CALL CENTRES - ETSI WORK ON ACOUSTIC EXPOSURE

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1 INTRODUCTION

Acoustic shock has been a known problem in telecommunications apparatus for many years. In the mid 1920s the GEC Hirst Research Centre in England experimented with the use of coherers fitted at feed bridges in exchanges so as to reduce the effect of disturbing clicks. In 1957 Palva[1] reported proven cases of hearing damage to 15 % of telephone operators caused by headphones that were not fitted with shock suppressors, but a later study of telephone operators in Holland reported by Martijn[2] in 1970 was unable to find any risk arising from their work.

In 1999 a UK report[3] alleged that 39 % of call centre operators are concerned that their hearing is being damaged as a result of exposure to noise at work.

Following this the Speech Transmission Quality (STQ) committee of ETSI commissioned a study into existing standards and approval documents dealing with acoustic safety requirements for telecommunications terminal equipment, together with other relevant background information. This resulted in a report[4] entitled "Acoustic Safety of terminal equipment (TE); An investigation on standards and approval documents". Safety standards are normally the responsibility of CEN/CENELEC, but here, STQ is providing expert guidance in the form of technical reports.

2 TELECOMMUNICATIONS REGULATION

2.1 European legislation

Note that the investigation was set up into terminal equipment. In the Telecommunications field it has been the practice to protect users by setting limits on the terminal equipment so as to limit any hazard at its source. Within Europe, there are a number of Directives that are applicable to telecommunications equipment.

The RTTE Directive 1999/5/EC[5] establishes a regulatory framework for the placing on the market, free movement and putting into service in the Community of radio equipment and telecommunications terminal equipment. In Article 3.1(a), "the protection of health and the safety of the user and any other person, including the objectives with respect to safety requirements contained in Directive 73/23/EEC[6] but with no voltage limit applying" is specified as an essential requirement of this Directive applying to all apparatus.

Directive 73/23/EEC[6], the Low Voltage Directive, thus applies to all telecommunications terminal equipment. It specifies that equipment “may be placed on the market only if, having been constructed in accordance with good engineering practice in safety matters in force in the Community, it does not endanger the safety of persons, domestic animals or property when properly installed and maintained and used in the applications for which it was made". It thus covers all safety aspects of this equipment, including protection from hazards of mechanical origin.

The Noise at work Directive 86/188/EEC[7] has as its aim the protection of workers against risks to their hearing including the prevention of such risks arising or likely to arise from exposure to noise at work. The Directive applies to workers in the telecommunications field and requires in Article 4.1 that "where the daily exposure of a worker to noise is likely to exceed 85 dB(A) or the maximum value of the unweighted instantaneous sound pressure is likely to be greater than 200 Pa (140 dB rel 20 μPa), appropriate measures shall be taken".

Workers are required to be informed of the potential risk, the measures being taken, the obligation to comply with protective measures and the wearing of personal ear protectors. They are required also to have access to the results of noise assessments. Article 6 of the Directive requires that where the daily personal noise exposure exceeds 90 dB(A), "personal ear protectors must be used", and that where the exposure exceeds 85 dB(A), "personal ear protectors must be made available to workers"

The new Physical Agents Directive 2003/10/EC[8] replaces the noise at work Directive and lays down minimum requirements for the protection of workers from risks to their health and safety arising or likely to arise from exposure to noise and in particular the risk to hearing. It will come into force throughout Europe at the latest by February 2006.

It sets 80 dB(A) as a lower exposure action value at which individual hearing protectors should be made available to workers and 85 dB(A) as an upper exposure action value at which such protection shall be used. It further states that under no circumstances shall the exposure of the worker exceed 87 dB(A) or a peak pressure of 200 Pa.

2.2 American legislation

Exporters of telecommunications equipment also have to take note of American legislation. Current American legislation is based upon work in 1965 by the National Academy of Sciences-National Research Council, Committee on Hearing, Bioacoustics, and Biomechanics (CHABA) which was an attempt to predict the hazard from nearly every conceivable noise exposure pattern based on Temporary Threshold Shift (TTS) experimentation.

