impact situations because the whole body response of the dummy may otherwise be unrepresentative.
- The dummy should inflict damage on the vehicle similar to that found from human impacts in accidents. Dummies in the past have usually been too stiff and have tended to buckle sheet steel structures in ways not found after human impact.
- Similarly the dummy should deform where struck in a representative manner as particularly specified for each body component. If the detailed dummy response is wrong then the impact

measurements at those points on the dummy will be wrong.

- The articulation of joints and the flexibility of parts of the dummy should be sufficient so as not to distort the response of the dummy for the intended impact conditions of those parts of the dummy whose responses are to be measured.

2.3 Repeatability and Reproducibility

- Each dummy should be repeatable in use. It is important that the dummy or several similar dummies should always react to a given impact in the same way so that the same measurements can be recorded. Reproducibility is repeatability between one dummy and another. Ideally measurements should be within 5% but 10% can be considered to be acceptable.

2.4 Sensitivity.

- The dummy should give very similar measurements when impacted in similar but slightly different ways. These differences may arise either from slightly different seated positions from test to test, or when the vehicle impact is slightly different from one occasion to another, or when the structural collapse of the vehicle is slightly different from vehicle to vehicle.

- Measuring devices should be fitted which are appropriate to each injury situation. For example an impact force may be critical only if spread over a small area of contact, whereas it might be acceptable if distributed over a larger area. Similarly, an acceleration may result from forces along more than one load path and so may not measure critical loadings. Measurements should not prevent the dummy response to each local impact being similar to a human response. In particular, measurements should clearly distinguish between loadings which are just above critical from those just below critical for human beings. In other words the parameter measured should be such that the rate of change of the measurement on the dummy should not be close to zero at the loading corresponding to the maximum tolerable human loading. The design of the dummy may slightly differ in detailed design features from the human being represented and so the human tolerance loads for humans may have to be replaced by slightly different but corresponding loads on the dummy. Frangible components which break at the critical loadings would not indicate the degree of overload imposed by the impact on a standard sized person. An overload of at least 50% without failure and permanent set is desirable.

2.5 Durability.

- It is strongly desirable that components should not break, permanently deform nor fail during testing, not only because full results would not then be available from the test but also because of the resulting delays for obtaining spares and for fitting them.

- The dummy should be cheap to use. The total cost of using a dummy is made up of capital repayment charges, the cost of replacing components, costs for certification procedures and re-setting if out of prescribed limits. It is desirable that these costs should represent a small fraction of the total cost of a full scale test.

2.6. Certification and procedures for certification.

Certification for a dummy is the mechanism by which the dummy can be checked and be shown to be within acceptable operating tolerances. Although this is not closely related to design requirements it is worthwhile to design a dummy so that it can readily be tested for certification and to ensure that the low test levels for certification do usefully check its full performance. The validation testing of EUROSID included a series of certification type tests and these provide useful experience for deciding upon the appropriate pattern of certification tests.

2.7 Relationship of EUROSID to other dummies.

EUROSID is designed to be the European legislative dummy for side impact testing and for this reason it is intended that it should match up with any dummy used for frontal impacts tests. It is thus appropriate that it should correspond to Hybrid II and III dummies to the greatest extent possible. EUROSID is produced in 50th percentile male form. Its dimensions and other features are generally designed to be the same or similar to those of Hybrid II. This has largely been achieved as regards the mass and mass distribution of the various major components but there are important exceptions. The changes are as a result of design convenience but with the more recent anthropomorphic (UMTRI) data in mind (13). There is some change between abdomen and pelvis. Also, as the lower arm and hand play no part in lateral impacts, at least until after the injury parameters have reached their maximum values, these have been deleted from the dummy and consequently from the overall mass. Their inclusion would only serve to increase the variability of test results.

Geometrically the shoulders are placed further forwards on the body in line with the most recent data from UMTRI (13).

2.8. Notes on mechanical design.

2.8.1 Head and neck

In real side impact accidents where the occupants are not ejected, the human head is usually injured by:-

- impacting the cant rail above the door.

- impacting the B post or the A post if thrown forwards.

- impacting the glass of the door.

- penetrating the glass and striking the impacting object (car, heavy vehicle, roadside tree or other object).

- the impacting object intrudes into the car and strikes the head.

- being thrown out of position in a double or multiple impact and striking almost anything within the car.

- injury without impact to the head is a possibility which occasionally occurs in side impact.

In test impacts it is likely that the head strikes the glass of the door and does not receive a severe impact. For this reason the full scale test should be supplemented by auxiliary head impact tests to check the range of impact sites. It also follows that the head impact in the side impact test using the complete dummy is of less importance than the impacts to the torso. EUROSID uses a head based on the Hybrid III design adapted as necessary to meet the lateral certification requirements.

As the neck is not one of the four prime body areas for which injury detection is required, it is not equipped with instrumentation. The main functions of the neck are;

a) to control the dynamic motion of the head until head contact so that a realistic head injury parameter measurement is made, and

b) to give the appropriate inertial response to the thorax.

2.8.2 Shoulder and arm.

The human shoulder is a complex joint which moves in three dimensions. When struck laterally the human shoulder can deflect, moving forwards and/or upwards and so exposing the thorax to a more direct impact. It is possible to fracture the clavicle, but this is not a frequent or very serious injury and so no instrumentation is provided in this area. Similarly no instrumentation is provided to record potential arm injury. The presence of an arm between a striking object and the thorax can markedly reduce the risk of injury to the chest. It can also add considerably to test variability. Consequently to test in the conventional "worst case" situation and to ensure better test repeatability, the arm is designed to be tested in a raised position; 40-45^0 being typical of observed arm positions. For the same reason, the shoulder is designed to encourage the arm to move out of the way of the chest rather than becoming trapped at some arbitrary position, leaving a more uniform impact situation for the thorax.

2.8.3 Thorax.

In side impact accidents the thorax is usually injured by direct impact rather than by crushing. It is the localised blow to the thorax which causes injury, and this, together with the loads through the spine, determine the sideways acceleration of the torso. The actual blow is usually from the distorted door, which may be of widely varying stiffness depending on whether the part of the door actually striking the thorax is a thin sheet or panel, or a strengthened edge, or is backed by a latch mechanism or by the colliding object itself. If the blow is from a flat panel severe injury usually only occurs when several ribs fracture. If the door is more distorted the blow is more localised and penetration of the thorax may occur with one or a few ribs being fractured and displaced into the thorax.

As the thorax is one of the prime injury sites, it should be possible, with suitable instrumentation, to measure the important injury parameters; namely the chest compression and the viscous criterion. It would be useful to be able to measure other proposed injury criteria such as TTI in addition. As localised force can be more injurious than a distributed force, the thorax should be divided into smaller detection areas. A three rib design is a suitable compromise between ability to detect local force and an over-complex thorax.

The response of the thorax should be sufficiently human-like to determine injury risk and to impact the vehicle structure realistically under the conditions of a vehicle impact. Because the effective stiffness of the thorax is of the same order as the stiffness of the interior of the vehicle that it impacts, it is critical that the test conditions for determining and tuning the performance of the thorax (striking mass, stiffness and velocity) are similar to those that are experienced in full scale vehicle impact tests.

2.8.4 Abdomen.

Injury to the abdomen in side impact may occur in three slightly different ways. At relatively high speeds of impact the inertial effects of the contents of the abdomen lead to it being relatively resistant to impact but nevertheless ruptures can occur internally. At low speeds of impact the abdomen is relatively soft and can be deformed by a blunt object without much injury, although pointed or sharp objects are obviously injurious. The third mechanism of injury occurs only very occasionally in side impact and results from the lap strap of a seat belt coming out of position and possibly penetrating the abdomen as the occupant is pushed sideways. This circumstance rarely occurs but may happen when there is a large rearwards component of impact which displaces the lap belt at its anchorage.

