Transport Canada testing in support of the global technical regulation on Door Locks and Door Retention Components

Presentation to NHTSA Team Members

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Standards and Regulations
Road Safety and Motor Vehicle Regulation

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OUTLINE

- Inertia Testing
- Latch Testing
- Combination Testing
Procedure

- 3 tests total as per gtr procedure:
  - 1 full vehicle test
  - 2 door-on-sled tests with 3 doors / test

- Hinged doors only

- Previously used in TC compliance programs

- Directions relative to VEHICLE axes, not LATCH / STRIKER axes
Vehicles

• 1 full vehicle test
  '00 Toyota Camry

• 2 door-on-sled tests with 3 doors / test
  '98 Toyota Camry  '03 Chevrolet TrailBlazer  '02 Ford Focus
Test #1 - Full Vehicle Test

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Door</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camry</td>
<td>All doors</td>
<td>Longitudinal Frontal</td>
</tr>
</tbody>
</table>

![Image showing the setup of the vehicle test](image-url)
# Test #2 - Door-on-Sled Test A

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Door</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>TrailBlazer</td>
<td>Driver</td>
<td>Longitudinal Frontal</td>
</tr>
<tr>
<td>Focus</td>
<td>Hatchback</td>
<td>Lateral</td>
</tr>
<tr>
<td>Camry</td>
<td>Front Passenger</td>
<td>Lateral (Door Opening)</td>
</tr>
</tbody>
</table>

![Image showing the sled test setup with vehicles and sled acceleration direction]
### Test #3 - Door-on-Sled Test B

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Door</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>TrailBlazer</td>
<td>Driver</td>
<td>Lateral (Door Opening)</td>
</tr>
<tr>
<td>Focus</td>
<td>Hatchback</td>
<td>Rear (Door Opening)</td>
</tr>
<tr>
<td>Camry</td>
<td>Front Passenger</td>
<td>Rollover (Towards Ground)</td>
</tr>
</tbody>
</table>

![Image of test setup with vehicle doors and sled acceleration direction indicated]
Preparation of Full Vehicle Buck
Preparation of Doors-on-Sled

Orthogonal View

Side View

Focus

TrailBlazer

Focus

TrailBlazer
Preparation of Doors-on-Sled
Measuring Door Opening

- 1 high-speed camera / door
- Low-resistance tape on full-vehicle doors
- Wires to determine primary + secondary latching
Results - Sled Pulse

- Door-on-Sled Test A
- Door-on-Sled Test B
- Full Vehicle Test
## Results #1 - Full Vehicle Test

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Door</th>
<th>Direction</th>
<th>Secondary Remained Latched</th>
<th>Primary Remained Latched</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camry</td>
<td>LF</td>
<td>Long. Frontal</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>LR</td>
<td>Long. Frontal</td>
<td>✓</td>
<td>✓</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>RF</td>
<td>Long. Frontal</td>
<td>✓</td>
<td>✓</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>RR</td>
<td>Long. Frontal</td>
<td>✓</td>
<td>✓</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

* Tape broke on ALL doors, even though none opened
* Wires broke on rear doors, even though none opened
Results #1 - Full Vehicle Test
Results #1 - Full Vehicle Test

Left Front

Right Front

Wires Intact

Broken Tape
Results #1 - Full Vehicle Test

Left Rear

Right Rear

Broken Wires
Broken Tape
Results - Wire Breaking

- RR Primary $t = 0.0108$ s
- RR Secondary $t = 0.0203$ s
- LR Secondary $t = 0.0282$ s
- LR Primary $t = 0.0102$ s
Results #1 - Full Vehicle Test

Post-test:

- 250 N load application: no door openings √
- Door opening, closing: all doors OK √
- Latch + striker inspection: no damage √
- Very little deformation of frame post-test √
# Results #2 - Door-on-Sled Test A

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Door</th>
<th>Direction</th>
<th>Secondary Remained Latched</th>
<th>Primary Remained Latched</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>TrailBlazer</td>
<td>Driver</td>
<td>Longitudinal</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Frontal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus</td>
<td>Hatchback</td>
<td>Lateral</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Camry</td>
<td>Front</td>
<td>Lateral (Door</td>
<td>√</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Passenger</td>
<td>Opening)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Camry likely went to secondary latch, then rebounded into primary latch
* Camry door difficult to open and re-close post-test
Results #2 - Door-on-Sled Test A

TrailBlazer

Focus

Wires Intact
Results #2 - Door-on-Sled Test A

Camry

Primary Wire Broken
Results - Wire Breaking

![Graph showing results of Door-on-Sled Test A and Camry Primary t = 0.0175 s.](image)
Results #2 - Door-on-Sled Test A

Post-test:

• 250 N load application: no door openings ✓

• Door opening, closing: all doors OK except Camry X

• Latch + striker inspection: minor damage to Camry latch X
## Results #3 - Door-on-Sled Test B

