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Report on EUROSID 1989

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EEVC Working Group 9 - Report on EUROSID 1989

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Abstract

The paper briefly describes the status of the production version of the European Side Impact Dummy, EUROSID. The paper details the improvements that have been made or are being considered to the Production Prototype dummies prior to the final specification of the Production EUROSID dummy EUROSID-1. The certification requirements are briefly described where they are different from those detailed in the 1987 EUROSID User's Manual. The overall performance of the production prototype dummy in crash testing is reviewed with comparisons being made to accident reconstructions and cadaver data.

Introduction

The European Side Impact Dummy EUROSID has been available in production prototype form for about two years. Examples have been purchased by both government and research laboratories as well as vehicle manufacturers. Apart from basic evaluation as a test device the dummy has been evaluated by several of the organisations for biofidelity and in the EEVC Side Impact Test Procedure (1).

The Production Prototype EUROSID has experienced several problems, in particular with instrumentation. These problems were reviewed in the Status Report on EUROSID (2a) presented at the special seminar on side impact that accompanied the 1988 IRCOBI conference (2). These problems have now been overcome. The later batch of dummies has incorporated several of the improvements detailed in that report. This seminar included several papers concerning the use and the biofidelity aspects of EUROSID (2b)(2c)(2d)(2e). In addition to these papers there have been a few other papers presented at other meetings and committees reviewing certain aspects of the dummy (3)(4)(5)(6). The purpose of this paper is to review briefly the current status of the EUROSID dummy and to comment on some of the important results published in these papers.

In general the published papers have commented only on the basic use of the dummy in vehicle testing, and its biofidelity compared with a collection of performance requirements for a side impact dummy (7)(8)(9)(10)(11)(12) developed by the ISO\TC22\SC12 Working Group 5. It should be noted that several of the ISO responses do not relate to the proposed performance criteria to be used with EUROSID in the EEVC test procedure.

EUROSID development

EUROSID has been developed under the auspices of the EEVC, within four European laboratories, with some funding in the early stages from the EEC. It has been developed to be used in the EEVC Side Impact Test Procedure as well as for scientific research and vehicle development. The dummy has been designed to be

a human surrogate in the vehicle impact so that data recorded in the test can be related to the risk of human injury. One of the main practical requirements for a test dummy is that it should not be seriously damaged in during an impact test.

Originally four First Prototype EUROSIDs were produced for testing within the EEVC. Subsequently, a Production Prototype design was produced for wider evaluation. Experience gained with the Production Prototypes is leading to the evolution of a final design specification of the dummy EUROSID.

EUROSID Performance

There are several aspects that must be examined in the evaluation of a crash test dummy. Much emphasis is placed on biofidelity at the expense of other equally important aspects. Not all aspects of EUROSID's performance can be reviewed within this paper, therefore only the principal areas of concern will be examined.

1) Repeatability.

Any test device to be used in a full scale test procedure must give the same output when subjected to the same input conditions. A simple assessment of repeatability is given by the coefficient of variation (CV), which can be determined from a number of repeated tests: the larger the number of repeated tests the greater will be the accuracy of the evaluation. One complication regarding the evaluation of repeatability is the repeatability of the test itself, another is the care taken to set up the dummy and carry out the test in exactly the same manner. The more complex the test procedure the greater is the likelihood of test variability.

The First Component Prototype EUROSIDs were evaluated for repeatability in impactor tests (13). The maximum CV for the injury criteria parameters were; 1.3-5.2% for chest deflection, 1.8-7.8% for the abdomen switch contact force and 3.3-6.6% for the pubic symphysis force.

Repeatability tests have been carried out by JARI/JAMA (5) on two dummies based on 5 simple impactor tests. The largest CV mentioned was 12.1% for accelerations on the spine. This is not the most important parameter with respect to the proposed performance criteria. The CVs of other important parameters were less than 10%. Some assessment of repeatability can also be estimated from repeat vehicle impacts, although this will be less statistically accurate, being based on only 2 or 3 tests. This is by far the best method of assessment since the dummy is being loaded in the same way as the human would be in a vehicle crash. In one test programme the UKs. Transport and Road Research Laboratory (TRRL), the Federal Highway Research Laboratory Germany (BASt) and FORD have tested the same small vehicle model to the same EEVC procedure (1,14). Also BASt have tested two Ford Fiestas and VW Polos (2e) and TRRL three small cars and three medium cars (15). For each dummy good repeatability of dummy loading was observed in all of these tests. The largest variation was associated with the head acceleration, as would be expected due to lack of control in the position of head contact.

The Netherlands Road Research Institute (TNO) have performed one other series of important tests that can give an indication of the repeatability of

EUROSID (16). In this test programme TNO reconstructed one of the FAT cadaver impacts. This test was repeated three times using EUROSID. Very good repeatability was observed in these tests. The injury criteria coefficient of variability for the head was 3%, for the thorax between 3 and 6% and the maximum instantaneous CVs of the pelvic forces were 12 and 30%, the worst being for the pubic force. It is expected that this variability will reduce with the new transducer to be used in future pelvese.

2) Reproducibility

Reproducibility is the ability of different dummies to produce the same results in a similar test as distinct from obtaining repeatable results from the same dummy as discussed above. This feature of the dummy was addressed in the original EEC supported validation programme on the first pre-production prototype dummies, the results of which were presented in Brussels 1986 (13). The reproducibility was assessed in that programme by a set of impact sled tests against a modified rigid wall. No similar programme to evaluate reproducibility has been carried out using the production prototype dummies, although several organisations have access to more than one dummy. JARI/JAMA (5) have been able to compare two dummies as an extension of their repeatability studies. Only rib acceleration is mentioned as giving a variation above the 10% threshold, at 10.1% and 12.1%. The tests performed by TRRL, BASt and Ford (1,14) on the same vehicle model at different test laboratories mentioned in the previous section also suggest good reproducibility since different dummies were used at each facility, yet the results were satisfactorily similar.

3) Durability

Although durability as a topic has not been tested systematically some idea of durability can be gauged by the request for spare parts and comments from users. At the moment there appears to be a problem with the neck in the first two production batches. The neck manufacture has since changed and it is hoped that these problems have been overcome. A few ribs have softened during use but manufacturing improvements have been made to overcome this problem.

