THE ASSESSMENT OF INDUSTRIAL NOISE - A REVIEW OF VARIOUS NATIONAL PRACTICES

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1. INTRODUCTION

A programme of research into the objective and subjective assessment of industrial noise is currently being carried out at the National Physical Laboratory (NPL) sponsored by the Building Research Establishment (BRE) on behalf of the UK Department of the Environment. This work includes an examination of the rating of noise with specific characteristics, for example tonal or impulsive noise, which tend to produce a heightened subjective response. It is intended that the results of this programme of research may assist in the further refinement of standards such as ISO 1996 "Acoustics - Description and measurement of environmental noise" (1) and BS 4142:1990 "Method for rating industrial noise in mixed residential and industrial areas"(2).

It was considered a useful part of the programme to gain a broader knowledge of current national practices on the rating of industrial noise by reviewing various national equivalents of BS 4142 and examining how ISO 1996 has been implemented. Furthermore, there is no European (CEN) standard adopted at present. The CEN committee TC211 may find the results of this review useful should they wish to examine the option of introducing a relevant European standard.

This paper firstly explains current UK practice in the rating of industrial noise and then describes the main aims of the review and how it was carried out. The response to the study and conclusions are discussed, and the results summarised in a set of tables.

2. CURRENT UK PRACTICE IN THE RATING AND ASSESSMENT OF INDUSTRIAL NOISE

ISO 1996 aims to provide authorities with material for the description of noise in community environments. The standard does not specify limits for environmental noise but, based on the principles described in the standard, acceptable limits of noise can be specified and compliance with these limits can be controlled. The standard uses L_{Aeq} to describe the noise and has recently been adopted as a dual numbered British Standard BS 7445:1992 (3) in an identical form. For the assessment of human reaction to noise, necessary adjustments are made to the measured values in order to arrive at a more meaningful basis for the assessment. The values for the adjustments are not specified but guidance notes are given for suggested methods for character identification and for tone adjustment values (5/6 dB for clearly audible tones or 2/3 dB for just detectable tones).

BS 4142:1990 (2) was updated to keep in line with ISO 1996 using L_{Aeq} to replace the Corrected Noise Level (CNL) of the earlier standard (4). This standard applies only to industrial noise affecting residential communities and predicts the likelihood of complaints by examining the intrusion of a specific noise (assessed by a rating level) above the residual noise. The standard is intended primarily for investigating complaints and for planning purposes although it is often used for applications outside its scope (5). The BS4142 rating method applies a 5 dB adjustment to take into account noise that is judged to be tonal or impulsive in nature or irregular enough to attract attention.

The UK Department of the Environment's Circular 10/73 "Planning and Noise" (6) gives guidance to local authorities on the use of their planning powers and includes guidance on industrial noise but is in the process of being updated (7). Noise can also be assessed as a nuisance under the provisions of the UK Environmental Protection Act (8) with the UK Control of Pollution Act (9) remaining in force to deal with construction noise, noise abatement zones, codes of practice and noise in streets. Construction noise is controlled using the British Standard method BS 5228 (10).

3. AIMS AND OBJECTIVES OF THE REVIEW

(1) To determine current practices in the rating and assessment of industrial noise.
(2) To establish how ISO 1996 has been adopted in various countries.
(3) To determine the indices adopted in the relevant standards.
(4) To examine the treatment of noise with specific characteristics within the relevant standards.
(5) To establish the types of rating procedure used.
(6) To obtain information on other relevant documents.

4. STRATEGY FOR OBTAINING INFORMATION

In June 1991, 38 letters were sent to various National Laboratories, Standards Institutions, Environmental Protection Authorities and Ministries of the Environment covering over 20 countries worldwide. Each letter explained the project and gave a brief description of standards and current practices in the UK for the rating and assessment of industrial noise. Enclosed with each letter was a printed list of questions to be answered and returned to NPL. These questions related to:

standards similar to BS 4142,
implementations of ISO 1996 and its relevance to industrial noise,
other legislative documents in use,
availability of English translations of any document referenced,
possible points of contact to obtain further information.

5. RESPONSE AND RESULTS

19 replies were returned to NPL giving various levels of detail about 13 countries and in some cases full copies of standards were enclosed. Table 1 summarises the useful responses and information.

