

Dummy Specified in the European Pole Test as Part of the EEVC Interior Headform Test Procedure

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Introduction

Part of the work programme of EEVC Working Group 13 is the study of side impact test procedures as they might be appropriate for the European situation and a type approval regime. The Terms of Reference of WG13 include the development of a repeatable and meaningful head impact test for the evaluation of head impact protection in side impacts.

Since the start of this work, WG13 has set out to determine the factors needed for development of draft EEVC Test Procedure, such as the determination of “worst case” test conditions for specifying contact point and approach angle, etc.. Likewise, the applicability of the FMVSS 201 pole test has been investigated, for the exemption for side head airbags mounted in the cant rail. The research particularly has focussed on the use of the EUROSID dummy, regulatory test device in the ECE MDB and EuroNCAP pole tests, instead of the SID-HIII dummy required in the United States.

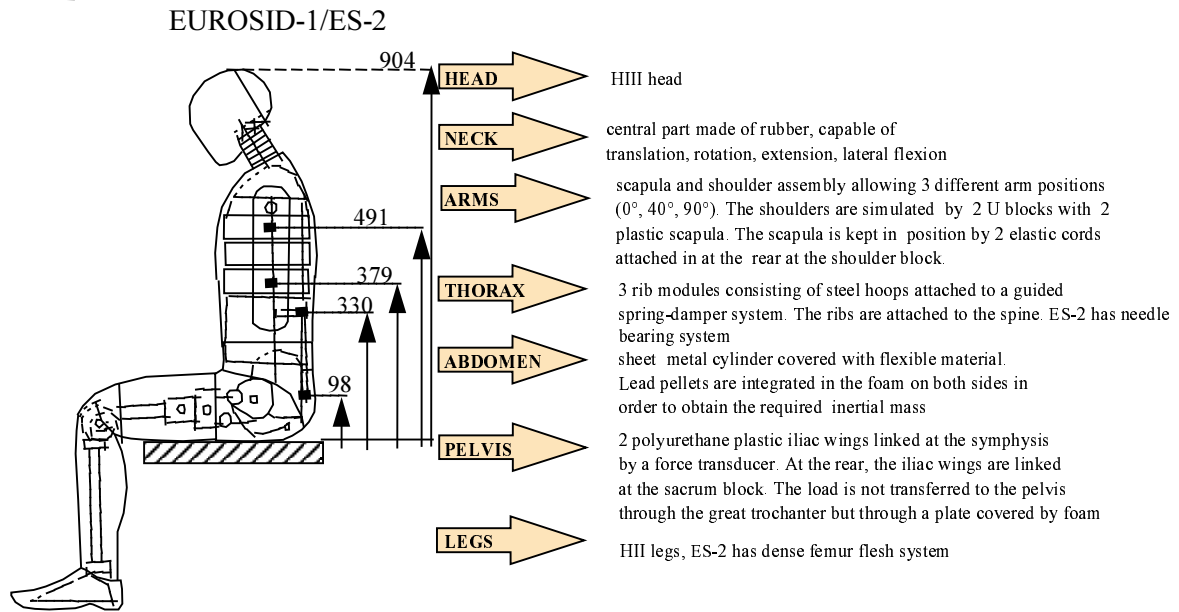
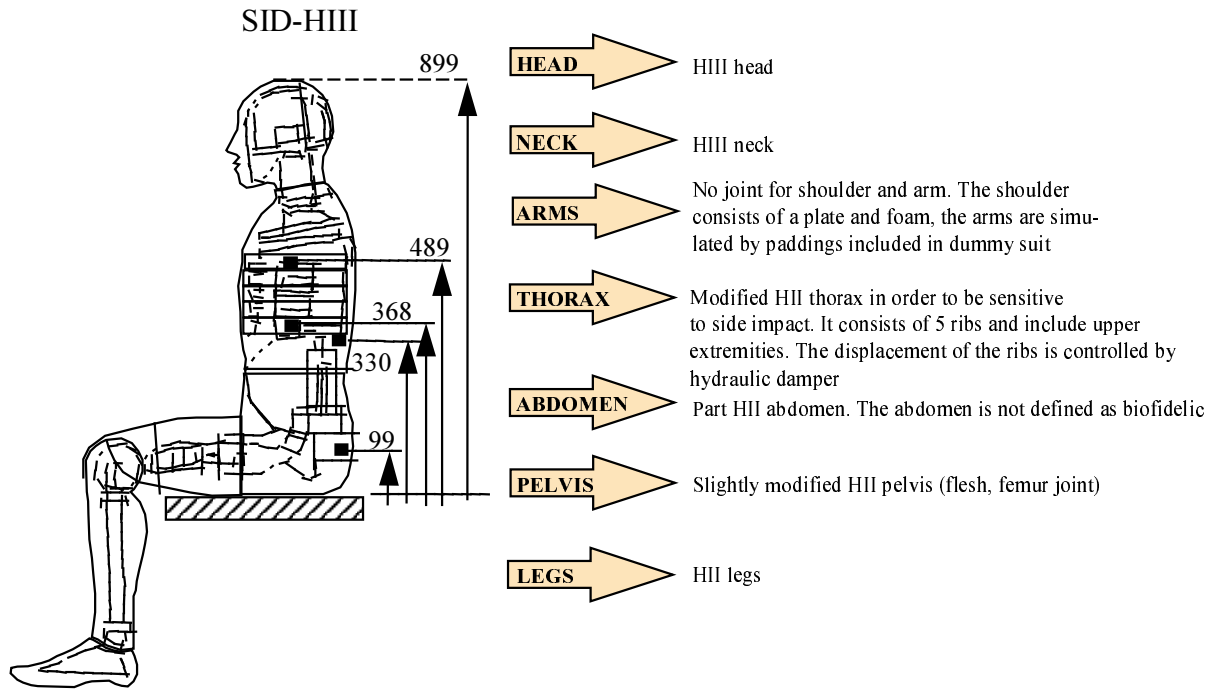
The WG13 members have been asked by the vehicle manufacturers whether testing with the SID-HIII could be considered as an alternative since some of them are already using this dummy. Consequently, the chair of WG13 has sought advice from WG12 on the suitability of SID-HIII for this test in Europe, either in place of EUROSID or as a specified alternative.