Peak force on the abdomen has been demonstrated to be related to injury risk in cadaver tests and the dummy should be equipped to detect this. As with the thorax, the dynamic response of the abdomen should be human-like at the range of velocities of impact experienced in full scale car impact tests.

2.8.5 Lumbar spine.

The lumbar spine is required to support the dummy in the pre-impact position and to provide appropriate load transfer between pelvis and thorax. Little is known about the latter except that there is a large variation between the tensed and relaxed state in volunteers. EUROSID uses the same spine as the Part 572 specification lumbar spine and only just holds itself in position when placed in a car seat.

2.8.6 Pelvis

The pelvic region is liable to serious injury if the pelvis is fractured or if the socket for the femur is damaged in a violent side impact. An actual impact is likely to be into the greater trochanter which loads the joint directly or possibly into the iliac wing. As this injury mechanism is related to structural failure, maximum force is the appropriate parameter. This is related uniquely to pelvic acceleration only if the effective mass of the pelvis is constant. The effective pelvic mass is significantly affected by the relative forces and time of impacts to the thorax and pelvis and is increased if the pelvis is trapped and prevented from moving laterally. The most common area of the pelvis to suffer fracture is the pubic ramii so that force measured in this area is appropriate.

For comparison purposes a standard accelerometer should be fitted, as is usual in impact dummies, at the base of the spine.

2.8.7 Legs.

It is not currently intended to measure injury risk to the legs. Consequently, the main function for the legs is to provide the appropriate inertial response on the torso, and to ensure a realistic seating position for the dummy.

SECTION 3 GENERAL DESCRIPTION

The Production European Side Impact Dummy : EUROSID 1

EUROSID is a dummy which has been designed specifically for the evaluation of vehicle occupant protection under conditions of lateral impact. Measurements can be made in the head, chest, abdomen and pelvis which relate to the risk of injury to these body parts.

Description by body part

3.1 Head.

The head is a Hybrid III-like head comprising an aluminium shell covered by a pliable vinyl skin. The lateral surfaces of the shell are smoothed where necessary to ensure repeatable performance. The interior of the shell is a cavity accommodating triaxial accelerometers and ballast with access provided by removal of a back cap. For more details of the Hybrid III see references (14) and (15).

3.2 Neck.

The EUROSID neck comprises three parts:

- a neck/torso interface piece,
- a head/neck interface piece,
- a central section made of rubber that links the two interfaces to one another.

Figure 1 shows the neck construction.

Each interface is composed of two plates; an exterior one (items 1 and 3) and an intermediary one (item 2) bound to the central part (item 5). Linking of these plates is made by means of a spherical bearing (item 4), which constitutes a point of rotation.

In order to control the head-neck and the neck-torso relative movements, two types of buffers are interposed between the plates as shown in Figure 1. The triangular section buffers and the neck central part are all part of the same system (item 5), they are made of 70-shore hardness rubber. The eight circular section buffers (items 6) are made in a range of shore hardness rubbers to permit tuning of the neck performance.

This design represents a system having 2 pivots and 3 modes of deformation. The two pivots are represented by the centre of the spherical bearings. The three modes of deformation possible for such a neck are:-

- simple lateral flexion (of the central part).
- translation and rotation (relative movements of the interface plates);
- extension of the central part.

The play which exists around the buffers and the compliance of these latter parts permit torsion; that is to say a rotation around the neck's vertical axis. The circular buffers can be changed for those with different hardness to permit tuning of the neck.

No instrumentation is provided in the neck.

3.3 Shoulder.

The shoulder comprises two polypropylene clavicles which are mounted in a block at the top of the thoracic spine (Figures 2 and 3). The clavicle contact with the shoulder block is in the shape of a cam (Figure 2) such that the initial point of contact and centre of rotation of the clavicle is at the posterior end of the block. The objective of this design is to provide a force couple tending to rotate the clavicle when the top of the arm is struck so that the arm is rotated forward to expose the side of the chest in a lateral impact. The centre of rotation of the clavicle moves forward as the clavicle rotates to help the arm clear the ribs. The clavicle is constrained to move in plane by plates at the top and bottom of the shoulder block. The clavicle is normally held back against a stop in its neutral position by an elastic strap.

No instrumentation is provided in the shoulder.

3.4 Arms.

The upper arms have a plastic skeleton (high density polythene) with shoulder joint movements that are limited but sufficiently realistic for lateral impacts. The upper arm flesh in the struck area is a high hysteresis solid polyurethane.

The lower arms and hands are not represented as they have negligible effect on the injury parameters until some time after the peak values have been reached in a lateral impact. They are sufficiently remote from the other body areas that their inertia does not have a noticeable effect until late in the impact.

The arm is attached to the end of the clavicle and does not contain instrumentation. The shoulder joint is provided with a sprung ball and detents such that the arm can be set at 0°, 40° and 90° to the torso line.

3.5 Chest.

The chest comprises three identical rib modules individually attached at the rear to a rigid thoracic spine box. (Figure 3). Each rib module consists of a hoop of spring steel attached at one end of the lateral control cylinder and at the other to the piston running in that cylinder. This piston is fixed to the struck side of the rib module. (Figure 4).

The piston runs on bearings within the cylinder and attached to the end of the piston. Between the end of the piston and the end of the cylinder is a sleeved spring, the stiffness of which can be selected to 'tune' the rib module. Lying parallel with the cylinder is a specially produced damper. The damper piston is connected to the struck side of the rib by a spring.

A high hysteresis foam* is attached to the outer surface of the steel rib to represent the flesh.

The whole module is attached to the spine box by the lateral control cylinder and can be removed intact as a unit. This concept allows the rib module to be serviced and certified separately from the whole dummy.

Each rib module is designed to accept a linear resistive displacement transducer. Provision has been made to attach a triaxial accelerometer at the top of the thoracic spine a uniaxial accelerometer at thebase of the thoracic spine. Uniaxial accelerometers may be attached to the inner surface of the ribs between the piston and damper attachments if acceleration figures are required.

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* Confor foam - a commercially available high energy absorption foam.

3.6 Abdomen.

The central part of the abdomen section is a metal drum which is rigidly attached to the lumbar spine-thorax box interface of the dummy. This drum is covered by a flexible material which makes up the shape of the abdomen and which allows a penetration of 40 mm before "bottoming out". Between this flesh-simulating material and the rigid drum are located three vertical steel force transducers. The force on each of these transducers can be recorded separately.

The inertial mass required to obtain correct biofidelity up to the point at which the tolerance levels are exceeded, is obtained by moulding a total of 1.16 kg of lead, partly as small pellets in the outside contour of each side of the flesh-simulating polyurethane foam (Figure 5).

The abdomen section is connected to the pelvis by a conventional solid rubber lumbar spine which is the same as a standard FMVSS 208 Part 572 unit.

3.7 Pelvis.

The shape of the pelvic bone is representative of the shape of the human pelvis at the points directly involved in a side impact and at the interactions with the car seat, as well as at the iliac crests where the seat belt fits around the pelvis. The external shape attempts to represent accurately the way in which a human sits on a car seat.

The pelvis is composed of two iliac wings made in a semi rigid polyurethane. The two iliac wings are linked together at the pubic symphysis by a force transducer. At the rear of the pelvis, they are linked by the sacrum which provides the base for the lumbar spine. (Figure 6).

The hip articulation of the EUROSID pelvis is intentionally different from the human one. The design is such that external forces are transmitted to the pelvis along a shaft passing through the hip ball joint, so that the thigh position has no effect on the way in which an impact to the greater trochanter loads the pelvis, but an impact to the thigh loads the pelvis at the same point as in humans.

The design of the hip joint allows adduction and abduction angles of about 25°; however, the adduction and abduction angles will be limited by the deformation capability of the foam in the pelvis area and the two thigh upper extremities. A large Conforfoam cylinder is attached to a steel plate fixed to the extremity of the shaft passing through the ball joint. The Conforfoam compensates for the rigidity of the hip joint unit. The skeletal assembly is covered with a polyurethane foam which in turn is covered in a PVC skin. The design permits the removal of the rigid parts without damage to the flesh.

