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ON THE CORRELATION BETWEEN OBJECTIVE MEASUREMENTS  
AND SUBJECTIVELY FELT DISTURBANCE FROM TRAFFIC

*Lary, 1975*

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16. Abstract In the expert opinion 3099/WS of November 11, 1974 on a comprehensive representation of the noise stress in Vienna, the results of measurements of traffic noise during the day were given for 90 measurement points selected with a distribution over the urban area of Vienna; in addition, the vehicle frequency ascertained at the individual measurement points was also noted. In the present report, these objective measurement results or various characteristic single values derived from them are to be compared with the results of the environmental survey of 1973 on the subjective noise stress from the outside indicated in dwellings. Suggestions for suitable measures to describe the traffic noise and to derive limit values are to be prepared. In this case the relationship between number of vehicles and noise and annoyance was to be considered.			
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ON THE CORRELATION BETWEEN OBJECTIVE MEASUREMENTS  
AND SUBJECTIVELY FELT DISTURBANCE FROM TRAFFIC

Höhere Technische Bundeslehr- und Versuchsanstalt,  
Berufspädagogisches Institut des Bundes, Vienna.

Subject

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In the expert opinion 3099/WS of 11 November 1974 on a comprehensive representation of the noise stress in Vienna, the results of measurements of traffic noise during the day were given for 90 measurement points selected with a distribution over the city area of Vienna; in addition, the vehicle frequency ascertained at the individual measurement points was also noted. The measurements were carried out in the time from 20 November 1973 until 25 June 1974.

In the present report, these objective measurement results or various characteristic single values derived from them are to be compared with the results of the environmental survey of 1973 on the subjective noise stress from the outside indicated in dwellings. Suggestions for suitable measures to describe the traffic noise and to derive limit values are to be prepared. In this case the relationship between number of vehicles, noise and annoyance was to be considered.

Procedure for the Study and Results

1) Selection of the Measurement Points and Subjects

For the individual measuring point, the residential building was selected which was affected by the noise measured at that point. The results of the environmental survey of 1973 for these addresses were provided on punch cards in a practical code by the Office for Organisation and Data (BOD) of the municipal administra-

\*Numbers in the margin indicate pagination in the foreign text.

tion<sup>1)</sup>. A total of 2624 personal responses were evaluated. The distribution of the persons in age and professional groups is compiled in the following table.

Table 1: Distribution of the Responses in various Age and Professional Groups

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<sup>a</sup> Alter (Jahre)	<sup>c</sup> 18 bis 25	<sup>c</sup> 26 bis 40	<sup>c</sup> 41 bis 60	<sup>c</sup> 61 bis 75	<sup>d</sup> über 75
<sup>b</sup> Anteil (%)	8,4	22,0	33,7	27,9	8,0

<sup>e</sup> Beruf	<sup>f</sup> berufstätig	<sup>g</sup> Schüler/Student	<sup>h</sup> Haushalt	<sup>i</sup> Pensionist/Rentner
<sup>b</sup> Anteil (%)	51,4	2,8	12,6	33,2

Key: a. age (years)                      e. profession  
 b. percentage                            f. employed  
 c. to                                        g. pupil/student  
 d. more than                            h. in the household  
    i. retired

49.2 % of all persons surveyed indicated that they were subjected to considerable stress due to traffic noise during the day.

It was possible to correlate the subjects to 61 different measurement points. The noise at these points, expressed in the customary unit of the energy equivalent constant sound level is given in stages of 5 dB(A) in the following table 2 and in appendix 1.

Table 2: Distribution of the answers to the various stages of energy equivalent constant sound level.

<sup>a</sup> energieäquivalenter Dauerschallpegel (dB(A))	50-55	55-60	60-65	65-70	70-75	75-80	80-85
<sup>b</sup> Anteil (%)	12,3	13,5	11,3	12,6	24,0	25,1	1,3

Key: a. energy equivalent constant sound level  
 b. percentage

<sup>1)</sup> A portion of the measurement points near larger residential complexes was not employed, since the data was not classified as to separate house numbers; such a separation is absolutely necessary for the correlation to certain noise situations.

In this case all persons residing in the buildings at the measurement points are included without consideration of the relationship of their dwelling to the street or courtyard and without considering the location of the measurement point in the street or courtyard.

## 2) Objective Parameters for Describing the Traffic Noise

The following individual data was calculated from the sound level frequency in order to describe the traffic noise, measured as a frequency distribution of the A-rated sound level, and it was then related to the subjective sensation of disturbance:

the energy equivalent constant sound level  $L_{eq3}$

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$$L_{eq3} = 10 \lg \frac{1}{100} \sum_i 10^{L_i/10} \cdot f_i$$

$L_i$  Sound level of individual classes in dB(A)

$f_i$  Frequency of occurrence of the individual classes in %

the equivalent constant sound level with halving parameter 4  $L_{eq4}$

$$L_{eq4} = 13,3 \lg \frac{1}{100} \sum_i 10^{L_i/13,3} \cdot f_i$$

a combined quantity of energy equivalent constant sound level  $L_{eq3}$  and peak sound level  $L_1$  (the sound level exceeded 1 % of the time)

$$\frac{L_{eq3} + L_1}{2}$$

the peak sound level  $L_1$

the sound level exceeded 10 % of the time,  $L_{10}$

the sound level exceeded 50 % of the time,  $L_{50}$

The dynamics of the sound level distribution described by the difference between the sound level exceeded 1 % and 90 % of the time

$$L_1 - L_{90}$$

the noise-pollution level  $L_{NP}$  from the energy equivalent constant sound level  $L_{eq3}$  and the standard deviation  $\sigma$

$$L_{NP} = L_{eq3} + 2,56 \sigma$$

the traffic-noise index TNI from the sound level exceeded 10 % of the time  $L_{10}$  and the sound level exceeded 90 % of the time  $L_{90}$

$$TNI = L_{90} + 4 (L_{10} - L_{90}) - 30$$

The energy equivalent constant sound level is applied most frequently on an international basis and also in the international and Austrian standard quantities for describing traffic noise.

The equivalent constant sound level with halving parameter 4 was proposed for describing aircraft noise and employed as a basis of the German law on aircraft noise and was considered in an earlier study<sup>1)</sup> as best suited for describing the disturbance due to traffic noise. /4

The opinion has been expressed repeatedly that the peak sound level is also decisive for the disturbance effect and for this reason the sound level exceeded 1 % of the time was also included in the study.

The sound level exceeded 10 % of the time is presently employed in England for describing traffic noise.

The noise-pollution level and the traffic-noise index<sup>2)</sup> were suggested in England.

The quantities mentioned are all more or less closely correlated to one another, as the following table (3) shows.

<sup>1)</sup> F. Bruckmayer and J. Lang: "Noise Pollution due to Traffic", Zeitschrift des Österr. Ing. und Arch. Vereins, Vol. 10, no. 8-10, (1967).

<sup>2)</sup> The authors of the traffic-noise index now state that this index is not particularly suitable.

Table 3: Relationship between various Parameters for Describing Traffic Noise and the Energy Equivalent Constant Sound Level.

a Größe	$L_{eq4}$	$\frac{L_{eq3} + L_1}{2}$	$L_1$	$L_{10}$	$L_{50}$	$L_{NP}$	TNI
b Zusammenhang	-3,64 + $1,03L_{eq3}$	8,02 + $0,95L_{eq3}$	16,04 + $0,91L_{eq3}$	-2,3 + $1,07L_{eq3}$	-12,12 + $1,10L_{eq3}$	9,77 + $1,07L_{eq3}$	-15,18 + $1,42L_{eq3}$
c Korrelationskoeffizient	1,00	0,99	0,98	0,99	0,95	0,92	0,69

Key: a. Parameter  
 b. Relationship  
 c. Correlation Coefficient

3) Connection of the Subjective Sensation of Annoyance to the Objective Parameters of Traffic Noise

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Although the sound level was only measured during the day, both the disturbance due to traffic during the day and at night were correlated to the parameters for describing noise. In this case only the statements of those persons were employed as a basis, indicating that the most important rooms of their dwelling face the measuring point.

The percentage of residents in adjacent residential buildings considerably annoyed by noise and with the most important rooms oriented to this measuring point is given in appendices 2 to 4 for all measuring points as a function of traffic noise. The traffic noise is presented in each case as the various, previously described parameters, and the results are compiled in groups for every 5 dB(A), corresponding to the different technical noise protection area categories<sup>1)</sup>.

<sup>1)</sup> The area categories are described in the ÖAL Guideline 21 and ÖNORM (Austrian Standards) S 5021.

The linear regression was also calculated and plotted according to the method of the smallest squares for the relationship between the percentage of the persons considerably annoyed by traffic noise during the day and the individual, objective quantity of traffic noise. The correlation coefficients obtained are compiled in the following table (4).

Table 4: Relationship between the Objective Quantity of Traffic Noise and Subjective Sensation of Annoyance.

a objektives Maß des Verkehrslärms	$L_{eq3}$	$L_{eq4}$	$\frac{L_{eq2}+L_1}{2}$	$L_1$	$L_{10}$	$L_{50}$	$L_1-L_{90}$	$L_{NP}$	TNI
b Korrelations- koeffizient	0,98	0,98	0,99	0,97	0,99	0,98	--	0,95	0,93

Key: a. objective measure of traffic noise  
b. coefficient of correlation

There is apparently a very high correlation between various quantities derived from the sound level frequency distribution for describing traffic noise and the subjective sensation of considerable annoyance. /6

The energy equivalent constant sound level applied for about the past 10 years and defined in the national and international standards is therefore well suited for describing traffic noise as an objective quantity with respect to the annoyance of the population in dwellings affected by traffic noise. The equivalent constant sound level with halving parameter 4, on the other hand, provides no improvement in validity of conclusions; even the sound level exceeded 50 % of the time would be just as good. The sound level exceeded 10 % of the time and the energy equivalent constant sound level are only slightly better, when the peak sound level  $L_1$  is considered. The peak sound level  $L_1$  is slightly less suited. The quantities of noise-pollution level and traffic-noise index are much more unfavorable.