In 1969 the Walsh-Healey noise standard that is in effect today was issued [34 Fed. Reg. 7,948 (1969b)]. This version, set a 5 dB exchange rate between noise level and exposure and formed the basis of subsequent Occupational Safety and Health Administration (OSHA) regulations[9] for the purpose of requiring preventive efforts for noise-exposed workers.

OSHA regulations call for the noise measurement to be made with an A-weighted meter having a slow response. An 8-hour permissible exposure is 90 dB(A) with a halving of exposure period for each 5 dB increase in noise level up to an upper limit of 115 dB(A) for periods of 1/4 hour or less. The exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level. A hearing conservation programme is required to be administered whenever the time weighted average exposure exceeds 85 dB(A).

Arising from a requirements of the Occupational Safety and Health Act of 1970, the US department of Health and Human Services in 1998 published a National Institute for Occupational Safety and Health (NIOSH) document[10] revising earlier recommendations for criteria for a recommended standard on occupational exposure to noise. This document supports 85 dB(A) as an 8-hour time-weighted limit. It gives 140 dB(A) as the ceiling limit for continuous, varying, intermittent or impulsive noise. It also recommends a 3 dB exchange rate for the calculation of time weighted average exposure rather than the 5 dB exchange rate still used by OSHA.

It points out that with a 40 year lifetime exposure using the 85 dB(A) limit, the excess risk of developing NIHL is 8 % - considerably lower than the 25 % excess risk at the 90 dB(A) permissible exposure limit currently enforced by OSHA. It also states that the 3 dB exchange rate is more firmly supported by scientific evidence. Although not yet embodied in US law, this is a clear indication that American thinking on noise exposure is currently falling into line with that of Europe.

Part 68 of the Rules of the Federal Communications Commission requires that since the 1st January 2000, all telephones, including cordless telephones, manufactured or imported for use in the United States (other than for export), "must be hearing aid compatible" by having a volume control feature consistent with the technical standards in 47 CFR subclause 68.317.

This requires that the telephone be equipped with a volume control that provides between 12 dB and 18 dB of gain. "The 12 dB of gain minimum must be achieved without significant clipping of the input signal". The telephone is also required to comply with the upper and lower limits of receive loudness rating defined in subclause 4.1.2 of ANSI/EIA-470-A-1987 when the volume control is set to its normal unamplified level.

Equivalent requirements apply to digital telephones. This law applies also to handsets used on PBX equipment but does not apply to headsets unless they are provided to a hearing impaired person for use in the workplace. The 18 dB of gain may be exceeded provided that the amplified receive capability automatically resets to nominal gain when the telephone goes on-hook.

3 STANDARDIZATION

3.1 International standardization

International telecommunications standardisation takes place in the ITU-T, previously the CCITT. The original recommendation dealing with acoustic shock was CCITT Recommendation K.7[11] (adopted in Geneva 1964). This recommended that when a voltage surge occurred on a telephone line that caused the protective device to operate, the amplitude of the sound pressure caused by the diaphragm of the receiver should not exceed 120 dB rel. $2x10^{-4}$ μbar (20 μPa) at 1 000 Hz. These figures were originally derived from results that were being achieved at the time that the limits were originally set with the components then available (selenium rectifiers and moving iron earphones). They were agreed as numbers that operators and manufacturers were "not uncomfortable with".

Subsequent work in Study Group 12 originally started at the beginning of the 1977 in the then CCITT and continued sporadically until 2000 culminating in the current ITU-T Recommendation P.360[12] that sets limits for handsets of +46 dBPa peak (140 dB SPL) and 31 dBPa(A) (125 dB SPL (A)) for a continuous 1kHz tone. A long term target of +41 dBPa is set for the peak value. The output signals are measured using either an artificial ear conforming to ITU-T Recommendation P.57[13] or a head and torso simulator (HATS) conforming to ITU-T Recommendation P.58[14]. For a headset, both limits are 7 dB lower. It further states that "it has been decided that the acoustic level measured by the artificial ear shall never be corrected. This means that for the Type 1 artificial ear the acoustic pressure level shall be measured at the ear reference point, and for all other types of artificial ears the acoustic pressure level shall be measured at the drum reference point.