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Door</th>
<th>Direction</th>
<th>Secondary Remained Latched</th>
<th>Primary Remained Latched</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>TrailBlazer</td>
<td>Driver</td>
<td>Lateral (Door Opening)</td>
<td>√</td>
<td>X</td>
<td>*</td>
</tr>
<tr>
<td>Focus</td>
<td>Hatchback</td>
<td>Rear (Door Opening)</td>
<td>√</td>
<td>?</td>
<td>**</td>
</tr>
<tr>
<td>Camry</td>
<td>Front Passenger</td>
<td>Rollover (Towards Ground)</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
</tbody>
</table>

* TrailBlazer likely went to secondary latch, then rebounded into primary latch
* TrailBlazer door completely jammed, much deformation
** Difficult to tell whether Focus went to secondary latch
Results #3 - Door-on-Sled Test B
Results #3 - Door-on-Sled Test B

TrailBlazer

Primary Wire Broken

Damage
Results #3 - Door-on-Sled Test B

Focus

Primary Wire Broken

Damage
Results #3 - Door-on-Sled Test B

Camry

Wires Intact, No Damage
Results - Wire Breaking

Door-on-Sled Test B

- TrailBlazer Primary $t = 0.0147$ s
- Focus Primary $t = 0.0253$ s
Results #3 - Door-on-Sled Test B

Post-test:

- 250 N load application: no door openings ✓
- Door opening, closing: all doors OK except TrailBlazer X
- Latch + striker inspection: major damage to Trailblazer door X
Post-test Procedure

• Side hinged doors:
  - must drill hole without damaging internal linkages
  - handle “center” needs better definition
Post-test Procedure

• Rear hatchbacks:
  
  - What to do about doors without handles?
  
  - e.g. Opens with key, from inside only
Conclusions - Results

• Failures = 0 / 10 tests

• Doors opening to secondary latched position =
  (2 or 3) / 3 lateral or door opening direction
  0 / 6 longitudinal direction
  0 / 1 rollover direction

• Worst case = lateral or door opening direction

• More deformation than expected
Conclusions - Procedure

• Tests feasible, more realistic than calculation

• Sled pulse initially difficult

• Monitoring door opening:
  - video absolutely necessary
  - tape method gives false results
  - wire method has potential
Conclusions - Cost Breakdown

- High cost for limited # of doors tested:
  - $25,000 CAD for vehicle + door-on-sled prep.
    - $6,900 CAD for full vehicle prep.
    - $6,000 CAD x 3 doors = $18,000 for door-on-sled prep.
  - $20,000 CAD for sled testing
    - $6,600 per test x 3 tests
## Conclusions - Procedure

<table>
<thead>
<tr>
<th>Full Vehicle</th>
<th>vs</th>
<th>Door-on-Sled</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ Interaction with door trim</td>
<td></td>
<td>- Not testing door system</td>
</tr>
<tr>
<td>- Need many cameras</td>
<td></td>
<td>- Costly preparation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Need expert machinist</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Difficult from compliance pt. of view</td>
</tr>
</tbody>
</table>
Conclusions - Procedure

TC can provide input into more detailed + improved procedure, e.g.:

• Detailed drawings of bucks for full vehicle + door-on-sled tests

• Wire method

• Post-test procedure
Conclusions - Canada’s thoughts

- Limited information regarding inertia openings in the field
- Full-vehicle more realistic than door-in-frame
- Tests expensive for information obtained
- Ideally, would like to do reconstructions of real-world inertia openings
LATCH TESTING
Objective

• What is max. load that latches can sustain?

• Perspective on loads required by gtr tests

• Selected latches
Procedure

As per CMVSS / FMVSS 206 procedure (SAE J839):
- Longitudinal, transverse directions
- Primary latch only (not secondary)
Specimens

• 2003 MY vehicles

• Power locks

• High volume sales vehicles:
  passenger car  minivan
  SUV          pickup truck
  (U.S. sales figures as of Oct 2003, Source: Automotive News)

• Latches, strikers, hardware:
  bought new from dealerships
### Results - Overview

<table>
<thead>
<tr>
<th>#</th>
<th>Vehicle</th>
<th>Latch</th>
<th>Dir.</th>
<th>Maximum Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ford F-150</td>
<td>Driver</td>
<td>Long.</td>
<td>21,128 N 4750 lb.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Trans.</td>
<td>19,669 N 4422 lb.</td>
</tr>
<tr>
<td>2</td>
<td>Toyota Camry</td>
<td>Front</td>
<td>Long.</td>
<td>26,292 N 5911 lb.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pass.</td>
<td>Trans.</td>
<td>24,899 N 5598 lb.</td>
</tr>
<tr>
<td>3</td>
<td>Dodge Caravan</td>
<td>Driver</td>
<td>Long.</td>
<td>29,948 N 6733 lb.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Trans.</td>
<td>17,143 N 3854 lb.</td>
</tr>
<tr>
<td>4</td>
<td>Chevrolet Trail Blazer</td>
<td>Driver</td>
<td>Long.</td>
<td>42,981 N 9663 lb.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Trans.</td>
<td>16,693 N 3753 lb.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dir.</th>
<th>CMVSS / FMVSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long.</td>
<td>11,000 N 2473 lb.</td>
</tr>
<tr>
<td>Trans.</td>
<td>8,900 N 2000 lb.</td>
</tr>
</tbody>
</table>
Results - Ford F-150

