

Monthly report

Railway Field Laboratory

January 2024

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).

Consultant: Müller-BBM Rail Technologies GmbH
Helmut-A.-Müller-Straße 1 - 5
82152 Planegg
www.MuellerBBM-Rail.com

Author: Natan Isert, Stefan Lutzenberger

Supervision BAFU / BAV: Fredy Fischer
Franz Kuster, Christoph Dürig

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.

Version: V1

Date: 26.2.2024

1. Status railway field laboratory

Construction work on the tracks:

- none

Downtimes of the measurement systems:

- none

Downtimes of the sensors:

- MQ 2_3: a-mq23-2-rh (probably caused by parts of a train hanging down) 7.10.-

Maintenance and sensor exchange:

- none

Modifications to the data, database, or analysis:

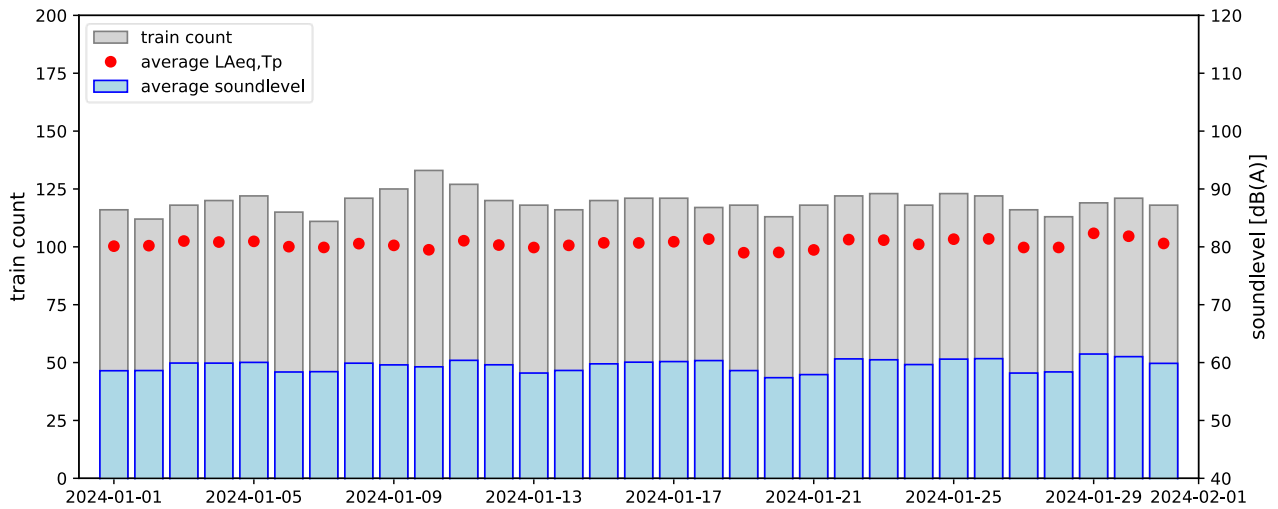
- none

Monthly data volume collected:

- 542 GB

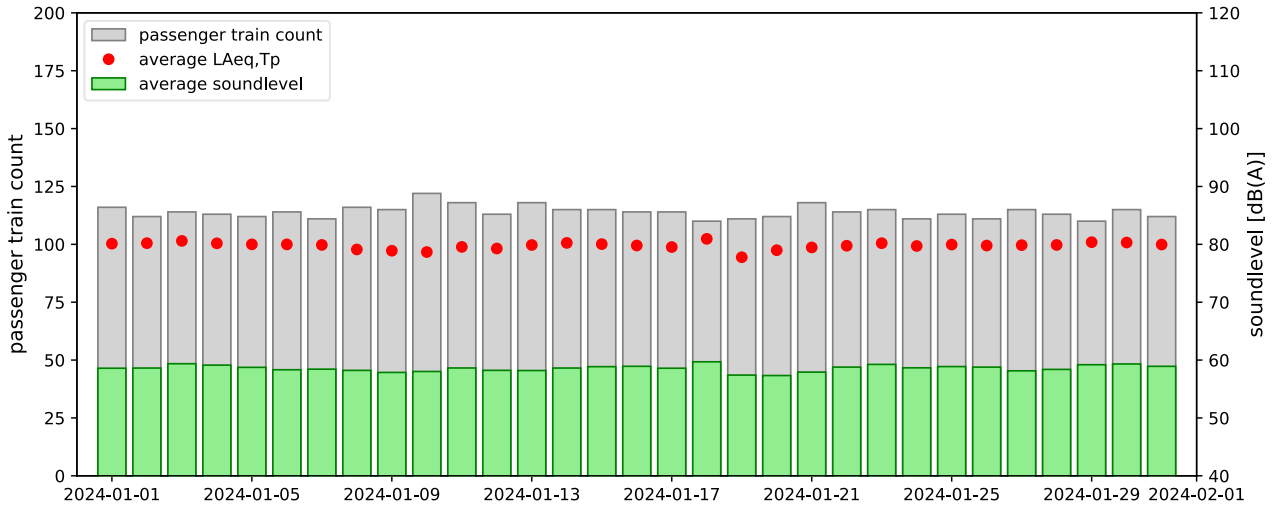
2. Measurement data

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



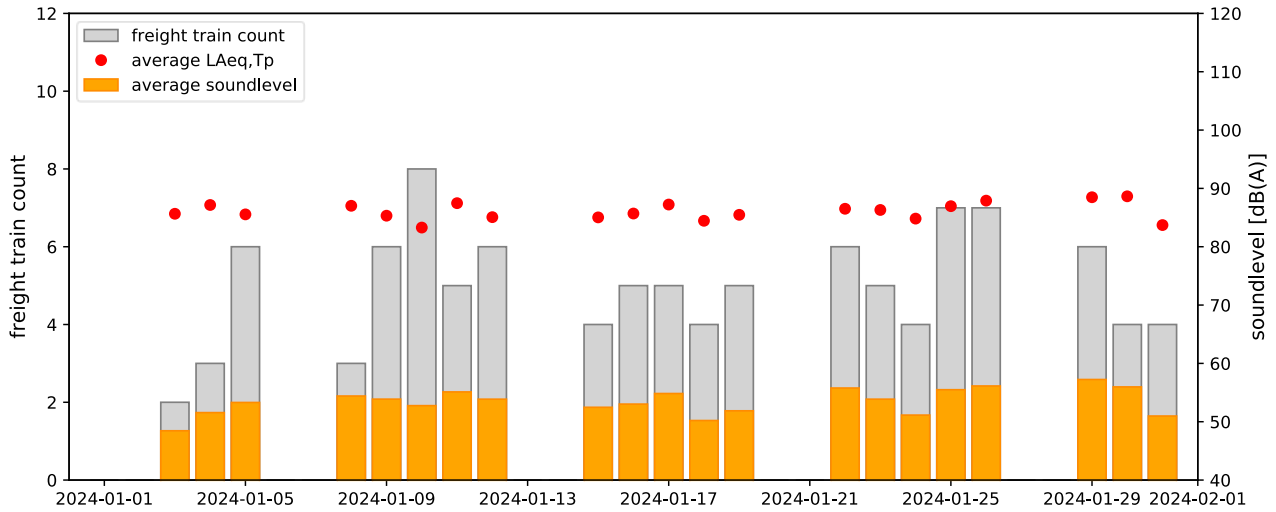
| date | location | train count | passenger train count | freight train count | service train count | average LAeqTp | average soundlevel |
|--------------|------------|-------------|-----------------------|---------------------|---------------------|----------------|--------------------|
| 01.01.2024 | REF | 116 | 116 | 0 | 0 | 80,1 | 58,6 |
| 02.01.2024 | REF | 112 | 112 | 0 | 0 | 80,2 | 58,6 |
| 03.01.2024 | REF | 118 | 114 | 2 | 2 | 81 | 59,9 |
| 04.01.2024 | REF | 120 | 113 | 3 | 4 | 80,8 | 59,9 |
| 05.01.2024 | REF | 122 | 112 | 6 | 4 | 80,9 | 60 |
| 06.01.2024 | REF | 115 | 114 | 0 | 1 | 80 | 58,4 |
| 07.01.2024 | REF | 111 | 111 | 0 | 0 | 79,9 | 58,4 |
| 08.01.2024 | REF | 121 | 116 | 3 | 2 | 80,6 | 59,9 |
| 09.01.2024 | REF | 125 | 115 | 6 | 4 | 80,3 | 59,6 |
| 10.01.2024 | REF | 133 | 122 | 8 | 3 | 79,5 | 59,3 |
| 11.01.2024 | REF | 127 | 118 | 5 | 4 | 81,1 | 60,4 |
| 12.01.2024 | REF | 120 | 113 | 6 | 1 | 80,3 | 59,6 |
