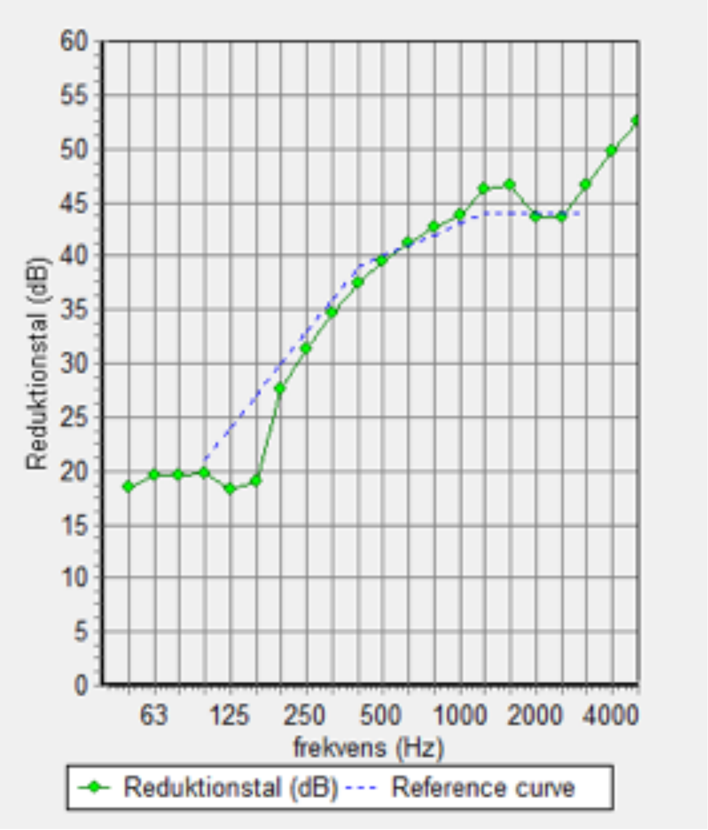
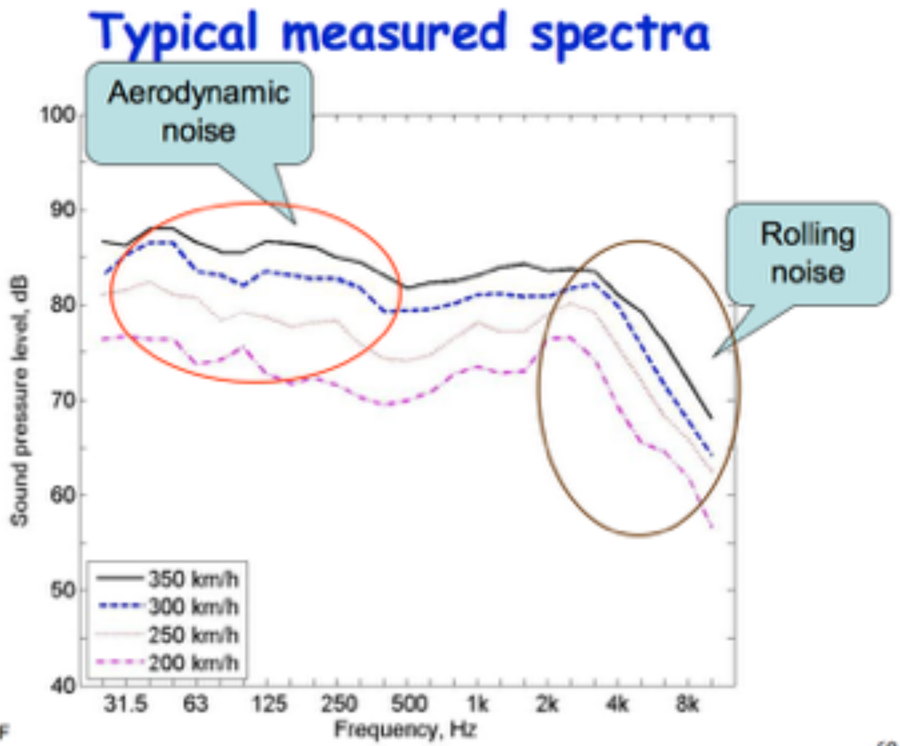
Swosch. Not swisch!

Aerodynamic noise

- Increases more rapidly than mechanical (rolling) noise
- Typical speed dependence of $60 \log_{10} V$ or more
- Important at high speeds, typically above 300 km/h
- Important for interior noise as well as exterior noise
- Sound generated within the acoustic medium increases complexity of analysis and measurement.