In response of this request, WG12 has collected information available in literature about the appropriateness of both SID-HIII and EUROSID in a biomechanical sense. In addition, WG12 has developed a questionnaire to get feedback on the use and experiences with these dummies from its members and technical advisers. This report summarises the main findings and draws conclusions on the basis of this research.

Comparison of SID-HIII and EUROSID Dummy

Two 50th percentile male side impact dummies are mostly used for pole testing today: the US.SID-HIII (based on US.SID and regulated for FMVSS 201) and the EUROSID (version 1 regulated in ECE R95 and ES-2 used in Euro NCAP as of Phase 12). Other non-regulatory side impact dummies, such as the BioSID and SID-IIs are not considered here.

Below the design features and main differences between the two dummy designs are shown. In addition, a comparison of some anthropometric data and injury assessment capabilities is presented.



Comparison of anthropomorphic measurements

Masses in kg	SID	EUROSID-1	Male 50 th perc. [2]
Head	4.5	4.05	4.13
Neck	0.8	1.06	0.96
Thorax + suit	Upper torso 29.6	22.5	23.76
Arm	---	1.26×2	3.79×2
Abdomen		5.07	2.36
Pelvis	Lower torso 16.7	11.91	11.41
Legs	12.45×2	12.6×2	13.18×2
Total	76.5	72.3	76.56