Damage to the soft flesh has occurred in some of the dummies. Some splitting of the abdomen flesh has been caused by misuse and non adherence to correct handling procedures, as detailed in the User's Manual (18). Some tears have occurred in the pelvic flesh. To some extent this can be attributed to the lack of support being given to the legs when the dummy has been lifted or placed in the vehicle. A vinyl skin on the pelvis should ease this particular problem along with better handling procedures.

Some of the damage could be related to the use of the dummy in extremely severe tests, or cumulative damage over a number of tests. There are little data available to quantify the expected life time of each dummy component, but regular examination and certification should reduce to a minimum the risk of failure during a test. Overall EUROSID has proved to be a very robust dummy well capable of being used in a full scale test procedure.

4) Sensitivity

Sensitivity has not been specifically addressed in any of the published reports in terms of dummy component testing. However this aspect was studied in the EEC validation programme (13) carried out on the First Prototype dummies, within a controlled environment. Sensitivity was studied in two ways - 1. Sensitivity to the environment, eg temperature, and 2. Sensitivity to the impact, eg mass and velocity. It was found that the EUROSID results were very insensitive to temperature, to impacting mass and impact direction (within the range ±20 degrees) but highly sensitive to impact velocity and contact area, as intended.

A few organisations have attempted to modify vehicles with the aim of improving them in terms of occupant injury. TRRL (15,16) have carried out tests, using both the EEVC mobile deformable barrier and car-to-car on two different models of car. Hobbs (16) and Glaeser (17) have both studied the effects of barrier velocity and mass as well other parameters on the results of the side impact test. EUROSID has been found to be able to detect changes in both barrier mass, type and impact velocity as well as design modifications in the vehicles. The sensitivity to barrier velocity was found to be greater than to barrier mass, the same trends as found within component testing. This work has also shown that EUROSID can detect changes between standard and modified vehicles.

5) Biofidelity

One of the main design features of a crash test dummy is that it should adequately model the living human being, such that the transducer records from the dummy can be related to the risk of human injury. It is acknowledged that this is possibly the most difficult area of design due to a shortage of biomechanical and biokinetic data. Anthropometric design data on which to base the overall shape of the dummy is easy to obtain. Biokinetic data is very difficult to obtain, especially in the high velocity and high energy environments in which the risk of injury is high. Clearly tests on volunteers are not severe enough to cause injuries thus human cadavers are used.

The precise level of biofidelity required in a crash test dummy is an arguable point. It is the opinion of the EEVC WG9 that the biofidelity of EUROSID should be sufficient to ensure that improvements in vehicle design based on its use will lead to improvements in the crash protection for humans, and thus reduce injury.

ISO Corridors

The ISO corridors have been developed as part of the work of the ISO Working Group TC22/SC12/WG5 (7,8,9,10,11,12). Much of the basic cadaver data on which these corridors were based were used in the development of the EUROSID dummy, which commenced in 1983/4. The basic cadaver data have now been modified by normalisation by ISO (19), and a set of biofidelity corridors created. The ISO documentation gives incomplete details of the test set up for the evaluation of each parameter, in addition some of the test conditions detailed are totally different from the original cadaver tests. It should be noted that some of the ISO

corridors have been derived from as few as two cadaver tests, others by combining data from different, and what might be considered non-compatible, test configurations. Some other apparently valid cadaver tests have not been incorporated in the ISO analysis. Reviewing all body areas there are some 53 requirements described by ISO for the evaluation of a side impact dummy, including 21 requirements for the neck alone. It is therefore the opinion of the EEVC Working Group 9 that these corridors are basic 'first estimates' and can only be used to assess the biofidelity of a side impact dummy in general terms and thus can only be viewed as design target areas. Many more cadaver results will be needed before these corridors can be viewed as providing a detailed design specification for a side impact dummy. THe corridors have been developed over several years and it is not clear which version has been used by each research group. It should be noted that many of the corridors are still under review.

ISO specifies that most of the dummy data should be 'normalised' to a specified standard effective mass. The range of normalisation factors quoted for the dummy is quite wide. Normalisation factors for the thorax can vary between about 0.91 and 1.08, meaning that dummy results require modification by nearly ±10%. This is a significant level of record modification thus great care should be taken to select the correct effective mass from which to derive the normalisation factors. The normalisation factor is also dependent upon the 'standard mass'. TNO (13) have raised several queries regarding both the selection of standard masses and velocities that should be used, especially for the pelvis where the selection of mass and velocity is especially sensitive.

Several research groups have assessed EUROSID against the ISO corridors, although only a few have published details of the normalisation factors and test set ups used. A complete specification of the test set up to be used for the determination of biofidelity has not been published by ISO. It is very likely that some of the differences between test laboratories could be attributed to differences between test conditions.

There is one factor that is not controlled within the test procedures. Several of the test conditions require the use of force transducers and load platforms. The design and use of load platforms is a very important with respect to natural frequencies and inertial properties. No standards have yet been described for these types of transducer the use of which can have significant effects on the final results, although inertia compensated load transducers are required in the rigid and padded wall impacts.

The following sections review, by body part, the biofidelity findings of several research groups.

1) Head Performance (7)

The head, according to the ISO requirements, must conform to two requirements, assessed in two drop tests.

1. A simple drop test onto a horizontal rigid surface with the head inclined to the surface at an angle of 35 degrees, from a height of 200mm.

2. A simple drop test onto a horizontal padded surface with the head inclined at 10 degrees to the surface from a drop height of 1200mm.

Both of these tests are performed on the dummy head detached from the neck and torso. The performance corridors are derived from tests on the whole cadaver. In one set of cadaver free fall impacts the heads were impacted on a padded surface. In the other condition cadaver heads were impacted in a swinging platform test in which the cadaver was strapped to a hinged pallet. Both test conditions are completely different from the ISO requirements, which do not account for mass and spring interaction effects of the neck and torso. It might be expected that the effective mass of the head would be higher when attached to the torso and indeed this was found to be the case by APR (2b). Therefore the deceleration experienced by a detached dummy head would be greater than those observed in the cadaver references.

