Rear Impact Protection
A Canadian View

United Nations GRSP
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Objectives

- Review of US regulation
- Canadian research
- Canadian regulatory proposal
- Cost/Benefit summary
- Proof of concept
Background

- FHWA - BMCS guard 1953
- ECE Regulation 58, published in 1989
- NHTSA final rule issued in 1996 - effective Jan 1998
- Canadian provinces Ontario and Quebec - rear underride requirements for 53 ft trailers
Typical NHTSA Guard
(rearview of trailer)

- 50 kN P1 & P2
- 100 kN at P3
- 5,650 J energy absorption
Typical NHTSA Guard
Typical NHTSA Guard
560 mm guard
Compliance Test @ P3

P3 Test - 560 mm guard

Total Energy Absorbed = 12.1 kJ
Compact Vehicle Collision
Rear Underride Research

- Started in 1997 stationary guard project
- Deformable guard research project
  - 3 vehicle sizes (minivan, compact and sub-compact)
  - 2 ground clearances (480 and 560 mm)
  - 3 impact speeds (48, 56 and 65 km/h)
  - 3 guard “designs”
  - 3 impact tests with dummies
  - 350 kN proof-of-concept test with dummies
Solid Guard Test Programme
Solid Guard Test Programme
What did we learn?

- Incidence of serious or fatal injuries could be reduced significantly if guards were much stiffer and somewhat lower.
Deformable Guard Test Programme
Deformable Guards
560 & 480 mm Guards

560 mm guard

480 mm guard
56 km/h, 480 mm w/stopper
480 mm guard with Stopper
560 mm Slanted Guard
FEA – Slanted Guard Design
Deformable Guard Test Programme

Passenger Compartment Displacement
Honda Civic - 48 km/h

- 480 mm guard
- 480 mm guard with stopper
- 560 mm slanted guard
## Deformable Guard Test Programme Summary

<table>
<thead>
<tr>
<th>Vehicle ID</th>
<th>Speed [km/h]</th>
<th>Guard</th>
<th>Displacement [metres]</th>
<th>Max Force [kN]</th>
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<tbody>
<tr>
<td>Cavalier</td>
<td>48</td>
<td>560 mm</td>
<td>2.0</td>
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<tr>
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<tr>
<td>Cavalier</td>
<td>65</td>
<td>Stopper</td>
<td>1.4</td>
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<td>480 mm</td>
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<td>Stopper</td>
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<td>Slanted</td>
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<td>308</td>
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<td>Civic</td>
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<td>560 mm</td>
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<td>176</td>
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<tr>
<td>Civic</td>
<td>56</td>
<td>Stopper</td>
<td>1.6</td>
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<tr>
<td>Windstar</td>
<td>48</td>
<td>560 mm</td>
<td>1.4</td>
<td>287</td>
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</table>
Analysis -- Dummy Response

Normalized Injury Response Values for the Head of the 50th Percentile Passenger
(Based on suggested IARV for in-position compliance)

- U.S. Guard
- Stopper
- Slanted Guard

Peak G

HIC15
Analysis -- Dummy Response

Normalized Injury Response Values for the Upper Neck of the 5th Percentile Female Driver
(Based on suggested IARV for in-position compliance)

- U.S. Guard
- Stopper
- Slanted Guard

Bar chart showing normalized injury response values for different forces and moments.
Deformable Guard Test Programme Conclusions

- A guard meeting the minimum requirement of the US FMVSS 223 did not adequately protect occupants in a 1998 Cavalier and Civic EVEN AT 48 km/h

- A guard that could withstand a uniform load of 300 kN adequately protected occupants in compact vehicles at 48 km/h
Deformable Guard Test Programme Design Results

- Full-width uniform test to better simulate interaction between colliding vehicle & guard
- Minimum 350 kN resistance to handle sub-compact vehicles at 56 km/h
- Minimum energy absorption requirement of 20 KJ
- Same P1 and P2 load tests as the U.S. to ensure lower structural member strength
- 560 mm clearance requirement measured after testing
Deformable Guard Test Programme
Canadian Guard
(rearview of trailer)
Uniform Load Application

