



**The Assessment of Industrial Noise -
A Review of Various National Practices**

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ABSTRACT

A review of current national practices for the rating of industrial noise was carried out as part of a larger programme of research into the subjective and objective assessment of industrial noise. This review investigated current standards and guidelines and in particular how International Standard ISO 1996 has been implemented in various countries. The results demonstrate the variety of practices currently in use. Principles incorporated in ISO 1996 have been shown to contribute significantly to the methods used. 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 the choice of L_{Aeq} as a suitable descriptor, but also large differences in areas such as the rating of noise with specific characteristics. The review has provided valuable information for the future refinement and development of national and international standards.

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Approved on behalf of Director, NPL, by Dr P Christmas, Acting Head of Division of Radiation
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1 INTRODUCTION

A three year programme of research at the National Physical Laboratory (NPL), sponsored by the Building Research Establishment (BRE) on behalf of the Department of the Environment, has examined the objective and subjective assessment of industrial noise. Work began in December 1990 with the overall aim of refining current methods for rating industrial noise. The research was divided into three parts:

- (1) A systematic evaluation of BS 4142:1990 "Method for rating industrial noise affecting mixed residential and industrial areas" by means of a data sheet study on its application.
- (2) A review of various national practices for rating industrial noise.
- (3) Subjective listening tests on the judged annoyance of specific types of industrial noise to explore the effect of impulsiveness and tonality on subjective annoyance and to assess the performance of objective assessment methods.

This report is concerned only with item 2 of this programme of work. Items 1 and 3 are covered in separate reports (3)(4).

It was intended that the research should provide data to support the refinement of standards such as ISO 1996 "Acoustics - Description and measurement of environmental noise" (1) and BS 4142:1990 "Method for rating industrial noise affecting mixed residential and industrial areas" (2). In this context it was considered useful to gain a broader knowledge of current national practices for the rating of industrial noise by reviewing various national equivalents of BS 4142 and examining how ISO 1996 has been implemented. Previous work reviewing international legislation on external industrial noise was carried out by Hay (5) nearly twenty years ago.

This review is limited to the noise impact on communities, i.e. noise immission, and does not deal with machinery noise emission standards or the health effects of noise on workers. The report firstly summarises 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 is discussed, and the results summarised in a set of tables. Following comments on noise regulation and standardisation, conclusions are drawn at the end.

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 (6) 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. More than one adjustment can be applied in a given situation. The advice on adjustments is set out as below :

4.3.1 Tone adjustment, K_1

If tonal components are essential characteristics of the sound within a specified time interval, an adjustment may be applied, for that time interval, to the measured equivalent continuous A-weighted sound pressure level. The value of this adjustment shall be stated.

Note - In some practical cases, a prominent tonal component may be detected in one-third octave spectra if the level of a one-third octave band exceeds the level of the adjacent bands by 5 dB or more, but a narrow-band frequency analysis may be required in order to detect precisely the occurrence of one or more tonal components in a noise signal. If tonal components are clearly audible and their presence can be detected by a one-third octave analysis, the adjustment may be 5 to 6 dB. If the components are only just detectable by narrow-band analysis, an adjustment of 2 to 3 dB may be appropriate.

4.1.4 Impulse adjustment, K_2

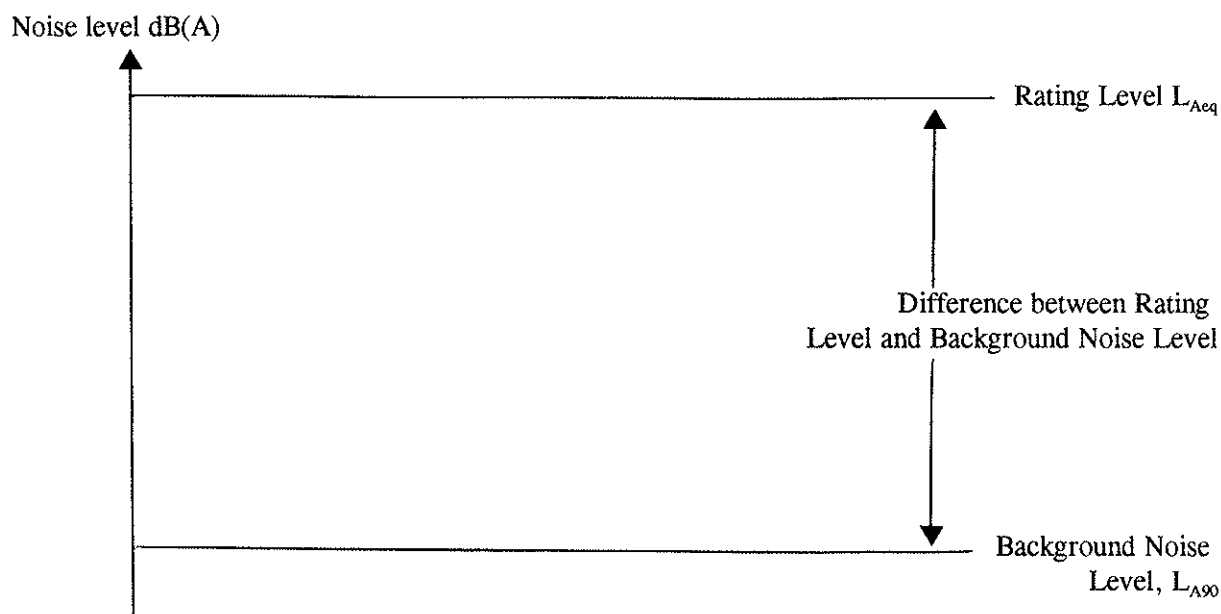
If impulse is an essential characteristic of the sound within a specified time interval, an adjustment may be applied, for this time interval, to the measured equivalent continuous A-weighted sound pressure level. The value of this adjustment shall be stated.

