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THE DEPARTMENT
OF TRANSPORT

Calculation of Railway Noise

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HMSO

APPENDIX A1

SOUND EXPOSURE LEVELS FOR RAILWAY VEHICLES, (SEL_V)

This Appendix gives details of the reference Sound Exposure Levels for single vehicles (SEL_V) that should be used as input to Stage 2 of the calculation procedure described in paragraph 14 of the Technical Memorandum. The Appendix also includes a description of the method which shall be adopted to add new railway vehicle categories to the list of SEL_V and the procedures to adopt when a new type of track or track support system is used which is not referred to in the Technical Memorandum.

Single Vehicle Sound Exposure Levels

The calculation process requires a value of the reference Sound Exposure Level (SEL_{ref}) for each different train type using the railway at a reference position located 25m from the near-side railhead of the track segment under consideration. (NB The height of the reception point shall be located in the range 1.2m above the ground (minimum) to 3.5m above the railhead (maximum).) For each train category the speed of the train has also to be defined.

For the purpose of the calculation a railway vehicle is either a coach (which can be powered) in the case of a passenger train, or a wagon when a freight train is being considered. Where a locomotive (diesel or electric) is being used to haul either a passenger train or a freight train then it will be necessary to consider each locomotive as a separate (single vehicle) train (see also paragraph 14.2 and example 6 of Appendix 2)

Charts A1.1 and A1.2 give the baseline SEL versus speed relationships that should be used in all cases for vehicles operating on standard track, and Table A1.1 gives corrections to apply to the values obtained from the Charts according to the type of railway vehicle being considered. Chart A1.1 gives the general relationship which is to be used for all railway vehicles and operations apart from diesel locomotives operating on full power. For this type of vehicle and operating condition, Chart A1.2 applies.

It is intended that each railway vehicle type using the railway should initially be categorised according to the listings given in Table A1.1 and the baseline SEL determined from the appropriate Chart by entering the speed of the vehicle. This value is then corrected using the vehicle type correction listed in Table A1.1. to obtain the value of the SEL_V for an individual railway vehicle. To facilitate accurate use of the Charts, the formula to the regression line is given in both cases. The reference Sound Exposure Level (SEL_{ref}) can then be determined for each train type by correcting the single vehicle SEL using the procedures described earlier in paragraphs 14-17 inclusive.

Procedure to Adopt For New Train Types.

Although the data given in the Charts and Table A1.1 will allow calculation in most cases, new or existing train types will be encountered which may not be covered in the original classification. Consequently, it will not be possible to determine an appropriate value of the SEL_V to use in the prediction method.

In some cases where the inclusion of a new type of railway vehicle will clearly have no significant effect on the overall levels of noise from the railway, or where the noise levels are well below the relevant noise levels for sound insulation entitlement, an approximate value for the SEL_V for the new types of railway vehicles can be obtained by taking appropriate values for similar vehicle types from the existing list. However, for situations where the new railway vehicles are expected to form a significant contribution to the total noise from the railway, or where the relevant noise levels are expected to be within 3 dB(A) of the specified levels for insulation, then it will be necessary to obtain accurate values of the SEL_V for the new railway vehicles. In these circumstances the following procedure applies:-

(i) Sound Exposure Levels will be determined by the railway operator or its appointed consultants.

(ii) The measurements, without intervening tracks, will be taken at a measurement position located, preferably, at 25m from the near-side rail. However, where this is not possible, due perhaps to high levels of background noise from other sources, measurements can be taken at closer distances to the railway and the results obtained adjusted to 25m using Chart 3. However, no measurements shall be taken at distances less than 15m from the near-side rail. All measurements of distance will be taken to an accuracy of 5%.

The height of the microphone shall be in the range 1.2m above the ground to 3.5m above the near-side railhead and will be directed vertically so that the microphone diaphragm is horizontal. The track opposite the measurement point will be an essentially level and straight section of Continuously Welded Rail (CWR) (ie flat bottomed CWR laid on monobloc concrete sleepers laid on ballast.) The length of track chosen will be in 'good condition'[8] prior to any measurements being taken. A description of the rail and support structure will be included in the Report of the measurements.

Figure A1.1 gives a diagram of the measurement set-up.

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[8] Where possible, measurements should be taken at a site where disc-braked passenger vehicles of known noise characteristics are running. This is an essential requirement when reference data are being obtained for disc-braked vehicles. The track shall be assumed to be satisfactory, provided the mean noise level for those vehicles does not exceed the expected noise level by more than 2 dB(A).

When the characteristics of tread-braked vehicles are required it is permissible, though not ideal, to assess the suitability of the track from measurements of noise from tread-braked passenger vehicles of known characteristics. The same assessment criterion as above should be used in these circumstances.

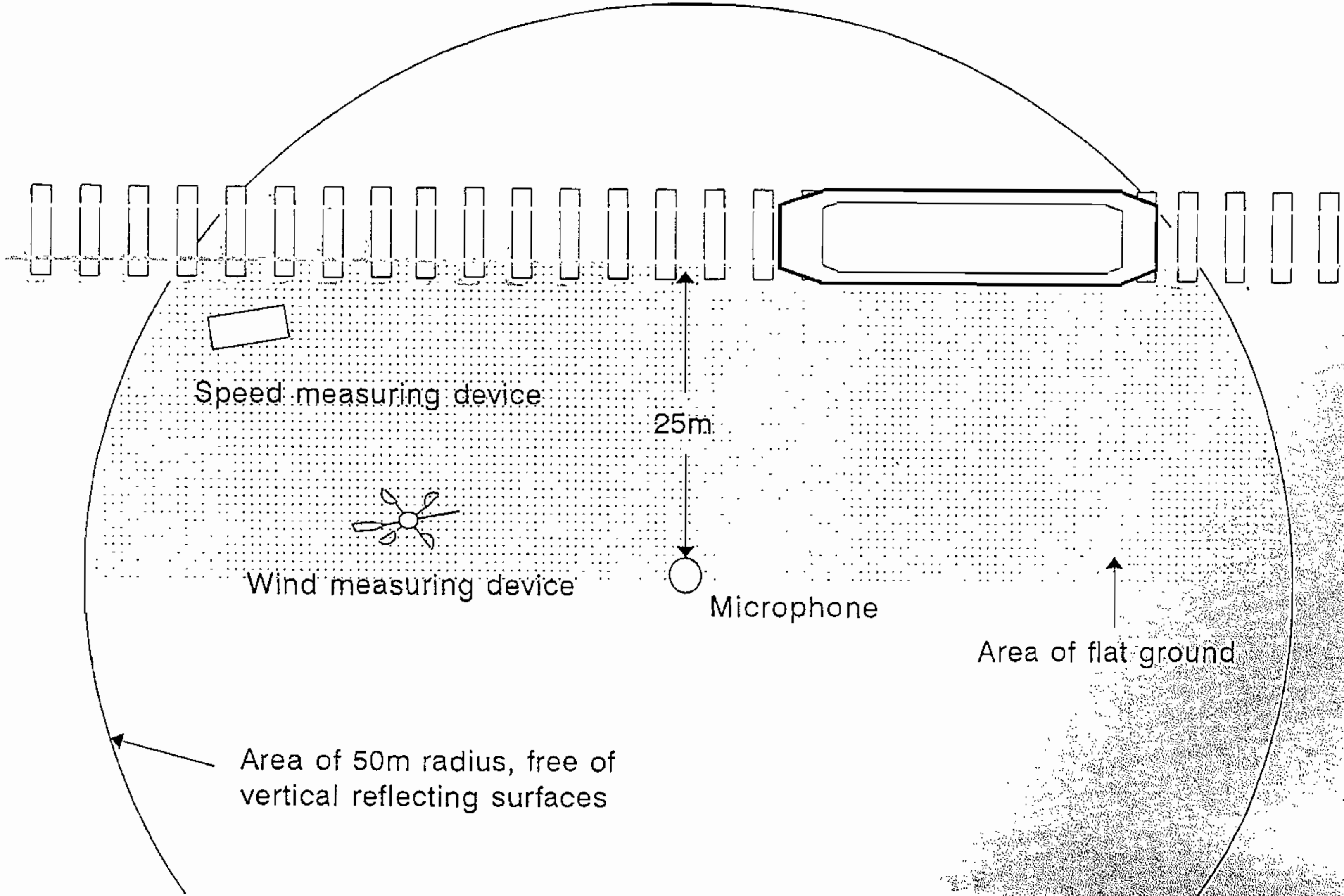

Figure A1.1: Site layout for the measurement of SELs from individual railway vehicles

(iii) The test site shall be such that sufficient free sound propagation exists between the sound source and the microphone. This condition may be considered to be fulfilled if the surroundings within 50m of the microphone are free of large, sound reflecting objects such as barriers, hills, rocks, bridges or buildings.

In the vicinity of the microphone there shall be no obstacles that could disturb the sound field. Therefore, no person shall be between the microphone and the noise source and the observer shall be in a position which does not influence the readings taken.

The area between the vehicle under test and the measuring microphone shall be as free as possible from sound absorbing covering such as tall grass or ballast of other tracks. A description of the type of ground cover should be included in the test report.

Measurements shall only be made if the wind speed recorded at the microphone height is below 5 m/s, and there is no rain or snow. The track should be dry and the ballast and adjoining ground should not be frozen. Wind speed and air temperature should be recorded and included in the test report.

iv) The noise measuring equipment used for the measurement of SEL shall conform to the specification described earlier in paragraph 42. The minimum calibration requirements are specified in paragraphs 44 and 45. All measurements will be taken with a microphone windshield fitted according to the manufacturers specifications.

(v) Measurements shall be taken of individual train pass-bys on the nearest track to the reception point of the railway. The train should be driven through the test site at steady speed. No braking or acceleration of the train during the test shall be allowed. During the pass-by the SEL and the speed of the train will be measured. (NB Care should be taken to ensure that the noise measurements encompass the complete passage of the train. In practice sufficiently accurate measurements will be obtained provided they encompass the period when the noise levels from the passing train are within 10 dB(A) of the maximum level. To avoid the results being affected by background noise the measurements shall only be taken when the levels of background noise are 10 dB or more below the noise levels generated by the train being measured.)

The measurements of speed shall be taken to an accuracy of $\pm 5\%$. Measurements will be taken for a range of passing speeds up to the maximum design speed for the railway vehicle. At least 10 different pass-by events suitably spaced[9] over the speed range shall be recorded.

(vi) From the measured data the SEL for the railway vehicle under consideration will be determined and a regression of SEL against log(speed) carried out.

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[9] It may be difficult to arrange for the speeds to vary over a wide range due to the constraints imposed by the operator of the railway. However, the data collected should aim to give as wide a range of speeds as possible.

The SEL is obtained by converting each measured SEL for the total train to a single vehicle SEL using the formula:

$$SEL_V = SEL_T - 10 \log N$$

where N is the number of identical vehicles in the train, and SEL_T is the SEL for the individual train. (NB When a train is powered by a locomotive the noise contribution from the locomotive shall be removed from the pass-by data using an appropriate technique. Such techniques include editing the pass-by characteristic to remove the contribution from the locomotive or, in some cases, measuring the SEL for the locomotive separately, and then subtract this from the total train SEL to obtain the SEL for the coaches or wagons.)

The measurements and corrected SELs shall be presented and tabulated. Table A1.2 gives an example data sheet which could be used for this purpose. Other forms of data sheet can be used, provided the information given matches that given in the Table. A graph of SEL versus speed (plotted on a log axis) shall be produced and a linear regression of SEL against log(speed) performed. The energy mean of the corrected SELs and the geometric mean of speed shall be set down in a Table of results as shown in the example data sheet, Table A1.2.

Procedure to Adopt When New Track and/or Rail Support System is Used

When a new type of train or an existing train type is intended to be run on a new design of track or rail support system, then it may be necessary to establish SEL values for the train/rail system in question before carrying out entitlement calculations. Clearly, in this case it may prove difficult to find a similar track system where identical trains can be tested prior to the new railway being constructed. If this is the case then it will be necessary to defer calculations until a suitable section of the new railway has been constructed where measurements can be carried out. The procedure to adopt is as follows:-

(i) Measure the SEL for an individual vehicle running on the track type under investigation using the procedures and conditions specified in (i) to (vi) above. Since the track type is different from the ballasted CWR 'standard track' assumed previously, it will not be possible to assess the roughness condition of the rail using the calibration technique described in footnote 8. In this case, the authority taking the measurements should be satisfied that the rail surface at the test site is free from obvious corrugations and other defects, which could affect the noise levels, and is judged to be representative of the rail type in good condition.

It should also be noted that in this case, since the rail or rail support system does not comply with the standard track condition assumed for all other calculations, it will not be possible to use the source enhancement corrections described in paragraph 16. Under these circumstances, it is recommended that the measurement method described in Section III of the Technical Memorandum should be used wherever the railway runs over sections of track where source enhancements are expected. For example, measurements would be needed where the railway runs over a steel bridge or viaduct.

TABLE A1.1 SOUND EXPOSURE LEVEL CORRECTIONS FOR INDIVIDUAL RAILWAY VEHICLES

Reference Single vehicle SEL_V = Baseline SEL (Charts A1.1 or A1.2) + Correction (Table A1.1)

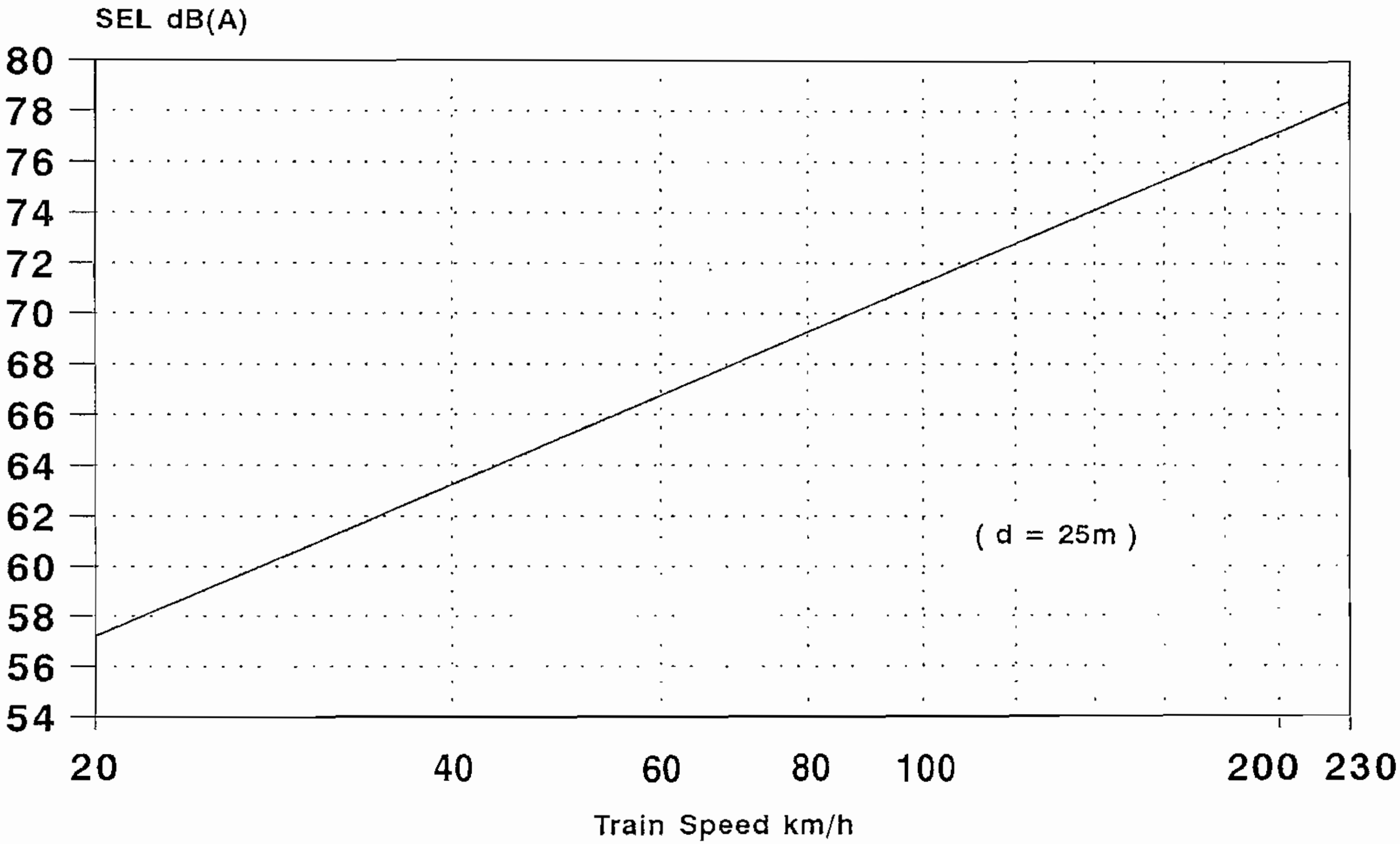
CATEGORY		VEHICLE DESCRIPTION	CORRECTION dB(A)
1:	**Tread Braked Passenger Coaches (4 axles)**	British Rail MkI	+14.8
		British Rail MkII	+14.8
		Gatwick Express	+16.7
		Class 421 EMU	+10.8
		Class 422 EMU	+10.8
		London Underground-A Stock	+12.9
		London Underground-Tube stock	+7.1
2:	**Disc Braked Passenger Coaches (4 axles)**	British Rail MkIII	+6.0
		British Rail MkIV	+6.0
		Class 319 EMU	+11.3
		Class 465 EMU	+8.4
		Class 466 EMU	+8.4
		Class 165 DMU	+7.0
		Class 166 DMU	+7.0
2a:	**Disc braked light railway passenger coach (6 axles)**	Manchester Metrolink LRV (articulated)	+15.8
2b:	**Disc braked light railway passenger coach (8 axles)**	South Yorkshire Supertram LRV (double articulated)	+14.9

3:	**Tread Braked Freight Vehicles (2 axles)**	2 axle tank wagons	+12.0
4:	**Tread Braked Freight Vehicles (4 axles)**	4 axle tank wagons	+15.0
5:	**Disc Braked Freight Vehicles (2 axles)**	Merry Go Round Coal Hopper HA	+8.0
6:	**Disc Braked Freight Vehicles (4 axles)**	Freightliner	+7.5
7:	**Locomotives (Diesel)**	Class 20	+14.8
		Class 31	+16.6
		Class 33	+14.8
		Class 37	+16.6
		Class 43	+18.0
		Class 47	+16.6
		Class 56	+16.6
		Class 59	+16.6
		Class 60	+16.6
	Locomotives (Electric)	Class 73	+14.8
		Class 86	+14.8
		Class 87	+14.8
		Class 90	+14.8
		Class 91	+14.8

