Danish Ministry
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Test cases for railway noise Nord2000

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The reports are, however, published because the Danish EPA finds that the studies represent a valuable contribution to the debate on environmental policy in Denmark.

Contents

Forord

Miljøstyrelsen bad i 2004 DELTA om at udarbejde et sæt af beregningsforudsætninger og dertil hørende beregningsresultater, som kan benyttes til test af computerprogrammer, der beregner vejtrafikstøj efter den nye nordiske beregningsmetode Nord2000. Testeksemplerne blev offentliggjort i Miljøstyrelsens "Environmental Project 1022/2005". Siden da er Nord2000-metoden i perioden 2005 – 06 blevet revideret i et fælles nordisk projekt, hvorved der blev ændret på både beregning af lydudbredelse og på kildemodellen for vejstøj. Siden revisionen af metoden er der fundet enkelte tilfælde, hvor det har været nødvendigt at forbedre metodens algoritmer, ligesom der er fundet mindre fejl i den software, der har været brugt til at beregne testeksemplerne med. Miljøstyrelsen har derfor flere gange bedt DELTA om at opdatere beregningsresultaterne for testeksemplerne i den nævnte rapport, så de er i overensstemmelse med den gældende udgave af Nord2000-metoden.

Der har ikke tidlige været testeksempler til rådighed for støj fra jernbaner. Hovedformålet med testeksemplerne i denne rapport er at teste implementeringen af kildedata for de togtyper, der er til rådighed i beregningsmetoden. Da støj fra jernbaner oftest beregnes med samme software som støj fra veje, er det ikke fundet strengt nødvendigt at udarbejde testeksempler med udbredelseseffekter ud over fladt, græsdækket terræn.

For hvert beregningspunkt er det angivet, inden for hvilke intervaller beregningsresultaterne skal befinde sig, for at den testede software kan siges at regne korrekt i henhold til Nord2000.

Målgruppen for rapporten er konsulenter og producenter af beregningsprogrammer.

Foreword

The Danish Environmental Protection Agency has in 2004 asked DELTA to develop test examples, which are a set of presumptions together with corresponding computation results, suitable for verifying that computer programmes indeed do perform in conformity with the new Nordic prediction method for road traffic noise, Nord2000. The test examples were reported in "Environmental Project 1022/2005". Since then the prediction method has been revised during 2005 – 06 in a joint Nordic project, where both the propagation calculations and the source model for road traffic noise were adjusted. Since the revision of the method there have been a few cases where it has been necessary to adjust the algorithms of the method and furthermore, minor errors have been found in the software used to calculate the test examples. As a consequence, DELTA has for the Danish Environmental Protection Agency revised the test results for road traffic noise several times to be in accordance with the newest version of Nord2000.

Test examples for railway noise have not previously been available. The main purpose of the test examples in the present report has been to test the implementation of railway source data for available Danish train types. As noise from railway and road traffic very often are calculated using the same software it has not been found necessary to test for the effect of sound propagation except for flat grass-covered ground.

Intervals have been specified that computation results shall fall within in order for the software to be declared as in conformity with Nord2000.

The target group for the present report is consultants and developers or distributors of software for railway traffic noise prediction.

Sammenfatning og konklusioner

Denne rapport indeholder et antal testtilfælde for beregning af støj fra jernbaner med Nord2000. Testtilfældene omfatter beregninger i to afstande fra et jernbanespor for alle danske togkategorier. Testeksemplerne skal benyttes ved kontrol af, at computerprogrammer beregner i overensstemmelse med Nord2000-metoden. Beregninger er udført dels af årsmiddelværdien af støjbelastningen L_{den} og af maksimalværdien L_{pAmaxS} med tidsvægtning Slow. Resultaterne omfatter både A-vægtede støjniveauer og støjniveauer i 1/3-oktavbånd.

Resultaterne er samlet i et Excel regneark.

Summary and conclusions

The present report contains a number of test cases for calculation of noise from railways using Nord2000. The test cases include calculations in two distances from a railway line for all Danish train categories. The purpose of the test cases is to provide a basis for testing software developed according to the Nord2000 model. Test results have been made for the yearly average of the noise exposure L_{den} and for the maximum noise level L_{pAmaxS} with time weighting Slow. The test results include overall A-weighted sound pressure levels as well as one-third octave band levels.