Comparison of injury assessment capabilities

Body part	SID-HIII	EUROSID-1/ES-2
Head	$\gamma(x,y,z)$	$\gamma(x,y,z)$
Neck	Upper neck	Upper (ES-2) and lower neck forces and moments
Upper extremities	None	Shoulder force (Fx, Fy, Fz) load cell
Thorax	Upper and lower rib γ , T12 $\gamma(x,y,z)$, T1 $\gamma(x,y,z)$, rib deflection	γ upper spine, γ lower spine, γ ribs, Rib deflection (3), backplate loads
Abdomen	None	Forces (3)
Lumbar spine	None	Forces (Fy, Fz) and moments (Mx)
Pelvis	$\gamma(x,y,z)$	$\gamma(x,y,z)$ pubis force
Lower extremities	None	Femur forces (Fx, Fy, Fz) and moments (Mx, My, Mz)

Different studies have been done to compare side impact dummies performance. Most have focussed on biofidelity of SID versus EUROSID, BioSID and more recently the WorldSID prototype, using ISO (TR 9790) requirements, EEVC or NHTSA criteria as a basis [1, 2]. Although differences in outcome exist, these studies are generally consistent in the way SID(-HIII) is rated against EUROSID. Illustrative is the most recent biofidelity comparison of the WorldSID prototype, ES-2 and SID-HIII dummies carried out by NHTSA [3], showing better lateral biofidelity for ES-2 than SID-HIII. In this study, the WorldSID dummy under development scores the overall best biofidelity, underlining its superiority in design.

NHTSA Comparison of biofidelity of side impact dummies. A lower rank means a higher biofidelity score

	SID-HIII	ES-2	WorldSID
Overall external biofidelity rank	3.8	2.7	2.5
Overall internal biofidelity rank (w/o abdomen)	1.9	1.6	1.5

Synthesis of questionnaire results

A questionnaire has been developed consisting a four parts. Information was requested on the respondent background, current test experience with regards to pole testing, dummy issues observed, and finally on harmonisation issues. The form was sent out WG12 members and their technical advisers. In Germany, the form was also distributed further amongst VDA members. In total 12 replies were received, distributed over countries and organisation as indicated below. Of the 6 manufactures that replied, 5 are currently selling cars on the US market. The list of research institutes includes 3 Euro NAP certified labs.

	OEM	Supplier	Research institute / government	Total
France			1	1
Germany	4	2	1	7
Italy	1			1
Netherlands			1	1
Sweden	1			1
United Kingdom			1	1
Total	6	2	4	12

Current test experience

Out of 12 organisations involved in this survey, 11 have useful experience with pole testing. Of those that have experience, all perform pole tests according to the Euro NCAP test protocol using EUROSID-1 and progressively more ES-2 dummies. Manufacturers that sell cars in the US perform pole tests according to the FMVSS201 standard. In this case, the required dummy is SID-HIII. Suppliers use both dummies in sled tests, simulating full scale crash tests referred to in FMVSS201 and Euro NCAP.

For OEMs and suppliers the primary interest is the development and compliance of restraint systems (side and curtain airbags) and vehicle structure, to certify US-models and to achieve a good Euro NCAP score. Euro NCAP certified labs perform tests pole tests mainly as part of the Euro NCAP program, including so called “pre-tests” for customers.

The measurements taken during the pole test vary considerably. On the vehicle (struck and non-struck side) accelerations, deformation or airbag parameters are often measured. Regarding the dummies, generally more measurements are taken than necessary for the assessment of the vehicle (based on head accelerations), in particular in the head, neck and chest region of the dummies. The replies received reflect that the fact that EUROSID-1/ES-2 dummy currently offers more instrumentation options than SID-HIII.

Dummy issues

Although both dummies are being used for pole tests, the EUROSID-type dummy is used more frequently. Of 11 organisations, 2 have indicated that SID-HIII is used more. Both are OEMs with a strong US market presence. No major problems were noted for both dummies. Some issues were mentioned for EUROSID-1 that have been addressed with ES-2. For SID-HIII, initial durability problems were mentioned at the head-neck interface (now solved with redesigned neck interface) and at the femur-knee/tibia connection.

