REPORT NUMBER: 201-VER-04-05

SAFETY COMPLIANCE TESTING FOR FMVSS 201
OCCUPANT PROTECTION IN INTERIOR IMPACT

TOYOTA MOTOR MANUFACTURING INDIANA, INC.
2004 TOYOTA SIENNA

NHTSA NUMBER: C45103
GD TEST NUMBER: 8655-F201-28

ADVANCED INFORMATION ENGINEERING SERVICES
A GENERAL DYNAMICS COMPANY
TRANSPORTATION SCIENCES CENTER
P.O. BOX 400
BUFFALO, NEW YORK 14225

Test Date: July 21, 2004

FINAL REPORT

PREPARED FOR:

U. S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Enforcement
Office of Vehicle Safety Compliance
Mail Code: NVS-220, Room 6111
400 Seventh Street, SW
Washington, DC 20590
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Prepared by: James Czarnecki, Project Engineer

Approved by: David J. Travale, Program Manager
Transportation Science Center

Approval Date: August 5, 2004

FINAL REPORT ACCEPTANCE BY:

NHTSA, Office of Vehicle Safety Compliance

Date of Report Acceptance: 7.11.2004

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Compliance tests were conducted on the subject vehicle, a 2004 Toyota Sienna, in accordance with the specifications of the Office of Vehicle Safety Compliance Test Procedure TP-201-02 for determination of FMVSS 201 compliance.

Test failures identified were as follows: None

Copies of this report are available from:
NHTSA Technical Reference Division
400 Seventh St, SW
Washington, DC 20590
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SECTION 1

PURPOSE AND TEST PROCEDURE

This head impact compliance test is part of the FMVSS 201 Occupant Protection in Interior Impact Test Program sponsored by the National Highway Traffic Safety Administration (NHTSA) under Contract No. DTNH22-01-C-01025. The purpose of this impact compliance test was to determine whether the subject vehicle, a 2004 Toyota Sienna, NHTSA No. C45103, meets the performance requirements of FMVSS 201, Occupant Protection in Interior Impact. The compliance test was conducted using the requirements found in the OVSC Laboratory Test Procedure No. TP-201-02 dated March 3, 1989.
SECTION 2

SUMMARY OF OCCUPANT PROTECTION IN INTERIOR IMPACTS

A 2004 Toyota Sienna, NHTSA No. C45103, was impacted at various locations throughout its instrument cluster/dash panel and seat back area by a 15 lb, 6.5 inch diameter steel headform. A total of five (5) impacts were performed in this test series. The five (5) chosen impact points were:

- Seat Back / Head Restraint Area (2 impacts)
- Instrument Panel Cluster Area
- Airbag Cover / Dash Panel Area (2 impacts)

The selected impact areas on the test vehicle appeared to comply with the performance requirements of FMVSS 201.

The 6.5 inch diameter steel headform weighed 15 lb and had an accelerometer mounted along its centerline.

One (1) channel of data for each target impact test was recorded on a Keyser-Threde data acquisition system. Data plots can be found in Appendix C. Still photographs can be found in Appendix A of this report.
TEST VEHICLE RECEIVING INSPECTION DATA SHEET

| VEHICLE YEAR/MAKE/MODEL/STYLE: | 2004 Toyota Sienna |
| NHTSA NO.: | C45103 |
| VIN: | STDZA23C34S070133 |
| DATE OF MANUFACTURE: | 09/03 (SEE CERTIFICATION LABEL) |
| COLOR: | Silver |
| ODOMETER READING: | 111 miles |
| LABORATORY: | GD Engineering |
| TEST DATE: | July 21, 2004 |

NUMBER OF SEATING POSITIONS:

FRONT: 2  REAR: 3

INSTRUMENT PANEL:

NOTE UNUSUAL FEATURES: None

TYPE OF FRONT SEATS:

BENCH: -  BUCKET: X  SPLIT BACKS: -

TYPE OF HEAD RESTRAINTS:

FIXED: -  ADJUSTABLE: X

VEHICLE EQUIPPED WITH ARMRESTS?

NO: -  YES: X  NUMBER: 6

LOCATION: Front and rear door panels with seat fold down arm rests

VEHICLE EQUIPPED WITH SUN VISORS?

NO: -  YES: X

VEHICLE EQUIPPED WITH INTERIOR DOOR LATCHES?

NO: -  YES: X  NUMBER: 1

LOCATION: Glove Box
HEADFORM IMPACT TEST RESULTS
INSTRUMENT PANEL

<table>
<thead>
<tr>
<th>VEHICLE YEAR/MAKE/MODEL/STYLE:</th>
<th>2004 Toyota Sienna</th>
</tr>
</thead>
<tbody>
<tr>
<td>NHTSA NO.:</td>
<td>C45103</td>
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<tr>
<td>VIN:</td>
<td>STDZA23C34S070133</td>
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<tr>
<td>DATE OF MANUFACTURE:</td>
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<tr>
<td>COLOR:</td>
<td>Silver</td>
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<tr>
<td>ODOMETER READING:</td>
<td>111 miles</td>
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<tr>
<td>LABORATORY:</td>
<td>GD Engineering</td>
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<tr>
<td>TEST DATE:</td>
<td>July 21, 2004</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>IMPACT LOCATION AND NUMBER</th>
<th>X (inches)</th>
<th>Y (inches)</th>
<th>ANGLE (degrees)</th>
<th>VELOCITY (mph)</th>
<th>PEAK ACCELERATION (3 ms Clip) Gs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Dash Cluster</td>
<td>24.25</td>
<td>0.0</td>
<td>-27</td>
<td>11.4</td>
<td>49.92</td>
</tr>
<tr>
<td>2 Left Side of Airbag Cover</td>
<td>28.75</td>
<td>12.5</td>
<td>-45</td>
<td>11.4</td>
<td>47.22</td>
</tr>
<tr>
<td>3 Right Side of Airbag Cover</td>
<td>27.75</td>
<td>22.3</td>
<td>-54</td>
<td>11.5</td>
<td>49.22</td>
</tr>
</tbody>
</table>

REFERENCE POINT: Seating Reference Position (SGRP) on front passenger side is the reference point (x positive forward from SGRP and y positive to the right of the vehicle centerline).

REMARKS:
# HEADFORM IMPACT TEST RESULTS
## SEAT BACKS

<table>
<thead>
<tr>
<th>VEHICLE YEAR/MAKE/MODEL/STYLE:</th>
<th>2004 Toyota Sienna</th>
</tr>
</thead>
<tbody>
<tr>
<td>NHTSA NO.:</td>
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</tr>
<tr>
<td>VIN:</td>
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</tr>
<tr>
<td>DATE OF MANUFACTURE:</td>
<td>09/03 (SEE CERTIFICATION LABEL)</td>
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<tr>
<td>COLOR:</td>
<td>Silver</td>
</tr>
<tr>
<td>ODOMETER READING:</td>
<td>111 miles</td>
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<tr>
<td>LABORATORY:</td>
<td>GD Engineering</td>
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<tr>
<td>TEST DATE:</td>
<td>June 9, 2004</td>
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</table>

<table>
<thead>
<tr>
<th>IMPACT LOCATION AND NUMBER</th>
<th>VELOCITY (mph)</th>
<th>PEAK ACCELERATION (3 ms Clip) Gs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front Seat Back</td>
<td>-10.3</td>
<td>14.6</td>
</tr>
<tr>
<td>2ND Row Seat Back</td>
<td>-53.9</td>
<td>14.9</td>
</tr>
</tbody>
</table>

REFERENCE POINT: SGRP on rear passenger side is the reference point (x positive forward from SGRP and y positive to the right of the seat centerline).
SUN VISOR AND ARMREST EVALUATION

VEHICLE YEAR/MAKE/MODEL/STYLE: 2004 Toyota Sienna
NHTSA NO.: C45103
VIN: 5TDZA23C34S670133
DATE OF MANUFACTURE: 09/03 (SEE CERTIFICATION LABEL)
COLOR: Silver
ODOMETER READING: 111 miles
LABORATORY: GD Engineering
TEST DATE: July 21, 2004

SUN VISOR INFORMATION:

1. Are sun visors constructed of or covered with energy absorbing material?
   YES (PASS): X    NO (FAIL): -

2. Are any edges statically contactable by a spherical 6.5 inch diameter headform of radius less than 0.125 inch?
   YES (FAIL): -    NO (PASS): X

ARMREST INFORMATION:

A. FIXED ARMREST

1. Is it constructed of energy absorbing material with the capability of laterally deflecting 2 inches without contacting any underlying rigid material?
   YES: N/A    NO: N/A

2. Is it constructed of energy absorbing material that deflects or collapses within 1.25 inches of the rigid test panel surface without contacting underlying rigid material between 0.50 and 1.25 inches from the panel which has a vertical height of less than 1 inch?
   YES: N/A    NO: N/A

3. Does it provide adequate pelvic area impact protection?
   YES: X    NO: -

4. Does it meet at least one of the criteria No. 1 to 3?
   YES (PASS): X    NO (FAIL): -

B. FOLDING ARMREST

Is it made of or covered with energy absorbing material? Or does it meet at least one of the criteria No. 1 to 3?
   YES (PASS): X    NO (FAIL): -
## DOOR LATCH EVALUATION

<table>
<thead>
<tr>
<th>VEHICLE YEAR/MAKE/MODEL/STYLE:</th>
<th>2004 Toyota Sienna</th>
</tr>
</thead>
<tbody>
<tr>
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<td>C45103</td>
</tr>
<tr>
<td>VIN:</td>
<td>5TDZA23C34S070133</td>
</tr>
<tr>
<td>DATE OF MANUFACTURE:</td>
<td>09/03 (SEE CERTIFICATION LABEL)</td>
</tr>
<tr>
<td>COLOR:</td>
<td>Silver</td>
</tr>
<tr>
<td>ODOMETER READING:</td>
<td>111 miles</td>
</tr>
<tr>
<td>LABORATORY:</td>
<td>GD Engineering</td>
</tr>
<tr>
<td>TEST DATE:</td>
<td>July 21, 2004</td>
</tr>
</tbody>
</table>

## LATCH ENGAGEMENT INTERFERENCE

<table>
<thead>
<tr>
<th>DESCRIPTION OF LATCH LOCATION</th>
<th>NO LOAD</th>
<th>10G HORIZONTAL TRANSVERSE</th>
<th>10G VERTICAL</th>
<th>30G HORIZONTAL LONGITUDINAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glove Box</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
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(APPENDIX B CONTAINS CALCULATION SHEETS WHICH ARE BASED ON MANUFACTURER’S DATA)
SUMMARY OF RESULTS

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<thead>
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<th>VEHICLE YEAR/MAKE/MODEL/STYLE:</th>
<th>2004 Toyota Sienna</th>
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<tbody>
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<td>LABORATORY:</td>
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<tr>
<td>TEST DATE:</td>
<td>July 21, 2004</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>NUMBER OF IMPACTS</th>
<th>PASS/FAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>INSTRUMENT PANEL</td>
<td>3</td>
<td>Pass</td>
</tr>
<tr>
<td>SEAT BACK</td>
<td>2</td>
<td>Pass</td>
</tr>
<tr>
<td>SUN VISORS</td>
<td>n/a</td>
<td>Pass</td>
</tr>
<tr>
<td>ARMRESTS</td>
<td>n/a</td>
<td>Pass</td>
</tr>
<tr>
<td>INTERIOR COMPARTMENT DOORS</td>
<td>n/a</td>
<td>Pass</td>
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REMARKS:
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<td>RIGHT SIDE VIEW OF VEHICLE</td>
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<td>A-3</td>
<td>3/4 FRONTAL VIEW FROM LEFT SIDE OF VEHICLE</td>
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<td>A-4</td>
<td>3/4 REAR VIEW FROM RIGHT SIDE OF VEHICLE</td>
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<td>VEHICLE'S TIRE INFORMATION LABEL</td>
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<td>A-7</td>
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<td>A-10</td>
<td>ARMREST 2ND ROW SEAT</td>
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<td>A-11</td>
<td>ARMREST REAR SEAT LEFT TRIM PANEL</td>
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<td>A-12</td>
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<td>INSTRUMENT PANEL LEFT SIDE AIRBAG COVER IMPACT PRE-TEST</td>
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<td>A-15</td>
<td>INSTRUMENT PANEL LEFT SIDE AIRBAG COVER IMPACT POST-TEST</td>
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<td>A-16</td>
<td>INSTRUMENT PANEL RIGHT SIDE AIRBAG COVER IMPACT PRE-TEST</td>
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<tr>
<td>A-17</td>
<td>INSTRUMENT PANEL RIGHT SIDE AIRBAG COVER IMPACT POST-TEST</td>
</tr>
<tr>
<td>A-18</td>
<td>INSTRUMENT PANEL CONSOLE VENT IMPACT PRE-TEST</td>
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<tr>
<td>A-19</td>
<td>INSTRUMENT PANEL CONSOLE VENT IMPACT POST-TEST</td>
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<td>FRONT SEAT HEAD RESTRAINT</td>
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<td>SECOND ROW SEAT HEAD RESTRAINT</td>
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<td>A-25</td>
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</table>
Figure A-17: INSTRUMENT PANEL RIGHT SIDE AIRBAG COVER IMPACT POST-TEST
Figure A-21: FRONT SEAT HEAD RESTRAINT IMPACT AREA PRE-TEST
APPENDIX B

INTERIOR COMPARTMENT DOOR CALCULATIONS
FMVSS No. 201
Latch Component Analysis Information

Latch component inertial analysis information for each interior compartment door assembly located in an instrument panel, console assembly, seat back, or side panel adjacent to a designated seating position in accordance with the procedure described in section 5 of SAE Recommended Practice J839b, "Passenger Car Side Door Latch Systems."

Such data shall include:

2004 model TOYOTA SIENNA

Instrument Panel Assembly

A: Passenger Upper Door  Page 2-5
B: Center Lower Box  Page 6-9
C: Center Storage Box (STD)  Page 10-14
D: Center Storage Box (HIGH GRADE)  Page 15-18
E: Glove Box  Page 19-22
F: Cup and Coin Box  Page 23-27
1. Geometric details of the latch/lock configuration.
2. Mass data for each element in the linkage.

1. SM1: Max Moment of the two spring to open direction
   SM1 = 0.109 Nm (Maximum Torque on drawing spec.)

2. W1: Weight of the Door assy = 2.35 N
   Mass of the Door assy = 239.5 g

3. W2: Weight of the lock knob = 0.0184 N
   Mass of the lock knob = 1.67 g

4. W3: Weight of the lock hook = 0.0231 N
   Mass of the lock hook = 2.36 g

5. Fs: Operation force to release knob = 4.12 N

6. F2: Operation force to the lock knob open = 3 N
   (Minimum force on drawing spec.)

7. Dimensions (mm)
   L1 = 114.5
   L2 = 49.8
   L3 = 34.9
   SL1 = 6.6
   SL2 = 32.1
   KL1 = 7.3
   KL2 = 0.9
   KL3 = 11.9
   KL4 = 11.6
3. Calculation results on “passenger upper door”

- **M1**: Moment of the Door received to open direction.
- **SM1**: Max Moment of the two spring to open direction.
- **M2**: Moment of the lock knob received to open direction.
- **W1**: Weight of the Door assy.
- **W2**: Weight of the lock knob.
- **W3**: Weight of the lock hook.
- **F1**: Force of the lock hook receive.
- **F2**: Operation force to the lock knob open.
- **F3**: Force of the lock hook receive force to up.
- **F4**: Force of the lock hook receive force to close.
- **F5**: Operation force to release knob.

1) 30G Rear Direction

\[ M1 = Gx \times W1 \times L2 - W1 \times L3 + F5 \times L1 \]
\[ = 30 \times 2.35 \times 49.8/1000 - 2.35 \times 34.9/1000 + 4.12 \times 114.5/1000 \]
\[ = 3.90 \text{ (Nm)} \]

The Lock knob & The lock hook do not receive force to open.

\[ F1 = M1 / L1 = 3.90 / (114.5/1000) = 34.07 \text{ (N)} \]

So, when the lock hook will not have failure by \( F1 \), the door will not open.

