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TELEPHONE TRANSMISSION QUALITY

SUBSCRIBERS' LINES AND SETS

EVALUATION OF THE EFFICIENCY OF TELEPHONE BOOTHS AND ACOUSTING HOODS

ITU-T Recommendation P.32

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation P.32 was published in Volume V of the *Blue Book*. This file is an extract from the *Blue Book.* While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Recommendation P.32

EVALUATION OF THE EFFICIENCY OF TELEPHONE BOOTHS AND ACOUSTING HOODS

(Melbourne, 1988)

The purpose of this Recommendation is to define the methods of measurement to evaluate the efficiency of either acoustic hoods or telephone booths intended to improve the quality of telephone transmission in noisy environments. In addition to the improvement of the transmission quality during a conversation between two users, this Recommendation takes into consideration the need to guarantee speech privacy for the user speaking from the acoustic hood or the booth with respect to a listener situated on the outside of the telephone booth.

1 Evaluation methods

The efficiency of a telephone booth or an acoustic hood can be evaluated using either subjective or objective measurements.

The objective measurements suitable for that purpose are those based on the acoustic insulation (for example in a reverberation chamber) resulting from the difference between the sound levels registered inside and outside the telephone booth or vice-versa. As the acoustic characteristics vary outside and inside the telephone booth, the acoustic insulation obtained in each case (noise source outside or inside the telephone booth) is not the same. In addition, if we consider open telephone booths or acoustic hoods, the measurement of the acoustic insulation gives results not correlatable to the ones obtained by means of a subjective evaluation of the booth performance.

A subjective measurement of the efficiency of booths or acoustic hoods consists in determining the intelligibility index inside the booth, in conditions of external noise (room noise, road noise, etc.). This measurement can also be objectively obtained by calculating the articulation index, by using, for example, the Kryter method as indicated in Annex A.

Another method used to measure subjectively the efficiency of booths and acoustic hoods consists in evaluating the intelligibility threshold variation observed between the intelligibility inside and outside the booth placed in a noisy ambient.

The performance of booths and acoustic hoods, related to the user’s privacy while speaking inside the booth, can be subjectively evaluated by measuring the intelligibility of the coversation from the inside to the outside of the booth or by using an objective measurement such as calculating the articulation index (according to Kryter’s method for example) outside the booth under specific noise conditions.

Since the intelligibility inside the booth is also a function of the sidetone of the telephone set used, a simple measurement of acoustic insulation which does not take into consideration the intelligibility reduction caused by the sidetone cannot furnish correct evaluations on the improvement of transmission quality due to telephone booths, or acoustic hoods.

Bearing in mind the following observations:

1) international telephone communication can be originated from telephone sets installed in noisy ambients and protected by booths or acoustic hoods;

2) there are no measurement methods recommended for evaluating the transmission quality improvement resulting from the use of the telephone booth;

3) an evaluation of the booth efficiency, based only on the acoustic insulation obtained by traditional methods (acoustic attenuation of the panels of the booth) is not always correlated to the subjective evaluation of the booth performance;

4) subjective measurements either of the intelligibility or of the intelligibility threshold variation give the possibility of evaluating the efficienty of a booth, but are time-consuming and expensive and also require a qualified and well-trained operator team;

5) there are no recommendations giving criteria relating the employement of the booths to the ambient noise level, in order to determine an acceptable quality of transmission,

methods of measurement as specified below are recommended[1]) :

a) evaluating the efficiency of telephone booths and acoustic hoods taking into consideration the intelligibility index, obtained from a listener inside the booth with the external ambient noise having a certain acoustic spectrum;

b) calculating the intelligibility index inside the telephone booth or the acoustic hood by means of the objective method defined in § 3, taking into consideration the acoustic attenuation of the booth and the sidetone of the telephone set used. This objective method allows a rapid evaluation of the booth performance, sufficiently precise for practical purposes;

c) considering the logatom intelligibility as an evaluation criterion related to the booth performance, calculated by means of the articulation index (AI). The conversion from AI to logatom intelligibility is language-dependent and it shall be performed with the appropriate relation;

d) evaluating the booth and the acoustic hood at the conditions of utilization, that is, when a user is speaking from the inside using a telephone set with a determined sidetone and with an external ambient noise having an average intensity level and a certain acoustic spectrum, both already known.

2 Definition and descriptions of parameters of calculation

Telephone conversations taking place in conditions of ambient noise are affected by ambient noise through three different paths:

1) acoustic noise (N_a) at the ear which is not engaged in the telephone call;

2) acoustic noise (N_b) at the ear which is engaged in the telephone call, determined by the acoustic leak between ear and handset;

3) noise picked up by the microphone and directed by sidetone (N_s) to the ear which is engaged in the conversation.