The SID-HIII has a rather different design compared to the EUROSID. In general the (body) readings are not comparable except for the head/neck. This due to the different body design as well as another instrumentation layout. Disparities in HIC values are small, and can be explained by the different head mass and the different design of the torsos. The kinematics of the two dummies are also different. By some, EUROSID is felt to be more reliable measurement device, with less damage and fluctuations occurring in comparison with SID-HIII. Handling of the SID-HIII on the other hand seem to be more simple because the dummy has less instrumentation.

Users have different opinion about the required level of biofidelity for a dummy used in pole tests. Some believe lateral biofidelity for this use is not important, others believe only head and neck need to be biofidelic. Most think, however, that the biofidelity of the spine and the shoulder is important as the dummy’s movement is predicted by the support of door trim parts with car specific geometry. In the same manner, the biofidelity (flexibility, stiffness, kind of freedoms, etc.) of the torso/pelvis system is directly influencing the neck/head kinematics. The latter is particularly the opinion of the suppliers, that use the dummy as a design tool rather than an assessment device.

Taking into account the different construction of SID-HIII and EUROSID and the limited assessment criteria, both dummies could be acceptable in today’s pole test configuration. However, EUROSID is the more the versatile dummy, with more realistic neck input. Overall, 4 out of 11 users recommended the use of SID-HIII, primarily since it is already required for FMVSS201 and due to its more simple design (no arm). When asked what dummy could be used in an oblique pole tests (as proposed by the IHRA SIWG), most were in favour of ES-2 due to the more distinct response to selective off-axis loads of the thorax and abdomen.

Harmonisation

In this survey, particular questions were asked about future regulations in relation to the development of the advanced WorldSID dummy and the new side impact test procedures developed by the IHRA group. All users more or less agreed that once WorldSID is available, this should be the preferred dummy for the pole test. On the intermediate solution and exact timing, the viewpoints were not in agreement:

- Most OEMs that are certifying vehicles for the US market have a strong preference for SID-HIII, only to be changed if FMVSS201 would allow ES-2 use. Specifying EUROSID as an additional option for the EEVC test procedure would be acceptable for some, taking into account that both dummies give similar head responses. One manufacturer suggested that the introduction of the EEVC test procedure should wait all together, until the IHRA procedure comes in specifying the WorldSID.
- All others seem to be in favour of adopting EUROSID-1 or ES-2 (depending on which is most current at the time of introduction of the test procedure), as this dummy is the dummy specified in ECE and used for Euro NCAP. The EEVC test procedure is meant as an extension to ECE R95. WorldSID will be introduced in parallel with the introduction of the IHRA test procedure, or whenever EUROSID/ES-2 is going to be replaced for ECE.

Conclusions

In practice, both SID-HIII as EUROSID/ES-2 have proven to be acceptable test devices to assess the risk at *head injury* in the pole test, taking into account the limited criteria that are used today.

The specification of SID-HIII for use in EEVC test procedure offers the opportunity for harmonisation with US standards. This eventually would add a second side impact dummy to the (extended) ECE R95 regulation which obviously has an adverse effect for manufacturers that produce the majority of car models solely for the domestic market.

From the viewpoint of biomechanics, dummy versatility, reliability and injury assessment capability, EUROSID-1 and ES-2 have technical advantages over the SID-HIII dummy. The WorldSID dummy which is under development offers the highest level of biofidelity and injury assessment.

If only one dummy needs to be chosen, it is recommended to use the existing regulatory side impact dummy in the ECE MDB test procedure for the EEVC test procedure. It could be advised to the regulatory test bodies to allow the alternative use of SID-HIII in the intermediate period up to harmonisation on a side impact test device is achieved. Such an advice, however, can only be made if backed up by sufficient evidence based on a range of European vehicles. Ultimately, once satisfactorily validated in pole test and other crash test configurations in particular with regards to the dummy's assessment of off-axis or oblique loads, it is expected that the WorldSID dummy will be the preferable test device due to its superior level of biofidelity and injury assessment capabilities.

References

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