The second column refers to standards or guidelines which specifically refer to noise from industry within the title but information has also been obtained about standards and guidelines which refer to environmental noise (column three). Where the information was available, a brief description of the rating or assessment methods is given explaining whether limits are set or how the rating of the response to the noise is carried out. An indication is also given of the relationship to ISO 1996. The main noise descriptors are then described with information, where available, about the time intervals used. The fifth column details the treatment of noise with specific characteristics and finally other relevant sources of information/documentation are referenced.

It should be pointed out that Table 1 may not form a comprehensive listing of all current rating methods or legislative documents but summarises the information from the relevant standards and the responses at the time of writing. We would welcome any additional information to update or extend this review or to include further countries.

6. CONCLUSIONS

Seven countries have been reported to have standards or guidelines that relate specifically to industrial noise assessment and twelve countries follow environmental noise standards or guidelines. Nine countries have methods which have been reported to be implementations of, or follow, ISO 1996. However ISO 1996 does not set noise limits and many countries have proceeded to recommend noise limits for various regions, time of day, indoor and outdoor receiver points, etc. These may be used to set criterion values for noise control measures, noise abatement actions, permissible/acceptable levels or for planning purposes.

Table 2 gives a comparison of the recommended outdoor noise guide limits applicable to industrial noise for various regions and times of day. The table also includes the maximum permissible "noise loads" for industrial noise taken from an OECD publication (41). It is interesting to compare these values with those from the draft revision of UK Circular 10/73, Planning Policy Guidance (7) which gives recommended exposure bands for new developments near existing sources. Noise is not considered to be a determining factor in granting planning permission for daytime mixed sources below 55 dB(A) and at nighttime for all sources below 42 dB(A). The level above which planning permission should normally be refused is recommended as 73 dB(A) for mixed sources during the daytime and 67 dB(A) for all sources at nighttime. However, the document does state

that for industrial noise, the rating level according to BS 4142 should be used. This is a draft document only and values defining exposure bands may change.

Several standards have gone further and have introduced community response indicators, e.g. France uses "level emergence" nuisance indicators to predict potential nuisance, and the UK method predicts complaint likelihood based on the difference between the rating level and background level. Others adopting a similar approach are Spain and Canada where the methods quantify the level of excess above a recommended value and hence the level of community response or action to be taken. USA, for impulsive noise affecting the community, adopt a system of estimating the percentage of people highly annoyed.

The most commonly used noise descriptor for the rating level of the specific noise is L_{Aeq} which is usually measured over a representative time period and averaged over various time intervals dependent on the time of day. This descriptor is in line with ISO 1996. The L_{Aeq} is often calculated from representative sound pressure levels (L_p) of steady noises, short-term L_{Aeq}, sound exposure levels (L_{AE}), sound power levels (L_w) etc. Background noise is described by various methods including an energy equivalent level, an average A-weighted sound pressure level, L_{A95} and L_{A90}. Maximum levels are taken into account in several standards.

The treatment of noise with specific characteristics varies with country and with the actual features and their levels in the noise. The procedures are both objective and subjective. Excluding the countries which closely follow ISO 1996, eight countries have been found to have procedures for dealing with noises with various characteristics. About half of these set out an objective procedure for calculating adjustments. The adjustment for tonal noise is commonly 2, 3, 5 or 6 dB. Impulsivity adjustments range from 0 to 6 dB.

Other sources of information referenced generally refer to the legislative process describing Policies, Acts of Law and Regulations setting out requirements for noise control and abatement, zoning, etc.

7. SUMMARY

A review of current national practices for the rating of industrial noise and the various implementations of ISO 1996 has shown the variety of practices currently in use. Principles incorporated in ISO 1996 have been shown to contribute significantly to the methods used by many countries. In addition to adopting the principles of ISO 1996, some countries have introduced recommended limits based on absolute acceptable or permissible levels or based on the use of "community response indicators". There is some commonality in the various practices, for example choice of L_{Aeq} as a suitable descriptor,

but also large differences in some areas such as the rating of noise with specific characteristics. The review has provided valuable information for the future refinement and development of international and European standards.

8. ACKNOWLEDGEMENTS

NPL would like to thank all the organisations that replied to our letters providing valuable information without which this paper could not have been written. NPL would also like to acknowledge the financial assistance of the UK Department of the Environment. Finally, I would like to thank Clare Shoults for her help with the collation of the data.

