07.02 Traffic Noise at Roadside Development (Edition 1997)

Overview

In Berlin there are currently 1.28 million motor vehicles registered. Not only does their use lead to enormous noise pollution in the road areas but, also both day and night, permanently detract from the living and occupational quality of the buildings and land located near the main network road. The effects are particularly grave in streets with traffic volumes exceeding 50,000 motor vehicles per 24 hour period. (e.g. Sachsendamm, Schöneberger Ufer, Frankfurter Allee, Gruner Strasse and See Strasse). Although these streets comprise only 1.7 % of the total length of the approx. 1,200 km long primary road network (main network), they carry approx. 19 % of all vehicle traffic.

Technical construction modifications to motor vehicles have resulted in significant reductions in the level of motor noise in the past years. In 1983, the EC's permissible noise emission level for motor vehicles lay at about 10 dB above today's limit, i.e. 10 vehicles of the current models are - from the standpoint of motor noise - not louder than one which was registered in 1983.

Despite that Berlin's streets have not become any quieter. The reason for this is the enormous increase in motor vehicle traffic and the fact that virtually no progress has been made in reducing the amount of noise from tires and road surfaces. The introduction of "30 km / hour" zones for 70 % of all roads has resulted in a reduction of traffic noise but, noise in the main traffic arteries has increased. Noticeable reductions can also be found for the sections of the tram network where the track beds have been renewed.

As a whole it is the noise from the primary road network - compared with other sources such as rail and air traffic, industry and small business as well as sports and leisure noise which because of both its extent and the number of affected persons - presents the most problematic pollution.

Noise is to be understood as every kind of sound which is undesired, disturbs, or irritates, and which detracts from physical, psychological, or social well-being.

Depending on the duration and intensity, noise can lead to a number of problems. Some of these are among others:

- reduction of the ability to concentrate,
- communications disturbances,
- disturbances to sleep and recreation,
- negative influences on vegetative nervous system (high blood pressure, cardio-vascular-complaints, disturbances in digestive organs),
- obstructions resp. damage to hearing,
- increased risk of cardio-vascular illnesses.

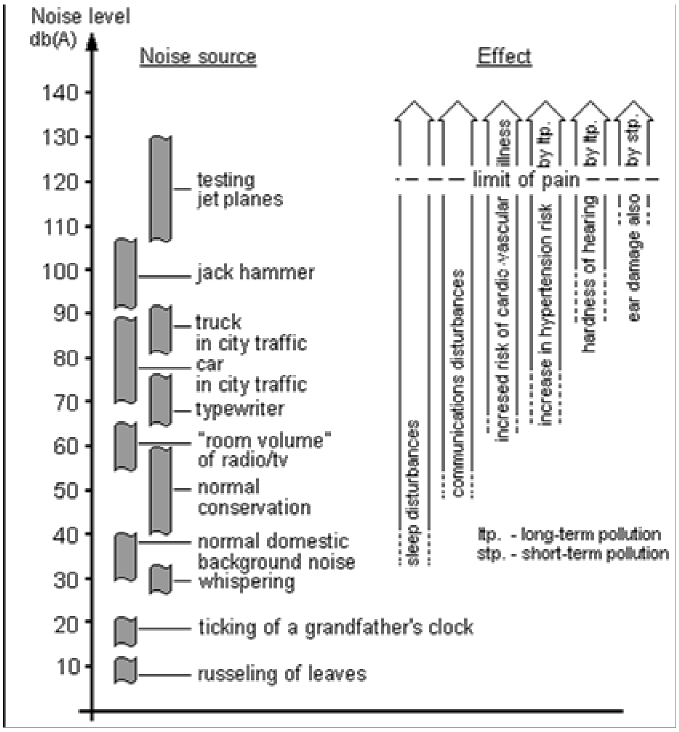

Fig. 1: Volume of Certain Noise Sources and their Possible Effects

Noise is subjectively valued sound and is therefore dependent on the respective attitude toward the given sound, the condition at the moment, the activity engaged in, and the level of current need for quiet, etc..