| 13.01.2024 | REF | 118 | 118 | 0 | 0 | 79,9 | 58,2 |
| 14.01.2024 | REF | 116 | 115 | 0 | 1 | 80,3 | 58,6 |
| 15.01.2024 | REF | 120 | 115 | 4 | 1 | 80,7 | 59,8 |
| 16.01.2024 | REF | 121 | 114 | 5 | 2 | 80,7 | 60,1 |
| 17.01.2024 | REF | 121 | 114 | 5 | 2 | 80,9 | 60,2 |
| 18.01.2024 | REF | 117 | 110 | 4 | 3 | 81,3 | 60,3 |
| 19.01.2024 | REF | 118 | 111 | 5 | 2 | 79 | 58,6 |
| 20.01.2024 | REF | 113 | 112 | 0 | 1 | 79 | 57,4 |
| 21.01.2024 | REF | 118 | 118 | 0 | 0 | 79,5 | 57,9 |
| 22.01.2024 | REF | 122 | 114 | 6 | 2 | 81,3 | 60,6 |
| 23.01.2024 | REF | 123 | 115 | 5 | 3 | 81,2 | 60,5 |
| 24.01.2024 | REF | 118 | 111 | 4 | 3 | 80,4 | 59,7 |
| 25.01.2024 | REF | 123 | 113 | 7 | 3 | 81,3 | 60,6 |
| 26.01.2024 | REF | 122 | 111 | 7 | 4 | 81,4 | 60,7 |
| 27.01.2024 | REF | 116 | 115 | 0 | 1 | 79,9 | 58,2 |
| 28.01.2024 | REF | 113 | 113 | 0 | 0 | 79,9 | 58,4 |
| 29.01.2024 | REF | 119 | 110 | 6 | 3 | 82,3 | 61,5 |
| 30.01.2024 | REF | 121 | 115 | 4 | 2 | 81,8 | 61 |
| 31.01.2024 | REF | 118 | 112 | 4 | 2 | 80,6 | 59,9 |
| month | REF | 3697 | 3532 | 105 | 60 | 80,6 | 59,6 |