<table>
<thead>
<tr>
<th>Physical Failure test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test method: Pull the this door by 51.1 N force. ( = F1 \times 150 % ) = FF1</td>
</tr>
<tr>
<td>( &lt;\text{Test}&gt; ) #1: No failure, #2: No failure, #3: No failure, #4: No failure, #5: No failure</td>
</tr>
<tr>
<td>So, this parts do not have failure by 51.1N force ( (&gt; F1) )</td>
</tr>
</tbody>
</table>

FF1 > F1 (51.11 > 34.07), so the door does not open.

Result: The Door will remain closed.

2) 30G Front Direction

The door assy does not receive force to open.

The lock knob receives moment to open.

\[ M2 = Gx \times W2 \times KL1 + W2 \times KL2 \]
\[ = 30 \times 0.0164 \times (7.3/1000) + 0.0164 \times (0.9/1000) \]
\[ = 0.0036 \text{ (Nm)} \]

The lock hook receive force to up

\[ F3 = M2 / KL4 \times \cos 20 - W3 \times \cos 20 + W3 \times \sin 20 \times 30G \]
\[ = (0.0036/11.6/1000) \times \cos 20 - 0.023 \times \cos 20 + 0.0231 \times \sin 20 \times 300 \]
\[ = 0.545 \text{ (N)} \]

The lock hook force to close

\[ F4 = F2 \times \cos 20 \times KL3 / KL4 \times \cos 20 \]
\[ = 3 \times \cos 20 \times (11.9/1000) / (11.6/1000) \times \cos 20 \]
\[ = 2.72 \text{ (N)} \]

Result: \( F3 < F4 \) (0.545 < 2.72) So the lock knob will not released.
3) 10G Down Direction

The door assy does not receive force to open.
The lock knob receives moment to open.
\[ M_2 = G_y \times W_2 \times KL_2 + W_2 \times KL_2 \times (0.9/1000) \]
\[ = 10 \times 0.0164 \times (0.9/1000) + 0.0164 \times (0.9/1000) \]
\[ = 0.000165 \text{ (Nm)} \]
The lock hook receives force to up
\[ F_3 = \frac{M_2}{KL_4 \times \cos 20} - G_y \times W_3 \times \cos 20 - W_3 \times \cos 20 \]
\[ = 0.000165 \times (11.6/1000) \times \cos 20 - 10 \times 0.023 \times \cos 20 - 0.023 \times \cos 20 \]
\[ = -0.22 \text{ (N)} \]
The lock hook force to close (down)
\[ F_4 = F_2 \times \cos 20 \times KL_3 / KL_4 \times \cos 20 \]
\[ = 2.72 \text{ (N)} \]
Result: \( F_3 < F_4 \) (-0.22 < 2.72) So, the lock hook will not released.

4) 10G Up Direction

A) To confirm failure due to force on hook

\[ M_1 = G_y \times W_1 \times L_3 - W_1 \times L_3 + F_s \times L_1 \]
\[ = 10 \times 2.35 \times (34.9/1000) + 2.35 \times (34.9/1000) + 4.12 \times (114.5/1000) \]
\[ = 1.37 \text{ (Nm)} \]
So, when the lock hook does not have failure by \( F_1 \), the door will not open.
\[ F_1 = M_1 / L_1 \]
\[ = 1.37 / (114.5/1000) \]
\[ = 11.9 \text{ (N)} \]

The lock does not open due to force because: \( FF > F_1 \) (62 > 11.9)

B) To confirm lock failure due to force on hook

The lock knob does not receive force to open.
\[ F_3 = G_y \times W_3 \times \cos 20 - 0.0231 \times \cos 20 \]
\[ = 10 \times 0.0231 \times \cos 20 - 0.0231 \times \cos 20 \]
\[ = 0.198 \text{ (N)} \]
The lock hook force to close
\[ F_4 = 2.72 \text{ (N)} \]
\[ F_3 < F_4 \] (0.198 < 2.72) So, the lock hook will not move to open direction (UP).

Result: The Door will remain closed.

5) Right & Left Direction

A transverse inertial load will not cause the lid to open because of the fore/aft location of the latch and hinge.
CENTER LOWER BOX
FMVSS201 INTERIOR COMPARTMENT DOOR CALCULATION

1. Geometric details of the latch/lock configuration.
2. Mass data for each element in the linkage.

1. W1 : Weight of the Box assy = 2.98 N
   Mass of the Box assy = 304 g

2. W2 : Weight of the lock knob = 0.1 N
   Mass of the lock knob = 10.7 g

3. F2 : Operation force to the lock knob open = 10.8 N

4. Dimension (mm)
   L1 = 172.9
   L2 = 74.7
   L3 = 19.1
   L4 = 1.7
   L5 = 18.8
   L6 = 4.6
   LF1 = 160.4
3. Calculation results on "center lower box"

M1: Moment of the Box received to open box.
M2: Moment of the lock knob received to open.
M3: Moment of the lock knob received to close knob by spring.
W1: Weight of the Box assy.
W2: Weight of the lock knob
F1: Force of the lock knob received by M1.
F2: Operation force to the lock knob open.
FF1: Push force of failure test.

1) 30G Rear Direction

A) To confirm failure due to force on hook

\[ M1 = W1 \times L3 + Gx \times W1 \times L2 \]
\[ = 2.98 \times 19.1/1000 + 30 \times 2.98 \times 74.7/1000 \]
\[ = 6.74 \text{ (Nm)} \]

\[ F1 = M1 / L1 = 6.74 / (172.9/1000) \]
\[ = 39.0 \text{ (N)} \]

**Physical Failure Test**

Test method: Push this box by FF1 force.

\[ FF1 = M1 / LF1 \times 150 \% = 6.71 / (160.4/1000) \times 1.5 = 63 \text{ (N)} \]

<Test> #1: No failure, #2: No failure, #3: No failure, #4: No failure, #5: No failure

So, this box does not open (failure) due to FF1 force.

The lock does not open due to linear force because: \( FF1 > F1 \) (63 > 39.0)

B) To confirm no lock rotation

\[ M2 = Gx \times W2 \times L6 - W2 \times L4 \]
\[ = 30 \times 0.1 \times 4.6/1000 - 0.1 \times 1.7/1000 \]
\[ = 0.0137 \text{ (Nm)} \]

\[ M3 = F2 \times L5 \]
\[ = 10.8 \times 18.8/1000 \]
\[ = 0.203 \text{ (Nm)} \]

\[ M2 < M3 \text{ (0.0137 < 0.203)}, \text{ The lock knob and lock hook will not rotate to open.} \]
The Box will not open.

Result: Because of items A) and B) the box will remain closed.

2) 30G Front Direction

The Box & lock knob will not receive force to open.
Result: The Box will remain closed.
3) 10G Down Direction

A) To confirm failure due to force on hook

\[ M_1 = W_1 \times L_3 + G_y \times W_1 \times L_3 \]
\[ = 2.98 \times 19.1/1000 + 10 \times 2.98 \times 19.1/1000 \]
\[ = 0.628 \text{ (Nm)} \]

\[ F_1 = M_1 / L_1 = \frac{0.628}{(172.9/1000)} \]
\[ = 3.62 \text{ (N)} \]

The lock does not open due to force because: \( F_1 > F \) (63 > 3.62)

B) To confirm no lock rotation

The lock knob will not receive a force to rotate open.

Result: Because of items A) and B) the box will remain closed.

4) 10G Up Direction

A) To confirm lock failure due to force on hook

The Box will not receive force to open.

B) To confirm no lock rotation

\[ M_2 = G_y \times W_2 \times L_4 - W_2 \times L_4 \]
\[ = 10 \times 0.1 \times 1.7/1000 - 0.1 \times 1.7/1000 \]
\[ = 0.0015 \text{ (Nm)} \]

\[ M_3 = F_2 \times L_5 = 0.203 \text{ (Nm)} \]

\[ M_2 < M_3 \text{ (0.0015 < 0.203)}, \] The lock knob and lock hook will not rotate to open.

The Box will not open.

Result: Because of items A) and B) the box will remain closed.