The head of the EUROSID dummy is a standard Hybrid III head, developed for frontal impact with no lateral requirement. Thus it would be surprising if the head fully complied with the ISO lateral requirements. JARI, APR (Association Peugeot Renault), TNO and GM have all evaluated the biofidelity of the head. In general the Hybrid III head gives higher head accelerations than the ISO limits, as might be expected, by about 20-50%, it is closer than the Hybrid II head used on the US SID.

In a vehicle test only one contact area is evaluated out of many possible ones. Working Group 9 believes that it is necessary to examine other possible areas with additional component tests. To this extent the biofidelity of the head is perhaps less important than that of some other body areas.

2) Neck Performance (8)

The main purpose of the neck is to transfer to the thorax the correct inertial mass from the head. It is not considered to be a critical component of the EUROSID with respect to injury and is therefore not instrumented.

There are three ISO test conditions for the neck. Resulting in a set of 21 output requirements. In addition the requirements all relate to peak or maximum output from a dummy test. In a vehicle, head contact normally occurs with head excursions well below the maximum noted in the ISO documentation, and so it would be more appropriate to compare head translation histories rather than peak values. Unfortunately the test conditions in the ISO requirements are not fully defined (eg:- temperature), thus strict comparison between research laboratories is not possible.

In none of the tests has the EUROSID neck fully met the requirements of ISO, but APR concluded(2b) that the neck is within or very close to the majority of the 15 ISO parameters described in requirements 1 and 3.

3) Shoulder and Arm Performance (9)

The ISO requirement is based on a simple impactor test, the cadaver data being generated by APR. The ISO specification does not describe the type of impactor, ie:- linearly guided or 4-,6- or 8-wire suspended. The specification of the

impactor type is very important, as was discovered during the development of the EUROSID shoulder. The shoulder is a moveable element in directions other than in line of impact and the guidance of the impactor can affect the performance of the shoulder since the shoulder could slide across the face of the impactor.

The shoulder and arm complex are not instrumented since injury to the shoulder is not clinically serious. The main purpose in incorporating an arm and shoulder into a side impact dummy is to attach to the torso the correct inertial masses. The one important requirement is that the shoulder should not provide an unrealistic load path into the spine.

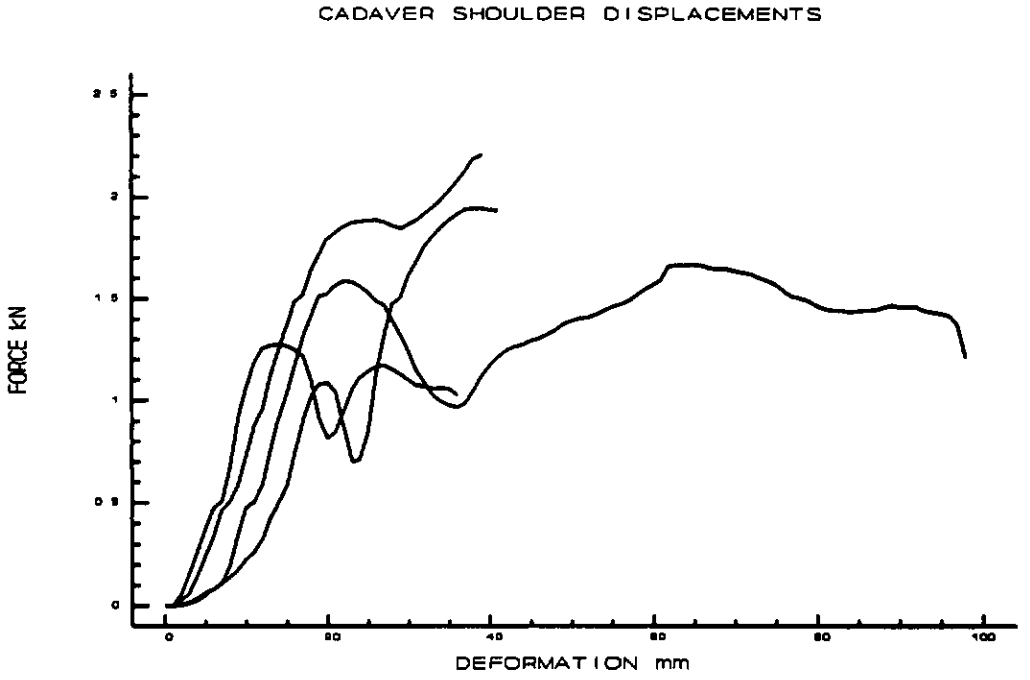

Figure 1.

TNO, APR and JARI/JAMA have evaluated the EUROSID shoulder. In general it is in good agreement with the ISO requirements except with respect to maximum deflection, which is greater in EUROSID (41 cf 83-90mm). However it is not clear that the ISO maximum deflection requirement is well founded since at least one cadaver resulted in a shoulder deflection of at least 100mm. The three other cadaver deflection records appear as if the records have been cut short for some unknown reason, as can be seen in Figure 1.

4) Thorax Performance (10)

The thorax is an important body area. Its performance is affected not only by its own mechanical performance but also by other components such as the head and neck, shoulder and arms, abdomen, lumbar and pelvis. Three sources of cadaveric data were used during the development of the thorax: lateral drop, rigid/padded wall impacts and impactor tests. The rib modules were developed using

computer modelling techniques (20). During development it was not possible to create a single set of simulation modelling parameters that could match all three sets of cadaver data, as has since been found by APR in their review of their cadaver data (21). One of the conclusions drawn from this phase of the design was that the three sets of cadaver data were incompatible in some way, not yet defined. It was therefore decided to base the design of the thorax on those tests which, it was felt, most closely represented the conditions and severities of impact that an occupant would experience in a car impact: this was deemed to be the 15mph rigid wall tests.

Three performance requirements are detailed by ISO. The first is a whole dummy drop test onto two platforms of unspecified size or precise position. A drop height of 1m is specified for a test onto a rigid platform and 2m for a drop onto two blocks of an open-celled urethane foam. The second requirement is a sled-based impact against a rigid load measuring wall from 6.8m/s and 8.9m/s and a test at 8.9m/s against the same wall onto which two urethane foam blocks have been attached. The third requirement is an impactor/pendulum (not defined) test similar to the Part 572 dummy thorax certification, but in the lateral direction from 4.3m/s.

Requirement 1. - Lateral Drop Tests.

