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TRANSPORTATION RESEARCH INSTITUTE
CHILD PASSENGER PROTECTION RESEARCH PROGRAM
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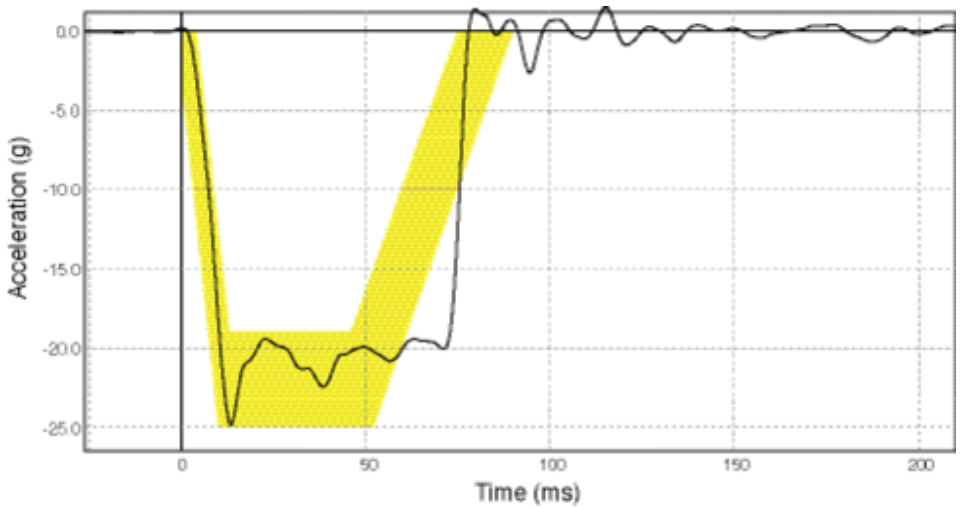
Child Restraint System Testing and Evaluation

Child restraint systems have been the subject of research and testing at The University of Michigan since the late 1960s. Staff expertise covers both the engineering and human factors aspects of the design and use of effective child restraint systems. Test facilities, instrumentation, and equipment offer flexibility in set-up and operation as well as immediate data processing and retrieval of results. Experienced laboratory staff can also provide special assistance as needed.

IMPACT SLED

Dynamic tests of child restraint systems are performed on an impact sled located at the University of Michigan Transportation Research Institute (UMTRI). The sled operates on a rebound principle, achieving a desired velocity change by reversing its direction of motion during the impact event. The crash pulse is trapezoidal in shape and is similar to that of a small automobile. The sled can simulate automobile crashes up to 80 km/h (50 mph) and up to 50 G deceleration.

For 48-km/h (30-mph) tests of child restraint systems, the sled pulse differs somewhat from that specified in the 2005 version of FMVSS 213 and tends to result in a more severe test environment. This difference in severity is due largely to the sustained acceleration, and associated steeper drop-off, at the end of the pulse. The longer-lasting stress on a marginal system can generate certain material failures that will not show up under less severe conditions. This test can therefore help the designer provide an appropriate margin of safety in the restraint system.



DUMMIES

Several different anthropomorphic dummies are available for use in child restraint testing. The size, weight, and instrumentation capabilities of each are given below. Additional weight can be added to some dummies for special purposes. Different dummies of a similar size may be appropriate for different test situations, and the use of any dummy may be restricted by the testing staff. Standard dummies used in FMVSS 213 version 2005 and CMVSS 213 (2011) crash testing are indicated by an asterisk.

	Height	Seated Height	Weight
Riley Low Birth Weight Infant	485 mm (19.0 in)	320 mm (12.5 in)	2.2 kg (4.8 lb)
*Part 572:K Newborn	520 mm (20.5 in)	320 mm (12.5 in)	3.4 kg (7.5 lb)
ECE Newborn (Ogle, TNO P-0)	520 mm (20.5 in)	333 mm (13.0 in)	3.4 kg (7.5 lb)
Part 572:D 6-Month	660 mm (26.0 in)	430 mm (17.0 in)	7.9 kg (17.4 lb)
*Part 572:J 9-Month (TNO P-3/4)	710 mm (28.0 in)	450 mm (17.7 in)	9.0 kg (19.8 lb)
*Part 572:R CRABI 12-Month Head and chest triaxial accelerometers Upper and lower neck forces and moments Shoulder and pubic forces	750 mm (29.5 in)	475 mm (18.7 in)	10.0 kg (22.0 lb)
CRABI 18-Month Head and chest triaxial accelerometers Upper and lower neck forces and moments Shoulder and pubic forces	815 mm (32.1 in)	505 mm (19.9 in)	11.5 kg (25.3 lb)
CPSC 18-Month	810 mm (31.8 in)	482 mm (19.0 in)	11.3 kg (24.8 lb)
Part 572:C Hybrid II 3-Year Head and chest triaxial accelerometers	975 mm (38.4 in)	570 mm (22.5 in)	15.1 kg (33.2 lb)
*Part 572:P Hybrid III 3-Year Head and chest triaxial accelerometers Upper neck forces and moments Chest deflection	945 mm (37.2 in)	546 mm (21.5 in)	15.5 kg (34.1 lb)
Part 572:I Hybrid II 6-Year Head and chest triaxial accelerometers	1200 mm (47.3 in)	650 mm (25.6 in)	21.5 kg (47.3 lb)
*Part 572:N Hybrid III 6-Year Head and chest triaxial accelerometers Upper neck forces and moments Chest deflection	1140 mm (44.9 in)	635 mm (25.0 in)	23.4 kg (51.6 lb)
*Part 572:S Hybrid III 6-Year	1140 mm (44.9 in)	635 mm (25.6 in)	29.5 kg (65.0 lb)
*Part 572:T Hybrid III 10-year Head and chest triaxial accelerometers Upper neck forces and moments Chest deflection	1298 mm (51.1 in)	724 mm (28.5 in)	35.3 kg (77.6 lb)

