

# Monthly report

## Railway Field Laboratory

September 2022

**Client:** Swiss confederation; Federal Offices for the Environment (FOEN) and Transport (FOT), CH-3003 Bern  
The FOEN and the FOT are offices of the Federal Department of the Environment, Transport, Energy and Communications (DETEC).

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**Remarks:** This report was published on behalf the Swiss Federal Office for the Environment (FOEN) and Transport (FOT). The consultant is responsible for the content and all data displayed.

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## **1. Status railway field laboratory**

Construction work on the tracks:

- none

Downtimes of the measurement systems:

- none

Downtimes of the sensors:

- MQ 1\_2: v-mq12
- MQ 2\_2: v-mq22

Maintenance and sensor exchange:

- none

Modifications to the data, database, or analysis:

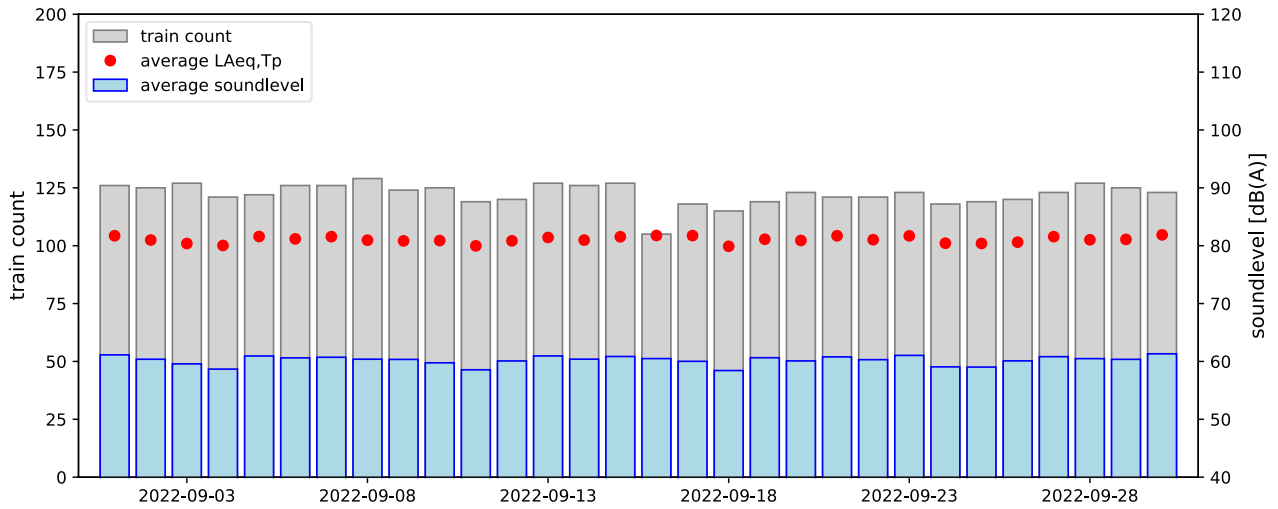
- Saving the third-octave spectra together with the measurement data

Monthly data volume collected:

- 272 GB

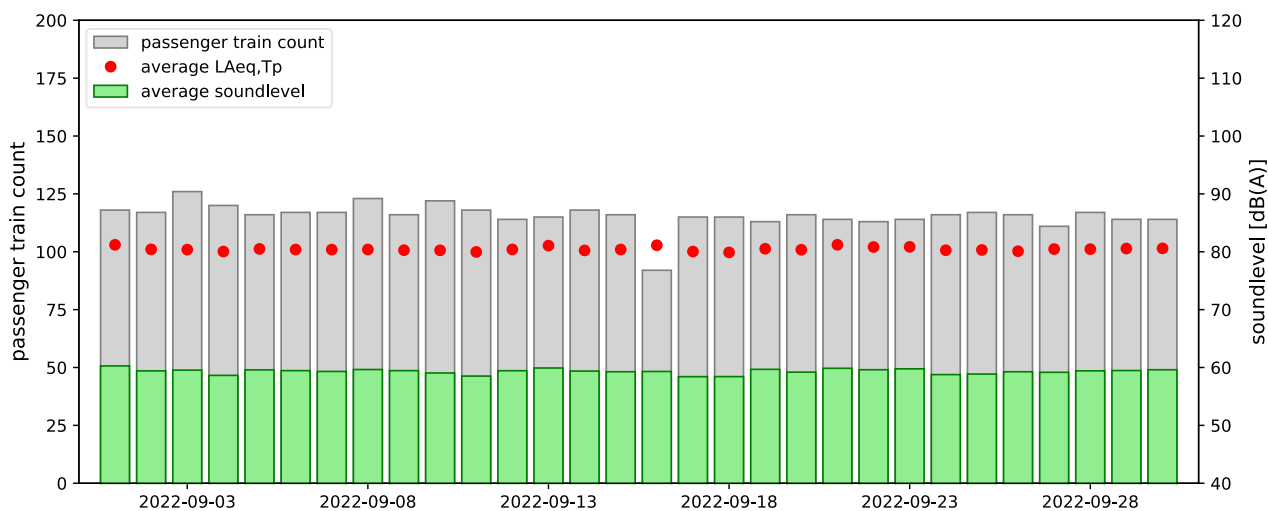
## 2. Measurement data

Daytime averages (24h) for all train passages at reference section (REF)