Two unguided drop tests are described in the ISO requirements. The first from a height if 1m onto a pair of rigid, force measuring, plates (of unspecified size) and the second from a height of 2m onto two blocks of specified padding mounted on the same force plates. Unfortunately incompatible cadaver tests have been combined to derive the corridors. This incompatibility is caused by the positioning of the arms and shoulders relative to the thorax and plates resulting in markedly different response curves for the cadavers. In addition cadaver tests on different types and shapes of padding have been combined in the derivation of the padded drop test corridors. WG9 supports APR in their proposal to use only cadaver data from the same test conditions for the derivation of the corridors. It is therefore felt inappropriate to comment on the results from these two test conditions since it is understood the corridors are under review and that much of the variability in results between the different laboratories could be attributed to the different test conditions used.

There is one further aspect of the interpretation of the cadaver test conditions over which care should be taken. There appears to be an increase in flesh/body mass on the struck side possibly due to the effects of gravity and the transfer of body fluid in the cadavers, as seen in the published photographs of the cadaver tests. This is likely to affect the force profile and the calculation of the effective displacement which is not representative of a human sitting in a car.

A further complication in the padded drop tests is that the density of the APR padding used in the cadaver impacts is not the same as that specified in the ISO procedures. The cadaver APR padding had a density of 115g/l whereas ISO specifies a padding of density 135 to 150g/l. This anomaly must be corrected since the density of the padding must have an affect on the performance of the dummy.

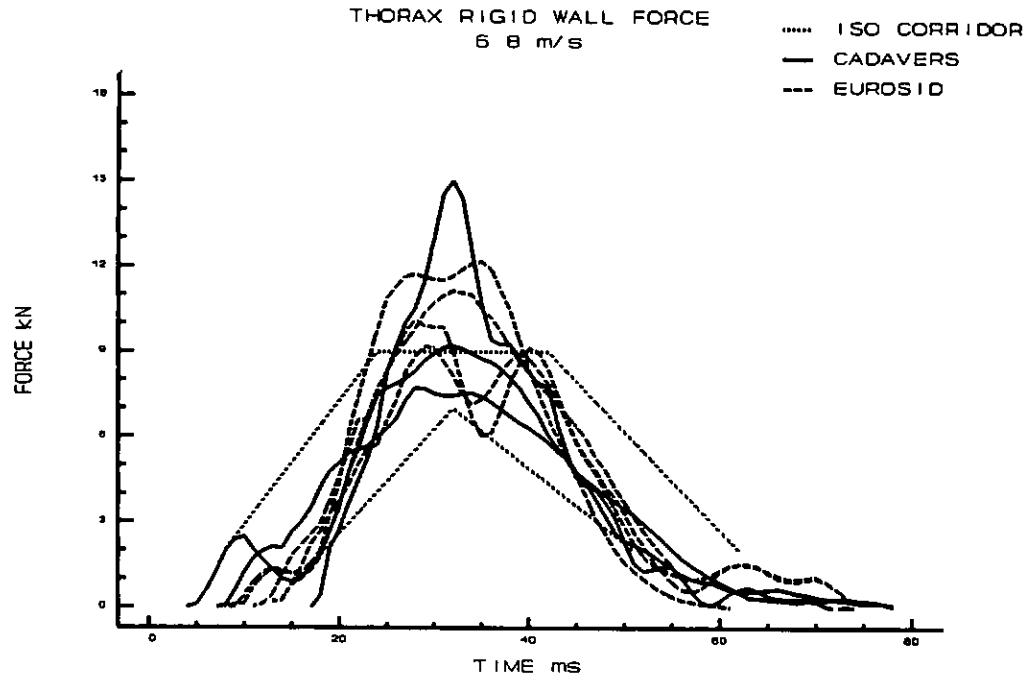

Figure 2.

Requirement 2. - Rigid and Padded Wall Sled Tests.

a) Three cadaver impacts were performed against the rigid wall at 6.8m/s. For an unspecified reason only two tests were used in the determination of the ISO corridor. Figure 2 shows the ISO corridor, all three cadaver curves for the 6.8m/s rigid wall impacts and the results of EUROSID tests performed by TNO and General Motors {[1]}. Although the EUROSID results lie outside the ISO corridor they lie within the range of the cadaver results. The cadaver with the largest response (H82015) received 2 rib fractures whilst the other two received 7 and 9 rib fractures. Thus EUROSID's response lies between cadaveric injury of 2 and 7 to 9 rib fractures, AIS 1 to 3 with a tendency towards the larger (higher AIS) number of rib fractures. Therefore WG9 believes the dummy response to be correct in this particular environment.

b) Only two cadavers were tested against the rigid wall at 8.9m/s. This test condition is very severe, resulting in injuries to cadavers well in excess of any acceptable performance levels. One cadaver received 12 rib fractures and the other 8 rib fractures. Figure 3 shows the ISO corridor and the two cadaver tests, as well as the EUROSID tests performed by TNO and GM. The dummy results are above the ISO corridors.

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[1] In Figure 2 and subsequent figures curves have been aligned by eye by movement along the time axis, by comparison of pulse shape and peak response. Mean EUROSID curves are shown when an organisation has repeated a test.

