Aviation Child Safety Device Performance Standards Review

Federal Aviation Administration

Presented to: **The Sixth Triennial International Aviation Fire and Cabin Safety Research Conference**

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Date: **October 26, 2010**

Introduction

- **Child Restraint Systems (CRS) meeting the auto safety standards (FMVSS-213) have been permitted on aircraft since 1985.**
- **Research revealed that forward facing CRS could provide poor performance when installed in some aircraft seat configurations.**

Introduction

Good interface with seat (belt anchor aft-ward)

Bad interface with seat (belt anchor forward)

Introduction

- As a result, SAE AS5276/1 "*Performance Standard for Child Restraint Systems in Transport Category Airplanes*" was developed to ensure proper restraint of infants and small children in the aircraft environment.
- TSO C-100b was issued in 2002 which referenced this document as a Minimum Performance Standard.

Introduction

- **Prototypes were developed to meet draft aviation CRS requirements. Optimized design improved performance.**

Implementation Challenges

- Development of CRS to meet aviation specifications has proven technically challenging. So far, no systems have been granted TSO approval.
- AS5276/1 requirements were based on FMVSS-213 and an aircraft seat configuration reflecting a near worst-case combination of parameters affecting CRS performance.

Implementation Challenges

- **CRS manufacturers identified specific test requirements as hindering their ability to meet the specifications:**
  - Belt Anchor Location. Most seat designs now have an anchor further aft than the location specified.
  - Seat Cushion Dimensions and Properties. Width and depth reflect average values, but the thickness and stiffness reflects the thickest and softest cushions in service.
  - Installation Method. Reflects an worst-case in-service installation scenario that could produce a loose fit of the CRS in the seat.

Seat Design Evolution

- **New aircraft seat designs with a better CRS interface (further aft belt anchor point) have entered service and are gradually replacing the older seat designs.**
- **This means that AS5276/1 tests are based on aircraft seat geometry that may no longer be representative of the majority of seats currently in service.**

Testing Technology Advances

- **A major revision to FMVSS-213 was adopted in 2005.**
  - Test fixtures revised to reflect current automotive seat geometry and the new LATCH anchorage systems.
  - Improved test dummies and test methods increased the level of safety provided.

Rule Changes

- **Aviation regulations were revised to accommodate certification of innovative CRS optimized for aviation use.**
- **These revisions removed the requirement that TSO-C100 CRS and other Aviation Child Safety Devices (ACSD) also have FMVSS-213 approval.**
- **This action may have removed some useful requirements since AS5276/1 had been developed to complement rather than replace FMVSS-213.**

Addressing Challenges and Changes

- **FMVSS-213 was reviewed to:**
  - Identify requirements that are applicable to CRS intended for aviation use that are not currently addressed in the aviation standards.
  - Identify requirements that offer an improvement over similar requirements currently cited in the aviation standards.
- **AS 5276/1 test requirements were reviewed to determine if they are still appropriate considering current seating configurations.**

FMVSS-213 Review

– Potential Additions to Aviation Standards

- **Design specifications for occupant support surfaces**
- **Belt and buckle strength and durability**
- **Defined restraint configuration, geometry and adjustment range**

FMVSS-213 Review
– Potential Improvements to Aviation Standards

- **Advanced Test Dummies**

CRABI 12-month-old

Hybrid-III 3-year-old

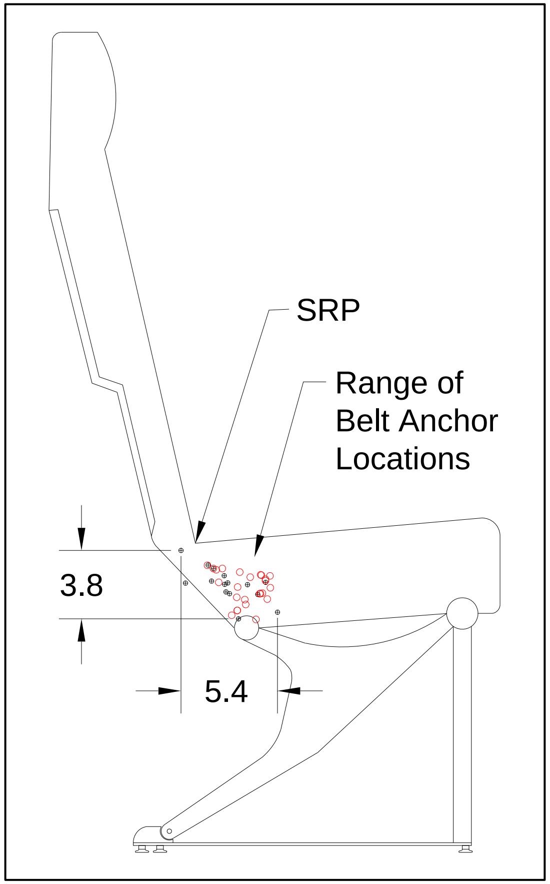
- **Test Dummy preparation and positioning procedures**
  - Dummy specific rather than generic