The EUROSID pelvis is designed to measure pelvic compressive force in the pubic symphysis area by a force transducer. In addition, the sacrum block is designed to accept a triaxial accelerometer so that pelvic acceleration may be measured if desired.

3.9 Legs.

The legs are based on a metal skeleton covered by a flesh simulation. Joints are provided to allow realistic motion at the knee and ankle. The legs are based on the standard FMVSS 208 Part 572 design. No instrumentation is provided in the legs.

The whole dummy, which represents a 50th percentile adult male based, as far as practical, on recent anthropomorphic data (16), (17) and (13), is shown in Figure 7.

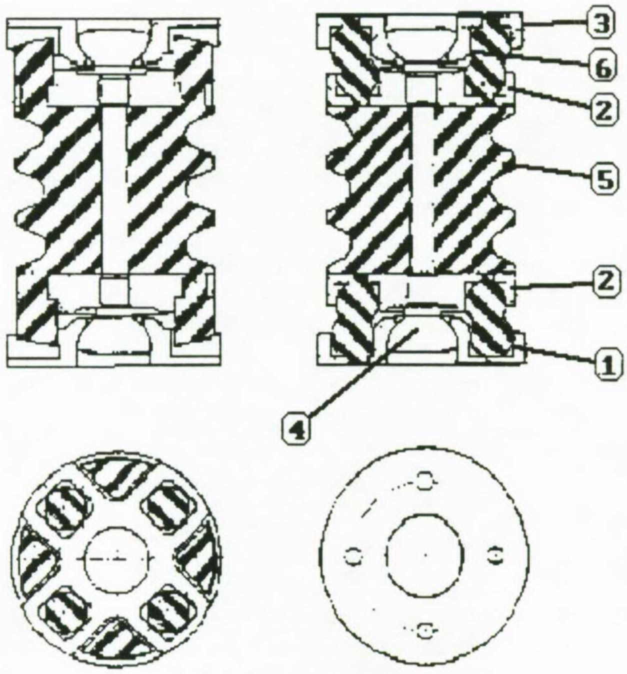

Figure 1. EUROSID Neck

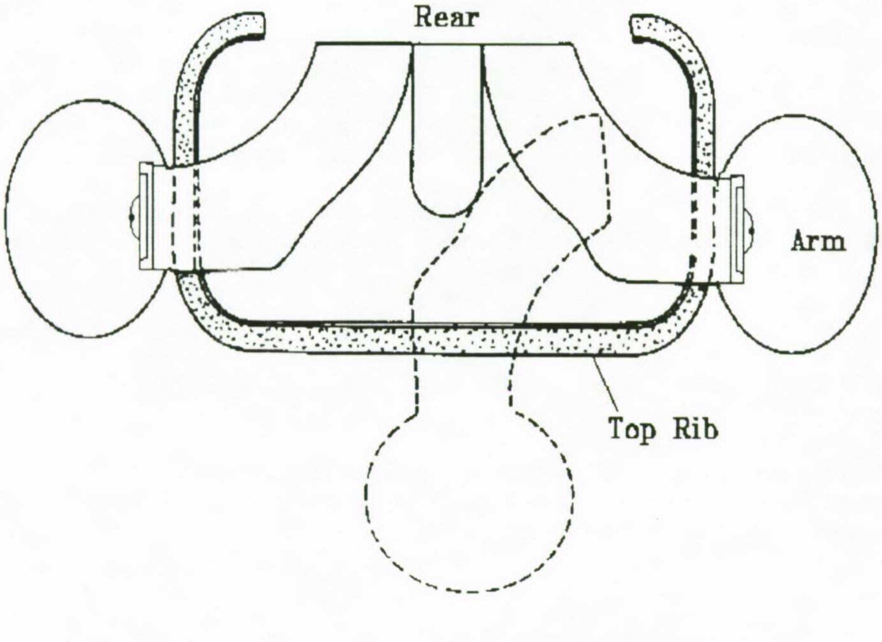

Figure 2. Diagram of EUROSID Shoulder Cam.