8:	Diesel Locomotives under Full Power	Class 20	0.0
		Class 31	0.0
		Class 33	0.0
		Class 37	0.0
		Class 43 (HST power car)	0.0
		Class 47	0.0
		Class 56	0.0
		Class 59	0.0
		Class 60	-5.0

CHART A1.1

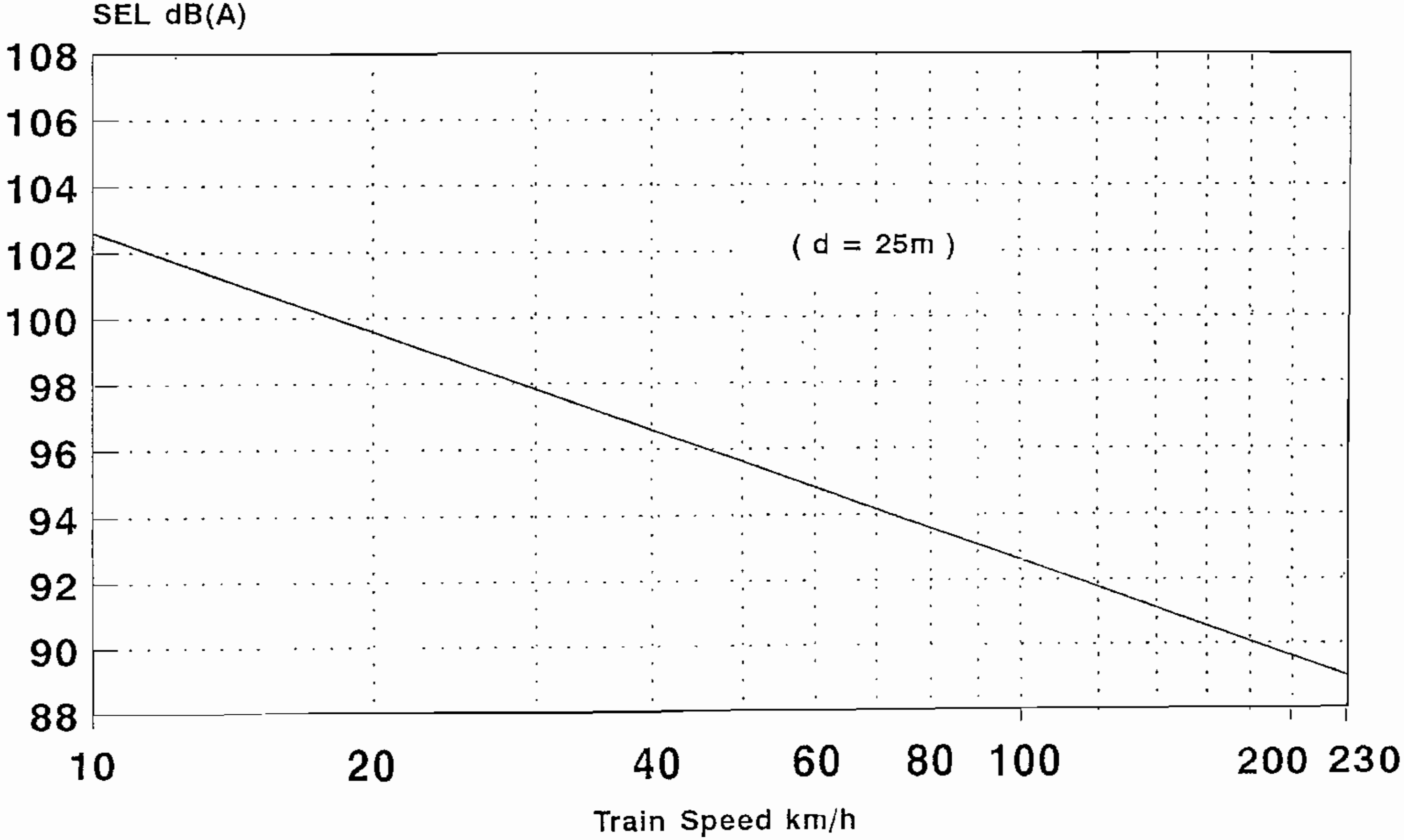
BASELINE SOUND EXPOSURE LEVELS (SEL)
FOR ROLLING RAILWAY VEHICLES



$$SEL = 31.2 + 20\log_{10}V \quad dB(A)$$

CHART A1.2

BASELINE SOUND EXPOSURE LEVELS (SEL) FOR DIESEL LOCOMOTIVES ON POWER



$$SEL = 112.6 - 10\log_{10}V \ \ dB(A)$$

TABLE A1.2: NOISE MEASUREMENT DATA SHEET FOR NEW TRAIN TYPES

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1. Type of rail vehicle

2. Measurement site details

Location:	Description of ground between microphone and rail:
Rail type and support:	

3. Equipment details (delete where appropriate)

Type of noise measurement equipment (including method and type of calibration):	
Microphone height: above the ground/rail	Speed equipment type
Microphone distance: 25 m	Microphone orientation: vertical
For automatic measuring equipment. Indicate the type of triggers and any levels set	

4. Environmental conditions

Weather: dry ground and track	Air Temperature:
Background noise level:	

5. Test data

Test	Vehicle			Noise levels		Wind conditions *1	
	No. carriages	No. locomotives	Speed (km/h)	SEL_T	$L_{A,max}$	Speed ($m\ s^{-1}$)	Direction (degrees)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

*1 The equipment should be orientated such that the 0° is indicated when the wind is blowing over the track towards the microphone.

Continue on new sheet if necessary

6. Analysis

Test	Total SEL SEL_T	Number of vehicles N	$SEL_v = SEL_T - 10Log_{10}N$	Speed (km/h)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
	Energy mean of SEL_v			
		Geometric mean of speed		

7. Comments

8. Confirmation

Signed (Survey controller):

Company: **Date:**

APPENDIX A2

WORKED EXAMPLES

The worked examples given in this Appendix are intended to illustrate the method of predicting railway noise levels described in the Technical Memorandum. The examples are set out so that the various stages of calculation can be readily identified and related to the relevant paragraphs in the text. The Examples also serve to illustrate the method of segmenting different railway layouts and site conditions.

For ease of working, each example is laid out so that all diagrams and associated calculations can be viewed on one double page. The examples are arranged in progressive order taking different elements of the prediction method in turn. It is recommended therefore that initially the user works through the examples, starting from the simplest case of a single track unscreened railway (ie Example 2) through to the more complex cases which are described towards the end of the Appendix.

The height of the reception point in each example is taken to be 4.0m above the ground. This value was chosen to be approximately equivalent to the height above ground of a bedroom window in a conventional two storey house. The source position is defined in the Technical Memorandum as at the railhead for rolling vehicle sources. This is taken, in all examples given in this Appendix, to be 0.7m above the adjoining ground. Clearly, the positions of both the source and reception point, used for the purpose of illustrating the calculation procedure, should not be assumed for actual calculations. In practice it will be necessary to determine these values from engineering plans or from site measurements.

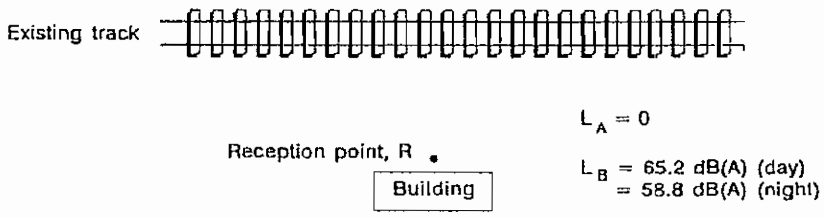
The types of trains and operations assumed in the calculations are not intended to be representative of an operating railway. The examples given have been simplified in many cases in order to demonstrate the method of calculation in a straightforward manner. It follows, of course, that entitlement calculations will require inputs which match closely the actual train types operating on the railway together with the actual flows, speeds and directions of travel of the trains.

EXAMPLE 1. ENTITLEMENT TO INSULATION UNDER THE RAILWAY NOISE INSULATION REGULATIONS - ADDING A SECOND TRACK BESIDE AN EXISTING TRACK.

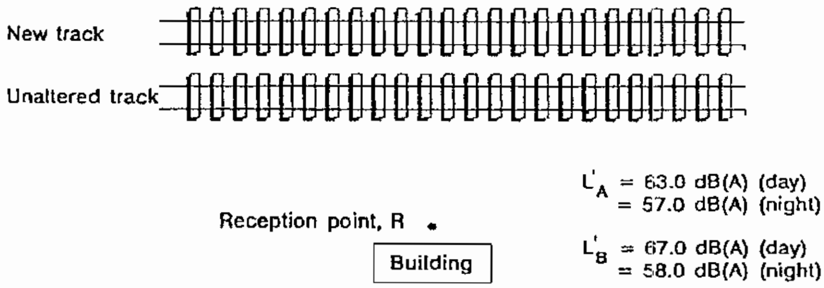
This example describes a hypothetical case where entitlement for insulation will need to be examined. The steps needed to determine eligibility are described.

PLAN

(a) Before additional works.



(b) After additional works.



General

The following definitions apply when considering the conditions for entitlement.

Prevailing Noise Level (PNL) = $10\ Log_{10}(\text{Antilog}\ L_A/10 + \text{Antilog}\ L_B/10)$

where L_A = noise level from a railway or other relevant system which are to be altered.

L_B = noise level from all other railways or relevant systems in the vicinity immediately before works to alter L_A begin.

Relevant Noise Level (RNL) = $10\ Log_{10}(\text{Antilog}\ L'_A/10 + \text{Antilog}\ L'_B/10)$

where L'_A = maximum noise level within 15 years from the altered railway or other relevant system or from completely new railway or relevant system.

L'_B = maximum level from all other railways or relevant systems within 15 years.

Taking the above definitions, a property is eligible for insulation when all the following conditions are satisfied:-

(i) **Either** the RNL $\geq$ 68 $L_{Aeq,18h}$ dB or RNL $\geq$ 63 $L_{Aeq,6h}$ dB.
(ii) RNL - PNL $\geq$ 1.0 dB(A)
(iii) RNL - L'_B $\geq$ 1.0 dB(A)

Case Description

An existing railway line is to be upgraded by adding a new track. There are no other significant railway noise sources in the vicinity. Using the procedures described in this Technical Memorandum it is found that the noise levels from the existing railway at the facade of the property are 65.2 dB(A) (day) and 58.8 dB(A) (night). The maximum noise levels from the pre-existing railway, over the 15 year period, are 67.1 dB(A) (day) and 58.1 dB(A) (night) and the corresponding noise levels from the new track are 63.1 dB(A) and 56.9 dB(A) respectively.

To calculate whether there is entitlement in this case, the following levels apply.

L_A = 0; The existing line will not be altered.
L_B = 65.2 dB(A) (day); 58.8 dB(A) (night)
L'_A = 63.1 dB(A) (day); 56.9 dB(A) (night)
L'_B = 67.1 dB(A) (day); 58.1 dB(A) (night)

The RNL is obtained by combining L'_A and L'_B using chart 9. to give RNL = 68.5 dB(A) (day) and 59.6 dB(A) (night).

The PNL is obtained by combining L_A and L_B using Chart 9. to give PNL = 65.2 dB(A) (day) and 58.8 dB(A) (night).

Day

(i) RNL = 69 dB(A)*, which exceeds the specified level of 68 dB(A).
(ii) RNL - PNL = 68.5 - 65.2 = 3.3 dB(A), which is greater than 1.0 dB(A).
(iii) RNL - L'_B = 68.5 - 67.1 = 1.5 dB(A), which is greater than 1.0 dB(A).

Night

(i) RNL = 60 dB(A)*, which does not equal or exceed the specified level of 63 dB(A).
(ii) RNL - PNL = 59.6 - 58.8 = 0.8 dB(A), which is less than the specified criteria of 1.0 dB(A)
(iii) RNL - L'_B = 59.6 - 58.0 = 1.6 dB(A), which is greater than 1.0 dB(A).

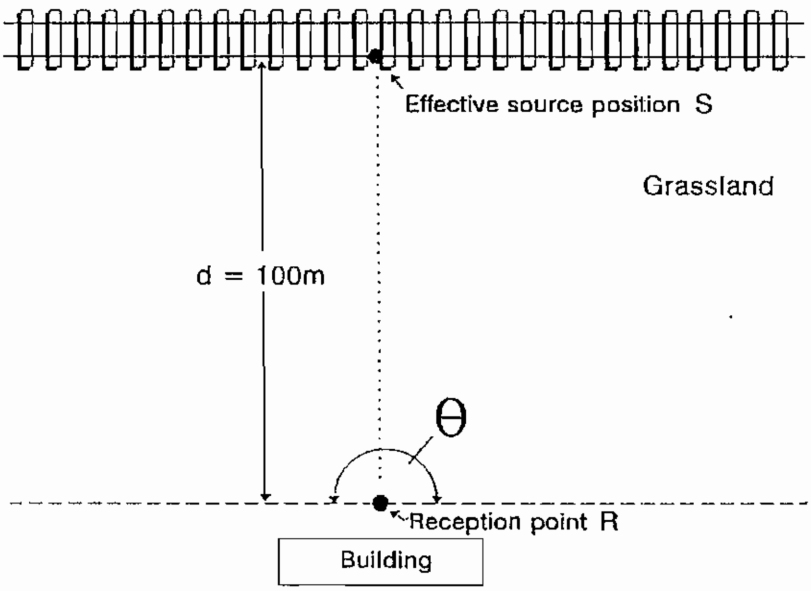
In this case, therefore, there is entitlement for insulation since all three conditions are satisfied for the day time period. The nightime period does not trigger eligibility in this example since conditions (i) and (ii) are not met.

* Note that the RNL is rounded to the nearest whole number when comparing with the specified level (day or night). When examining conditions (ii) and (iii) the levels are rounded to the nearest 0.1 dB(A).

EXAMPLE 2. SINGLE TRACK RAILWAY WITH ONE TRAIN TYPE

In this example, the railway comprises a single track running horizontally and in a straight line. Only one type of train operates on this section of the railway and all trains travel at a constant speed of 150 km/h. The trains consist of 10 identical tread braked passenger coaches. 179 trains pass the reception point during the day and 13 pass during the night. The ground alongside the track is grassland and the area between the track and the reception point can be assumed to be flat. The track is CWR laid on ballast. There is no screening along the section of the railway being considered. For this example, the reception point is located 100m from the nearside rail at a height of 4m above the ground.

PLAN



OBJECT: To predict the values of $L_{Aeq,6h}$ and $L_{Aeq,18h}$ at a reception point located 1 m from the facade of a building, 4m above the ground.

STAGE 1: DIVIDE RAILWAY INTO SEGMENTS

The trains are all of one type and are travelling on a single track at a constant speed. The track is straight and level with no buildings or barriers between the track and the reception point. Only one segment is required with an angle of view θ, of 180°. (Para.12)

INPUT DATA:

Segment 1:	Ground cover is grassland.		Angle of view	= 180°
Track 1:	Continuously Welded Rail (CWR) on ballast (B)			
Train type 1:	Category 1.	10 tread braked passenger coaches.	Speed	= 150 km/h
	Number of trains:	Midnight - 0600 hrs	Q_{NIGHT}	= 13
		0600 hrs - Midnight	Q_{DAY}	= 179
	Reception point:	Height above rail head	h	= 3.3 m
		Distance from track	d	= 100 m
	Av. height of propagation (rail head 0.7m above ground)		H	= (4.0 + 0.7)/2 = 2.35 m

STAGE 2: CALCULATE THE REFERENCE NOISE LEVEL SEL_{ref}

2.1 Reference noise level: Each train operating on the track consists only of category 1 vehicles travelling at 150 km/h. The baseline SEL (single vehicle) at a reference distance of 25 m is determined from Chart A1.1 and then corrected for vehicle type using Table A1.1. (Para.14)

2.2 Correction for the number of vehicles: The baseline SEL for a single vehicle is adjusted to take account of the number of vehicles in the train, which for this example is 10. The correction is determined by using Chart 2. (Para.15)

2.3 Track/support structure correction: The track is CWR laid on ballast. Table 1 shows that no correction is required. (Para.16)

Segment	1			1
Train type	1			
Speed V (km/h)	150	Baseline SEL	CHART A1.1	74.7
		Correction	TABLE A1.1	+14.8
No of vehicles N	10	Correction	CHART 2	+10.0
Track/support	CWR/B	Correction	TABLE 1	0.0
		REFERENCE NOISE LEVEL SEL_{ref}		**99.5 dB**

STAGE 3: PROPAGATION

3.1 Distance correction: The reception point is located 3.3m above the rail head and 100m from the track, a correction for distance is required using Chart 3. The value to enter into Chart 3 is the value of the slant distance d'. (Figure 1. Para. 19)

3.2 Air absorption correction: A correction is required for air absorption, Chart 4. (Para. 20).

3.3 Ground correction: The ground cover between the track and the reception point is grassland. A correction is required. (Chart 5. Para. 21)

3.4 Correction for ballasted track: Although the track is laid on ballast no correction is required since only a single track is being considered. (Para. 22)

3.5 Screening correction: There are no barriers or other obstructions between the reception point and the noise source, therefore no correction is required.

3.6 Angle of view correction: The angle of view, θ, for this single segment example is 180°and from Chart 7 the correction is zero. (Para. 30)

Segment	1			1
Distance d (m)	100			
Height h (m)	3.3			
Distance d' (m)	100.1	Distance corr.	CHART 3	-6.0
		Air abs. corr.	CHART 4	-0.6
Soft ground I	1			
Height H (m)	2.35	Ground corr.	CHART 5	-1.3
Ballast	None	Correction	Para. 22	0.0
Screening	None	Screen correction	CHART 6	0.0
Angle of view				
$\alpha°$	90			
$\theta°$	180	Correction	CHART 7	0.0
		PROPAGATION CORRECTION		**-7.9 dB**

STAGE 4: REFLECTION EFFECTS

4.1 Facade correction: A correction is required as the reception point is 1m from a facade. (Para. 31.1)

4.2 Opposite facade correction: There are no buildings or other hard rigid surfaces on the other side of the track and therefore no correction is required. (Para. 31.2)

Segment	1			1
Facade	Yes	Correction	Para. 31.1	+2.5
Opposite facade	None	Correction	Para. 31.2	0.0
		REFLECTION CORRECTION		**+2.5 dB**

STAGE 5: CONVERT SEL TO L_{Aeq}

The SEL at the reception point from a single train for the segment is determined by summing the totals from stages 2 to 4.