SIDE VIEW

Trailer rear extremity or rigid test fixture

Position of rear impact guard horizontal member at start of load test

TOP VIEW

Supports

Horizontal rear impact guard

Minimum length of the force application device

Right test fixture assembly

Force

L

26
Uniform Test Load
Force Deflection Curve

Area represents energy absorbed
(Minimum 20,000 joules)
FEA
CMVSS 223 Compliant Rear Impact Protection

Displacement (mm)

Load (kN)

Design #1
Design #2
Design #3
Ground Clearance Requirement

- Position of rear impact guard horizontal member after uniform load test is complete
- Trailer rear extremity or rigid test fixture
- Position of rear impact guard horizontal member at start of load test
- Trailer rear extremity or rigid test fixture
- Position of rear guard horizontal member at start of load test
- Force
- Ground clearance
- Vertical rise displacement
### Summary of U.S. & Canadian Guard Requirements

<table>
<thead>
<tr>
<th></th>
<th>U.S. FMVSS 223/224</th>
<th>CANADIAN CMVSS 223</th>
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<tbody>
<tr>
<td><strong>Guard height</strong></td>
<td>560 mm (before testing)</td>
<td>560 mm (after testing)</td>
</tr>
<tr>
<td><strong>Strength requirements</strong></td>
<td>50 kN at P1, 50 kN at P2, 100 kN at P3</td>
<td>50 kN at P1, 50 kN at P2, 350 kN uniform load test</td>
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<tr>
<td><strong>Energy Absorption</strong></td>
<td>5,650 Joules</td>
<td>20,000 Joules</td>
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Rear Impact Fatalities Vs Underride Vs PCI

- From the 1995 fatal truck study
  - 23 fatals in rear trailer impacts
  - Underride occurred in 60% of the cases where details known
  - Passenger compartment intrusion (PCI) occurred in 40% of the cases where details known
Why A Stronger Guard?

Collision Severity vs Delta V Speed kph

Michigan Study
Why an After Test Height Requirement?

Sub-Compact Vehicles Over-represented

- NHTSA - sub-compacts represented 12% of underride fatalities - 2.4% of noted 1993 sales
- Sub-compacts - 11% of Canadian fleet
- Compacts - 25% of the Canadian fleet
- 1995 truck fatality study
  - 22% of occupant fatalities in sub-compact vehicles, thus 2X over representation in this study
  - 26% of occupant fatalities in compact vehicles
Injury Estimates

- From TRAID
  - Est. 300 injuries/yr in rear truck impacts
  - From the 1995 fatal truck study Underride occurred in 64% of the cases where details known - 192 Injuries/yr.
  - Passenger compartment intrusion (PCI) occurred in 42% of the cases where details known - 126 injuries/yr.
## Cost Benefit Comparison (millions)

<table>
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<tr>
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<th>Guard Cost</th>
<th>Minimum Benefits</th>
<th>Maximum Benefits</th>
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<tbody>
<tr>
<td>Option 1</td>
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<td>Option 3</td>
<td>$3.6</td>
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<td>$7.66</td>
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</table>
Canadian Guard Vs. U.S./ECE Guard
$30 Cost Differential

Canadian guard

NHTSA guard
Regulation Phased-In

- Allow time for industry to prepare for the Canadian specific requirements and the NHTSA to consider upgrading their regulation
- Proposed that regulation effective 1 year after publication in the Canada Gazette
- During phase 1 – two year period following registration - either NHTSA Guard or Canadian Guard allowed
- Phase 2 – three years after publication - Canadian Guard only (Sept 1, 2007)
Industry Built Trailer
Rear Impact 56 k/hr Honda Civic
Industry Built Trailer
Rear Impact 56 k/hr Honda Civic
Should Passenger Car Underride Protection be our Next Project?