D.2.1b – Report on revision of regulation
EQUS9910208C

Project Acronym: **Smart RRS**

Project Full Title: **Innovative concepts for smart road restraint systems to provide greater safety for vulnerable road users.**

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SUMMARY:

Following the tasks marked on Work Package 2 of the Smart Road Restraint Systems Project, Task 2.1b contains a revision of the French regulation for evaluation of motorcyclist protection systems. This evaluation was designed by the LIER institution under request from the government. The EQUS9910208C test is then analysed in the same way as the Spanish UNE135900 was analysed.

The EQUS9910208C protocol is very similar to the previously analysed Spanish protocol, although it does contain some slight variations. The protocol establishes a 30º trajectory with a 60 km/h approaching velocity, and also uses a modified dummy comprised of elements from several dummies: Hybrid II thorax, limbs and shoulders, a pelvis from a pedestrian kit in order to give it an articulate standing position; Hybrid III Head and Neck allowing measures of acceleration, force and moments. It wears a leather suit, gloves and homologated helmet.

In this particular case, there are two crash configurations: one in which the dummy’s linear plane is perpendicular to the trajectory and another case in which the dummy’s linear plane is perpendicular to the barrier, thus, evaluating two different scenarios.

The dummy launching and approaching speed is 60 km/h, as this velocity is found to be a little above average on this type of accidents, providing a worst case scenario result. Validation for the systems comes from the HIC values obtained from the dummy measurements. Also, the dummies have to be launched on their back from a launching device and must slide for at least 2 m before contacting the barrier.

It is clear that the LIER protocol has very similar strengths and weaknesses as the UNE135900 test, in which it is a very visual system but variations may be produced from environmental conditions, launching system and other disturbances that come with the testing device.
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NOTATION

DGT Dirección General de Tráfico (General Traffic Institute)
E_{friction} Energy dissipated by friction (contact driver – road) (J)
E_{gravity} Energy corresponding to the work done by the gravity (J)
E_{kinetic} Kinetic energy (J)
EN 1317 European Norm 1317: Road Side Barriers
EPS Expanded Poly Stiroil
FR Fatality Risk
FEM Finite Element Method
HIC Head Injury Criteria
INRETS Institut National de Recherche sur les Transports et leur Sécurité
L Distance covered by the rider sliding on the road
LIER Laboratoire d’essais INRETS Equipement de la Route
MFD Motorcyclist Friendly Devices
NCAP New Car Assessment Programme
PU Polyurethane
PE Polyethylene
RRS Road Restraint System
SIR Severe Injury Risk
SPM Sistemas de Protección a Motoristas
UNE 135900
V_i Initial velocity (m/s)
V_f Final velocity (m/s)
(X, Y, Z) Coordinate referential
\alpha Slope of the road (°)
\mu_{rider – road} Friction coefficient (no unit)
g Gravity (m/s2)
m Mass of the rider (kg)
Report on revision of regulation EQUS9910208C

1. INTRODUCTION

1.1 BACKGROUND

Similar to the Spanish case, in France, motorcyclist accidents against a roadside barrier started to become important and motorcyclist associations were pushing the government to come up with a solution to the problem. As done before, accidents were analyzed and a study including a protocol was ordered by the INRETS to LIER. This protocol establishes the requirements that all roadside barrier elements must comply with in the case of a motorcyclist accident.

1.2 PROTOCOL

French LIER protocol is very similar to the Spanish UNE protocol. In this case, a set of two tests need to be performed, with the only variation of the dummy positioning with respect to the barrier. The aim of having these two positions is to discriminate the results obtained in the case where the driver hits the barrier directly with the head against the results obtained from a crash with contact of the shoulder and head. A difference found between protocols is that the LIER protocol is used only for continuous protective devices, having the impact located in a mid location along the barrier (not against a support).

When the motorcyclist protection system is added to an existing road safety system, the containment level must be unchanged, the only vehicle test to be performed being the test with the heaviest vehicle. For a new design of safety barrier, the system must satisfy all the specifications from the European standards EN 1317-1 and 2.
2. REVIEW OF REGULATIONS

In France, the “Institut National de Recherche sur les Transports et leur Sécurité" (INRETS) defined an experimental test of motorcyclist impacts against metal barriers. This test protocol has been carried out by the “Laboratoire d’essais INRETS Équipements de la Route” (LIER), belonging to INRETS. It has been defined based on an accident study developed by INRETS in 1995 through the medical observation of 230 motorcyclists involved in accidents in the region of Lyon. Although the quantity of cases is high, the disadvantage of this study is that the information contained in the report concerns all type of motorcyclist accidents, not only collisions against barriers.

2.1 LIER PROTOCOL (EQUS9910208C)

2.1.1 TEST PROTOCOL

In 1998 the LBSU, a laboratory of INRETS, the French National transport and safety research institute (Institut National de Recherche sur les Transports et leur Sécurité) elaborated a report concerning a test procedure (Bouquet et al, 1998). The objective of the study was to help the laboratory, INRETS Road Equipment Test Laboratory (Laboratoire d’essais Inrets Equipements de la Route) with the final preparation of a protection device test protocol for motorcyclists. Firstly LBSU performed accident analysis in order to choose the test configuration, as well as different biomechanical criteria needed for assessing the impact severity of a chosen dummy, taking into account the potential risk of injury.

From the accidentology analysis, two test configurations were identified. Configuration 30°: the motorcyclist is launched against the safety device (guardrail) lying down with his/her back on the surface and with the head in the direction of impact, this describes a trajectory that forms a 30° angle (tolerance 0.5°) with the barrier.