	Reference noise level SEL_{ref}	99.5
	Propagation Correction	-7.9
	Reflection Correction	+2.5
SEL FOR SEGMENT		**94.1 dB**

The SEL for the segment is then converted to $L_{Aeq,6h}$ and $L_{Aeq,18h}$ using equations 5.1 and 5.2 respectively and entering the appropriate number of trains for each time period. (Para. 32)

Segment	1			1
Number of trains				
Q_{NIGHT}	13	$L_{Aeq,6h}$	Para. 32	61.9
Q_{DAY}	179	$L_{Aeq,18h}$	Para. 32	68.5

STAGE 6: CALCULATE THE TOTAL L_{Aeq} FOR THE RAILWAY

Since there is only one segment the segment L_{Aeq} values calculated in stage 5 are the total L_{Aeq} values for the railway.

Total $L_{Aeq,6h}$	CHART 9	**61.9 dB**
Total $L_{Aeq,18h}$	CHART 9	**68.5 dB**

These values are then rounded to the nearest whole number to give:

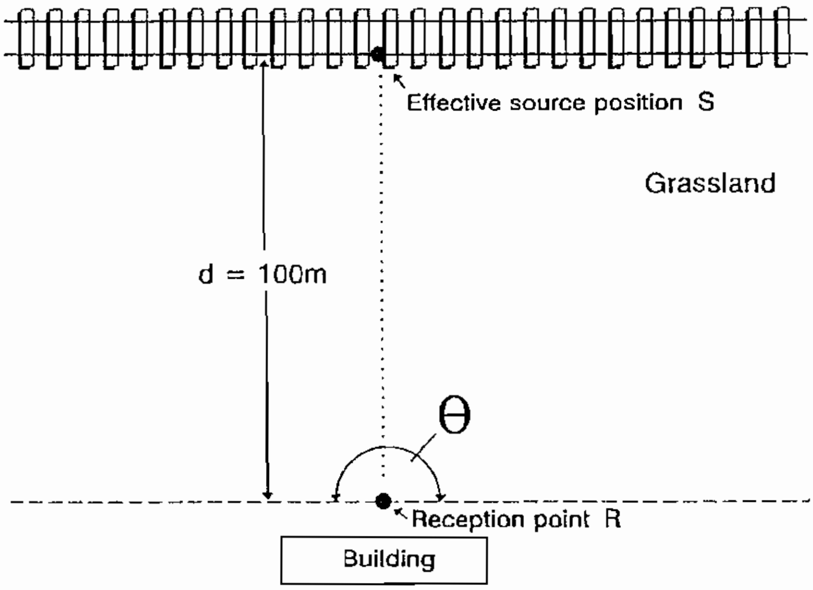
PREDICTED TOTAL $L_{Aeq,6h}$ FOR THE RAILWAY = 62 dB

PREDICTED TOTAL $L_{Aeq,18h}$ FOR THE RAILWAY = 69 dB

EXAMPLE 3. SINGLE TRACK RAILWAY WITH TWO TRAIN TYPES

This example is similar to Example 2 in that the railway is a single track running horizontally in a straight line. Two types of train operate on the railway; trains consisting of 10 identical tread braked passenger coaches travelling at 150 km/h, and trains consisting of 6 disc braked passenger coaches travelling at 120 km/h. The number of trains passing the reception point during the day is 179 and 340 for each train type respectively. During the night 13 and 27 pass for each train type respectively. The railway is not screened and the area between the track and the reception point is flat grassland. The reception point is located at a distance of 100m from the railhead at a height above ground of 4m.

PLAN



OBJECT: To predict the values of $L_{Aeq,6h}$ and $L_{Aeq,18h}$ at a reception point 1m from the facade of a building, at 4m above the ground.

STAGE 1: DIVIDE RAILWAY INTO SEGMENTS

There are two train types both travelling at constant speed on a single track. The track is straight and level with no buildings or barriers between the track and the reception point. Only one segment is required with an angle of view θ, of 180°. [Para.12]

INPUT DATA :

Segment 1:	Ground cover is grassland.		Angle of view	= 180°
Track 1:	Continuously Welded Rail (CWR) on ballast (B)			
Train type 1:	Category 1.	10 tread braked passenger coaches.	Speed	= 150 km/h
	Number of trains:	Midnight - 0600 hrs	Q_{NIGHT}	= 13
		0600 hrs - Midnight	Q_{DAY}	= 179
Train type 2:	Category 2.	6 disc braked passenger coaches.	Speed	= 120 km/h
	Number of trains:	Midnight - 0600 hrs	Q_{NIGHT}	= 27
		0600 hrs - Midnight	Q_{DAY}	= 340
	Reception point:	Height above rail head	h	= 3.3 m
		Distance from track	d	= 100 m
	Av. height of propagation (rail head 0.7m above ground)		H	= (4+0.7)/2 = 2.35 m

STAGE 2: CALCULATE THE REFERENCE NOISE LEVEL SEL_{ref}

2.1 Reference noise level: Train type 1 consists only of category 1 vehicles travelling at 150 km/h whilst train type 2 consists of category 2 vehicles travelling at 120 km/h. The baseline SEL (single vehicle) at a reference distance of 25 m is determined from Chart A1.1 and then corrected for vehicle type using Table A1.1. [Para.14]

2.2 Correction for the number of vehicles: The baseline SEL for a single vehicle type is adjusted to take account of the number of vehicles in the train, which for this example is 10 for train type 1 and 6 for train type 2. The correction is determined by using Chart 2. [Para.15]

2.3 Track/support structure correction: The track is CWR laid on ballast. Table 1 shows that no correction is required. [Para.16]

Segment	1	
Train type	1	2
Speed V km/h	150	120
No of vehicles N	10	6
Track/support	CWR/B	CWR/B

		1	
		1	2
Baseline SEL	CHART A1.1	74.7	72.8
Correction	TABLE A1.1	+14.8	+6.0
Correction	CHART 2	+10.0	+7.8
Correction	TABLE 1	0.0	0.0
REFERENCE NOISE LEVEL SEL_{ref}		**99.5**	**86.6 dB**

STAGE 3: PROPAGATION

3.1 Distance correction: The reception point is 3.3m above the rail head and 100m from the track, a correction for distance is required using Chart 3. The value to enter into Chart 3 is the value of the slant distance d'. (Figure 1. Para. 19)

3.2 Air absorption correction: A correction is required for air absorption, Chart 4. (Para. 20).

3.3 Ground correction: The ground cover between the track and the reception point is grassland. A correction is required. (Chart 5. Para. 21)

3.4 Correction for ballasted track: Although the track is laid on ballast no correction is required since only a single track is being considered. (Para. 22)

3.5 Screening correction: There are no barriers or other obstructions between the reception point and the noise source, therefore no correction is required.

3.6 Angle of view correction: The angle of view, θ, for this single segment example assumes a value of 180° and from Chart 7 the correction is zero. (Para. 30)

Segment	1			1
Distance d (m)	100			
Height h (m)	3.3			
Distance d' (m)	100.1	Distance corr.	CHART 3	-6.0
		Air abs. corr.	CHART 4	-0.6
Soft ground I	1			
Height H (m)	2.35	Ground corr.	CHART 5	-1.3
Ballast	None	Correction	Para. 22	0.0
Screen	None	Screen correction	CHART 6	0.0
Angle of view				
α°	90			
θ°	180	Correction	CHART 7	0.0
		PROPAGATION CORRECTION		**-7.9 dB**

STAGE 4: REFLECTION EFFECTS

4.1 Facade correction: A correction is required as the reception point is 1m from a facade. (Para. 31.1)

4.2 Opposite facade correction: There are no buildings or other hard rigid surfaces on the other side of the track and therefore no correction is required. (Para. 31.2)

Segment	1			1
Facade	Yes	Correction	Para. 31.1	+2.5
Opposite facade	None	Correction	Para. 31.2	0.0
		REFLECTION CORRECTION		**+2.5 dB**

STAGE 5: CONVERT SEL TO L_{Aeq}

The SEL at the reception point from a single train of each train type for the segment is determined by summing the totals from stages 2 to 4.

Segment	**1**	
Train type	**1**	**2**
Reference noise level SEL_{ref}	99.5	86.6
Propagation Correction	-7.9	-7.9
Reflection Correction	+2.5	+2.5
SEL FOR SEGMENT	**94.1**	**81.2 dB**

The SEL for the segment is then converted to $L_{Aeq,6h}$ and $L_{Aeq,18h}$ using equations 5.1 and 5.2 respectively and entering the appropriate number of trains of each train type for each time period. (Para. 32)

Segment	**1**				**1**	
Train type	**1**	**2**			**1**	**2**
Number of trains						
Q_{NIGHT}	13	27	$L_{Aeq,6h}$	Para. 32	61.9	52.2
Q_{DAY}	179	340	$L_{Aeq,18h}$	Para. 32	68.5	58.4

STAGE 6: CALCULATE THE TOTAL L_{Aeq} FOR THE RAILWAY

Since there is only one segement the total L_{Aeq} values for the railway are determined for both time periods by combining the separate L_{Aeq} values obtained for the two train types using Chart 9.

Total $L_{Aeq,6h}$	CHART 9	**62.3 dB**
Total $L_{Aeq,18h}$	CHART 9	**68.9 dB**

These values are then rounded to the nearest whole number to give:

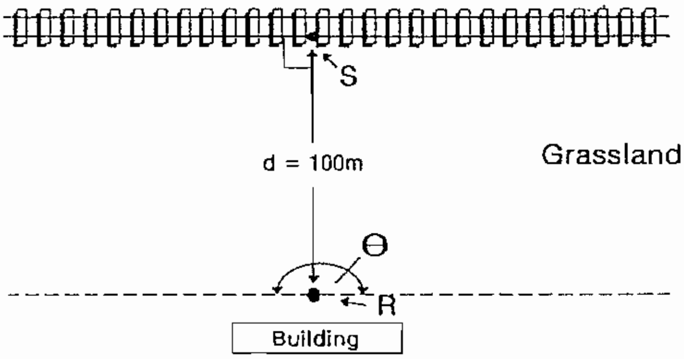
PREDICTED TOTAL $L_{Aeq,6h}$ FOR THE RAILWAY = 62 dB

PREDICTED TOTAL $L_{Aeq,18h}$ FOR THE RAILWAY = 69 dB

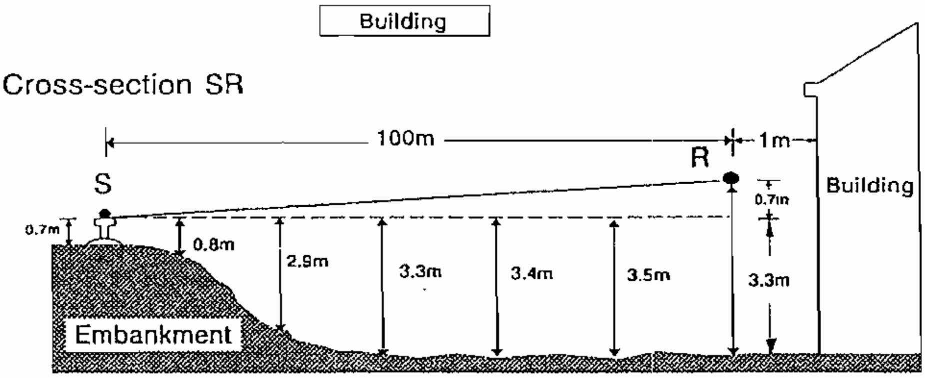
EXAMPLE 4. SINGLE TRACK RAILWAY ON AN EMBANKMENT WITH ONE TRAIN TYPE CONSISTING OF TWO DIFFERENT VEHICLE CATEGORIES

This example demonstrates the calculation of mean height of propagation where the railway is on an embankment and also illustrates the procedure to adopt when the train consists of two vehicle types. In this example the track is CWR on ballast. The trains consist of 5 tread braked passenger coaches and 5 disc braked passenger coaches, travelling at 150 km/h. The number of trains passing the reception point is 179 during the day and 13 during the night. The reception point is located at a height of 4m above the ground and 1m in front of a building facade.

PLAN



Cross-section SR



OBJECT: To predict the values of $L_{Aeq,6h}$ and $L_{Aeq,18h}$ at a reception point 1m from the facade of a building, at 1st floor level.

STAGE 1: DIVIDE RAILWAY INTO SEGMENTS

Each train operating on the single track comprise of two different vehicle categories. Each vehicle category is treated as a separate train type. The trains are travelling on a single track at a constant speed. The track is straight and level with no buildings or barriers between the track and the reception point. Only one segment is required with an angle of view θ, of 180°. (Para.12)

INPUT DATA :

Segment 1: Ground cover is grassland. Angle of view = 180°

Track 1: Continuously Welded Rail (CWR) on ballast (B)

Train type 1:	Category 1.	5 tread braked passenger coaches.	Speed	= 150 km/h
Train type 2:	Category 2.	5 disc braked passenger coaches.		
	Number of trains:	Midnight - 0600 hrs	Q_{NIGHT}	= 13
		0600 hrs - Midnight	Q_{DAY}	= 179
	Reception point:	Height above rail head	h	= 0.7 m
		Distance from track	d	= 100 m

Av. hgt. of propagation: $H = \frac{0.7 + 0.8 + 2.9 + 3.3 + 3.4 + 3.5 + 3.3}{7} + \frac{0.7}{2} = 2.907\text{m}$

STAGE 2: CALCULATE THE REFERENCE NOISE LEVEL SEL_{ref}

2.1 Reference noise level: Each train operating on the track consists of two types of coaches travelling at 150 km/h. The baseline SEL (single vehicle) at a reference distance of 25 m is determined from Chart A1.1 and then corrected for vehicle type using Table A1.1. (Para.14)

2.2 Correction for the number of vehicles: The baseline SEL for a single vehicle is adjusted to take account of the number of vehicles for each train, which for this example is 5 for each type. The correction is determined by using Chart 2. (Para.15)

2.3 Track/support structure correction: The track is CWR laid on ballast. Table 1 shows that no correction is required. (Para.16)

Segment	1	
Train type	**1**	**2**
Speed V km/h	150	150
No of vehicles N	5	5
Track/support	CWR/B	CWR/B

Segment		1	
		1	**2**
Baseline SEL	CHART A1.1	74.7	74.7
Correction	TABLE A1.1	+14.8	+6.0
Correction	CHART 2	+7.0	+7.0
Correction	TABLE 1	0.0	0.0
REFERENCE NOISE LEVEL SEL_{ref}		**96.5**	**87.7 dB**

STAGE 3: PROPAGATION

3.1 Distance correction: The reception point is 0.7m above the rail head and 100m from the track, a correction for distance is required using Chart 3. The value to enter into Chart 3 is the value of the slant distance d'. (Figure 1. Para. 19)

3.2 Air absorption correction: A correction is required for air absorption, Chart 4. (Para. 20).

3.3 Ground correction: The ground cover between the track and the reception point is grassland. A correction is required (Chart 5. Para. 21). The average height of propagation is calculated as shown in Fig. 3b.

3.4 Correction for ballasted track: Although the track is laid on ballast no correction is required since only a single track is being considered. (Para. 22)

3.5 Screening correction: (In this example it is assumed that the embankment does not offer any degree of screening). Although there are no barriers or other obstructions between the reception point and the noise source the reception point is in the illuminated zone of the diffracting edge of the embankment, B, it is necessary, therefore, to check whether ground absorption or the screening performance of the embankment will result in the lower overall noise level, see para. 25.4. In this case the ground effect can be shown to be dominant.

3.6 Angle of view correction: The angle of view, θ, for this single segment example assumes a value of 180° and from Chart 7 the correction is zero. (Para. 30)

Segment	1			1
Distance d (m)	100			
Height h (m)	0.7			
Distance d' (m)	100	Distance corr.	CHART 3	-6.0
		Air abs. corr.	CHART 4	-0.6
Soft ground I	1			
Height H (m)	2.91	Ground corr.	CHART 5	-1.1
Ballast	None	Correction	Para. 22	0.0
Screening	None	Screen correction	CHART 6	0.0
Angle of view				
α°	90			
θ°	180	Correction	CHART 7	0.0
		PROPAGATION CORRECTION		**-7.7 dB**

STAGE 4: REFLECTION EFFECTS

4.1 Facade correction: A correction is required as the reception point is 1m from a facade. (Para. 31.1)

4.2 Opposite facade correction: There are no buildings or other hard rigid surfaces on the other side of the track and therefore no correction is required. (Para. 31.2)

Segment	1			1
Facade	Yes	Correction	Para. 31.1	+2.5
Opposite facade	None	Correction	Para. 31.2	0.0
		REFLECTION CORRECTION		**+2.5 dB**

STAGE 5: CONVERT SEL TO L_{Aeq}

The SEL at the reception point from a single train for the segment is determined by summing the totals from stages 2 to 4.

Segment	1	
Train type	1	2
Reference noise level SEL_{ref}	96.5	87.7
Propagation Correction	-7.7	-7.7
Reflection Correction	+2.5	+2.5
SEL FOR SEGMENT	**91.3**	**82.5 dB**

The SEL for the segment is then converted to $L_{Aeq,6h}$ and $L_{Aeq,18h}$ using equations 5.1 and 5.2 respectively and entering the appropriate number of trains for each time period. (Para. 32)

Segment	1				1	
Train type	1	2			1	2
Number of trains						
Q_{NIGHT}	13	13	$L_{Aeq,6h}$	Para. 32	59.1	50.3
Q_{DAY}	179	179	$L_{Aeq,18h}$	Para. 32	65.7	56.9

STAGE 6: CALCULATE THE TOTAL L_{Aeq} FOR THE RAILWAY

Since there is only one segment the segment L_{Aeq} values calculated in stage 5 are the total L_{Aeq} values for the railway.