The acoustic noise flowing through the acoustic leak between ear and handset has a spectrum which changes as a function of the pressure of the handset against the ear. To evaluate the performance of booths, the acoustic attenuation (L_{RNE}) of this path can be taken into consideration.

The noise N_S is due to sidetone changes according to the telephone set used and it generally has a spectrum which is different from that of N_b. In spite of their mutual correlation, the power summation of the respective spectra seems the best estimate of the global noise (N_g) which affects the ear engaged in the conversation.

In addition, the noises at the two ears (N_a, N_b) are generally different, both in level and in spectrum; experimental intelligibility measurements [1] [2] have demonstrated that this disturbing effect can be evaluated by subtracting 10 dB from the noise level (N_a) at the free ear.

The aforesaid experiment measurements have also shown that the *total* equivalent noise N_T to be used in intelligibility calculations is given by the amplitude sum of noise spectra at the two ears. Consequently, the total equivalent noise N_T is given from the relation:

$$N_T = 20\log_{10}\left(10\frac{N_a - 10}{20} + 10\frac{N_g}{20}\right) \qquad \text{dB}$$

The sidetone noise N_S is a function of the mouth-to-ear sidetone loss L_{MEST} and it should be measured at the actual noise level, typically 65 dB SPL, under diffuse field conditions. This is particularly important in the case of telephone sets with carbon microphones or of electronic telephone sets with automatic gain control or provided with noise cancelling microphones.

3 Calculation of the booth or acoustic hood efficiency

Given a particular telephone booth or an acoustic hood, the following procedure shall be followed for determining the articulation index in actual operating conditions.

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[1]) Documentation about the specifications in this Recommendation is not yet sufficient to confirm their validity, thus they are subject to future enhancement and should be regarded as provisional.

Calculate:

a) the noise spectrum N_a inside the booth by subtracting the acoustic attenuation of the booth (L_a) from the external noise spectrum (N_e). The attenuation should be measured in third octave bands, with a person inside the booth (or a baffle providing an equivalent acoustic absorption) and in a diffuse field condition;

b) the spectrum of the noise N_b by subtracting the leakage attenuation of the handset (L_{RNE}) from the noise spectrum inside the booth N_a;

c) the sidetone noise spectrum N_S by subtracting the acoustic sidetone attenuation L_{RNST}[2)] from the noise spectrum inside the booth N_a;

d) the spectrum of global noise N_g at the ear pressed against the handset as the power sum of N_s and N_b;

e) the spectrum of total equivalent noise N_T as the amplitude sum of noises at both ears, after having subtracted 10 dB from the noise spectrum at the ear not engaged;

f) the articulation index, AI by Kryter's method [3], assuming a listening speech level of 70 dBA, a value corresponding to the limit of the attenuation of the line loss distribution.

An example of application of the calculation method is shown in Appendix I.

4 Efficiency limits of booths and acoustic hoods

Efficiency of booths or acoustic hoods can be considered satisfactory if an AI equal to 0.6 is guaranteed.

This value corresponds for most languages to a logatom intelligibility of 80% inside the booth, according to the results of French and Steinberg [4], in Figure 1/P.32. It can be assumed as the minimum acceptable limit of performance, corresponding to the maximum external noise level that the booth can withstand in order to guarantee a good quality of telephone transmission inside the booth.

Therefore, each booth can simply be classified by specifying a *maximum external noise level* (MENL), which is the level that gives AI = 0.6.

The MENL that classifies the telephone booth shall be determined by repeating the calculation of the AI, as is indicated in § 3, with different levels of external noise. By means of the curve representing the values of the AI as a function of the outside noise level, the MENL corresponding to an AI = 0.6 can be determined. This MENL depends not only on the acoustic attenuation of the booth or acoustic hood, but also on the received speech level which is assumed to have a reference value of 70 dBA, and on the sidetone performances of the telephone set which should be measured at a proper sound pressure level, (about 65 dB SPL) and in free field conditions.

2) It is important the room noise sidetone sensitivity L_{RNST} which makes use of a diffuse room noise source within the booth. It may also be necessary to include within the booth a manikin to stimulate the presence of a subscriber.

