

ACEA Comments on the current development stage of FlexPLI

The following comments refer to the stage of development of the FlexPLI version GT as presented in the 4th meeting of the FlexPLI Technical Evaluation Group (TEG). The experiences mentioned in this document are collected in a test series conducted at the Federal Highway Research Institute (BASt) by BGS Boehme & Gehring in a joint project of BASt and ACEA with the prototype version Flex GT α . The final conclusions of this test series are attached separately.

Robustness of test tool

- **Legform is as robust as other legform impactors.**
- **Instrumentation wiring is not acceptable.**

Testing to date indicates that the legform has the potential to offer the required level of robustness. However, ACEA has some concern with instrumentation cable damage that can be caused by rebound of the legform after the initial vehicle impact. The cables are directly connected to the instrumentation and therefore any cable damage means the legform has to be stripped down completely to 'fault find' and repair. This results in lengthy time delays between tests, which ACEA deems to be unacceptable, particularly for witness certification testing.

The measurement of the bending moments in the femur and the tibia section via strain gauges should be redesigned by installation of a full bridge configuration which is directly attached to the bone elements in order to avoid e.g. strain gauge elongation due to temperature variations.

New version Flex GT has minor changes, results are comparable with Flex GT α .

From the data presented ACEA agrees that the differences between Flex GT and Flex GT α have negligible effect on injury levels and the results are comparable.

Impact height 75 mm above ground is acceptable.

Injury results obtained indicate that the proposed injury limits can be met with both impact heights, the base height of 25 mm or the impact height increased by 50 mm above the base height (to 75 mm above the ground). If the increased height is proven to produce more biofidelic results (JARII simulation analysis) then ACEA agrees that this impact height can be used.

Handling/Repairing

- **Handling effort is comparable with EEVC WG 17 legform.**
- **Repairing and rebuilding is more complicated compared to the EEVC WG 17 legform.**

ACEA agrees that the handling effort is comparable with EEVC WG 17 legform if no damage to FlexPLI occurs during a test. If the leg is damaged the repair and rebuild is more involved on the FlexPLI due to the number of individual components and the number of sensors.

In addition, special training is also likely to be required for test engineers due to the additional technical knowledge required to use the more complex FlexPLI.

Preparations for the test laboratory are comparatively negligible, but significantly more data channels than in other pedestrian protection impactor tests are needed.

First test results indicate that repeatability is at least acceptable.

First test data presented indeed indicated that repeatability was within acceptable limits. However, for the knee ligaments (specifically ACL and PCL, anterior and posterior cruciate ligaments) a tendency to increasing scatter was noted in more detailed analysis of the test results. This could possibly lead to repeatability issues in further tests and therefore is not acceptable. Further detailed research is necessary on this.

Test results of a “good” performing vehicle with WG 17 legform were confirmed by FlexPLI. Function on a “marginal” performing vehicle has to be checked.

The tests completed to date show that a good performing vehicle (“green” EuroNCAP rating) gives a good performance with the FlexPLI with the currently proposed injury risk thresholds. However, this needs to be double-checked when the injury risk thresholds are finally agreed. In addition, it is necessary to compare the WG 17 legform injuries resulting from a marginal performing vehicle with FlexPLI injuries to confirm the above statement.

FlexPLI is compatible with current passive pedestrian protection features in general. Active systems such as deployable bonnet systems require further investigation.

In terms of injury levels, ACEA agrees that a vehicle already achieving a green rating in EuroNCAP lower leg tests could comply with proposed FlexPLI injury criteria with additional countermeasures.

However, with respect to deployable bonnet systems the use of the FlexPLI may result in a different sensor calibration. For example, the contact sensor signal on the Jaguar XK during tests performed on behalf of ACEA was lower than that of the peak amplitude obtained from WG 17 legform. Further investigation is currently ongoing to understand the consequences to system deployment.

Additional comments not covered in the conclusions of the above mentioned test series

The FlexPLI represents a right leg only. Therefore ACL and PCL results are dependant on the side of the vehicle that is impacted, thus making pedestrian test results asymmetrical. This is not the case for WG 17 legform, which (assuming symmetrical vehicle design) allows injury results from one side of the vehicle to be read across to the opposite side. Whether and how this will be incorporated in any future legislation needs to be understood as it could result in additional testing.

In addition, the legform is performing better during tests at vehicle centre line or at impact points in areas almost perpendicular to impact direction, most likely due to unavoidable rotation. As the FlexPLI additionally assesses 'knee twist' (ACL and PCL) which tends to increase with greater curvature, this may necessitate changes to front end designs to be “flatter”. ACEA believes further work is necessary to understand these effects.

The current certification procedure (in the latest documents also called repeatability and reproducibility evaluation test and assembly test) seems insufficient and does not give detailed information on the calibration status of the test equipment components; in general it is just a functional test for the overall legform. Therefore, either justification is necessary that this test procedure is sufficient or certification and calibration procedures for the components of the legform and the sensors should be defined.

Regarding the criteria for the bending angle the correlation (transfer function) between bending angle and ligament elongation (MCL) should be illustrated in an extra TEG paper (see table “tentative threshold” of TEG/22/). This would close the gap between the 50%-injury-risk level for bending angle and the actually measured ligament elongation value.

In the draft GTR there is an exemption zone defined for the legform test where the deceleration limit is 250g. How can the higher threshold limit for the rigid TRL legform be translated to the proposed measurement criteria of the FlexPLI?

Finally, CAE models and their associated robust correlations for standardized cases (i.e. calibration tests) and the effect of variability on different vehicle front-end configurations are not yet available but crucial for vehicle design.

Summary

ACEA believes that the FlexPLI has much potential and is a wholly worthwhile impactor because of its greater biofidelic performance when compared with the WG 17 impactor.

However, following our initial assessment of information that is currently available, ACEA therefore requires the following points to be solved by means of further work and investigations:

- Robustness – A connection box or separate connectors need to be added into the cable lines (preferably within the confines of the legform) to eliminate the need for a complete strip-down if cable damage occurs. Reconsideration of the measurement of bending moment is recommended.
- Deployable bonnet sensor performance - This issue needs to be fully understood.
- Good / marginal results comparison between FlexPLI and WG 17 legform - Additional FlexPLI testing is required to establish comparison with a vehicle performing marginal with WG 17 legform.
- Front end curvature – Additional tests are required on vehicles with high plan curvature to establish radius/angle limitations.
- Additional tests are to be carried out with a car which has a flat front (sports car) with a “conventional” design, i.e. no “soft nose” design.
- Asymmetrical test results - Further understanding is required as to whether and how this will be incorporated into future legislation. In principle, the test tool must reflect symmetrical vehicle structures and should not require additional tests.
- Ageing behaviour and wear of the fibre glass “bones” and of the rubber “skin and flesh” as well as of the plastic segments of the FlexPLI needs to be investigated.
- The illustration of the transfer function (bending angle to MCL elongation) is needed.
- Extra set of proposed criteria is required for the exemption zone of the GTR legform test.
- A simulation model needs to be made available.