Total $L_{Aeq,6h}$	CHART 9	**59.6 dB**
Total $L_{Aeq,18h}$	CHART 9	**66.2 dB**

These values are then rounded to the nearest whole number to give:

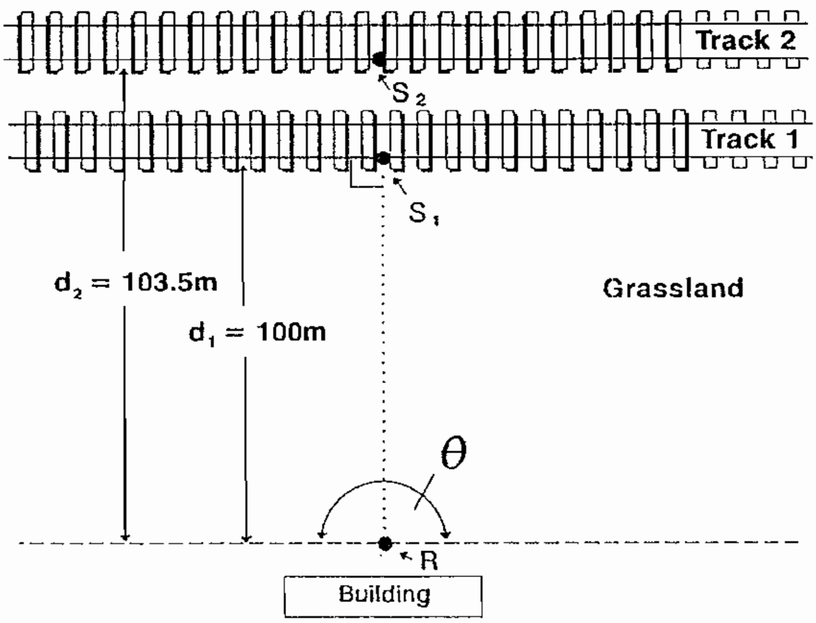
PREDICTED TOTAL $L_{Aeq,6h}$ FOR THE RAILWAY = 60 dB

PREDICTED TOTAL $L_{Aeq,18h}$ FOR THE RAILWAY = 66 dB

EXAMPLE 5. DOUBLE TRACK RAILWAY WITH TWO TRAIN TYPES

This is an example which demonstrates the calculation procedure for a two track railway where two types of trains operate. The nearest track (track 1) is continuously welded rail laid on ballast whilst the further track (track 2) is jointed track. The trains operating on track 1 are all of one type and consist of 5 identical tread braked passenger coaches travelling at 150 km/h. Similarly on track 2 the trains are identical and each consists of 5 disc braked passenger coaches travelling at 130 km/h. The number of trains passing the reception point during the day and night periods respectively is 179 and 13 for track 1 and 340 and 27 for track 2. As in the previous two cases the railway is not screened at any point and the area between the track and the reception point is flat grassland. The reception point is located at a distance of 100m from the nearest rail at a height above ground of 4m.

PLAN



OBJECT: To predict the values of $L_{Aeq,6h}$ and $L_{Aeq,18h}$ at a reception point 1m from the facade of a building at a height of 4m above the ground.

STAGE 1: DIVIDE RAILWAY INTO SEGMENTS

Although there is only one segment with an angle of view θ, of 180°, each track is treated separately. Each track has a different type of train operating at constant speed. (Para.12)

INPUT DATA :

Segment 1:	Ground cover is grassland.		Angle of view	= 180°
Track 1:	Continuously Welded Rail (CWR) on ballast (B)			
Track 2:	Jointed Track (JT)			
Train type 1:	Category 1.	5 tread braked passenger coaches.	Speed	= 150 km/h
	Number of trains:	Midnight - 0600 hrs	Q_{NIGHT}	= 13
		0600 hrs - Midnight	Q_{DAY}	= 179
Train type 2:	Category 2.	5 disc braked passenger coaches.	Speed	= 130 km/h
	Number of trains:	Midnight - 0600 hrs	Q_{NIGHT}	= 27
		0600 hrs - Midnight	Q_{DAY}	= 340
	Reception point:	Height above rail head	h	= 3.3 m
		Distance from track	d_1	= 100 m
			d_2	= 103.5 m
	Av. hgt. of propagation (rail head 0.7m above ground)		H	= (4+0.7)/2 = 2.35 m

STAGE 2: CALCULATE THE REFERENCE NOISE LEVEL SEL_{ref}

2.1 Reference noise level: For each train operating on each track the baseline SEL (single vehicle) at a reference distance of 25 m is determined from Chart A1.1 and then corrected for vehicle type using Table A1.1. (Para.14)

2.2 Correction for the number of vehicles: The baseline SEL for a single vehicle type is adjusted to take account of the number of those vehicles in each train, which for this example is 5 of each vehicle type. The correction is determined by using Chart 2. (Para.15)

2.3 Track/support structure correction: Track 1 is CWR laid on ballast and track 2 is JT on ballast. Table 1 shows a correction is required.

Segment	1				1	
Track number	1	2			1	2
Train type	1	2			1	2
Speed V km/h	150	130	Baseline SEL	CHART A1.1	74.7	73.5
			Correction	TABLE A1.1	+14.8	+6.0
No of vehicles N	5	5	Correction	CHART 2	+7.0	+7.0
Track/support	CWR/B	JT	Correction	TABLE 1	0.0	+2.5
			REFERENCE NOISE LEVEL SEL_{ref}		96.5	89.0 dB

STAGE 3: PROPAGATION

3.1 Distance correction: The reception point is 3.3m above the rail head, 100m from track 1 and 103.5m from track 2. A correction for distance is required using Chart 3. The value to enter into Chart 3 is the value of the slant distance d'. (Figure 1. Para. 19)

3.2 Air absorption correction: A correction is required for air absorption, Chart 4. (Para. 20).

3.3 Ground correction: The ground cover between the track and the reception point is grassland so a correction is required. (Chart 5. Para. 21)

3.4 Correction for ballasted track: A correction is required for track 2 as track 1 is laid with ballast and therefore provides some reduction in the sound propagating from trains travelling on track 2. (Para. 22)

3.5 Screening correction: There are no barriers or other obstructions between the reception point and the noise source, therefore no correction is required.

3.6 Angle of view correction: The angle of view, θ, for this single segment example assumes a value of 180° and from Chart 7 the correction is zero. (Para. 30)

Segment	1				1	
Track number	1	2			1	2
Distance d (m)	100	103.5				
Height h (m)	3.3	3.3				
Distance d'(m)	100.1	103.6	Distance corr.	CHART 3	-6.0	-6.2
			Air abs. corr.	CHART 4	-0.6	-0.6
Soft ground I	1	1				
Height H (m)	2.35	2.35	Ground corr.	CHART 5	-1.3	-1.4
Ballast	None	Yes	Correction	Para. 22	0.0	-1.5
Screen	None	None	Screen correction	CHART 6	0.0	0.0
Angle of view						
$\alpha°$	90	90				
$\theta°$	180	180	Correction	CHART 7	0.0	0.0
			PROPAGATION CORRECTION		**-7.9**	**-9.7 dB**

STAGE 4: REFLECTION EFFECTS

4.1 Facade correction: A correction is required as the reception point is 1m from a facade. (Para. 31.1)

4.2 Opposite facade correction: There are no buildings or other hard rigid surfaces on the other side of the track and therefore no correction is required. (Para. 31.2)

Segment	1				1	
Track number	1	2			1	2
Facade	Yes	Yes	Correction	Para. 31.1	+2.5	+2.5
Opposite facade	None	None	Correction	Para. 31.2	0.0	0.0
			REFLECTION CORRECTION		**+2.5**	**+2.5 dB**

STAGE 5: CONVERT SEL TO L_{Aeq}

The SEL at the reception point from each train type travelling on each of the tracks within the segment are determined by summing the totals from stages 2 to 4.

Segment	1	
Track	1	2
Train type	1	2
Reference noise level SEL_{ref}	96.5	89.0
Propagation Correction	-7.9	-9.7
Reflection Correction	+2.5	+2.5
SEL FOR SEGMENT	**91.1**	**81.8 dB**

The SEL for the segment is then converted to $L_{Aeq,6h}$ and $L_{Aeq,18h}$ using equations 5.1 and 5.2 respectively and entering the appropriate number of trains for each time period. (Para. 32)

Segment	1				1	
Track number	1	2			1	2
Train type	1	2			1	2
Number of trains						
Q_{NIGHT}	13	27	$L_{Aeq,6h}$	Para. 32	58.9	52.8
Q_{DAY}	179	340	$L_{Aeq,18h}$	Para. 32	65.5	59.0

STAGE 6: CALCULATE THE TOTAL L_{Aeq} FOR THE RAILWAY

Since there is only one segment the total L_{Aeq} values for the railway are determined for both time periods by combining the separate L_{Aeq} values obtained for the two tracks and train types using Chart 9.

Total $L_{Aeq,6h}$	CHART 9	**59.9 dB**
Total $L_{Aeq,18h}$	CHART 9	**66.4 dB**

These values are then rounded to the nearest whole number to give:

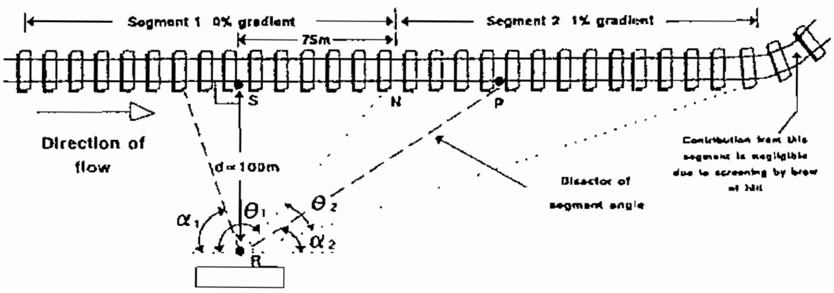
PREDICTED TOTAL $L_{Aeq,6h}$ FOR THE RAILWAY = 60 dB

PREDICTED TOTAL $L_{Aeq,18h}$ FOR THE RAILWAY = 66 dB

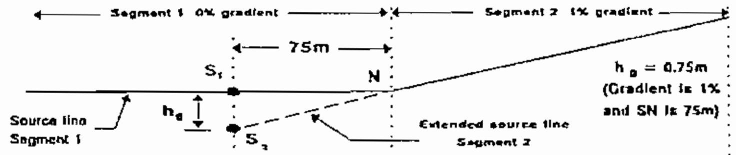
EXAMPLE 6. SINGLE TRACK RAILWAY WITH GRADIENT - TRAIN PULLED BY A DIESEL LOCOMOTIVE.

This example demonstrates the calculation procedure for a single track railway where part of the railway is on a gradient. Beyond the top of the gradient the track is effectively screened by the brow of the hill and the noise contribution from this section of the track can be assumed to be negligible for the purpose of the calculation. The track is continuously welded rail laid on ballast. The trains operating on the railway are all of one type and consist of 10 identical tread braked passenger coaches pulled by a diesel locomotive at 150 km/h. During the day and night periods respectively 179 and 13 trains pass the reception point travelling in the direction indicated on the plan. With this proviso the locomotive is under power only on the uphill section of the railway. The source height for the locomotive will therefore be either at the rail head at the effective source position, S_1, when the locomotive is operating on the section of railway at grade, or 4m above the effective source position, S_2, when the locomotive is on power on the uphill section.

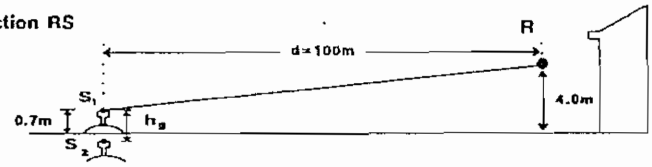
PLAN



Cross section SP



Cross section RS



OBJECT: To predict the values of $L_{Aeq,6h}$ and $L_{Aeq,18h}$ at a reception point 1m from the facade of a building, 4m above the ground.

STAGE 1: DIVIDE RAILWAY INTO SEGMENTS

Part of the track is on a gradient so the railway is divided into three segments: segment 1, the track is level with a gradient of 0% : segment 2, the track is on an uphill gradient of 1%, and segment 3: the track is screened by the brow of the hill and the contribution to the overall noise level from this segment is assumed to be negligible.

INPUT DATA :	**Segment 1**		**Segment 2**	
Ground cover:	Grassland		Grassland	
Track:	Both segments use Continuously Welded Rail (CWR) on ballast (B)			
Angle of view:	α_1 = 63.5°	θ_1 = 127°	α_2 = 33°	θ_2 = 40°
	Train 1	**Train 2**	**Train 1**	**Train 2**
Category:	1	7	1	8
Train type:	10 Tread braked passenger coaches	Diesel locomotive BR Class 47	10 Tread braked passenger coaches	Diesel locomotive under power. BR Class47
Number of trains:				
Midnight - 0600 hrs	Q_{NIGHT} = 13	Q_{NIGHT} = 13	Q_{NIGHT} = 13	Q_{NIGHT} = 13
0600 hrs - Midnight	Q_{DAY} = 179	Q_{DAY} = 179	Q_{DAY} = 179	Q_{DAY} = 179
Speed:	150 km/h	150 km/h	150 km/h	150 km/h
Hgt. of reception pt. above source position:	3.3m	3.3m	4.05m	0.05m
Distance from track:	100m	100m	100m	100m
Av. hgt. propagation:	2.35m	2.35m	2.35m	4.35m

STAGE 2: CALCULATE THE REFERENCE NOISE LEVEL SEL_{ref}

2.1 Reference noise level: As each train is pulled by a diesel locomotive the coaches and locomotive are treated separately as two train types. The baseline SEL (single vehicle) at a reference distance of 25m is determined from Chart A1.1 for rolling railway vehicles ie train type 1 for both segments and train type 2, the locomotive under constant speed, for segment 1. For the locomotive under full power use Chart A1.2. The values are then corrected for vehicle type using Table A1.1. (Para.14)

2.2 Correction for the number of vehicles: The baseline SEL for a single vehicle is adjusted to take account of the number of vehicles in the train. Train type 1 consists of 10 vehicles and train type 2 is a single vehicle, the locomotive. The correction is determined by using Chart 2. (Para.15)

2.3 Track/support structure correction: The track is CWR laid on ballast. Table 1 shows that no correction is required. (Para.16)

Segment	1		2			1		2	
Train type	1	2	1	2		1	2	1	2
Speed V km/h	150	150	150	150	B'line SEL CHT A1.1/2	74.7	74.7	74.7	90.8
					Correction TBLE A1.1	+14.8	+16.6	+14.8	0.0
No of vehicles N	10	1	10	1	Correction CHART 2	+10.0	0.0	+10.0	0.0
Track/support	CWR/B	CWR/B	CWR/B	CWR/B	Correction TABLE 1	0.0	0.0	0.0	0.0
					REFERENCE NOISE LEVEL SEL_{ref} (dB)	**99.5**	**91.3**	**99.5**	**90.8**

STAGE 3: PROPAGATION

3.1 Distance correction: The reception point is 3.3m above the rail head and 100m from the track, a correction for distance is required using Chart 3. The value to enter into Chart 3 is the value of the slant distance d'. For the locomotive under full power for segment 2 the source is assumed to be 4m above the rail head. (Figure 1. Para. 19)

3.2 Air absorption correction: A correction is required for air absorption, Chart 4, except for the locomotive when under full power for segment 2 (Para. 20).

3.3 Ground correction: The ground cover between the track and the reception point is grassland. A correction is required. (Chart 5. Para. 21)

3.4 Correction for ballasted track: Although the track is laid on ballast no correction is required since only a single track is being considered. (Para. 22)

3.5 Screening correction: There are no barriers or other obstructions between the reception point and the noise source, therefore no correction is required.

3.6 Angle of view correction: The angle of view, θ, for both segments requires a correction, Chart 7 (Para. 30)

Segment	1		2				1		2	
Train type	1	2	1	2			1	2	1	2
Distance d (m)	100	100	100	100						
Height h (m)	3.3	3.3	4.05	0.05						
Distance d'(m)	100.1	100.1	100.1	100.1	Distance corr.	CHART 3	-6.0	-6.0	-6.0	-6.0
					Air abs. corr.	CHART 4	-0.6	-0.6	-0.6	0.0
Soft ground I	1	1	1	1						
Height H (m)	2.35	2.35	2.35	4.35	Ground corr.	CHART 5	-1.3	-1.3	-1.3	-0.6
Ballast	None	None	None	None	Correction	Para.22	0.0	0.0	0.0	0.0
Screen	No	No	No	No	Screen correction	CHART 6	0.0	0.0	0.0	0.0
Angle of view										
$\alpha°$	63.5	63.5	33	33	Correction	CHART 7	-0.7	-0.7	-8.6	-
$\theta°$	127	127	40	40		CHART 8	-	-	-	-7.3
					PROPAGATION CORRECTION (dB)		**-8.6**	**-8.6**	**-16.5**	**-13.9**

STAGE 4: REFLECTION EFFECTS

4.1 Facade correction: A correction is required as the reception point is 1m from a facade. (Para. 31.1)

4.2 Opposite facade correction: There are no buildings or other hard rigid surfaces on the other side of the track and therefore no correction is required. (Para. 31.2)

Segment	1	2		1	2
Facade	Yes	Yes	Correction Para. 31.1	+2.5	+2.5
Opposite facade	None	None	Correction Para. 31.2	0.0	0.0
			REFLECTION CORRECTION	**+2.5**	**+2.5 dB**

STAGE 5: CONVERT SEL TO L_{Aeq}

The SEL at the reception point from each train type in each segment is determined by summing the totals from stages 2 to 4.

Segment	1		2	
Train type	1	2	1	2
Reference noise level SEL_{ref}	99.5	91.3	99.5	90.8
Propagation Correction	-8.6	-8.6	-16.5	-13.9
Reflection Correction	+2.5	+2.5	+2.5	+2.5
SEL FOR SEGMENT	**93.4**	**85.2**	**85.5**	**79.4 dB**

The SEL for each train type and segment is then converted to $L_{Aeq,6h}$ and $L_{Aeq,18h}$ using equations 5.1 and 5.2 respectively and entering the appropriate number of trains for each time period. (Para. 32)

Segment	1		2				1		2	
Train type	1	2	1	2			1	2	1	2
Number of trains										
Q_{NIGHT}	13	13	13	13	$L_{Aeq,6h}$	Para. 32	61.2	53.0	53.3	47.2
Q_{DAY}	179	179	179	179	$L_{Aeq,18h}$	Para. 32	67.8	59.6	59.9	53.8

STAGE 6: CALCULATE THE TOTAL L_{Aeq} FOR THE RAILWAY

The segment L_{Aeq} values calculated in stage 5 are combined to give the total L_{Aeq} values for the railway.