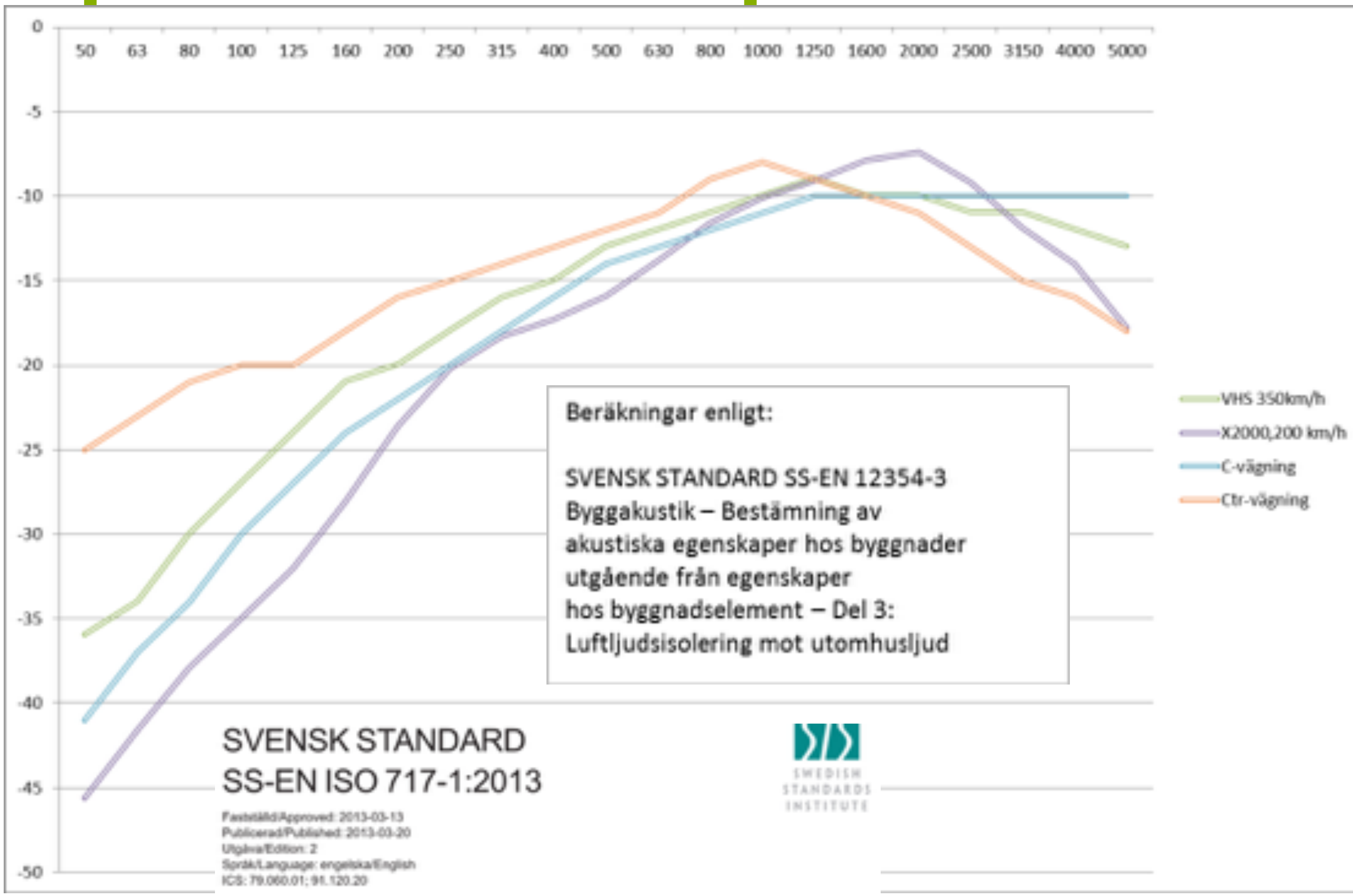
Consequence windows/facade/indoor





Data from SNCF

Simplified – consequence facade



SVENSK STANDARD
SS-EN ISO 717-1:2013

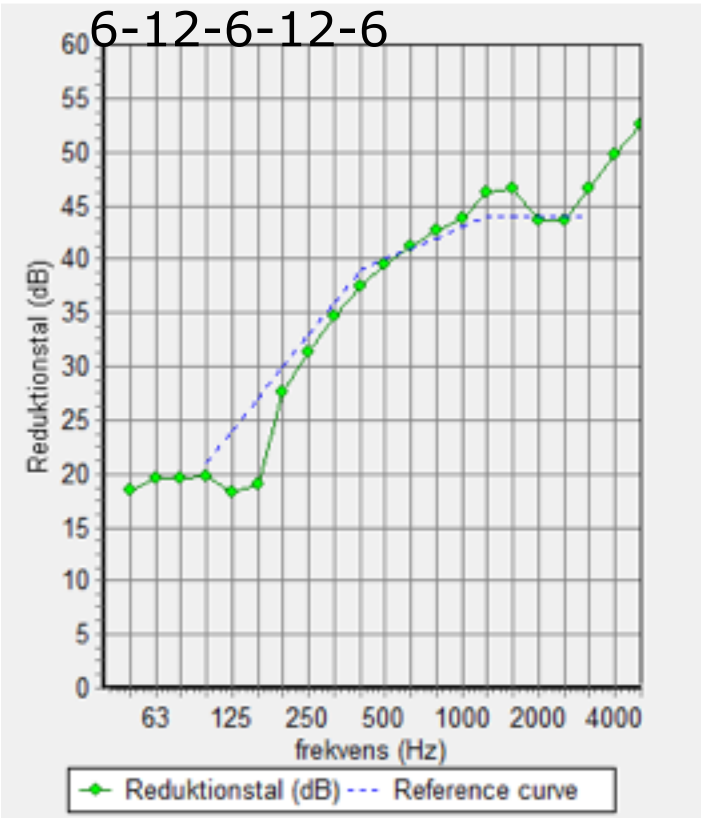
SWEDISH STANDARDS INSTITUTE

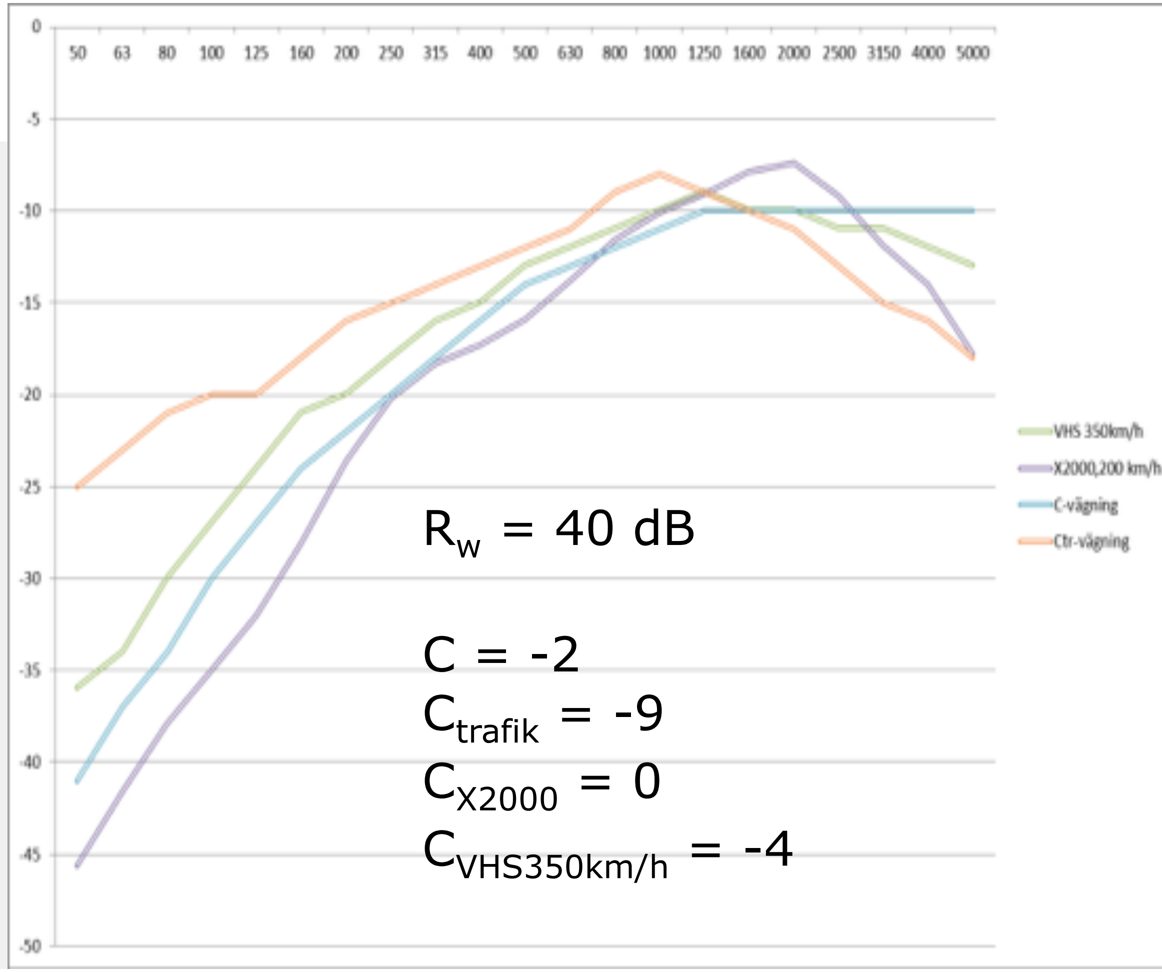
Fastställd/Approved: 2013-03-13
Publicerad/Published: 2013-03-20
Utgåva/Edition: 2
Språk/Language: engelska/English
ICS: 79.060.01; 91.120.20

Byggakustik – Värdering av ljudisolering i byggnader och hos byggdelar –
Del 1: Luftljudsisolering (ISO 717-1:2013)

Impact / facade / Window -> indoor noise

3-pane window
6-12-6-12-6





R_w = 40 dB

C = -2
C_{trafik} = -9
C_{X2000} = 0
$C_{VHS350km/h}$ = -4

Sum up

- Higher speed with aerodynamic noise (low frequency) -> better facade insulation needed
- X2000 (200 km/h) – better facade-insulation than ”ordinary” train
- The spektra of sound insulation matters (heavy glass – better low frequency)