It therefore appears practical and justified to continue to apply the energy equivalent constant sound level for describing traffic noise in cities and to employ this as a basis for certain technical noise protection area categories.

4) Traffic Noise Limit values for Different Degrees for Annoyance

The limit values in Table 5 for the protection of a certain percentage of the population from considerable annoyance due to traffic noise can be derived from the relationship between percentage of the persons considerably annoyed in their dwellings by traffic noise and the energy equivalent constant sound level in the adjacent street.

Table 5: Limit Values of the Energy Equivalent Constant Sound Level for Protecting various Percentages of the Residents in Dwellings facing City Streets

a. Prozentsatz der erheblich belästigten Bewohner der Wohnungen an der Straße	10	25	50	100
b. Energieäquivalenter Dauerschallpegel (dB(A))	56	60	67	81

- Key: a. Percentage of the residents in dwellings on the street who are considerably annoyed  
 b. Energy equivalent constant sound level (dB(A))

This includes persons in dwellings with the most important room affected by traffic noise. When this differentiation is not made, but rather the percentage of considerably annoyed persons is determined from the total number of residents in buildings on streets with a certain traffic noise level (independent of the position of the dwelling to the street), the relationship shown in appendix 5 results.

The limit values compiled in the following table (6) for the energy equivalent constant sound level then result for various percentages of considerably annoyed residents in dwellings on city streets.

Table 6: Limit Values for the Energy Equivalent Constant Sound Level for Protecting various Percentages of Residents in Buildings on City Streets

a	Prozentsatz der erheblich belästigten Bewohner der Wohnhäuser	10	25	50	100
b	energieäquivalenter Dauerschallpegel dB(A)	57	62	69	84

Key: a. Percentage of the considerably annoyed residents  
 b. Energy equivalent constant sound level dB(A)

The limit value given in the ÖAL Guideline 21 and the ÖNORM (Austrian Standards) S 5021 for city residential areas of  $L_{eq3} = 55$  dB(A) therefore protects almost the entire population in the residential buildings from considerable annoyance due to traffic noise. About 3/4 of the population is protected against considerable annoyance due to traffic noise with the limit value of 60 dB(A), applicable to core areas, also including residential buildings.

The evaluation of the extent of disturbance in those dwellings with the most important rooms not facing the street, but rather situated on the courtyard or garden side away from the street, is also interesting in relation to the traffic noise level at the street. This relationship is shown in appendix 6 (with a total of 314 responses).

The disturbance in the dwellings facing away from the street 8 is apparently substantially less than in those facing the street, although a certain dependency on traffic noise level at the street can also be seen. The plotted regression line (coefficient of correlation 0.84) demonstrates that more than 50 % are protected against considerable noise pollution on the side of buildings away from the streets in which there is virtually a sound level of up to 85 dB(A); merely 10 % are disturbed at 64 dB(A) and 25 % at 72 dB(A).

It is interesting to find in all figures that the number of persons considerably disturbed by noise is less at night than in the daytime. Limit values and protective measures for traffic noise therefore must be adjusted to the traffic during the day (this applies for the measuring points studied in the city of Vienna and can definitely be generalized).

5) Effect of Profession and Age of the Persons on the Extent of the Disturbance

An evaluation was also carried out in which the percentage of considerably annoyed persons was determined separately according to age and professional groups in questionnaires in order to determine the possible effect. The evaluation was carried out only as a function of the energy equivalent constant sound level, which had been proven suitable for this purpose. The percentage of annoyed persons is presented separately according to age and profession in appendix 7. Only statements of those persons with living rooms facing the measuring point were employed in this case.

In order to facilitate the interpretation of the illustration, age is plotted (each average of an age group) against the extent of traffic noise. The annoyance during the day is apparently not dependent on age. There is a slight reduction in the extent of annoyance with age at high sound levels at night.

The division according to occupation shows the same dependency of annoyance on equivalent constant sound level for all groups. There is only a variation in dependency for pupils/students at low sound levels, but this is not significant because of the very small number of responses (entered in parentheses).

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6) Effect of Dynamics, Sound Level Peaks and Proportion of Trucks on the Extent of Annoyance

In order to determine the possible effect of dynamics and the sound level peaks on the extent of disturbance, an evaluation was

also conducted in which the measuring points were divided according to the sound level difference  $L_1 - L_{90}$  and the peak level  $L_1$  at the same energy equivalent constant sound level and they were also divided according to the proportion of trucks, usually decisive for the dynamics and sound level peaks. The effect of the sound level peaks  $L_1$ , however, was also already taken into consideration in point 3 by the quantity  $\frac{L_{eq} + L_1}{2}$ .

The percentage of the considerably disturbed persons is plotted in appendix 8 as a function of  $L_1$ ,  $L_1 - L_{90}$  and the proportion of trucks with the energy equivalent constant sound level as parameter.

In this case, also, only the persons with dwellings facing the measuring point were employed.

The dynamics or the peak level apparently only has an effect at lower traffic noise levels ( $< 70$  dB(A)); smaller dynamics and smaller peak levels appear to cause more pollution than larger dynamics and greater peak levels at the same energy equivalent constant sound level. The only possible explanation is that the same energy equivalent constant sound level at smaller peak levels is caused by a longer dominance of medium sound levels, leading to the higher degree of annoyance. In the case of individual, high peaks, however, lower levels dominate for a longer time with the same equivalent constant sound level, so the impression of annoyance does not arise. At higher equivalent constant sound levels, these quiet periods do not exist and there is therefore no apparent relationship of dynamics or peaks.

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In the relationship of annoyance to the proportion of trucks, a slight increase in the (low) number of annoyed persons with rising proportion of trucks in the sound level range of 60-65 dB(A) is demonstrated; there is no apparent influence in higher sound level ranges.

## 7) Effect of the Floor Number on the Extent of Annoyance

In order to determine the possible effect of position of the dwelling above the street, a separate evaluation was also carried out for different floors.

The percentage of considerably annoyed persons in the dwellings oriented to the street is plotted as a function of the floor in appendix 9.

The annoyance is apparently identical on all floors.

## 8) Relationship of Traffic and Extent of Annoyance

It is also significant for the traffic and municipal plans, whether there is a direct connection between urban traffic or amount of traffic and annoyance of the residents in buildings on the urban streets. This relationship was therefore also evaluated. The relationship of the percentage of the persons annoyed during the day by traffic noise and by heavy truck traffic noise was plotted as a function of the number of vehicles per hour and the number of trucks per hour (determined in each case during noise measurements). The dependency on the number of cars is also plotted for comparison. In this case the amount of traffic was collected in groups of 1-2, 2-5, 5-10, 10-20 etc. and a logarithmic scale was employed, since the sound level rises almost in a linear manner with the logarithm of the amount of traffic. Again, only the responses of those persons were employed with dwellings in which the most important rooms face the street where the vehicles were counted.

A differentiation was made in the evaluations as to streets with and without streetcars, in order to determine whether the streetcars are an additional source of annoyance.

Furthermore, the dependency of annoyance on the amount of traffic in groups for different proportions of trucks was also

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plotted in appendix 11. No clear dependency on the proportion of trucks resulted in this case, possibly also because partially very few answers were available in the individual groups (illegible).

There is apparently a clear relationship between annoyance due to traffic and the number of vehicles and there is an especially good correlation with the number of trucks per hour<sup>1)</sup>.

Marked annoyance due to heavy truck traffic, however, is only demonstrated at a very high number of trucks. The correlation of the annoyance with the number of cars is clearly less than that with the number of trucks.

For purposes of traffic and municipal planning, the following limit values in Table 7 can be provided for limiting the disturbance.

Table 7: Limit values for the amount of traffic per hour for the protection of different percentages of residents in dwellings facing the street in urban areas.

a) Prozentsatz der erheblich belästigten Bewohner der Wohnungen an der Straße	10	25	50
b) Belästigung durch Straßenverkehr; stündliche Verkehrsmenge (einschl. LKW)	<10	25	130
stündliche LKW-Menge	2	4	15
c) Belästigung durch schweren LKW-Verkehr			
stündliche LKW-Menge	6	44	250

Key: a. percentage of persons residing in dwellings on the street.

b. annoyance due to traffic; hourly amount of traffic (including trucks)  
hourly amount of trucks

c. annoyance due to heavy truck traffic; hourly amount of trucks

<sup>1)</sup> This result is in agreement with Swedish studies, according to which the number of trucks has a substantial effect on the extent of disturbance.

Streetcars only travel in streets with such heavy traffic that there is no significant difference between the annoyance with and without streetcars.

9) Relationship between the Number of Vehicles and the subjective Importance of Combatting Noise /12

It is interesting to compare the number of responses, terming the combat against noise as the most pressing environmental question to be solved in Vienna with the number of vehicles in the street adjacent to the residential dwelling. This relationship is presented in appendix 12. The number of persons who consider the combat against noise as the most pressing problem clearly increases with the number of vehicles in the street at the place of residence (and the accompanying traffic noise). The evaluation again was conducted for all measuring points on the street and all responses of persons with dwellings in which the most important rooms face the street. More than 50 % responded that the combat against noise is the most pressing environmental problem to be solved when the number of cars exceeded 600 per hour.

Summary

The measured results on traffic noise at 61 points in Vienna from the years 1973 and 1974 were compared to the results of the environmental survey of 1973 on the subjective considerable annoyance due to noise penetrating dwellings from the outside and stemming from traffic and heavy truck traffic.

The responses of a total of 2624 persons living in residential buildings exposed to the traffic noise measured in each case were evaluated for this purpose.

Calculations were carried out on the basis of the sound level frequency distribution in order to determine a suitable measure for describing the traffic noise with respect to the reaction of the population:

the energy equivalent constant sound level  $L_{eq3}$ , the equivalent constant sound level with halving parameter 4  $L_{eq4}$ , the energy equivalent constant sound level with consideration of the peak sound level  $\frac{L_{eq3} + L_1}{2}$ , the sound level exceeded 50 % of the

time  $L_{50}$ , the sound level exceeded 10 % of the time  $L_{10}$ , the sound level exceeded 1 % of the time  $L_1$ , the noise-pollution level  $L_{NP}$  and the traffic-noise index TNI. All these quantities are also strongly correlated to one another.