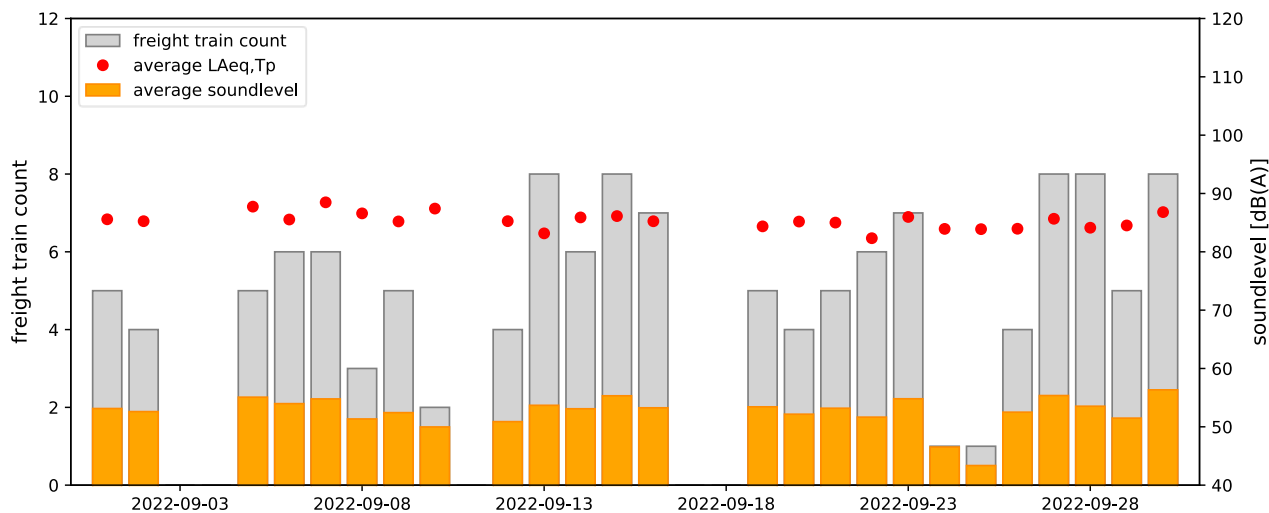
| date         | location   | train count | passenger train count | freight train count | service train count | average LAeq,Tp | average soundlevel |
|--------------|------------|-------------|-----------------------|---------------------|---------------------|-----------------|--------------------|
| 01.09.2022   | REF        | 126         | 118                   | 6                   | 1                   | 81.7            | 61.1               |
| 02.09.2022   | REF        | 125         | 118                   | 6                   | 0                   | 81.0            | 60.4               |
| 03.09.2022   | REF        | 127         | 126                   | 0                   | 0                   | 80.4            | 59.6               |
| 04.09.2022   | REF        | 121         | 120                   | 0                   | 0                   | 80.0            | 58.7               |
| 05.09.2022   | REF        | 122         | 116                   | 5                   | 0                   | 81.6            | 60.9               |
| 06.09.2022   | REF        | 126         | 118                   | 7                   | 1                   | 81.2            | 60.6               |
| 07.09.2022   | REF        | 126         | 118                   | 6                   | 1                   | 81.6            | 60.7               |
| 08.09.2022   | REF        | 129         | 123                   | 3                   | 1                   | 81.0            | 60.4               |
| 09.09.2022   | REF        | 124         | 116                   | 5                   | 0                   | 80.8            | 60.3               |
| 10.09.2022   | REF        | 125         | 122                   | 2                   | 1                   | 80.9            | 59.8               |
| 11.09.2022   | REF        | 119         | 118                   | 0                   | 0                   | 80.0            | 58.6               |
| 12.09.2022   | REF        | 120         | 114                   | 4                   | 1                   | 80.8            | 60.1               |
| 13.09.2022   | REF        | 127         | 115                   | 8                   | 1                   | 81.4            | 61.0               |
| 14.09.2022   | REF        | 126         | 118                   | 6                   | 1                   | 81.0            | 60.4               |
| 15.09.2022   | REF        | 127         | 116                   | 8                   | 1                   | 81.5            | 60.9               |
| 16.09.2022   | REF        | 105         | 93                    | 7                   | 2                   | 81.8            | 60.5               |
| 17.09.2022   | REF        | 118         | 115                   | 0                   | 0                   | 81.7            | 60.0               |
| 18.09.2022   | REF        | 115         | 115                   | 0                   | 0                   | 79.9            | 58.4               |
| 19.09.2022   | REF        | 119         | 114                   | 5                   | 0                   | 81.1            | 60.6               |
| 20.09.2022   | REF        | 123         | 116                   | 5                   | 0                   | 80.9            | 60.1               |
| 21.09.2022   | REF        | 121         | 114                   | 6                   | 0                   | 81.7            | 60.8               |
| 22.09.2022   | REF        | 121         | 113                   | 6                   | 2                   | 81.0            | 60.3               |
| 23.09.2022   | REF        | 123         | 114                   | 7                   | 0                   | 81.7            | 61.0               |
| 24.09.2022   | REF        | 118         | 116                   | 1                   | 0                   | 80.4            | 59.1               |
| 25.09.2022   | REF        | 119         | 117                   | 1                   | 0                   | 80.4            | 59.0               |
| 26.09.2022   | REF        | 120         | 116                   | 4                   | 0                   | 80.6            | 60.1               |
| 27.09.2022   | REF        | 123         | 111                   | 8                   | 1                   | 81.6            | 60.8               |
| 28.09.2022   | REF        | 127         | 117                   | 8                   | 0                   | 81.0            | 60.5               |
| 29.09.2022   | REF        | 125         | 114                   | 5                   | 4                   | 81.1            | 60.4               |
| 30.09.2022   | REF        | 123         | 114                   | 8                   | 0                   | 81.9            | 61.3               |
| <b>month</b> | <b>REF</b> | <b>3670</b> | <b>3475</b>           | <b>137</b>          | <b>18</b>           | <b>81.1</b>     | <b>60.3</b>        |

Daytime averages (24h) for all passenger train passages at reference section (REF)