Notes

- 1 *A method of describing the impulse characteristic of the sound within a specified time interval is to measure the difference between the A-weighted sound pressure level, determined with time-weighting characteristic I averaged over the same time interval, and $L_{Aeq,T}$. The sound pressure levels should be determined simultaneously. The character of the noise may be further illustrated by determining the peak level and the number of impulses during a specified time interval.*
- 2 *For large-amplitude noise, such as the noise generated by sonic booms, mining or quarry blasts, measurements with C-weighting are used in some countries to determine the rating level.*

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 (7). 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 (8). The BS 4142 rating method applies a 5 dB adjustment to the rating level to take into account noise that is subjectively judged to be tonal or impulsive in nature or irregular enough to attract attention. The rating procedure is summarised in Figure 1 and Table 1. Only a single adjustment is applied for noise with specific characteristics as described in section 7 of the standard:

- 7.2 *If the noise contains a distinguishable, discrete, continuous note (whine, hiss, screech, hum, etc.), or if there are distinct impulses in the noise (bangs, clicks, clatters, or thumps), or if the noise is irregular enough to attract attention, add 5 dB to the specific noise level to obtain the rating level. Make only a single 5 dB correction if one or more of the above characteristics is present.*



Rating Level is the sound pressure level (L_{Aeq}) at the measurement position produced by the specific noise over a given reference interval plus any adjustment for the character of the noise.

Figure 1: The BS 4142:1990 Rating Method

Table 1: Complaint Potential as inferred by BS 4142:1990

Rating level minus background noise level	Complaint likelihood
10 dB or higher	Complaints are likely
Around 5 dB	Marginal significance
Below 5 dB	The lower the value, the less likelihood there is that complaints will occur
-10 dB	Positive indication that complaints are unlikely

The UK Department of the Environment's Circular 10/73 "Planning and Noise" (9) gives guidance to local authorities on the use of their planning powers and gives guidance on industrial noise. This is in the process of being updated to a Planning Policy Guidance (10). This sets out the UK Government's policies on different aspects of planning which should be taken into account by local authorities as they prepare their development plans. It gives guidance to local authorities on the use of their powers to minimise the adverse impact of noise. It outlines the considerations to be taken into account in determining planning applications both for noise-sensitive developments and for those activities which will generate noise. It also introduces the concept of noise exposure categories for residential development, encourages their use and recommends appropriate levels (absolute values) for exposure to different sources of noise as detailed on the next page in Table 2.

Noise can also be assessed as a nuisance under the provisions of the UK Environmental Protection Act (11) with the UK Control of Pollution Act (12) 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 (13). In 1993 the Noise and Statutory Nuisance Act (14) came into force and extended the Environmental Act to include noise that is prejudicial to health or a nuisance and is emitted from or caused by a vehicle, machinery or equipment in a street. A summary of noise nuisance legislation is given in (15).

Having outlined the UK practice for rating industrial noise, let us now examine how the review of practices in other countries was carried out and analyze the results.