The relationship between the percentage of the persons considerably annoyed by traffic and the measured traffic noise, expressed in various quantities mentioned, was determined. A clear relationship was ascertained for all quantities between annoyance and extent of the traffic noise. The regression lines were calculated and the coefficients of correlation given. A high correlation coefficient of 0.98 resulted for the energy equivalent constant sound level, applied for the past 10 years in national and international standards; this is slightly increased to 0.99, when the peak in sound level is taken into consideration by the quantity  $\frac{L_{eq3} + L_1}{2}$ . It appears practical and justified to continue applying  $\frac{L_{eq3} + L_1}{2}$  the energy equivalent constant sound level for describing urban traffic noise. Guidelines for limiting traffic noise in order to protect a certain percentage of the population from considerable annoyance due to noise were derived from this data. The limit value for urban residential areas of 55 dB(A) during the day then protects almost the entire population, while that of 60 dB(A) for the core area about 3/4 of the population. More than 50 % are protected from considerable noise annoyance in the building sections facing away from the street, even with the highest possible sound levels occurring during the day. The disturbance due to traffic noise was ascertained to be greater during the day than at night for all measurement points.

Occupation and age of the persons have no effect on the extent of annoyance.



Additional evaluations demonstrated that in the range of lower energy equivalent constant sound level of traffic noise smaller dynamics and smaller peak sound levels may produce greater annoyance with the identical  $L_{eq}$ .

The extent of annoyance was not related to the floor on which the persons live.

The evaluation also produced a clear relationship between the percentage of persons considerably annoyed by traffic noise and the number of vehicles and especially the number of trucks.

No effect of streetcars on the extent of annoyance was discovered, especially because streetcars only travel in streets with heavy 14 vehicle traffic.

The evaluation of responses to the question about the most pressing environmental problem produced the result that combatting noise was mentioned by an increasing number as the exposure to traffic noise increased. More than 50 % consider combatting noise the most pressing problem when the number of vehicles exceeds 600 per hour.

12 appendices No. 3486/WS.

Vienna, 27 October 1975

The Director:  
(signature)

The Supervisor of the  
Test Institute

(signature)

Judith Lang

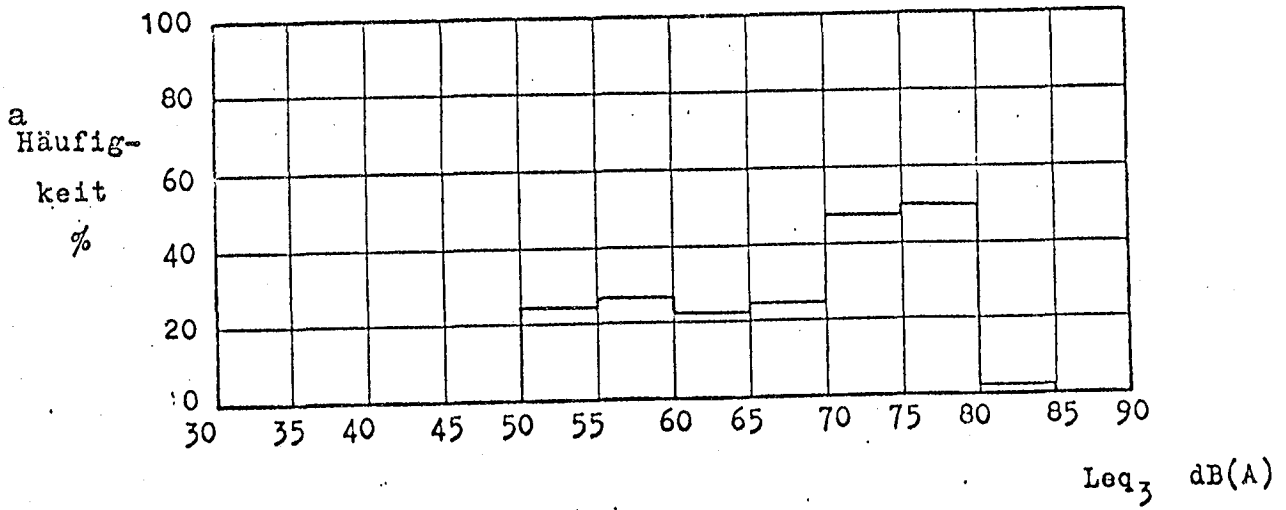


Fig. 1: Division of the Responses to the Areas of the Energy Equivalent Constant Sound Level  $L_{eq3}$ .  
 Key: a. frequency

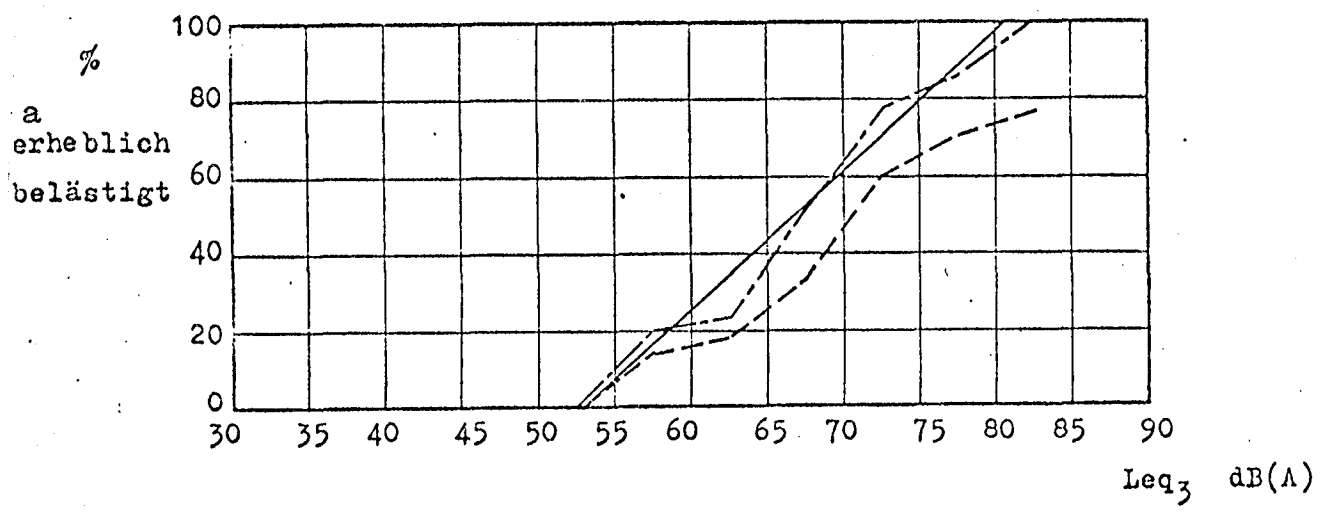


Fig. 2: Percentage of Considerably Annoyed Persons as a Function of Traffic Noise  
 Persons with a Dwelling Facing the Traffic Noise  
 Key: a. considerably annoyed

A. Energy Equivalent Constant Sound Level

----- during the day  
 - - - - - at night

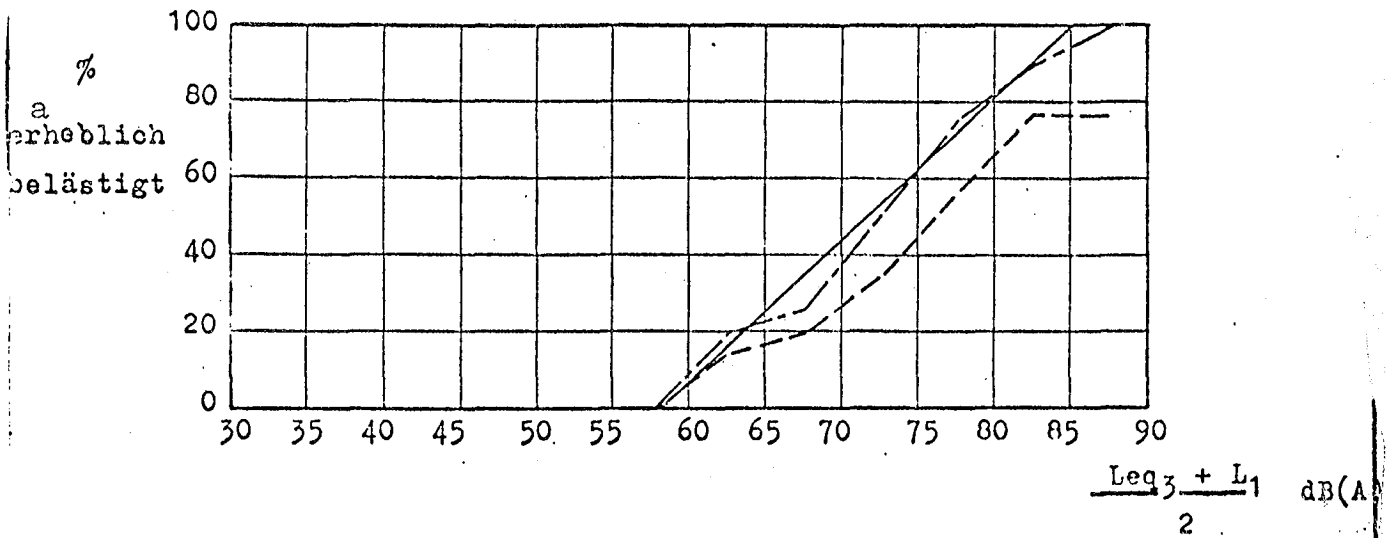


Fig. 2 B: Energy Equivalent Constant Sound Level, taking the Peak Level into Consideration