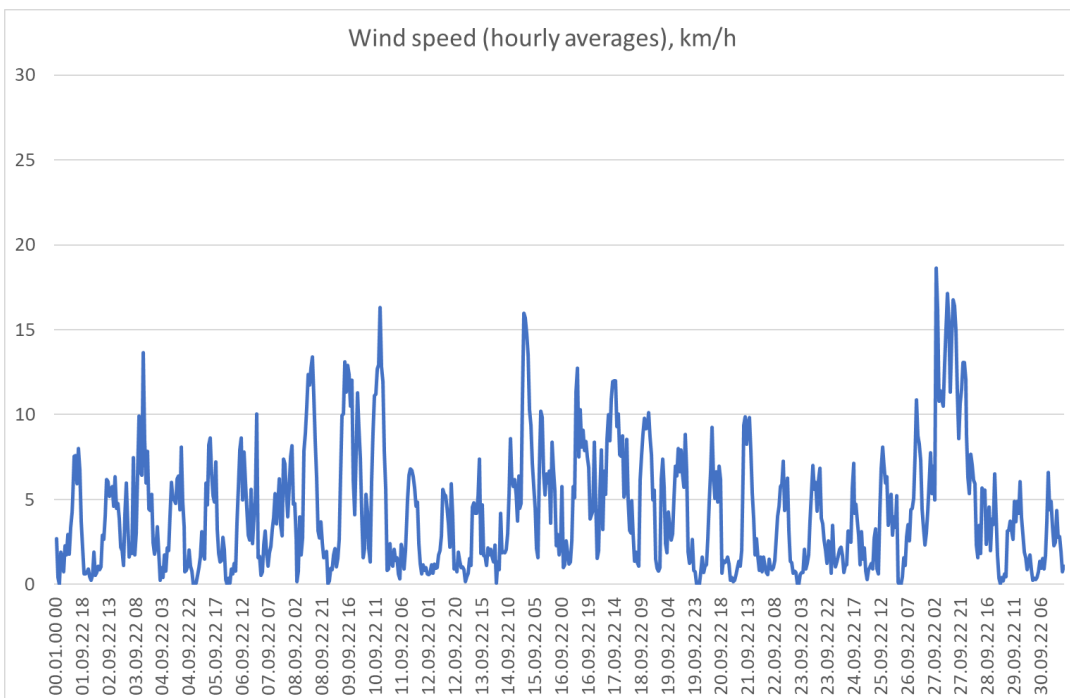
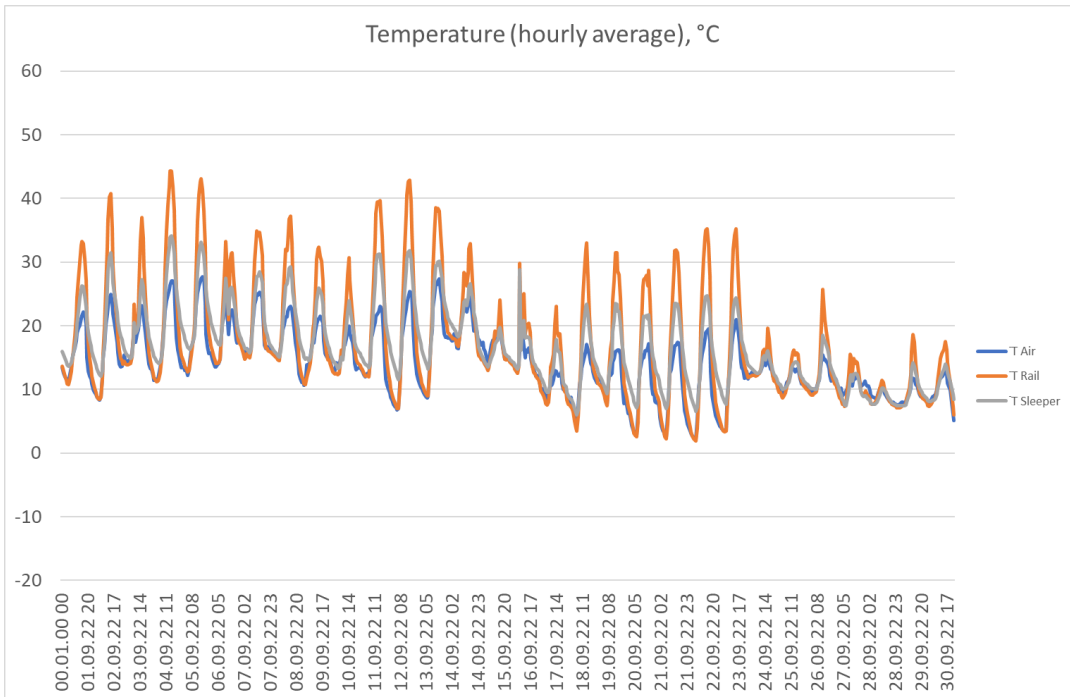
| date         | location   | passenger train count | average speed | average length | average axlecount | average LAeqTp | average soundlevel |
|--------------|------------|-----------------------|---------------|----------------|-------------------|----------------|--------------------|
| 01.09.2022   | REF        | 118                   | 112           | 161            | 24                | 81.2           | 60.3               |
| 02.09.2022   | REF        | 118                   | 113           | 167            | 24                | 80.4           | 59.4               |
| 03.09.2022   | REF        | 126                   | 113           | 157            | 23                | 80.4           | 59.5               |
| 04.09.2022   | REF        | 120                   | 111           | 138            | 20                | 80.0           | 58.6               |
| 05.09.2022   | REF        | 116                   | 113           | 164            | 24                | 80.5           | 59.6               |
| 06.09.2022   | REF        | 118                   | 110           | 159            | 23                | 80.4           | 59.5               |
| 07.09.2022   | REF        | 118                   | 112           | 158            | 23                | 80.4           | 59.3               |
| 08.09.2022   | REF        | 123                   | 110           | 157            | 23                | 80.4           | 59.6               |
| 09.09.2022   | REF        | 116                   | 112           | 167            | 25                | 80.3           | 59.5               |
| 10.09.2022   | REF        | 122                   | 113           | 147            | 22                | 80.3           | 59.1               |
| 11.09.2022   | REF        | 118                   | 112           | 140            | 21                | 80.0           | 58.5               |
| 12.09.2022   | REF        | 114                   | 113           | 163            | 24                | 80.4           | 59.4               |
| 13.09.2022   | REF        | 115                   | 113           | 159            | 23                | 81.1           | 59.9               |
| 14.09.2022   | REF        | 118                   | 110           | 160            | 23                | 80.2           | 59.4               |