Table 2: Recommended Noise Exposure Categories for Dwellings, $L_{Aeq,T}$ dB Near Existing Noise Sources (taken from draft (10))

Noise source	Noise Exposure Category			
	A	B	C	D
road traffic (0700-2300)	< 55	55-63	63-72	> 72
rail traffic (0700-2300)	< 55	55-66	66-74	> 74
air traffic (0700-2300)	< 57	57-66	66-72	> 72
mixed sources * (0700-2300)	< 55	55-63	63-72	> 72
all sources ** (2300-0700)	< 42	42-57	57-66	> 66

* "Mixed (0700-2300)" applies to any combination of road, rail, air and industrial noise sources, provided the industrial noise is not dominant.

** "All sources (2300-0700)" covers any individual transport source, and any combination of transport and industrial noise sources, except where industrial noise source is dominant. Developments proposed in areas where noise events exceed an L_{Amax} of 82 dB (S time weighting) on a nightly basis should be treated as being in NEC C (unless already in NEC D). For situations involving aircraft noise at night, regard should also be given to the findings of the "Report of a Field Study of Aircraft Noise and Sleep Disturbance", published by the Department of Transport, January 1993.

Noise exposure category A: for proposals in this category noise need not be considered as a determining factor in granting planning permission, although the noise level at the high end of the category should not be regarded as a desirable level

Noise exposure category B: for proposals in this category local planning authorities should take noise into account when determining planning applications, and require appropriate noise control measures.

Noise exposure category C: for proposals in this category planning permission should not normally be granted. Where it is considered that permission should be given, for example because there are no alternative quieter sites available, conditions should be imposed to ensure an adequate level of protection against external noise.

Noise exposure category D: for proposals in this category planning permission should normally be refused.

3 OBJECTIVES OF THE REVIEW

The objectives of the review were:

- (1) To determine current practices in the rating and assessment of industrial noise.
- (2) To establish how ISO 1996 had 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.

Papers giving the results were presented at two European conferences (16) (17) in 1992 during which requests were made for additional information. Finally, at the end of 1993, letters were sent out to various organisations to check and update existing data and to obtain information relating to some additional countries.

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 3 summarises the useful responses and information. Full references to each document are given in section 10 of the report.

The second column in Table 3 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. Where there is a relationship between the referenced document and ISO 1996, Table 3 denotes this as:

- * ISO 1996 is followed as a national standard
- ** the standard is the same as ISO 1996 but renamed

*** the standard is based on, takes account of or is similar to ISO 1996.

The availability of an English translation is denoted by ^T.

It should be pointed out that Table 3 may not form a comprehensive listing of all current rating methods but summarises the information from responses received at the time of writing. Table 4 gives an approximate comparison of the recommended outdoor noise guide limits for various countries for different regions and times of day.

Table 3: Summary of Responses Relating to Current Practices for the Assessment of Industrial Noise

([†]: English translation available * ISO 1996 followed as a national standard ** same as ISO 1996 *** based on, takes account of or similar to ISO 1996)

Country	Standards or guidelines referring to noise from industry within the title	Environmental noise standards or guidelines	Noise descriptors in use	Treatment of noise with specific characteristics	Other information and sources of information eg legislation
Australia		AS 1055 (18) *** Standard does not specify actual criteria to assess noise. Severity of noise annoyance can be predicted from $L_{Aeq,24h,T} - L_{Aeq,T}$. Long term rating level. Where it is not possible to measure background noise, guide values from Appendix B are used. Each state and territory sets its own noise limits as described in (19). For example, in New South Wales, when the difference above exceeds 5 dB, this is indicator of a noise being offensive.	For AS 1055 (18): L_{Aeq} for Rating Level using L_{pA} and L_{AE} . L_{Amax} and L_{A95} also may be adopted. Descriptor employed depends on noise limit requirement chosen. Long term arithmetic average A-weighted background sound pressure level, L_{A95} used.	For AS 1055 (18): 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 instrumentation): 2 dB penalty for just detectable tonal/impulsive components; 5 dB penalty for clearly audible tonal/readily detectable impulsive components.	(19) describes policies and legislation which vary from state to state (many based on AS 1055). Most states subjectively assess noise e.g in New South Wales the EPA determine if noise is offensive using AS 1055 as a guide. States may use recommended outdoor background noise levels for planning purposes. (20) Env. Prot. Policy (Vict). not based on AS 1055. This specifies noise limits and noise is objectively assessed. (21) Env. Prot. Act (Victoria).
Austria		Austrian Standard ÖNorm S 5021 *** (22): giving basic acoustic principles for town, regional and physical planning. Austrian guideline ÖAL - Richtlinie Nr. 3 (23): used for judging noise immissions and noise disturbance in the vicinity of noise sources. Table 1 gives some noise limits, table 2 gives an indication of the severity of reaction to the noise. Austrian guideline ÖAL - Richtlinie Nr 28 (24): for noise radiation and propagation. This gives a method for calculating the attenuation of sound.	For ÖNorm S 5021 (22): L_{Aeq} used For ÖAL - Richtlinie Nr. 3 (23): Guideline limits set in dB(A) terms For ÖAL - Richtlinie Nr. 28 (24): Measurements and calculations based on various descriptors including L_{pA} , L_w etc.		No general federal law for Noise control. (25) Gewerbeordnung Federal Law mainly concerned with safety of plants. (26) Example of regional regulation determining immission limits for regional planning.