Key: a. considerably annoyed

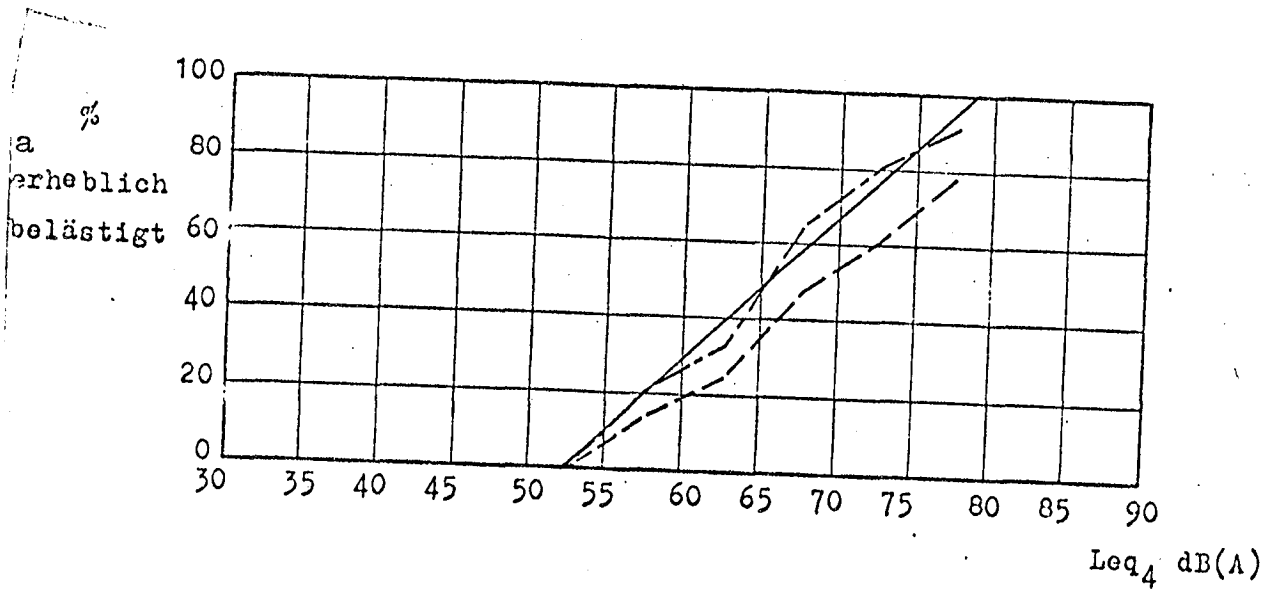


Fig. 2 C: Equivalent Constant Sound Level with Equivalence Parameter 4

Key: a. considerably annoyed

----- during the day  
 \_\_\_\_\_ at night

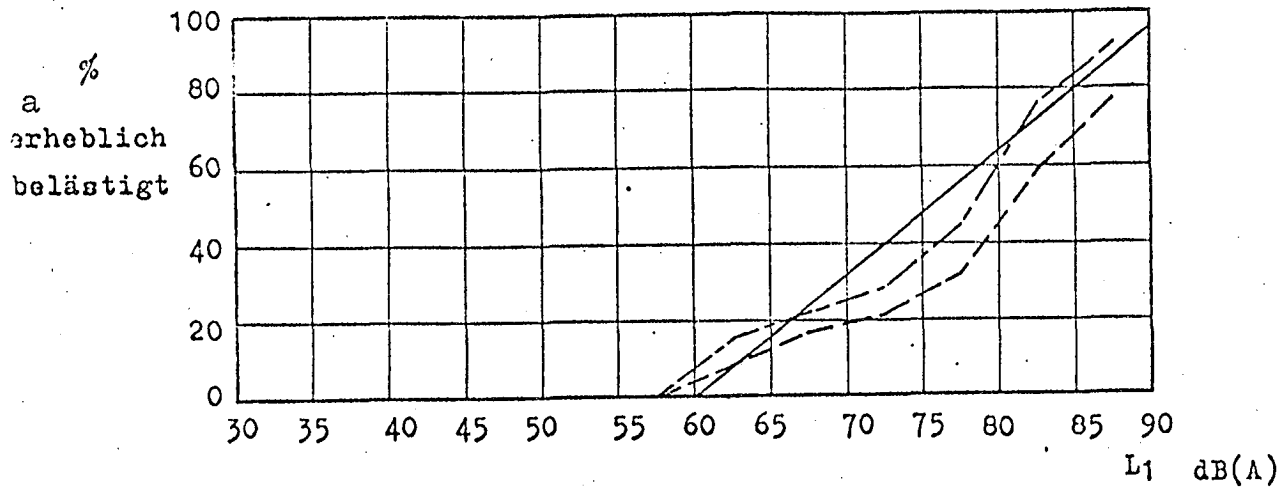


Fig. 3: Percentage of Considerably Annoyed Persons as a Function of Traffic Noise

Persons with Dwellings facing the Traffic Noise

Key: a considerably annoyed

A. Peak Sound Level

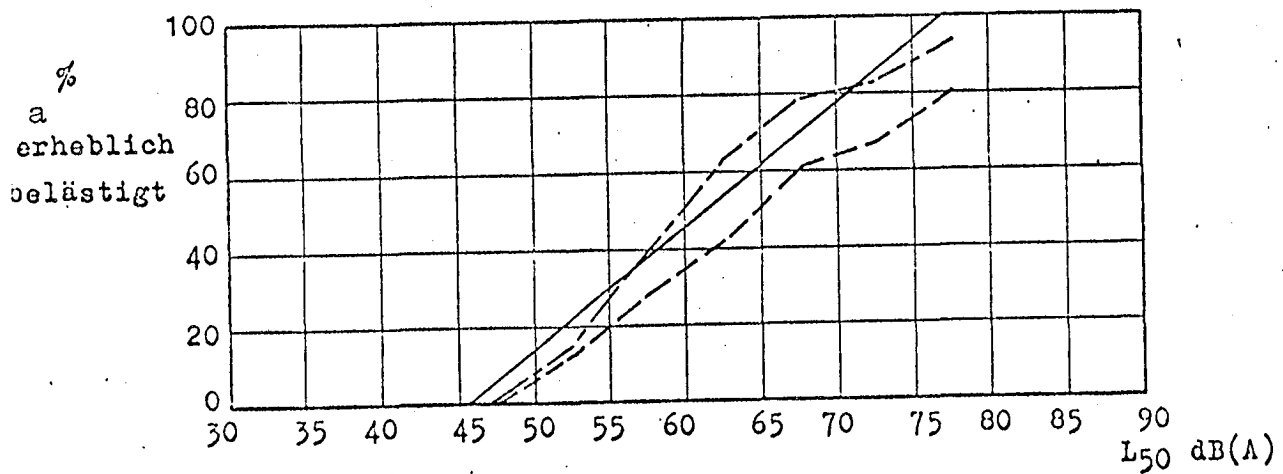


Fig. 3 B: Sound Level exceeded 50 % of the Time

Key: a. considerably annoyed

--- during the day

— at night

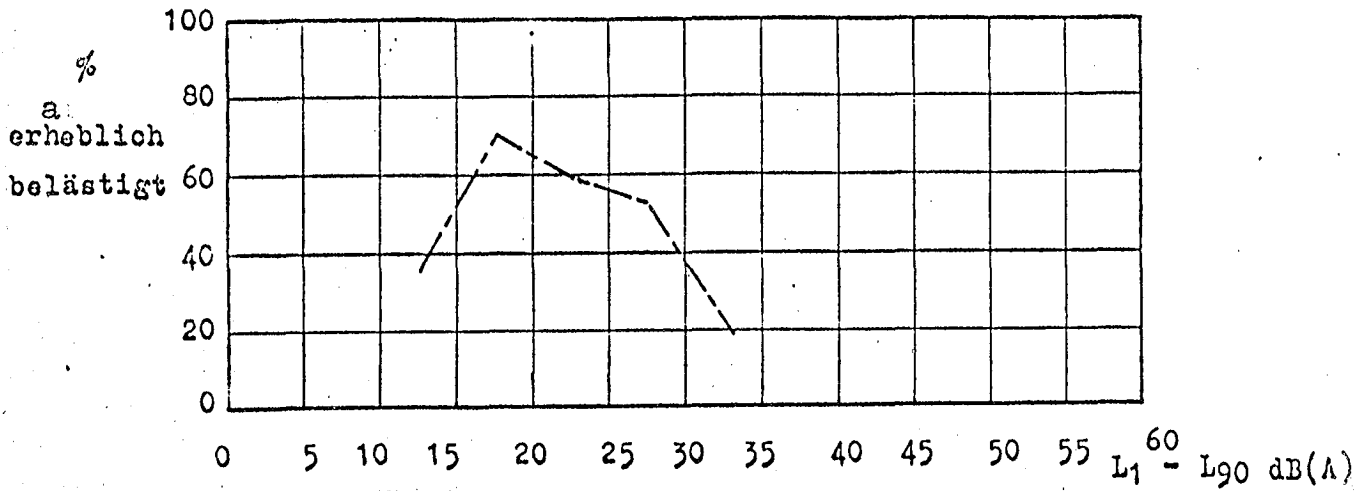


Fig. 3 C: Dynamics of the Sound Level  
 Key: a. considerably annoyed

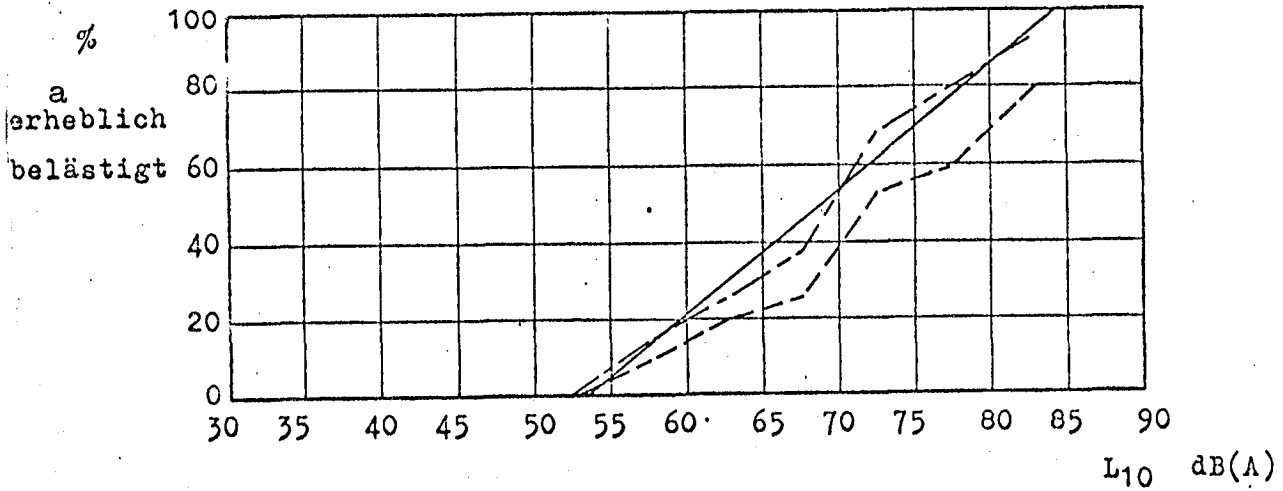


Fig. 4: Percentage of Considerably Annoyed Persons as a Function of Traffic Noise  
 A. Sound Level Exceeded 10 % of the Time  
 Key: a. considerably annoyed  
 - - - - - during the day  
 \_\_\_\_\_ at night