5) Right & Left Direction

A transverse inertial load will not cause the lid to open because of the fore/aft location of the latch and hinge.
1. Geometric details of the latch/lock configuration.
2. Mass data for each element in the linkage.

1. W1: Weight of the upper Door assy = 0.833 N
   Mass of the upper Door assy = 85.1 g

2. W2: Weight of the lower Door assy = 0.51 N
   Mass of the lower Door assy = 52.2 g

3. F2: Operation force of the upper door push open
   F2 = 4 N (Minimum force on drawing spec.)

4. F4: Operation force of the lower door push open
   F4 = 4 N (Minimum force on drawing spec.)

5. Dimension (mm)
   L1 = 43.3
   L2 = 5.6
   L3 = 1.4
   L4 = 44.1
   L5 = 27
   L6 = 2.4
   L7 = 11.1
   L8 = 32
3. Calculation results on "center storage box (STD)"

M1: Moment of the upper Door received to open direction.
Mc1: Moment of the upper Door having to close.
M2: Moment of the lower Door received to open direction.
Mc2: Moment of the lower Door having to close.
W1: Weight of the upper Door assy.
W2: Weight of the lower Door assy.
F1: Force of the upper door lock hook receive
F2: Operation force of the upper door push open
F3: Force of the lower door lock hook receive
F4: Operation force of the lower door push open

**UPPER DOOR**

1) 30G Rear Direction

*Door Open moment*

\[ M1 = Gx \times W1 \times L2 - W1 \times L3 = 30 \times 0.833 \times 5.6/1000 - 0.833 \times 1.4/1000 \]
\[ = 0.139 \text{ (Nm)} \]

*Door Close moment*

(Force of close is as same as the operation force to open.)

\[ Mc1 = F2 \times \cos30.1 \times L4 = 4 \times \cos30.1 \times 44.1/1000 \]
\[ = 0.153 \text{ (Nm)} \]

**Result:** M1 < Mc1 (0.139 < 0.153). So the upper door will remain closed.

2) 30G Front Direction

The upper Door is not received force to open direction.
So, when the door does not have failure by F1, the door will not open.

\[ Mc1 = Gx \times W1 \times L2 + W1 \times L3 + F2 \times \cos30 \times L4 = 30 \times 0.833 \times 5.6/1000 + 0.833 \times (1.4/1000) + 4 \times \cos30 \times (44.1/1000) \]
\[ = 0.293 \text{ (Nm)} \]

\[ F1 = Mc1 / L1 = 0.293 / (43.3/1000) = 6.77 \text{ (N)} \]

**Physical Failure test**

Test method: Pull the this door by 10.0 N force. (≈F1 x 150 %) = FF3
(Pull force direction & point is as same as F1)

<Test> #1: No failure, #2: No failure, #3: No failure, #4: No failure, #5: No failure

So, this parts do not have failure by 10.0 N force (> F1)

FF3 > F1 (10 > 6.77), so the door does not open.

**Result:** The Door will remain closed.
3) 10G Down Direction

The upper Door is not received force to open direction.
So, when the door does not have failure by F1, the door will not open.

\[
M_{c1} = G_y \times W_1 \times L_3 + W_1 \times L_3 + F_2 \times \cos 30 \times L_4.
\]
\[
= 10 \times 0.833 \times 1.4/1000 + 0.833 \times 1.4/1000 + 4 \times \cos 30 \times (44.1/1000)
\]
\[
= 0.166 \text{ (Nm)}
\]

\[
F_1 = \frac{M_{c1}}{L_1} = \frac{0.168}{(43.3/1000)}
\]
\[
= 3.83 \text{ (N)}
\]

\[
F_{F1} > F_1 \quad (10.0 > 3.83) \quad \text{so, the door does not open.}
\]

Result: The box will remain closed.

4) 10G Up Direction

Door Open moment
\[
M_1 = G_y \times W_1 \times L_3 - W_1 \times L_3
\]
\[
= 10 \times 0.833 \times 1.4/1000 - 0.833 \times (1.4/1000)
\]
\[
= 0.0105 \text{ (Nm)}
\]

Door Close moment
(Force of close is as same as the operation force to open.)
\[
M_{c1} = F_2 \times \cos 30.1 \times L_4 = 4 \times \cos 30.1 \times (44.1/1000)
\]
\[
= 0.153 \text{ (Nm)}
\]

Result: \( M_1 < M_{c1} \quad (0.0105 < 0.153) \) So, the upper door will remain closed.

Right & Left Direction

A transverse inertial load will not cause the lid to open because of the fore/aft location of the latch and hinge.

LOWER DOOR

1) 30G Rear Direction

The lower Door does not receive force to open direction.
So, when the door does not have failure by F3, the door will not open.

\[
M_{c2} = G_x \times W_2 \times L_6 + W_2 \times L_7 + F_4 \times \cos 45.7 \times L_8
\]
\[
= 30 \times 0.51 \times 2.4/1000 + 0.51 \times 11.1/1000 + 4 \times \cos 45.7 \times 32/1000
\]
\[
= 0.132 \text{ (Nm)}
\]

\[
F_3 = \frac{M_{c2}}{L_5} = \frac{0.132}{(27/1000)}
\]
\[
= 4.89 \text{ (N)}
\]

Physical Failure test

Test method: Pull the this door by 7.3 N force, \( F_3 \times 150 \%) = FFL.
(Pull force direction & point is as same as F3.)
<br>
<Test> #1: No failure, #2: No failure, #3: No failure, #4: No failure, #5: No failure
<br>
So, this parts do not have failure by 7.3 N force (> F3)

FFL > F3 (7.3 > 4.89), so the door does not open.

Result: The Door will not open by 30G rear direction.
2) 30G Front Direction

Door Open moment
\[ M_2 = G x W_2 x L_6 - W_2 x L_7 \]
\[ = 30 x 0.51 x 2.4/1000 - 11.1/1000 \]
\[ = 0.031 \text{ (Nm)} \]

Door Close moment
(Force of close is as same as the operation force to open.)
\[ M_{c2} = F_4 x \cos 45.7 x L_8 \]
\[ = 4 x \cos 45.7 x 32/1000 \]
\[ = 0.0894 \text{ (Nm)} \]

Result: \[ M_2 < M_{c2} (0.031 < 0.0894) \] So, the lower door will remain closed.

3) 10G Down Direction

The lower Door do not receive force to open direction. So, the lower door will not open.

\[ M_{c2} = G y W_2 x L_7 + W_2 x L_7 + F_4 x \cos 45.7 x L_8 \]
\[ = 10 x 0.51 x 11.1/1000 + 11.1/1000 + 4 x \cos 45.7 x 32/1000 \]
\[ = 0.152 \text{ (Nm)} \]

\[ F_3 = M_{c2} / L_5 = 0.152 / (27/1000) = 5.62 \text{ (N)} \]

Physical Failure test

Test method: Pull the this door by 8.43 N force. (= F_3 x 150 %) = FFA
(Pull force direction & point is as same as F_3.)

<Test> #1: No failure, #2: No failure, #3: No failure, #4: No failure, #5: No failure

So, this parts do not have failure by 8.43 N force (> F_3)

FFA > F_3 (8.43 > 5.62), so the door does not open.

Result: The Door will remain closed.

4) 10G Up Direction

Door Open moment
\[ M_2 = G y W_2 x L_7 - W_2 x L_7 \]
\[ = 10 x 0.51 x 11.1/1000 - 0.51 x 11.1/1000 \]
\[ = 0.051 \text{ (Nm)} \]

Door Close moment
(Force of close is as same as the operation force to open.)
\[ M_{c2} = F_4 x \cos 45.7 x L_8 = 4 x \cos 45.7 x 32/1000 \]
\[ = 0.0894 \text{ (Nm)} \]

Result: \[ M_2 < M_{c2} (0.051 < 0.0894) \] The lower door will remain closed.

Right & Left Direction

A transverse inertial load will not cause the lid to open because of the fore/aft location of the latch and hinge.
1. Geometric details of the latch/lock configuration.
Mass data for each element in the linkage.