Table 3 (contd): Summary of Responses Relating to Current Practices for the Assessment of Industrial Noise

([†]: English translation available * ISO 1996 followed as a national standard ** same as ISO 1996 *** based on, takes account of or similar to ISO 1996)

Country	Standards or guidelines referring to noise from industry within the title	Environmental noise standards or guidelines	Noise descriptors in use	Treatment of noise with specific characteristics	Other information and sources of information eg legislation
Belgium Four regions: Flanders Brussels Walloon and the German community	A standard exists for the Flemish region and gives target values.		For the Flemish standard, $L_{Aeq,1hr}$ is adopted.		Each region has own laws. National laws also exist. For Flemish region, all environmental legislation is contained in VLAREM I and II (27).
Canada		National Guidelines (28) - 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.	(28) dBA(l) recommended for impulsive noise from specific industrial operations. $L_{Aeq,1hr}$ recommended for the abatement of industrial/ commercial noise sources.		
Denmark	Environmental Noise from Industry Guidelines 5/1984 (29)***, 6/1984 (30)***. Limits for region/time of day set outside and for structurally transmitted indoor noise. (31) used for calculation of noise levels.	ISO 1996 *	For Guidelines in column 2, limits set in terms of free field L_{Aeq} , indoor L_{Aeq} with $L_{p,max}$ for various reference time intervals.	(30) prescribes 5 dB penalty for clearly audible tones and impulses and includes an objective measurement method to determine if tones are clearly audible, based on comparing the tone sound pressure level with the level of the noise in a critical band around the tone. English description of method can be found in (32).	
France		NF S 31-010 (33). Investigation of complaints against noise with suggested methods of determining limit values of nuisance indicators from ambient noise and level emergence. NF S 31-110 (34) ***	For NF S 31-010 (33): L_{Aeq} (representative time periods for day and night reference intervals) and short L_{Aeq} (with time period less than or equal to 1 min). For NF S 31-110 (34): As in ISO 1996	For NF S 31 010 (33): 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 the complaint and, if appropriate, the competent authorities. For NF S 31 010 (34): As in ISO 1996	(35) Arrête du 20 août 1985

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Country	Standards or guidelines referring to noise from industry within the title	Environmental noise standards or guidelines	Noise descriptors in use	Treatment of noise with specific characteristics	Other information and sources of information eg legislation
Germany	VDI 2058 Blatt 1 (36)**** used for rating industrial noise in the neighbourhood. TA Lärm T (37): Industrial noise abatement regulations. It contains guideline values for immissions and sets out measurement methods for determining an evaluation level which is compared with the standard immission levels. The Federal Government is preparing an amendment to be brought in line with (40) and to be developed into a comprehensive set of regulations for the reduction of industrial, commercial and leisure noise.	DIN 45 645-Teil 1 (38)*** (part 3) DIN 18005-Teil 1 Teil 2 (39)*** (part 2) (No limits set in DIN Standards).	For VDI 2058 Blatt 1 (36): L_{AFR} , $L_{A(10)}$, $L_{A(FTN)}$ For TA Lärm T (37): Taktmaximalpegel $L_{A(FTN)}$	For VDI 2058 Blatt 1 (36): for tonal components 3/6 dB(A) depending on degree of intrusiveness (judged subjectively); for impulse components, $L_{Aeq} - L_{AFeq}$, $L_{AFTeq} - L_{AFeq}$ or 3/6 dB(A) depending on degree of intrusiveness (judged subjectively). For TA Lärm T (37): 5 dB is added for special sound characteristics (individual notes or sounds with striking changes in level) or for one or more clearly audible individual sources (e.g. humming, hooting, shrieking, whistling).	BImSchG (40) T - Law for the prevention of harmful effects on the environment caused by air pollution, noise, vibration and similar phenomena.
Hong Kong		(41) - Corrected Noise Level compared with acceptable limits to determine compliance with Noise Abatement Requirements.	For Technical Memorandum (41): $L_{Aeq(20h)}$ for CNL, and dB(A) limits which vary depending on area and time of day.	For Technical Memorandum (41): 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 (42)

