Reverse Warning Sound Device
Sound Device without noise reduction
Outdoor Sound Measurement
Device Installation

Standard installation

90 degree rotation

Truck: "Dundret"
Microphone Positions

- Korea
- AVAS
- PIEK
- 7/14/21

All results are calculated with integration time constant $\tau=125\,ms$ ("Fast")
Pre-/Post-Calibration

![Graph](image-url)
Korea
Specification

KMVSS Art. 53-2: QRTV (2017.07)

Acceptance criteria:
- $65 < L_p < 90$ dB(A)
- tone within 500Hz and 4kHz 1/3oct band

Article 53.2 (Rear pedestrian safety device)
(1) The vehicle shall be equipped with at least any one of each of following safety devices. The school bus shall be equipped with all the devices applicable to Item 1 and Item 2.
1. Rear-monitor system with which an observation rod (30 millimeters in diameter and 500 millimeters in height) installed in an area of 1,000 mm on left/right side and 300 – 2,000 mm behind the center of the rear side can be seen.
2. Approach-warning sound system notifying the driver that the pedestrian closes to the rear side of vehicle when driving in rearward direction.
3. Rearward-warning sound system notifying the pedestrian the vehicle in rearward motion.

(2) Rearward-warning sound system shall meet each the following requirements pursuant to Clause 1 Item 3.
1. The warning sound shall be operated and paused repeatedly. And the sound of same tone shall be generated at regular intervals.
2. The warning sound shall meet each of the following requirements of sub-para, upon 2 meters test from the rear side.
   a. $60$ dB(A) or more and $85$ dB(A) or less for PC, small-sized bus/truck, and special purposed vehicle
   b. $65$ dB(A) or more and $90$ dB(A) or less for vehicles other than sub-para a.
3. The tone of warning sound shall have the maximum volume where one-third octave band is between 500Hz and 4000Hz.

Figure 2. the method of installing the microphone for rear warning sound system
Setup

1.2m above ground

2.0 / 2.5 / 3.0 m
## Summary (Standard installation)

### SOUND LEVEL

<table>
<thead>
<tr>
<th>No</th>
<th>Ambient noise [dB(A)]</th>
<th>Measured value [dB(A)]</th>
<th>Result [dB(A)]</th>
<th>Requirements [dB(A)]</th>
<th>Judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>47.7</td>
<td>75.8</td>
<td>75.9</td>
<td>65 ≤ L_{AF} ≤ 90</td>
<td>OK</td>
</tr>
<tr>
<td>2</td>
<td>75.6</td>
<td>75.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>76.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SOUND TONE

<table>
<thead>
<tr>
<th>No</th>
<th>The highest 1/3 octave center frequency [Hz]</th>
<th>Requirements [Hz]</th>
<th>Judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3150</td>
<td>500 ≤ B ≤ 4000</td>
<td>OK</td>
</tr>
<tr>
<td>2</td>
<td>3150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3150</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results: Standard installation

- 2.0 m behind vehicle: 75.9 dB(A)
- 2.5 m behind vehicle: 66.9 dB(A)
- 3.0 m behind vehicle: 71.4 dB(A)
- background level: 47.7 dB(A)
Results: 90 degree rotation

- 2.0 m behind vehicle: 79.3 dB(A)
- 2.5 m behind vehicle: 81.1 dB(A)
- 3.0 m behind vehicle: 75.2 dB(A)
- background level: 44.7 dB(A)
Results: Frequency Band

Loudest 1/3oct band: 3150 Hz
AVAS
Specification

KMVSS Art. 53-3: R138 (AVAS)

Acceptance criteria:
- see Table

Minimum Sound Level Requirements in dB(A) (Article 53-3):

<table>
<thead>
<tr>
<th>Frequency in Hz</th>
<th>50km/h in Forward Direction [dB(A)]</th>
<th>90km/h in Forward Direction [dB(A)]</th>
<th>20km/h in Reverse Direction [dB(A)]</th>
<th>40km/h in Reverse Direction [dB(A)]</th>
<th>1.2 ± 0.02 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column 1</td>
<td>Column 2</td>
<td>Column 3</td>
<td>Column 4</td>
<td>Column 5</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>160</td>
<td>44</td>
<td>44</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>160</td>
<td>44</td>
<td>44</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>44</td>
<td>44</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>44</td>
<td>44</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>315</td>
<td>44</td>
<td>44</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>650</td>
<td>45</td>
<td>50</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>45</td>
<td>50</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>630</td>
<td>44</td>
<td>51</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>700</td>
<td>46</td>
<td>51</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>46</td>
<td>51</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1200</td>
<td>46</td>
<td>51</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1600</td>
<td>44</td>
<td>49</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>42</td>
<td>47</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2500</td>
<td>39</td>
<td>44</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3150</td>
<td>34</td>
<td>41</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5000</td>
<td>31</td>
<td>36</td>
<td>47</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Article 53.3 (Acoustic Vehicle Aiding System (AVAS) for Quiet Road Transport Vehicles (QRTV))

The AVAS complies with each of the following items shall be equipped in QRTV (vehicle using the electric energy such as EV, FCEV, HV etc.). However, if the vehicle not equipped with an AVAS fulfills the overall levels as specified in Table 5.33 lower than a margin of +3 dB(A), it may be regarded as meeting the requirements.