FMVSS-213 Review
– Potential Improvements to Aviation Standards

- **Head injury assessment procedure**
  - HIC36 evaluates injury potential due to both contact and non-contact (inertial) head acceleration.
- **CRS installation procedures**
  - Provides a repeatable installation method since it requires a specific lap belt tension (15 lb.).

AS5276/1 Review
– Belt Anchor

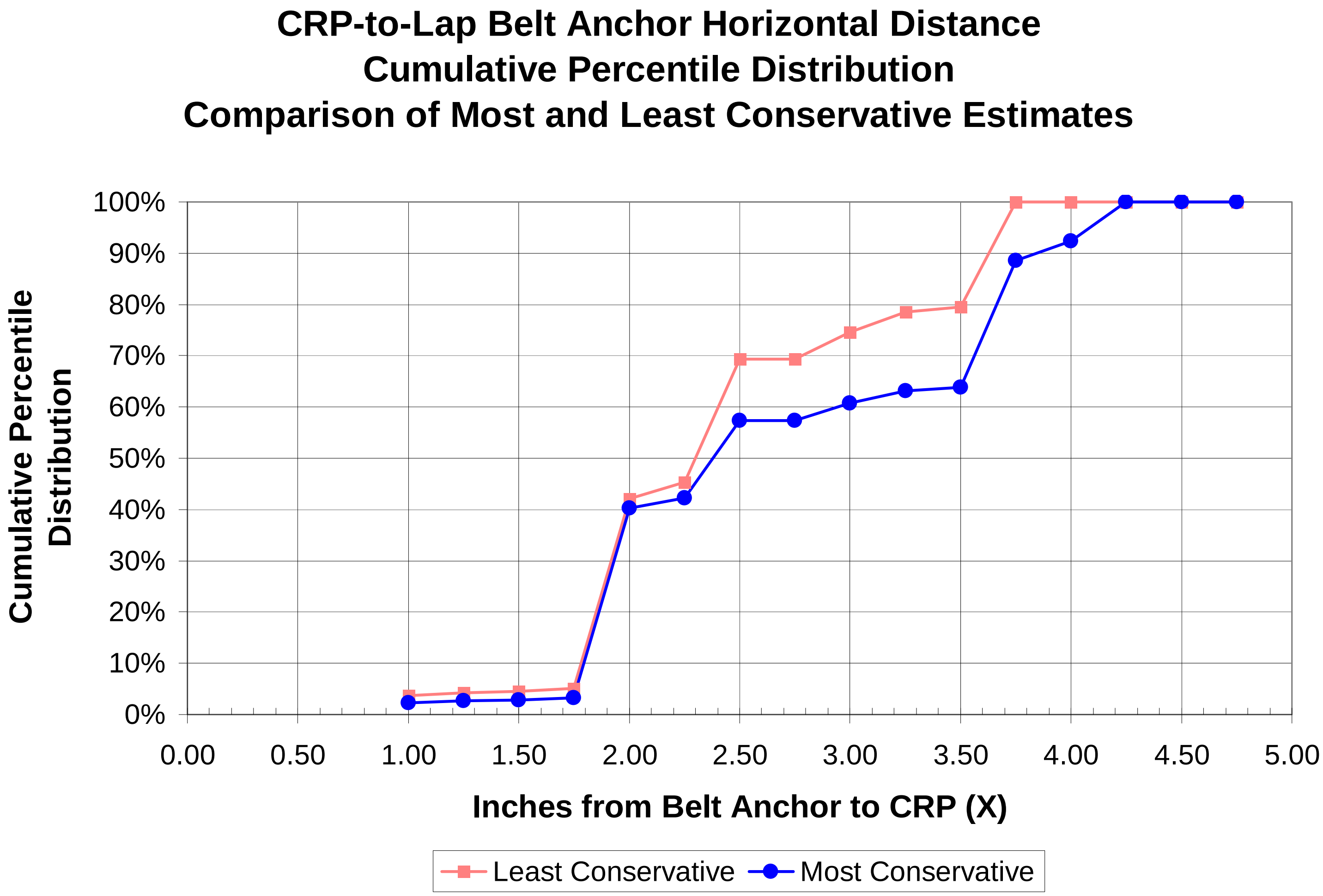
- **Belt anchor location is a major factor affecting CRS performance.**
  - head excursion increases as the belt anchor is moved further forward.
- **Original selection based on 1996 survey of transport fleet.**