Total $L_{Aeq,6h}$	CHART 9	**62.5 dB**
Total $L_{Aeq,18h}$	CHART 9	**69.1 dB**

These values are then rounded to the nearest whole number to give:

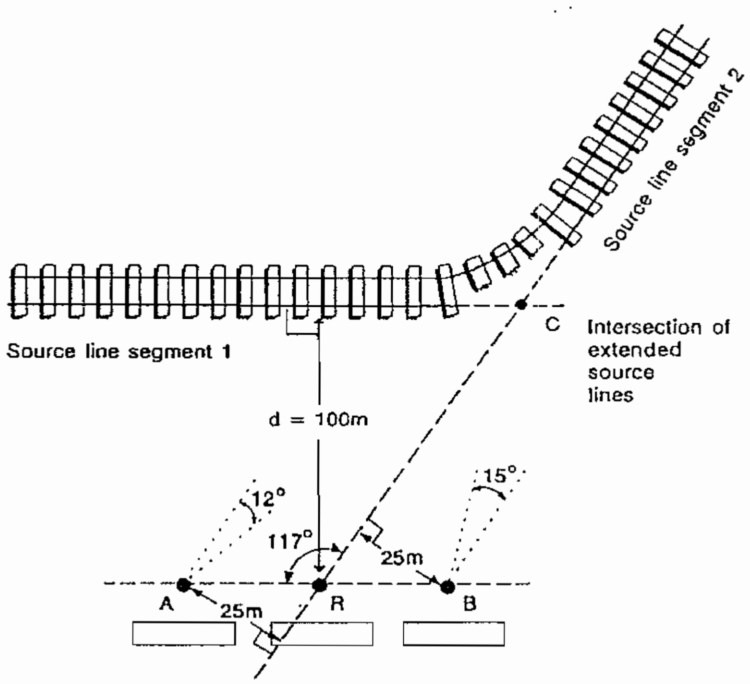
PREDICTED TOTAL $L_{Aeq,6h}$ FOR THE RAILWAY = 63 dB

PREDICTED TOTAL $L_{Aeq,18h}$ FOR THE RAILWAY = 69 dB

EXAMPLE 7. CURVED SINGLE TRACK RAILWAY WITH ONE TRAIN TYPE - EXTENDED SOURCE LINE PASSING CLOSE TO RECEPTION POINT.

This example demonstrates the calculation procedure for a curved section of track where the extended source line passes close to the reception point. The railway comprises a single track which is continuously welded rail laid on ballast. The trains operating on track are all of one type and consist of 10 identical tread braked passenger coaches travelling at 150 km/h. The number of trains passing the reception point is 179 during the day and 13 during the night. As in previous examples, the reception point is located 4m above the ground and 1m from the facade of a building.

PLAN



OBJECT: To predict the values of $L_{Aeq,6h}$ and $L_{Aeq,18h}$ at a reception point R, 1m from the facade of a building, 4m above the ground.

STAGE 1: DIVIDE RAILWAY INTO SEGMENTS

The curved track is approximated by extending each arm to meet at point C forming two segments. However, for segment 2 it can be seen that the extended source line passes through the reception point which makes it impossible to apply the distance correction in this case. To determine the contribution from segment 2 at R, the noise levels at two further postions, A and B, are determined which are close to R but where the distance correction can be determined. The noise contribution at R is then determined by interpolating between the values determined at A and B.

INPUT DATA :	**Segment 1**	**Segment 2**
Ground Cover:	Grassland	Grassland
Track:	Both segments use Continuously Welded Rail (CWR) on ballast (B)	
Train type:	Both segments carry 10 category 1 tread braked passenger coaches	
Number of trains:		
Midnight - 0600 hrs	Q_{NIGHT} = 13	Q_{NIGHT} = 13
0600 hrs - Midnight	Q_{DAY} = 179	Q_{DAY} = 179
Speed:	150 km/h	150 km/h

Reception point:	**R**	**A**	**B**
Height above rail head:	3.3 m	4 m	4 m
Distance from track:	100 m	25 m	25 m
Av. height of propagation:	2.35 m	2.35 m	2.35 m
Angle of view:	α = 58.5° θ = 117°	α = 6° θ = 12°	α = 7.5° θ = 15°

STAGE 2: CALCULATE THE REFERENCE NOISE LEVEL SEL_{ref}

2.1 Reference noise level: Each train operating on the track consists only of category 1 vehicles travelling at 150 km/h. The baseline SEL (single vehicle) at a reference distance of 25 m is determined from Chart A1.1 and then corrected for vehicle type using Table A1.1. (Para.14)

2.2 Correction for the number of vehicles: The baseline SEL for a single vehicle type is adjusted to take account of the number of vehicles in the train, which for this example is 10. The correction is determined using Chart 2. (Para.15)

2.3 Track/support structure correction: The track is CWR laid on ballast. Table 1 shows that no correction is required. (Para.16)

Segment	**1**	**2**	
Reception point	**R**	**A**	**B**
Speed V km/h	150	150	150
No of vehicles N	10	10	10
Track/support	CWR/B	CWR/B	CWR/B

		1	**2**	
		R	**A**	**B**
Baseline SEL	CHART A1.1	74.7	74.7	74.7
Correction	TABLE A1.1	+14.8	+14.8	+14.8
Correction	CHART 2	10.0	10.0	10.0
Correction	TABLE 1	0.0	0.0	0.0
REFERENCE NOISE LEVEL SEL_{ref} (dB)		99.5	99.5	99.5

STAGE 3: PROPAGATION

3.1 Distance correction: The reception point is 4m above the rail head. For segment 1 the reception point is 100m from the track, a correction for distance is required using Chart 3. The value to enter into Chart 3 is the value of the slant distance d'(Figure 1. Para. 19). But for calculating the noise contribution from segment 2 at reception points A and B the value of d is in both cases 25m.

3.2 Air absorption correction: A correction is required for air absorption, Chart 4. (Para. 20).

3.3 Ground correction: The ground cover between the track and the reception point is grassland. A correction is required. (Chart 5. Para. 21)

3.4 Correction for ballasted track: Although the track is laid on ballast no correction is required since only a single track is being considered. (Para. 22)

3.5 Screening correction: There are no barriers or other obstructions between the reception point and the noise source, therefore no correction is required.

3.6 Angle of view correction: Each segment is corrected for angle of view, Chart 7 (Para. 30)

Segment	1	2	
Reception point	**R**	**A**	**B**
Distance d (m)	100	25	25
Height h (m)	3.3	3.3	3.3
Distance d'(m)	100.1	25.2	25.2
Soft ground I	1	1	1
Height H (m)	2.35	2.35	2.35
Ballast	None	None	None
Screen	No	No	No
0.0			
Angle of view			
$\alpha°$	58.5	6	7.5
$\theta°$	117	12	15

Segment		1	2	
Reception point		**R**	**A**	**B**
Distance corr.	CHART 3	-6.0	0.0	0.0
Air abs. corr.	CHART 4	-0.6	0.0	0.0
Ground corr.	CHART 5	-1.3	0.0	0.0
Correction	Para.22	0.0	0.0	0.0
Screen correction	CHART 6		0.0	0.0
Correction	CHART 7	-1.1	-27.2	-24.3
PROPAGATION CORRECTION (dB)		**-9.0**	**-27.2**	**-24.3**

STAGE 4: REFLECTION EFFECTS

4.1 Facade correction: A correction is required as the reception point is 1m from a facade. (Para. 31.1)

4.2 Opposite facade correction: There are no buildings or other hard rigid surfaces on the other side of the track and therefore no correction is required. (Para. 31.2)

Segment	1	2				1	2	
Reception point	**R**	**A**	**B**			**R**	**A**	**B**
Facade	Yes	Yes	Yes	Correction	Para. 31.1	+2.5	+2.5	+2.5
Opposite facade	None	None	None	Correction	Para. 31.2	0.0	0.0	0.0
				REFLECTION CORRECTION (dB)		**+2.5**	**+2.5**	**+2.5**

STAGE 5: CONVERT SEL TO L_{Aeq}

The SEL at the reception point from a single train for each segment is determined by summing the totals from stages 2 to 4. The contribution from segment 2 is obtained by taking the average for the sites A and B.

Segment		1	2		
Reception point		**R**	**A**	**B**	
Reference noise level SEL_{ref}		99.5	99.5	99.5	
Propagation Correction		-9.0	-27.2	-24.3	
Reflection Correction		+2.5	+2.5	+2.5	
SEL FOR SEGMENT	**(dB)**	**93.0**	**74.8***	**77.7***	(* mean = **76.3**)

The SEL for the segment is then converted to $L_{Aeq,6h}$ and $L_{Aeq,18h}$ using equations 5.1 and 5.2 respectively and entering the appropriate number of trains for each time period. (Para. 32)

Segment	1	2			1	2
Number of trains						
Q_{NIGHT}	13	13	$L_{Aeq,6h}$	Para. 32	60.8	44.1
Q_{DAY}	179	179	$L_{Aeq,18h}$	Para. 32	67.4	50.7

STAGE 6: CALCULATE THE TOTAL L_{Aeq} FOR THE RAILWAY

The contribution from all segments are combined to give the L_{Aeq} values calculated in stage 5 are the total L_{Aeq} values for the railway.

Total $L_{Aeq,6h}$	CHART 9	**60.9 dB**
Total $L_{Aeq,18h}$	CHART 9	**67.5 dB**

These values are then rounded to the nearest whole number to give:

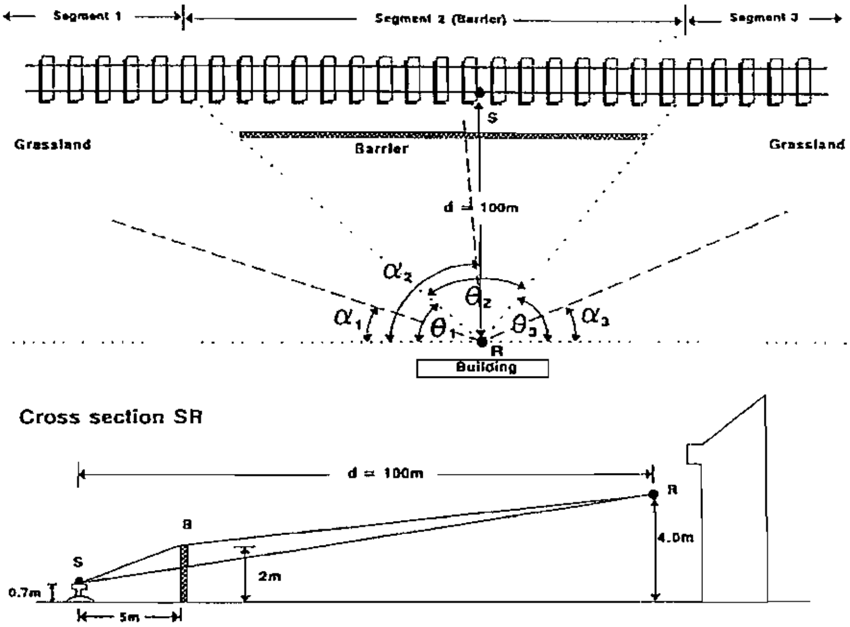
PREDICTED TOTAL $L_{Aeq,6h}$ FOR THE RAILWAY = 61 dB

PREDICTED TOTAL $L_{Aeq,18h}$ FOR THE RAILWAY = 68 dB

EXAMPLE 8. SINGLE TRACK RAILWAY WITH PURPOSE-BUILT REFLECTIVE NOISE BARRIER

This example describes the procedure for calculating the noise from a railway where a purpose built noise barrier has been erected alongside part of the track. The barrier is 300m long, 2m high and is positioned 5m from the nearside rail head. As in previous examples, the track is at grade and is ballasted CWR. The trains are all of one type and each consists of 10 identical tread braked passenger coaches travelling at 150 km/h. The number of trains passing the reception point is 179 during the day and 13 during the night. Propagation is over a grass covered area to a reception point located 1m from the facade of a building and 4m above the ground.

PLAN



OBJECT: To predict the values of $L_{Aeq,6h}$ and $L_{Aeq,18h}$ at a reception point R, 1m from the facade of a building, 4m above the ground.

STAGE 1: DIVIDE RAILWAY INTO SEGMENTS

The trains are all of one type and are travelling on a single track at a constant speed. The track is straight and level. A 300m long reflective barrier is constructed 5m from the nearside rail head as shown on the plan. Three segments are required with angles of view θ, of 29°, 115° and 36°. (Para.12)

INPUT DATA :

Segment:	1	2	3
Ground cover	grassland	screened	grassland
Angle of view	29°	115°	36°

All segments:

Track 1:	Continuously Welded Rail (CWR) on ballast (B)			
Train type 1:	Category 1,	10 tread braked passenger coaches.	Speed	= 150 km/h
	Number of trains:	Midnight - 0600 hrs	Q_{NIGHT}	= 13
		0600 hrs - Midnight	Q_{DAY}	= 179
	Reception point:	Height above rail head	h	= 3.3 m
		Distance from track	d	= 100 m
	Av. hgt. of propagation (rail head 0.7m above ground)		H	= (4+0.7)/2 = 2.35 m

STAGE 2: CALCULATE THE REFERENCE NOISE LEVEL SEL_{ref}

2.1 Reference noise level: Each train operating on the track consists only of category 1 vehicles travelling at 150 km/h. The baseline SEL (single vehicle) at a reference distance of 25m is determined from Chart A1.1 and then corrected for vehicle type using Table A1.1. (Para.14)

2.2 Correction for the number of vehicles: The baseline SEL for a single vehicle is adjusted to take account of the number of vehicles in the train, which for this example is 10. The correction is determined by using Chart 2. (Para.15)

2.3 Track/support structure correction: The track is CWR laid on ballast. Table 1 shows that no correction is required. (Para.16)

Segment	**1**	**2**	**3**			**1**	**2**	**3**
Train type	1	1	1					
Speed V (km/h)	150	150	150	Baseline SEL	CHART A1.2	74.7	74.7	74.7
				Correction	TABLE A1.1	14.8	14.8	14.8
No of vehicles N	10	10	10	Correction	CHART 2	10.0	10.0	10.0
Track/support	CWR/B	CWR/B	CWR/B	Correction	TABLE 1	0.0	0.0	0.0
				REFERENCE NOISE LEVEL SEL_{ref}		99.5	99.5	99.5 dB

STAGE 3: PROPAGATION

3.1 Distance correction: The reception point is 3.3m above the rail head and 100m from the track, a correction for distance is required using Chart 3. The value to enter into Chart 3 is the value of the slant distance d'. (Figure 1. Para. 19)

3.2 Air absorption correction: A correction is required for air absorption, Chart 4. (Para. 20).

3.3 Ground correction: For segments 1 and 3, which are unscreened, the ground cover between the track and the reception point is grassland. A correction is required, (Chart 5. Para. 21). For segment 2, which is screened, no correction is required.

3.4 Correction for ballasted track: Although the track is laid on ballast no correction is required since only a single track is being considered. (Para. 22)

3.5 Screening correction: For segment 2, which is screened by a reflective barrier, a correction is required. The path difference is calculated along the cross-section RS, the top of the barrier is 2m above the ground and the path difference δ = SB+BR-SR = 0.132m. The barrier is reflective so a further correction is needed, Chart 6(c).

3.6 Angle of view correction: A correction for the angle of view for each segment is required. (Para. 30)

Segment	1	2	3			1	2	3
Distance d (m)	100	100	100					
Height h (m)	3.3	3.3	3.3					
Distance d' (m)	100.1	100.1	100.1	Distance corr.	CHART 3	-6.0	-6.0	-6.0
				Air abs. corr.	CHART 4	-0.6	-0.6	-0.6
Soft ground I	1	-	1					
Height H (m)	2.35	-	2.35	Ground corr.	CHART 5	-1.3	0.0	-1.3
Ballast	None	None	None	Correction	Para. 220.0	0.0	0.0	
Screen	None	Yes	None					
Path diff. δ (m)		0.132		Screen correction	CHART 6(a)	0.0	-11.7	0.0
D (m)		5.0		Refl. barr. corr.	CHART 6(c)	0.0	+3.8	0.0
Angle of view								
α°	14.5	86.5	18					
θ°	29	115	36	Correction	CHART 7	-15.9	-0.4	-13.2
				PROPAGATION CORRECTION		**-23.8**	**-14.9**	**-21.1 dB**

STAGE 4: REFLECTION EFFECTS

4.1 Facade correction: A correction is required as the reception point is 1m from a facade. (Para. 31.1)

4.2 Opposite facade correction: There are no buildings or other hard rigid surfaces on the other side of the track and therefore no correction is required. (Para. 31.2)

Segment	1	2	3			1	2	3
Facade	Yes	Yes	Yes	Correction	PARA. 31.1	2.5	2.5	2.5
Opposite facade	None	None	None	Correction	PARA. 31.2	0.0	0.0	0.0
				REFLECTION CORRECTION		**+2.5**	**+2.5**	**+2.5 dB**

STAGE 5: CONVERTING SEL TO L_{Aeq}

The SEL at the reception point from a single train for each segment is determined by summing the totals from stages 2 to 4.