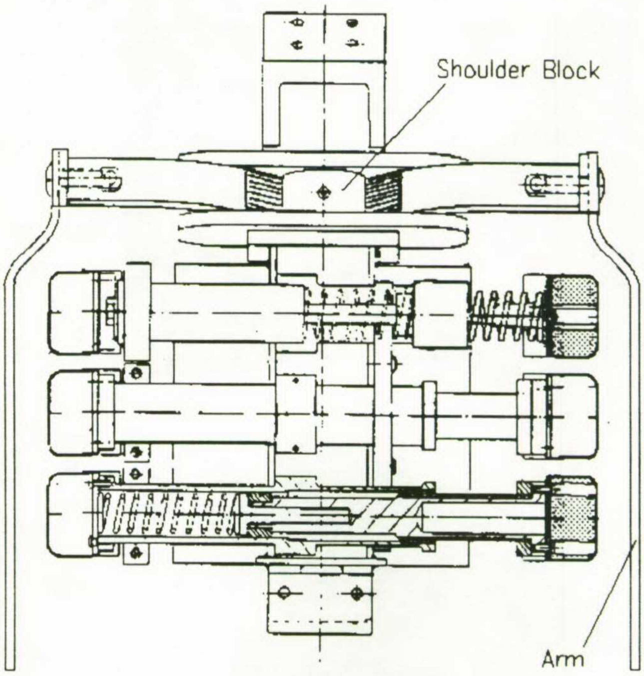

Figure 3. EUROSID Thorax

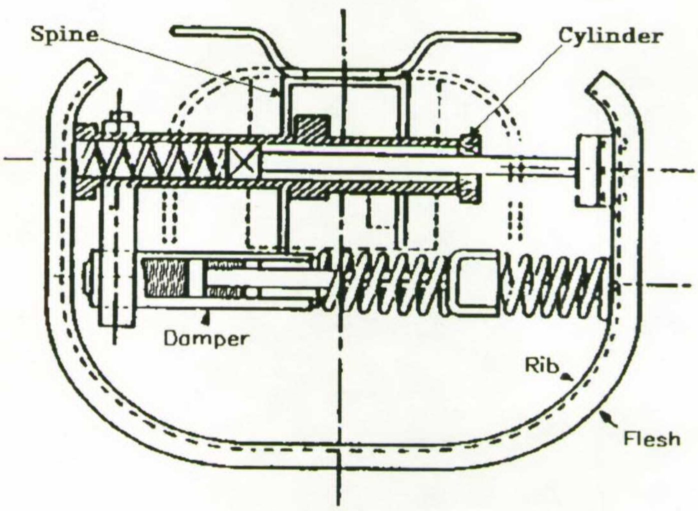

Figure 4. Diagram of EUROSID Rib-Piston-Damper Module

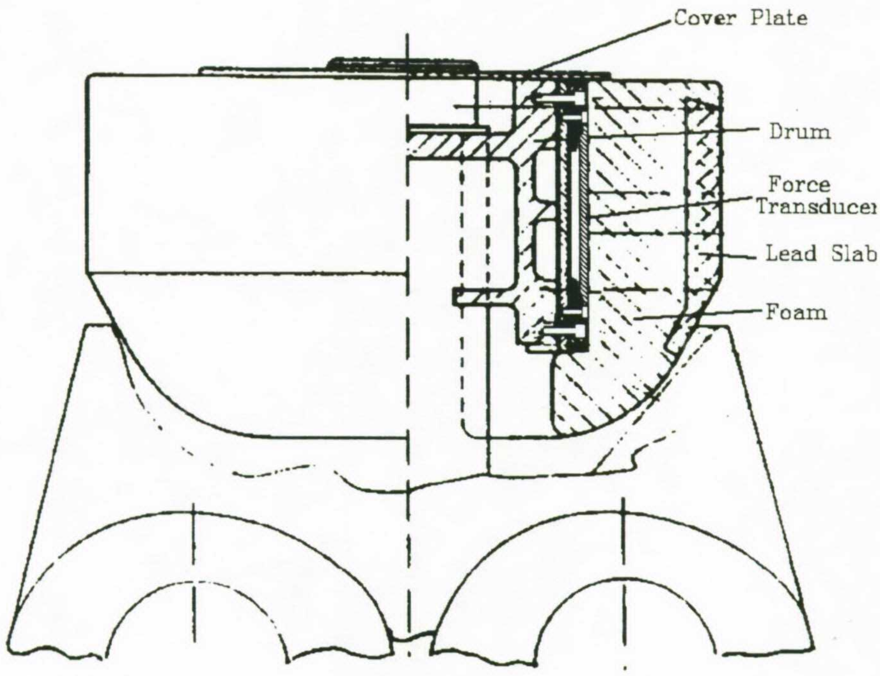

Figure 5. Diagram of EUROSID Abdomen

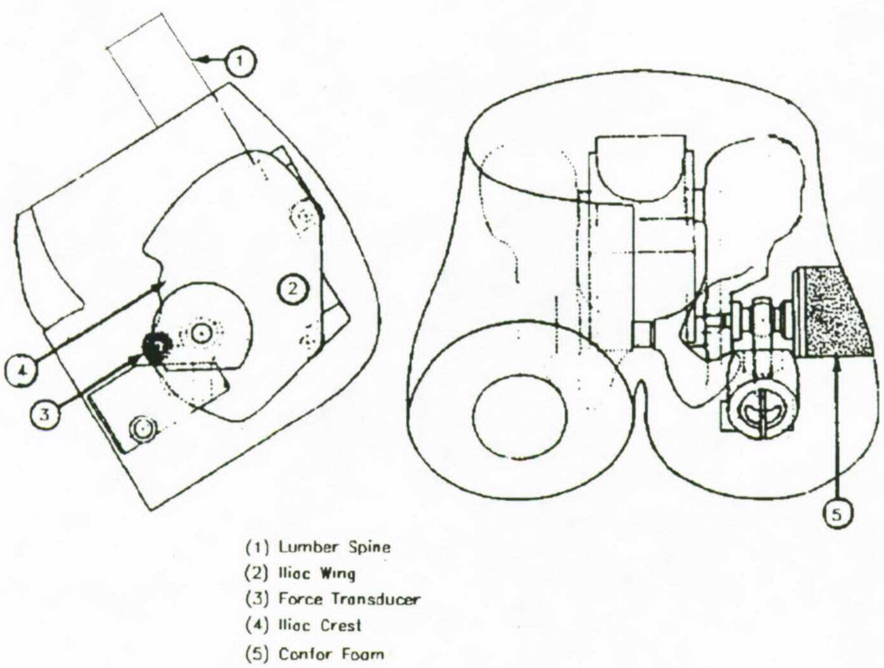

Figure 6. EUROSID Pelvis Design

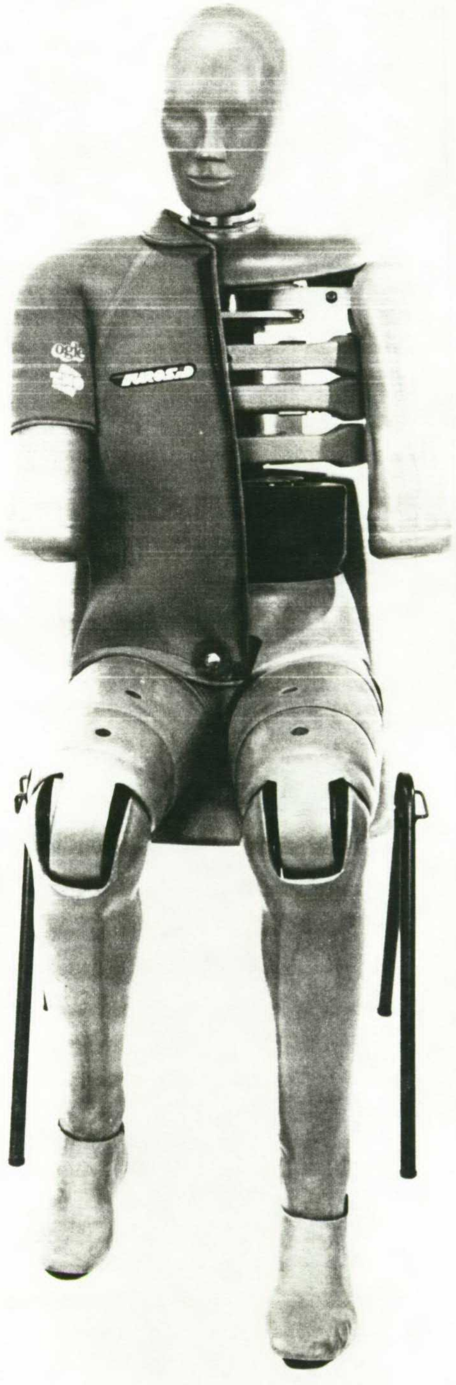

Figure 7 EUROSID 1

SECTION 4. HANDLING

EUROSID Test Set-up and Seating Procedure

4.1 EUROSID set up

After certification of the single dummy-components, the dummy should be assembled again as described in the EUROSID user's manual.

The adjustable dummy leg joints should be adjusted to hold between 1 and 2 g's. This adjustment just barely restrains the weight of the individual limb when it is extended horizontally.

One principle item of dummy clothing is a rubber suit with short sleeves and no legs. The dummy may optionally be clothed with form-fitting cotton stretch vest and/or undertrousers and the feet equipped with shoes.

The dummy must not be stored nor transported by suspending it from the head, because the neck is not designed to support the weight of the dummy. A screw location for lifting is provided at the base of the neck. The legs must be supported when lifting to keep the dummy in a sitting position.

4.2 EUROSID Instrumentation

The dummy is equipped to accept a triaxial accelerometer in the head. Provisions have been made to mount accelerometers in the chest and pelvis also, if required. The standard rib deflection transducers are linear potentiometers. There is additional provision for mounting uniaxial accelerometers on the inside of each rib close to the point of impact. Furthermore, it is possible to mount accelerometers on the spine at the T1 and T12 level. The abdomen has three force transducers on the impacted side. The pelvis has provision for a Sensotec Model 31/5000 force transducer in the pubic symphysis.

The filtering of the different measuring channels should be made according to ISO 6487.

Instrumentation		**Channel Frequency Class**
Head	triaxial accelerometer at C of G	1000
Chest	deflection transducer (one for each of the 3 ribs)	180
Abdomen	force transducer (3)	600
Pelvis	force transducer (pubic symph.)	600

Section 4.4 describes additional instrumentation that may be used with EUROSID and gives details of appropriate filtering for these.

4.3 Recommended EUROSID Seating Procedure

There are two major reasons for specifying the seating procedure. The first is to define the positions of the head, chest, abdomen and pelvis relative to the car side structure in a consistent manner. The second is to position the upper arms relative to the torso centre line such that there is repeatable and realistic exposure of the thorax to the intruding car side structure and so that there is no damping or distribution of loads by the arm in the area of the ribs.

The car shall be at the required height before placing the dummy in the seat on the impacted side.

If there are separate seats, the plane of symmetry of the dummy shall coincide with the vertical median plane of the seat. If there are bench seats, the plane of symmetry of the dummy shall lie in the vertical plane passing through the steering wheel centre and parallel to the longitudinal median plane of the vehicle. If the seating position is determined by the shape of the bench, the seat shall be regarded as a separate seat.