1. W₁: Weight of the Door assy = 0.52 N
   Mass of the Door assy = 53.06 g

2. F₂: Operation force of the door push open = 4 N

3. Dimension (mm)
   L₁ = 30.1
   L₂ = 7.4
   L₃ = 7.0
   L₄ = 39.5
Calculation results on "center storage box (High grade)"

M1 : Moment of the Door received to open door.
Mc1: Moment of the Door having to close door.
W1 : Weight of the Door assy.
F1 : Force of the door lock hook receive
F2 : Operation force of the door push open.

1)30G Rear Direction

A) To confirm moment

Door Open moment
M1 = Gx x W1 x L2 + W1 x L3
    = 30 x 0.52 x 7.4/1000 + 0.52 x 7.0/1000
    = 0.119 (Nm)

Door Close moment
(Force to close is same as the operation force to open.)
Mc1 = F2 x cos40.8 x L4 = 4 x cos40.8 x 39.5/1000
    = 0.120 (Nm)

M1 < Mc1 (0.119 < 0.120), So, the door will not open.

Result: The door will remain closed.

2)30G Front Direction

The Door will not receive force to open.
So, the door does not have failure by F1, the door will not open.

Mc1 = Gx x W1 x L2 - W1 x L3 + F2 x cos40.8 x L4
     = 30 x 0.52 x 7.4/1000 - 0.52 x 7.0/1000 + 4 x cos40.8 x 39.5/1000
     = 0.24 (Nm)

F1 = Mc1 / L1
    = 0.24 / (30.1/1000)
    = 7.97 (N)

Physical Failure test

Test method : Pull the this door by 11.0 N force. (= F1 x 150 %) = Fp
(Pull force direction & point is as same as F1.)
<Test> #1: No failure, #2: No failure, #3: No failure, #4: No failure, #5: No failure

So, this door does not have failure at 11.0N force (> F1)

The door does not open due to force: Fp > F1 (11.0 > 7.97)

Result : The Door will remain closed.
10G Down Direction
The Door does not receive force in open direction.
So, the door will not have failure by F1, the door will not open.

\[ Mc1 = Gy \times W1 \times L3 - W1 \times L3 + F2 \times \cos 40.8 \times L4 \]
\[ = 10 \times 0.52 \times 7/1000 - 0.52 \times 7/1000 + 4 \times \cos 40.8 \times 39.5/1000 \]
\[ = 0.15 \text{ (Nm)} \]

\[ F1 = \frac{Mc1}{L1} \]
\[ = \frac{0.15}{(30.1/1000)} \]
\[ = 4.98 \text{ (N)} \]

The door does not open due to force: \( Fp > F1 \ (11.0 > 4.98) \)

Result: The door will remain closed.

4) 10G Up Direction
A) To confirm moment

Door Open moment

\[ M1 = Gy \times W1 \times L3 + W1 \times L3 \]
\[ = 10 \times 0.52 \times 7/1000 + 0.52 \times 7.0/1000 \]
\[ = 0.04 \text{ (Nm)} \]

Door Close moment
(Force of close is as same as the operation force to open.)
\[ Mc1 = F2 \times \cos 40.8 \times L4 = 4 \times \cos 40.8 \times 39.5/1000 \]
\[ = 0.120 \text{ (Nm)} \]

\[ M1 < Mc1 \ (0.04 < 0.120) \] So, the door will not move to open.

Result: The door will remain closed.

5) Right & Left Direction

A transverse inertial load will not cause the lid to open because of the fore/aft location of the latch and hinge.
GLOVE BOX
FMVSS201 INTERIOR COMPARTMENT DOOR CALCULATION

Geometric details of the latch/lock configuration.
1. W1 : Weight of the Box assy = 15 N
   Mass of the Box assy = 1534 g

2. W2 : Weight of the lock knob = 0.38 N
   Mass of the lock knob = 39.2 g

3. W3 : Weight of the lock hook = 0.03 N
   Mass of the lock hook = 3.0 g

4. F2 : Operation force to the lock knob open = 22 N

6. Dimension (mm)
   L1 = 252.3
   L2 = 138.4
   L3 = 71.2
   L4 = 4.1
   L5 = 13.1
   L6 = 5.7
   L7 = 10.8
   L8 = 0.1
3. Calculation results on "glove box"

M1 : Moment of the Box received to open direction
M2 : Moment of the lock knob received to open direction.
M3 : Moment of the lock hook received to open direction.
M4 : Moment of the lock knob having to close direction by spring force.
W1 : Weight of the Box assy.
W2 : Weight of the lock knob.
W3 : Weight of the lock hook.
F1 : Force of the lock knob received by M1
F2 : Operation force to the lock knob open.

1) 30G Rear Direction

A) To confirm failure due to force on hook

\[
M1 = W1 \times L3 + Gx \times W1 \times L2
= 15.0 \times 71.2/1000 + 30 \times 15.0 \times 138.4/1000
= 63.4 \text{ (Nm)}
\]

\[
F1 = \frac{M1}{L1} = \frac{63.4}{(252.3/1000)} = 251.3 \text{ (N)}
\]

**Physical Failure Test**

Test method: Pull the this door by 377 N force, (= F1 \times 150 \%) = FL
(Pull force direction & point is as same F1.)

<Test> #1: No failure, #2: No failure, #3: No failure, #4: No failure, #5: No failure

So, this box does not open (failure) due to FL force.

The lock does not open due to force because: FL > F1 (377 > 251.3)

B) To confirm no lock rotation

\[
M2 = Gx \times W2 \times L6 + W2 \times L4
= 30 \times 0.38 \times 5.7/1000 + 38.5 \times 4.1/1000
= 0.067 \text{ (Nm)}
\]

\[
M3 = Gx \times W3 \times L8 + W3 \times L7
= 30 \times 0.03 \times 0.1/1000 + 0.03 \times 10.8/1000
= 0.0042 \text{ (Nm)}
\]

\[
M2 + M3 = 0.0712 \text{ (Nm)}
\]

\[
M4 = F2 \times L5 = 22 \times 13.1/1000
= 0.29 \text{ (Nm)}
\]

M2 + M3 < M4 (0.0712 < 0.29), So, the lock knob and lock hook will not rotate to open.

The Box will not open.

Result: Because of items A) and B) the box will remain closed.
2) 30G Front Direction

The Box, lock knob and lock hook do not receive force to open direction. So, the Box will not open.

4) 10G Down Direction

A) To confirm failure due to force on hook

\[ M1 = W1 \times L3 + G_y \times W1 \times L3 \]
\[ = 15.0 \times 71.2/1000 + 10 \times 15.0 \times 71.2/1000 \]
\[ = 11.75 \text{ (Nm)} \]

\[ F1 = M1 / L1 = 11.75 / (252.3/1000) = 46.6 \text{ (N)} \]

The lock does not open due to linear force because: \( FL > F1 \) (377 > 46.6)

B) To confirm no lock rotation

\[ M2 = G_y \times W2 \times L4 + W2 \times L4 \]
\[ = 10 \times 0.38 \times 4.1/1000 + 0.38 \times 4.1/1000 \]
\[ = 0.018 \text{ (Nm)} \]

\[ M3 = G_y \times W3 \times L7 + W3 \times L7 \]
\[ = 10 \times 0.03 \times 10.8/1000 + 0.03 \times 10.8/1000 \]
\[ = 0.00356 \text{ (Nm)} \]

\[ M2 + M3 = 0.022 \text{ (Nm)} \]

\[ M4 = F2 \times L5 = 22 \times 13.1/1000 \]
\[ = 0.29 \text{ (Nm)} \]

\[ M2 + M3 < M4, \ (0.022 < 0.29) \] So, the lock knob and lock hook will not rotate to open. The Box will not open.

Result: the Box will remain closed.

4) 10G Up Direction

The Box, the lock knob and lock hook are not received force to open direction. So, the Box will not open.

5) Right & Left Direction

A transverse inertial load will not cause the lid to open because of the fore/aft location of the latch and hinge.
CUP & COIN HOLDER
FMVSS201 INTERIOR COMPARTMENT DOOR CALCULATION

Geometric details of the latch/lock configuration.
2. Mass data for each element in the linkage.