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33. State Pollution Control Authority Guidelines (Norway) on measurement of industrial noise, TA-590 1984.
34. Control of Pollution Act 1981, Norway.
35. Spanish Standards Institution UNE 74-022-81 "Valoración del ruido en función de la reacción as colectividades", 1981. (Assessment of noise with respect to community response).
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39. ASA 76-89 Quantities and procedures for description and measurement of environmental sound Part 1.
40. Code of Federal Regulations (CFR), Protection of the Environment 40 Part 190 to 259, Revised 1990.
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TABLE 1: SUMMARY OF RESPONSES RELATING TO CURRENT PRACTICES ON THE ASSESSMENT OF INDUSTRIAL NOISE

COUNTRY	STANDARDS OR GUIDELINES REFERRING TO NOISE FROM INDUSTRY WITHIN THIS TITLE	ENVIRONMENTAL NOISE STANDARDS OR GUIDELINES	NOISE DESCRIPTORS IN USE	TREATMENT OF NOISE WITH SPECIFIC CHARACTERISTICS	OTHER SOURCES OF INFORMATION eg LEGISLATION
Australia	Australian Standard (11) Not published at time of information. State Policies may give methods for control of noise from commerce, industry and trade with methods for noise measurement and determination of noise limits.	AS 1055 (12) *** Severity of noise annoyance can be predicted from LAmax,adj,T - LAbg,T, Long term rating level - noise limit set by Regulatory Authority or difference between percentile levels.	For AS 1055 (12): LAeq for Rating Level using LpA and LAE. LAmax and LA% also may be adopted. Descriptor employed depends on noise limit requirement chosen. Long term arithmetic average A-weighted background sound pressure level, LAbg, used.	For AS 1055 (12): Objective assessment: 0 to 13 dB adjustment per band for tonal noise (1/3 octave band analysis). Impulsive adjustments made from measurements using time weighting 'I' (in accordance with AS 1259). Subjective assessment (in absence of suitable instrumentation): 2 dB penalty for just detectable tonal/impulsive components. 5 dB penalty for clearly audible tonal/readily detectable impulsive components.	(13) describes policies which vary from state to state (many based on AS 1055) (14) Env. Prot. Policy (Vict). not based on AS 1055
Belgium		ISO 1996 *	As with ISO 1996	As with ISO 1996	
Canada		National Guidelines (15) - methods for assessment, measurement and legislative control of env. noise. Guide limits given with excesses quantified into magnitude of problem and level of noise control measures/action to be taken.	(15) dBA(I) recommended for impulsive noise from specific industrial operations. LAeq1h recommended for the abatement of industrial/ commercial noise sources.		
Denmark	Environmental Noise from Industry Guidelines 5/1984 (16)***, 6/1984 (17)***. Limits for region/time of day set outside and for structurally transmitted indoor noise. (18) used for calculation of noise levels.	ISO 1996 *	For Guidelines in column 2, limits set in terms of free field LAeq, indoor LAeq with LpAmax for various reference time intervals.		

Key: ( ) *Reference number* T *English translation available*
* *ISO 1996 followed as national standard* ** *same as ISO 1996* *** *based on, takes account of or similar to ISO 1996*

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France		NF S 31-010 (19). Investigation of complaints against noise with suggested methods of determining limit values of nuisance indicators (from ambient noise and level emergence. N F S 31-110 (20) ***	For NF S 31-010 (19): LAeq (representative time periods for day and night reference intervals) and short LAeq (with time period less than or equal to 1 min). For NF S 31-110 (20):As with ISO 1996	For NF S 31 010 (19): Objective methods are given for the measurement of tonal and impulsive character. In the absence of quantitative data about the judgments of the general public, appraisal is left to the judgment of the expert responsible for investigating complaint and, if appropriate, competent authorities. For NF S 31 010 (20): As with ISO 1996	(21) Arrêtc du 20 Août 1985
Germany	VDI 2058 -Blatt 1 (22)*** T. (1973 version). Rating level compared with standard values and in addition intrusiveness above background to assess danger, disadvantage or nuisance.	DIN 45 645-Teil 1 (23) ***(part 3) DIN 18005-Teil 1 Teil 2 (24)***(part 2) (No limits set in DIN Standards).	For VDI 2058 Blatt 1 (1973 Version): An averaged dB(A) level, LAeq (with reference periods of 16 hours for day and 1 hour for night). LA95 for Background.	For VDI 2058 Blatt 1 (1973 version): Tonal/impulsive adjustment is 3/6 dB(A) depending on intrusiveness of tone/impulse. (judged by their subjective audibility). Impulsive noise in "dense" sequence is not adjusted as above, average level calculated separately.	TA Lärm (25) BImSchG (26) T
Hong Kong		(27) - Corrected Noise Level compared with acceptable limits to determine compliance with Noise Abatement Requirements.	For Technical Memorandum (27): LAeq(30m) for CNL, and dB(A) limits which vary depending on area and time of day.	For Technical Memorandum (27): Objective procedures given for adjustments for tonality (0, 3 or 6 dB(A)), intermittency (3 or 6 dB(A)) and subjectively for impulsivity (not more than 3 dB(A))	Section 13, Noise Control Ordinance (28)
Japan	JIS Z 8731/83 (29) is an industrial standard applicable to community and work environments.	JIS Z 8731/83 (29) ***T Procedures for determination of noise quantities.	For JIS Z 8731/83 (29): LAeq, LAE, LpA, LA%, LA90	For (29): Objective procedure given for measuring and describing noise of an impulsive nature.	