Although the published information suggests that the presently used limits are based upon detailed considerations of noise exposure, a study of the unpublished contributions that led up to the recommendations reveal that in fact this is not so. The justification in the ITU-T of figure of 125 dB for continuous signals was generated in 1986, well after the limit of 125 dB was first used in the US and was constructed on the basis of OSHA 5 dB/time halving. The 1998 justification used for ITU-T Recommendation P.360[12] was based on 3 dB/ time halving but used different correction factors which conveniently arrived at the same limits.

There has also been work in other international bodies. In July 1991 IEC/TC74 WG 7 made a proposal to extend IEC 950 with a new work item on the control of acoustic levels. The first draft amendment was based on rather poor rewording of CCITT Recommendation P.36[15] and at voting in early 1993 received a number of negative comments, mainly from European countries. It was found impossible to reach an agreement between US and European telecommunications limits and finally a 1996 amendment was withdrawn before going to its vote. In Europe, this work was paralleled by CENELEC, which finally concluded that that further research would be needed.

3.2 Other relevant standards

EN 50332 Pt 1 for headphones and earphones associated with sound system equipment[17] sets an output limit of 100dB SPL measured on a Head and Torso Test Set (HATS) using a test signal representing musical signals. The signal measured at the DRP is converted to a free field pressure using the HATS transfer function.

ISO Publication 1999[18] sets out procedures for the determination of occupational noise exposure and provides a large collection of formulae for the estimation of noise-induced hearing impairment. It aims to provide a means of estimating the likelihood of an exposed worker suffering hearing impairment at various ages after a number of year's exposure to various levels of noise. The standard uses the concept of Noise Induced Permanent Threshold Shift (NIPTS) in its calculations. A difficulty in using this standard is that it does not lay down fixed criteria for the frequencies at which hearing impairment is assessed nor give guidance on the levels of impairment that cause handicap. Thus different users of the standard can obtain significantly differing results depending in the criteria chosen.

BS 5330[19] describes a method of test for estimating the risk of hearing handicap due to noise exposure. When it was published in 1976 it differed substantially from the then current version of ISO Publication 1999[18]. It still differs substantially from the 1990 version of that standard in that it deems handicap to occur if the arithmetic average of the hearing threshold levels, of the two ears combined, at 1 kHz, 2 kHz and 3 kHz is equal to or greater than 30 dB. This single rule leads to a great simplification in the derivation of the results. The document provides useful information on the effects of the exposure to noise for that longer period than the normal working life as would occur with normal telephone usage. It also gives data on the various levels of risk of suffering impairment at any particular age.

3.3 ETSI documents

There are 19 ETSI documents, which make reference to acoustic shock. Before 1994 the various standards set limits. Following regulatory guidance that the prevention of acoustic shock was not an essential telecommunications requirement, later standards specified no requirements but pointed out that the prevention of acoustic shock is a safety requirement arising from the Low Voltage Directive (73/23/EEC[6]). They stated that in the absence of any relevant safety standard, a supplier's self-declaration could be based on recommendations (usually given in an advisory annex), which were essentially identical with the previously specified requirements.

Early documents (e.g. ETSI ETS 300 085[20] on ISDN handset terminals) specified limits of 24 dBPa rms (equivalent to 118 dB rel 20 μPa) measured at the Ear Reference Point (ERP) for continuous signals. For analogue telephones, testing was performed using a generator delivering a pure tone signal with an e.m.f of 24 dBV (ETSI I-ETS 300 480[21]). For ISDN telephones the digitally encoded signal representing the maximum possible signal at the digital interface was used (ETSI I-ETS 300 245-2[22]). A figure of 36 dBPa (equivalent to 130 dB rel 20 μPa) at the Ear Reference Point (ERP) was set as the limit for peak signals. In general, no tests were described.

ETSI I-ETS 300 131[23] contains requirements for audible incoming call indication on the cordless portable part (CPP). The sound pressure at the ERP is not permitted to exceed 24 dBPa, and where the audible indication is generated other than through the earpiece, the sound pressure at the commencement of such indication is not permitted to exceed 50 dB A-weighted at 1 m free field in any direction. It is noted that the initial level should rise in increments no greater than 6 dB, at a rate not greater than 6 dB/s, to a maximum within not less than 6 s.