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



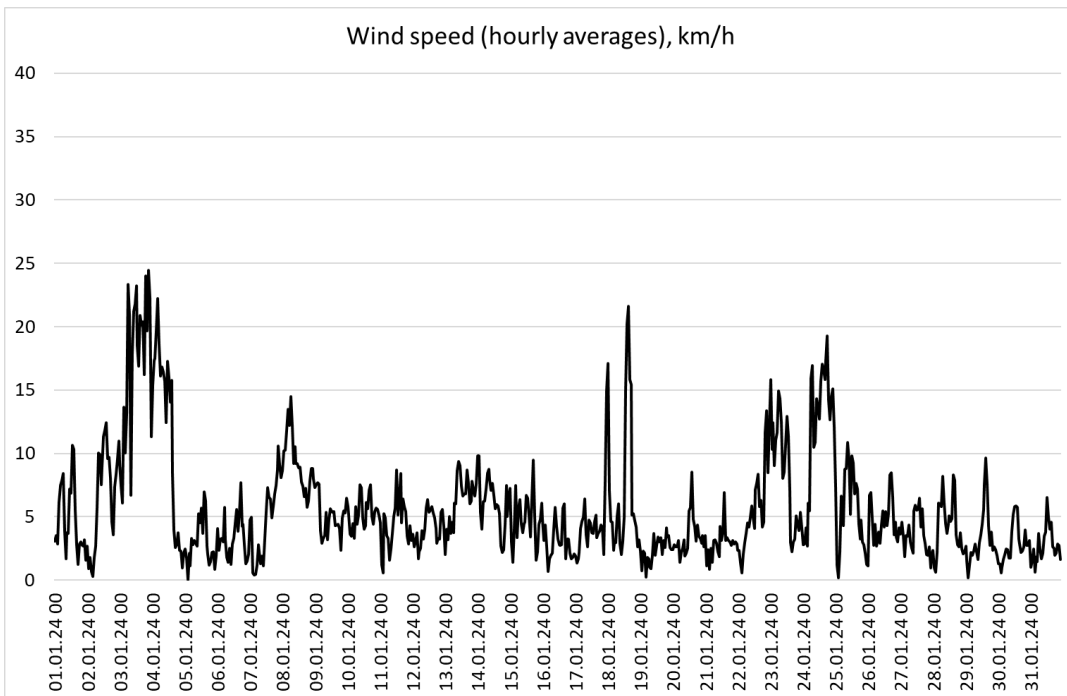
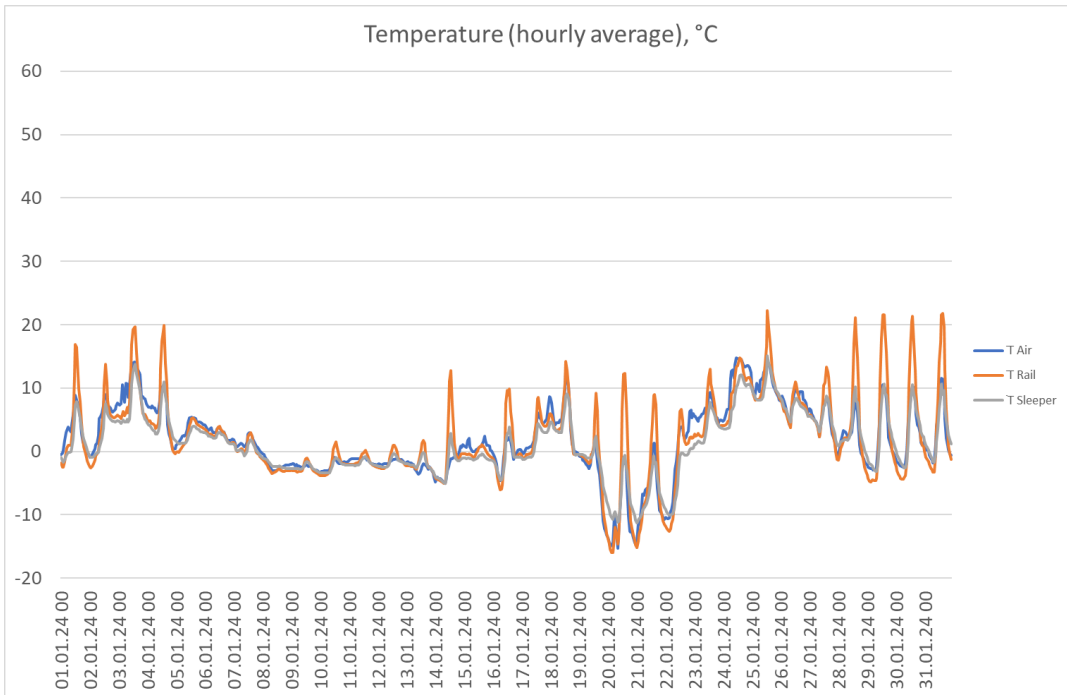
| date | location | passenger train count | average speed | average length | average axlecount | average LAeqTp | average soundlevel |
|--------------|------------|-----------------------|---------------|----------------|-------------------|----------------|--------------------|
| 01.01.2024 | REF | 116 | 111,5 | 145,7 | 21,1 | 80,1 | 58,6 |
| 02.01.2024 | REF | 112 | 111,5 | 145,1 | 21 | 80,2 | 58,6 |
| 03.01.2024 | REF | 114 | 111,4 | 159 | 23,5 | 80,6 | 59,4 |
| 04.01.2024 | REF | 113 | 110,9 | 166,8 | 24,6 | 80,2 | 59,1 |
| 05.01.2024 | REF | 112 | 111,9 | 165,8 | 24,3 | 80 | 58,7 |
| 06.01.2024 | REF | 114 | 112 | 142,9 | 20,6 | 80 | 58,3 |
| 07.01.2024 | REF | 111 | 109,7 | 149,5 | 21,7 | 79,9 | 58,4 |
| 08.01.2024 | REF | 116 | 110,2 | 168,2 | 24,8 | 79,1 | 58,2 |
| 09.01.2024 | REF | 115 | 112,5 | 168,6 | 24,9 | 78,9 | 57,9 |
| 10.01.2024 | REF | 122 | 111,3 | 171,1 | 25 | 78,7 | 58 |
| 11.01.2024 | REF | 118 | 111,9 | 168,5 | 24,9 | 79,6 | 58,6 |
| 12.01.2024 | REF | 113 | 110,2 | 167,8 | 24,8 | 79,3 | 58,2 |
| 13.01.2024 | REF | 118 | 113,9 | 139,2 | 20,1 | 79,9 | 58,2 |