Sound Paths

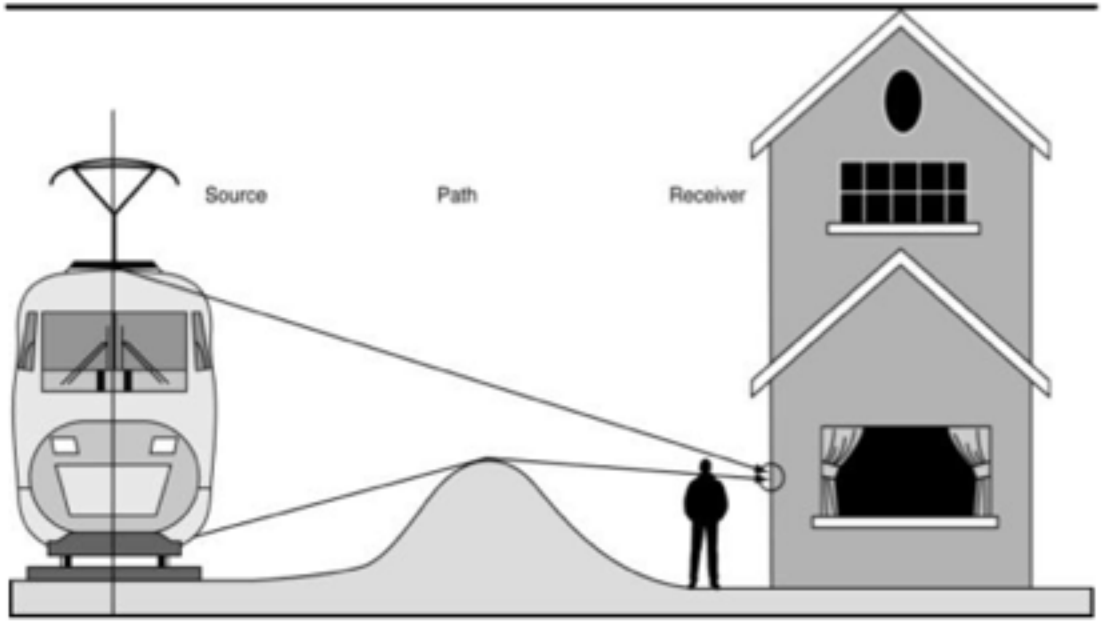
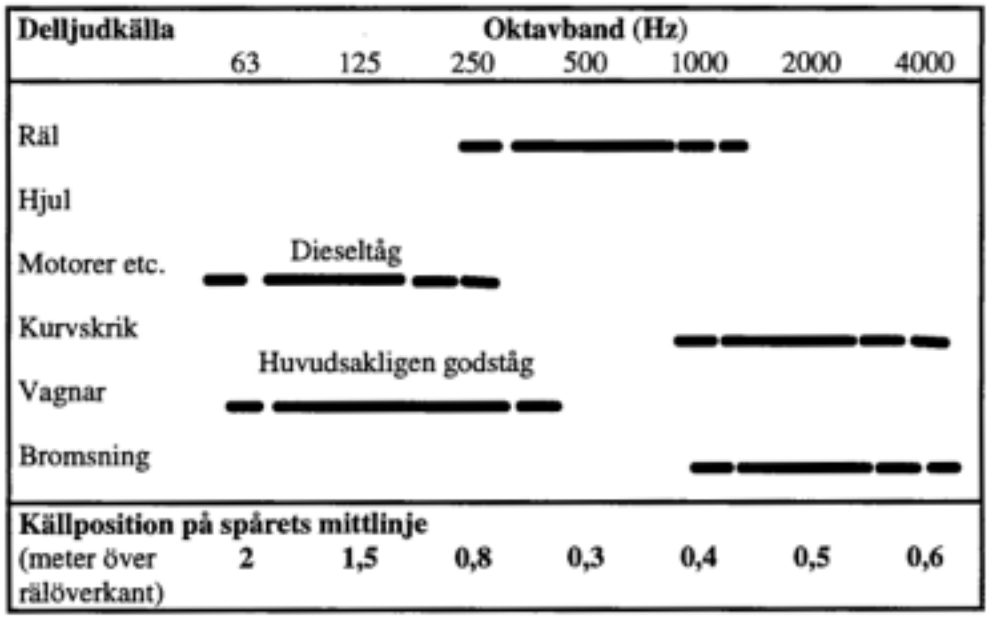


Figure 2-1 The Source-Path-Receiver Framework

Source Height Calculation Model–NMT



Figur 3. Källhöjder som används i NMT. Rälens övre kant är normalt 0,2 m över banvallen.

Maximum height 2 metres

US & Germany

5-10 High-Speed Ground Transportation Noise and Vibration Impact Assessment

Table 5-2 Source Reference SELs at 50 feet

System Category and Features[a]	Example Systems	Subsource Component		Subsource Parameters: Length Definition, len	Subsource Parameters: Height Above Rails (ft)	Reference Quantities: SEL_{ref} (dBA)	Reference Quantities: len_{ref} (ft)	Reference Quantities: S_{ref} (mph)	Reference Quantities: K
HS ELECTRIC • *Steel-Wheeled* • *High-Speed* • *Locomotive-Hauled* • *Electric Power*	X2000 Talgo (electric) Amtrak Acela	Propulsion		len_{power}	3	73	70	90	15
		Wheel-rail		len_{train}	1	83	634	90	28
HS FOSSIL FUEL • *Steel-Wheeled* • *High-Speed* • *Locomotive-Hauled* • *Fossil Fuel Power*	RTL-2 Talgo (gas turbine) Jet-Train	Propulsion		len_{power}	10	83	73	20	10
		Wheel-rail		len_{train}	1	91	634	90	20
HS EMU • *Steel-Wheeled* • *High-Speed* • *Electric Multiple Units (EMU)*	Pendolino IC-T	Propulsion		len_{power}	10	86	73	20	1
		Wheel-rail		len_{train}	1	91	634	90	20
VHS ELECTRIC • *Steel-Wheeled* • *Very High-Speed* • *Locomotive-Hauled* • *Electric Power*	TGV Eurostar ICE Shinkansen	Propulsion		len_{power}	12	86	73	20	0
		Wheel-rail		len_{train}	1	91	634	90	20
		AERO	Train Nose	len_{power}	10	89	73	180	60
			Wheel Region	len_{train}	5	89	634	180	60
			Pantograph	[b]	15	86	-	180	60
MAGLEV	TR08	Propulsion		len_{train}	1.5	68	165	90	8
		Guideway/Structural		len_{train}	-3	80	295	90	30
		AERO	Train Nose	len_{power}	5	61	20	90	50
			TBL[c]	len_{train}	10	78	82	120	50

[a] *HS* (High-Speed) = maximum speed 150 mph
VHS (Very High-Speed) = maximum speed 250 mph
MAGLEV = maximum speed 300 mph

[b] originates as a point source (no length)