4 SPECIAL CONDITIONS

4.1 Call centres

Operators at call centres generally use headphones rather than handsets and are using the telephone for most of the working day. The fact that they are using headsets means that they cannot rapidly remove themselves from exposure to sudden loud noises. Their work subjects them to a significantly longer daily time exposures than other telephone users.

There are many different types of call centres with a wide range of working conditions. The results or recent HSE work indicate that the risk of hearing damage from using a headset is extremely low. Although call handlers may occasionally experience high noise levels, these are usually of very short duration. Consequently, even taking these events into consideration, call handlers' overall daily personal noise exposure is unlikely to exceed the 85dB(A) action level defined in Directive 86/188/EEC[7] although these risks may need to be reassessed in view of the requirements of the new physical agents directive 2003/10/EC[8].

In spite of these results, telephone operators in emergency call centres have in the past made claims to have been damaged by acoustic shock. In two European countries concerned it has been shown that that there were noise limiting devices fitted that worked correctly, limiting the levels to 112 dB or 118 dB. There is little published on these cases as most were settled out of court with no admission of liability. The main symptoms complained of were nausea, dizziness and noise recruitment. In private papers in early 2000 it was suggested that the effect of some sudden relatively low level noises could in some circumstances cause some sort of startle trauma.

It is now seems possible that the postulated startle trauma may be real. A large number of cases were reported at a seminar entitled “Risking acoustic shock. A seminar on acoustic trauma from headsets in call centres”[24] that was held in Australia in September 2001. Unfortunately the effect is still indeterminate and is the subject of ongoing research. The cause is believed to be in some way related to stress.

4.2 Hearing aid users

Particularly in view of the use of amplified handsets to assist the hard of hearing, it is necessary to consider whether different limits should be applied for hearing aid users. Wide variations of susceptibility to hearing loss are recognised[25] but it is generally assumed that, due to the normal mechanism of hearing loss, the same limits should be applied.

Radley[26] points out that hearing is not ordinarily considered to be sufficiently impaired to require assistance until the loss of sensitivity for speech is of the order of 30 dB. Unfortunately there is seldom, if ever, any corresponding increase in the level at which speech sounds produce a sensation of pain or discomfort and thus there is a physiological limit to the maximum acoustic power that a hearing aid should deliver. He proposed that a deaf aid should be linear up to an output of 200 dynes/cm^2. This figure was used as the output limit for an amplified telephone handset for use by hearing impaired people, made for the British Post Office by Ericssons[27] in 1960.

Users of hearing aids often receive sound pressure levels that would normally be considered dangerous but it should be remembered that hearing aids are fitted by qualified audiologists, and special considerations apply. In the UK the Department of Health and Social Security has given information on some hearing aids which discloses that what are considered low powered aids have maximum outputs of 125 dB SPL and higher powered aids produce maximum levels of 138 dB SPL. Advice with a very high powered aid giving outputs up to 149 dB SPL states that due to the possibility of damage to residual hearing it may be fitted only on the specific recommendation of a consultant otologist. This advice appears to be given for any aid capable of producing levels of about 140 dB.

When setting a limit, the likely use of any fitted volume control would need to be considered. There is some evidence to suggest that there is little margin left for the use of a volume control to increase the level of the received signal significantly above the normal limits.

5 OTHER FACTORS

There are a number of other factors that may be taken into account when setting limits for telecommunications terminal equipment. One point of uncertainty noted by the FDA was the allowance for the difference between free field and artificial ear measurements. They noted that it was suggested that some ears amplified the free field levels by as much as 8 dB so that the artificial ear measurement was said to be artificially high and that 8 dB should be subtracted from the result.

Shaw[28] reported data on the transformation of sound pressure level from the free field to the eardrum showing it to be highly variable, directional and frequency dependent with excursions ranging from +20 dB to –17 dB dependent on the frequency and direction of the source. ITU-T Recommendation P.58[14] the ITU-T Recommendation for a head and torso simulator, quotes nominal data for the frequency response from free field to its type 3.3 artificial ear for frontally incident sounds. It also gives similar data for the diffuse field response.