It is difficult to provide a scale for the degree of annoyance caused by a sound. Along with the previously mentioned subjective parameters, the following also play a role:

- information content of the sound,
- time of occurrence,
- temporal quality,
- frequency,
- impulse and tonal content,
- transmission route,
- specific source.

Described physically, sound is caused by vibrating bodies, i.e. by pressure variations within elastic medium (gases, liquids, solid bodies). The pressure variations can be caused by impact, rubbing or streaming gases (the principle of all musical instruments). The pressure variations caused disperse through the ambient medium air at high speed (330 m/s) and can be perceived by the ear if they reach sufficient intensity - if the vibrations per second (measured in hertz [Hz]) are greater than 16 and less than 20,000.

The pressure variations within the range of perception by the human ear (vibration amplitude or sound volume) lies between 20 µPa (audio threshold) and 200,000,000 µPa (pain threshold). Micropascal (µPa) is the measuring unit for this pressure.

To avoid having to deal with such huge numbers, a logarithmic measure was introduced, the so-called decibel (dB) - scale. In this case, 20 µPa equals the audio threshold, 0 dB and 200,000,000 µPa (pain threshold) 140 dB.

The decibel scale, which describes the ”sound pressure level”, is therefore not an absolute unit of measurement, such as i.e. the gram or the meter. Rather it only specifies the relationship to the audio threshold, i.e. it tells how much a sound exceeds the audio threshold.

As a rule, sounds consist of a mixture of high, medium and low frequency segments. The human ear perceives these frequency segments with various degrees of sensitivity. In order to reflect these properties of the ear, measuring devices are equipped with acoustic filters. The acoustic filter ”A” shows the best correspondence between ear and measuring device for the usual environmental sounds. The corrected sound volume is therefore given in ”dB(A)”.

The sounds found in our environment, e.g. also traffic noise, are rarely uniform. Rather they exhibit short-term fluctuation as well as in the course of the day and week (c.f. Map Traffic Volume 07.01).

Therefore, to assess and compare sounds, it is practical to use a ”single value”, which is an average of the sound volume level occurrence.

In other words: a sound fluctuating within a particular time segment is replaced by a constant sound with constant volume level and equivalent energy. ”**Mean volume**” is also called the (energy-) ”equivalent constant sound volume”. Thus, the mean volume is not to be understood as an arithmetic average but as corresponding to a physically equivalent energy average. This procedure allows the peak noise to be given special consideration.

The logarithmic laws are applied to calculations with sound volume. Thus the e.g. die doubling of the number of similarly loud sound sources (motor vehicles) increases the sound volume by 3 dB (equals $10 \cdot \log 2$); a trebling by 5 dB (equals $10 \cdot \log 3$), ten times by 10 dB ($10 \cdot \log 10$). A sound with a 10 dB(A) higher level is felt as if twice as loud.

In the same way, a quadrupling of the exposure time for sounds within a certain assessment period (day resp. night) has a similar effect. That means a prolongation of the exposure period, e.g. from 10 to 20 minutes or from 2 to 4 hours, increases the mean volume by 3 dB. A shortening of the exposure period of a sound from 600 to 60 minutes would correspond to a volume reduction of 10 dB.

In comparison to limits or standards, the so-called ”assessment level” is usually given. This is distinguished from the mean, resp. equivalent constant volume in that particular increases or decreases which take into account the various noise perception levels. In the case of traffic noise, increased perception levels for brake and acceleration sounds especially near traffic signals taken into account by means of an increase.

The empirically demonstrated reduced perception level for rail traffic noise is taken into account by a decrease, the so-called rail bonus.

The **statutory regulations** for limiting road traffic noise pollutions on existing streets remain currently unsatisfactory.

The Federal Pollution Control Law and the Traffic Noise Control Regulation (16 BImSchV) as well as the Traffic Routes and Sound Protection Measures Regulation (24 BImSchV) are only valid for the construction or substantial modification of road or rail routes.

Existing traffic noise situations are not subject to these regulations.