Table 3 (contd): Summary of Responses Relating to Current Practices for the Assessment of Industrial Noise

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

Country	Standards or guidelines referring to noise from industry within the title	Environmental noise standards or guidelines	Noise descriptors in use	Treatment of noise with specific characteristics	Other information and sources of information eg legislation
Italy		DPCM 1/3/1991 (43): Different noise limits in six categories of land use. UNI 9433 (44): Assessment of noise in dwellings (under revision).	L_{Aeq} for ambient noise L_{Aeq} for residual noise.	For DPCM 1/3/1991 (43): For impulsive components where $L_{Aeq(0)} - L_{Aeq(5)} > 5$ dB then the penalty of 3 dB is given. For tonal components using 1/3 octave band analysis, if the difference between adjacent band levels > 5 dB then a penalty of 3 dB is given. For both impulsive and tonal components, 6 dB penalty is applied. For intermittent noise, 15 mins - 1 hour : -3 dB < 15 mins : -5 dB	
Japan	JIS Z 8731/83 (45) *** is an industrial standard applicable to community and work environments. It gives procedures for determination of noise quantities.		For JIS Z 8731/83 (45): L_{Aeq} , L_{Ae} , $L_{A\alpha}$, $L_{A\beta}$, $L_{A\gamma}$, $L_{A\delta}$	For (45): Objective procedure given for measuring and describing noise of an impulsive nature.	For Tokyo: Noise Regulation law (46), Tokyo Metropolitan Environmental Pollution Ordinance (47). Factories with machinery that is classified as being a source of noise and vibration (special factories) are regulated according to standards set by national law. In addition the Metropolitan Government enforces its own ordinances on general factories. As of March 31st 1992, specified factories subject to control by the terms of the Noise Regulation Law no. 29,225 (46).

Table 3 (contd): Summary of Responses Relating to Current Practices for the Assessment of Industrial Noise

(†: English translation available * ISO 1996 followed as a national standard ** same as ISO 1996 *** based on, takes account of or similar to ISO 1996)

Country	Standards or guidelines referring to noise from industry within the title	Environmental noise standards or guidelines	Noise descriptors in use	Treatment of noise with specific characteristics	Other information and sources of information eg legislation
Luxembourg	Regulation concerning noise levels in the immediate vicinities of factories (48). This sets out recommended levels for six types of dwelling zones together with rules for complying with these levels. The levels of noise are determined according to the method in the appendix (unavailable).				
Malaysia	Guide for the siting and zoning of industries (49): sets out general guidelines for industries and gives noise levels at factory boundaries not to be exceeded and recommended buffer distances between factories and nearest residential buildings.			For (49): for light industries, they must not generate excessive impulsive or continuous noise from machineries, fans, compressors, motors etc. No objective procedure is given.	(50) (51)
Netherlands	IL-HR-13-01 (52) † Guide for noise measurement and assessment for zoning and nuisance.		For IL-HR-13-01 (52): Assessment based on a 24h L_{Aeq} value. Other measurements and calculations from L_p , L_w	For IL-HR-13-01 (52): 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 (53)
Norway	TA-506 (54) TA-590 (55) Guideline limits depend on region/time of day.		L_{Aeq} guideline limits given for day, evening and night time intervals.		Control of Pollution Act (56)

Table 3 (contd): Summary of Responses Relating to Current Practices for the Assessment of Industrial Noise

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Country	Standards or guidelines referring to noise from industry within the title	Environmental noise standards or guidelines	Noise descriptors in use	Treatment of noise with specific characteristics	Other information and sources of information eg legislation
Portugal		NP-1730 Degree of human reaction to noise *** (57) : considers uniform and non-uniform noise. Noise is measured and corrected for on-time with a penalty for tonal noise. It provides an estimate of community response as a function of the (corrected) difference between L_{Aeq} and L_{95} .	L_{Aeq} and L_{A95}	Pure tones or narrow band noise are penalised by 5 dB(A). Non-uniform noise and tonality are penalised by 8 dB(A).	Decreto-Lei no. 251/87 (58) - general framework of the law "General Regulations on Noise" updated by Decreto-Lei no. 292/89 (59). It states that the difference between L_{Aeq} and L_{95} should not exceed 10 dB(A). Decreto-Lei no. 251/87 (58) also classifies the sites for the construction of buildings in three categories using L_{95} .
Spain		UNE 74-022-81 (60) *** for rating noise in residential and in industrial areas: difference between rating and criterion level gives level of response.	For UNE 74-022-81 (60): Rating Level, L_r , adopted as L_{Aeq} level, (calculated from L_p as necessary).	For (60): 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.	Limits vary from one city to another and local authorities are responsible. e.g for Bilbao max L_{A95} for areas with industrial activities is 70 dB(A) day and 60 dB(A) night time. A Royal Decree relating to environmental noise developing Law 38 of 1972 is planned which will fix limits of noise levels in every land use area.
Switzerland		Noise abatement ordinance (61) protects the population against outdoor noise pollution. The ordinance provides the general legal framework for applying limit values to noise immissions from different types of installations. It also specifies the method for evaluating the noise. Appendix 6 gives limit values relating to industrial installations.	L_{Aeq} with a reference time of 720 minutes.	For (61): Tonality/impulse penalties are 0/2/4/6 dB(A) each depending on the audibility of each characteristic (subjectively judged).	Federal Law relating to the protection of the Environment (62).