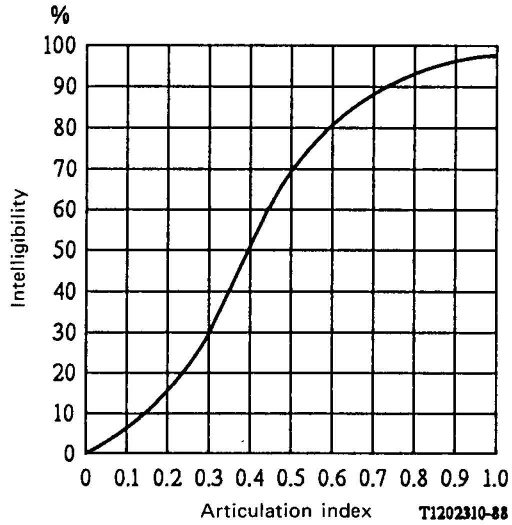

FIGURE 1/P.32

Relation articulation index and logatom intelligibility

5 Speech privacy of telephone communications

The booth can also guarantee speech privacy of conversation by reducing the vocal signals radiated towards outside in order to make them unintelligible. Applying Kryter's calculation method of the articulation index of the speech signals transmitted through the booth to the external ambient at a predetermined noise level, the distance at which the logatom intelligibility or AI falls to a pre-determined value (for example, AI = 0.3) can be estimated. This method can be used to determine the curves of equal intelligibility (isophenes) in any direction, increasing distance from the booth.

Note - The quality improvement of the conversation for the subscriber at the other end of the telephone connection, during a call with a telephone in a booth or acoustic hood has not yet been studied. The evaluation of this aspect is required in any case to consider a number of other factors such as the natural increase of speech loudness in noisy environments and the effective signal-to-noise ratio of transmitted signals.

ANNEX A

(to Recommendation P.32)

Example of efficiency calculation of a telephone booth

The articulation index (AI) is calculated according to Kryter's method.

The acoustic attenuation of a telephone booth measured in an echo chamber at each one-third octave band is reported in Table A-1/P.32, column 2. The total noise level outside the booth is 80 dBA and the sound level of the noise at each centre frequency band is indicated in column 3. The sidetone response characteristics (L_{RNST}) of the telephone set used inside the booth is given in column 4.

The noise level inside the booth at each centre frequency band (N_a) is obtained by subtracting column 2 from column 3 (column 5). It is supposed that the handset of the telephone instrument used in the booth has the acoustic attenuation indicated in Figure A-1/P.32 and reported in column 6.

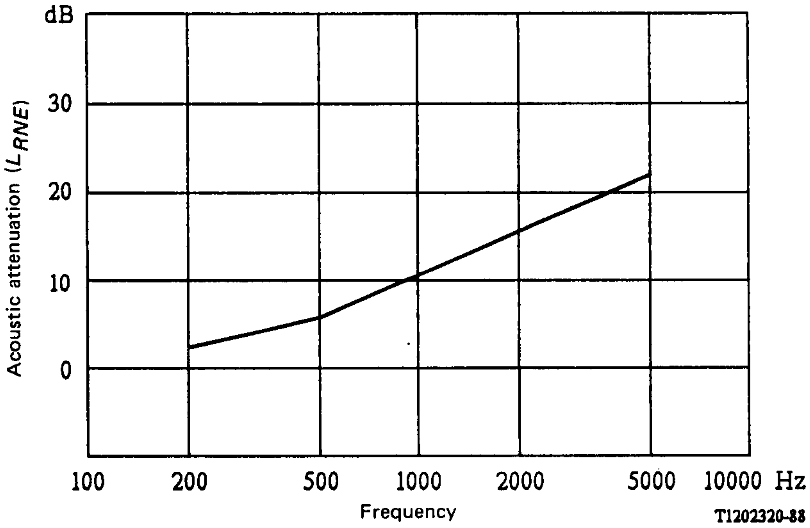

FIGURE A-1/P.32

Acoustic attenuation of handset pressed against the ear

The values of noise (N_b) due to acoustic leakage between ear and handset obtained by subtracting column 6 from column 5 are reported in column 7.

The values, at each frequency band, of the sidetone noise (N_s) obtained by subtracting column 4 from column 5 are reported in column 8. The global noise at engaged ear (N_g) is reported in column 9 as the power sum of the levels indicated in columns 8 and 7. The total equivalent noise is obtained by adding the levels of column 9 to the values of column 5 reduced by 10 dB (column 10). The speech spectrum (β’) is reported in column 11 and the signal-to-noise ratio corrected by 12 dB (considering the peaks of the speech signal) is indicated, at each one-third octave band, in column 12. Kryter’s coefficients are indicated for each one-third octave band in column 13.

The articulation index (AI) is obtained by multiplying the values of column 12 by those of column 13 and adding the results. By repeating the calculation with other external noise levels, it is possible to draw the diagram of the AI as a function of external noise levels for the considered booth, as shown in Figure A-2/P.32. It can be seen that this booth is designed for withstanding a maximum external noise of about 77 dBA which is the MENL value that classifies the booth.