| 14.01.2024 | REF | 115 | 111,9 | 142,6 | 20,8 | 80,2 | 58,6 |
| 15.01.2024 | REF | 115 | 113,1 | 165,5 | 24,3 | 80 | 58,9 |
| 16.01.2024 | REF | 114 | 109,7 | 169,3 | 25 | 79,8 | 58,9 |
| 17.01.2024 | REF | 114 | 110,4 | 168,3 | 24,8 | 79,5 | 58,6 |
| 18.01.2024 | REF | 110 | 110,7 | 170,1 | 25 | 80,9 | 59,7 |
| 19.01.2024 | REF | 111 | 113,2 | 174,7 | 25,6 | 77,8 | 57,4 |
| 20.01.2024 | REF | 112 | 112,4 | 146,2 | 21,1 | 79 | 57,3 |
| 21.01.2024 | REF | 118 | 111,9 | 141,4 | 20,5 | 79,5 | 57,9 |
| 22.01.2024 | REF | 114 | 110,8 | 166,9 | 24,5 | 79,8 | 58,8 |
| 23.01.2024 | REF | 115 | 111,6 | 167,7 | 24,6 | 80,2 | 59,3 |
| 24.01.2024 | REF | 111 | 110,5 | 168,7 | 24,8 | 79,7 | 58,7 |
| 25.01.2024 | REF | 113 | 112,4 | 169,4 | 24,9 | 80 | 58,9 |
| 26.01.2024 | REF | 111 | 112,3 | 173,7 | 25,5 | 79,8 | 58,8 |
| 27.01.2024 | REF | 115 | 113,5 | 142 | 20,5 | 79,9 | 58,1 |
| 28.01.2024 | REF | 113 | 111,1 | 149,6 | 21,7 | 79,9 | 58,4 |
| 29.01.2024 | REF | 110 | 112,8 | 171,6 | 25,2 | 80,4 | 59,2 |
| 30.01.2024 | REF | 115 | 109,2 | 164,4 | 24,1 | 80,3 | 59,3 |
| 31.01.2024 | REF | 112 | 111,4 | 168,3 | 24,7 | 80 | 58,9 |
| month | REF | 3532 | 111,5 | 160,5 | 23,5 | 79,8 | 58,6 |