| 15.09.2022   | REF        | 116                   | 113           | 158            | 23                | 80.4           | 59.3               |
| 16.09.2022   | REF        | 93                    | 112           | 170            | 25                | 81.1           | 59.3               |
| 17.09.2022   | REF        | 115                   | 112           | 138            | 20                | 80.0           | 58.4               |
| 18.09.2022   | REF        | 115                   | 112           | 141            | 21                | 79.9           | 58.4               |
| 19.09.2022   | REF        | 114                   | 113           | 163            | 24                | 80.5           | 59.7               |
| 20.09.2022   | REF        | 116                   | 113           | 157            | 23                | 80.4           | 59.2               |
| 21.09.2022   | REF        | 114                   | 114           | 157            | 23                | 81.2           | 59.9               |
| 22.09.2022   | REF        | 113                   | 113           | 161            | 24                | 80.8           | 59.6               |
| 23.09.2022   | REF        | 114                   | 113           | 166            | 24                | 80.8           | 59.8               |
| 24.09.2022   | REF        | 116                   | 112           | 142            | 21                | 80.3           | 58.8               |
| 25.09.2022   | REF        | 117                   | 111           | 140            | 21                | 80.3           | 58.9               |
| 26.09.2022   | REF        | 116                   | 109           | 162            | 24                | 80.1           | 59.3               |
| 27.09.2022   | REF        | 111                   | 113           | 163            | 24                | 80.5           | 59.2               |
| 28.09.2022   | REF        | 117                   | 112           | 161            | 24                | 80.4           | 59.4               |
| 29.09.2022   | REF        | 114                   | 112           | 161            | 24                | 80.6           | 59.5               |
| 30.09.2022   | REF        | 114                   | 111           | 169            | 25                | 80.6           | 59.6               |
| <b>month</b> | <b>REF</b> | <b>3475</b>           | <b>112.0</b>  | <b>156.7</b>   | <b>23.0</b>       | <b>80.5</b>    | <b>59.3</b>        |