1. The AVAS shall operate in the speed range of at least 20 km or less from the start.
2. The warning sound pursuant to item 1 shall meet the requirements specified in each of the following sub-paragraphs:
   a. The overall sound shall be not less than the overall minimum sound level requirements specified in Table 5.33.
   b. The alarm has at least two of the one-third octave bands applicable to the minimum sound level requirements pursuant to Table 5.33. At least one of these bands shall be below or within the 1,500 Hz one-third octave band.
3. The warning sound shall have frequency shift characteristics applicable to each of the following items to inform road users about the change in vehicle speed when driving in forward direction:
   a. The warning sound emitted by the vehicle shall vary proportionally with speed within each individual gear ratio by an average of at least 0.8% per 1 km/h in the speed range from 5 km/h to 20 km/h.
   b. The warning sounds meeting the requirements of the sub-paragraph shall be within the frequency range in Table 5.33, at least one of them shall meet the requirements of the frequency shift characteristics.
4. The overall sound level shall not exceed 75 dB(A) when driving in forward direction.
5. The function enabling the driver to deactivate the warning sound (warning sound off-switch) shall not be installed.
6. AVAS equipped with various type of warning sounds, shall meet the requirements specified in Item 1 thru Item 5.
Setup

1.2m above ground

Left

Right

2.0 m

2.0 m
Summary (Standard installation)

<table>
<thead>
<tr>
<th>No</th>
<th>Ambient noise [dB(A)]</th>
<th>Measured value [dB(A)]</th>
<th>Result [dB(A)]</th>
<th>Requirements [dB(A)]</th>
<th>Judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left</td>
<td>Right</td>
<td>Left</td>
<td>Right</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>47.9</td>
<td>48.8</td>
<td>71.0</td>
<td>80.4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>70.2</td>
<td>80.0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>70.0</td>
<td>80.1</td>
<td>70</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>69.6</td>
<td>80.1</td>
<td></td>
</tr>
</tbody>
</table>

If $L_p > 47 + 3 \text{ dB(A)}$, no dedicated AVAS system is needed for rearward operation
Results: Left side

- **standard installation: 70.2 dB(A)**
- **90 degree rotation: 73.0 dB(A)**
- **background level: 47.9 dB(A)**
Results: Right side

- standard installation: 80.2 dB(A)
- 90 degree rotation: 74.2 dB(A)
- background level: 48.8 dB(A)
Observation

Results: Right side (90 degree rotation)

Moving microphone 10cm upwards increases sound level by > 6 dB!
PIEK
4.4 Reversing alarm system and blind spot warning

The measurement is only carried out if the system can be used when manoeuvring during loading and unloading. If applicable, the measurement will be carried out in PEAK mode, which automatically reduces the volume emitted by the warning signal. If the system is not present or is switched off automatically in ‘PEAK mode’, the measurement does not need to be taken.

Acceptance criteria:

- \( L_p < 72 \text{ dB(A)} \)

The following procedure must be completed for measuring the sound signal:

- Only the towing vehicle will be measured, i.e. without trailers or articulated elements.
- The vehicle is stationary during the test, and the warning systems for reversing and turning right (blind spot) are measured. The warning systems are operating separately for this. See Figure 4.4 for the measurement setup.
- Reversing: The noise from the reversing alarm system is measured three times at a distance of 7.5m from the rear of the vehicle (signal duration 30 seconds).
- Turning right: The noise is measured three times at a distance of 7.5m from the side of the vehicle, directly across from the cabin’s rear (signal duration 30 seconds).

The highest value from each measurement point is determined separately and rounded to a whole number in accordance with Section 3.3; these are the measurement results.

Figure 4.2: Microphone positions for measurements of reverse and blind spot warning systems
Setup

1.2m above ground
## Summary (Standard installation)

<table>
<thead>
<tr>
<th>No</th>
<th>Ambient noise [dB(A)]</th>
<th>Measured value [dB(A)]</th>
<th>Result [dB(A)]</th>
<th>Requirements [dB(A)]</th>
<th>Judgement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>68.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>52.2</td>
<td>68.3</td>
<td>69</td>
<td>&lt; 72</td>
<td>OK</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>68.1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*If the system is not present or is switched off automatically in 'PEAK mode', the measurement does not need to be taken.*
Results: 7.5m behind truck

- 7.5m behind, 1.2m above ground
- 7.5m behind, 1.2m above ground (background)
7/14/21 m
Specification

Adjust height in steps of 0.1 m, from 0.5 to 1.5 m

14m simulating semi-trailer distance
21m simulating multi-trailer distance
7/14/21m Setup

0.5-1.5 m above ground

21 m

7 m

14 m
Results: 7m / 14m / 21m @ 0.5-1.5m

Standard installation

90 degree rotation

Each data point is an average of 40 peaks (30s)
Max/Min values (during 30s) indicated with bars
Observation

21m/1.5m, Standard installation

Level difference 52-63 dB(A) within 8s
Observation

21m/1.5m, 90degree rotation

Level difference 55-65 dB(A) within 8s
Conclusions – Standard Installation

• Sound source is strongly directive
• Tone frequency fluctuates over time; 2750-2900 Hz
• Tone frequency selection is unfortunate, close to cut-off frequency between 1/3 octave bands 2500 and 3150 ($f_{c/o} = 2818$ Hz)

• Recommendations for further studies:
  o Hemi-anechoic chamber preferred (reduce environmental influence; wind, temperature, etc that may cause level and/or frequency fluctuations)
  o Use external power source (controlled voltage & current)
  o Choose a tone such that its centre frequency is laying within a 1/3 octave band
Thank You