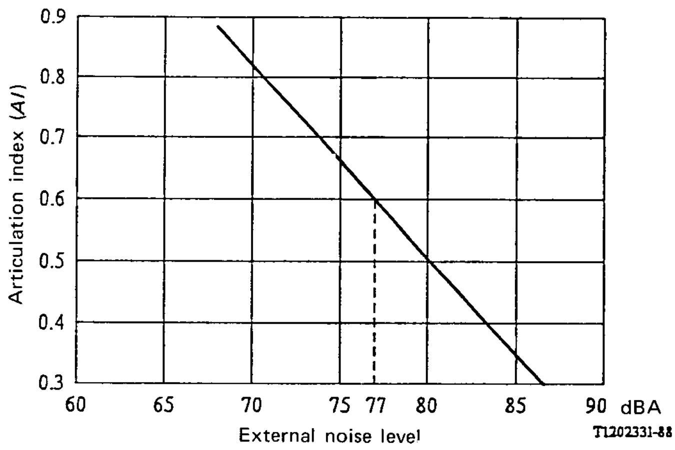

FIGURE A-2/P.32

Articulation index as a function of external noise levels

(MENL of the booth = 77 dBA)

TABLE A-1/P.32

Central frequency one-third octave band (Hz)	Acoustic attenuation of the booth, L_a (dB)	External noise, N_e (dB SPL)	Acoustic sidetone attenuation, L_{RNST} (dB)	Noise inside the booth, N_a (dB SPL)	Acoustic attenuation of handset, L_{RNE} (dB)	Noise due to acoustic leakage, N_b (dB SPL)	Sidetone noise, N_s (dB SPL)	Global noise at engaged ear, N_g (dB SPL)	Total equivalent noise, N_T (dB SPL)	Speech spectrum, β' (dB SPL)	Signal + 12 dB / Noise	Kryter's coefficient	Products (13) x (12)
(1)	(2)	(3)	(4)	(5) = (3) – (2)	(6)	(7) = (5) – (6)	(8) = (5) – (4)	(9)	(10)	(11)	(12) = (11) + 12dB – (10)	(13)	(14)
200	10	77.5	12	67.5	3	64.5	55.5	65.0	68.1	61	4.9	0.004	0.0196
250	13	76.5	12	63.5	4	59.5	51.5	60.1	63.4	63	11.6	0.001	0.0116
315	13	73.5	11	60.5	5	55.5	49.5	56.5	60.0	64	16.0	0.001	0.0160
400	15	74.0	9	59.0	6	53.5	50.0	54.8	58.4	65	18.6	0.0014	0.0260
500	14	72.5	9	58.5	7	51.5	49.5	53.6	57.4	65	19.6	0.0014	0.0277
630	14	72.0	10	58.0	8.5	49.5	48.0	51.8	56.1	63	18.9	0.002	0.0378
800	16	72.0	12	56.0	10.0	46.0	44.0	48.1	53.1	62	20.9	0.0020	0.0418
1000	15	71.0	12	56.0	11.5	44.5	44.0	47.3	52.7	61	20.3	0.0024	0.0487
1250	15	69.5	9	54.5	13.0	41.5	45.5	47.0	51.9	60	20.1	0.0030	0.0603
1600	15	68.0	9	53.0	14.5	38.5	44.0	45.1	50.1	58	19.9	0.0037	0.0736
2000	11	66.0	8	55.0	16.0	39.0	47.0	47.6	52.4	54	13.6	0.0037	0.0503
2500	11	64.0	10.5	53.0	17.5	35.5	42.5	43.3	49.2	49	11.8	0.0034	0.0401
3150	12	62.0	14	50.0	19.0	31.0	36.0	37.2	44.7	47	14.3	0.0034	0.0486
4000	12	61.5	14	49.5	20.5	29.0	35.5	36.4	44.1	39	6.9	0.0024	0.0166
TOTAL (dBA)		80.0		66.3					64.7	70.0			AI = 0.52

SPL Sound pressure level

References

[1] CCITT Contribution – COM XII-No. 122, (France), Study period 1981-1984.

[2] CCITT Document – Annex 2, AP VII-No. 115.

[3] KRYTER, (K.): Methods for the calculation and use of Articulation Index, *J.A.S.A.* Vol. 34, 1962.

[4] FRENCH, (N. R.) and STEINBERG (J. C.): Factors governing the intelligibility of speech sounds, *J.A.S.A.* Vol. 19, 1947.

Bibliography

CCITT Contribution – COM XII-No. 139, (Italy), Study period 1973-1976.

CCITT Contribution – COM XII-No. 130, (Norway), Study period 1977-1980.

CCITT Contribution TD 26, (Sweden), WP Laboratory (Geneva, 17-19 January 1984)

KRYTER (K.): The effects of noise on man, *Academic Press*, pp. 70-77, 1970.