Thus data exists for two potential corrections. One from free field (or diffuse field) to the ear reference point (ERP), and a second from the ERP to the eardrum (DRP). Which, if either or both, should be applied to measurements made using an artificial ear, in order to relate them to noise exposure is still a matter for debate.

When considering limits to be set, the statistical risk of the occurrence of damage is a major factor. When setting limits for telephones, it may reasonably be considered that the permitted exposure of members of the public should be less than that of employees who receive some financial compensation for the risk to which they are exposed in the normal course of their work.

Similarly for telephones, if a limit were to be set based upon noise at work considerations, some correction would need to be made for the exposure lifetime, as the period of telephone usage is likely to be greater than the 30 or 40 years exposure expected at work. Such a correction could be derived from BS 5330[19] or ISO Publication 1999[18].

If a limit were to be set based upon noise at work considerations, some correction would need to be made for the daily exposure period, with different exposure periods being assigned to differing usages or exposures. The exposure of call centre operators would clearly be different from domestic users.

Based on over 200 octave spectra of various noisy environments in industry, Hardy[29] stated that on average, the spectra of industrial noises are almost flat with frequency. However the deviations from that average are great. This is the type of exposure for which the noise at work regulations were designed. Some argue that corrections should be made for specific type of narrow band signals likely to be met when using the telephone.

6 CURRENT WORK IN ETSI

6.1 Work in STQ

In the ETSI STQ committee, two work items are currently open on acoustic exposure.

The first, entitled "Acoustic output from terminal equipment; Limits" will give guidance on the acoustic output from terminal equipment and the limits required to avoid the excessive exposure of users to such outputs. The second, entitled "Acoustic output from terminal equipment; Test methods" may at some later stage be combined with the first.

The work has so far proceeded somewhat slowly, being considered controversial by some committee members. Recently work has speeded up and it has been able to agree that the primary aim of the work is to prevent injury to users (rather than reduce complaints). It has also been agreed that any recommendation must align with the Physical Agents Directive.

It has been agreed to use the ITU-T transfer function from Drp to Erp as set out in P.57 and P.58 and to use the manufacturer's figure for Drp to free or diffuse field. There is still however some difference of opinion as to whether a free field or diffuse field correction should be used. There is reluctance to use the free field correction due to the peak that occurs around 8 kHz.

Limits have not been set yet but it was agreed that in theory any possible recommended new limits should not be constrained by the current ITU-T limits and existing ETSI advice. In practice, if the answers are too different, it will be necessary to check carefully and come up with closely detailed justification.

Limits are expected to be set for peak output and for continuous tones as might be received from fax machines or be caused by instabilities. Investigations will be made to determine the relationship between Receive Loudness Rating and exposure to assess the risk of exceeding daily permitted limits particularly for high volume control settings.

In general, no difficulties are expected with measurement methods which will follow normal ITU-T Recommendations for measuring telephones and headsets. It is presently considered that that use of a suitable minimum-phase filter for the HATS transfer function should prevent potential problems in measuring outputs with transient input signals.

It was agreed not to attempt to deal with startle incidents, on the grounds that the necessary information is not currently available.

6.2 Work in TC HF

The Human Factors committee has recently published a report entitled "Human Factors of work in call centres"[30]. This document draws heavily on the work of the Health & Safety Executive/Local Authorities Enforcement Liaison Committee (HELA) as described in Local Authority Circular No 94/1[31].

As acoustic shock was outside the scope of the document, it says little more than "There is some evidence that the susceptibility to injury from some types of shock may be in some way related to stress[23]. Clause 8.3 gives some advice on stress reduction, and call handlers should be encouraged to report to management exposure to all acoustic shock incidents or any other abnormally loud noises. Management should make a record of these reported events."

It also points out that "It is good practice for employers to conduct hearing tests on induction and at regular intervals thereafter, especially for employees whose daily personal noise exposure is likely to be high."

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