Child Restraint System Certification Requirements Summary

Federal Aviation Administration

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Introduction

- **The FAA encourages the use of Child Restraint Systems (CRS) on Aircraft.**
- **Currently there are several ways child restraints can be approved for use on aircraft.**
- **The approved devices fall into two categories:**
  - Devices meeting auto safety standards,
  - Devices meeting aviation certification requirements.

Introduction

- **Accepted Automotive Standards**
  - US Federal Motor Vehicle Safety Standard (FMVSS) 213
  - UN or a foreign government standard
- **Automotive Standards consist of:**
  - Performance requirements that demonstrate the level of safety provided by the system in an automotive crash environment. Dynamic tests use representative seat and restraint configuration, impact pulse and direction, and occupant (ATD) size.
  - Design requirements that address safety issues that cannot be fully controlled by the dynamic tests. These include requirements such as minimum support surface areas, support surface angles, belt geometry, and belt adjustment range.

Introduction

- **Aviation Certification Requirements**
  - **TSO-C100c Aviation Child Safety Device**: Devices meeting it receive approval for use on any aircraft.
  - **Type Certificate or Supplemental Type Certificate**: Approved as part of a specific type of aircraft. The requirements are unique to each device and aircraft.
  - **14 CFR 21.8(d):** Devices approved are required to show they provide an equivalent level of safety as a TSO-C100c approved device.
- **ASCD:** To avoid consumer confusion, a child restraint system which is only approved for use on aircraft is referred to by the FAA as an Aviation Child Safety Device (ACSD) regardless of which certification method is used for its approval.

Introduction

- **TSO-C100c Development**
  - An aviation-specific standard was developed to address poor performance issues exhibited by devices meeting automotive standards when installed in some aircraft seats. It references SAE AS5276/1 for many requirements.
  - The TSO addressed fitment and occupant excursion issues by setting overall device size limitations and by using an aviation relevant seat configuration for dynamic tests. It references SAE ARP 4466 for the fitment requirements.
  - The TSO also incorporates the automotive CRS requirements (from FMVSS-213) that are relevant to the aviation environment.
  - The TSO is well suited for evaluation of conventional (shell type) restraints.

Introduction

- **TSO-C100c Defined Level of Safety**
  - The TSO is also used as a safety benchmark against which devices approved by TC, STC, or 14 CFR 21.8(d) are compared.
  - Some ASCD cannot be evaluated using the specific TSO-C100c performance and design criteria because they attach to the seat in a unique manner or lack some required design features.
  - To evaluate these designs, the FAA follows an approval process requiring a device to demonstrate a level of safety equivalent to that required by the latest version of TSO-C100.
  - So far, one such device, the AmSafe CARES, which adds upper torso restraint straps to the existing seat belt, has been approved. Note 14 CFR 21.8(d) was previously numbered 14 CFR 21.305(d), which is cited on this device's approval tag.

TSO-C100c Performance Requirements

(Dynamic Test Setup)

- **Test seat:** Fixture reflects a transport passenger seat configuration that has the worst combination of features (from a ACSD performance standpoint). The two features that have the greatest effect are the bottom cushion construction and the lap belt anchor location.
- **Test severity:** Reflects transport aircraft emergency landing condition, horizontal impact scenario. 16 g, 44 ft/s triangular pulse shape, forward impact vector (no yaw).
- **ATD selection:** Based on range of expected occupants.

TSO-C100c Performance Requirements

(Injury Criteria for All Orientations of ACSD)

- **Head Injury Criteria (HIC):** Same limit of 1000 as required for other aviation occupants. Non-contact accelerations counted and time interval limited to 36 milliseconds to be consistent with automotive standards. Limits head injury risk.
- **Chest Resultant Acceleration:** Same 60 g peak resultant acceleration limit as in auto standard. Limiting chest acceleration limits internal organ and skeletal fracture injury risks.

TSO-C100c Performance Requirements

(Injury Criteria for All Orientations of ACSD)

- **Neck Extension Limit**: Rearward rotation of the test dummy head must be limited so that the angle between the head and torso does not increase by more than 45 degrees during the test. Limit is intended to reduce neck injury risk.
- **Torso Protection:** Must retain the torso within the system. Retaining the torso prevents flailing and contact with surrounding objects, either of which can be injurious.

TSO-C100c Performance Requirements

(Injury Criteria for Forward-Facing ACSD)

- **Head Excursion:** Same maximum excursion distance from seat bite (same location as Cushion Reference Point in TSO) as for forward-facing automotive CRS (26 inches). Distance specified decreases the risk of the child's head contacting the seat row in front. Head contact can increase head injury risk.

