# Analysis of Head Vertical Excursion Requirement for Booster Cushions in UN Regulation 129

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### I. INTRODUCTION

Booster cushions were introduced into UN Regulation 129 (R129) in May 2020 [1], having previously been Type Approved to UN Regulation 44 (R44). One of the main differences between the regulatory requirements was the introduction of a requirement to ensure the booster cushion positions the child's head at a height that would allow it to benefit from the vehicle safety systems, e.g., curtain airbag.

R129 also has a requirement that during the dynamic tests the head of the dummy does not cross a vertical plane. This assessment is designed to prevent contact between the head of the child and the roof of the vehicle.

However, the new R129 static requirement will typically lead to thicker booster cushion designs than previously available on the market. This means the largest test dummy (Q10) will be very close to exceeding the head vertical excursion plane. This problem was highlighted by [2]. This study will explore this problem further, with the aim to eventually find a solution.

#### **II. METHODS**

#### **Regulation 129 requirements**

R129 requires the thickness of the booster cushion to be such that it positions the head of the child above 770 mm when seated on the R129 test bench (Figure 1). Where 770 mm is the head position of the Hybrid III 5<sup>th</sup> percentile test dummy sat on the R129 test bench.

However, the head of the test dummy cannot exceed a vertical plane of 840 mm (DA) during the forward movement of the test dummy during the R129 frontal dynamic crash test (Figure 2).

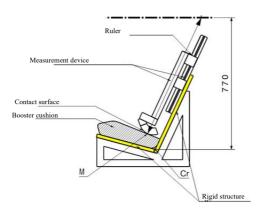
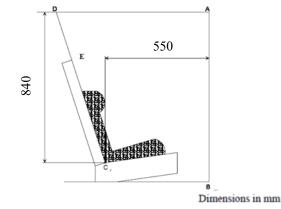
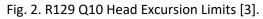


Fig. 1. R129 Head Position Assessment Device [1].





# Euro NCAP Assessment

Curtain airbags are not mandatory for vehicles Type Approved in Europe. However, the European New Car Assessment Programme (Euro NCAP) tests and additional assessments have driven vehicle manufacturers to include them as standard equipment. Euro NCAP carry out a static assessment of the curtain airbag coverage. A Head Protection Device (HPD) Zone is calculated based on the head position of the smallest and largest adult test dummies. The HPD zone is calculated using the H-point position average, to determine the position (Z) of the centre of gravity (CoG) of the hybrid 5<sup>th</sup> percentile and 95<sup>th</sup> percentile test dummies. If the seat is adjustable in X, this adjustment is also considered. The HPD zone is then rounded using 82mm (head radius) around the CoG positions (Figure 3).

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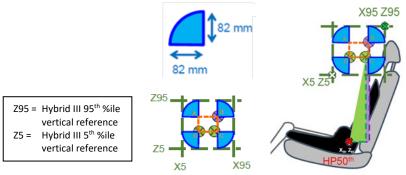


Fig. 3. Example of Euro NCAP HPD Zone on Rear Seat [4].

#### **III. INITIAL FINDINGS**

There were no design constraints on the thickness of a booster cushion Type Approved to R44. However, testing of existing R44 booster cushions with the Q10 has shown that the head position is already at 840 mm [5].

Adalian et al. [4] assessed the head centre of gravity (CoG) positions and measured HPD zones from forty-six vehicles tested by Euro NCAP between 2016 and 2020. The Q10 head position in front and side impact tests was compared to the Hybrid III 5<sup>th</sup> and the HPD zone (Figure 4). This showed that the Q10 head (red, yellow) was always positioned above the head of the Hybrid III 5<sup>th</sup> (blue). The average difference was 36 mm. But importantly the Q10 was always at least 120 mm lower than the Hybrid 95<sup>th</sup> percentile HPD reference zone (green dots).

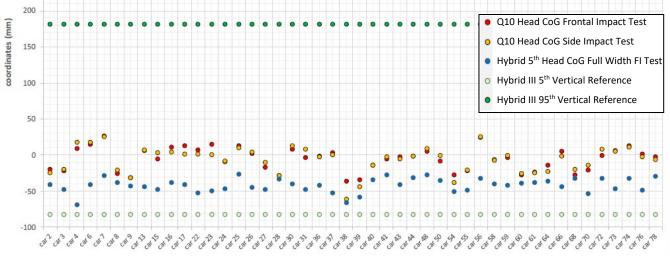


Fig. 4. Q10 & Hybrid III 5th Head CoG Vertical Position [4].

# **IV. DISCUSSION**

R129 has created conflicting requirements for booster cushions that are challenging to achieve. It is likely that R129 booster cushions will need to be thicker than most R44 booster cushions in order to meet the static head position assessment (Figure 1). The consequence being that the vertical head excursion plane will be exceeded even before the dynamic test starts. However, the Euro NCAP head position measurements presented by [4] show that the R129 vertical head excursion plane could be increased and still be below the head position of the Hybrid 95<sup>th</sup> percentile HPD reference zone. The next stage of this work will be to gather vehicle measurement information to confirm the space is available and to propose a new suitable vertical head excursion limit for testing booster cushions in R129.

# V. REFERENCES

[1] UN website, https://unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/2020/R129r4am3e.pdf

[2] Jakobsson L et al., Protection of Children in Cars, 2020.

- [3] UN website, https://unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/2020/R129r4e.pdf
- [4] Adalian C et al., Protection of Children in Cars, 2020.
- [5] Pitcher M et al., Protection of Children in Cars, 2019.