	1	2	3
Reference noise level SEL_{ref}	99.5	99.5	99.5
Propagation Correction	-23.8	-14.9	-21.1
Reflection Correction	+2.5	+2.5	+2.5
SEL FOR EACH SEGMENT	**78.2**	**87.1**	**80.9 dB**

The SEL for each segment is then converted to $L_{Aeq,6h}$ and $L_{Aeq,18h}$ using equations 5.1 and 5.2 respectively and entering the appropriate number of trains for each time period. (Para. 32)

Segment	1	2	3			1	2	3
No of trains								
Q_{NIGHT}	13	13	13	$L_{Aeq,6h}$	Para. 32	46.0	54.9	48.7
Q_{DAY}	179	179	179	$L_{Aeq,18h}$	Para. 32	52.6	61.5	55.3

STAGE 6: CALCULATE THE TOTAL L_{Aeq} FOR THE RAILWAY

The total $L_{Aeq,6h}$ and $L_{Aeq,18h}$ values are calculated by summing the contributions from each segment for the relevant time periods:

Total $L_{Aeq,6h}$	CHART 9	**56.3 dB**
Total $L_{Aeq,18h}$	CHART 9	**62.9 dB**

These values are then rounded to the nearest whole number to give:

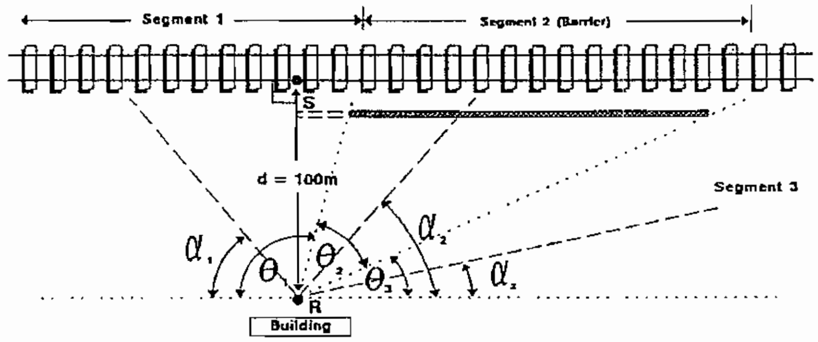
PREDICTED TOTAL $L_{Aeq,6h}$ FOR THE RAILWAY = 56 dB

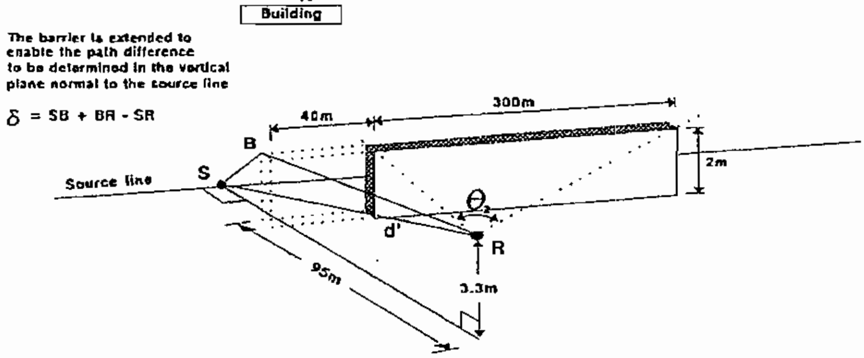
PREDICTED TOTAL $L_{Aeq,18h}$ FOR THE RAILWAY = 63 dB

EXAMPLE 9. SINGLE TRACK RAILWAY WITH A RECEPTION POINT NOT DIRECTLY BEHIND A NOISE BARRIER.

This example is similar to that described in Example 8. However, in this case the reception point is not located directly behind the barrier. The barrier is reflective, it is 2m high and 300m long, and is positioned 5m from the nearside rail head. As in previous examples the track is at grade and is ballasted CWR. The trains consist of 10 identical passenger coaches travelling at 150 km/h. The number of trains passing the reception point during the day is 179 and 13 pass during the night. Propagation is over a grass covered area to a reception point located 1m from the facade of a building and 4m above ground.

PLAN





OBJECT: To predict the values of $L_{Aeq,6h}$ and $L_{Aeq,18h}$ at a reception point 1m from the facade of a building, at 1st floor level.

STAGE 1: DIVIDE RAILWAY INTO SEGMENTS

The trains are all of one type and are travelling on a single track at a constant speed. The track is straight and level. A 2m high, 300m long reflective barrier is constructed 5m from the rail nearside head. Three segments are required with angles of view θ, of 112.8°, 51.6° and 15.6°. (Para.12)

INPUT DATA:

Segment:	1	2	3
Ground cover	grassland	screened	grassland
Angle of view	112.8°	51.6°	15.6°

All segments:

Track 1:	Continuously Welded Rail (CWR) on ballast (B)			
Train type 1:	Category 1.	10 tread braked passenger coaches.	Speed	= 150 km/h
	Number of trains:	Midnight - 0600 hrs	Q_{NIGHT}	= 13
		0600 hrs - Midnight	Q_{DAY}	= 179
	Reception point:	Height above rail head	h	= 3.3 m
		Distance from track	d	= 100 m
	Av. hgt. of propagation (rail head 0.7m above ground)		H	= (4+0.7)/2
				= 2.35 m

STAGE 2: CALCULATE THE REFERENCE NOISE LEVEL SEL_{ref}

2.1 Reference noise level: Each train operating on the track consists only of category 1 vehicles travelling at 150 km/h. The baseline SEL (single vehicle) at a reference distance of 25 m is determined from Chart A1.1 and then corrected for vehicle type using Table A1.1. (Para.14)

2.2 Correction for the number of vehicles: The baseline SEL for a single vehicle is adjusted to take account of the number of vehicles in the train, which for this example is 10. The correction is determined by using Chart 2. (Para.15)

2.3 Track/support structure correction: The track is CWR laid on ballast. Table 1 shows that no correction is required. (Para.16)

Segment	1	2	3			1	2	3
Train type	1	1	1					
Speed V (km/h)	150	150	150	Baseline SEL	CHART A1.2	74.7	74.7	74.7
				Correction	TABLE A1.1	14.8	14.8	14.8
No of vehicles N	10	10	10	Correction	CHART 2	10.0	10.0	10.0
Track/support	CWR/B	CWR/B	CWR/B	Correction	TABLE 1	0.0	0.0	0.0
				REFERENCE NOISE LEVEL SEL_{ref}		99.5	99.5	99.5 dB

STAGE 3: PROPAGATION

3.1 Distance correction: The reception point is 3.3m above the rail head and 100m from the track, a correction for distance is required using Chart 3. The value to enter into Chart 3 is the value of the slant distance d'. (Figure 1. Para. 19)

3.2 Air absorption correction: A correction is required for air absorption, Chart 4. (Para. 20).

3.3 Ground correction: For segments 1 and 3, which are unscreened, the ground cover between the track and the reception point is grassland. A correction is required. (Chart 5. Para. 21). For segment 2, which is screened, no correction is required.

3.4 Correction for ballasted track: Although the track is laid on ballast no correction is required since only a single track is being considered. (Para. 22)

3.5 Screening correction: For segment 2, which is screened by a reflective barrier, a correction is required. To calculate the potential barrier correction the barrier is extended so that the path difference to be entered in Chart 6(a) and 6(b) is calculated along the cross-section SR. In this case the value of δ = SB+BR-SR = 0.132m which is identical to that calculated in Example 8. As before since the barrier is reflective a further correction is required using Chart 6(c).

3.6 Angle of view correction: A correction for the angle of view for each segment is required.(Para. 30)

Segment	1	2	3			1	2	3
Distance d (m)	100	100	100					
Height h (m)	3.3	3.3	3.3					
Distance d' (m)	100.1	100.1	100.1	Distance corr.	CHART 3	-6.0	-6.0	-6.0
				Air abs. corr.	CHART 4	-0.6	-0.6	-0.6
Soft ground I	1	-	1					
Height H (m)	2.35	-	2.35	Ground corr.	CHART 5	-1.3	0.0	-1.3
Ballast	None	None	None	Correction	Para. 220.0	0.0	0.0	
Screen	None	Yes	None					
Path diff. δ (m)		0.132		Screen correction	CHART 6(a)	0.0	-11.7	0.0
Refl dist. D (m)		5.0		Refl. barr. corr.	CHART 6(c)	0.0	+3.8	0.0
Angle of view								
$\alpha°$	56.4	41.4	7.8					
$\theta°$	112.8	51.6	15.6	Correction	CHART 7	-1.3	-6.0	-23.8
				PROPAGATION CORRECTION		**-9.2**	**-20.5**	**-31.7 dB**

STAGE 4: REFLECTION EFFECTS

4.1 Facade correction: A correction is required as the reception point is 1m from a facade. (Para. 31.1)

4.2 Opposite facade correction: There are no buildings or other hard rigid surfaces on the other side of the track and therefore no correction is required. (Para. 31.2)

Segment	1	2	3			1	2	3
Facade	Yes	Yes	Yes	Correction	PARA. 31.1	2.5	2.5	2.5
Opposite facade	None	None	None	Correction	PARA. 31.2	0.0	0.0	0.0
				REFLECTION CORRECTION		**+2.5**	**+2.5**	**+2.5 dB**

STAGE 5: CONVERTING SEL TO L_{Aeq}

The SEL at the reception point from a single train for each segment is determined by summing the totals from stages 2 to 4.

	1	2	3
Reference noise level SEL_{ref}	99.5	99.5	99.5
Propagation Correction	-9.2	-20.5	-31.7
Reflection Correction	+2.5	+2.5	+2.5
SEL FOR EACH SEGMENT	**92.8**	**81.5**	**70.3 dB**

The SEL for each segment is then converted to $L_{Aeq,6h}$ and $L_{Aeq,18h}$ using equations 5.1 and 5.2 respectively and entering the appropriate number of trains for each time period. (Para. 32)

Segment	1	2	3			1	2	3
No of trains								
Q_{NIGHT}	13	13	13	$L_{Aeq,6h}$	Para. 32	60.6	49.3	38.1
Q_{DAY}	179	179	179	$L_{Aeq,18h}$	Para. 32	67.2	55.9	44.7

STAGE 6: CALCULATE THE TOTAL L_{Aeq} FOR THE RAILWAY

The total $L_{Aeq,6h}$ and $L_{Aeq,18h}$ values are calculated by summing the contributions from each segment for the relevent time periods:

Total $L_{Aeq,6h}$	CHART 9	**60.9 dB**
Total $L_{Aeq,18h}$	CHART 9	**67.5 dB**

These values are then rounded to the nearest whole number to give:

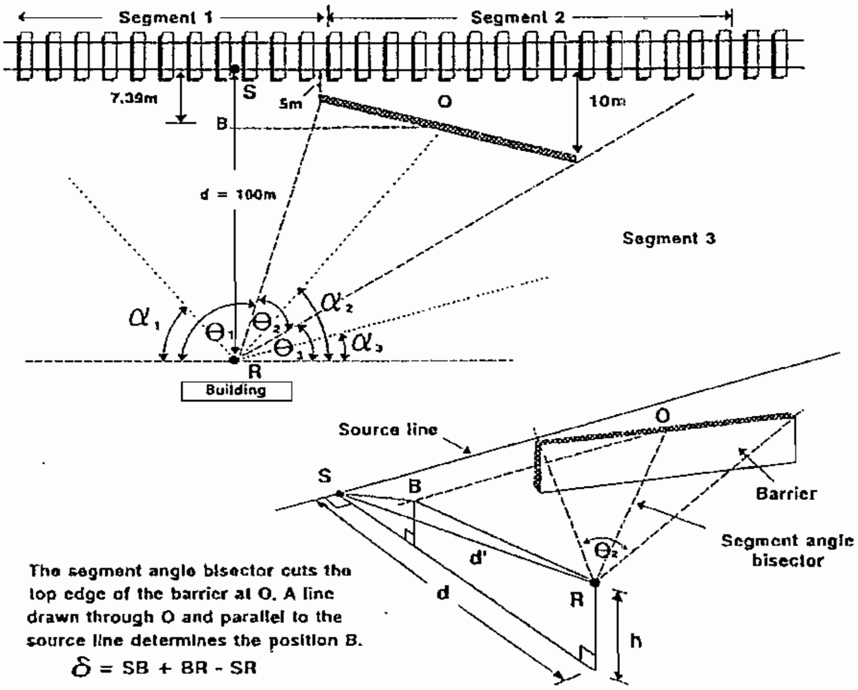
PREDICTED TOTAL $L_{Aeq,6h}$ FOR THE RAILWAY = 61 dB

PREDICTED TOTAL $L_{Aeq,18h}$ FOR THE RAILWAY = 68 dB

EXAMPLE 10. SINGLE TRACK RAILWAY WITH A NOISE BARRIER WHICH IS NOT PARALLEL TO THE SOURCE LINE.

This example is similar to that described in Example 9. However, in this case the barrier is not parallel to the source line. As in previous examples the barrier is reflective, 2m high and 300m long. The track is at grade and is ballasted CWR. The trains consist of 10 tread braked passenger coaches travelling at 150 km/h. 179 trains pass the reception point during the day and 13 pass during the night. Propagation is over a grass covered area to a reception point located 1m from the facade of a building and 4m above the ground.

PLAN



OBJECT: To predict the values of $L_{Aeq,6h}$ and $L_{Aeq,18h}$ at a reception point 1m from the facade of a building, at 1st floor level. A 2m high, 300m long reflective barrier is positioned at an angle to the track.

STAGE 1: DIVIDE RAILWAY INTO SEGMENTS
The trains are all of one type and are travelling on a single track at a constant speed. The track is straight and level. A 2m high, 300m long reflective barrier is constructed similar to that shown in Example 9 but is not parallel to the source line. To check that the noise contribution from the screened segment can be adequately approximated by a single segment the potential variation in barrier performance must be assessed. Based on path differences calculated in the vertical plane RS the variation in performance of the barrier ends should not be greater than 2 dB. In this example three segments are required with angles of view θ, of 112.8°, 52.4° and 14.8°. (Para.12)

INPUT DATA:

Segment:	1	2	3
Ground cover	Grassland	Screened	Grassland
Angle of view	112.8°	52.4°	14.8°

All segments:

Track 1:	Continuously Welded Rail (CWR) on ballast (B)			
Train 1:	Category 1.	10 tread braked passenger coaches.	Speed	= 150 km/h
	Number of trains:	Midnight - 0600 hrs	Q_{NIGHT}	= 13
		0600 hrs - Midnight	Q_{DAY}	= 179
	Reception point:	Height above rail head	h	= 3.3 m
		Distance from track	d	= 100 m
	Av. height of propagation (railhead 0.7m above ground)		H	= (4+0.7)/2
				= 2.35 m

STAGE 2: CALCULATE THE REFERENCE NOISE LEVEL SEL_{ref}

2.1 Reference noise level: Each train operating on the track consists only of category 1 vehicles travelling at 150 km/h. The baseline SEL (single vehicle) at a reference distance of 25 m is determined from Chart A1.1 and then corrected for vehicle type using Table A1.1. (Para.14)

2.2 Correction for the number of vehicles: The baseline SEL for a single vehicle is adjusted to take account of the number of vehicles in the train, which for this example is 10. The correction is determined by using Chart 2. (Para.15)

2.3 Track/support structure correction: The track is CWR laid on ballast. Table 1 shows that no correction is required. (Para.16)

Segment	1	2	3
Train type	1	1	1
Speed V (km/h)	150	150	150
No of vehicles N	10	10	10
Track/support	CWR/B	CWR/B	CWR/B

		1	2	3
Baseline SEL	CHART A1.2	74.7	74.7	74.7
Correction	TABLE A1.1	14.8	14.8	14.8
Correction	CHART 2	10.0	10.0	10.0
Correction	TABLE 1	0.0	0.0	0.0
REFERENCE NOISE LEVEL SEL_{ref}		99.5	99.5	99.5 dB

STAGE 3: PROPAGATION

3.1 Distance correction: The reception point is 3.3m above the rail head and 100m from the track, a correction for distance is required using Chart 3. The value to enter into Chart 3 is the value of the slant distance d'. (Figure 1. Para. 19)

3.2 Air absorption correction: A correction is required for air absorption, Chart 4. (Para. 20).

3.3 Ground correction: For segments 1 and 3, which are unscreened, the ground cover between the track and the reception point is grassland. A correction is required (Chart 5. Para. 21). For segment 2, which is screened, no ground correction is required.

3.4 Correction for ballasted track: Although the track is laid on ballast no correction is required since only a single track is being considered. (Para. 22)

3.5 Screening correction: For segment 2, which is screened by a reflective barrier, a correction is required. The screening performance of the barrier is calculated by rotating the barrier parallel to the source line about the point O, where the segment angle bisector cuts the top of the barrier. The barrier is then extended parallel to the source line and the path difference is calculated in the perpendicular plane containing both R and S. The value of the path difference in this case is δ = SB+BR-SR = 0.080m. As before the barrier is reflective and so a further correction is needed using Chart 6(c).

3.6 Angle of view correction: A correction for the angle of view for each segment is required.(Para. 30)

Segment	1	2	3			1	2	3
Distance d (m)	100	100	100					
Height h (m)	3.3	3.3	3.3					
Distance d' (m)	100.1	100.1	100.1	Distance corr.	CHART 3	-6.0	-6.0	-6.0
				Air abs. corr.	CHART 4	-0.6	-0.6	-0.6
Soft ground I	1	-	1					
Height H (m)	2.35	-	2.35	Ground corr.	CHART 5	-1.3	0.0	-1.3
Ballast	None	None	None	Correction	Para. 220.0	0.0	0.0	
Screen	None	Yes	None					
Path diff. δ (m)		0.080		Screen correction	CHART 6(a)	0.0	-10.3	0.0
Refl dist. D (m)		7.39		Refl. barr. corr.	CHART 6(c)	0.0	3.2	0.0
Angle of view								
$\alpha°$	56.4	41.0	7.4					
$\theta°$	112.8	52.4	14.8	Correction	CHART 7	-1.3	-5.9	-24.5
				PROPAGATION CORRECTION		**-9.2**	**-19.6**	**-32.4 dB**

STAGE 4: REFLECTION EFFECTS

4.1 Facade correction: A correction is required as the reception point is 1m from a facade. (Para. 31.1)

4.2 Opposite facade correction: There are no buildings or other hard rigid surfaces on the other side of the track and therefore no correction is required. (Para. 31.2)

Segment	1	2	3			1	2	3
Facade	Yes	Yes	Yes	Correction	PARA. 31.1	2.5	2.5	2.5
Opposite facade	None	None	None	Correction	PARA. 31.2	0.0	0 0	0.0
				REFLECTION CORRECTION		**+2.5**	**+2.5**	**+2.5 dB**

STAGE 5: CONVERTING SEL TO L_{Aeq}

The SEL at the reception point from a single train for each segment is determined by summing the totals from stages 2 to 4.