Daytime averages (24h) for all freight train passages at reference section (REF)



| date       | location | freight train count | average speed | average length | average axle count | average LAeq,Tp | average soundlevel |
|------------|----------|---------------------|---------------|----------------|--------------------|-----------------|--------------------|
| 01.09.2022 | REF      | 6                   | 89            | 210            | 47                 | 85.6            | 53.1               |
| 02.09.2022 | REF      | 6                   | 91            | 241            | 44                 | 85.2            | 52.6               |
| 03.09.2022 | REF      | 0                   |               |                |                    |                 |                    |
| 04.09.2022 | REF      | 0                   |               |                |                    |                 |                    |
| 05.09.2022 | REF      | 5                   | 94            | 213            | 44                 | 87.7            | 55.1               |
| 06.09.2022 | REF      | 7                   | 87            | 223            | 52                 | 85.5            | 54.0               |
| 07.09.2022 | REF      | 6                   | 98            | 168            | 33                 | 88.5            | 54.8               |
| 08.09.2022 | REF      | 3                   | 88            | 201            | 45                 | 86.6            | 51.3               |
| 09.09.2022 | REF      | 5                   | 86            | 202            | 40                 | 85.2            | 52.4               |
| 10.09.2022 | REF      | 2                   | 94            | 204            | 50                 | 87.4            | 50.0               |
| 11.09.2022 | REF      | 0                   |               |                |                    |                 |                    |
| 12.09.2022 | REF      | 4                   | 81            | 170            | 31                 | 85.3            | 50.9               |
| 13.09.2022 | REF      | 8                   | 75            | 221            | 49                 | 83.2            | 53.7               |
| 14.09.2022 | REF      | 6                   | 90            | 174            | 36                 | 85.9            | 53.1               |
| 15.09.2022 | REF      | 8                   | 81            | 185            | 41                 | 86.1            | 55.3               |
| 16.09.2022 | REF      | 7                   | 91            | 181            | 42                 | 85.2            | 53.3               |
| 17.09.2022 | REF      | 0                   |               |                |                    |                 |                    |
| 18.09.2022 | REF      | 0                   |               |                |                    |                 |                    |
| 19.09.2022 | REF      | 5                   | 79            | 247            | 54                 | 84.4            | 53.4               |
| 20.09.2022 | REF      | 5                   | 78            | 198            | 39                 | 85.2            | 52.2               |
| 21.09.2022 | REF      | 6                   | 91            | 263            | 64                 | 85.0            | 53.2               |
| 22.09.2022 | REF      | 6                   | 73            | 225            | 49                 | 82.3            | 51.7               |
| 23.09.2022 | REF      | 7                   | 88            | 209            | 46                 | 86.0            | 54.8               |
| 24.09.2022 | REF      | 1                   | 87            | 367            | 88                 | 83.9            | 46.5               |
| 25.09.2022 | REF      | 1                   | 38            | 78             | 19                 | 83.9            | 43.4               |
| 26.09.2022 | REF      | 4                   | 70            | 281            | 68                 | 84.0            | 52.5               |
| 27.09.2022 | REF      | 8                   | 85            | 219            | 47                 | 85.7            | 55.4               |
| 28.09.2022 | REF      | 8                   | 74            | 182            | 41                 | 84.1            | 53.5               |
| 29.09.2022 | REF      | 5                   | 76            | 174            | 37                 | 84.5            | 51.5               |
| 30.09.2022 | REF      | 8                   | 89            | 223            | 50                 | 86.8            | 56.3               |
| month      | REF      | 137                 | 84.0          | 208.1          | 45.4               | 85.4            | 52.4               |