The EUROSID is placed in the vehicle seat with its pelvis positioned such that a lateral line passing through the dummy H-point is perpendicular to the longitudinal centre plane of the seat. The H-point can be determined by using the three-dimensional H-point manikin according to SAE J 826. The line through the femur neck bolts should be horizontal with a max. inclination of ± 2°. It must be ensured that the rear of the pelvic flesh is in contact with the backrest.

The upper torso shall be bent forward and then laid back fast against the seat back. The shoulders shall be placed in the most rearward position.

The restraint system, if used, shall be adapted to fit the dummy in accordance with the manufacturer's instructions, otherwise secure the dummy, drawing the belt fast. The shoulder belt shall be placed across the upper chest in a normal wearing position leaving the shoulder joint free for motion.

The angle between upper arm and torso centre line on each side shall be 40° ± 5°. The fixed detents in the shoulder joint allow the arm to be positioned at 0°, 40° and 90° to the torso line.

The dummy shall not be allowed to apply its weight to the vehicle seat for longer than 2 hours before the test takes place.

4.4 Additional Instrumentation

EUROSID is designed to accept the following additional instrumentation, which may be used for research or dummy comparison purposes.

	Instrumentation	**Channel Frequency Class**
Head	9-accelerometer unit for the calculation of rotational acceleration.	1,000
Chest	triaxial acceleration at T1	180
	lateral acceleration at T12	180**
	lateral acceleration on each rib (3)	180**
Pelvis	triaxial accelerometer at C of G	180

** If the TTI is calculated, filtering of these accelerations should use a FIR filter of 100 Hz.

SECTION 5 MASS DISTRIBUTION

The total mass for EUROSID 1 is 72kg ± 0.5kg representing the mass of a mid size adult male except for the mass of the lower arms and hands.

The mass by body part, including instrumentation where specified, is as follows;

Body Part	Principle contents	Mass (kg)
HEAD	Dummy head to the head/neck joint, including triaxial accelerometer.	4.0 ±0.4
NECK	Neck, not including the neck bracket	1.0 ± 0.1
THORAX	Neck bracket, shoulders, arm attachment bolts, spine box, rib modules, rib deflection transducers, lumbar spine/thorax interface, torso back plate, shoulder flesh, abdomen drum and transducers, cover and latching plate, 2/3 jacket.	22.4 ±1.5
ARM	Upper arm, including arm positioning detent plate.(each)	1.35 ± 0.1
ABDOMEN	Abdomen flesh and lumbar spine	4.9 ± 0.5
PELVIS	Pelvic flesh, sacrum block, lumbar spine bottom plate, energy absorbing blocks, hip ball joints, upper femurs, ilium wings, pubic force transducer, 1/3 jacket.	12.0 ± 1
LEG	Foot, lower and upper leg and flesh as far as the junction with the upper femur (each).	12.5 ± 1.0
TOTAL		**72 ± 0.5**

SECTION 6 CERTIFICATION [To be completed]

6.1 General Introduction

The certification procedures for the several body parts are based primarily on existing Standard Part 572 procedures. An exception is made for the thorax; the rib modules are separately tested in three series of drop tests. Furthermore the abdomen is certified statically as well as by means of a pendulum impact.

The Impacts are of course on the side of the dummy. Depending on the impact side, the dummy parts should be certified on the left hand side or right hand side. The rib modules (including instrumentation) of the thorax and the force transducers of the abdomen have to be converted to the impact side.

Disassembly of the dummy is required for the following components:

Head: a free-fall drop test with the upper side of the head impacting a flat rigid surface;
Neck: a Part 572 neck-pendulum type test with the head-neck system causing lateral neck flexion, as well as head rotation and translation; [Note; a new symmetrical headform replaces the EUROSID head in this procedure]
Chest: drop tests with special impactors on each rib module to test rib, springs and damper;
Lumbar spine: a dynamic pendulum test similar to the neck certification test.

The remaining certification tests are performed with the complete dummy (without suit):

Shoulder: a lateral impact with the Part 572 pendulum on the upper arm pivot;
Abdomen: a lateral impact with the Part 572 pendulum, equipped with an armrest-face ;
Pelvis: a lateral impact with the Part 572 pendulum on the great trochanter of the pelvis.

The certification procedure of each body part is described in the next sections. Special tuning and certification equipment necessary to perform the tests are described in section 6.2.

6.2 Special certification and tuning equipment

For the free-fall head drop test a support - and release mechanism for the head is necessary, as well as a rigid, flat impact surface. This equipment can be similar to that of the Standard Part 572 head drop test.

For the neck-bending test a pendulum is required similar to the Standard Part 572 neck-bending pendulum. The pendulum is decelerated by aluminium honeycomb (Hexcell).

The headform centre of gravity displacement and the headform flexion angle relative to the pendulum in the neck certification test should be measured by an appropriate device or method. High speed film analysis is possible if accurate measurements can be performed. The headform is designed to allow the use of a transducer system including potentiometers.

For the impacts on the shoulder, abdomen and pelvis a pendulum suspended by wires is necessary, which is similar to the Standard part 572 pendulum. In the abdomen test this pendulum is equipped with an 'armrest' face. The dimensions of this impactor-face are shown in Fig. 6.1.

For the certification of the rib modules a drop rig is necessary, consisting of an impactor, a release system, drop weight guide cables, a mounting bracket, a deflection measuring device and a support table.

The test set-up is presented in section 6.5.2.

Before the abdomen can be certified the force transducers should be calibrated.

Tuning springs and damper oil are necessary for the certification of the rib modules (if they do not conform to the specifications).

6.3 Head

6.3.1 Introduction

The head should be visually checked for damage.

6.3.2 Test set-up

This test is to be conducted using only the dummy's head. The dummy's head is to be positioned with a 200mm ± 3mm spacing between it and a flat, rigid impact surface. The impact surface is to be horizontal and the head is to be oriented so that its midsagittal plane makes an angle of 35° with the impact surface and its anterior-posterior axis is horizontal. A 'quick release' mechanism is required to drop the head onto the impact surface. The mass of any head support must not exceed 70gms.

The dummy's head is to be instrumented with a triaxial accelerometer package located at its centre of gravity. Accelerations are to be filtered using SAE channel Class 1000. The head performance can be adjusted to meet the requirements by altering the friction characteristics of the skull-flesh interface.

6.3.3 Requirements

The peak resultant head acceleration should be between 100 g to 150 g.

6.4 Neck

6.4.1 Introduction

The head and neck should be disassembled from the dummy.

The neck should be visually checked. If the neck is permanently bent or twisted the circular section buffers must be replaced. If the central rubber section is damaged (e.g. tears) it must be replaced.

The upper and lower half-sphere screws must be tight and the spherical bearing surfaces lubricated.

Then a dynamic calibration test should be performed as described in the following sections.

6.4.2 Test set-up

The neck is attached to the special headform. Then the head-neck system must be laterally attached to the standard Part 572 neck-pendulum. The neck should be mounted, without bracket, on an aluminium plate (thickness 9 mm) fixed to the pendulum. The headform midsagittal plane should be vertical and coinciding with a plane passing through the pendulum lateral centre-line.

The temperature in the test laboratory should be between 18°C and 22°C. The time during which the pendulum is in the pre-impact position should not exceed 5 minutes.

The pendulum should be released and be allowed to freely fall from a height to achieve a velocity of 3.4 m/s ± 0.1 m/s (measured at the centre of the accelerometer).

The pendulum is decelerated by an impact on a fixed aluminium honeycomb and the neck is laterally bent. The deceleration time-history of the pendulum should correspond to the pulse specified in Figure 6.2. The maximum pendulum deceleration should not exceed [33] g and not be lower than [27] g. The maximum Honeycomb deformation is about 30 mm.

The head centre of gravity displacements and the head flexion angle relative to the pendulum should be measured by an appropriate device or method.

6.4.3 Requirements

For the neck the following specifications are given:

- The maximum head flexion angle relative to the pendulum should be [ ]* degrees and should occur between[ ] and[ ]ms.