	1	2	3
Reference noise level SEL_{ref}	99.	99.5	99.5
Propagation Correction	-9.2	-19.6	-32.4
Reflection Correction	+2.5	+2.5	+2.5
SEL FOR EACH SEGMENT	**92.8**	**82.4**	**69.6 dB**

The SEL for each segment is then converted to $L_{Aeq,6h}$ and $L_{Aeq,18h}$ using equations 5.1 and 5.2 respectively and entering the appropriate number of trains for each time period. (Para. 32)

Segment	1	2	3			1	2	3
No of trains								
Q_{NIGHT}	13	13	13	$L_{Aeq,6h}$	Para. 32	60.6	50.2	37.4
Q_{DAY}	179	179	179	$L_{Aeq,18h}$	Para. 32	67.2	56.8	44.0

STAGE 6: CALCULATE THE TOTAL L_{Aeq} FOR THE RAILWAY

The total $L_{Aeq,6h}$ and $L_{Aeq,18h}$ values are calculated by summing the contributions from each segment for the relevent time periods:

Total $L_{Aeq,6h}$	CHART 9	**61.0 dB**
Total $L_{Aeq,18h}$	CHART 9	**67.6 dB**

These values are then rounded to the nearest whole number to give:

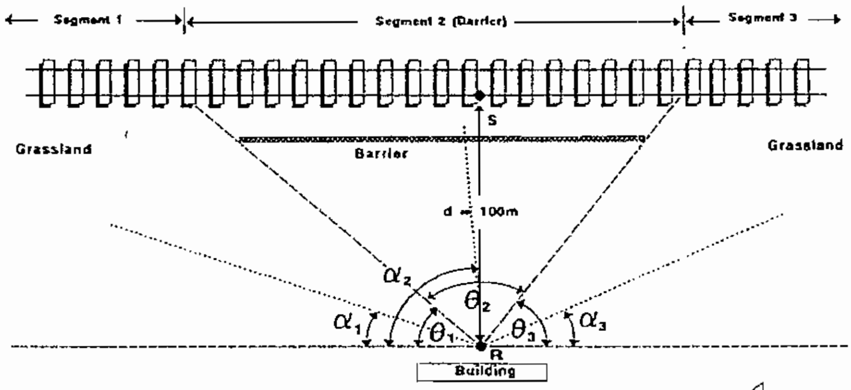
PREDICTED TOTAL $L_{Aeq,6h}$ FOR THE RAILWAY = 61 dB

PREDICTED TOTAL $L_{Aeq,18h}$ FOR THE RAILWAY = 68 dB

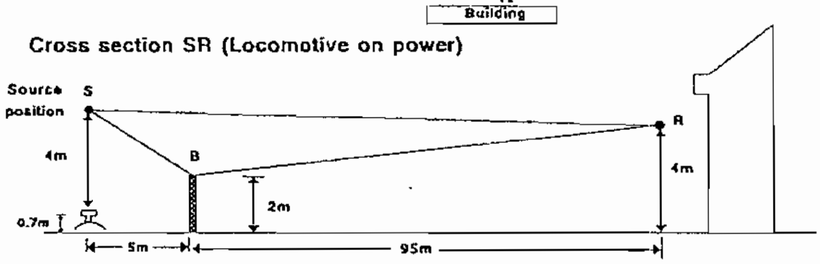
EXAMPLE 11. SINGLE TRACK RAILWAY WITH PURPOSE-BUILT NOISE BARRIER TRAIN PULLED BY A DIESEL LOCOMOTIVE ON POWER

This example uses the same layout as Example 8 to illustrate the procedure for calculating the screening provided when a train is pulled by a diesel locomotive on power. The track, barrier and propagation characteristics remain identical to those assumed in Example 8. Each train consists of 10 tread braked passenger coaches which are pulled by a BR Class 47 diesel locomotive on power. The number of trains passing the reception point is 179 during the day and 13 during the night. The reception point is 1m from the facade of a building, at a height of 4m above the ground. The following calculations deal only with the locomotive on power until stage 6 where values for the passenger coaches are imported from Example 8 and combined.

PLAN



Cross section SR (Locomotive on power)



OBJECT: To predict the values of $L_{Aeq,6h}$ and $L_{Aeq,18h}$ at a reception point R, 1m from the facade of a building, 4m above the ground.

STAGE 1: DIVIDE RAILWAY INTO SEGMENTS

There are two train types both travelling on a single straight and level track. A reflective barrier 300m long and 2m high runs parallel to the source line at a distance of 5m. Three segments are required with angles of view θ, of 29°, 115° and 36°.(Para.12)

INPUT DATA :

Segment:	1	2	3
Ground cover	grassland	screened	grassland
Angle of view	29°	115°	36°

All segments:

Track 1:	Continuously Welded Rail (CWR) on ballast (B)			
Train type 1:	All calculation identical to Example 8			
Train type 2:	Category 8.	BR Class 47 diesel loco. on power	Speed	= 150 km/h
	Number of trains:	Midnight - 0600 hrs	Q_{NIGHT}	= 13
		0600 hrs - Midnight	Q_{DAY}	= 179
	Reception point:	Height above rail head	h	= 3.3 m
		Distance from track	d	= 100 m
	Av. hgt. of propagation (effective source position 4.7m above ground)		H	= (4.7 + 4.0)/2 = 4.35 m

STAGE 2: CALCULATE THE REFERENCE NOISE LEVEL SEL_{ref}

2.1 Reference noise level: Each train is comprised of two vehicle types, ie. the coaches and the locomotive. Each type must therefore be treated seperately. The baseline SEL (single vehicle) at a reference distance of 25m is determined from Chart A1.1 for the rolling railway vehicles (ie. train type 1) in each segment (see Example 8). For train type 2, the locomotive on full power, Chart A1.2 is used. Both values are corrected for vehicle type using Table A1.1. (Para.14)

2.2 Correction for the number of vehicles: The baseline SEL for a single vehicle is adjusted to take account of the number of vehicles in the train. Train type 1 consists of 10 vehicles and train type 2 is a single vehicle. The corrections are determined by using Chart 2. (Para.15)

2.3 Track/support structure correction: The track is CWR laid on ballast. Table 1 shows that no correction is required. (Para.16)

Segment	1	2	3
Train type:	2	2	2
Speed V (km/h)	150	150	150
No of vehicles N	1	1	1
Track/support	CWR/B	CWR/B	CWR/B

		1	2	3
Baseline SEL	CHART A1.2	90.8	90.8	90.8
Correction	TABLE A1.1	0.0	0.0	0.0
Correction	CHART 2	0.0	0.0	0.0
Correction	TABLE 1	0.0	0.0	0.0
REFERENCE NOISE LEVEL SEL_{ref}		90.8	90.8	90.8 dB

STAGE 3: PROPAGATION

3.1 Distance correction: The reception point is 3.3m above the rail head and 100m from the track, a correction for distance is required using Chart 3. The value to enter into Chart 3 is the value of the slant distance d'. For the locomotive on full power the source position is assumed to be 4m above the railhead. (Figure 1. Para. 19)

3.2 Air absorption correction: For a diesel locomotive on power no correction is required for air absorption, (Para. 20).

3.3 Ground correction: For segments 1 and 3, which are unscreened, the ground cover between the track and the reception point is grassland. A correction is required, (Chart 5. Para. 21). Segment 2 is screened though a ground correction is still required due to poor barrier performance in the given situation. (See also Para. 3.5 below)

3.4 Correction for ballasted track: Although the track is laid on ballast no correction is required since only a single track is being considered. (Para. 22)

3.5 Screening correction: Segment 2 is screened by a reflective barrier. For the locomotive under power the path difference is calculated along the cross-section RS with the effective source position located 4.7m above the ground. The top of the barrier is 2m above the ground and for this geometry the path difference = 0.701m. The reception point is in the illuminated zone of the barrier (Para.24. Figure 4) and for this value of δ the correction is zero. The ground correction therefore exceeds the barrier correction in this example and is applied to the screened segment (Para. 25.3). The correction for a reflective barrier is not applicable in this case.

3.6 Angle of view correction: A correction for the angle of view for each segment is required. (Para. 30)

Segment	1	2	3
Distance d (m)	100	100	100
Height h (m)	4.7	4.7	4.7
Distance d' (m)	100	100	100
Soft ground I	1	1	1
Height H (m)	4.35	4.35	4.35
Ballast	None	None	None
Screen	None	Yes	None
Path diff. δ (m)		0.701	
Angle of view			
$\alpha°$	14.5	86.5	18
$\theta°$	29	115	36

		1	2	3
Distance corr.	CHART 3	-6.0	-6.0	-6.0
Air abs. corr.	CHART 4	-0.6	-0.6	-0.6
Ground corr.	CHART 5	-0.6	-0.6	-0.6
Correction	Para. 220.0	0.0	0.0	
Ill. screen corr.	CHART 6(a)		0.0	
Correction	CHART 8	-12.0	-0.7	-10.2
PROPAGATION CORRECTION		**-19.2**	**-7.9**	**-17.4 dB**

STAGE 4: REFLECTION EFFECTS

4.1 Facade correction: A correction is required as the reception point is 1m from a facade. (Para. 31.1)

4.2 Opposite facade correction: There are no buildings or other hard rigid surfaces on the other side of the track and therefore no correction is required. (Para. 31.2)

Segment	1	2	3
Facade	Yes	Yes	Yes
Opposite facade	None	None	None

		1	2	3
Correction	PARA. 31.1	2.5	2.5	2.5
Correction	PARA. 31.2	0.0	0.0	0.0
REFLECTION CORRECTION		**+2.5**	**+2.5**	**+2.5 dB**

STAGE 5: CONVERTING SEL TO L_{Aeq}

The SEL at the reception point from the loco. under power in each segment is determined by summing the totals from stages 2 to 4.

	1	2	3
Reference noise level SEL_{ref}	90.8	90.8	90.8
Propagation Correction	-19.2	-7.9	-17.4
Reflection Correction	+2.5	+2.5	+2.5
SEL FOR EACH SEGMENT	**74.1**	**85.4**	**75.9 dB**

The SEL for each segment is then converted to $L_{Aeq,6h}$ and $L_{Aeq,18h}$ using equations 5.1 and 5.2 respectively and entering the appropriate number of trains for each time period. (Para. 32)

Segment	1	2	3
No of trains			
Q_{NIGHT}	13	13	13
Q_{DAY}	179	179	179

		1	2	3
$L_{Aeq,6h}$	Para. 32	41.9	53.2	43.7
$L_{Aeq,18h}$	Para. 32	48.5	59.8	50.3

STAGE 6: CALCULATE THE TOTAL L_{Aeq} FOR THE RAILWAY

The segment L_{Aeq} values calculated in Stage 5 for each train type (passenger coach values imported from Example 8) are combined to give total L_{Aeq} values for the railway.

Total $L_{Aeq,6h}$	CHART 9	**58.3 dB**
Total $L_{Aeq,18h}$	CHART 9	**64.9 dB**

These values are then rounded to the nearest whole number to give:

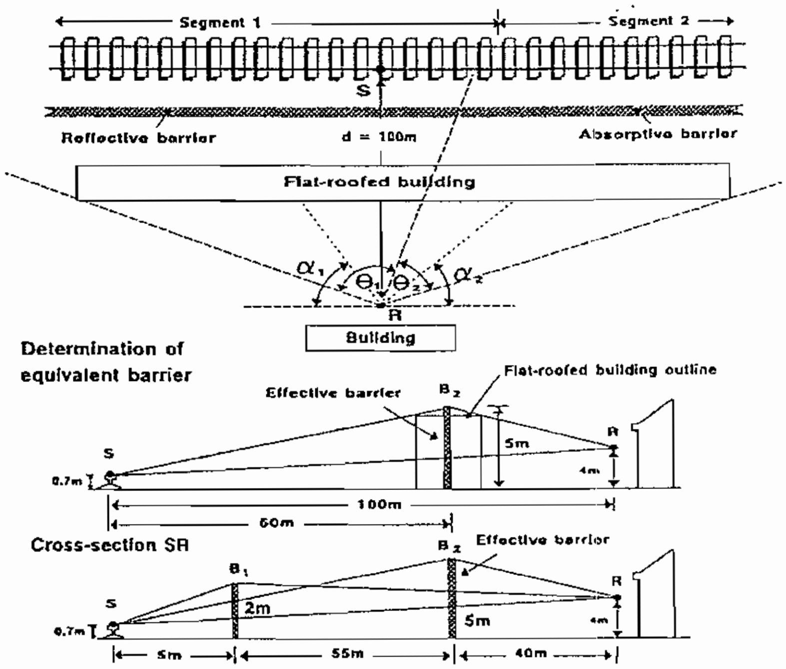
PREDICTED TOTAL $L_{Aeq,6h}$ FOR THE RAILWAY = 58 dB

PREDICTED TOTAL $L_{Aeq,18h}$ FOR THE RAILWAY = 65 dB

EXAMPLE 12. SINGLE TRACK RAILWAY WITH THE RECEPTION POINT BEHIND A PURPOSE BUILT NOISE BARRIER AND A FLAT ROOFED BUILDING

This example describes the procedure for calculating the noise from a railway where multiple barriers are erected alongside the track. Two purpose built noise barriers are positioned 5m from the nearside railhead, parallel to the track. One barrier is reflective the other is absorptive. A flat-roofed building is located between the barriers and the reception point as shown on the plan. The track is at grade and is ballasted CWR. The trains consist of 10 identical passenger coaches. 179 trains pass the reception point during the day and 13 pass during the night. Propagation is over a grass covered area to a reception point 1m from the facade of a building and 4m above the ground. The contributions of the unscreened outer segments are assumed to be negligible in this example.

PLAN



Object: To predict the values of $L_{Aeq,6h}$ and $L_{Aeq,18h}$ at a reception point 1m from the facade of a building, at 1st floor level.

STAGE 1: DIVIDE RAILWAY INTO SEGMENTS

The trains are all of one type and are travelling on a single straight and level track. As shown on the plan, a 2m high barrier runs parallel to the track at a distance of 5m from the nearside railhead. Approximately one half of the barrier is reflective, the remainder is absorptive. A flat-roofed building is located between the purpose built noise barriers and the reception point such that an effective barrier of height 5m is formed at a distance of 60m from the nearside railhead. The outer unscreened segments are assumed to have negligible contributions for the purpose of illustration. Two segments are required with angles of view 97° and 58°.

INPUT DATA:

Segment:	1	2
Ground cover	Grassland	Grassland
Angle of view	97°	58°

All segments:

Track 1:	Continuously Welded Rail (CWR) on ballast (B)			
Train type 1:	Category 1.	10 tread braked passenger coaches.	Speed	= 150 km/h
	Number of trains:	Midnight - 0600 hrs	Q_{NIGHT}	= 13
		0600 hrs - Midnight	Q_{DAY}	= 179
	Reception point:	Height above rail head	h	= 3.3 m
		Distance from track	d	= 100 m
	Av. hgt. of propagation (rail head 0.7m above ground)		H	= (4 + 0.7)/2 = 2.35 m

STAGE 2: CALCULATE THE REFERENCE NOISE LEVEL SEL_{ref}

2.1 Reference noise level: Each train operating on the track consists only of category 1 vehicles travelling at 150 km/h. The baseline SEL (single vehicle) at a reference distance of 25 m is determined from Chart A3.1 and then corrected for vehicle type using Table A3.1. (Para.14)

2.2 Correction for the number of vehicles: The baseline SEL for a single vehicle is adjusted to take account of the number of vehicles in the train, which for this example is 10. The correction is determined by using Chart 2. (Para.15)

2.3 Track/support structure correction: The track is CWR laid on ballast. Table 1 shows that no correction is required. (Para.16)

Segment	1	2			1	2
Train type	1	1				
Speed V (km/h)	150	150	Baseline SEL	CHART A3.2	74.7	74.7
			Correction	TABLE A3.1	14.8	14.8
No of vehicles N	10	10	Correction	CHART 2	10.0	10.0
Track/support	CWR/B	CWR/B	Correction	TABLE 1	0.0	0.0
			REFERENCE NOISE LEVEL SEL_{ref}		99.5	99.5 dB

STAGE 3: PROPAGATION

3.1 Distance correction: The reception point is 3.3m above the rail head and 100m from the track, a correction for distance is required using Chart 3. The value to enter into Chart 3 is the value of the slant distance d'. (Figure 1. Para. 19)

3.2 Air absorption correction: A correction is required for air absorption, Chart 4. (Para. 20).

3.3 Ground correction: Segments 1 and 2 are both screened. No correction is required.

3.4 Correction for ballasted track: Although the track is laid on ballast no correction is required since only a single track is being considered. (Para. 22) In addition it should be noted that the ballast correction is not applied for screened segments, (Para. 24).

3.5 Screening correction: Each segment contains two barriers so the screening provided by each must be calculated separately to allow the lowest of the resulting noise levels to be used (Para. 25.4). For each barrier the path difference is calculated in the vertical plane RS using the equation $\delta = SB + BR - SR$. The potential screening performance is calculated using charts 6(a) and 6(c).

Segment:	1		2
Barrier:	Reflective	Building	Absorptive
Path diff. (m):	0.133	0.112	0.133
Screen correction dB(A):	-11.7	-11.2	-11.7
Reflection correction dB(A):	3.8	0.0	0.0
Total:	-7.9	-11.2	-11.7

In this example the flat-roofed building provides a greater degree of screening than the reflective barrier in segment 1. In segment 2 the absorptive barrier provides more screening than the flat-roofed building.

3.6 Angle of view correction: A correction for the angle of view for each segment is required.(Para. 30)

Segment	**1**	**2**			**1**	**2**
Distance d (m)	100	100				
Height h (m)	3.3	3.3				
Distance d' (m)	100.1	100.1	Distance corr.	CHART 3	-6.0	-6.0
			Air abs. corr.	CHART 4	-0.6	-0.6
Soft ground I	1	1				
Height H (m)	2.35	2.35	Ground corr.	CHART 5	-1.3	0.0
Ballast	None	None	Correction	Para. 220.0	0.0	
Screen	Yes	Yes				
Path diff. δ (m)	0.112	0.133	Screen correction	CHART 6(a)	-11.2	-11.7
Refl dist. D (m)	60.0	-	Refl. barr. corr.	CHART 6(c)	0.0	0.0
Angle of view						
$\alpha°$	63.5	39				
$\theta°$	97	58	Correction	CHART 7	-1.4	-5.8
			PROPAGATION CORRECTION		**-20.5**	**-24.1 dB**

STAGE 4: REFLECTION EFFECTS

4.1 Facade correction: A correction is required as the reception point is 1m from a facade. (Para. 31.1)

4.2 Opposite facade correction: There are no buildings or other hard rigid surfaces on the other side of the track and therefore no correction is required. (Para. 31.2)

Segment	**1**	**2**			**1**	**2**
Facade	Yes	Yes	Correction	PARA. 31.1	2.5	2.5
Opposite facade	None	None	Correction	PARA. 31.2	0.0	0.0
			REFLECTION CORRECTION		**+2.5**	**+2.5 dB**

STAGE 5: CONVERTING SELs TO L_{Aeq}

The SEL at the reception point from a single train for each segment is determined by summing the totals from stages 2 to 4.