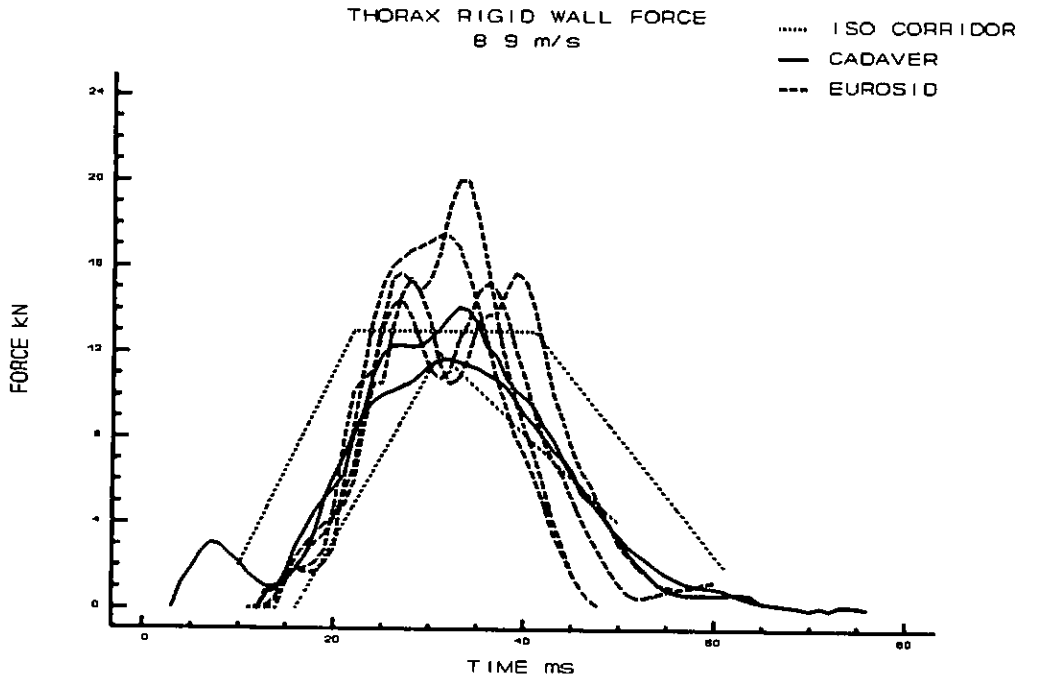

Figure 3.

c) Marcus et al (22). referred to three cadavers tested against the padded wall at 8.9m/s. He reported the response curves from only two of these cadavers and only these two results have been used in the derivation of the ISO corridor. Figure 4 compares the ISO corridors, the two published cadaver results and results from EUROSID. As can be seen, in this test environment there is good agreement between cadaver results and EUROSID.

In both the rigid wall, and to a lesser extent the padded wall impacts the thoracic force is influenced by the presence and positioning of the struck side arm, which is not defined by ISO. In addition the thorax and pelvic forces are influenced by the inertial properties of the load cells and the inclination of the dummy against the force plates after the free sliding phase of the impact, the latter not being controllable.

Requirement 3. - Impactor Tests.

The cadaver tests were performed with both arms supported above the head but in the ISO requirements only the struck side arm is required to be supported. Four cadaver tests were performed but only three have been used in the derivation of the corridor. It is interesting to note that of the four cadavers two were aged 60 and the others 62 and 69 males, so they are likely to be weaker than the average person. Figure 5 shows the ISO corridor with the cadaver responses and EUROSID data. It can be seen that in this particular test the Production Prototype EUROSID is not in good agreement with the cadaver data. A revised rib flesh system is being evaluated along with a rib minus the stiffening riblet, used in the Production Prototype dummy, reducing the inertial mass on the struck side. First results with these minor changes indicate that the performance of the ribs can be brought closer to the ISO impactor corridors. It is thought that these improvements

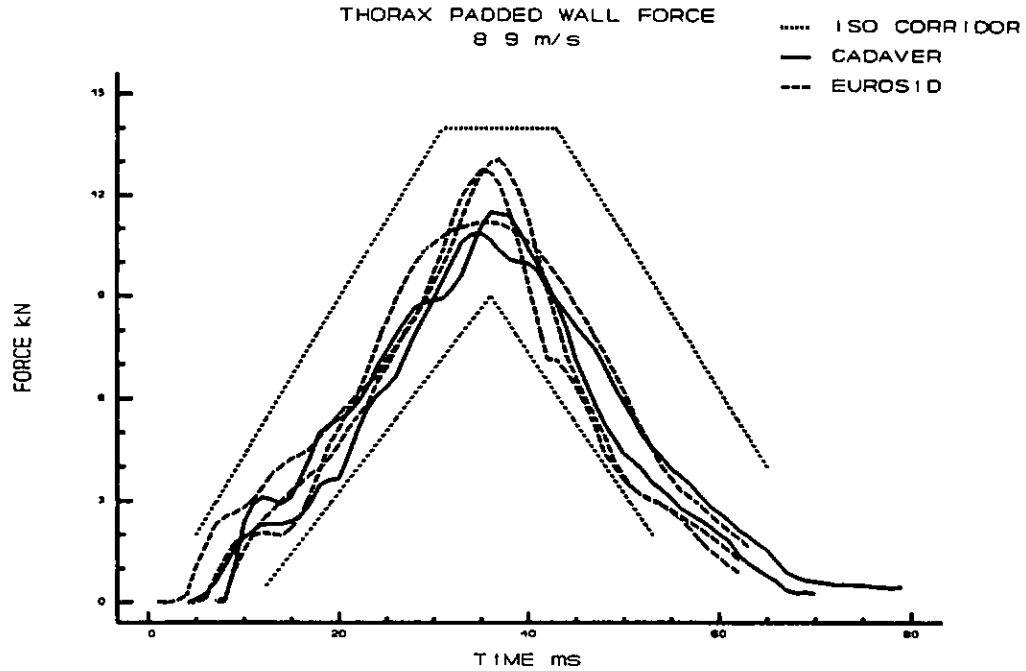

Figure 4.

will affect only this test condition, this is being verified.