- The maximum head c.g. displacements in the lateral and vertical direction should be [mm and]mm respectively.

If the given values can not be achieved, the circular section buffers (dumbells) can be replaced and further tests performed with a 30 minutes time interval between tests in order to tune the neck to the correct performance. If the subsequent tests with alternative buffer hardnesses are not satisfactory, the neck has to be replaced.

6.5 Thorax

6.5.1 Introduction

The thorax of the EUROSID should be re-certified after every ten vehicle impacts or impacts of similar severity. If results of a test are suspect the thorax should be re-certified. The certification of the EUROSID thorax is performed off the dummy on a simple drop test rig.

Each rib module is certified separately. A dynamic velocity displacement corridor is specified for each part of the rib module. If a rib module fails certification, tuning of the rib can be carried out (see Annex to this section). The first checks on the rib are visual. A black deposit over the piston is expected, this film is a layer of PTFE deposited from the bearings.

Following a visual inspection the full rib module must be dynamically certified, Section 6.5.3. If the module fails to meet the certification corridor the damper must be removed and the presence of air in the damper checked audibly, Section 6.5.4. If the damper has air in with the oil it should be bled, refitted in the rib and the full module should be retested. If the rib module still fails certification, some tuning can be performed and the damper performance checked. (see Annex)

6.5.2 Test set-up

Figure 6.3 shows the drop test rig used for the rib module certification. It can, with slight modification, be used also for tuning the rib and checking the damper (Annex). The damper tests use a specially shaped free fall 1 kg impactor. The maximum impact velocity is 10 m/s, a free drop height of just over 5 m. The full module and primary rib tuning tests use a 7.78 kg impactor with a face similar to the Part 572 pendulum. The maximum impact velocity for these two procedures is 4 m/s, a free drop height of approximately 0.9 m. For these two tests the thorax displacement measuring system can be used, alternative methods must be adapted for the damper tests.

6.5.3 Requirements full rib module

The rib module should first be visually inspected for signs of damage, e.g.: flesh damage, damaged piston, non-symmetry in the rib, loss of oil from the damper, in addition check that the rib easily expands back out to the bump stop without assistance. If the module appears satisfactory and the damper spring is correctly adjusted the rib module should be evaluated in the certification procedure described below.

The full rib module should be mounted in the drop rig, struck side uppermost. Care should be taken that the guide pin is not obstructed of the length of its travel. (Figure 6.3) The 7.78 kg mass should free fall onto the rib with impact velocities between 1.0 and 4.0 m/s. The fall should be guided with the centre line of the mass over the centre line of the piston. At each impact velocity the peak rib deflection should be recorded. The impact velocity should not vary from that specified by more than 2%. The performance corridor is given in Table 6.1.

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*The values for the requirements will be determined when sufficient numbers of EUROSID 1 necks have been built and tested.

Table 6.1.
Certification corridor of the Full Rib Module.

Impact Velocity (m/s)	Minimum Displacement (mm)	Maximum Displacement (mm)
1.0	11.0	14.0
2.0	24.5	26.0
3.0	36.5	38.0
4.0	46.0	49.5

If any rib displacement fails to conform to the corridor the test can be repeated until two displacements are the same. If the rib still fails to meet the specification the rib should be removed from the test apparatus and the damper removed. The damper should be checked for the presence of air in the oil. If air is present the damper should be bled (Section 6.5.4) and the module reassembled and retested. If the module still fails the stiffness of the rib itself should be checked (Annex). Following tuning of the rib alone or replacement, the module should be rebuilt and retested.

If it still fails certification the damper should either be checked (Annex) or be replaced with a fully certified damper. In the unlikely event that the module still fails certification the adjustment of the damper spring should be verified; if the adapter is screwed to far so that the damper is being precompressed the rib can fail even though the individual components are good.

6.5.4 Bleeding of the damper

1. Hold damper vertically with piston rod uppermost. Stroke the piston whilst listening for any squishing noises of air in the oil. (This procedure causes any air to collect at the top end of the damper).

2. Reverse the orientation of the damper by 180 degrees (piston rod down) and stroke the piston, again listening for any squishing noises. (This procedure will cause any air collected in action 1 to pass through the damper piston, during which time the noise of any air within the oil will be noticeable).

3. If necessary repeat actions 1 and 2. If air is heard in the oil repeat action 2 slowly but using strokes of decreasing amplitude and with the piston rod nearly fully withdrawn. Support the damper vertically for a few moments. (This procedure causes all air to collect on the annular side of the piston and the rest period allows the air that has been emulsified in the oil to collect at the bleed hole.

4. Carefully remove the bleed screw and either add some extra oil to the damper or carefully push in the piston, lifting the oil up to the top of the bleed hole.

Replace bleed screw - DO NOT over tighten the bleed screw. NOTE: Use only the special EUROSID damper oil. Other hydraulic oils are not suitable and would ensure the damper would be out of specification. Having bled the damper recheck for air, operations 1 and 2, in addition check that the stroke of the damper is at least 50 mm. (This procedure forces the air out of the bleed hole and also checks that the damper has not inadvertently been overfilled).

6.6 Shoulder

6.6.1 Introduction

The mechanics of the shoulder and the condition of the upper arm flesh should be inspected for obvious damage. The mechanics should be cleaned. The shoulder is checked statically as well as dynamically.

6.6.2 Static test

The shoulder return force must be set prior to certification. The arm should be removed. The force required to move the shoulder cam forward, when applied within 4 mm of the outer edge of the clavicle, should be between 30 and 40 N in a forward direction in the plane of the cam. To adjust the return force the length of the elastic cord should be adjusted at the clamping point at the rear of the shoulder block.

Then a dynamic test should be performed as described in the following sections.

6.6.3 Dynamic test set-up

The dummy (without suit) should be sat on a flat, horizontal, rigid surface with no back support. Two sheets of 2 mm thick Teflon are placed between the dummy and the surface. The dummy legs should be horizontal and the thorax vertical. To maintain this position the dummy can be supported, however, without preventing the dummy falling sideways in the direction of impact. The dummy should be positioned so that the anterior-posterior axis of the dummy is perpendicular to the direction of impact and the axis of the impactor coincides with the axis of the upper arm pivot. The arms should be set with the arm at an angle of 40 degrees forward of the vertical using the detent stop.

The impactor is the Standard Part 572 pendulum of 23.4 kg and 150 mm diameter. The impactor must be suspended from a rigid support by four wires with the centre line of the impactor at least 3.5 m below the rigid support. The included angle of the wires must not be more than 20 degrees (viewed from axially along the impactor). A linearly guided impactor will result in higher force levels since the arm slides across the face of the impactor during the impact. The impactor should freely swing onto the shoulder of the dummy. The impact velocity of the impactor shall be 4.3 m/s.

The impactor is equipped with an accelerometer sensitive in the direction of impact and located on the impactor axis. The acceleration-signal should be filtered to Channel Class 180.

6.6.4 Requirements dynamic test

The peak acceleration of the impactor shall be between 9 and 11 g.

If the shoulder fails to meet the specification the upper arm should be replaced.

6.7 Arms

No dynamic certification procedure is defined for the arms. Testing of the upper arm flesh is part of the shoulder certification (see section 6.6).

6.8 Lumbar spine

A certification procedure using the symmetrical headform is being developed fined for the lumbar spine and is given in the EUROSID users manual.

It is recommended to use only a lumbar spine, which fulfils the Standard Part 572 specifications.

6.9 Abdomen

6.9.1 Introduction

The abdomen section should be disassembled from the dummy. The construction should be visually checked for damage, especially the flexible foam covering and the steel leaf springs. These parts should be replaced if significant tears or permanent deformation are observed.

Before dynamic certification tests are performed the transducers must be calibrated.