1. W1: Weight of the cup&coin holder = 2.72 N
   Mass of the cup & coin holder = 277 g

2. W2: Weight of the push knob = 0.0186 N
   Mass of the push knob = 1.698 g

3. W3: Weight of the lock hook = 0.00344 N
   Mass of the lock hook = 0.351 g

4. Tms: Max Torque of main spring
   Tms = 0.213 Nm (Maximum Torque on drawing spec.)

5. Fls: Force of lock knob spring
   Fls = 3 N (Minimum operation force on drawing spec.)

6. Dimension (mm)

   L1 = 22.4
3. Calculation results on “cup and coin box”

Fh : Force of cup&coin holder open
Fk : Force of push knob movement (Release holder)
Fhk : Force of lock hook movement.
Fhkp : Force of pulling the lock knob to push position
W1 : Weight of the cup&coin holder
W2 : Weight of the push knob
W3 : Weight of the lock hook
L1 : Length between the main spring center and rack

Tms : Max Torque of main spring
Fls : Force of lock knob spring

1) 30G Rear Direction

A) Compare the force to open cup holder to force at 30G

The force to open cup&coin holder (not affected by lock hook).

\[ Fh = \frac{Tms}{L1} + 30 \times W1 \times \cos6.2 - W1 \times \sin6.2 \]
\[ = 0.219/0.0224 + 30 \times 2.72 \times \cos 6.2 - 2.72 \times \sin6.2 \]
\[ = 90.0 \text{ (N)} \]

Physical Failure test

Test method: Pull this cup&coin holder, and measure the force at failure.

<Test> #1: 119N, #2: 112N, #3: 120N, #4: 115N, #5: 112N x = 115.6 (NF)
\( x = 115.6 \text{ (g)} \)
\( \sigma = 4.0 \text{ (g)} \)
\( x-3 = 103.6 \text{ (N)} \)

Result: The cup holder will have failure (the lock hook move to open position) over 103.6N.

Fh < Fl (90.0 < 103.6), So the cup holder (the lock hook will not move to open position) will not open.

Result: So, the cup&coin holder will remain closed.

2) 30G Front Direction

For the cup&coin holder, this direction is close direction.

For the force to push the lock knob to push:

\[ Fk = 30 \times W2 \times \cos6.2 + W2 \times \sin6.2 \]
\[ = 30 \times 0.0166 \times \cos6.2 + 0.0166 \times \sin6.2 \]
\[ = 0.487 \text{ (N)} \]

Force of lock knob spring : Fls = 3 (N)

Force of lock hook to move up:

\[ Fhk = W3 \times 30G \times \sin6.2 + W3 \times \cos6.2 \]
\[ = 0.0034 \times 30 \times 0.108 - 0.0034 \times 0.99 \]
\[ = 0.00768 \text{ (N)} \]

Force to pull the knob to push position

\[ Fhk = \cos45 \times \cos45 \times Fhk \]
\[ = 0.0038 \text{ (N)} \]

Fls > Fk + Fhk (3 > 0.500), so the lock hook does not move

Fk < Fls (0.487 < 3.0), so the lock knob will not open by 30G front direction.

Result: The cup&coin holder will remain closed.
3) 10G Down Direction

For the cup&coin holder and lock hook, this direction is close direction.

Force of lock knob push:
\[ F_k = 10G \times W2 \times \sin6.2 + W2 \times \sin6.2 \]
\[ = 10 \times 0.0166 \times \sin6.2 + W2 \times \sin6.2 \]
\[ = 0.0197 \text{ (N)} \]

Force of lock knob spring: \( F_{ls} = 3 \text{ (N)} \)

\( F_k < F_{ls} \) (0.0197 < 3.0) so the lock knob will not move to open direction by 10G front direction.
And the cup&coin holder will not open.

Result: The cup&coin holder will remain closed.

4) 10G Up Direction

Force of pulling the lock hook to push position
\[ F_{hp} = F_{hk} \times \cos45 \times \cos45 \]
\[ = (10G \times W3 \times \cos6.2 - W3 \times \cos6.2) \times \cos45 \times \cos45 \]
\[ = (0G \times 0.0034 \times \cos6.2 - 0.0034 \times \cos6.2) \times \cos45 \times \cos45 \]
\[ = 0.0159 \text{ (N)} \]

\( F_{hp} < F_{ls} \) (0.0159 < 3.0), so the lock knob will not move to open direction by 10G front direction.
And the cup&coin holder will not open.

Result: The cup&coin holder will remain closed.

5) Right & Left Direction

A transverse inertial load will not cause the lid to open because of the fore/aft location of the latch and hinge.
FMVSS No. 201
Latch Component Analysis Information

Latch component inertial analysis information for each interior compartment door assembly located in an instrument panel, console assembly, seat back, or side panel adjacent to a designated seating position in accordance with the procedure described in section 5 of SAE Recommended Practice J839b, "Passenger Car Side Door Latch Systems."

Such data shall include:

2004 model TOYOTA SIENNA

Console Assembly

A: RELEASE HANDLE PAGE 2
B: RR STORAGE BOX PAGE 3-4
C: MAIN LID PAGE 5-7
D: MEMO LID PAGE 8-9
E: MAIN LOCK TO FLOOR STRIKER PAGE 10-11
F: FIGURE 1 PAGE 12
G: FIGURE 2 PAGE 13
H: FIGURE 3 PAGE 14
I: FIGURE 4 PAGE 15
1. Geometric details of the latch/lock configuration.

SEE FIGURE 1: Page 12

2. Mass data for each element in the linkage.

RELEASE HANDLE = 0.0393 kg
RELEASE HANDLE SPRING TORQUE = 359 N mm

3. Calculation results on "release handle"

<table>
<thead>
<tr>
<th>Inertial load and Direction</th>
<th>Calculation needed?</th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
<tbody>
<tr>
<td>+30g L</td>
<td>Yes</td>
<td>1.7</td>
<td>619.2</td>
</tr>
<tr>
<td>-30g L</td>
<td>Yes</td>
<td>262</td>
<td>359</td>
</tr>
<tr>
<td>+10g W</td>
<td>No opening Moment in this direction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10g W</td>
<td>No opening Moment in this direction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+10g H</td>
<td>Yes</td>
<td>1.7</td>
<td>376.3</td>
</tr>
<tr>
<td>-10g H</td>
<td>Yes</td>
<td>19.0</td>
<td>359</td>
</tr>
</tbody>
</table>

RELEASE HANDLE ONLY -30g L: (Show M1<M2 about Pivot Point A)

Opening Moment: M1

M1: 30 (9.81) (0.0393) 22.5 + (9.81) (0.0393)(4.5)
260.2 + 1.75
282

Retaining Moment: M2

M2: 359

The Release Handle will not release because M1<M2(282<359)

RELEASE HANDLE ONLY +30g L: (Show M1<M2 about Pivot Point A)

Opening Moment: M1

M1: (9.81) (0.0393)(4.5)
1.73
1.7

Retaining Moment: M2

M2: 359 + 30 (9.81) (0.0393) 22.5
359 + 260.2
619.2

The Release Handle will not release because M1<M2(1.7<619)

RELEASE HANDLE ONLY 10g -H: (Show M1<M2 about Pivot point A)

Opening Moment: M1

M1: 10 (9.81) (0.0393) (4.5)+9.81(0.0393)(4.5)
17.3+1.73
19

Retaining Moment: M2

M2: 359

The Release Handle will not release because M1<M2(19<359)

RELEASE HANDLE ONLY 10g +H: (Show M1<M2 about Pivot point A)

Opening Moment: M1

M1: 9.81(0.0393)(4.5)
1.73
1.7

Retaining Moment: M2

M2: 359 + 10 (9.81) (0.0393) (4.5)
359 + 17.3
376.3

The Release Handle will not release because M1<M2(1.7<376.3)
1. Geometric details of the latch/lock configuration.

   SEE FIGURE 3: Page 14

2. Mass data for each element in the linkage.
   
   Latch Mass = 0.0278 kg
   Spring force = 4.2 N Min.

   Spring Force is the Retaining Force; Fr.