### 3. Weather data



## Appendix: measurement quantities

### Transit Exposure Level *TEL*

A-weighted sound pressure level of a single train pass-by as energetic average over the entire exposure duration  $T$  and averaged over the pass-by duration  $T_p$ .

$$TEL = 10 \log \left( \frac{1}{T_p} \int_0^T \frac{p_A^2(t)}{p_0^2} dt \right) \quad (1)$$

Where

$p_A(t)$  = the A-weighted sound pressure, [Pa]

$p_0 = 20 \mu Pa$  (reference pressure), [Pa]

$T_p = T_2 - T_1$  = pass-by duration of the train, time interval during which a train is within the measurement cross-section and which starts with the entry time  $T_1$  into the measurement cross-section and ends with the exit time  $T_2$ , [s]

$T$  = time interval which starts when the smoothed sound pressure level (sound pressure level smoothed as a function of time with the frequency weighting A and a time weighting F („fast“ or averaging over a duration period of time, e.g. 100 ms) is for the last time 10 dB below that prevailing at the time of entering the measurement cross-section and which ends when the smoothed sound pressure level is for the first time 10 dB below the one at the time of leaving the measurement cross-section. [s]

### A-weighted equivalent sound pressure level of the train pass-by $L_{Aeq,Tp}$

The A-weighted equivalent sound pressure level equals the (energetic) average of the sound pressure level over the train pass-by time  $T_p$  according to the following equation:

$$L_{Aeq,Tp} = 10 \log \left( \frac{1}{T_p} \int_{T_1}^{T_2} \frac{p_A^2(t)}{p_0^2} dt \right) \quad (2)$$

where

$p_A(t)$  = the A-weighted sound pressure, [Pa]

$p_0 = 20 \mu Pa$  (reference sound pressure), [Pa]

$T_p = T_2 - T_1$  = pass-by duration of the train, [s]

### Sound Exposure Level *SEL*

The sound exposure level *SEL* references the acoustic energy of the entire pass-by event to one second. The SEL is used in calculating average sound level contributions from trains over longer periods of time (i.e. days/months/year). The SEL is related to the transit exposure level TEL through:

$$SEL = TEL - 10 \log (T_0 / T_p) \quad (3)$$

where

$T_0 = 1$  [s]



$T_p$  = pass-by duration of the train, [s]

### Average sound level (period)

Average (energetic) A-weighted sound pressure level measured over a given period of time.

For the average sound level contributions from train pass-byes this equals the sum (energetic) of all sound exposure levels during the period for a given measurement position:

$$\text{average soundlevel} = 10 \cdot \log_{10} \left( \sum 10^{\frac{SEL}{10}} \right) - A1 \quad (4)$$

where

$A1 = 10 \cdot \log_{10}(n \cdot 24 \cdot 3600)$  for a 24-hour period

$SEL$  (see equation 3) taken from measurement data

$n$  = number of days being averaged over

### Average $L_{Aeq,Tp}$

Average (energetic) sound level of all the A-weighted sound pressure levels from the individual equivalent sound level of all train pass-byes in a given period of time (day/month/year).

Calculated per train category and per period day/night, month, year, etc. and per measurement location:

$$\text{average } L_{Aeq,Tp} = 10 \cdot \log_{10} \left( \sum T_p \cdot 10^{\frac{L_{Aeq,Tp}}{10}} \right) + 10 \cdot \log_{10} \left( \frac{1}{\sum T_p} \right) \quad (5)$$

where

$T_p$  = pass-by duration of the train [s]

$L_{Aeq,Tp}$  (see equation 2) is calculated directly from the measurement data