AS5276/1 Review
– Belt Anchor

- **Estimates of anchor point distribution in the current fleet were made by combining:**
  - Fleet size and makeup from the FAA's Safety Performance Analysis System
  - Seating requirements defined in each aircraft's Type Data Sheet
  - Defined belt geometry (16 G seats have a belt anchor located no more than 2 inches forward of the CRP)
  - The 1996 survey results (primarily 9 G seats)
  - Assumptions about belt anchor locations on seats in aircraft that were retired / replaced since 1996

AS5276/1 Review
– Belt Anchor



AS5276/1 Review
– Belt Anchor

- **Both estimation methods are conservative due to:**
  - 16 G compatible seats may have been installed on many aircraft delivered after 1992 or installed on older aircraft during refurbishments.
  - The continued retirement and refurbishment of older aircraft, plus the requirement to install 16 G seats on all newly built aircraft, will tend to move the typical anchor location further aft over time.

AS5276/1 Review
– Belt Anchor

- **Analysis results indicate that a belt anchor location 3.7 inches forward of the CRP is the most appropriate location for a minimum performance standard test procedure.**

Lap Belt Anchor X Location Estimated Distribution	50%tile Location	75%tile Location	95%tile Location
Original Analysis	3.6	3.7	4.2
Most Conservative Analysis	2.4	**3.6**	4.1
Least Conservative Analysis	2.3	3.0	**3.7**

AS5276/1 Review
– Seat Cushion

- **Size and Stiffness bounded by conflicting design goals of accommodating a range of occupant sizes while being compact.**
- **Review of new economy class seats indicated that current seat cushions are still similar to AS5276/1 specifications.**