6.9.2 Test set-up

The test is performed with the abdomen installed in the dummy. The dummy (without suit) should be placed in an upright seated position on a flat, rigid, horizontal surface with no back support. Two sheets of 2 mm thick Teflon are placed between the dummy and the surface. The dummy legs and arms should be horizontal and the thorax vertical. To maintain this position the dummy can be supported, however, without preventing the dummy falling sideways in the direction of impact. The dummy should be positioned so that the anterior-posterior axis of the dummy is perpendicular to the direction of impact and the axis of the impactor should be aligned with the centre of the middle transducer

The impactor is the Standard Part 572 pendulum of 23.4 kg and 150 mm diameter. The pendulum is equipped with a horizontal impact face of 1.0 kg (so total impactor mass is 24.4 kg). The 'rigid' armrest is 70 mm high, 150 mm wide and should be allowed to penetrate at least 60 mm in the abdomen. (Figure 6.4). The centre of the armrest lies on the longitudinal axis of the pendulum. The pendulum is suspended by long wires to allow a non-guided impact to the abdomen with a velocity of 6.30 ± 0.1m/s

The pendulum should be equipped with an accelerometer located on the impactor axis and sensitive in the direction of impact. The accelerometer signals should be filtered to Channel Class 180 and the force transducer signals to Channel Class 600.

6.9.3 Requirements

The peak pendulum acceleration should be within the time and amplitude corridors specified in Table 6.2.

Table 6.2
Specification for the abdomen certification tests

Impact velocity (m/s)	Max. acceleration (g's)	Transducer force {-sum of 3} (kN)
6.30	[41 - 47]	[7]

If the abdomen fails this specification the flexible foam covering should be replaced.

Check the abdominal components again visually for failures. Damaged parts should be replaced. If the force is correct and no damage can be seen, the flexible foam covering should be replaced.

6.10 Pelvis

6.10.1 Dynamic test set-up

Check the construction visually for damage and replace parts if necessary.

The dynamic certification is performed with the whole dummy, the legs and lumbar spine are attached to the pelvis. The pubic symphysis load cell is placed in its position and the pelvis is provided with an accelerometer.

The dummy should be placed in an upright seated position on a flat, rigid, horizontal surface with no back support. Two sheets of 2 mm thick Teflon are placed between the dummy and the surface. The dummy should have a free sideways motion on the teflon foils of about 50 cm. The dummy legs should be horizontal, the arms set at 90° to the torso line and the thorax vertical. To maintain this position the dummy can be supported, however, without preventing the dummy falling sideways in the direction of impact. The dummy should be positioned so that the anterior-posterior axis of the dummy is perpendicular to the direction of impact and the axis of the impactor should be aligned with the centre of the confor foam block. this location is identical to the H-point of the dummy. (Figure 6.5)

The impactor is the Standard Part 572 pendulum of 23.4 kg mass and 150 mm diameter. The impactor is suspended by wires to allow a free swing onto the pelvis with an impact speed of 4.3 ±0.1 m/s. The impactor is equipped with an accelerometer located on the impactor axis and sensitive in the direction of impact. The acceleration-signals of pendulum and pelvis should be filtered to Channel Class 180. The pubic symphysis load-signal should be filtered to Channel class 600.

6.10.2 Requirements dynamic test

The impactor force (acceleration of pendulum multiplied by the mass of the pendulum) is required to be [4500 - 5000] N. The lateral pelvis acceleration should be [23] g ± 3 g and the public symphysis load cell should indicate a load [N].

The parts of the pelvis should be checked again if these specifications are not fulfilled. If repeated tests do not show the required results the energy absorbing block should be renewed.

6.11 Legs

No dynamic certification procedure is defined for the legs.

The mechanism of the joints and the construction of the legs and feet should be visually checked for damage.

ANNEX

A.6.1 Rib sub-component performance

a) Damper

The damper performance test uses a specially shaped 1 kg impactor. The impact face of the impactor is recessed and the centre of gravity of the impactor is below this face. The test can be performed on the same free fall drop rig used for the full module with a different mounting plate. The damper is checked with the stiff damper spring attached. The performance corridor is a velocity - damper displacement corridor. The impact velocities ranging up to 10 m/s. This requires a free fall drop of just over 5 m. (It is more important to certify at the higher velocities than the lower ones because this is the impact range experienced in the dummy in vehicle tests and it is also the range over which the damper is most likely to fail through valve failure). The displacement of the damper is measured at the piston rod. No particular method of measuring this displacement is suggested. The mass of the adapter and the moving parts of the user's defined displacement measuring system, mounted on the piston must be between 30 - 35 grams. The piston rod thread is not a standard M10 pitch, the thread is M10 x 1.25. The length of the damper return spring should be set to 70 - 72 mm. for this test.

The impactor should free fall onto the end of the stiff damper spring. The axis of the mass falling directly over the spring. The mass should not fall sideways on impact. If it does or the recorded displacement is not within the corridor the test at that velocity should be repeated. The damper performance corridor is shown in Table A.6.1.

Table A.6.1.
Performance corridor for the damper

Impact Velocity (m/s)	Minimum Displacement (mm)	Maximum Displacement (mm)
3.0	13.4	15.6
4.0	17.4	19.6
5.0	21.1	23.4
6.5	26.0	28.6
8.0	30.5	33.3
10.0	35.3	38.7

b Rib

The rib minus damper, damper spring and sternum spacer is checked in the same way as for the full rib module (Section 6.5.3). the same impactor is used but the impact velocities are lower.

The certification procedure consists of a static and dynamic check. The static procedure is described below;

1. Remove the four screws holding the rib onto the cylinder.

2. Check that the action of the piston is smooth throughout the stroke.

3. Check that the guide pin is free to rotate and that the nylon outer shell is intact

4. Check rib for permanent set. Hold the rib horizontal with the piston out. The gap between rib and cylinder should not be less than about 4 mm. (This is not a precise measurement because of the difficulty measurement). This gap gives the rib a small amount of precompression. With the rib re-attached and without any tuning spring the rib should recover up to the end of travel without any extra force having first been compressed by hand.

The dynamic test methodology is the same as for the full module, Section 6.5.3, but with a different certification corridor. The rib corridor is shown in Table A.6.2. If the rib fails to meet the corridor, the spring inside the cylinder should be changed for either a weaker or stiffer one depending upon the current performance of the rib and the spring already in use. If any of the available springs are not suitable the rib should be replaced.

Table A.6.2
Performance corridor for the rib

Impact Velocity (m/s)	Minimum Displacement (mm)	Maximum Displacement (mm)
1.0	15.5	18.5
1.5	23.5	26.5
2.0	31.5	34.5
2.5	40.0	42.5

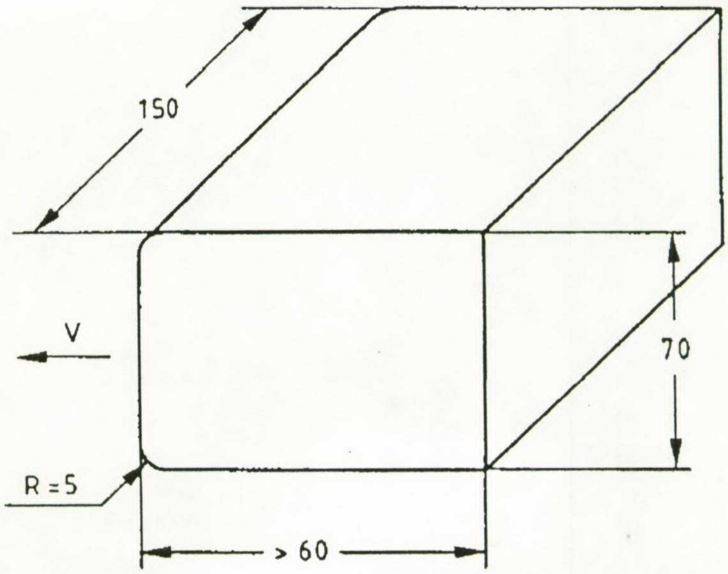

Figure 6.1
Impactor face for the Abdomen Certification Test. (Dimensions in mm.)

