

Proposed Seat Design of Additional Third-Row Seats

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Introduction

Guidelines for the construction and installation of after-market additional seats are provided under Vehicle Standard Bulletin (VSB) 5A *Commercial Manufacture and Installation of additional seats* and VSB 5B *Construction and Installation of additional seats by Individuals*. These VSBs (referred to as VSB 5) recognise three categories of additional seats:

- Category 1: Additional seats intended for use by adults;
- Category 2: Additional seats intended for use by children up to 12 years of age;
- Category 3: Additional seats intended for use by children up to 8 years of age.

The NSW Centre for Road Safety has been examining the crash protection afforded by these seats. For children under 4 years old, our previous study found that a child occupant sitting in a child restraint on a Category 2 or Category 3 seat (*Additional Seat*) was better protected than a child occupant sitting directly on an *Additional Seats*, but was not as well protected as a child in a child restraint in a standard vehicle seat (Suratno, 2011).

There is also an issue for children aged between 4 and 7 because the space requirements for *Additional Seats* under VSB 5 make it impossible to meet the general requirement that children must be secured in a suitable approved child restraint or booster seat. Hence, some states in Australia have amended the laws allowing children aged between four and seven years to occupy these seats without using a child restraint or booster seat provided they are wearing a lap/sash seatbelt or a lap-belt in conjunction with a child safety harness.

However, even when seated directly on the *Additional Seat*, the space requirements for VSB 5 may not be sufficient to ensure acceptable safety for children aged between 4 and 12 because they are at risk of being injured by striking the seat in front or the vehicle roof.

Illustrating the issue

To illustrate the issue, a series of fittings was conducted to demonstrate the current requirements for head and leg spacing (Radius A and B as shown in Figure 1) matched with the anthropometry of the children allowed to use these seats.

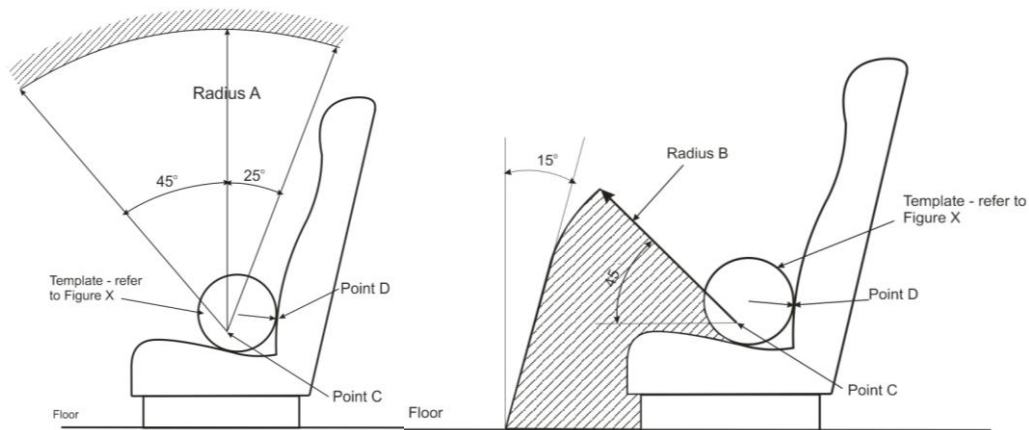


Figure 1
Head and leg spacing

TNO P3, P6, P10 and 5th percentile Hybrid III female dummies were used to represent average four-, six-, ten- and 12-year old children. The P3 dummy was chosen as the closest available dummy for a four-year old child. The 5th percentile female Hybrid III dummy was used to represent a 12-year old child. This dummy has anthropometry very similar to a 50th percentile 12-year old regarding stature, sitting height, weight and buttock-knee length (Andersson, 2012). These dummies were placed one by one on a Category 2 seat fitted into a Ford Falcon Station Wagon.

Photographs from dummy fittings using TNO P3, P6, P10 and the 5th percentile female Hybrid III dummies seated in a typical category 2 seat are presented in Figure 2a, 2b, 2c and 2d. As seen in these Figures, a typical category 2 seat is able to accommodate smaller dummies (P3 and P6) comfortably with their feet on the floor, their thighs resting on the seat cushion and the lap belt on the dummy's pelvic area. In larger dummies (P10 and the 5th percentile female), the leg spacing of this seat is too narrow in such a way that the dummy's thighs are unable to rest flat on the seat cushion and need to be raised, thereby causing the lap belt to ride up onto the dummy's lower abdomen area and increasing the risk of submarining (the pelvis slips under the lap part of the seat belt in a crash). In case of the 5th percentile female dummy, the seat leg spacing is not even able to accommodate the dummy's thighs, resulting in the knees abutting against the top seat back of the front seat.

