## BRAKING PERFORMANCE OF LIGHT TRUCK

1. Brake regulations for Commercial Vehicle and Passenger Car

◆ **UN-R13 is considered the use of commercial vehicles.**

### < Service brake >

<table>
<thead>
<tr>
<th>Loading Conditions</th>
<th>R13H Unladen / Laden</th>
<th>R13 Unladen / Laden</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Braking effort [N]</strong></td>
<td>500 Max</td>
<td>&lt; 700 Max</td>
</tr>
<tr>
<td>Initial velocity V0 [km/h]</td>
<td>100</td>
<td>&gt; 80</td>
</tr>
<tr>
<td>MFDD [m/s²]</td>
<td>6.43</td>
<td>&gt; 5.00</td>
</tr>
<tr>
<td>(Mean fully developed deceleration) 0.8V0~0.1V0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Braking distance [m]</strong></td>
<td>70.0</td>
<td>61.2</td>
</tr>
</tbody>
</table>
2. Brake regulation conformity of the light truck

*The maximum deceleration of the light truck is 7m/s².
*The initial velocity of R13 is 80km/h.
*The braking effort of R13 is 700N.
Based on the above conditions and as follow Fig., **the light truck is complied with R13.**
3. The reason of the difference of the brake performance

< The feature of CV >

(1) Loading shipment

(2) Loading difference of rear wheels at unladen and laden → Large

< The feature of Light Truck >

(3) Rear wheel load of unladen is small

<table>
<thead>
<tr>
<th></th>
<th>Light Truck</th>
<th>Light Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>unladen[kg]</td>
<td>1012</td>
<td>1051</td>
</tr>
<tr>
<td>laden[kg]</td>
<td>1362</td>
<td>1201</td>
</tr>
</tbody>
</table>

Rear wheel loading rate @0m/s²
3. The reason of the difference of the brake performance

Difference of Light truck and Light vehicle

In case of 9m/s² deceleration, the rear wheel loading rate of the light truck is only 6%. Then, the rear wheel side force decreases, the vehicle’s behavior becomes unstable.
BRAKING PERFORMANCE OF LIGHT TRUCK

4. Brake performance limitation of Light trucks

(1) The deceleration of the light truck is determined by the rear wheel load during braking, as bellows.

\[ \Delta W_r \times L = W \times \alpha \times H \]

\[ \Delta W_r = \alpha \times W \times \frac{H}{L} \]

<table>
<thead>
<tr>
<th>Wheel base L</th>
<th>Gravity height H</th>
<th>Front wheel load Wf</th>
<th>Rear wheel load Wr</th>
<th>Vehicle weight W</th>
<th>Rear unsprung weight wr</th>
<th>制動時後輪荷重WrB[kgf]</th>
<th>Rear wheel load; small ⇒ Rear side force: decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Truck</td>
<td>1905</td>
<td>560</td>
<td>644</td>
<td>316</td>
<td>960</td>
<td>90</td>
<td>WrB 316 231 146 104 89 75 61</td>
</tr>
<tr>
<td>Light Vehicle</td>
<td>2450</td>
<td>595</td>
<td>629</td>
<td>531</td>
<td>1160</td>
<td>90</td>
<td>WrB 531 446 362 319 305 291 277</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>WrB-wr 226 141 56 14 -1 -15 -29</td>
</tr>
</tbody>
</table>

Deceleration; \( \alpha \) [m/s²] ⇒

Need to limit deceleration at 7m/s² Maximum

## UNLADEN (2P)

Wheel base \( L \) Gravity height \( H \) Front wheel load \( W_f \) Rear wheel load \( W_r \) Vehicle weight \( W \) Rear unsprung weight \( w_r \)制動時後輪荷重WrB[kgf] Rear wheel load; small ⇒ Rear side force: decrease

0 3 6 7 8 8.5 9

Wf  (front wheel weight) Wr  (rear wheel weight)
BRAKE SYSTEM DESIGN

4. Brake performance limitation of Light trucks

(2) The braking force distribution of the light truck

The braking force distribution curve of the light truck at unladen, as bellows,

The light truck must be limit the rear wheel braking force in order to avoid rear wheel locking for the light vehicle.

Ideal braking force distribution curve (IBFD)

Actual brake force
Rear wheel locking area
IBFD for light sedan
IBFD for light truck
9 m/s^2
[ at unladen ]
4. Brake performance limitation of Light trucks

(3) The adhesion utilization curve of the light truck

Show the adhesion utilization curve of the light truck at unladen as bellows,

**At unladen, the rear wheel adhesion utilization rate is 100% at 7m/s², so the rear wheels are locked.**
5. Comparison of the rear wheel load decrease

Full cab trucks of N1 are the different position compare to other vehicles of N1 and M1

FIG 1. Index of the rear wheel load decrease

\[ \frac{W_r}{W} \times \frac{L}{H} = 1.0 \]

- N1 full cab
- N1
- M1
BRAKING PERFORMANCE OF LIGHT TRUCK

6. Proposal for (N1 full cab vehicle)

In case of \( \alpha = \frac{W_r}{W} \times \frac{L}{H} \leq 1.3 \) “

C2C Maximum relative impact speed is 35km/h @unladen

Maximum speed reduction for N1 full cab trucks
(Calculated by AEBS-05-06(D) AEBS Calculation Tool)

<table>
<thead>
<tr>
<th>Avoidance speed</th>
<th>35K</th>
<th>40K</th>
<th>45K</th>
<th>60K</th>
<th>Max. Deceleration</th>
<th>Time_to_1g</th>
<th>TTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>[km/h]</td>
<td>[km/h]</td>
<td>[km/h]</td>
<td>[km/h]</td>
<td>[km/h]</td>
<td>[m/s2]</td>
<td>[sec]</td>
<td>[sec]</td>
</tr>
<tr>
<td>M1/N1</td>
<td>42</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>35</td>
<td>9</td>
<td>0.6</td>
</tr>
<tr>
<td>N1 Full cab</td>
<td>35</td>
<td>0</td>
<td>15</td>
<td>25</td>
<td>40</td>
<td>7</td>
<td>0.6</td>
</tr>
</tbody>
</table>