The Use of Public Address System to Improve Tunnel Safety - Current Practices

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We Keep Your World Moving
Content

1. Introduction
2. Overview of Survey Responses
3. Discussion
4. Conclusion
Introduction

TC C3.3’s report on “Improving Safety In Road Tunnels Through Real Time Communication With Users”

- PA loudspeaker system a means for real-time communication to facilitate tunnel operations.
- Effectiveness of tunnel loudspeaker system is subjective.
  - Difficult to maintain intelligibility in tunnel, especially when ventilation fans are turned on.
Introduction

Singapore was working on technical specifications for its latest road tunnel project and wanted to better understand the deployment of public address loudspeaker systems in road tunnels in other countries.

- Survey with PIARC TC D.5 members initiated in March 2016:
  - Any requirements for PA speakers in road tunnels?
  - If so, is it a mandatory requirement?
  - If it is not mandatory, is it a common practice?
- 19 responses from TC D.5.
Overview of Survey Responses

Generally, EU Directive 2004/54/EC sets the baseline requirements for EU countries:

- Compliance with minimum safety requirements for Trans-European road network with lengths > 500 metres.

  E.g. shelters and other facilities where evacuating tunnel users must wait, before they can reach the outside shall be equipped with loudspeakers for the provision of information to users.

Some countries implement further provisions over and above those specified in the directive.
Overview of Survey Responses

- For non-EU PIARC member countries, though no common baseline requirement, many have installed PA system in road tunnels according to criteria and requirements specific to each country.

- Installation of loudspeaker PA system along carriageways inside road tunnel can be categorised as mandatory and non-mandatory.
Overview of Survey Responses

Countries that **mandate** installation of loudspeakers in road tunnel carriageways:

**New South Wales/Australia**
- Tunnel PA system to be audible in all areas throughout tunnel (“Austroads Guide to Road Tunnels Part 2”).
- For NorthConnex tunnel, PA system to achieve STI of 0.5 or better.

**Austria**
- Mandatory to fulfil “Austrian Standard for Tunnel Equipment”
- Sound pressure level of at least 110dB(A) at 3m in range of 1 to 4kHz; CIS (Common Intelligibility Scale) $\geq 0.7$ is desirable.
Overview of Survey Responses

**Czech Republic**
- Mandatory for tunnel categories TA and TB.
- Non-mandatory for TC category.

**Japan**
- Mandatory for AA category tunnel.

**South Korea**
- Mandatory for emergency exits and tubes of tunnels >500m.

**Netherlands**
- PA system legally required for road tunnels >500m.
- Provision to make announcements to the public through loud speakers, on every road and escape route in tunnel.
Overview of Survey Responses

- Typically, tunnel category is used to determine whether provision of loudspeaker PA system in a road tunnel is mandatory.
- **South Korea and Netherlands** - for tunnels > 500m.
- **Czech Republic** - for Classes TA and TB tunnels.
- **Japan** - for Class AA tunnel.

Tunnel category typically a function of tunnel length and traffic volume.
Overview of Survey Responses

Countries that **do not mandate** installation of loudspeakers in road tunnel carriageways:

**Flanders/Belgium**

**France**
- No mandatory requirement for loudspeakers in tunnel, only a recommendation.

**Germany**
- Common practice (recommendation) since 2003 for tunnels longer than 400m.
Overview of Survey Responses

**Greece**
- Adopts EU Directive. No legislative requirement for PA speaker in tunnel. In certain cases, can be a recommendation as a result of risk analysis.

**Italy**
- PA speakers are mandatory in areas of refuge. Not in tunnel.

**Norway**
- Not yet mandatory.

**Singapore**
- Not mandatory.
Overview of Survey Responses

*Slovak Republic*
- PA speakers mandatory in specific areas – entrances to cross galleries, inside cross galleries, pre-portal areas, escape gallery (if any), emergency assembly points. Not mandatory in other areas.

*South Africa*
- PA speakers not installed in tunnel tubes.

*Sweden*
- No requirements for PA speakers in road tunnels. Only a recommendation.