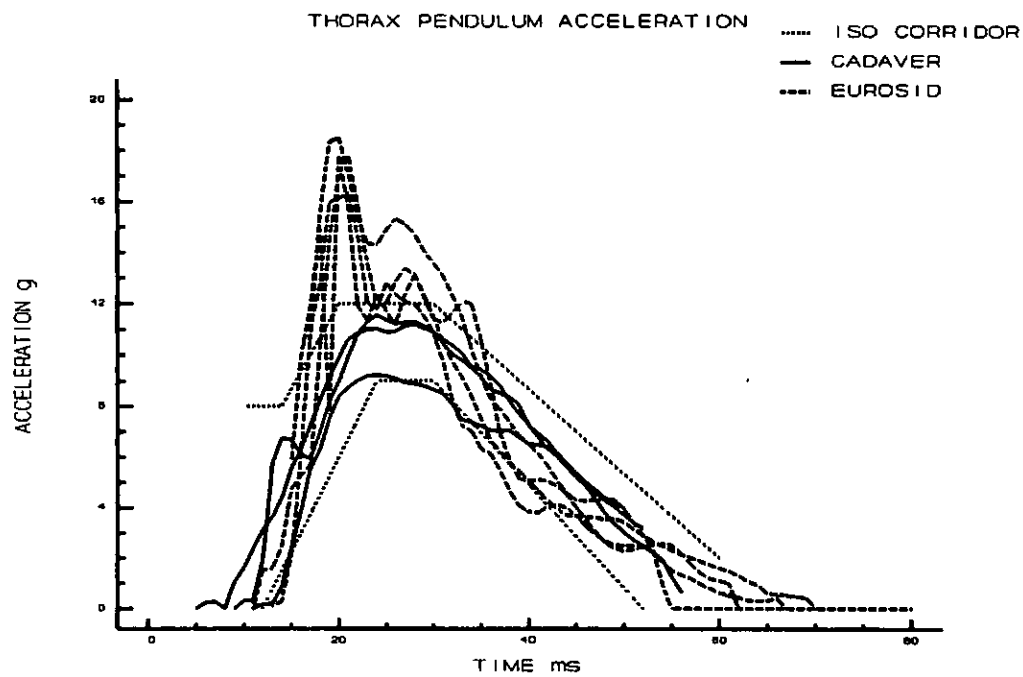

Figure 5.

5) Abdomen Performance (11)

The abdomen of EUROSID was designed as an injury threshold detector based on a combination of force and penetration, with tolerance limits (4.5kN and 39mm) proposed by APR, for an AIS 3 injury level. Figure 6 shows cadaver force deflection curves up to the threshold settings adopted for the switches (13). The abdomen was not designed to be biofidelic above these limits.

There are two different ISO performance corridors based on the APR cadaver drop tests, with tests onto a simulated arm rest from 1m and 2m. These test conditions rely on biofidelity well into the severe injury range, and as such they are inappropriate for EUROSID which is designed to be biofidelic up to the 4.5kN and 39mm limits. Nonetheless for completeness cadaver and EUROSID results for the 1m and 2m drop tests are shown in Figures 7 and 8. It can be seen that the dummy is in good agreement with the proposed corridors up to the performance level of 4.5 kN.

For the 1m drop test, the ISO corridors, shown in Figure 7, combine data from three different tests on arm rests of depths 31, 41 and 51mm. For the 2m drop, Figure 8, results from two different cadaver tests are combined onto arm rests of 31 and 51mm depths. The ISO requirements are based on tests using an arm rest of 41mm.

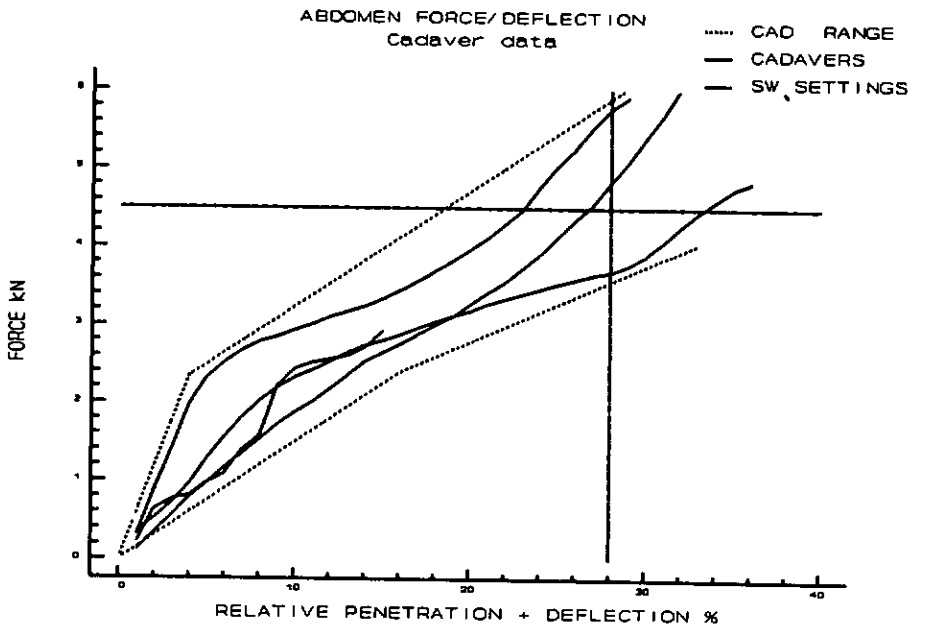

Figure 6.

It is understood that APR are proposing an amendment to the ISO test procedure and location of the arm rest, in the drop test, to a position centred on the 9th rib rather than in the abdomen section of the dummy. One further aspect of the drop tests that could confuse the interpretation of the cadaver results is that of the mass distribution in the cadavers when suspended horizontally. Excess body fluid on

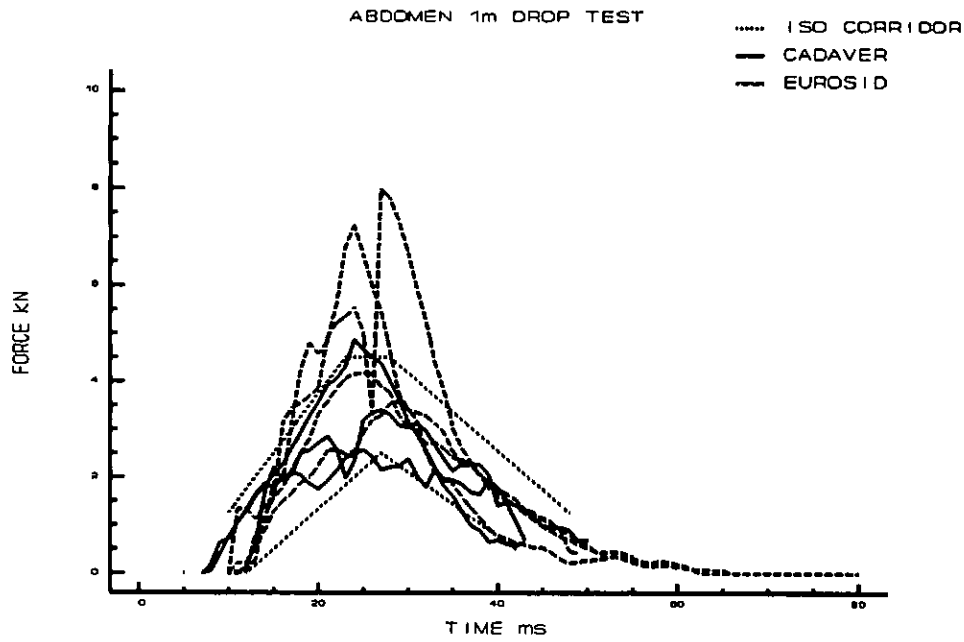

Figure 7.

the struck side could influence the force levels and displacement measurements, as for the thorax.