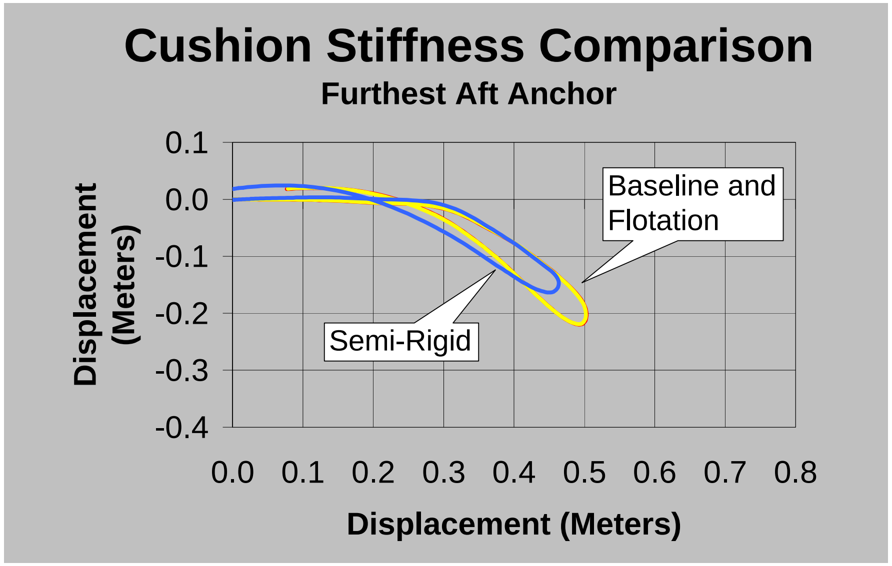
AS5276/1 Review
– Seat Cushion

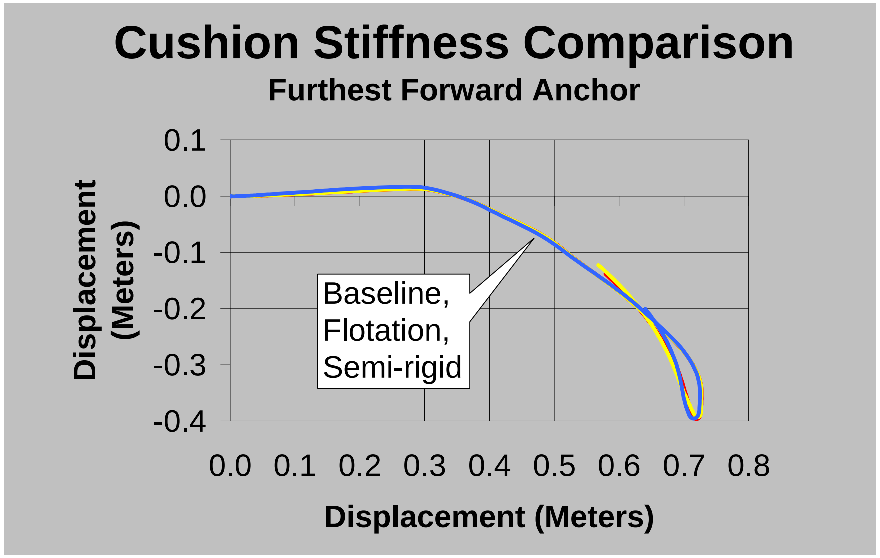
- **Seat Cushion Parameter Comparison**

Bottom Cushion Parameter	AS 5276 Specifications	Review Results
Top Surface Angle	5.5 Degrees	4.5 -7.5 Degrees
Cushion Depth	16.2 Inches	17 – 18 Inches
Support Structure Depth	14.8 Inches	15 – 16 Inches
Thickness above forward support	3.5 Inches polyurethane + 0.5 Inches polyethylene	3 – 4.75 Inches
Foam/Cushion Stiffness	21-27 ILD for the polyurethane layer	44 – 81 IFD

AS5276/1 Review
– Seat Cushion

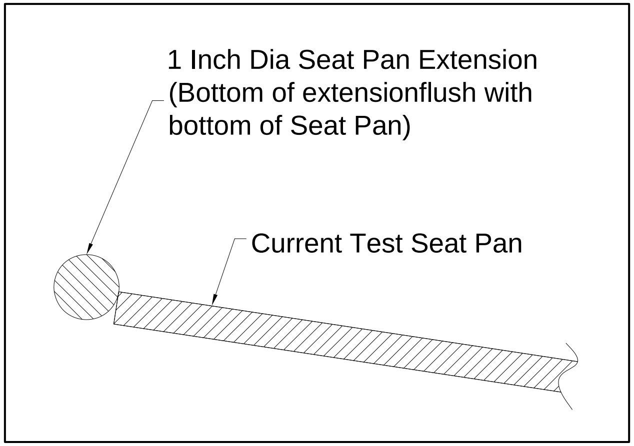
- **Computer modeling results indicate that cushion stiffness has little affect on CRS performance.**





AS5276/1 Review
– Seat Cushion

- Seat Pan specified in test procedures is somewhat shorter than typical.
- A one inch diameter cylindrical extension to pan would improve realism.



AS5276/1 Review
– Installation Method

- **Current AS 5276 method can result in widely varying pre-test lap belt tension due to variations in belt adjuster friction**

- **FMVSS-213 method produces consistent pre-test tension values since tension is measured directly.**

AS5276/1 Review
– Installation Method

- **Following CRS manufacturer's instructions will likely result in tension values similar to the FMVSS-213 test specifications.**

Conclusions

- Incorporating applicable FMVSS-213 requirements into the aviation standards should provide a safety benefits for ACSD.
- Utilizing applicable automotive requirements would also allow ACSD users to benefit from the extensive research that went into the development of those requirements.

Conclusions

- **Revising test requirements to be more representative of the current aircraft environment should advance the development of ACSD while maintaining or improving the current level of safety.**

Acknowledgment

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Compilation of Fleet Statistics from the Safety Performance Analysis System

John Petrakis

FAA Headquarters

Reference

A report containing the details of this project will be published as an Office of Aviation Medicine Report available at: www.faa.gov

DeWeese R, Moorcroft D, Taylor, M."*Aviation Child Safety Device Performance Standards Review*", Washington DC: Department of Transportation /Federal Aviation Administration; In Press