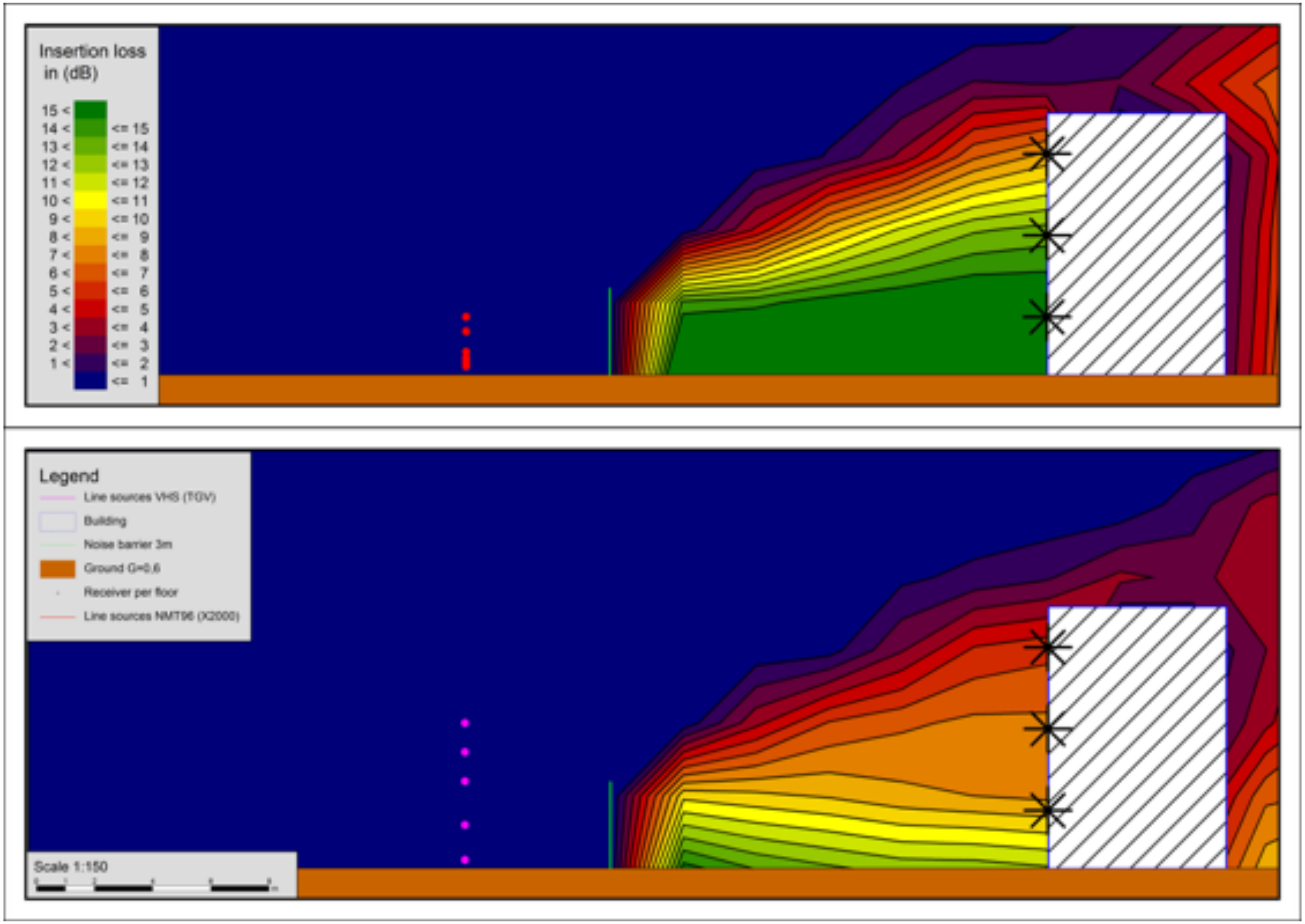
[c] Turbulent Boundary Layer

Tabelle 5: Schallquellenarten an Fahrzeugen für Eisenbahnen

Spalte	A	B	C	D	E
Zeile	**Schallquellen-art**	**Höhenbe-reich h**	**Höhe h_s über SO**	**Teilquellen m**	**Geräuschursache, Komponente**
1	Rollgeräusche	1	0 m	1	Schienenrauheit
2		1	0 m	2	Radrauheit
3		2	4 m	3	Abstrahlung des als Körperschall übertragenen Rollgeräusches aufgrund der Schienenrauheit durch Kesselwagenaufbauten
4		2	4 m	4	Abstrahlung des als Körperschall übertragenen Rollgeräusches aufgrund der Radrauheit durch Kesselwagenaufbauten
5	Aerodynamische Geräusche	3	5 m	5	Stromabnehmerwippe
6		2	4 m	6	Stromabnehmerfuß, Gitter von Kühl- und Klimaanlagen im Dachbereich
7		1	0 m	7	Umströmung der Drehgestelle
8	Aggregatgeräusche	2	4 m	8	Ventilatoren von Kühl- und Klimaanlagen, Saugseite im Dachbereich
9		1	0 m	9	Ventilatoren von Kühl- und Klimaanlagen, Saug- und Druckseite im Unterflurbereich
10	Antriebsgeräusche	2	4 m	10	Abgasanlage
11		1	0 m	11	Motor, Getriebe

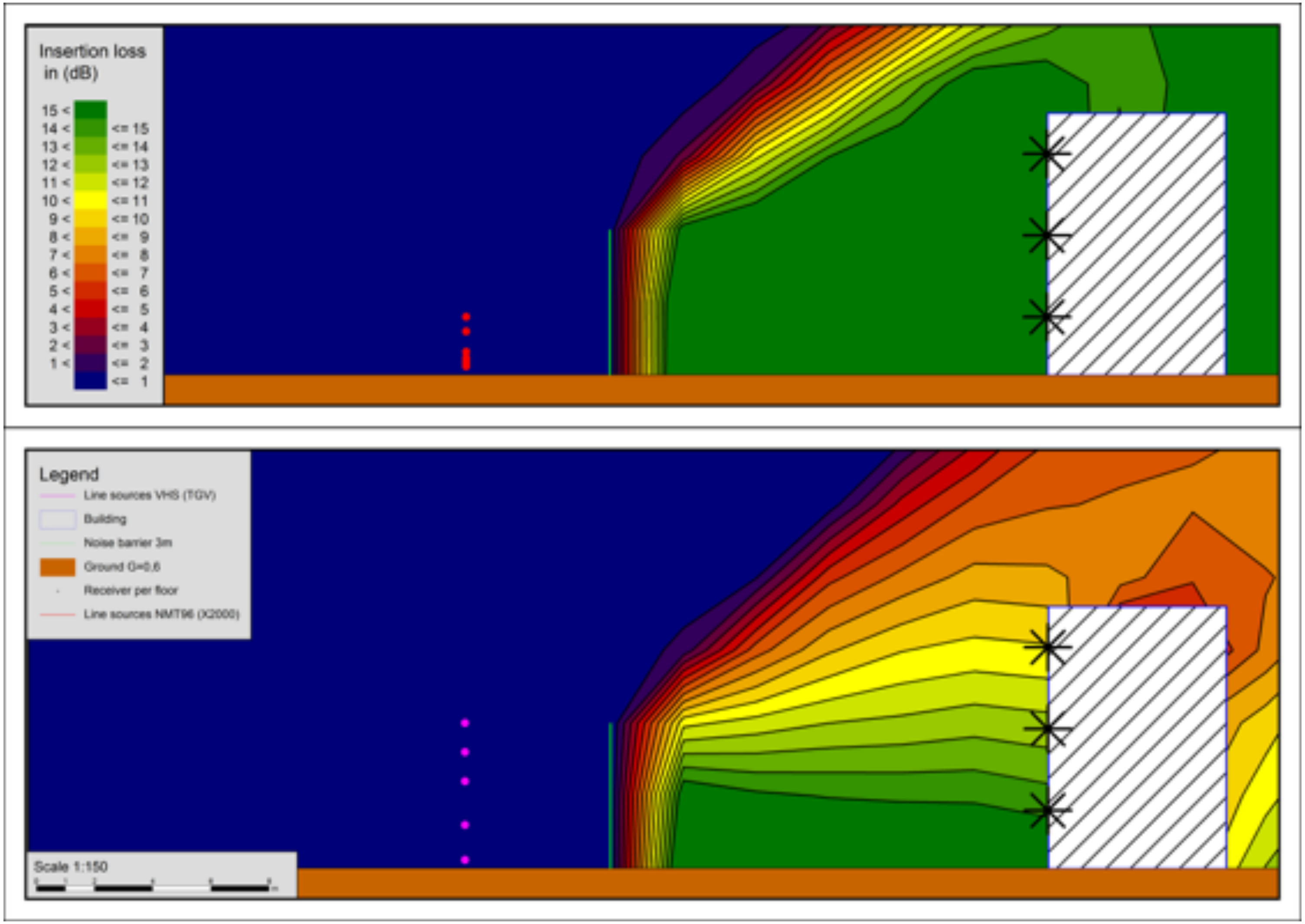
A) Verkehrslärmschützverordnung – 16.BlmSchV (2012)
B) High-Speed Ground Transportation Noise and Vibration Impact Assessment (2005)