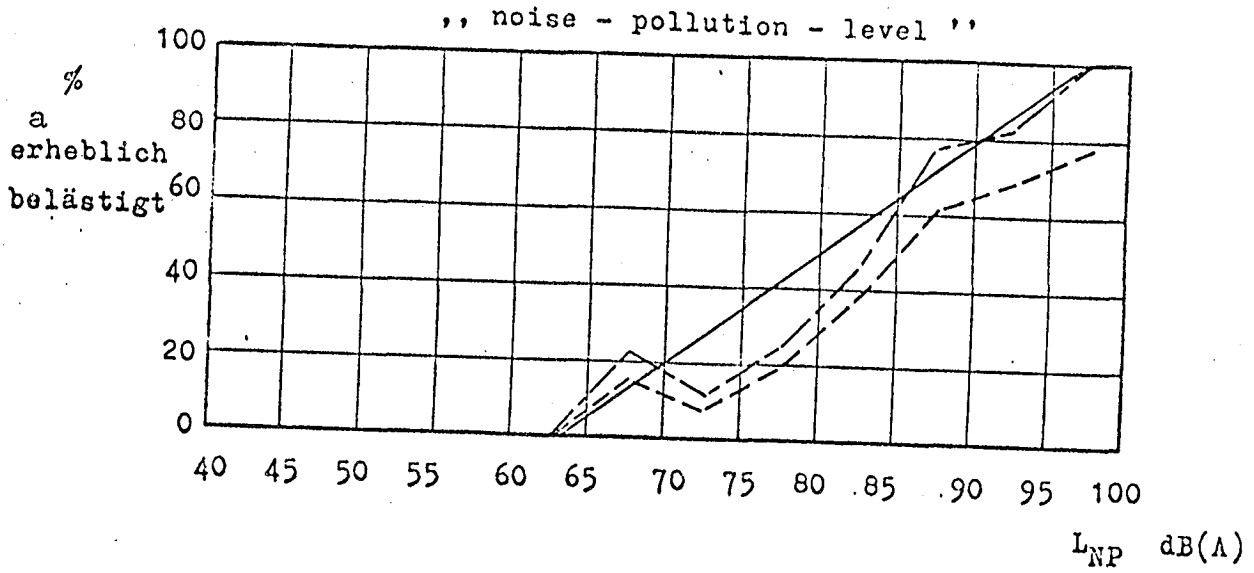


Fig. 4 B: Noise Pollution Level  
Key: considerably annoyed

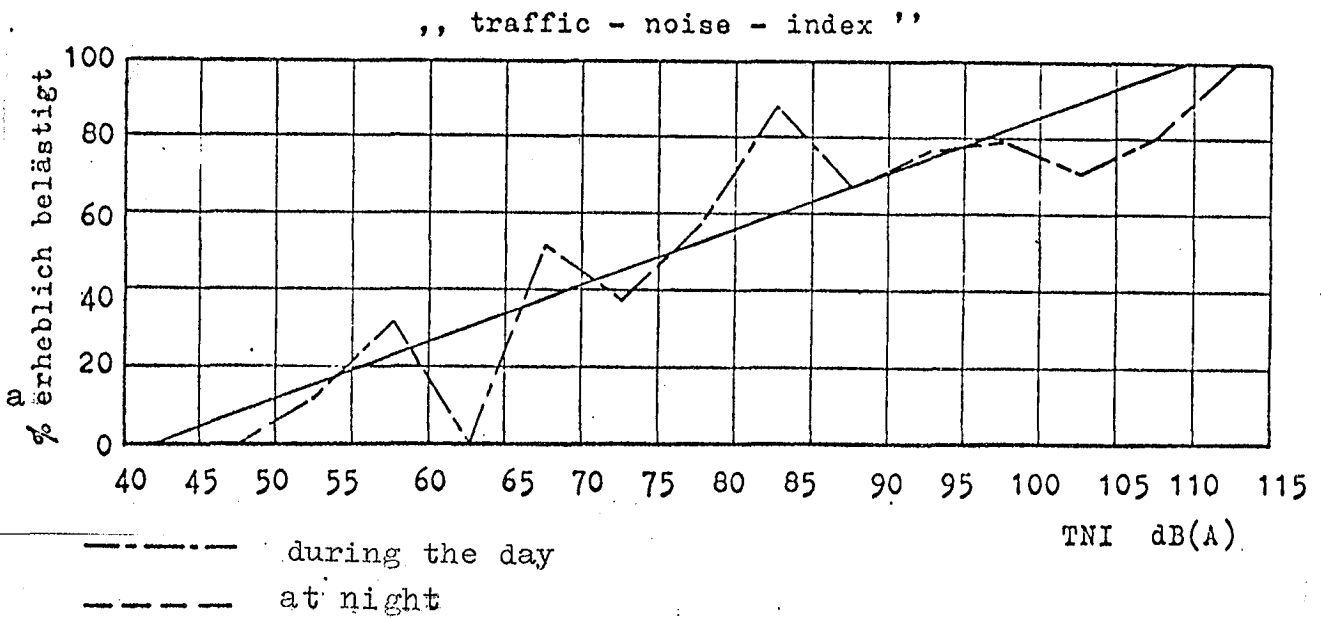


Fig. 4 C: Traffic Noise Index  
Key: a. considerably annoyed

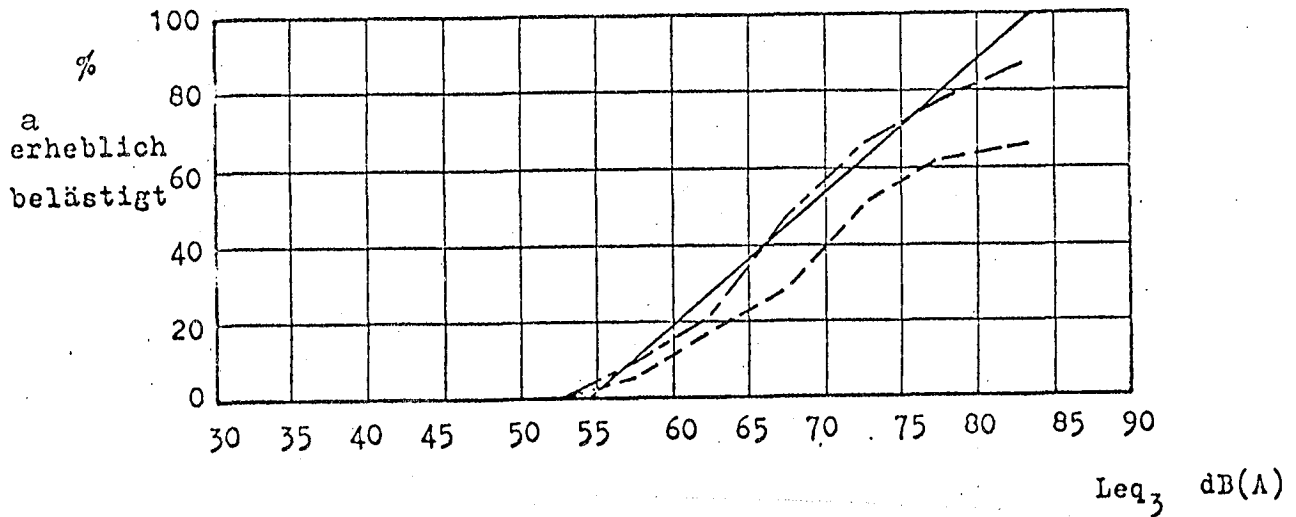


Fig. 5: Percentage of considerably annoyed persons as a Function of Traffic Noise

Persons who live in buildings exposed to traffic noise, independent of the dwelling orientation to the street.