The test results are available in an Excel spreadsheet.

1 Introduction

The present report contains a number of test cases for which calculations have been carried out by the Nordic railway noise calculation method Nord2000. The model is described in Ref. [1], [3], [4], and [5] (Ref. [5] contains a complete description of the propagation model including the latest changes). Source data for Danish trains are given in Ref. [2] (the values shown in [1] are not correct!).

Calculations have been carried out for all available source data and two propagation distances. For each case the yearly average of the noise level has been calculated as well as the maximum noise level corresponding to time weighting Slow.

2 Test Case Calculation Input

Calculations have been carried out for the eight sets of train source data shown in Table 1. The table also shows the train speed that has been used in the calculations. The source data are taken from Ref [2]. For the train type "Øresundstog" the data of Table 6 in Ref. [2] has been used (reduced data) and for the train type "Metro" the data of Table 7 in Ref. [2] has been used (all data).

Table 1: Source data of 8 train groups.

No.	*Train type*	*Speed (km/h)*
1	A & D: Passenger trains IC3 or IR4	120
2	Øresundstog	120
3	X2000	120
4	B, C, H & I: Passenger and goods train with ME, MZ or EA locomotives	120
5	E: Diesels train sets (MR), Y-trains, IC2-trains, RegioSprinter, Desiro	120
6	F2 & F3: S-trains, 2nd and 3rd generation	80
7	F4: S-trains, 4th generation	80
8	Metro	80

In calculations of the yearly average of the noise exposure L_{den} the total length of the trains per day divided on the time-of-day periods are shown in Table 2.

Table 2: Traffic information

Time-of-day period	*Total length of train per day (m)*
Day	11000
Evening	3000
Night	3000

In the calculation of the maximum level each train is assumed to have a length of 300 m (same value is used for all train groups).

The ground surface between the railway track and the receiver is flat and covered with grass and the rail bed has the same height as the ground. The height of the rail above the rail bed is 0.2 m. The rail bed and the ground surface are assumed to have surface properties corresponding to Nord2000 impedance class D (flow resistivity of 200,000 Nsm^{-4}). Calculations are performed for a receiver 1.5 m above the ground surface and 10 and 100 m from the nearest rail.

The source line at the nearest rail has been divided into 179 source points placed with constant angle seen from the receiver. The angle resolution is 1°, and consequently the source points cover horizontal immission angles between ±89°.

The method for calculating the yearly average of L_{den} is described in [6]. The meteorological statistics for nine meteo-classes to be used in the calculations

can be found in the Excel spreadsheet file containing the calculation results (in the sheet “Met. statistics”). It contains for each time-of-day period the percentage of occurrences in each meteo-class and the corresponding air temperature and relative humidity. In excess of this information the turbulence is defined by the structure parameters $C_v^2 = 0.12\ m^{4/3}/s^2$ and $C_t^2 = 0.008\ K/s^2$. In the calculations the railway line is assumed to have the direction North-South with the receiver placed east of the railway line. The train is assumed to move towards North.

The procedure for calculating a maximum noise level which corresponds to time weighting Slow is described i Ref. [1] but [1] contains no guideline for taking into account varying weather conditions. In the calculations the maximim level is determined for all nine meteo-classes included in the calculation of L_{den} using the maximum of these values.

3 Test Case Calculation Results

The results of the 16 cases (8 train categories and 2 distances) are given in Excel file “RailTest_20110714” with one worksheet for each test case. (20110714 in the filename is the date July 14, 2011). An example of a sheet is shown in Appendix A (Test Case No. 1). The results are:

- The yearly average of the noise exposure level L_{den} and the corresponding spectrum per one-third octave band (unweighted)

- The A-weighted maximum level L_{AmaxS} with time weighting Slow and the corresponding spectrum per one-third octave band (unweighted)

- The absolute A-weighted maximum level L_{Amax} defined as the maximum level assuming that the source in the horizontal direction is considered a point source. This value is only for information and is not considered a part of the test (the number is shown on a grey background).