According to 16 BImSchV the following pollution limits apply:

Tab. 1: Limits of the 16 BImSchV (Traffic Noise Control Regulation)		
Region	**Day 6:00 a.m. - 10:00 p.m.**	**Night 10:00 p.m. - 6:00 a.m.**
Hospitals, schools, homes for the elderly	57 dB(A)	47 dB(A)
Purely and generally residential areas, small settlement areas	59 dB(A)	49 dB(A)
Core, village and mixed areas	64 dB(A)	54 dB(A)
Small business	69 dB(A)	59 dB(A)

Tab. 1: Limits of the 16 BImSchV (Traffic Noise Control Regulation)

For streets and city expressways maintained by the federal government, there are noise abatement measures available pursuant to the "Richtlinien für den Verkehrslärmschutz an Bundesfernstraßen in der Baulast des Bundes - VLärmSchR 97" (Guidelines for the Traffic Noise Control on Federal Highways Subject to Federal Maintenance) via a voluntary undertaking of the Federal Transport Minister.

Noise abatement, especially by means of sound-proofing windows, are possible if the assessment level exceeds the following limits:

Tab. 2: Overall Limits for the Traffic Noise Control on Federal Highways Subject to Federal Maintenance		
Region	**Day 6:00 a.m. - 10:00 p.m.**	**Night 10:00 p.m. - 6:00 a.m.**
Hospitals, schools, purely and generally residential areas	70 dB(A)	60 dB(A)
Core, village and mixed areas	72 dB(A)	62 dB(A)
Small business	75 dB(A)	65 dB(A)

Tab. 2: Overall Limits for the Traffic Noise Control on Federal Highways Subject to Federal Maintenance

Most possible sound abatement measures provided for in these guidelines have been implemented in Berlin.

Given certain preconditions, noise abatement measures in the area of road traffic are also possible under traffic regulations as per § 45 StVO.

Rules applicable to this area are to be found in the "Vorläufigen Richtlinien des Bundesministeriums für Verkehr für straßenverkehrsrechtliche Maßnahmen zum Schutz der Bevölkerung vor Lärm" (Transport Ministry Provisional Guidelines for Traffic Regulatory Measures for Protection against Noise).

The day/night - guidelines lie at about 70/60 dB(A) for residential areas and installations which are similarly worthy of protection as well as 75/65 dB(A) for core, village, mixed and small business areas.

Statistical Base

The traffic noise levels shown in the map are based on the survey results for the main network for 1993 by the Berlin Department of Construction, Housing, and Transport.

The resulting average daily traffic load (DTV) forms the basis for the calculation. For the traffic volume of the main network see also Map 07.01.

The traffic schedule of the tram network was drawn from the timetables as well as the usual return journeys.

Methodology

Noise emissions and pollution data were calculated in the framework of an expert opinion based on the ”Richtlinien für den Lärmschutz an Straßen - RLS 90” (Guidelines for Noise Abatement on Roads).

The calculation takes into account speed, percentage of trucks, road surface and quality (a vehicle makes about 5 dB less noise on asphalt than on cobblestone), the distance between road and buildings (distance doubling reduces the volume by 3 dB), height and type of roadside development (open or closed construction) and reflection conditions.

The noise load due to tram traffic was determined in accordance with the Berechnungsvorschrift Schall 03 (Calculation Regulation, Sound 03). Accordingly a deduction of 5 dB(A) (rail bonus) was made in calculating the mean volume.

Although their contributions have been recorded individually, the map of motor vehicle and tram noise depicts the combined load.

The total length of the entire Berlin road network is some 5,200 km. 1,228 km of that, about a quarter, belongs to the primary road network.

1,150 km of the main network (equal to 2,300 km roadsides) was divided into some 7,000 road segments. Their traffic and acoustically relevant parameter were recorded. The results for the built-up road segments (totaling 1,800 km roadsides) are shown in the map. The noise pollution was taken with a standard interval of 25 m for the road segments without roadside development. This was not depicted in the map to avoid any misinterpretations.