Key: a. considerably annoyed

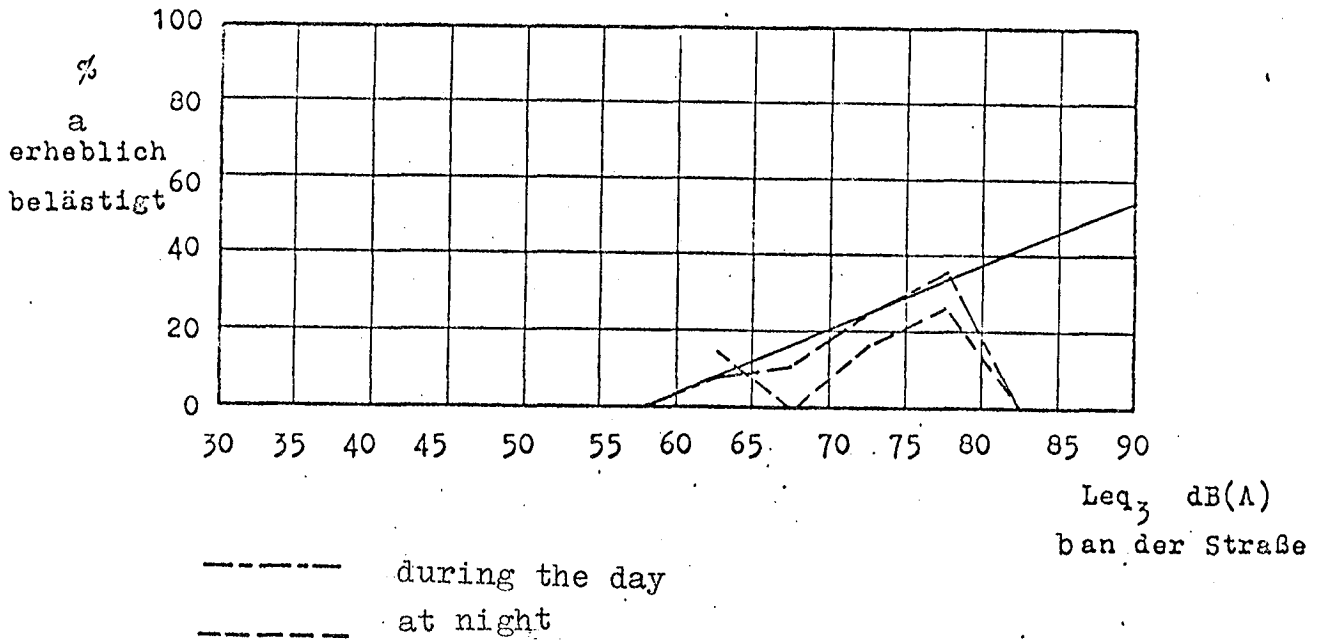


Fig. 6: Percentage of considerably annoyed persons with dwellings facing the courtyard or garden as a function of traffic noise in the street.

Key: a. considerably annoyed

b. at the street

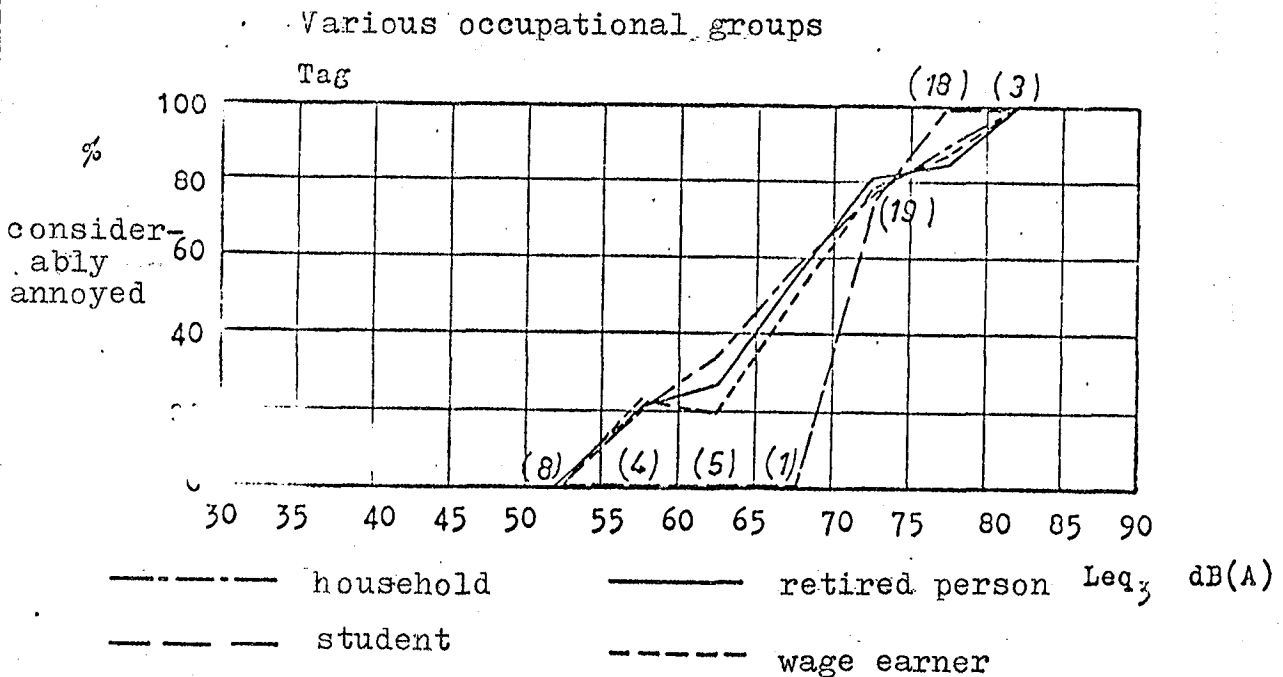
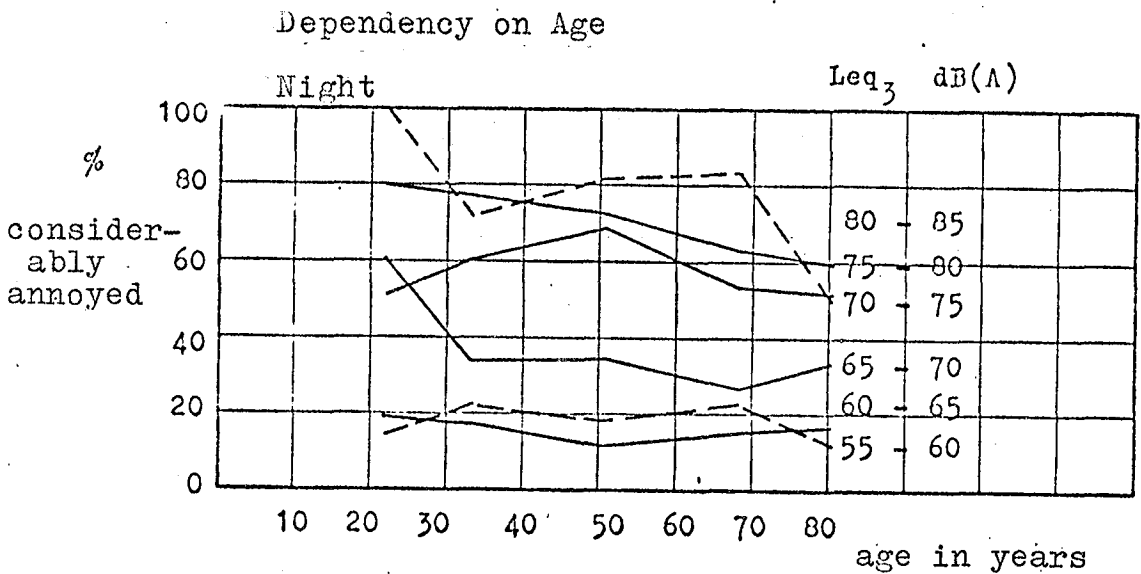
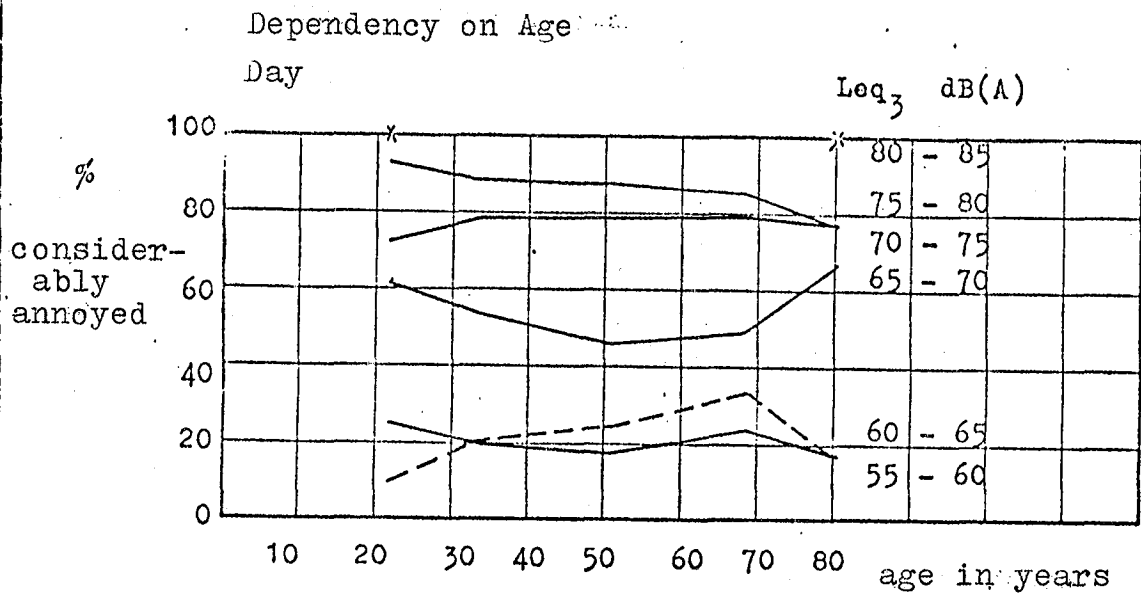
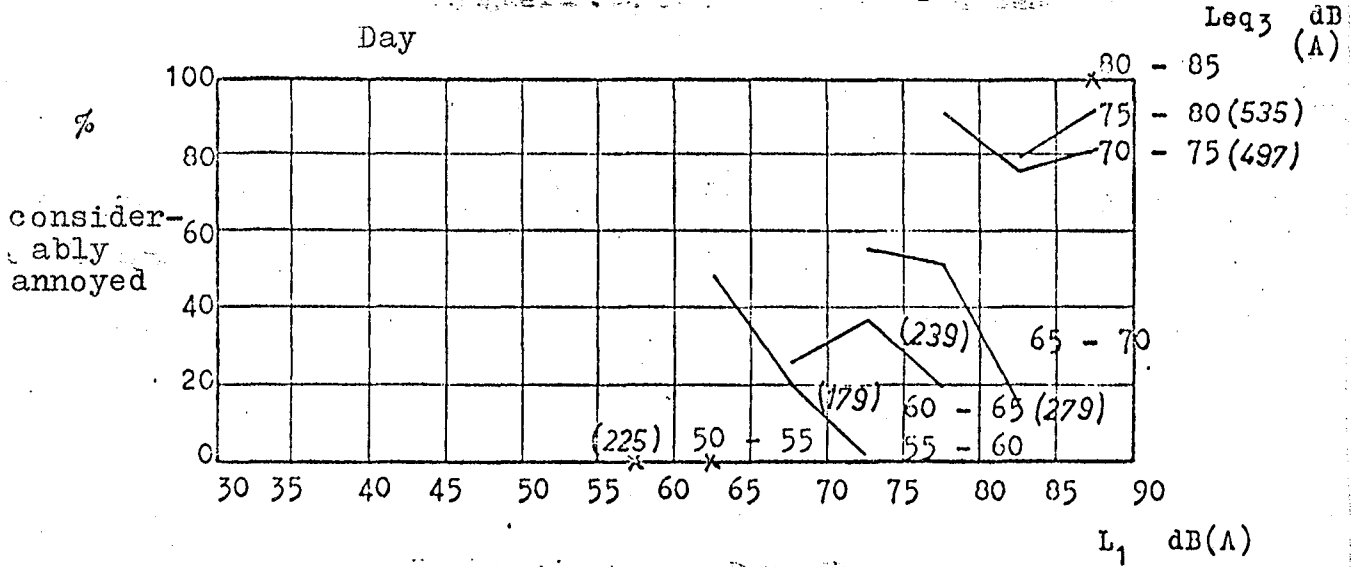