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 LAeqTp | average soundlevel |
|--------------|------------|---------------------|---------------|----------------|--------------------|----------------|--------------------|
| 01.01.2024 | REF | 0 | | | | | 0 |
| 02.01.2024 | REF | 0 | | | | | 0 |
| 03.01.2024 | REF | 2 | 95,9 | 202,1 | 47 | 85,6 | 48,4 |
| 04.01.2024 | REF | 3 | 81,7 | 193,8 | 40 | 87,2 | 51,6 |
| 05.01.2024 | REF | 6 | 82,9 | 198,3 | 41,3 | 85,5 | 53,3 |
| 06.01.2024 | REF | 0 | | | | | 0 |
| 07.01.2024 | REF | 0 | | | | | 0 |
| 08.01.2024 | REF | 3 | 86,8 | 368,8 | 90 | 87 | 54,4 |
| 09.01.2024 | REF | 6 | 82,7 | 216 | 44,3 | 85,3 | 53,9 |
| 10.01.2024 | REF | 8 | 83,8 | 194,1 | 38,5 | 83,3 | 52,8 |
| 11.01.2024 | REF | 5 | 84,2 | 222,8 | 50,4 | 87,5 | 55,1 |
| 12.01.2024 | REF | 6 | 79,8 | 236,8 | 53,7 | 85,1 | 53,9 |
| 13.01.2024 | REF | 0 | | | | | 0 |
| 14.01.2024 | REF | 0 | | | | | 0 |
| 15.01.2024 | REF | 4 | 72,3 | 239,6 | 55 | 85 | 52,5 |
| 16.01.2024 | REF | 5 | 92,4 | 227,1 | 46,4 | 85,7 | 53 |
| 17.01.2024 | REF | 5 | 85,1 | 223,2 | 49,2 | 87,2 | 54,8 |
| 18.01.2024 | REF | 4 | 90,2 | 186,9 | 39 | 84,4 | 50,2 |
| 19.01.2024 | REF | 5 | 85,2 | 181,7 | 39,2 | 85,5 | 51,9 |
| 20.01.2024 | REF | 0 | | | | | 0 |
| 21.01.2024 | REF | 0 | | | | | 0 |
| 22.01.2024 | REF | 6 | 86,6 | 271,1 | 66,3 | 86,5 | 55,8 |
| 23.01.2024 | REF | 5 | 91,5 | 242,5 | 61,2 | 86,3 | 53,9 |
| 24.01.2024 | REF | 4 | 77,8 | 189,1 | 40 | 84,8 | 51,1 |
| 25.01.2024 | REF | 7 | 78 | 182,6 | 41,7 | 87 | 55,5 |
| 26.01.2024 | REF | 7 | 93,2 | 198,2 | 44,3 | 87,9 | 56,1 |
| 27.01.2024 | REF | 0 | | | | | 0 |
| 28.01.2024 | REF | 0 | | | | | 0 |
| 29.01.2024 | REF | 6 | 94,9 | 270,5 | 61,7 | 88,5 | 57,2 |
| 30.01.2024 | REF | 4 | 82,2 | 247,5 | 58,5 | 88,6 | 56 |
| 31.01.2024 | REF | 4 | 81,9 | 246,7 | 61,5 | 83,7 | 51 |
| month | REF | 105 | 85 | 223 | 50 | 86,3 | 52,2 |

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

$$T_0 = 1 \text{ [s]}$$

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:

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

where

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

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:

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

where

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

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