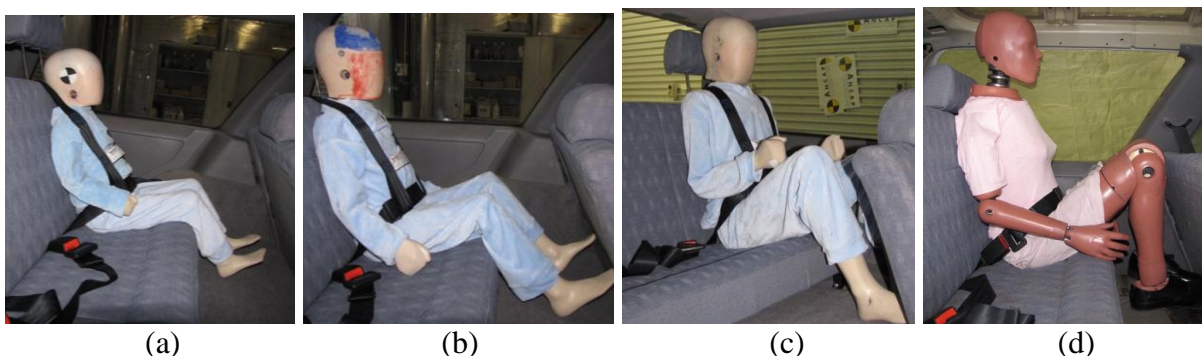


Figure 2

TNO P3 (3a), TNO P6 (3b), TNO P10 (3c) and 5th percentile female Hybrid III (3d) dummies when seated in a typical Category 2 seat.

Matching seat geometries and child anthropometry

Having illustrated the issue, the next step was to match seat geometries with data on the anthropometry of children. The authors of this paper are not aware of any studies conducted to assess Australian child anthropometry. Therefore, this study used anthropometry data from studies conducted by the University of Michigan (Snyder et al. 1975).

In designing the head and leg spacing, one needs to take into account the extra spacing required to accommodate the occupant's movement during a crash. The leg spacing should include the occupant's knee length measured from the hip (H-point) plus a 100 mm allowance for seatbelt elasticity. Similarly, the head spacing should include the occupant's seated height measured from H-point plus 100 mm allowance for the occupant's head upward movement at the rebound stage in a crash, which also provides spacing for getting in and out of the seat.

Figure 3 and Figure 4 show comparison of Radius A and B as defined in the current VSB 5 with the seated height from H-point (plus 100 mm allowance) and the knee length (plus 100 mm allowance) of a range of children aged between 2 to 18 years. Results from these Figures indicate that the current maximum head space requirements are too short and narrow to accommodate the intended occupants.

Thus, for a Category 1 seat, the current minimum head space requirement of 710 mm is shorter than that required for an average 18 year old child (900 mm). For a Category 2 seat, the current minimum head space requirement of 630 mm is shorter than that required for an average 12 year old child (774 mm). And for a Category 3 seat, the current maximum head space requirement of 630 mm is shorter than that required for an average 8 year old child (704 mm).

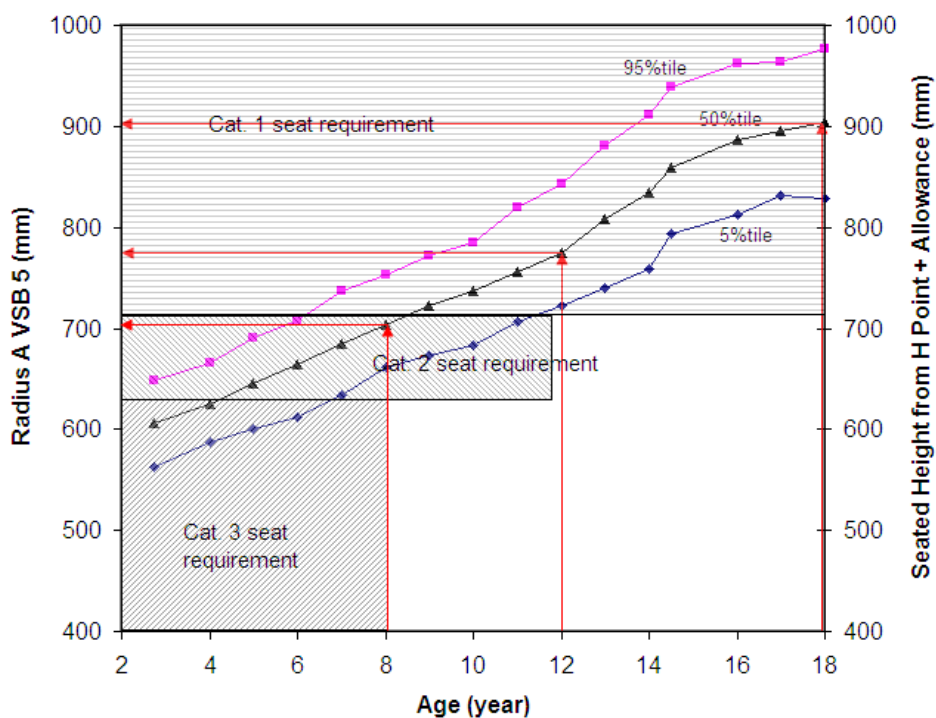


Figure 3

Comparison of Radius A as defined in the current VSB 5 with the seated height from hip (+ allowance) of the intended seat occupants.