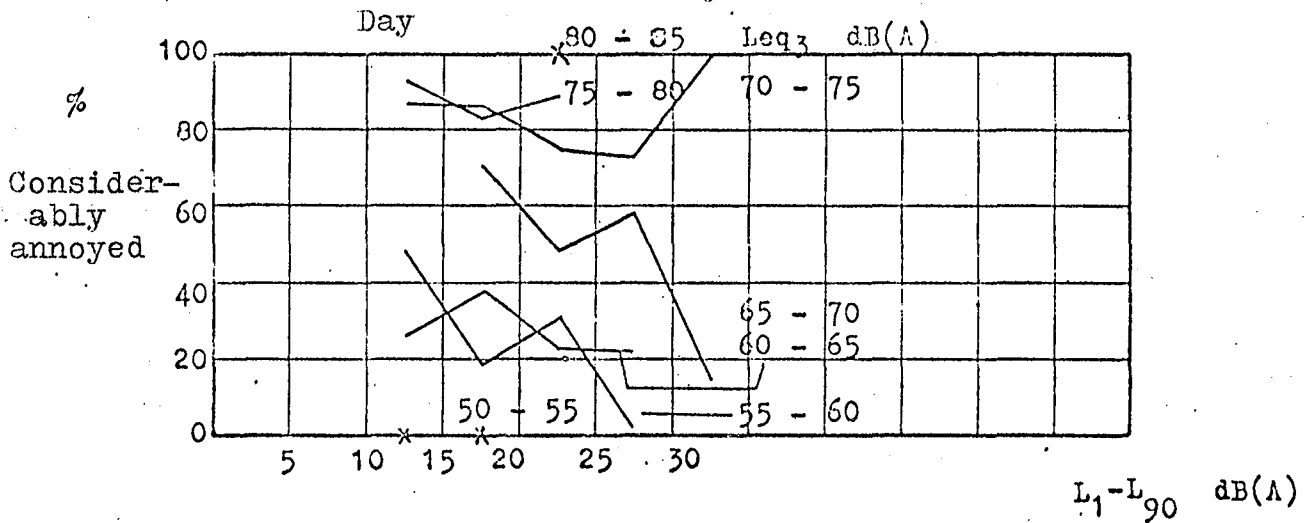
Fig. 7: Percentage of considerably annoyed persons as a function of traffic noise.



As a function of sound level peaks



As a function of dynamics



As a function of proportion of trucks

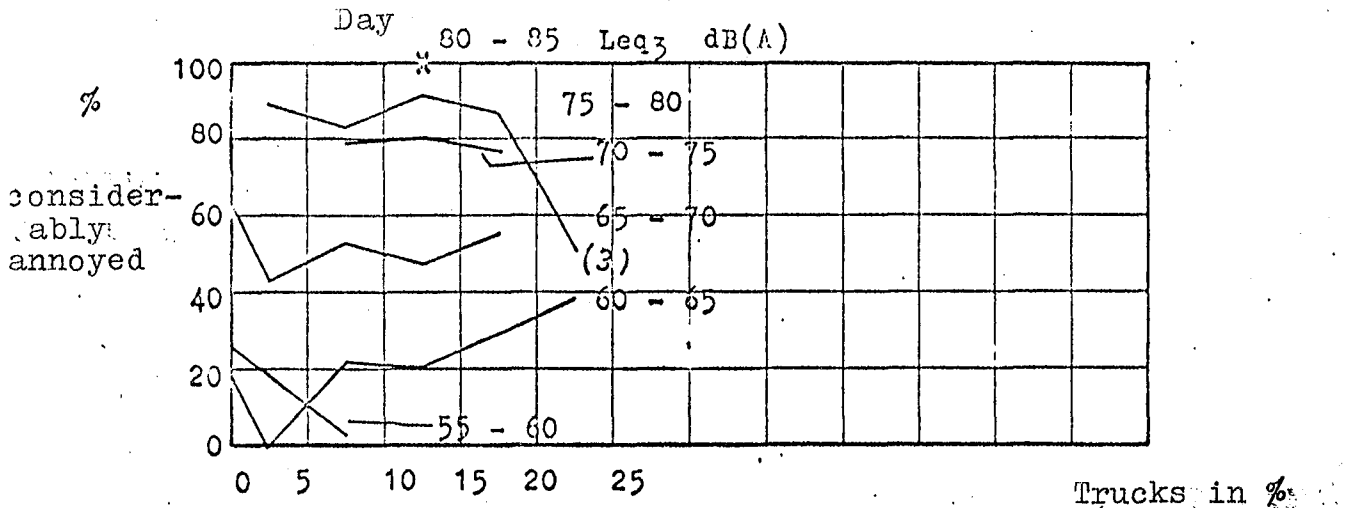


Fig. 8: Percentage of considerably annoyed persons as a function of traffic noise.

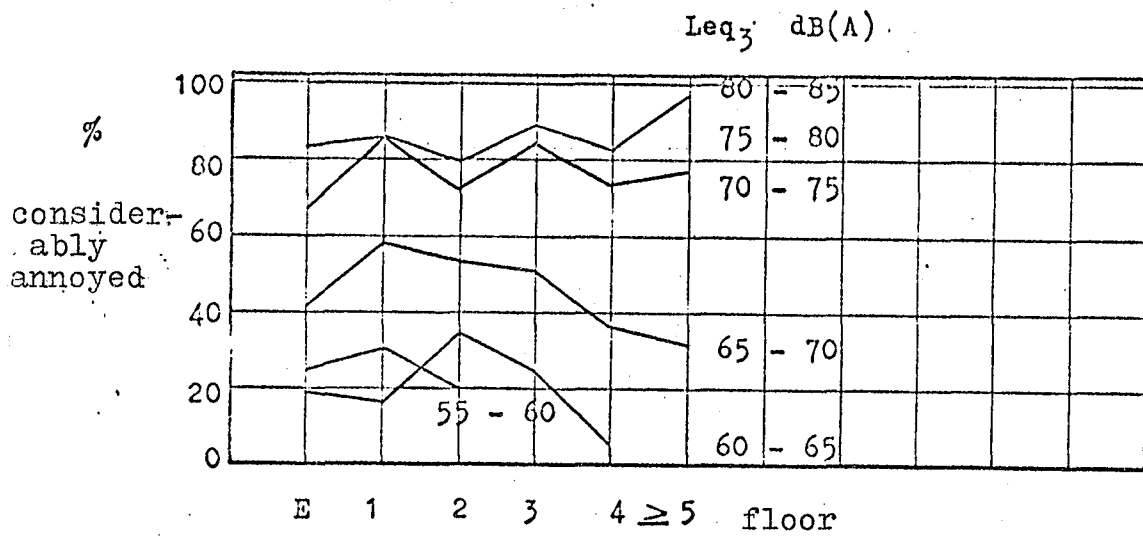
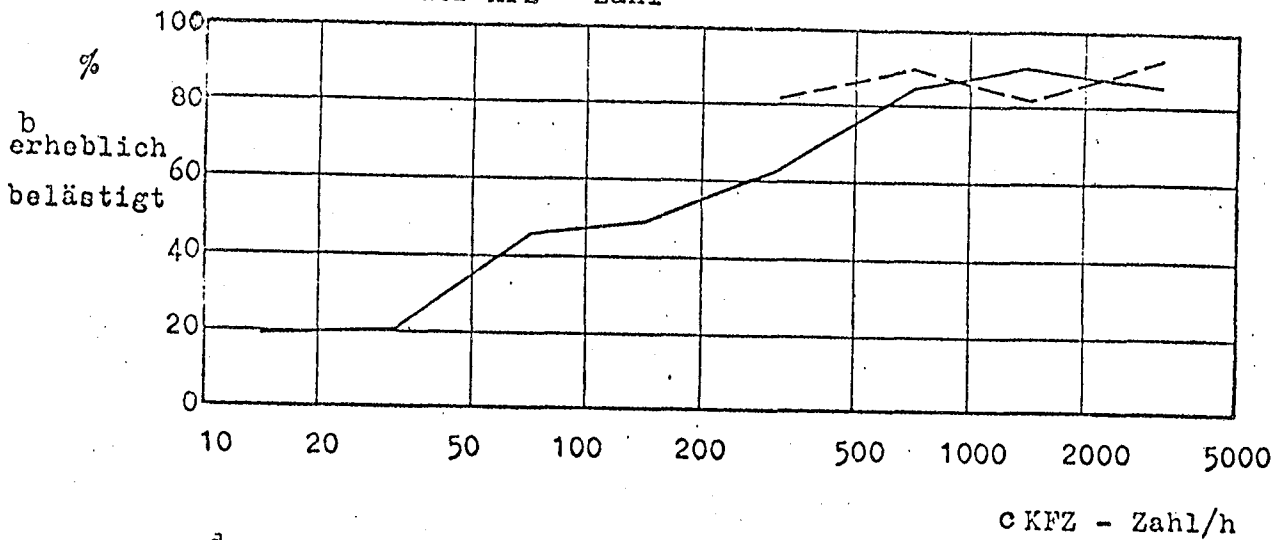
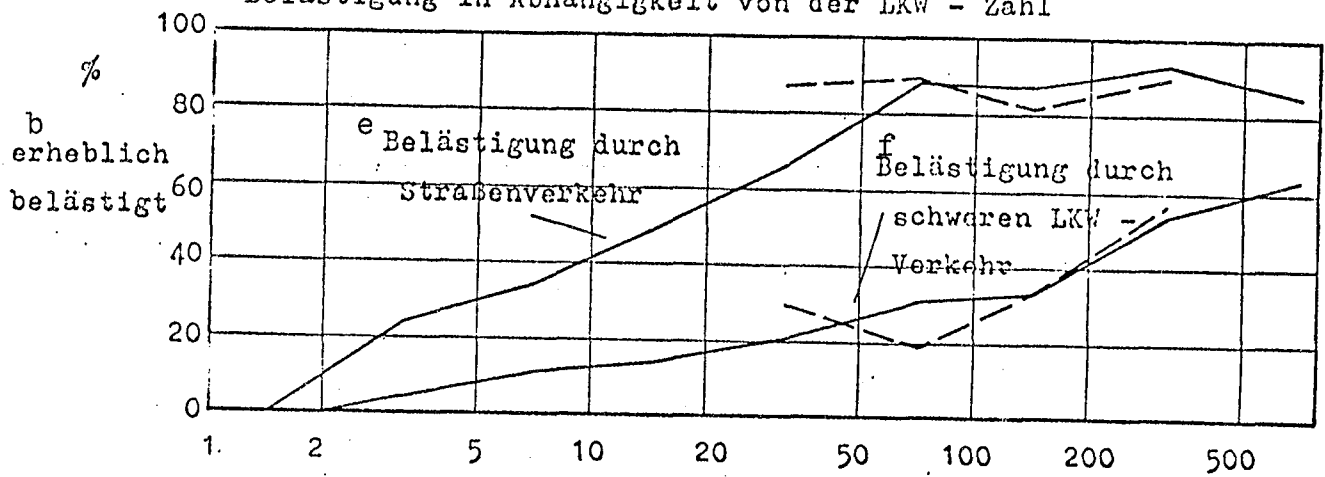