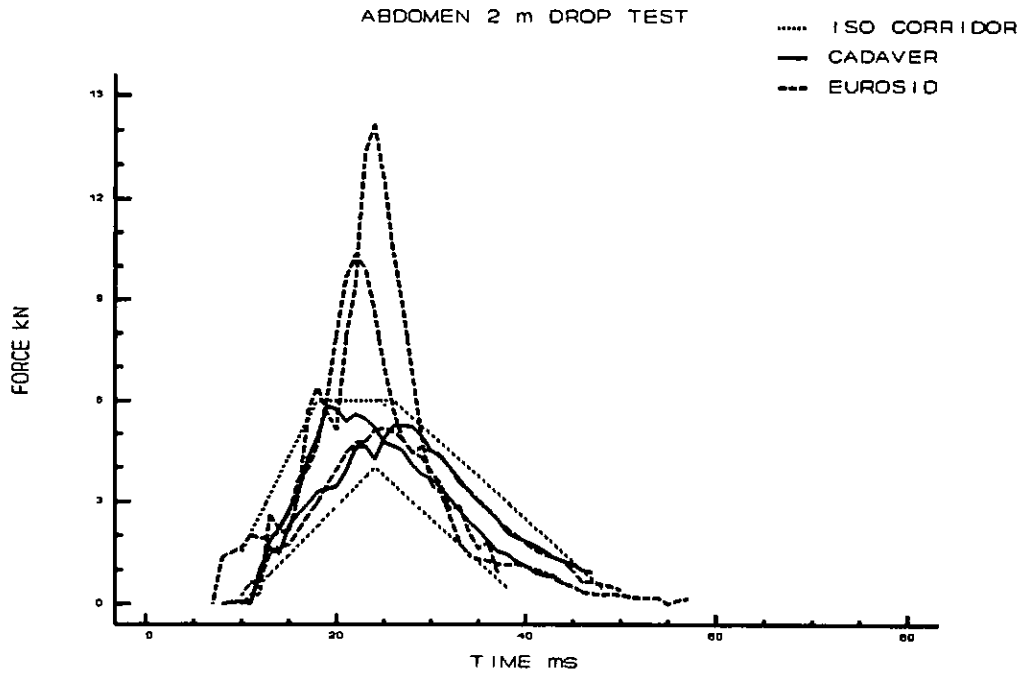

Figure 8.

6) Pelvis Performance (12)

As with other body components the rigid impactor tests on the pelvis emphasise any differences in stiffness between the human and the dummy. The difference in stiffness is less important where the stiffness of the human part is much greater than that of the vehicle structure against which it impacts as is likely to be the case at the pelvis level. ISO specifies three sets of pelvic responses based on three different sets of cadaver tests. The requirements are based on the cadaver drop tests performed by APR, the Heidelberg sled tests and impactor tests performed by the French Research Laboratory ONSER (now called INRETS). The first two conditions are similar to the tests on the thorax, but peak output values are specified rather than performance corridors. Some of the comments made earlier for the thorax, regarding test set up, apply also to the pelvis.

TNO have observed that the normalised pelvic results are very sensitive to the standard mass used in the procedure. During development of the ISO requirements the standard mass used for normalisation has changed. It is not known what normalisation factors most research groups have used, thus comparisons must be made with caution. It is understood that in the current proposal only the impactor tests require normalisation, based on an standard mass of 14.5kg.

For the impactor tests APR, TNO and GM all report peak forces up to 2 and 3 times that required by ISO. In the rigid surface drop tests GM and TNO report forces only just above the ISO requirements. GMs peak forces for the 2m padded drop, the closest to the car situation, are within the corridor. JARI forces range, for the three drop tests, from being within the specified range to about 30% above, the worst being for the 1m rigid surface condition.

Cesari et. al. have reported on the biofidelity of the pelvis at a previous conference (23). They observed that the pelvic responses were too high when compared with the cadaver results and the ISO corridor, and have carried out a parametric study on the EUROSID pelvis to determine the influence on the pelvis, of other body parts. Cesari commented on the effect of the stiffness of the lumbar and the mass and stiffness of the pelvese components. The greatest improvement in biofidelity was observed by changing the stiffness of the ilium, the impactor force being reduced by between 20 and 40% when a more compliant material was used. Figure 9 shows the relationship between peak impactor force and impact velocity for the existing aluminium ilium and the new, less stiff, elastomeric ilium. The new more compliant and biofidelic elastomeric ilium is being considered for use EUROSID-1.

Summary of biofidelity

The precise level of biofidelity necessary in a crash test dummy is a subject of great debate. It is the view of EEVC Working Group 9 that the biofidelity should be sufficient so that transducer records taken from the dummy in a crash test can be related to the risk of injury in a living occupant. The biofidelity reported by EUROSID users in the previous sections compares the dummy against performance