Table 1

The current VSB 5 head space requirements compared to the seated height of the intended occupant

	CATEGORY OF SEAT		
	1	2	3
Current VSB 5 requirements (mm)	710 min	630 min; 710 max	630 max
Seated height of the intended occupant (mm)	900	774	700

Similarly, for a Category 1 seat, the current minimum leg space requirement of 460 mm is narrower than that required for an average 18 year old child (530 mm). For a Category 2 seat, the current minimum leg space requirement of 370 mm is narrower than that required for an average 12 year old child (453 mm). And for a Category 3 seat, the current minimum leg space requirement of 300 mm is narrower than that required for an average 8 year old child (394 mm).

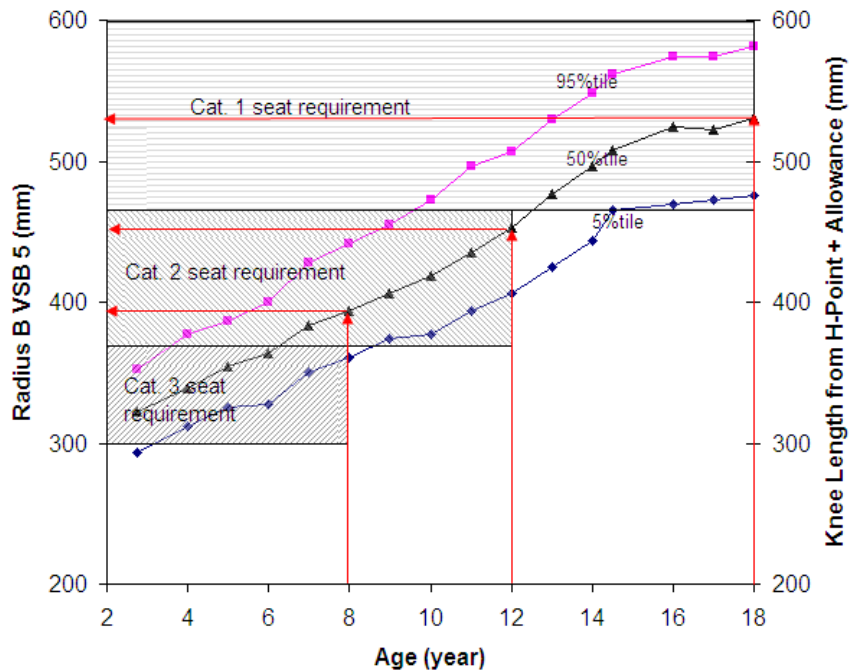


Figure 4

Comparison of Radius B as defined in the current VSB 5 with the knee length from hip (+ allowance) of the intended seat occupants.

Table 2

The current VSB 5 leg space requirements compared to the knee length of the intended occupant

	CATEGORY OF SEAT		
	1	2	3
Current VSB 5 requirements (mm)	460 min	370 min	300 min
Knee length of the intended occupant (mm)	530	453	394

Proposed revisions to VSB 5

The current VSB 5 requires revision on a number of grounds. First, the current VSB 5 classifications allow children from birth to 8 years old (for Category 3 seats) or 12 years old

(for Category 2 seats) to be transported in these seats. As mentioned above, even using child restraints, children younger than 4 years old are less safe in an Additional Seat than in a standard vehicle seat. We propose therefore that children younger than 4 years old not be allowed to use *Additional Seats*, even with a child restraint.

Second, for consistency with the Road Rules where children up to the age of 7 years old must be secured in a child restraint, it is proposed that the upper limit for Category 3 seat be limited to 7 years of age. This makes complying with the VSB simpler for consumers and manufacturers.

Third, the anthropometry data above demonstrate clearly that the current VSB 5 does not offer adequate spacing for occupants. These need to be revised to accommodate, at minimum, the average-sized child occupant of the maximum age intended for that Category of seat.

Hence, the proposed VSB 5 would include the following categories:

- Category 1 - Seats intended for use by adults.
- Category 2 - Seats suitable for children approximately 4 to 12 years of age.
- Category 3 - Seats suitable for children approximately 4 to 7 years of age.

The minimum head and leg space requirements are increased to accommodate the intended occupant. The proposed spacing is summarised in Table 3.

Table 3
Proposed minimum head and leg spacing

DIMENSION	CATEGORY OF SEAT		
	1	2	3
Radius A	898 mm	803 mm	700 mm
Radius B	560 mm	490 mm	400 mm

References

Andersson M. (2012). Child Safety in Car Crashes: A Modeling Approach for Safety System Improvements. *Thesis for the Degree of Doctor of Philosophy, Chalmers University of Technology.*

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Snyder R.G., Spencer M.L., Owings C.L., & Schneider L.W. (1975). Physical characteristics of children as related to death & injury for consumer product safety design. University of Michigan. Report nr UM-HSRI-BI-75-5.

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