Evaluation of Wheelchair Seating System Crashworthiness -

Wheelchair Back Surfaces and Attachment Hardware

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•Ha et al, June 2000

A Research Lecture

from the website of Wheelchair University (http://www.wheelchairnet.org/)

which is a project of the

Rehabilitation Engineering Research Center (RERC) on Wheeled Mobility

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This research was funded by:

Paralyzed Veterans of America,

Center for Disease Control through the Center for Injury Research and Control (CIRCL), and

NIDRR through the Rehabilitation Engineering Research Center on Wheeled Mobility

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Abstract

Automotive seats are tested for compliance with federal motor vehicle safety standards (FMVSS) to assure safety during impact. Many wheelchair users rely upon their wheelchairs to serve as vehicle seats. However, the crashworthiness of these wheelchairs during the impacts is often unknown. This study evaluated the crashworthiness of five Wheelchair Seating Systems (WCSS) back surfaces and attachment hardware using a static test procedure simulating crash loading conditions. The crashworthiness was tested applying a rearward load to each seating system at the center of gravity of the reference loader gauge. The magnitude of the applied loads was established through computer simulation and biodynamic calculations. None of the five tested WCSS withstood the simulated crash forces. All failures were associated with attachment hardware.

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Full Citation

Ha, DR; Bertocci, G; Deemer, E.; vanRoosmalen, L; & Karg, P. (2000). Evaluation of Wheelchair Seating System Crashworthiness - Wheelchair Back Surfaces and Attachment Hardware. The Proceedings of the Annual RESNA Conference, Orlando, FL, June 28-July 2. p 420-422.

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Background

- ADA requires the public transportation systems to be accessible
  - More wheelchair users use public transportation.
  - Wheelchair users travel in their wheelchairs when using public transportation.
- Wheelchairs used as vehicle seats

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After ADA required all the public transportation systems, such as buses, subways and trains, to be accessible to individuals with disabilities, increased wheelchair users travel in their wheelchairs when using public transportation.

Also, wheelchair users who cannot transfer to vehicle seats use their wheelchairs as vehicle seats while they travel.

Background

- Wheelchairs are designed to provide mobility to individuals
- Wheelchair Seating system (WCSS):
  - Unknown level of an occupant protection under impacts

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Background

ANSI/RESNA WC/19 – Wheelchairs Used as Seats in Motor Vehicles

- Sled impact testing of a complete wheelchairs
- 20g/48kph (30mph) frontal crash

Substitute-seating systems will not be sled tested by ANSI/RESNA WC/19.

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There is ANSI/RESNA WC/19 standard to test Wheelchairs Used as Seats in Motor Vehicles.

The standard requires the complete wheelchairs to be sled impact tested using a 20g/48kph (30mph) frontal crash pulse.

However, substitute-seating systems are often added as after-market products and will not be sled tested by the ANSI/RESNA WC/19 standard.

Background

- Automotive seats - tested to meet government crashworthiness and occupant protection regulations
- WCSS used as seats should provide similar level of occupant protections to the automobile seats

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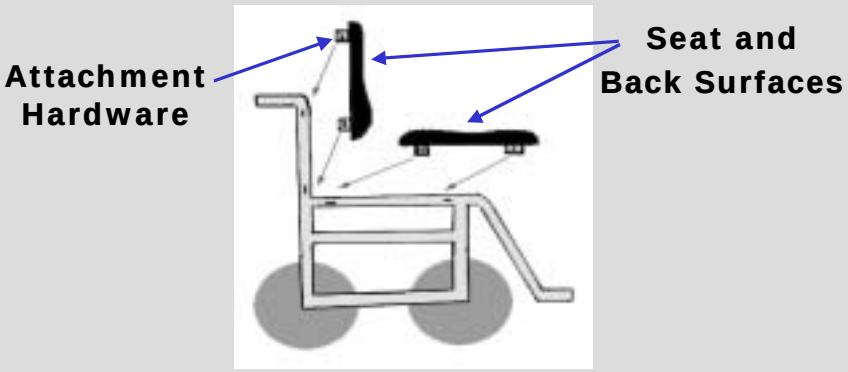
Manufacturers of automotive seats are required to perform extensive testing to assure that

their production vehicle meets government crashworthiness and occupant protection regulations.

Therefore, wheelchair seating systems should also be tested and provide similar level of occupant protections to the automotive seats if they are used as seats in vehicles.

Wheelchair Seating Systems



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As shown on the Figure, a typical WCSS consists of a separate seat and back surface with cushions mounted onto the wheelchair frame using attachment hardware.

The integrity of supporting surfaces and attachment hardware must be maintained during a crash.

This study…

- Proposes a static test method
- Applies the method to evaluate five commercial wheelchair seat backs and their associated attachment hardware
  - Jay2 Deep Contour Back, Jay2 Back Tall, Jay Fit Back System, Personal Back, and Sit Rite Back.

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Research Question

Do commercially available wheelchair seat backs and their associated attachment hardware withstand loads encountered in a motor vehicle crash?

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Loading conditions

Rear impact:

- FMVSS 207 test criterion with consideration of occupant's weight and inertia effects
- 20 x (weight of the upper torso of a 50th percentile male + weight of each wheelchair seat back)
- Approximately **2400 lb.**

Rebound associated with frontal impact:

- Computer crash simulation
- approximately **2280 lb.**

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Two loading conditions which wheelchair seat backs may be exposed to, are rebound loads associated with frontal impacts,

and loads encountered during rear impacts.

Rear impact loads were derived following FMVSS 207 test criterion which applies a 20g static load to seating systems.

Rebound loads associated with frontal impact were determined from computer crash simulations.