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Nether -lands	IL-HR-13-01 (30) T Guide for noise measurement and assessment for zoning and nuisance.		For IL-HR-13-01 (30): Assessment based on a 24h LAeq value. Other measurements and calculations from Lp, Lw	For IL-HR-13-01 (30): For granting of permits, 5 dB(A) penalty applied for impulsive or tonal character based on the subjective criterion of clear audibility.	Noise Abatement Act (31)
Norway	TA-506 (32) TA-590 (33) Guideline limits depend on region/time of day.		LAeq guideline limits given for day, evening and night time intervals.		Control of Pollution Act (34)
Spain		UNE 74-022-81 (35)*** for rating noise in residential and in industrial areas, difference between rating and criterion level gives level of response.	For UNE 74-022-81 (35): Rating Level, Lr, adopted as LAeq level, (calculated from LpA as necessary).	For (35): 5 dB penalty for tones/impulses, on-time corrections between 0 and -30 dB(A). In general, tonal and impulsive nature appears to be subjectively judged although advice given on analysis of frequency content in terms of NR Curves.	
Turkey		TS 2606 (36) **	As with ISO 1996	As with ISO 1996	Noise Control Regulation (37)
UK	BS4142:1990 *** (2). Intrusion above background noise level predicts likelihood of complaint.	BS 7445:1992 (3) **	For (2) and (3): LAeq used to describe Rating Noise Level. For BS 4142 (2): LA90 used to describe background noise level.	BS 4142:1990 (2): 5 dB penalty for tones/ impulses/ noise that is irregular enough to attract attention (Subjective judgments). ISO 1996(1)/BS 7445(3): Necessary adjustment made (guidance notes given).	(6) (7) (8) (9) (10)
USA		ANSI S12.4 (38)Assessment of high energy impulsive sounds (residential communities). This includes estimated community response. ASA 76 -89 (39)	For ANSI S12.4 (38): LCE (referenced to 1s), Ldn (averaged over a 24h period).		Code of Federal regulations (CFR) (40)

Key: *( ) Reference number* *T English translation available*
* *ISO 1996 followed as national standard* ** *same as ISO 1996* *** *based on, takes account of or similar to ISO 1996*

TABLE 2: COMPARISON OF RECOMMENDED OUTDOOR NOISE GUIDE LIMITS FOR WEEKDAYS APPLICABLE TO INDUSTRIAL NOISE

Type of Area	Time of day	Australia (12) (41) dB(A) *	Canada (15) dB(A)	Denmark (16) (17) LAeq	France (19) dB(A)	Germany (22) dB(A)	Hong Kong (27) ANL	Japan (41) dB(A) *	Nether-lands (41) dB(A) *	Norway (32) (33) LAeq
Heavy industrial/industrial	Day Evening Night	55		70 70 70	70 65 60	70 70 70	75 70 65	55-65		
Light industrial/ commercial/certain industries not permitted	Day Evening Night	50		60 60 60	65 60 55	65 50	75 70 65		65 **	
Mixed residential and industrial	Day Evening Night	40		55 45 40	60 55 45	60 45	70-75 65-70 55-65	50-55		
Urban residential	Day Evening Night	35			55 50 45	55 40	70 65 55	50-50	60 **	50 45 40
Suburban residential	Day Evening Night	35	50	45 40 35	50 45 40	50 35	65 60 50	50-50	60 **	50 45 40
Leisure/recreational /hospital	Day Evening Night	30	55	40 35 35	45 40 35	45 35		40-45	55 ***	40 35 35

Key: * *from OECD publication*
** *for existing dwellings*
*** *for new dwellings to be built*

NB: Please note that area/region descriptions and intervals for time of day differ between documents and that this table gives an approximate comparison only.