TEST SET-UP

The child restraint system is usually mounted on the Standard Bench Seat specified by both U.S. and Canadian child restraint standards, although other seating or vehicle environments can be used. A lap belt, made of standard automotive belt webbing, is used to attach the child restraint to the test buck, and a tether strap is attached if required. Alternatively, LATCH anchors are available as appropriate. The lap belt or LATCH attachments are pretensioned between 53 and 66 N (12 and 15 lb) for CRS equipped with harnesses, unless otherwise requested. In a typical test, a single restraint system is

anchored in the center seating position, where the most repeatable test results are obtained. If, however, basic structural integrity of a restraint system is the primary concern, two systems can be anchored by lap belts or LATCH in semi-outboard seating positions and tested side-by-side. Either outboard seating position is also available for booster or other tests with a lap/shoulder belt assembly.

Pre-test conditioning to simulate very cold environments can be achieved if needed. Freezer capacity is available for overnight soaking of several child restraints.

TEST CONFIGURATIONS

The test benches, impact directions, and belt systems currently available are listed below, and other combinations may be developed as needed.

FMVSS 213 (2005) and CMVSS 213 (2010) Standard Bench Seat
- Frontal impact only
- Rigid seat back
- Center or semi-outboard lap belts
- Center or semi-outboard LATCH anchors
- Outboard static (standard) or ELR lap/shoulder belts
- Center static (standard) or ELR lap/shoulder belts
- Center, semi-outboard, or outboard tether anchors

FMVSS 213 Standard Bench Seat (pre-2005 version)
- Frontal impact only
- Deforming (U.S.) or rigid (Canadian) seat back
- Center or semi-outboard lap belts
- Center LATCH anchors
- Outboard static (standard) or ELR lap/shoulder belts
- Center, semi-outboard, or outboard tether anchors

ECE R-44.02 Test Seat
- All impact directions
- Right or left static lap/shoulder belt

CRABI (Airbag) Test Fixture
- Frontal impact only
- Lap or lap/shoulder belt

ELECTRONIC DATA

Electronic signals generated by the accelerometers, velocity probes, and/or load transducers are digitized live using a TDAS onboard data acquisition system and analyzed on a workstation. All test signals are filtered according to the requirements of SAE J-211, and signal output conforms to the SAE J-1733 sign convention. Results, such as impact speed, head injury criterion (HIC), neck forces, or belt loads, are available within minutes.

PHOTOGRAPHY

Visual documentation of the crash event is provided by high-speed (1000 frames per second) digital video cameras from both side and overhead or forward directions. The digital video can be analyzed during testing if precise excursion information is needed immediately. Copies of the pre- and post-test pictures, test videos and data are available to download securely on the M+Box system.

REPORTS

A written report is prepared that includes some portion of the following information, depending on the test requirements and the dummy used:

Sled velocity and acceleration
Initial and maximum back angle (rear-facing restraints)
Head and knee excursion (forward-facing restraints)
Head accelerations and resultant
Head injury criterion (HIC)
Chest accelerations and resultant
Neck forces and moments
Shoulder and pubic forces
Buckle release force
Belt loads during impact
Comments on structural performance
Chest deflection

Included with the report are pre-test and post-test photographs and a time sequenced image of the impact event. This report is usually sent within two weeks of the test.

DATA LIMITATIONS AND USE

Results of any tests conducted are advisory in nature and are not to be construed as endorsement of a product or certification of its compliance with a government regulation. The data may be used as technical support for self-certification by a restraint system manufacturer, and copies of one or more test reports may be provided to interested individuals at that manufacturer's discretion. At no time, however, shall the name of the University of Michigan or Transportation Research Institute be used in any advertising material or public media release in connection with any restraint system tested.