3 meter noise reduction screen



ÅF 2014, test new in house calculation method

5 meter noise reduction screen



ÅF 2014, test new in house calculation method

Experience - Netherlands

Noise barriers

High speed line in the Netherlands

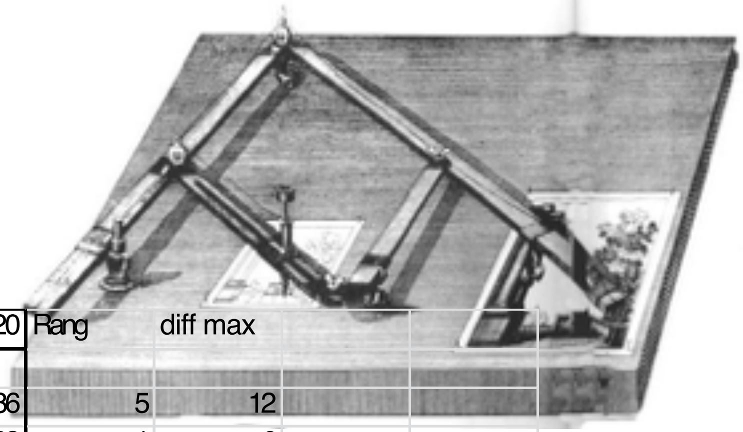
- Many noise barriers
- Some are up to 12 m high (railway + motorway).
- Tunnel under 'Groene Hart'.

- Costly
- Visually intrusive
- Control at source potentially more cost-effective

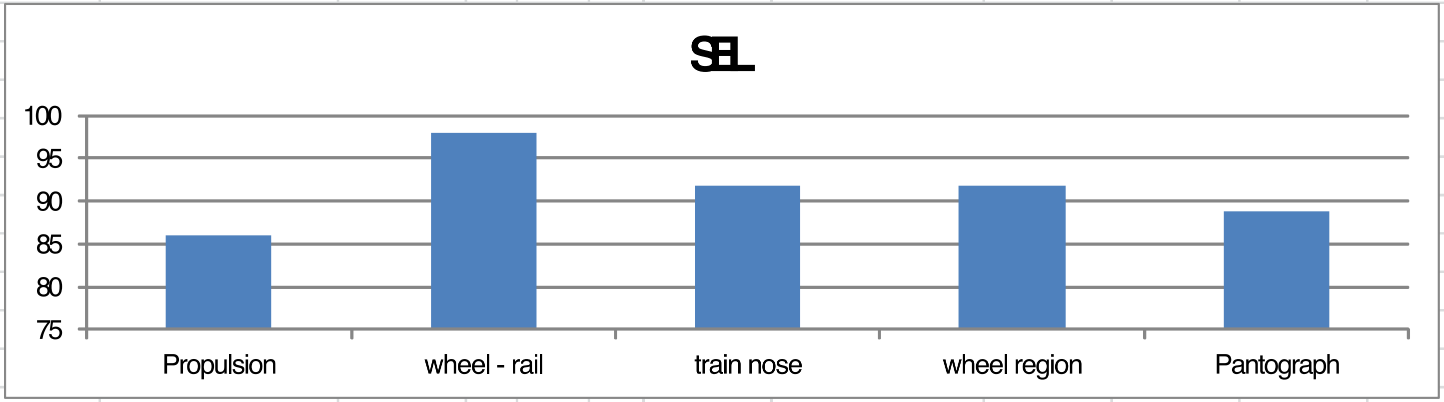
Noise barriers – Dutch high speed line

David Thompson, ISVR,
Southampton,
Storbritannien

Source Strength -Ranking



					Speed [km	320	Rang	diff max
Source	height	sel	mph	k	km/h	SEL at speed		
Propulsion	12	86	20	0	32	86	5	12
wheel - rail	1	91	90	20	144	98	1	0
train nose	10	89	180	60	288	92	2	6
wheel region	5	89	180	60	288	92	2	6
Pantograph	15	86	180	60	288	89	4	9



Landscape Bridges - NMT

Räl med skarv	$\Delta L_e = +3$ dB
10 m spårlängd för vardera av växlar och korsningar	$\Delta L_e = +6$ dB
Delsträckor på bro utan ballast	$\Delta L_e = +6$ dB
Delsträckor på bro med ballast	$\Delta L_e = +3$ dB

Own experience:

	Brotyp	Ljudnivåskillnad, dB(A).
1.	Broar helt i stål utan ballast	+8 till +12
3.	Stålbroar med ballastfyllning och under-liggande bärande låd- eller I-balkar	+1 till +5
4.1	Ballastfyllda betongtråg på under-liggande bärande lådbalkar av stål	+1 till +4
4.2	Ballastfyllda betongtråg på under-liggande bärande I-balkar av stål	-4 till +1
4.3	Ballastfyllda betongtråg mellan bärande höga I-balkar av stål (avskärmande)	-5 till -1
5.	Ballastfyllda helbetongkonstruktioner	-1 till +3

Slab track - bridges

“Slab track is noisy”

- Slab track is used for high speed lines in Germany and Netherlands
- Slab track has a reputation for being noisy

- Dutch high speed line has recent high profile noise problems with interim domestic trains (cast-iron brake blocks)
- Thalys noisier on slab track than on ballasted track

