Child Restraint System Support Leg Reaction Forces in UN Regulation No. 129 Front Impact Tests

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I. INTRODUCTION

A support leg is an anti-rotation device that creates a load path between the child restraint system and the vehicle floor. In United Nations (UN) Regulation No. 129 (R129), an anti-rotation device (either a support leg or a top tether) is mandatory for ISOFIX child restraints approved for universal use. This is necessary because ISOFIX child restraints would otherwise rotate about the ISOFIX vehicle anchorages into the seat cushion in a front impact. An anti-rotation device is therefore needed for the regulatory test bench to safely predict the performance of ISOFIX CRS in real vehicles, where the seat cushion properties vary and might differ from the bench. A support leg (or a top tether) can also be found on some larger, seat belt-attached child restraints, typically to improve their performance.

Proposals to amend the support leg compatibility requirements in both child restraint and vehicle regulations were submitted to the 70th session of the UN Working Party on Passive Safety (GRSP) [1-2]. These proposals sought to increase the support leg volume height and to explicitly allow the use of support legs on booster seats (especially booster seats that convert from an integral child restraint when the child has reached a certain height). During the discussions that followed, GRSP concluded more data were needed on the forces generated by support legs on the vehicle floor [3]. The aims of this study were to measure the support leg reaction force in a range of different child restraint types under UN R129 regulatory test conditions and to provide data to support these regulatory discussions.

II. METHODS

Nine front impact experiments were carried out on an acceleration sled at the CYBEX Safety Centre in Germany. All experiments followed the frontal impact test procedure in the 03 series of amendments to UN R129. The regulatory front impact test conditions comprise an impact speed of 52^{+0}_{-2} km/h and an acceleration corridor that peaks between 20 g and 28 g. A uniaxial load cell (Trancell DBSL 'pancake' 5t) was attached to the floor of the impact sled below an aluminium load plate of 155 x 300 mm. The load plate surface was set at the highest position specified in UN R129. This meant each child restraint support leg was adjusted to its shortest position, which was a likely worst-case for the reaction force since it minimised the potential for leg bending.

Fig. 1. Typical experimental setup.

Three child dummies (Q3, Q6 and Q10) were seated in a convenience sample of child restraint systems. These comprised rear-facing and forward-facing integral child restraints (in which the child was restrained by a five-point harness or an impact shield) as well as booster seats. The integral child restraints were predominantly ISOFIX, but one example of a seat belt-attached model was included in the study sample. One of the booster seats was a prototype model, which was installed either with ISOFIX in combination with the seat belt or with the seat belt only. All other child restraints were type-approved to UN R129. The dummies were manufactured by Humanetics, Germany, and certified and prepared for testing in line with the regulatory procedure. The largest dummy within the upper height limit of the child restraint was used in each experiment. The dummies were instrumented in the head, neck, chest, abdomen and pelvis and were equipped with a hip liner. However, the primary output of the experiments was the support leg reaction force, measured with the floor loadcell. All measurement and data analysis conformed to ISO 6487.

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III. INITIAL FINDINGS

The peak support leg reaction force ranged from 4,048 N to 4,544 N for the Q3 dummy in integral ISOFIX child restraints (Fig. 2). The force was slightly higher in the rear-facing models compared with the forward-facing model, but the difference was marginal. The support leg reaction force ranged from 4,630 N to 6,893 N for the Q6 dummy in integral child restraints. The force was markedly higher in the rear-facing models compared with the forward-facing model. The means of attachment of the rear-facing child restraints (ISOFIX vs. the seat belt) appeared not to influence the reaction force greatly. The peak support leg reaction force ranged from 3,834 N to 4,211 N with the Q10 in booster seats.

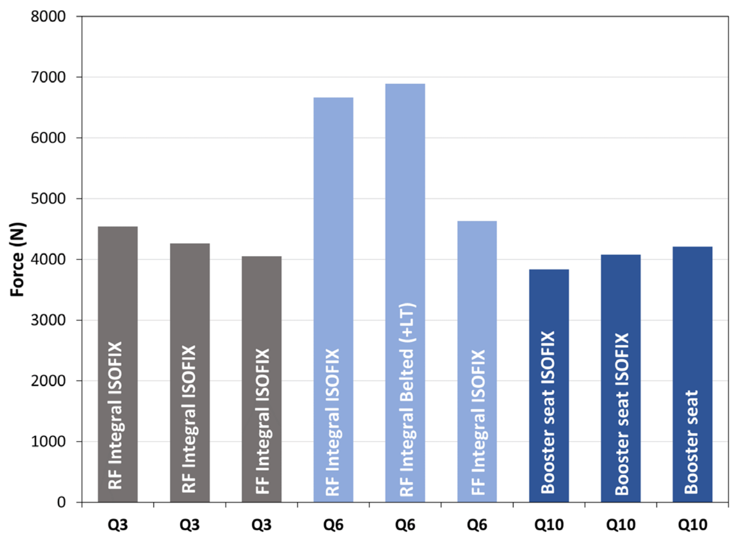

Fig. 2. Peak floor reaction force from the support leg of RF (rear-facing) and FF (forward-facing) integral child restraints and booster seats (LT = lower tether).

IV. DISCUSSION

UN Regulation No. 145 (UN R145) specifies floor strength requirements for i-Size seating positions in cars. A Static Force Application Device (SFAD), which includes a support leg probe, is attached to the ISOFIX anchorages in the car. A force of 8,000 N is applied horizontally to the SFAD for a minimum period of 0.2 s. Engineering calculations show that the test generates a force of 3,200 N to 3,600 N to the vehicle floor (depending on the distance of the support leg probe from the ISOFIX anchorages) [4]. The peak support leg reaction force was typically in the region of 4,000 N for most combinations of dummy and child restraint type during our experiments and reached nearly 7,000 N for the Q6 dummy in rear-facing integral child restraints. However, the response of the vehicle floor under dynamic loading is likely to be different from that under quasi-static loading and hence these values may not be directly comparable.

Research tests were carried out to determine the support leg reaction force during the development of UN R129 [5-6]. These tests were used as a reference when corresponding vehicle requirements were developed for UN R145 shortly after. These 'legacy tests' measured forces in the range of 3,956 N to 5,691 N, with the P3 dummy in rear- and forward-facing child restraints[1]. No tests were performed with larger dummies. Our measurements suggest that most current child restraints generate support leg reaction forces that are similar in magnitude to the legacy data, including our tests with the Q10 dummy in booster seats. Our measurements with the Q6 dummy in rear-facing child restraints were larger than those of the legacy tests, and probably larger than the loads envisaged during the development of the UN R145 requirements. However, incidents of floor failure appear to be rare and have not been raised at regulatory working groups or in child safety literature.

Currently, only i-Size child restraints are subject to a limit on their weight (combined with the child). Similarly, only i-Size seating positions are required to comply with the SFAD test in UN R145. The seat belt-attached rear-facing child restraint was not i-Size and therefore relies on the child restraint manufacturer to inform the user about which seating positions it is compatible with. This also relies on the child restraint manufacturer to contact car manufacturers to determine whether their non-i-Size seating positions can withstand the forces from their child restraint support leg, given the weight of the child restraint and the heaviest child. However, this is not well-defined in child restraint or vehicle legislation.

[1] The UN Regulation No. 44 (UN R44) test bench was used in the legacy tests because the UN R129 bench was not defined at the time. The sled pulse used in the legacy tests was the same as that used in our experiments (UN R44 and UN R129 have the same pulse).

V. REFERENCES

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