The data on which this is based (inter alia motor vehicle use, truck share, local public transport timetables, type and condition of road surface, topographical and construction details) are stored together with all acoustic information in a data base and can be called up via a geographical information system for a wide range of uses.

The noise map itself necessarily contains only a portion of the available data. For instance, it is hardly possible to accurately show the influence of traffic signals, important for the formation of the assessment level, using a scale of 1 : 50,000. An increase of 1 to 3 dB would be necessary according to the RLS 90 for an interval of up to 100 m. One gets the assessment level for which the above mentioned guidelines or limits apply. In the remaining areas, the assessment volume is the same as the mean volume shown.

The noise contribution of intersecting side streets is not taken into account.

For a specific location, e.g. for building and planning projects, these corrections can also be made after the fact. Detailed information can be obtained from Section V B of the Berlin Department of Urban Development, Environmental Protection and Technology. This information is subject to charges as specified in the environmental fee regulations.

The volume class shown in the noise map, with a breadth of 5 dB(A) reflect the noise pollution at a height of 3.5 m in front of the effected building facades in a street segment where the distance between the facade and the nearest road land is typical.

Moreover, the units of rounded off mean volume are shown as digits next to the road segments. In some areas, where many road segments are concentrated, some digits have been omitted for the sake of clarity.

The street traffic noise pollution shown in the map pertain to daytime (6:00 a.m. - 10:00 p.m.) and nighttime (10:00 p.m. - 6:00 a.m.). The sound volumes lie at round 10 dB below daytime levels. In some cases, the difference is even noticeably lower.

Map Description

It can be seen from the map that the traffic on the main network roads causes a very high noise load.

In Table 3, the length of the effected built-up roadsides or their percentage of the overall length is shown for each volume level.

During the **day** load levels between 65 and 70 dB(A) occur most frequently: about 760 km, that is 42 %, lie in this volume range.

Extreme loads over 80 dB(A) were measured for one segment a kilometer long (0.1 %). If one sets a basic level of 65 dB(A), which can be seen, according to current noise research, as the threshold for increased heart attack risk (c.f. Ising et al. 1997), then 1,270 km of built-up roadsides, or 70 %, could be seen as excessively polluted.

The following situation applies at **night**: The emphasis lies in the volume level from 55 to 60 dB(A), namely 658 km or approx. 36 %.

Levels exceeding 75 dB(A) only occur seldom. More than 1,478 km, or about 82 %, carry a load of more than 55 dB(A).

Tab. 3: Noise Pollution (Mean Volume) Day and Night in the Primary Road Network by km Built-up Roadside

Noise pollution dB(A) classes	Day			Night		
	km roadside	%	% cumulative	km roadside	%	% cumulative
bis 50	4.9	0.3	0.3	80.9	4.5	4.5
> 50 - 55	24.0	1.3	1.6	251.3	13.9	18.4
> 55 - 60	109.5	6.1	7.6	658.3	36.4	54.7
> 60 - 65	401.8	22.2	29.8	650.0	35.9	90.6
> 65 - 70	759.4	42.0	71.8	157.5	8.7	99.3
> 70 - 75	462.0	25.5	97.3	11.9	0.7	100.0
> 75 - 80	47.1	2.6	99.9	0.1	0.0	100.0
> 80	1.0	0.1	100.0	0.0	0.0	100.0
Total	**1,810.0**	**100.0**		**1,810.0**	**100.0**	

Tab. 3: Noise Pollution (Mean Volume) Day and Night in the Primary Road Network by km Built-up Roadside

High traffic noise loads are caused not only by high traffic volume but, by very narrow streets with closed roadside construction on both sides. A substantial increase in volume level (up to 5 dB) is induced through cobblestone or heavily damaged road surfaces. In the eastern boroughs of the city, the tram often contributes to the night volume level. Table 4 gives an overview of street segments with unusually high noise loads.

Tab. 4: Highly Polluted Berlin Road Segments (In general, the volume level does not apply to the entire road but only to a certain segment.)