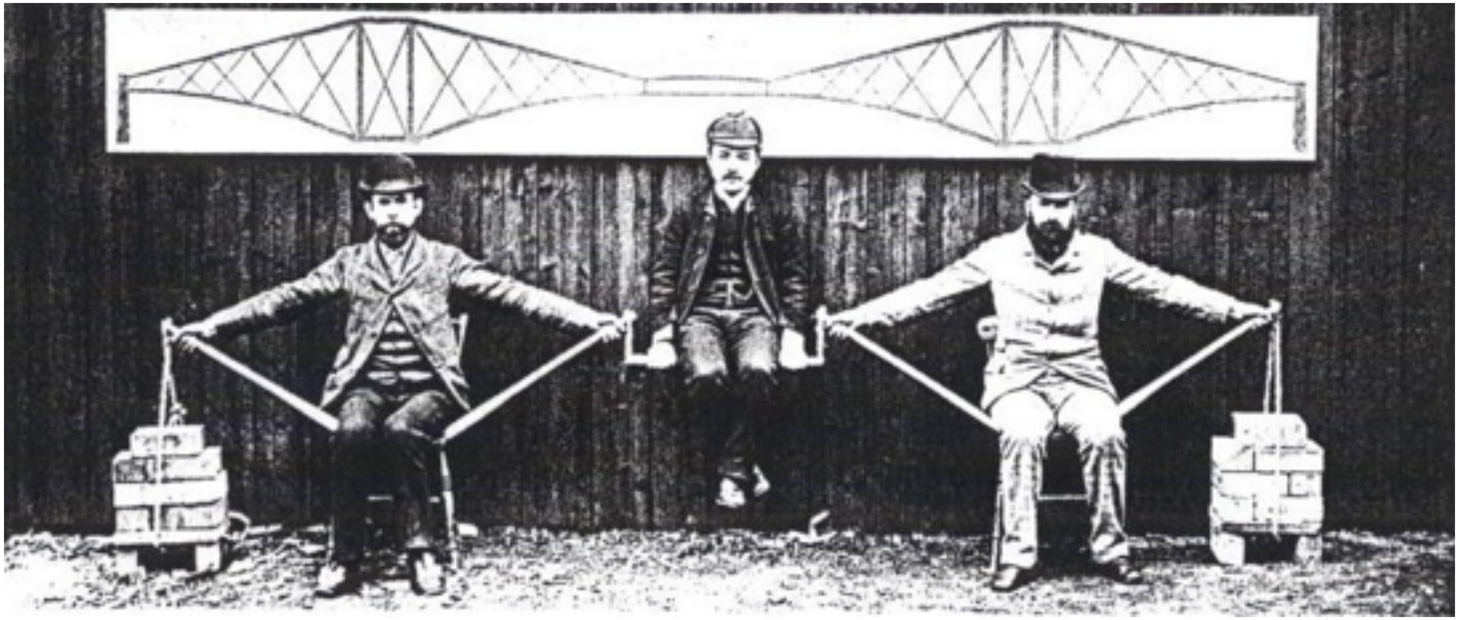
David Thompson, ISVR, Southampton, Storbritannien

Verkehrslärmschützverordnung – 16.BImSchV (2012)

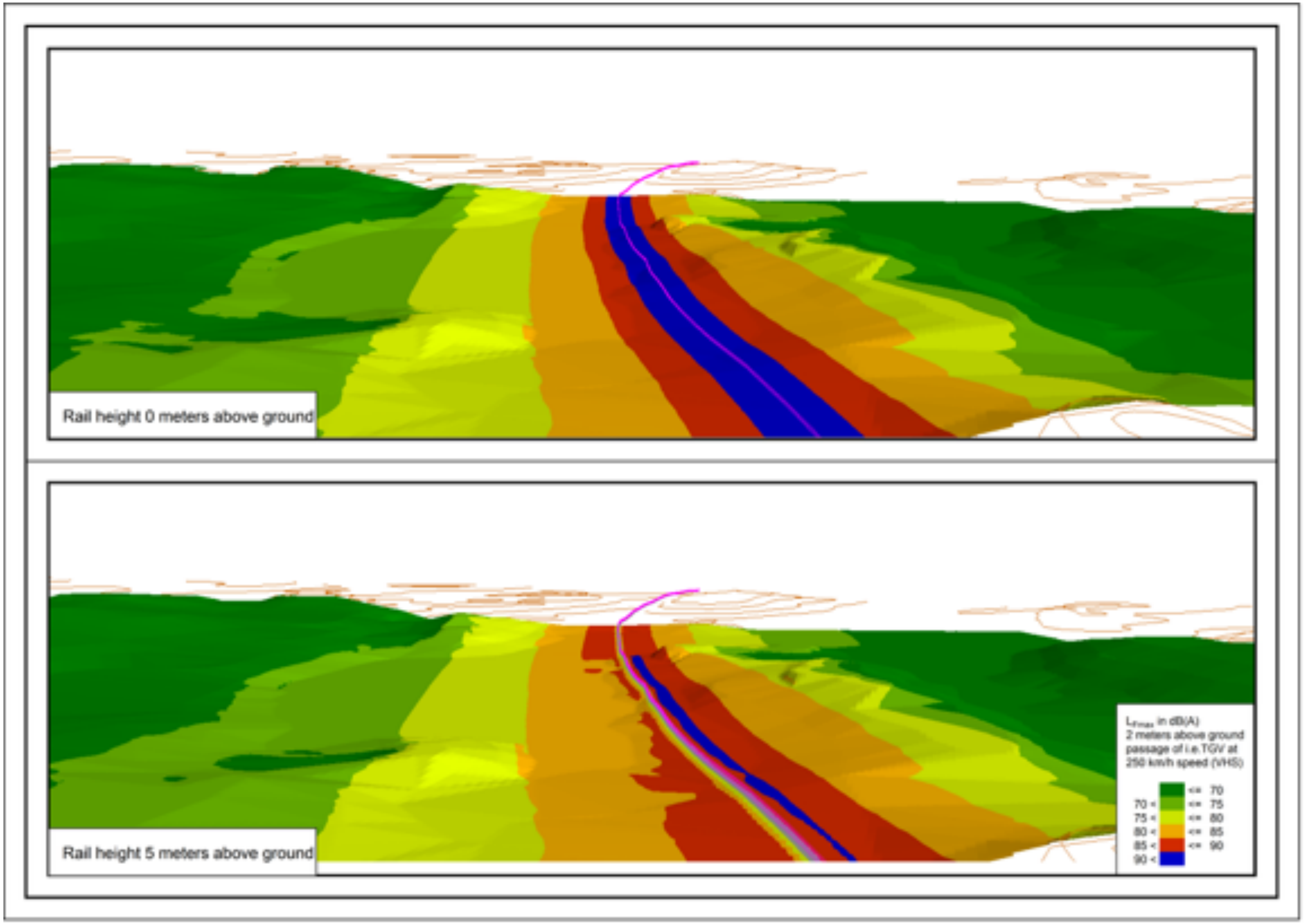
Tabelle 7: Pegelkorrekturen $c1$ für Fahrbahnarten

Spalte	A	B	C							
Zeile	**Einflussgröße**		**Pegelkorrekturen $c1$ in dB für Oktavband-Mittenfrequenz, in Hz**							
			63	125	250	500	1 000	2 000	4 000	8 000
1	**Feste Fahrbahn**	Erhöhte Schienenabstrahlung	0	0	0	7	3	0	0	0
2		Reflexion an der Fahrbahn	1	1	1	1	1	1	1	1