Table 3 (contd): Summary of Responses Relating to Current Practices for the Assessment of Industrial Noise

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Country	Standards or guidelines referring to noise from industry within the title	Environmental noise standards or guidelines	Noise descriptors in use	Treatment of noise with specific characteristics	Other information and sources of information eg legislation
Turkey		TS 10792 (63) **	As in ISO 1996	As in ISO 1996	Noise Control Regulation (64)
UK	BS 4142:1990 *** (2). Intrusion above background noise level predicts likelihood of complaint.	BS 7445:1992 (6) **	For (2) and (6): L_{Aeq} used to describe Rating Noise Level. For BS 4142 (2): L_{Aeq} 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 made). ISO 1996(1)/BS 7445(6): Necessary adjustment made.	(9) (10) (11) (12) (13) (14)
USA		ANSI S12.9 parts 1 to 4 (65-68): Quantities and procedures for description and measurement of environmental sound. (see (69) for details of content of each part). S12.9 Part 1 *** provides basic quantities for the description of sound in community environments and general procedures for measurement. Compliance limits based on these quantities and procedures may be specified by authorities for assessment, regulation and land use planning. Part 4: intended to be applied in the preparation of environmental assessments, no criteria for acceptable levels are included although guidelines provided upon which such criteria may be based. ANSI S12.7 (70): Methods for measurement of impulse noise. ANSI S12.4 (71) Assessment of high energy impulsive sounds (residential communities). This includes estimated community response. ANSI S12.40 (72): Sound level descriptors for determination of compatible land use.	For ANSI S12.4 (71): L_{Ceq} (referenced to 1s), L_{90} (averaged over a 24h period).		Code of Federal regulations (CFR) (73) There exists a Federal Agency Report which recommends environmental noise criteria levels to be used by various federal agencies. The measure used is the day-night average sound level (DNL) and the criteria for the start of impact is 65 dB and extreme impact at 75 dB for housing and other similar noise sensitive land uses.

Table 4: Comparison of recommended outdoor noise guide limits for weekdays

(based on various values for planning, immission limits, recommended ambient levels, zones etc...Please note that area/region descriptions and intervals for time of day differ between documents and that this table gives a guide comparison only. For a complete definition of areas and limits, the text of each standard should be consulted)

Type of Area	Time of day	Australia (18) (74) dB(A) ¹ Guide values based on (18), but each state and territory sets its own limits e.g. Victoria (20)		Austria (L _{eq})		Belgium (27)	Canada (28) dB(A)	Denmark (29) (30) L _{Aeq}	France (33) dB(A)	Germany (36) (37) dB(A)	Hong Kong (41) ANL
		(18)	Victoria (20)	(22) Immission limits for planning	(23)						
Heavy industrial/industrial	Day Evening Night	55	68 56	65 55				70 70 70	70 65 60	70 70 70	75 70 65
Light industrial/commercial/certain industries not permitted	Day Evening Night	50		60/65 50/55	55 45	60 55 55		60 55 60	65 60 55	65 60 50	75 70 65
Mixed residential and industrial	Day Evening Night	40		60 50	50-55 40-45	50 45 40		55 45 40	60 55 45	60 45 45	70-75 65-70 55-65
Suburban residential	Day Evening Night	35		55 45	45 35	45 40 35		45 40 35	50 45 40	50 35 35	65 60 50
Urban residential	Day Evening Night	35	50 39	50 40	40 30	45 40 35	50	50 ² 45 ² 40 ²	55 50 45	55 40 40	70 65 55
Leisure/recreational/hospital	Day Evening Night	30		45/50 35/45	35 25	40-50 35-45 30-40	55	40 35 35	45 40 35	45 35 35	