	1	**2**
Reference noise level SEL_{ref}	99.5	99.5
Propagation Correction	-20.5	-24.1
Reflection Correction	+2.5	+2.5
SEL FOR EACH SEGMENT	**81.5**	**77.9 dB**

The SEL for each segment is then converted to $L_{Aeq,6h}$ and $L_{Aeq,18h}$ using equations 5.1 and 5.2 respectively and entering the appropriate number of trains for each time period. (Para. 32)

Segment	**1**	**2**			**1**	**2**
No of trains						
Q_{NIGHT}	13	13	$L_{Aeq,6h}$	Para. 32	49.3	45.7
Q_{DAY}	179	179	$L_{Aeq,18h}$	Para. 32	55.9	52.3

STAGE 6: CALCULATE THE TOTAL L_{Aeq} FOR THE RAILWAY

The total $L_{Aeq,6h}$ and $L_{Aeq,18h}$ values are calculated by summing the contributions from each segment for the relevant time periods:

Total $L_{Aeq,6h}$	CHART 9	**50.9 dB**
Total $L_{Aeq,18h}$	CHART 9	**57.4 dB**

These values are then rounded to the nearest whole number to give:

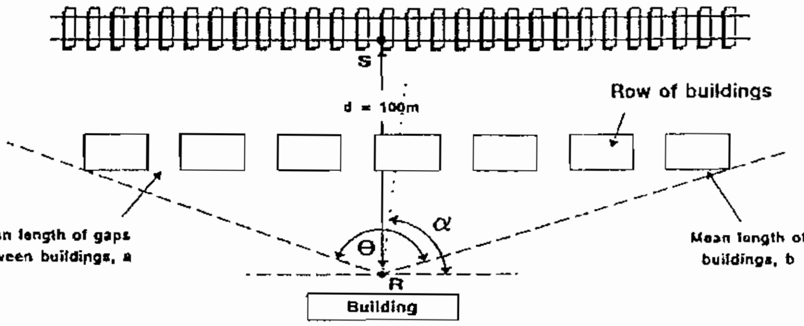
PREDICTED TOTAL $L_{Aeq,6h}$ FOR THE RAILWAY = 51 dB

PREDICTED TOTAL $L_{Aeq,18h}$ FOR THE RAILWAY = 57 dB

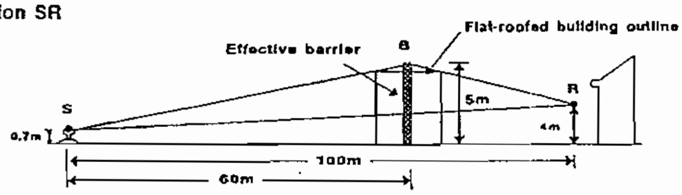
EXAMPLE 13. SINGLE TRACK RAILWAY WITH THE RECEPTION POINT BEHIND A ROW OF BUILDINGS

This example uses a similar layout to Example 12 to illustrate the procedure for calculating the noise from a railway when a row of buildings with gaps are positioned alongside the track. Seven flat-roofed buildings are located between the sourceline and reception point as shown on the plan. As in previous examples the track is at grade and is ballasted CWR. The trains consist of 10 identical passenger coaches. 179 trains pass the reception point during the day and 13 pass during the night. Propagation is over a grass covered area to a reception point located 1m from the facade of a building and 4m above the ground. The contributions of the unscreened outer segments are assumed to be negligible for the purposes of this example.

PLAN



Cross-section SR



OBJECT: To predict the values of $L_{Aeq,6h}$ and $L_{Aeq,18h}$ at a reception point 1m from the facade of a building, at 1st floor level.

STAGE 1: DIVIDE THE RAILWAY INTO SEGMENTS

The trains are all of one type and are travelling on a single straight and level track. As shown on the plan and cross-section a row of houses are located such that each forms an effective barrier of height 5m at a distance of 60m from the nearside railhead. Using the method described in Para 26.3, Figure 6c, with suitably adjusted segment angles, the individual buildings are considered together as a single screened segment and the gaps between the buildings are considered together as a single unscreened segment. For the purpose of this example, railway noise from the outer segments are assumed to have a negligible contribution to the overall noise from the railway. Two segments are required with a total angle of view, θ, of 155°.
Segment 1 is the unscreened segment and segment 2 is the screened segment.

INPUT DATA:

Mean length of gaps between buildings, a = 9m. Mean length of buildings, b = 17.6m.
Correction to angle of view, Y = b/(a + b) = 0.66.

Segment:	**1**	**2**
Ground cover	Grassland	Grassland
Angle of view	$\theta(1\text{-}Y)$ = 155x(1-0.66) = 52.44°	θY = 155 x 0.66 = 102.55°

All segments:

Track 1:	Continuously Welded Rail (CWR) on ballast (B)			
Train type 1:	Category 1.	10 tread braked passenger coaches.	Speed	= 150 km/h
	Number of trains:	Midnight - 0600 hrs	Q_{NIGHT}	= 13
		0600 hrs - Midnight	Q_{DAY}	= 179
	Reception point:	Height above rail head	h	= 3.3 m
		Distance from track	d	= 100 m
	Av. hgt. of propagation (rail head 0.7m above ground)		H	= (4 + 0.7)/2 = 2.35 m

STAGE 2: CALCULATE THE REFERENCE NOISE LEVEL SEL_{ref}

2.1 Reference noise level: Each train operating on the track consists only of category 1 vehicles travelling at 150 km/h. The baseline SEL (single vehicle) at a reference distance of 25 m is determined from Chart A1.1 and then corrected for vehicle type using Table A1.1. (Para.14)

2.2 Correction for the number of vehicles: The baseline SEL for a single vehicle is adjusted to take account of the number of vehicles in the train, which for this example is 10. The correction is determined by using Chart 2. (Para.15)

2.3 Track/support structure correction: The track is CWR laid on ballast. Table 1 shows that no correction is required. (Para.16)

Segment	1	2			1	2
Train type	1	1				
Speed V (km/h)	150	150	Baseline SEL	CHART A1.2	74.7	74.7
			Correction	TABLE A1.1	14.8	14.8
No of vehicles N	10	10	Correction	CHART 2	10.0	10.0
Track/support	CWR/B	CWR/B	Correction	TABLE 1	0.0	0.0
			REFERENCE NOISE LEVEL SEL_{ref}		**99.5**	**99.5 dB**

STAGE 3: PROPAGATION

3.1 Distance correction: The reception point is 3.3m above the rail head and 100m from the track, a correction for distance is required using Chart 3. The value to enter into Chart 3 is the value of the slant distance d'. (Figure 1. Para. 19)

3.2 Air absorption correction: A correction is required for air absorption, Chart 4. (Para. 20).

3.3 Ground correction: For segment 1 which represents the unscreened sections of track the propagation is over grassland. A correction is required (Chart 5. Para. 21). For segment 2, which is screened, no correction is required.

3.4 Correction for ballasted track: Although the track is laid on ballast no correction is required since only a single track is being considered. (Para. 22)

3.5 Screening correction: For segment 2 which approximates the screening provided by the individual buildings a correction is required. The path difference is calculated for the effective barrier in the vertical plane RS using the equation SB + BR-SR = 0.112m. The screening performance is calculated using Charts 6(a) or 6(b) and 6(c).

3.6 Angle of view correction: A correction for the angle of view for each segment is required.(Para. 30)

Segment	1	2			1	2
Distance d (m)	100	100				
Height h (m)	3.3	3.3				
Distance d' (m)	100.1	100.1	Distance corr.	CHART 3	-6.0	-6.0
			Air abs. corr.	CHART 4	-0.6	-0.6
Soft ground I	1	1				
Height H (m)	2.35	2.35	Ground corr.	CHART 5	-1.3	0.0
Ballast	None	None	Correction	Para. 220.0	0.0	
Screen	None	Yes				
Path diff. δ (m)		0.112	Screen correction	CHART 6(a)	0.0	-11.2
D (m)		60	Refl. barr. corr.	CHART 6(c)	0.0	0.0
Angle of view						
$\alpha°$	87.5	87.5				
$\theta°$	52.4	102.6	Correction	CHART 7	-2.7	-0.6
			PROPAGATION CORRECTION		**-10.6**	**-18.4 dB**

STAGE 4: REFLECTION EFFECTS

4.1 Facade correction: A correction is required as the reception point is 1m from a facade. (Para. 31.1)

4.2 Opposite facade correction: There are no buildings or other hard rigid surfaces on the other side of the track and therefore no correction is required. (Para. 31.2)

Segment	1	2			1	2
Facade	Yes	Yes	Correction	PARA. 31.1	2.5	2.5
Opposite facade	None	None	Correction	PARA. 31.2	0.0	0.0
			REFLECTION CORRECTION		**+2.5**	**+2.5 dB**

STAGE 5: CONVERTING SEL TO L_{Aeq}

The SEL at the reception point from a single train for each segment is determined by summing the totals from stages 2 to 4.

	1	2
Reference noise level SEL_{ref}	99.5	99.5
Propagation Correction	-10.6	-18.4
Reflection Correction	+2.5	+2.5
SEL FOR EACH SEGMENT	**91.4**	**83.6 dB**

The SEL for each segment is then converted to $L_{Aeq,6h}$ and $L_{Aeq,18h}$ using equations 5.1 and 5.2 respectively and entering the appropriate number of trains for each time period. (Para. 32)

Segment	1	2			1	2
No of trains						
Q_{NIGHT}	13	13	$L_{Aeq,6h}$	Para. 32	59.2	51.4
Q_{DAY}	179	179	$L_{Aeq,18h}$	Para. 32	65.8	58.0

STAGE 6: CALCULATE THE TOTAL L_{Aeq} FOR THE RAILWAY

The total $L_{Aeq,6h}$ and $L_{Aeq,18h}$ values are calculated by summing the contributions from each segment for the relevant time periods:

Total $L_{Aeq,6h}$	CHART 9	**59.9 dB**
Total $L_{Aeq,18h}$	CHART 9	**66.5 dB**

These values are then rounded to the nearest whole number to give:

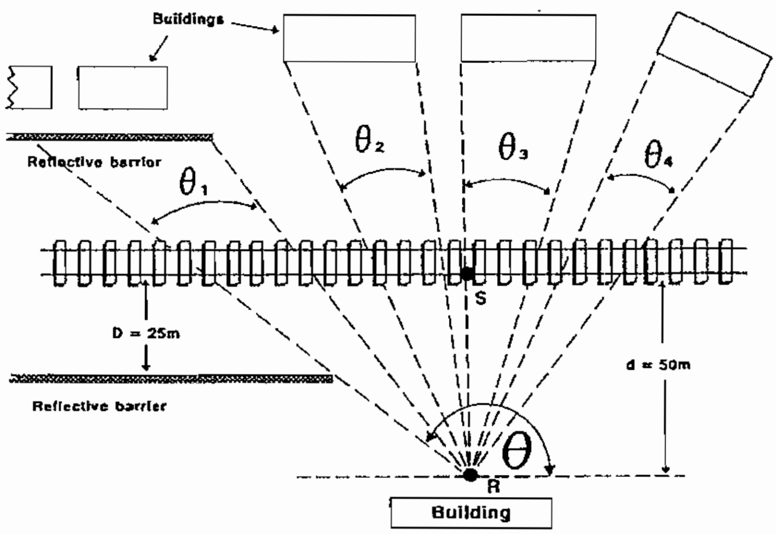
PREDICTED TOTAL $L_{Aeq,6h}$ FOR THE RAILWAY = 60 dB

PREDICTED TOTAL $L_{Aeq,18h}$ FOR THE RAILWAY = 67 dB

EXAMPLE 14. SINGLE TRACK RAILWAY WITH PARALLEL NOISE BARRIERS AND A FAR SIDE ROW OF BUILDINGS

This example illustrates the calculation procedure for a single track railway where the source line passes between parallel noise barriers and where a row of buildings are situated on the far side of the track. The track is at grade and is ballasted CWR. The trains consist of 10 identical tread braked passenger coaches. 179 trains pass the reception point during the day and 13 trains pass during the night. The barriers are reflective, 2.7m high and located as shown on the plan. Propagation is over a grass covered area to a reception point located 1m from the facade of a building and 4m above the ground.

PLAN



OBJECT: To predict the values of $L_{Aeq,6h}$ and $L_{Aeq,18h}$ at a reception point 1 m from the facade of a building, at 1st floor level.

STAGE 1: DIVIDE THE RAILWAY INTO SEGMENTS

The trains are of one type and are travelling on a single straight and level track. As shown on the plan two reflective barriers of height 2.7m lie parallel with the source line, one on either side of the track. A row of buildings are situated along the far side of the track. Two segments are required with angles of view 38° and 142°.

INPUT DATA:

Segment:	1	2
Ground cover	Grassland	Grassland
Angle of view	38°	142°

All segments:

Track 1:	Continuously Welded Rail (CWR) on ballast (B)			
Train type 1:	Category 1.	10 tread braked passenger coaches.	Speed	= 150 km/h
	Number of trains:	Midnight - 0600 hrs	Q_{NIGHT}	= 13
		0600 hrs - Midnight	Q_{DAY}	= 179
	Reception point:	Height above rail head	h	= 3.3 m
		Distance from track	d	= 50 m
	Av. hgt. of propagation (rail head 0.7m above ground)		H	= (4 + 0.7)/2 = 2.35 m

STAGE 2: CALCULATE THE REFERENCE NOISE LEVEL SEL_{ref}

2.1 Reference noise level: Each train operating on the track consists only of category 1 vehicles travelling at 150 km/h. The baseline SEL (single vehicle) at a reference distance of 25 m is determined from Chart A1.1 and then corrected for vehicle type using Table A1.1. (Para.14)

2.2 Correction for the number of vehicles: The baseline SEL for a single vehicle is adjusted to take account of the number of vehicles in the train, which for this example is 10. The correction is determined by using Chart 2. (Para.15)

2.3 Track/support structure correction: The track is CWR laid on ballast. Table 1 shows that no correction is required. (Para.16)

Segment	1	2			1	2
Train type	1	1				
Speed V (km/h)	150	150	Baseline SEL	CHART A1.2	74.7	74.7
			Correction	TABLE A1.1	14.8	14.8
No of vehicles N	10	10	Correction	CHART 2	10.0	10.0
Track/support	CWR/B	CWR/B	Correction	TABLE 1	0.0	0.0
			REFERENCE NOISE LEVEL SEL_{ref}		99.5	99.5 dB

STAGE 3: PROPAGATION

3.1 Distance correction: The reception point is 3.3m above the rail head and 50m from the track, a correction for distance is required using Chart 3. The value to enter into Chart 3 is the value of the slant distance d'. (Figure 1. Para. 19)

3.2 Air absorption correction: A correction is required for air absorption, Chart 4. (Para. 20).

3.3 Ground correction: Segment 1 is screened therefore no correction is required. Segment 2 is unscreened and the ground cover between the reception point and source position is grassland. A correction is required. (Chart 5. Para. 21)

3.4 Correction for ballasted track: Although the track is laid on ballast no correction is required since only a single track is being considered (Para. 22). In addition it should be noted that no correction would be needed for screened segments, (Para. 24).

3.5 Screening correction: For segment 1, which is screened by a reflective barrier, a correction is required. The path difference is calculated in the vertical plane SR as in previous examples. The geometry is the same as before, $\delta = SB + BR - SR = 0.004m$. The barrier is situated such that D > 20m and therefore the correction using Chart 6(c), is zero. An additional correction is required for the reflective noise barrier situated on the far side of the track (Para. 29. Figure 8b). This barrier is 2m above the railhead and the correction equals 0.5 x 2 = 1 dB(A). (ie. +0.5 dB(A) per metre of far side barrier height which is above the railhead). (Para. 29).

3.6 Angle of view correction: A correction for the angle of view for each segment is required.(Para. 30)

Segment	1	2
Distance d (m)	50	50
Height h (m)	3.3	3.3
Distance d' (m)	50.1	50.1
Soft ground I	1	1
Height H (m)	2.35	2.35
Ballast	None	None
Screen	Yes	None
Path diff. δ (m)	0.004	-
D (m)	25.0	-
Angle of view		
$\alpha°$	19	64
$\theta°$	38	142

		1	2
Distance corr.	CHART 3	-3.0	-3.0
Air abs. corr.	CHART 4	-0.2	-0.2
Ground corr.	CHART 5	0.0	-0.7
Correction	Para. 22	0.0	
Screen correction	CHART 6(a)	-6.1	0.0
Refl. barr. corr.	CHART 6(c)	0.0	0.0
Dual barrier corr.	PARA. 29	1.0	-
Correction	CHART 7	-12.5	-0.4
PROPAGATION CORRECTION		-20.	-4.3 dB

STAGE 4: REFLECTION EFFECTS

4.1 Facade correction: A correction is required as the reception point is 1m from a facade. (Para. 31.1)

4.2 Opposite facade correction: A row of buildings and part of the reflective barrier are situated along the far side of the railway subtending a combined angle, θ', of 63° $(\theta_1 + \theta_2 + \theta_3 + \theta_4)$. A correction is required (Para. 31.2, Figure 10), which is given by the equation $+1.5 \times (\theta'/\theta) = +1.5 \times (63/142) = +0.7$ dB(A). NB. Reflections from the far side barrier were taken into account at stage 3 of segment 1 calculations.

Segment	1	2
Facade	Yes	Yes
Opposite facade	-	Yes

		1	2
Correction	PARA. 31.1	2.5	2.5
Correction	PARA. 31.2	0.0	0.7
REFLECTION CORRECTION		+2.5	+3.2 dB

STAGE 5: CONVERTING SEL TO L_{Aeq}

The SEL at the reception point from a single train for each segment is determined by summing the totals from stages 2 to 4.

	1	2
Reference noise level SEL_{ref}	99.5	99.5
Propagation Correction	-20.8	-4.3
Reflection Correction	+2.5	+3.2
SEL FOR EACH SEGMENT	81.2	98.4 dB

The SEL for each segment is then converted to $L_{Aeq,6h}$ and $L_{Aeq,18h}$ using equations 5.1 and 5.2 respectively and entering the appropriate number of trains for each time period. (Para. 32)

Segment	1	2
No of trains		
Q_{NIGHT}	13	13
Q_{DAY}	179	179

		1	2
$L_{Aeq,6h}$	Para. 32	49.0	66.2
$L_{Aeq,18h}$	Para. 32	55.6	72.8

STAGE 6: CALCULATE THE TOTAL L_{Aeq} FOR THE RAILWAY

The total $L_{Aeq,6h}$ and $L_{Aeq,18h}$ values are calculated by summing the contributions from each segment for the relevant time periods:

Total $L_{Aeq,6h}$	CHART 9	66.3 dB
Total $L_{Aeq,18h}$	CHART 9	72.9 dB

These values are then rounded to the nearest whole number to give:

PREDICTED TOTAL $L_{Aeq,6h}$ FOR THE RAILWAY = 66 dB

PREDICTED TOTAL $L_{Aeq,18h}$ FOR THE RAILWAY = 73 dB

APPENDIX A3

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