Example showing influence height of bridges



TGV – 250 km/h



ÅF 2014, test new in house calculation method

Speed dependence

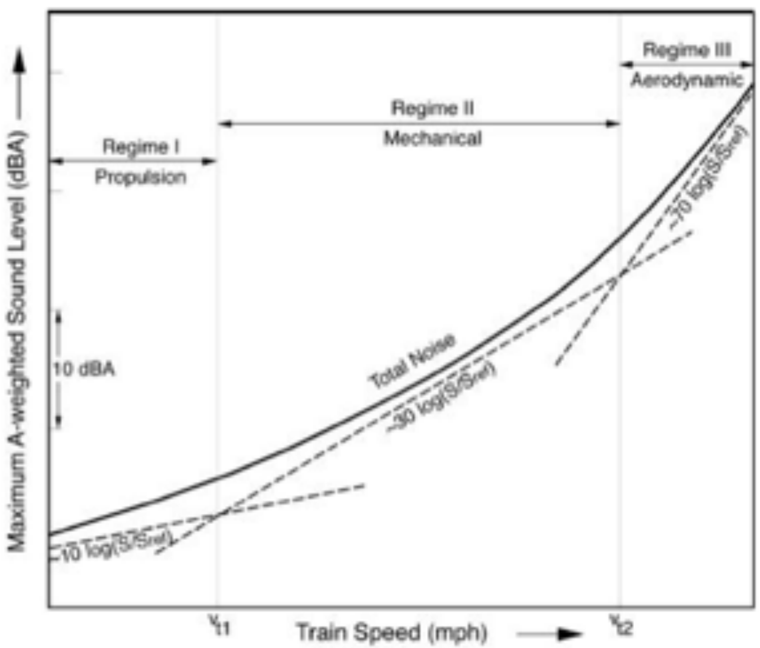
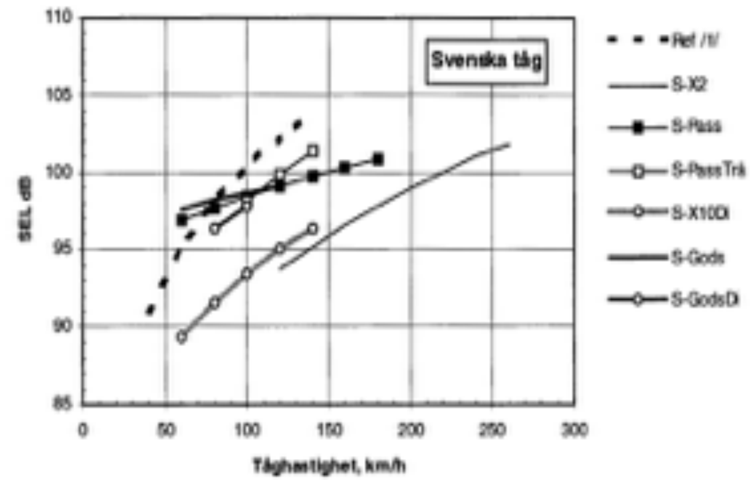


Figure 2-7 Generalized Sound Level Dependence on Speed

US – transit federation

Méthode et données d'émission sonore pour la réalisation des études prévisionnelles du bruit des infrastructures de transportferroviaire dans l'environnement (60-300 km/h)

$$L = L_0 + 30 log \frac{V}{V_0}$$



Figur 2. Svenska tåg

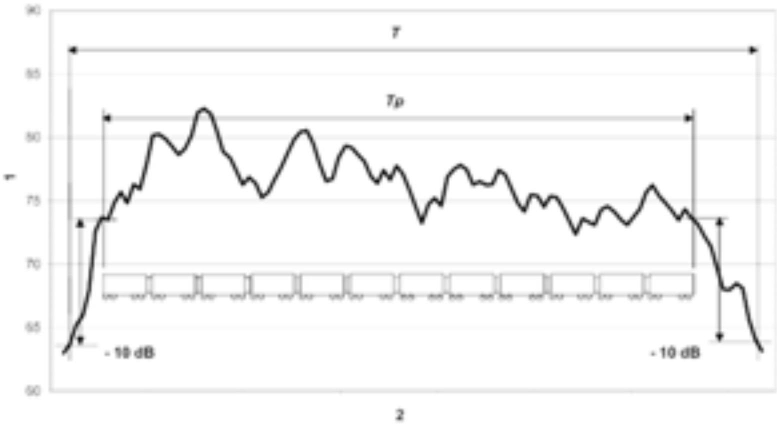
NMT – Nordic Model
Frekvensberoende: ganska invecklad
Ca 27*log(v/v0) för X2000

Tabelle 6: Geschwindigkeitsfaktor b für Eisenbahnen

Spalte	A	B	C							
Zeile	**Schallquellenart**	**Teilquellen** m	**Geschwindigkeitsfaktor** b **in der Oktavband-Mittenfrequenz, in Hz**							
1			63	125	250	500	1 000	2 000	4 000	8 000
2	**Rollgeräusche**	1, 2, 3, 4	–5	–5	–5	0	10	25	25	25
3	**Aerodynamische Geräusche**	5, 6, 7	50							
4	**Aggregatgeräusche**	8, 9	–10							
5	**Antriebsgeräusche**	10, 11	20							

Type de matériel : TGV 200 (TGV–Duplex)

L_0 = 92 dB(A)
à 300 km/h



Vitesse maximale : 300 km/h

Longueur : 200,1 m

Type de freinage : Disques sur bogies moteurs (motrices)
Disques sur bogies porteurs (remorques)

Point de mesure : d = 25 m, h = 3,5 m

Fichier DEF

TGV-D
#RAME
.IDENTIFICATION : TGV-D
.LONGUEUR : 200,1 m
.NOMBRE.BOGIES : 13
.ESPACEMENT : 15 m
.VITESSE : 300 km/h
.VARIATION : 30 * log10 (V/Vréf)
.FREQUENCE : 125 250 500 1000 2000 4000 Hz
.PUISSANCE : 117.7 116.7 116.6 118.2 119.2 116.2 dB

Niveaux sonores et spectre de référence au point de mesure en $L_{eq,tp}$

1/3 oct.	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz
dB	84,5	83,0	81,2	81,0	82,0	81,6
1/3 oct.	400 Hz	500 Hz	630 Hz	800 Hz	1000 Hz	1250 Hz
dB	81,0	80,3	80,4	81,4	81,7	82,1
1/3 oct.	1600 Hz	2000 Hz	2500 Hz	3150 Hz	4000 Hz	5000 Hz
dB	81,5	81,0	82,8	80,8	77,5	74,5

Tp - EN ISO 3095:2005 (E)

Méthode et données d'émission sonore pour la réalisation des études prévisionnelles du bruit des infrastructures de transport ferroviaire dans l'environnement

SNCF, 2007

Maximum Level?