Key: ¹ from OECD publication (74)
² limit applies in residential areas with multi-storey buildings

Table 4 (contd): Comparison of recommended outdoor noise guide limits for weekdays

(based on various values for planning, immission limits, recommended ambient levels, zones etc. .Please note that area/region descriptions and intervals for time of day differ between documents and that this table gives a guide comparison only. For a complete definition of areas and limits, the text of each standard should be consulted)

Type of Area	Time of day	Italy (43) L_{Aeq}	Japan dB(A)			Luxembourg (48)	Malaysia (49)	Netherlands dB(A) (53)	Norway (54) (L_{Aeq})	Spain (60) ³	Switzerland (61) ⁴
				(74) ¹	(47)						
Heavy industrial/industrial	Day	70			70 (60 ⁵)	70	65	55		60-70	65
	Evening Night	70	55-65		60 55	60	55	50 45		55-65 50-60	55
Light industrial/commercial/certain industries not permitted	Day	70-65			60 (55 ⁵)	65		55		55-65	65
	Evening Night	60-55			55 50	50		50 45		50-60 45-55	55
Mixed residential and industrial	Day	65-60			50 (45 ⁵)	60	60	50		50-60	60
	Evening Night	55-50	50-55		45 45	45	50	45 40		45-55 40-50	50
Suburban residential	Day	55			45 (40 ⁵)	50-55		50	50	40-50	55
	Evening Night	45	30-50		40 40	35-40		45 40	45 40	35-45 30-40	45
Urban residential	Day	60-55			50 (45 ⁵)	60			50	45-55	55
	Evening Night	50-45	30-50		45 45	45			45 40	40-50 35-45	45
Leisure /recreational/hospital	Day	50				45		45	40	35-45	50
	Evening Night	40	40-45			35		35	35	30-35 25-30	40

Key:

- ¹ from OECD publication (74)
- ² limit applies in residential areas with multi-storey buildings
- ³ night values may have another 5 dB subtracted.
- ⁴ planning limits (+ 5 dB for immission limits, + 15 for alarm values)
- ⁵ early morning (6am-8am)

6 DISCUSSION

Nine out of twenty countries have been reported to have standards or guidelines that relate specifically to industrial noise assessment and fifteen countries follow environmental noise standards or guidelines. Eleven 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 4 gives a comparison of the recommended outdoor noise guide limits for various regions and times of day. The table also includes the maximum permissible noise loads for industrial noise taken from an OECD publication (74). The range of values shows Hong Kong to have higher limits than most other countries whilst Australian limits form the lower end of the scale. Excluding Hong Kong, daytime limit values fall within a span of 5 dB.

It is interesting to compare these values with those from the Planning Policy Guidance Document (10) as given in table 2. Noise is not considered to be a determining factor in granting planning permission for daytime mixed sources below 55 dB(A) and for night-time for all sources below 42 dB(A). These values could be compared against the guide limits given in Table 4 for mixed residential and industrial areas, and as expected fall near to the bottom end of the range of values for day and night. Further information on guideline values can be found in some excellent work by Gottlob (75) recently reviewing the basic concepts of noise regulations (for various sources) in Germany as compared to some European guidelines.

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 in BS 4142 predicts complaint likelihood based on difference between the rating level and background level. Others adopting a similar approach are Spain, Austria 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. The USA, for impulsive noise affecting the community, adopts 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 $L_{Aeq,T}$ 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, shorter term levels (L_{Aeq}), sound exposure levels (L_{AE}), sound power levels (L_w) etc (e.g. Japan and Netherlands). Interestingly, the Flemish standard differs and adopts an $L_{A95,1h}$ value.

Background noise is described by various methods including an energy equivalent level, an average A-weighted sound pressure level (e.g. Australia) and L_{A90} (e.g. U.K.). Maximum levels are taken into account in several standards (e.g. Denmark).

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, thirteen 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 including Australia, Denmark, France, Hong Kong, Italy and Japan. In the case of Australia, a subjective

procedure seems to be followed when the necessary instrumentation is not available. The adjustment for tonal noise is commonly 2, 3, 5 or 6 dB. Impulsivity adjustments range from 0 to 6 dB.