3. Calculation results on "RR storage box"

<table>
<thead>
<tr>
<th>Inertial Load and Direction</th>
<th>Calculation needed?</th>
<th>Fo</th>
<th>Fr</th>
</tr>
</thead>
<tbody>
<tr>
<td>30g, +L</td>
<td>Yes</td>
<td>3.2</td>
<td>4.2</td>
</tr>
<tr>
<td>30g, -L</td>
<td>Yes</td>
<td>0.3</td>
<td>7.2</td>
</tr>
<tr>
<td>10g, +W</td>
<td>No opening Force in this direction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10g, -W</td>
<td>No opening Force in this direction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10g, +H</td>
<td>Yes</td>
<td>0.3</td>
<td>6.7</td>
</tr>
<tr>
<td>10g, -H</td>
<td>Yes</td>
<td>3.0</td>
<td>4.2</td>
</tr>
</tbody>
</table>

   Show that Fr is greater than Fo for following inertial loading scenario's: 30g, +L, 30g, -L, 10g, +H, 10g, -H.

   (STORAGE BOX) 30g, +L: (Show Fr>Fo)

   Only the inertial forces and spring force acting on the latch need to be considered:

   Opening Force Fo:
   \[ Fo: 30 (9.81)(0.0278) \sin 21.1 + (9.81)(0.0278) \cos 21.1 \]
   \[ 2.96 + 0.25 \]
   \[ 3.2 \]

   Retaining Force Fr:
   Fr: 4.2

   The RR Storage Box will remain closed because Fr>Fr(4.2>3.2)

   (STORAGE BOX) 10g, -H: (Show Fr>Fo)

   Only the latch and latch spring need to be considered:

   Opening Force; Fo
   \[ Fo: (10 (9.81) (0.0278)) + (9.81) (0.0278)) \cos 21.1 \]
   \[ 2.72 + 0.25 \]
   \[ 3.0 \]

   Retaining Force; Fr
   Fr: 4.2

   The RR Storage Box will remain closed because Fr>Fr(4.2>3.0)

   (STORAGE BOX) 30g, -L: (Show Fr>Fo)

   Only the latch and latch spring need to be considered:

   Opening Force; Fo
   \[ Fo: (9.81)(0.0278) \cos 21.2 \]
   \[ 0.25 \]
   \[ 0.3 \]

   Retaining Force: Fr
   Fr: 4.2 + 30 (9.81) (0.0278) \sin 21.1
   \[ 4.2 + 2.96 \]
   \[ 7.2 \]

   The RR Storage Box will remain closed because Fr>Fr(7.2>0.3)
(STORAGE BOX) 10g, +H: (Show Fr>Fo)

Only the latch and latch spring need to be considered:

Opening Force; Fo

\[
F_o = (9.81) (0.0278) \cos(21.2)
\]

0.25

0.3

Retaining Force; Fr

\[
F_r = 4.2 + 10 (9.81) (0.0278) \cos(21.2)
\]

4.2 + 2.54

6.7

The RR Storage Box will remain closed because \( F_r > F_o (6.7 > 0.3) \)
1. Geometric details of the latch/lock configuration.

See Figure 1 & 2: Page 12 & 13

2. Mass data for each element in the linkage.

Main Lid Latch Mass = 0.0077kg
Main Lid Latch Measured Spring Torque = 17.5mm x 4.9N = 85.75 N mm
Main Lid Mass = 1.05 kg
Main Lid Spring Torque Minimum = 3.248 N mm
F = Force on the Main Lid Latch
F2 = Force on the Main Lid Latch
F3 = Force on the Lid cushions when there is no force on the latch
(Note: cushions not shown in Figures)

3. Calculation results on "main lid"

<table>
<thead>
<tr>
<th>Inertial Load and Direction</th>
<th>Calculation needed?</th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
<tbody>
<tr>
<td>+30g L</td>
<td>Yes</td>
<td>9.5</td>
<td>226</td>
</tr>
<tr>
<td>-30g L</td>
<td>Yes</td>
<td>0</td>
<td>235.6</td>
</tr>
<tr>
<td>+10g W</td>
<td>No opening Moment in this direction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10g W</td>
<td>No opening Moment in this direction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+10g H</td>
<td>Yes</td>
<td>3.3</td>
<td>418.1</td>
</tr>
<tr>
<td>-10g H</td>
<td>Yes</td>
<td>0</td>
<td>89.4</td>
</tr>
</tbody>
</table>

(Main Lid) +30g L: (Show M1 < M2 about Pivot Point B)

First find the force on the Main Lid; Latch:

Opening moment; M1
M1: Main Lid Spring Torque + 30 (9.81) (1.05) (20)
3,248 + 30 (9.81) (1.05) (20)
3,248 + 6,180.30

Retaining moment; M2
M2: F (277.2) + (9.81) (1.05) (163.5)
F (277.2) + 1,684.13

F = (3,248 + 6,180.30 - 1,684.13) / 277.2
F = 28 N

Next find the Moments on the Main Lid; Latch about Pivot Point D.

Opening moment; M1
M1 : 30(9.81)(0.0077) (4.2)
9.52
9.5

Retaining moment; M2
M2 : (9.81)(0.0077)(4.4) + F(5) + 85.75
0.33 + 140 + 85.75
226

Thus the only way for the lid to open is for the latch to break at or below 28N.
Through physical testing the minimum strength of the latch is greater than 350 N. Therefore, the lid will remain closed.
(Main Lid) +10g H: (Show M1 '×M2 ' about Pivot Point B)

First find the force on the Main Lid; Latch:

Opening moment; M1
10(9.81)(1.05)(163.5) + 3.248
16,841 + 3,248
20,089

M2: Retaining moment; M2
F (277.2) + (9.81) (1.05) (163.5)
F (277.2) + 1,684
F = (20,089 - 1,684)/277.2
F= 66.4N

Next find the Moments on the Main Lid, Latch about Pivot Point D.

Opening moment; M1 ' Retaining moment; M2 '
M1 ': 10 (9.81)(0.0077) (4.4)
3.3
M2 ': 9.81 (0.0077)(4.4) + F (5)+85.75+(3.248/277.2)(5)
0.33 +66.4(5) + 85.75 + 0.059
418.1

Thus the only way for the lid to open is for the latch to break at or below 66.4N.
Through physical testing the minimum strength of the latch is greater than 350 N. Therefore, the lid will remain closed.

(Main Lid) -30g L: (Show M1 '×M2 ' about Pivot Point B)

1st find the force on the Main Lid; Latch:

Opening moment; M1
Spring Torque
3,248
3,248

M2: Retaining moment; M2
F3 (277.2) + (9.81) (1.05) (163.5) + 30 (9.81) (1.05) (20)
F3 (277.2) + 1,684.1 +6,180.3
F3 = (3,248 - 6,180.3 -1,684.1)/277.2
F3= -71 N

F3 represents the additional retaining force, or (compression force on the lids rubber cushions). Therefore, there is no force acting to open the lid.

Next find the Moments on the Main Lid; Latch about Pivot Point D

Opening moment; M1 Retaining moment; M2 '
M1 0
M2 (9.81)(0.0077)(4.4) + (28)(5) + 85.75 + 30(9.81)(0.0077) (4.2)
0.33 + 140 + 85.75 + 9.52
235.6

Thus there is no moment acting to open the latch. Therefore, the lid will remain closed.
(Main Lid) - 10g H: (Show M1 < M2 about Pivot Point B)

1st find the force on the Main Lid; Latch:

Opening moment; M1

\[ M1 = 3248 \]

Retaining moment; M2

\[ M2 = \frac{F_3 (277.2) + (9.81)(1.05)(163.5) + 10(9.81)(1.05)(163.5)}{1} = 1,684 \quad \text{+16,841} \]

\[ F_3 = \frac{(3,248 - 1,588 - 15,879)}{277.2} = -55.1 \text{N} \]

F3 represents the additional retaining force, or (compression force on the lid's rubber cushions). Therefore, there is no force acting to open the lid.

Next find the Moments on the Main Lid, Latch about Pivot Point D)

Opening moment; M1

\[ M1 = 0 \]

Retaining moment; M2

\[ M2 = 9.81 (0.0077)(4.4) + 10(9.81)(0.0077)(4.4) + 85.75 \]

\[ 0.33 + 3.3 + 85.75 = 89.4 \]

Thus there is no moment acting to open the latch. Therefore, the lid will remain closed.
1. Geometric details of the latch/lock configuration.