Figure 1. First trajectory defined by the LIER protocol [site www.lier.fr]
Configuration 0º: the motorcyclist is launched against the safety device which describes a 30º angle trajectory. However, in this case, the body is parallel to the barrier to be tested so that the dummy will impact with the shoulder and the head.

![Figure 2. Parallel impact](site www.lier.fr)

The impact speed in both cases is 60 km/h with a tolerance margin of 5%. The surface of the road was required to be made slippery for the dummy in order to reach the barrier, due to the significant reduction of speed caused by the motorcyclist sliding along the ground prior to impact.

The dummy selected for performing the tests was an assembly of elements from other dummies. It had no specific technical card. This dummy was comprised of:

Hybrid II dummy thorax, limbs and shoulders and a pelvis from a pedestrian kit in order to give it an articulate standing position. Hybrid III Head and Neck allowing measures of acceleration, force and moments, motorcyclist equipment: suit, glove, boots and helmet.

Biomechanical criteria that the measured data has to comply with the values are given next.

**Table 1. Biomechanical criteria used in LIER test**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Biomechanical limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resultant head acceleration</td>
<td>220 g</td>
</tr>
<tr>
<td>HIC</td>
<td>1000</td>
</tr>
<tr>
<td>Neck flexional moment</td>
<td>190 Nm</td>
</tr>
<tr>
<td>Neck extension moment</td>
<td>57 Nm</td>
</tr>
<tr>
<td>Neck lateral flexion</td>
<td>-</td>
</tr>
<tr>
<td>Neck Fx</td>
<td>330 daN</td>
</tr>
<tr>
<td>Neck Fz traction</td>
<td>330 daN</td>
</tr>
<tr>
<td>Neck Fz compression</td>
<td>400 daN</td>
</tr>
</tbody>
</table>
The HIC limit, measured in the gravity centre of a Hybrid III Head, corresponds to a probability of 40% of suffering an AIS3. No value is defined for lateral flexion (Mx) although this parameter is also measured to be used as an indicative and comparative index between the different systems tested. All the measured curves were filtered with 1000Hz.

With regards to the dummy used, it should not be forgotten that the Hybrid II was conceived for frontal impacts and so some of its body elements, such as the shoulder and the knee, might not comply properly with the strict duration requirements for lateral tests.

It was reported that parts of the dummy fractured in tests with a concrete barrier. The parts that failed were the clavicle and the knee. It was therefore suggested to improve the design of the Hybrid II by changing the fragile pieces that broke during the test or to make them from a plastic material in order to withstand lateral loading more robustly.

With consideration to the helmet, it was concluded that reference to this should be well defined before performing any tests, as its energy absorption characteristics influence the values measured in the dummy.
3. CONSIDERATION OF THE LIER PROTOCOL

The aim of this assessment is to define the strengths and weaknesses of this testing procedure in order to bring improvements to it, or in other words try to make it more reliable.

3.1 STRENGTHS

3.1.1 FULL SCALE TEST

The procedure defined by LIER defines a full scale test with an entire dummy (instead of body part impacts) which allows a complete analysis of the dummy’s behaviour at the impact time but also its trajectory after the impact. The behaviour of the tested system can be analysed as well. Situations as dummy over passing the barrier, or body parts of the dummy being blocked into / under the barrier, or detachment of some of the system’s parts are directly noticed.

3.1.2 IMPACT VELOCITY

The impact velocity used for the test is 60 kph. According to the previous in-depth study, this velocity is quite representative of the real cases analysed. By considering the cases involving severely injured victims, a velocity of 60 kph would probably be higher than the average of real cases, tending to give empiric situations, consequently leading to development of good protecting systems.

3.1.3 DUMMY POSITIONS

Testing the systems with several dummy positions allows for an assessment of two possible injurious situations, which is good for the structural analysis of the whole system as it must act in different manner according to the case while maintaining the security performance for heavy vehicles.

3.2 WEAKNESSES

3.2.1 IMPACT ANGLE

As demonstrated in the in-depth study, real cases attest the variety of impact angles which can be found in motorcyclists – barrier crashes. However the norm is defining only one angle of impact, whichever the system to be tested. These systems are probably not as efficient when being impacted with another angle, especially higher angles which may lead to higher stress on head and neck. The procedure as such is consequently only covering a fraction of the real accident situations.
3.2.2 BIO FIDELITY OF THE DUMMY

The dummy used for the tests is a Hybrid II, which is designed for frontal crashes and hence some of the parts are not adapted for these kinds of tests. Clavicle and knee resulted as the most sensible parts which would need to be modified in order to withstand the impact forces. More work is required to obtain a dummy with higher biofidelity for these tests.
4. COMMENTS AND CONCLUSIONS

The UNE 135900 and the LIER testing protocol, both based on analysis of real accidents, are defining similar testing procedures. By definition and to ensure the systems homologated under these procedures provide good protection to the motorcyclists, it is crucial for the testing procedures to be good representations of real case accidents.

UNE 135900 differs from the LIER test in the amount of tests carried on and the impact configuration for the dummy. While UNE test is capable of testing punctual and continuous systems (or a combination of both) considering two potential contact zones (mid barrier and post), the LIER protocol considers only one impact zone but with two dummy positions (parallel to the barrier or with 30º), where the HIC values will be different as the body of the dummy will receive the contact with the head or with a neck/head combination.

In both cases, the dummy launching and approaching speed is 60 km/h, as this velocity is found to be a little above average on this type of accidents, providing a worst case scenario result. Validation for the systems comes from the HIC values obtained from the dummy measurements. Also, the dummies have to be launched on their back from a launching device and must slide for at least 2 m before contacting the barrier.
References