Fig. 9: Percentage of considerably annoyed persons as a function of traffic noise and floor number. Persons with dwellings facing the traffic noise.

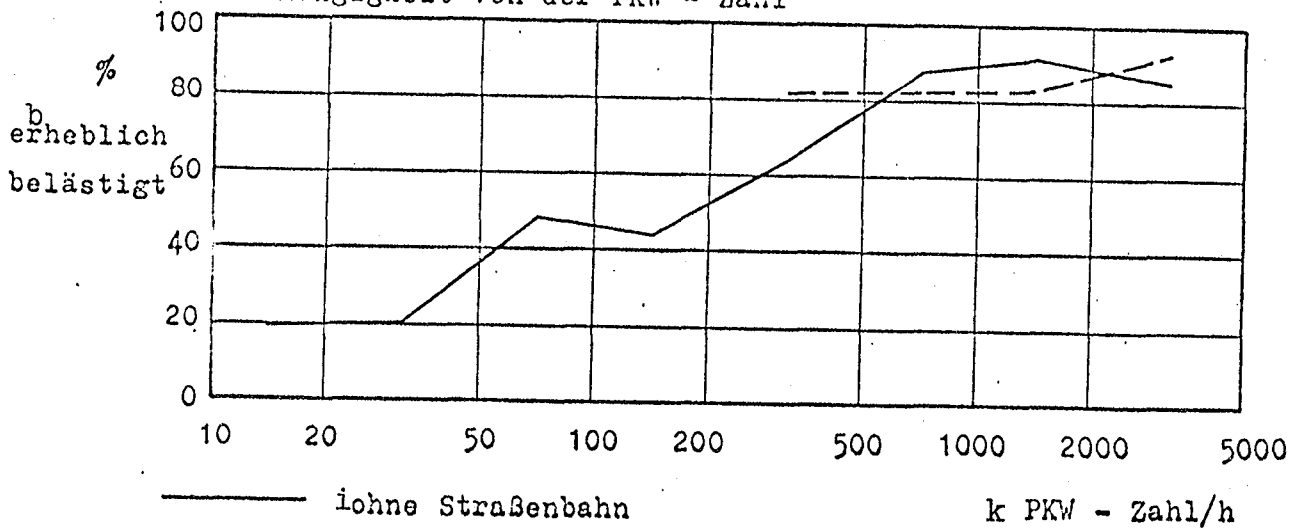
a Belästigung durch Straßenverkehr in Abhängigkeit von der KFZ - Zahl



d Belästigung in Abhängigkeit von der LKW - Zahl



h Belästigung durch Straßenverkehr in Abhängigkeit von der PKW - Zahl



— ohne Straßenbahn  
 - - - mit Straßenbahn  
 k PKW - Zahl/h

Fig. 10: Percentage of considerably annoyed persons as a function of the number of vehicles

See Key on next page

Key for Fig. 10:

- a. Annoyance due to traffic as a function of the number of vehicles
- b. considerable annoyance
- c. number of vehicles per hour
- d. Annoyance as a function of the number of trucks
- e. Annoyance due to traffic
- f. Annoyance due to heavy truck traffic
- g. number of trucks per hour
- h. Annoyance due to traffic as a function of the number of cars
- i. without streetcars
- j. with street cars
- k. number of cars per hour

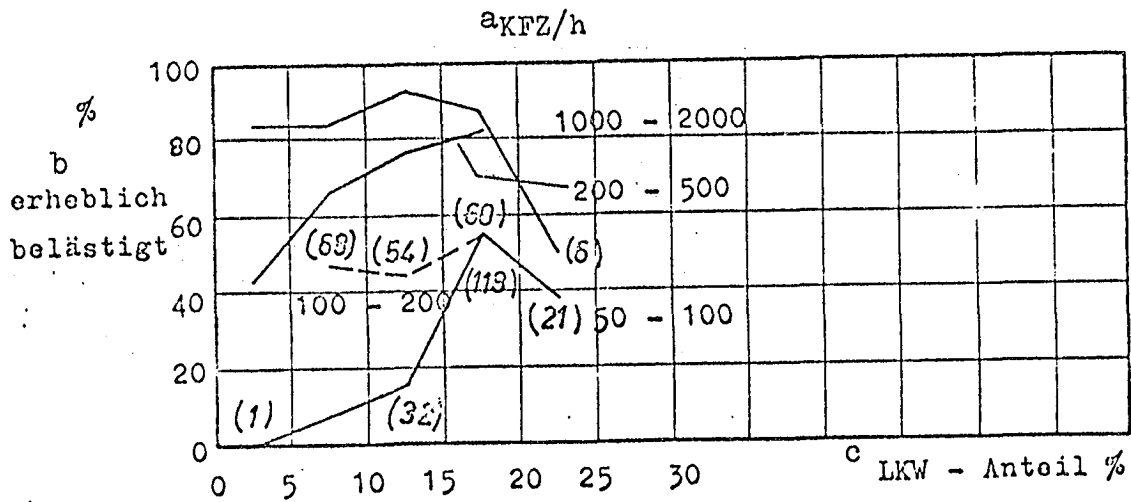


Fig. 11: Percentage of considerably annoyed persons as a function of the number of vehicles with varying portions of trucks.

- Key:
- a. vehicles per hour
  - b. considerable annoyance
  - c. trucks in %

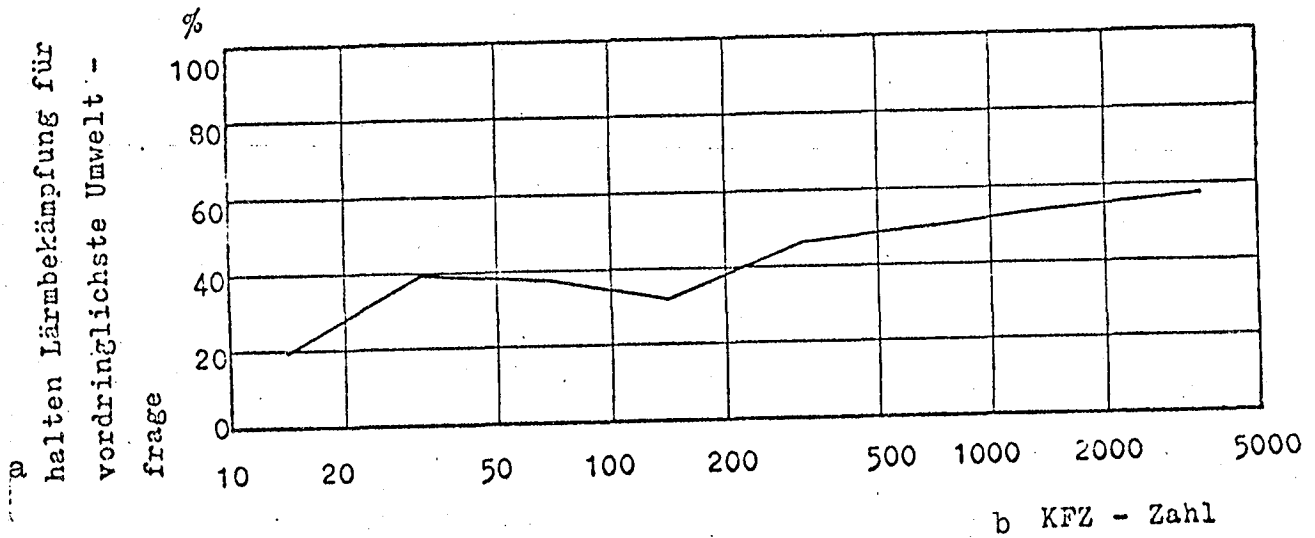


Fig. 12: Significance of combatting noise as a function of the number of vehicles

- Key: a. consider combatting noise as the most pressing environmental problem  
b. number of vehicles