Figure 6.2
Neck pendulum acceleration-time corridor.

[To be added when tests on the first four EUROSID 1 dummies are complete.]

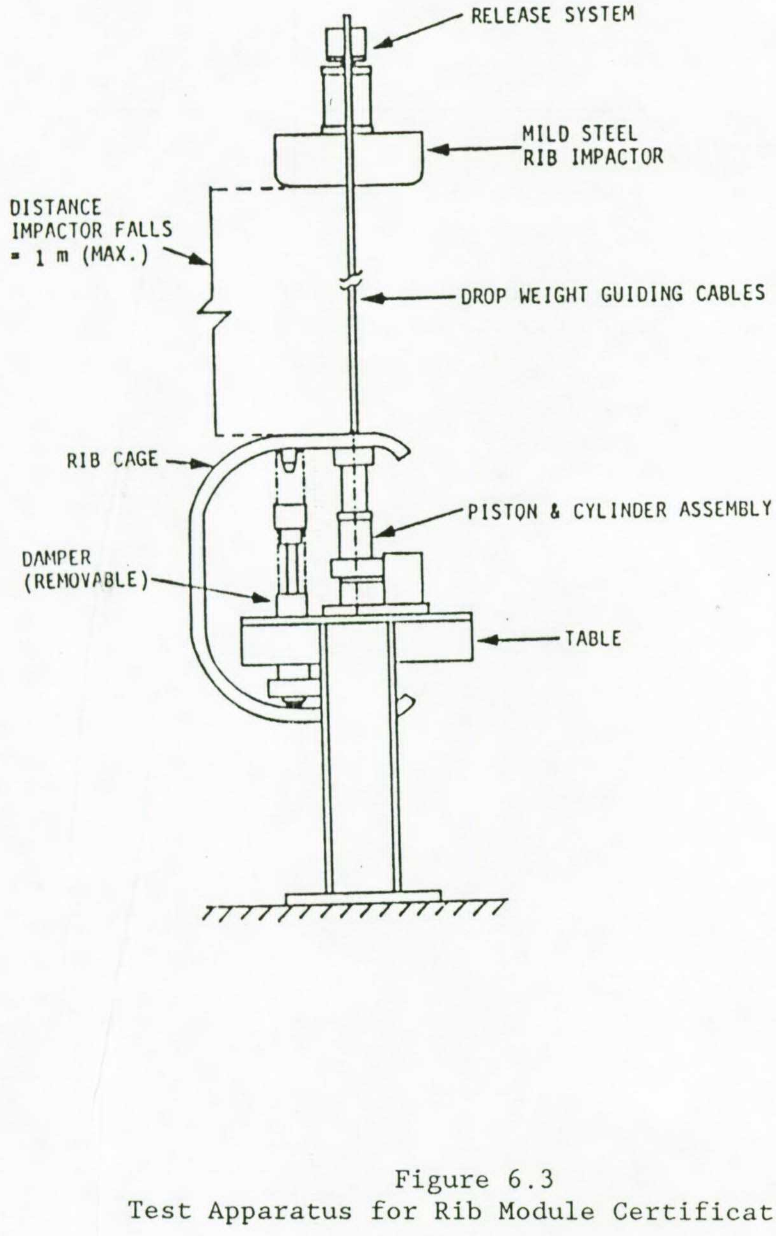

Figure 6.3
Test Apparatus for Rib Module Certification

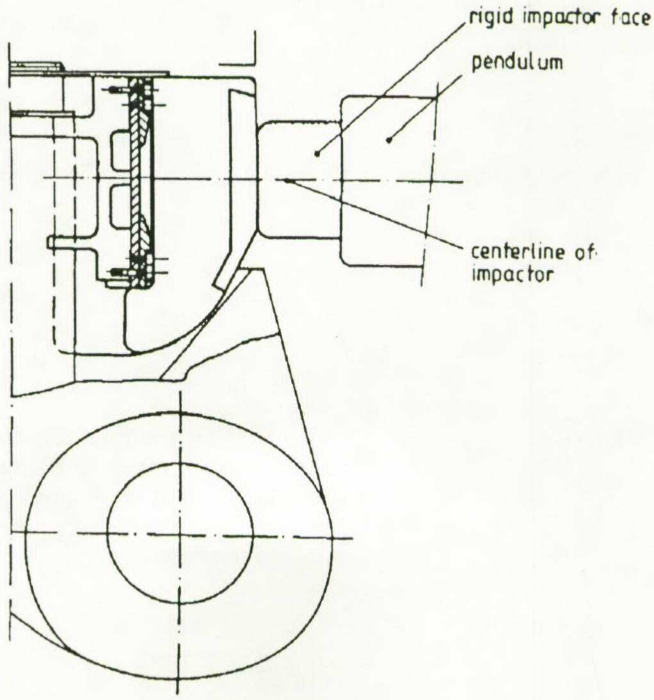

Figure 6.4
Impactor Alignment for Abdomen Certification Test.

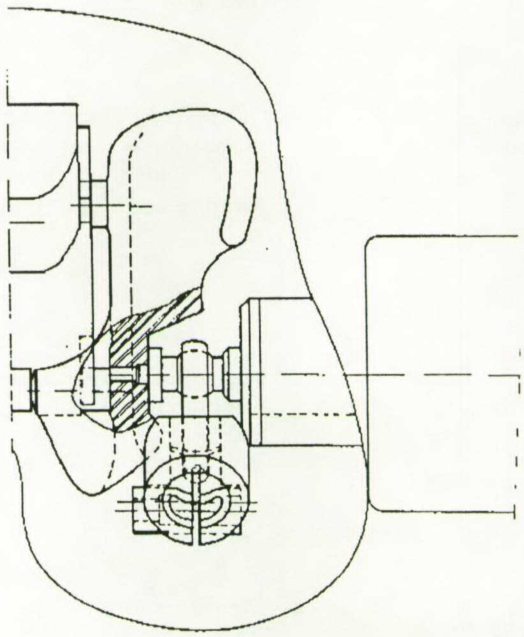

Figure 6.5
Impactor Alignment for Pelvis Certification Test.

SECTION 7 PERFORMANCE CRITERIA

Recommended Performance Criteria for EUROSID 1 when used in the EEVC Side Impact Test Procedure.

Recommendation of the EEVC

HEAD HIC < 1000 secs.	Calculated for the total duration of the impact from the resultant acceleration measured at the centre of gravity of the head, filtered at channel class 1000 HIC is the maximum value of the expression:- $\left[\frac{1}{(t_2 - t_1)}\int_{t_1}^{t_2} a\,dt\right]^{2.5} (t_2-t_1)$ where t_1 and t_2 are any two times during the impact.
THORAX Peak chest deflection on any rib < 42 mm.	Measured on the EUROSID transducers, filtered at channel class 180.
Peak viscous response V*C < 1.0m/sec	Calculated from the instantaneous product of the proportional compression of the half thorax (140mm.) and the velocity of compression derived by differentiation of the compression, filtered at channel class 180
ABDOMEN Internal force Peak force < 2.5kN.	Measured as the sum of the instantaneous forces on the three abdomen force transducers, filtered at channel class 600.
PELVIS Pubic symphysis force Peak force < 10kN.	Measured on the pubic symphysis force transducer and filtered at channel class 600.

Additional measurements.

The above mentioned parameters are those considered to be the most relevant to injury risk with current knowledge. Other parameters which might be of interest, primarily for research purposes or for comparison of dummies and biomechanical reference data or between dummies, and which could be recorded without any criteria attached to them are;

Head: Peak head resultant acceleration and that exceeded for 3 msec.

Thorax: Peak lateral spine acceleration measured at T1 and T12 Peak rib acceleration measured on the struck side of each rib.

TTI calculated from the rib and T12 accelerations filtered using a special 100hz. FIR routine.

Pelvis: Peak lateral acceleration.

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