SEE FIGURE 1: Page 12

2. Mass data for each element in the linkage.

   Memo Lid Mass=0.395kg
   Latch Force F1=20.6 N
   Note: Frictional torque in
   the hinge is ignored.

3. Calculation results on "memo lid"

<table>
<thead>
<tr>
<th>Inertial load and Direction</th>
<th>Calculation needed?</th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
<tbody>
<tr>
<td>30g, +L</td>
<td>Yes</td>
<td>721</td>
<td>4,141</td>
</tr>
<tr>
<td>30g, -L</td>
<td>Yes</td>
<td>0</td>
<td>4,982</td>
</tr>
<tr>
<td>10g, +W</td>
<td>No opening Moment in this direction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10g, -W</td>
<td>No opening Moment in this direction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10g, +H</td>
<td>Yes</td>
<td>2,662</td>
<td>4,141</td>
</tr>
<tr>
<td>10g, -H</td>
<td>Yes</td>
<td>0</td>
<td>6,803</td>
</tr>
</tbody>
</table>

(Memo Lid) 30g, +L: (Show M2 > M1 about Pivot Point C)

Opening moment; M1
M1: 30 (9.81) (0.395) (6.2)
720.74
721
Retaining moment; M2
M2: F1 (188.1) + (9.81) (0.395)(68.7)
20.6 (188.1) + 266.21
3,874.86 + 266.21
4,141

The memo lid will remain closed because M2>M1(4141>721)

(Memo Lid) 10g, +H: (Show M2 > M1 about Pivot Point C)

Opening moment; M1
M1: 10 (9.81) (0.395) (68.7)
2,662.1
2,662
Retaining moment; M2
M2: F1 (188.1) + 9.81 (0.395) (68.7)
(20.6) (188.1) + 266.21
3,874.86 + 266.21
4,141

The memo lid will remain closed because M2>M1(4141>2662)

(Memo Lid) 30g, -L: (Show M2 > M1 about Pivot Point C)

Opening moment; M1
M1: 0
Retaining moment; M2
M2: F1 (188.1) + (9.81) (0.395)(68.7) + 30 (9.81) (0.395) (6.2)
20.6 (188.1) + 266.21 + 720.7
3,874.86 + 266.21 + 720.7
4,662

The memo lid will remain closed because M2>M1(4662>0)
(Memo Lid) 10g. -H: (Show M2 > M1 about Pivot Point C)

Opening moment; M1

\[ M1: \quad 0 \]

Retaining moment; M2

\[ M2: \quad F1 (188.1) + 9.81 (0.395) (88.7) + 10 (9.81) (0.395) (88.7) \]
\[ \quad (20.6) (188.1) + 266.21 + 2,622.09 \]
\[ \quad 3,874.86 + 266.21 + 2,622 \]
\[ \quad 6,803 \]

The memo lid will remain closed because \( M2 > M1 \) (6803 > 0)
1. Geometric details of the latch/lock configuration.

See Figure 4: Page 15

2. Mass data for each element in the linkage.

Ratchet Mass = 0.0493 kg
FS = Spring Force = 18.3 N Min.

3. Calculation results on "main lock to floor striker"

<table>
<thead>
<tr>
<th>Inertial load and Direction</th>
<th>Calculation needed?</th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
<tbody>
<tr>
<td>30g, +L</td>
<td>Yes</td>
<td>17.2</td>
<td>1,088.4</td>
</tr>
<tr>
<td>30g, -L</td>
<td>Yes</td>
<td>440.9</td>
<td>664.7</td>
</tr>
<tr>
<td>10g, +W</td>
<td>No opening Moment in this direction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10g, -W</td>
<td>No opening Moment in this direction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10g, +H</td>
<td>Yes</td>
<td>58.3</td>
<td>664.4</td>
</tr>
<tr>
<td>10g, -H</td>
<td>Yes</td>
<td>17.2</td>
<td>705.8</td>
</tr>
</tbody>
</table>

(Main Lock) 30g, -L: (Show M2 > M1 about Pivot Point E)
(Note: Need only consider the inertial loading affect on the Ratchet and Spring)

Opening moment; M1
M1: 30 mg(29.2) + FSsin21.3 (2.9)
30 (0.0493) (9.81) (29.2) + 16.3sin21.3 (2.9)
423.66 + 17.2
440.9

Retaining moment; M2
M2: Spring Force (43.5)cos21.3 + mg(8.5)
16.3 (43.5)cos21.3 + (0.0493) (9.81) (8.5)
660.62 + 4.11
664.7

The main lock will not release because M2>M1(665>441)

(Main Lock) 30g, +L: (Show M2 > M1 about Pivot Point E)
(Note: Need only consider the inertial loading affect on the Ratchet and Spring)

Opening moment; M1
M1: FSsin21.3 (2.9)
16.3sin21.3 (2.9)
17.2

Retaining moment; M2
M2: Spring Force (43.5)cos21.3 + mg(8.5) + 30 mg(29.2)
16.3 (43.5)cos21.3 + (0.0493) (9.81) (8.5) + 30 (0.0493) (9.81) (29.2)
660.62 + 4.11 + 423.66
1,088.4

The main lock will not release because M2>M1(1088>17)

(Main Lock) 10g, +H: (Show M2 > M1 about Pivot Point E)
(Note: Need only consider the inertial loading affect on the Ratchet and Spring)

Opening moment; M1
M1: 10 (mg) (8.5) + FSsin21.3 (2.9)
10 (0.0493) (9.81) (8.5) + 16.3sin21.3 (2.9)
41.1 + 17.2
58.3

Retaining moment; M2
M2: Spring Force (43.5)cos21.3 + mg(8.5)
16.3 (43.5)cos21.3 + (0.0493) (9.81) (8.5)
660.62 + 4.11
664.7

The main lock will not release because M2>M1(665>58)
(Main Lock) 10g, -H: (Show M2 > M1 about Pivot Point E)
(Note: Need only consider the inertial loading affect on the Ratchet and Spring)
Opening moment; M1
Retaining moment; M2

\[ M1: F \sin 21.3 \times (2.9) \]
\[ 16.3 \sin 21.3 \times (2.9) \]
\[ 17.2 \]

\[ M2: \text{Spring Force} \times (43.5) \cos 21.3 + mg(8.5) + 10 \text{ (mg)} \]
\[ 18.3 \times (43.5) \cos 21.3 + (0.0493) \times (9.81) \times (8.5) + 10 \times (0.0483) \times (9.81) \times (8.5) \]
\[ 680.82 + 4.11 + 41.1 \]
\[ 705.8 \]

The main lock will not release because \( M2 > M1 \) (705.8 > 17)
APPENDIX C

DATA PLOTS
FMVSS 201 Linear Impact - 2004 Toyota Sienna - Right Side Airbag -54 Deg
Headform Front Ax
Max: 29.3 [g] at 0.038 [s]
Min: -51.9 [g] at 0.068 [s]
FMVSS 201 Linear Impact - 2004 Toyota Sienna - Right Side Airbag -54 Deg

Headform Front Ax Velocity

Max: 11.6 [mph] at 0.049 [s]
Min: -6.3 [mph] at 0.089 [s]
FMVSS 201 Linear Impact - 2004 Toyota Sienna - Center Dash -27 Degrees
Headform Front Ax

Max: 29.1 [g] at 0.037 [s]
Min: -55.2 [g] at 0.064 [s]
FMVSS 201 Linear Impact - 2004 Toyota Sienna - Seat Back -17.0 Degrees
Headform Front Ax

Max: 45.5 [g] at 0.043 [s]
Min: -42.3 [g] at 0.078 [s]
FMVSS 201 Linear Impact - 2004 Toyota Sienna - Seat Back -17.0 Degrees
Headform Front Ax Velocity

Max: 14.6 [mph] at 0.050 [s]
Min: -2.7 [mph] at 0.122 [s]
FMVSS 201 Linear Impact - 2004 Toyota Sienna - Seat Back 2 -17.0 Deg
Headform Front Ax Velocity

Max: 15.0 [mph] at 0.050 [s]
Min: -2.6 [mph] at 0.108 [s]