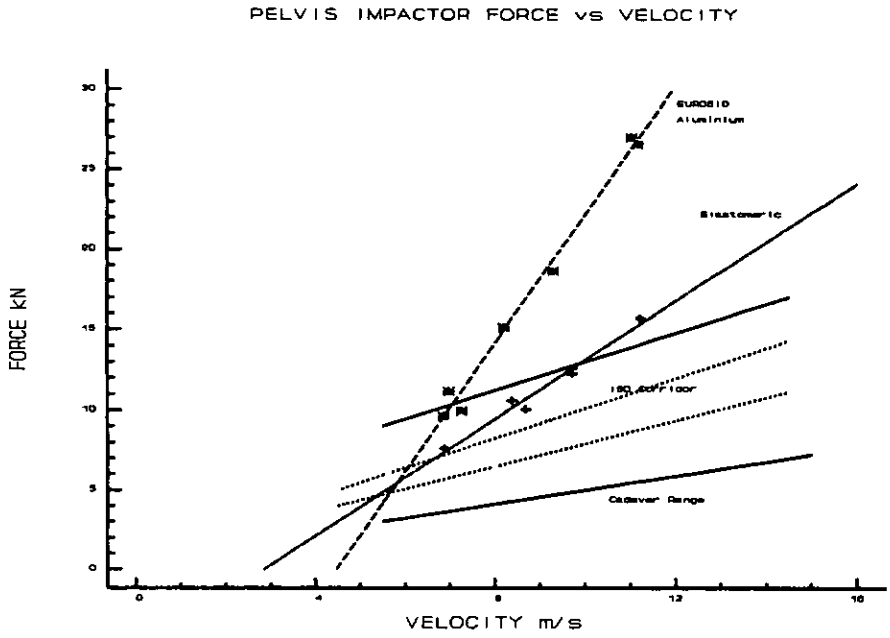

Figure 9.

corridors developed by ISO. WG9 believes that these are good target areas for design but cannot, at the present time, be used as definitive goals not to be infringed. Although some areas of biofidelity in EUROSID are not perfect it is believed that adequate biofidelity has been achieved for EUROSID to be considered a good living human surrogate, within existing knowledge.

One further indication that EUROSID reproduces cadaver responses reasonably well, in impact tests, is given in reference 16 which discusses TNOs tests reproducing one of the FAT whole vehicle tests with cadavers.

Use of EUROSID

In general few adverse operational comments have been received from EUROSID users with respect to setting up procedures for the vehicle impact. The placement of the arms and hands has been the major item of difficulty: there have been problems with the measurement of arm angles and maintenance of their position since they have not been designed to be torqued to any fixed setting. There have been a few comments made regarding the adjustment of the shoulder joint, the upper arm securing screw becoming over tight or loose after manipulation of the arm.

Some representatives of the motor industry, both in Europe and the United States, have proposed that, since the lower arms have no effect on the performance of the dummy in a car test, except to add to variability in the results, they should be removed. WG9 has considered the incorporation of this proposal into the design EUROSID-1, and is evaluating a new design of short arm that can easily be positioned and supported at the correct angle.

Each EUROSID dummy is supplied with a comprehensive User's Manual (18) giving a description of the dummy, its certification and handling procedures. The EUROSID dummy is a more sophisticated dummy than the Part 572 or Hybrid III dummies normally used by test laboratories, and as such requires greater attention to detail in use. TNO have organised two technical training courses for users of the Production Prototype dummies. These courses are regarded as being very important with regard to the training of EUROSID technicians. Several of the problems that have occurred with the Production Prototype dummies would have been avoided with adequate training and adherence to the operating procedures described in the manuals. Further courses will be held by TNO as requested.

Specification of the Production EUROSID-1

It is expected that existing users of the Production Prototype EUROSIDs will be able to upgrade their dummies to the final production specification, by replacement of some components and by retuning of others.

The following modifications are being proposed and evaluated to the specification of the Production EUROSID dummy, the specification of which will be produced by mid 1989.

1. Neck - No change in the design but durability will be improved and a facility for tuning, with respect to certification, will be introduced.

2. Shoulder and arms -

a. Revised arms. The lower arm and hand may be removed. The upper arm skeleton has been modified preventing the flesh around the shoulder shifting over or falling away from the joint.

b. The shoulder/arm pivot will incorporate a thrust bearing and two detent stops to assist in setting the arm position relative to the thorax, and will avoid the arm joint becoming over-tightened or loosened during movement. The arms and shoulder cams will remain reversible as in the current design.

3. Thorax -

a. Revised flesh system (material specification and depth).
b. No internal riblets on the struck surface.
c. Minor detailed improvements to the inside of the dampers.
d. Improved optical displacement transducers.

(Instead of the optical transducers linear potentiometers, or other transducer systems, could be used if the resulting signal was without distortion in both directions. The alternative transducer must be capable of recording at least 55mm of displacement, with a resolution of 0.5mm or better, at a maximum velocity of at least 10m/s in both directions and acceleration levels of at least 200g.)

4. Abdomen -

a. A revised continuously measuring transducer will be available as a direct replacement for the tape switches. It should be noted though that the threshold switch now being used is considered adequate for use in the EEVC test procedure.

5. Pelvis -

a. The external flesh system will have a vinyl skin.
b. The pubic load cell will now be the RDP Sensotec Type 31 5000lbf tension/compression force transducer. (This transducer cannot be fitted into the first two batches of Production Prototype EUROSID pelvese.)
c. The pelvic bones, currently produced in aluminium, may be manufactured in a rigid elastomer and will be removable for servicing or replacement.

Certification Procedures

All certification procedures will remain fundamentally the same. Some slight changes to the certification corridors and operating procedures will be included in the User's Manual to improve the ease of certification. The principal changes related to the neck, thorax and lumbar. To eliminate head rotation about the vertical axis, which can occur in pendulum certification, a new symmetrical headform has been developed with the correct lateral inertial properties. This new test head permits the use of electronic measurement rather than photographic.

Current lumbars require certification in a different dummy (Part 572) in a frontal direction. A new simple certification procedure is to be adopted using the same test device as used for the neck. Lumbars will then require certification in the lateral direction. Full details will be included in the User's Manual.

Summary and Conclusions

1. EUROSID has been shown to be a robust dummy with sufficient repeatability, reproducibility and sensitivity to be used in the EEVC Side Impact Test Procedure.

2. Biofidelity has been assessed by several research laboratories and compared with the ISO corridors. It is the view of EEVC WG9 that these corridors, in their current state, can only be used as target areas and not as definitive objectives.

3. The EEVC believes that the EUROSID dummy is sufficiently biofidelic for use in the Side Impact Test Procedure.

4. EUROSID has been shown to be able to differentiate between vehicle models and to detect modifications that have been made to standard vehicles to improve their impact performance in side impacts.

5. The improvements detailed in the report will overcome most of the problems reported by users of the current Production Prototype Dummies.

6. New certification procedures are to be adopted for the neck and lumbar. Others are to be improved.

7. Several improvements are to be made to the design of the Production Prototype EUROSID. Users of this version of the dummy will easily be able to upgrade their dummies to the final design.

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