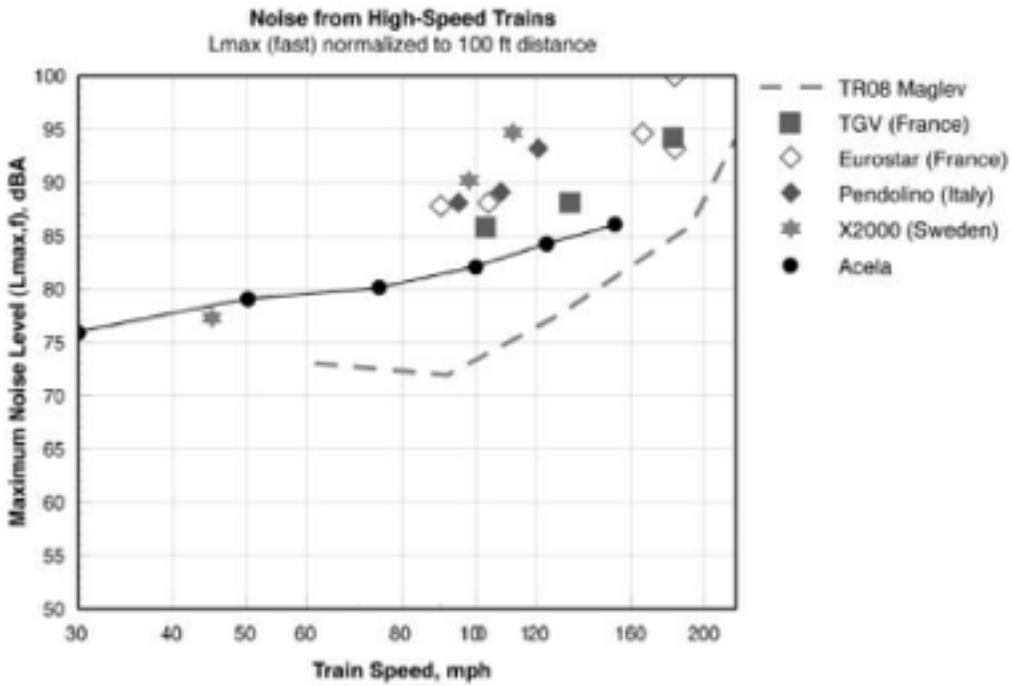


Figure 2-13 Measured Values of $L_{max,s}$ vs Speed from High-Speed Trains

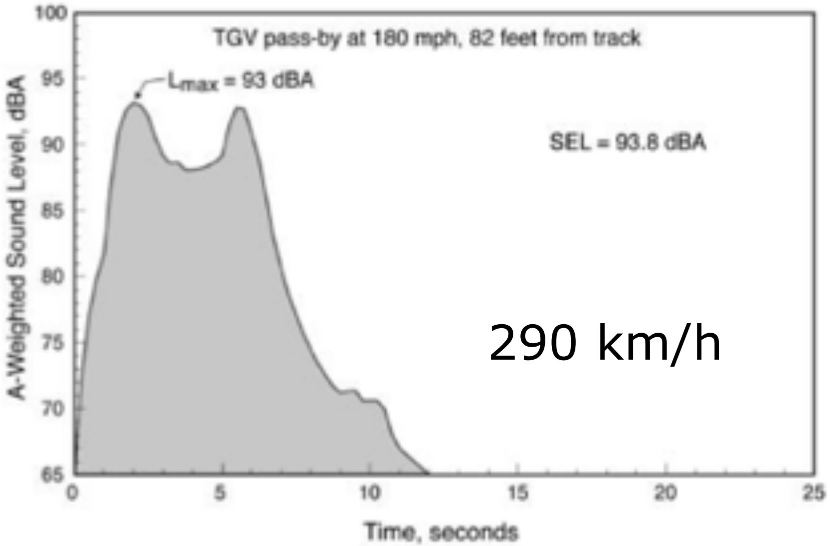


Figure 2-3 Typical High-Speed Train Passby

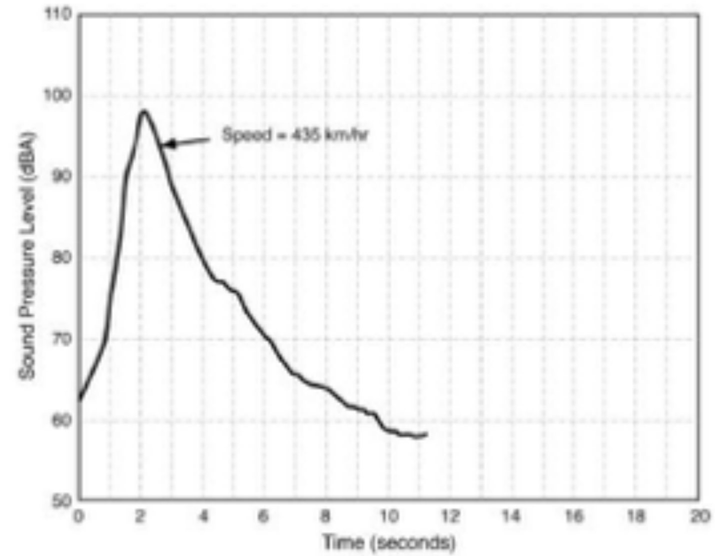


Figure A-6 Time History of A-Weighted Sound Level of Maglev at 25 m

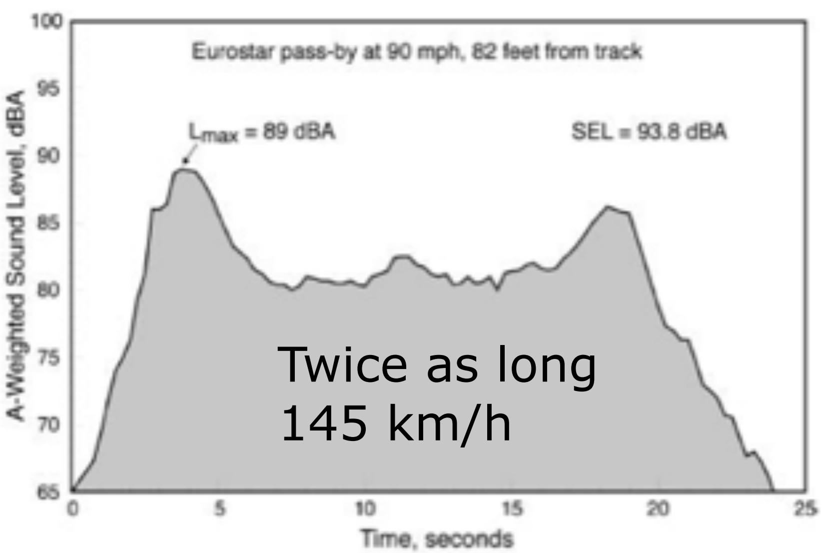


Figure 2-4 Typical Longer-Duration High-Speed Train Event

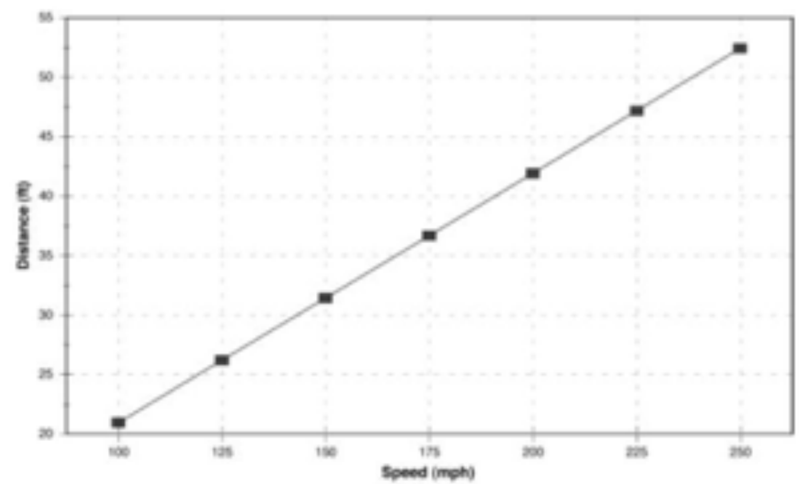


Figure 4-2 Distance from Tracks within which Surprise Can Occur for HST

On-set rate!

Structure Borne Sound
Safety distance/Speed dependencies

On the basis och measurements and calculations we have concluded these speed dependencies:

- 20*log(v/vref) between 80-160 km/h
- 10*log(v/vref) between¨r 160-240 km/h
- 18*log(v/vref) between¨r 240-320 km/h
- Constant over 320 km/h

	80 km/h	200 km/h	320 km/h
safety distance	1	1,6-2,2	2,0-2,8