TSO-C100c Performance Requirements

(Injury Criteria for Forward-Facing ACSD)

- **Knee Excursion:** Same maximum excursion distance from seat bite as for forward-facing automotive CRS (30 inches). Excessive knee excursion is an indicator that the occupant is sliding under the lap belt (submarining) or that the lap belt is not effective. Submarining can result in excessive abdominal loading which can produce serious injuries.

TSO-C100c Performance Requirements

(Injury Criteria for Aft-Facing ACSD)

- **Back Support Surface Maximum Angle:** Same 70 degree angle (from vertical) limit for aft-facing seats as in the auto standard. Limiting the back angle tends to reduce restraint loading and the amount of occupant forward excursion.
- **Retain Head:** The center of gravity point of the test dummy head shall not travel beyond the forward-most edge of the system support surfaces. Limits risk of head contact injuries.

TSO-C100c Performance Requirements

(Structural Integrity)

- **Structural Failure:** No fractures, separation of joints, release of fasteners, or creation of sharp edges.
- **Post-Test Entrapment:** No deformations that have the potential to entrap or otherwise cause injury to the occupant.
- **Pinching Hazards:** No opening larger than 0.25 inch shall become smaller during testing.
- **Deformation of Support Surface:** Forward-facing ASCD shall not allow the angle between the system's back support surfaces and the seating surface to be less than 45 degrees at the completion of the test. Prevents crushing type injuries.

TSO-C100c Design Requirements

- **Head Support Surfaces:** Rear support surfaces must have a specific minimum width and height, depending on the size of the occupant. These surfaces prevent excessive rearward motion of the head.
- **Torso Protection:** Back and side supporting surfaces must be flat or concave, and have a specific size, depending on the size of the occupant. These surfaces provide uniform support for the spine, rib cage, and abdomen.
- **Protrusion Limitation:** No protrusions on rigid, contactable support surfaces greater than 0.375 inch high. This limits the amount of concentrated loading permitted.

TSO-C100c Design Requirements

- **Back Support Surface Angle:** Initial installed angle with respect to the vertical not less than 45 degrees for aft-facing seats. A steep recline angle can be hazardous for sleeping infants.
- **Belt configuration:**
  - *Dual shoulder straps*: Dual straps spread load out over the torso and increases effectivity during yawed impacts.
  - *Lap belt angle*: When worn, the lap belt must make an angle between 45 and 90 degrees to the seating surface. This lap belt angle range increases the likelihood that the belt will initially bear on the pelvis and remain there as the occupant moves forward.

TSO-C100c Design Requirements

- **Belt Configuration (cont.):**
  - *Crotch Strap*: A crotch strap connected to the lap belt is required for occupants over 22 lb. This strap keeps the lap belt from being pulled upward onto the abdomen by shoulder belt forces. Excessive loads applied to the abdomen can cause serious injuries.
  - *Adjustment Range*: Proper range of adjustment permits the belt to fit snugly on all intended occupants.

TSO-C100c Design Requirements

- **Harness performance:**
  - *Belt Strength*: 2473 lb minimum breaking strength for new webbing.
  - *Belt Durability*: After abrasion exposure, must retain 75% of new breaking strength.
  - *Belt Minimum Width*: 1.5 inches
  - *Buckle Release Force*: Must release between 9 and 14 lb.
  - *Single Point Release*: The occupant harness must release from a single actuation point.

TSO-C100c Level of Safety

(Application to unconventional ASCD designs)

- **Meeting the dynamic test performance requirements of TSO-C100c only addresses a portion of overall safety requirements.**

- **Design requirements such as support surface size and specific harness system geometry are based on the proven, real-world performance of conventional automotive CRS having those features. ATD technology and injury criteria is not available to adequately address designs that deviate significantly from these requirements.**

TSO-C100c Level of Safety

(Application to unconventional ASCD designs)

- **ACSD designs that do not incorporate all specific design requirements should have features that can be shown to provide the same safety benefit as the specified designs.**

- **ACSD developers are encouraged to contact their local FAA Aircraft Certification Office early in the design process to determine the specific certification requirements applicable to their product.**

Disclaimer

- **This presentation is intended to highlight the most critical ACSD certification requirements and explain their safety function.**

- **This presentation is not intended to be an all-inclusive list of the requirements. Product specific certification plans should reference the source documents, not this summary.**

Acknowledgment

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