Longitudinal

Failure = 21,128 N (4750 lb.)
Mode = striker bolts stripped

Transverse

Failure = 19,669 N (4422 lb.)
Mode = 2 latch bolts failed
Results - Toyota Camry

Longitudinal

Failure = 26,292 N (5911 lb.)
Mode = striker bolts stripped

Transverse

Failure = 24,899 N (5598 lb.)
Mode = striker failed at base
Results - Dodge Caravan

**Longitudinal**

Failure = 29,948 N (6733 lb.)
Mode = striker failed at top

**Transverse**

Failure = 17,143 N (3854 lb.)
Mode = striker failed in 2 places
Results - Chevy TrailBlazer

Longitudinal
Failure = 42,981 N (9663 lb.)
Mode = striker failed in 2 places

Transverse
Failure = 16,693 N (3753 lb.)
Mode = latch opened
Summary - Maximum Loads

<table>
<thead>
<tr>
<th>Dir.</th>
<th>CMVSS / FMVSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long.</td>
<td>11,000 N</td>
</tr>
<tr>
<td>Trans.</td>
<td>8,900 N</td>
</tr>
</tbody>
</table>

- Longitudinal loads
  1.9x - 3.9x limit
  21,128 N - 42,981 N

- Transverse loads
  1.9x - 2.8x limit
  16,693 N - 24,899 N
Summary - Failure Modes

- Longitudinal Failure Modes:
  4 / 4 related to striker

- Transverse Failure Modes:
  2 / 4 related to striker
  1 / 4 related to latch bolts
  1 / 4 related to latch opening
COMBINATION TESTING

Direction of Applied Force
- Simulating force parallel to latch face along vehicle’s transverse axis.

Direction of Applied Force
- Simulating force perpendicular to latch face along vehicle’s longitudinal axis.

LATCH STRIKER

Longitudinal Loading Device

Movement of loading device to mate the latch with the striker

Transverse Loading Device

Transverse Constraint

LATCH OPENING

Transport Canada
Transports Canada
Objective

- Evaluate test procedure, suggest improvements
- Obtain results for 4 latches
- Compare results to latch testing program results
Procedure

- 4 tests total:
  - 2 tests as per gtr procedure in long. **COMPRESSION**
  - 2 tests in longitudinal **TENSION**

- Directions relative to
  - LATCH / STRIKER axes, not VEHICLE axes

- Force application rate:
  - Longitudinal as per gtr (1.0 cm/min)
  - Lateral 0 - 6,650 N in 10 s (unspecified in gtr)
## Test Matrix

<table>
<thead>
<tr>
<th>#</th>
<th>Vehicle</th>
<th>Latch</th>
<th>Longitudinal Force</th>
<th>Load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Direction</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Ford F-150</td>
<td>Driver</td>
<td>Compression</td>
<td>16,000 N</td>
</tr>
<tr>
<td>2</td>
<td>Toyota Camry</td>
<td>Front</td>
<td>Compression</td>
<td>16,000 N</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pass.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Dodge Caravan</td>
<td>Driver</td>
<td>Tension</td>
<td>16,000 N</td>
</tr>
<tr>
<td>4</td>
<td>Chevrolet Trail</td>
<td>Driver</td>
<td>Tension</td>
<td>16,000 N</td>
</tr>
<tr>
<td></td>
<td>Blazer</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Test Setup

Free lateral movement

Lateral force application

Long force application
Test Setup

Latch-supporting plate
Results - Long. Compression

F-150

Lateral Force

Long. Force

Long. Displacement

Time (s)

Load (N)

Displacement (mm)
Results - Long. Compression

CAMRY

Lateral Force

Long. Force

Long. Displacement

Transport Canada

Transports Canada
Results - Long. Compression

e.g. CAMRY
Results - Long. Compression

- Interference between striker plate and latch-supporting plate

- Tests results insignificant
Results - Long. Compression

CARAVAN

Load (N)

Long. Displacement
Lateral Force
Long. Force

Displacement (mm)

Time (s)
Results - Long. Compression

TRAILBLAZER

Load (N)

Time (s)

Displacement (mm)

Long. Displacement

Lateral Force

Long. Force
Results - Long. Tension

- No failures
- No damage to any parts
Results - Long. Tension

e.g. TRAILBLAZER
Conclusions

• Tests are feasible (both compression + tension)

• Challenging simultaneous force application

• TC can provide:
  - detailed drawings of test setup + latch support plates
  - input into more detailed + improved procedure
Conclusions

• TC does not recommend the longitudinal compression test using the current test procedure: not testing latch performance, testing fixture

• Difficult to simulate offset frontal crash forces using only latch

• Longitudinal tension test has potential, BUT:
  - research needed into lateral + longitudinal forces during actual offset collisions
  - is this realistic of UNSTRUCK side?