Besides the results, the sheet contains for each test case the traffic parameters and the propagation distance.

4 Acceptable Deviation

To check whether a software provider has implemented the Nord2000 railway source data correctly, all the test examples in this report shall be calculated.

The A-weighted noise exposure level L_{den} shall not deviate by more than 1 dB from the calculated results in any example specified in the present report. In most cases the deviations can be kept within 0.5 dB. Deviations exceeding 0.5 dB should therefore give rise to increased awareness concerning possible errors in the software under test, and the reasons for the deviation should be explained.

The corresponding calculated one-third octave band spectra of L_{den} shall be compared to the one-third octave spectra in this report. Deviations less than 1 dB are in general acceptable for the sound level values in each frequency band. Deviations exceeding 1 dB in one frequency band shall be investigated. Special problems may occur at ground effect dips in the frequency spectrum where the uncertainty may increase. A shift in the dip may lead to a considerable sound level difference in a frequency band close to the dip. A shift in the dip frequency of one third octave will in general be considered acceptable in such cases.

Maximum noise levels can be expected to be more sensitive to local details in the calculations than the noise exposure levels. If the deviations of the maximum levels are within the limits defined for noise exposure levels the accuracy is considered acceptable without further explanation. If the limits are exceeded the deviation shall be investigated and an explanation shall be found. However, it is expected that it can be necessary to accept deviations twice the size of those defined above for noise exposure levels.

5 References

[1] H. J. Jonasson and Svein Storeheier, ***Nord2000. New Nordic prediction method for rail traffic noise***, SP Report 2001:11, Borås 2001.

[2] D. Hoffmeyer, ***Kildestyrkedata for togstøj til Nord2000 (Source data for railway noise in Nord2000)***, Miljøstyrelsen, Miljøprojekt Nr. 1014, 2005 (in Danish).

[3] B. Plovsing, ***Nord2000. Comprehensive Outdoor Sound Propagation Model. Part 1: Propagation in an Atmosphere without Significant Refraction***, DELTA Acoustics & Vibration, Report AV 1849/00 (revised), Hørsholm 2006.

[4] B. Plovsing, ***Nord2000. Comprehensive Outdoor Sound Propagation Model. Part 2: Propagation in an Atmosphere with Refraction***, DELTA Acoustics & Vibration, Report AV 1851/00 (revised), Hørsholm 2006.

[5] B. Plovsing, ***Proposal for Nordtest Method: Nord2000 – Prediction of Outdoor Sound Propagation***, DELTA Acoustics, Report AV 1106/07 (revised), Hørsholm 2010.

[6] R. Eurasto, ***Nord2000 for road traffic noise prediction. Weather classes and statistics***, VTT Research Report No. VTT-R-02530-06, Esbo 2006.

Appendix A

As an example, one case from the Excel file ”RailTest_20110714.xls” is shown below (train type no. 1 and propagation distance 10 m).

Nord2000 - Rail Traffic

Traffic parameters

Train type	1	
l(day)	11000	m per 24h
l(evening)	3000	m per 24h
l(night)	3000	m per 24h
l(max)	300	m
Speed	120	km/h

Propagation parameters

Distance	10	m

Calculated noise levels

Lden	67.70	dB
LpAmaxS	86.97	dB
LpAmax	94.70	dB

Calculated spectra

Freq.	Lden	LpmaxS
Hz	dB	dB
25	50.18	68.08
31.5	50.09	67.98
40	53.24	71.12
50	58.79	76.64
63	61.85	79.67
80	60.95	78.70
100	58.62	76.27
125	56.95	74.44
160	54.70	71.93
200	57.42	76.51
250	56.15	75.27
315	55.40	74.54
400	54.64	73.81
500	53.27	72.64
630	53.59	73.54
800	56.33	76.43
1000	58.76	78.47
1250	59.05	78.16
1600	58.70	77.76
2000	58.78	78.04
2500	56.67	75.56
3150	54.59	74.31
4000	52.08	69.88
5000	49.02	67.88
6300	45.33	64.84
8000	43.70	63.19
10000	42.64	61.12