*Switzerland*
- Not mandatory for the tube.
Overview of Survey Responses

**UK**
- Considered a good practice, not a requirement of standards. Safety requirements are derived using performance-based approach. There are some prescriptive requirements but PA is not one.

**USA**
- No mandatory requirements for PA systems in tunnels.
Overview of Survey Responses

- Though not mandatory, responses from members generally indicated that PA in tunnels are considered useful.

- Some members, e.g. Czech Republic, Norway and Switzerland also shared the positive effects of providing early audio guidance in facilitating incident management.

- Some countries are testing/installing PA systems in tunnel tubes though the provision is not mandatory.
Overview of Survey Responses

Testing of Road Tunnel PA Speakers in Singapore
Discussion

- For PA system to be effective, PA messages should be intelligible to, and be understood by tunnel users.
- IEC 60268-16 defines speech intelligibility as the "rating of the proportion of speech that is understood".
- Speech Transmission Index (STI), expressed between 0 and 1, is an objective measure of speech intelligibility.
- ISO 9921 provides the intelligibility ratings against the corresponding STI ranges.

Speech Transmission Index (STI) Intelligibility Ratings

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<thead>
<tr>
<th>STI</th>
<th>Intelligibility Rating</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>Bad</td>
</tr>
<tr>
<td>0.3</td>
<td>Poor</td>
</tr>
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<td>0.45</td>
<td>Fair</td>
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<tr>
<td>0.6</td>
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<tr>
<td>0.75</td>
<td>Excellent</td>
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IEC 60268-16:  Sound system equipment – Part 16: Objective rating of speech intelligibility by speech transmission index
ISO 9921:  Ergonomics — Assessment of speech communication
Discussion

- Annex B of NFPA 502 (Standard for Road Tunnels, Bridges, and Other Limited Access Highways):
  - for informational purpose and not part of the NFPA requirements, i.e. not mandatory.
  - where amplified speech is used as part of the emergency response within a tunnel, it should achieve measured STI of not less than 0.45 and an average STI of not less than 0.5.
Discussion

- Intelligibility specification of road tunnel PA system typically not specified except for Australia, Austria, Germany and Netherlands:
  - **Australia**: Minimum STI of 0.5 for the NorthConnex tunnel.
  - **Austria**: Common Intelligibility Scale (CIS) of 0.7 (equivalent to STI 0.5) or better.
  - **Germany**: Considering STI of 0.45 or higher.
  - **Netherlands**: Average STI of between 0.44 and 0.5.

- Values above are largely along the intelligibility rating of “fair” (STI of between 0.45 & 0.6).
Discussion

- Difficult to achieve good intelligibility in road tunnels due to the harsh acoustic environment.
  - High ambient noise, e.g. traffic noise (vehicle engines, tyre noise) and ventilation fans.
  - Long reverberation time (high reverberant level) due to hard surfaces of tunnel walls and roads. That is, it takes a long time for the sound to “die down”.

- Acoustic treatments to improve acoustic environment in road tunnels costly and not practical.

- Difficult for conventional loudspeakers to deliver good intelligibility in road tunnels.
Discussion

- Proprietary, purpose-built road tunnel loudspeakers.
- Generally high-power and directional loudspeakers optimised for operation in road tunnels.

Examples of Purpose-Built Road Tunnel Loudspeaker

References:
Conclusion

- In general, members agree that tunnel loudspeaker system can help facilitate road tunnel operations and incident management.

- For loudspeaker system to be effective, intelligibility is a key consideration. The Speech Transmission Index (STI) defined in IEC 60268-16 provides objective measure of intelligibility.

- With the exception of a few countries, STI generally not specified for road tunnel PA system.

- STI in the range between 0.45 & 0.5 (within the “fair range”) appears to be a reasonable specification to adopt.
Conclusion

- Difficult for conventional loudspeakers PA systems to deliver good STI in road tunnels.
- Proprietary, purpose-built PA speakers optimised for operation in road tunnels are available in the market.
Thank you for your attention