Street	Mean volume in dB(A)	
	Day	Night
01. Schneller Strasse (Treptow) Höhe Bhf. Schöneweide	82	73
02. Edison Strasse (Köpenick)	81	73
03. Flughafen Strasse (Neukölln) Höhe Hermann Strasse	81	72
04. Berliner Allee (Weissensee) Höhe Pistorius Strasse	80	73
05. Prenzlauer Promenade (Pankow) Höhe Thule Strasse	80	72
06. Hermann Strasse (Neukölln) Höhe Flughafen Strasse	80	71
07. Alt Köpenick (Köpenick)	79	75
08. A 100 AS Hohenzollerndamm	79	74
09. Bahnhof Strasse (Köpenick)	79	73
10. Kolonnen Strasse (Schöneberg) Höhe Naumann Strasse	79	71
11. Müggelheimer Strasse (Köpenick)	79	71
12. Spandauer Damm (Charlottenburg)	79	70

Tab. 4: Highly Polluted Berlin Road Segments
(In general, the volume level does not apply to the entire road but only to a certain segment.)

The level of the mean volume in a street does not permit an opinion as to whether this constitutes an important noise problem for the population. The number of effected residents is significant for an interpretation of the load data. It is essential to consider the number of directly effected residents when setting truck night driving prohibitions, selecting detour routes, and routes for heavy transport traffic, and priorities for noise abatement measures, etc..

For this reason, an estimation of the number of residents directly effected by traffic noise, together with a probability factor for their actual presence, was made for each acoustically tested road segment.

This effected persons potential in the close range to the tested streets is shown in Table 5 according to the individual volume level classes.

Tab. 5: Potential Effects in the Buildings along the Primary Road Network (Effected persons within 1 ½-times the average construction intervals form the basis for the noise pollution calculation for individual street segments.)

dB(A) classes	Day			Night		
	Number	%	% cumulative	Number	%	% cumulative
bis 50	111	0.0	0.0	9,504	3.9	3.9
> 50 - 55	2,145	0.9	0.9	39,757	16.5	20.4
> 55 - 60	20,348	8.4	9.4	76,666	31.8	52.2
> 60 - 65	50,713	21.0	30.4	90,837	37.6	89.8
> 65 - 70	91,496	37.9	68.3	23,013	9.5	99.4
> 70 - 75	69,759	28.9	97.2	1,493	0.6	100.0
> 75 - 80	6,485	2.7	99.9	0	0.0	100.0
> 80	213	0.1	100.0	0	0.0	100.0
Total	**241,270**	**100.0**		**241,270**	**100.0**	

Tab. 5: Potential Effects in the Buildings along the Primary Road Network (Effected persons within 1 ½-times the average construction intervals form the basis for the noise pollution calculation for individual street segments.)

If one assumes again that the daytime limit of 65 dB(A) for an increased heart attack risk when interpreting this table, then approx. 70 % of effected residents, or about 168,000, are subject to excessive loads.

Approximately 24,500 residents, or 10 %, are even subjected to levels exceeding 65 dB(A) at night. This requires priority action.

In order to deal with this hazard, a volume reduction of up to 15 dB(A) would be necessary.

Such a load reduction can only be achieved over the long term - if at all. Although technical development can lead to a decrease in motor and motion noises, the long life of motor vehicles as well as the limited financial resources for repair and modernization of road services will only allow these changes to be noticed far into the future.

A radical reduction in motor vehicle traffic - a reduction by 50 % would lead to a drop of 3 dB(A) - cannot be expected.

Measures such as speed reduction, night driving prohibitions for trucks, user preferences for low noise trucks, improvement of local public transport, promoting the attractiveness of bicycle and pedestrian traffic could altogether lead to a lower noise load. The effects are relatively low and - as to be expected - they are comparatively minimal and in part defy quantification.

To protect the health of the effected residents in highly polluted streets, the installation of windows with noise reduction insulation (as necessary, with integrated ventilation elements) should be accelerated. This is also the responsibility of owners and lessors of apartments.

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