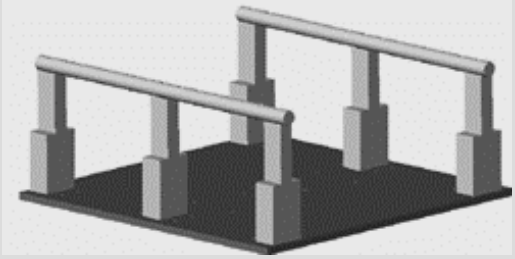
In determining the target test load, the worse case loading scenario between two conditions was chosen.

The **target loading** for the test was based upon rear impact conditions, which was **2400 lb**.

Test Fixture

Two 1” diameter solid rods simulate the wheelchair frames

Rods were spaced 18” apart - represent a common adult wheelchair back frames



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For the testing, the test fixture which simulate the wheelchair frames was developed.

Back Unit of Reference Loader Gauge (RLG)

Top View

Bottom View

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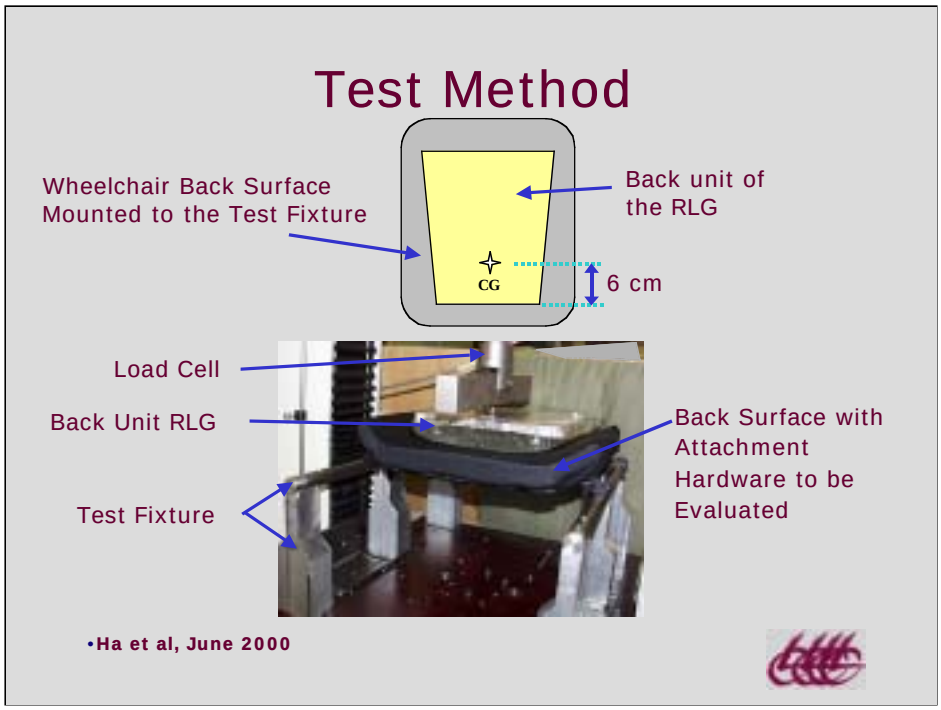
Back unit of the reference loader gauge,which represents the upper torso of the 50%-tile man, was also developed to apply distributed load to the seating systems.



The loads applied to the WCBS and AH were generated using the Instron loading machine, which is designed to test materials in either tension or compression.

This shows a test set up.

1. A back surface was mounted to the rods of the test fixture with manufacture-provided hardware.

2. The back unit of the RLG was placed on top of the surface.

3. A downward force was applied to the back unit of RLG at the center of gravity of the RLG (CGRLG).

Results – Hardware Failure

Jay Fit

Jay2
Deep
Contour

Jay2 Back Tall

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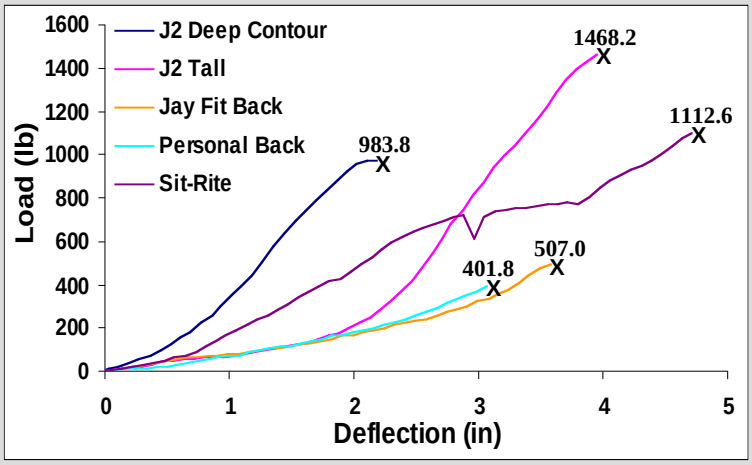
Results of study show that all five wheelchair seat backs failed to withstand the target force because of attachment hardware failure.

Hardware was severe deformation as shown here, and some of the lower hardware was released from retention slots.

Results



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This Figure shows the load versus deflection curves of the five tested wheelchair backs.

It also shows the load that each WCBS and AH withstood : "X"s on the graph indicate the failure points.

Four out of five tested seat backs failed at a force less than 50% of the targeted force of 2400 lb.

Conclusions

None of the tested commercially available wheelchair backs and their attachment hardware withstood the target load

Future works:

validating the proposed static test methods to assure dynamic impact test similarity

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The results of this study show that none of the tested commercially available wheelchair seat backs and their attachment hardware withstood the forces that may be encountered during a rear impact or rebound associated with frontal impact.