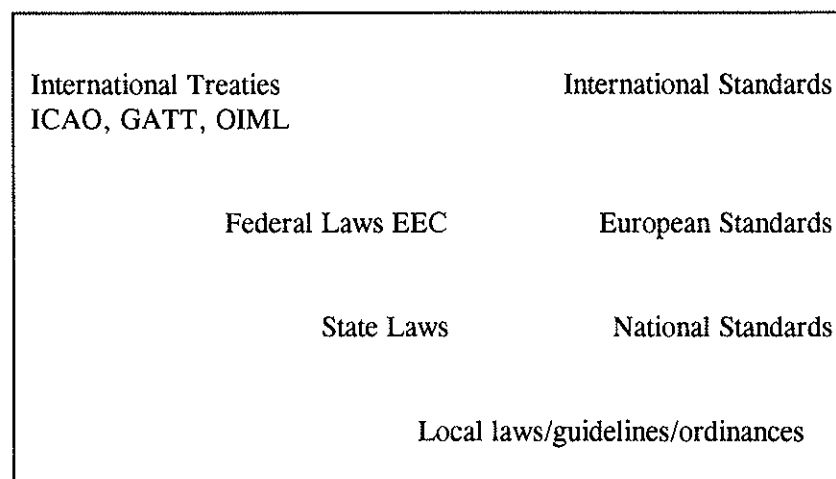
7 FURTHER COMMENT

Noise is an inevitable by-product of our mechanised society and much of it arises from sources of an industrial nature. The OECD report (74) effectively summarises the government measures available to reduce noise, involving five functions:

1. Planning
2. Regulating
3. Enforcement of regulations
4. Incentives
5. Investment

The OECD report states that hardly any country consistently uses all of these instruments today.

The planning and regulating functions are used most frequently to control noise, and make use of legislation and standardization. An interesting view on noise regulations and standards was given during a presentation by Von Gierke (76) who identified the following tiers of laws and standards:



Verdan, in his address to the FASE 92 Congress (77), presented his views on the public aspects of noise control and described the instruments of government policy available for noise abatement. He commented that some countries take a 'reactive' approach to noise control, permitting only the most pressing problems to be solved. He pointed out that other countries, such as the Netherlands and Switzerland, have a more preventative and co-ordinated policy on noise abatement which should lead systematically to more acceptable acoustic environments without depending on complaints. Finally he sets out six elements for a coherent and comprehensive noise abatement policy. Verdan expresses the view that in order to solve the noise problems of the future, economic incentives are important to complement regulations.

Muller of the Commission of the European Communities (CEC) Directorate General XI, "Environment, Nuclear Safety and Civil Protection" (Sound and Vibration), in his presentation to the Institute of Acoustics Autumn Conference (78), gave some interesting personal reflections on the future of noise policy in the European Commission. It was explained that future noise activities of the Commission in the area of

environmental protection are laid down in the 5th Environmental Action Programme (79). The objective "no person should be exposed to noise levels which endanger health and quality of life" is in agreement with Art. 130r of the EEC Treaty. To protect EC citizens against unreasonable noise, he recommends that a directive on noise criteria must be set up which would involve:

- choosing the most suitable descriptors for defining a noise situation, following ISO 1996 as closely as possible
- reviewing noise quality criteria from selected countries in order to examine a scheme of noise quality criteria.
- considering how the competence of the Community and the Member States should be shared.

A proposal has been drafted for a Council Directive on "Integrated Pollution Prevention and Control" (80) which deals with the emissions from industrial installations. Muller would like to see immission limit values established according to the category of neighbourhood in which an installation is sited, and to compare the sound pressure levels measured at residences affected by the noise with the appropriate immission limit values.

The rationale for the review of national practices reported here was to contribute to a larger study on the subjective and objective assessment of industrial noise, but the information contained herein may provide information in working towards defined noise quality criteria. As Daldrup pointed out during Internoise '93 (81) "international co-operation and harmonisation of research and development and, where necessary, recommendations and regulation in international bodies such as OECD, ICAO and the EC are a logical step in the effort to improve the noise situation in our countries".

The material in this report was believed to be up to date at the time of writing. However, it is recommended that regular updating of this information should be carried out to provide a sound basis for reference and further study.

8 CONCLUSIONS

A review of current national practices for the rating of industrial noise, and of 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 the choice of L_{Aeq} as a suitable descriptor, but also large differences in some areas such as the rating of noise with specific characteristics. Working towards an international or a European standard for the rating and assessment of industrial noise could therefore present a problem when trying to harmonise standards between countries.

An effective noise assessment method should provide as complete a description of the noise as possible, lead to consistent decision making, and ideally point the way to a cost effective method of noise control. The standards and guidelines identified in this study generally fulfil these requirements only to a limited extent, and further development of the standards for noise assessment may benefit from a fresh approach (4).

During the ICBEN Congress, Noise and Man '93, Team 9 "Standards and Regulations" presented its results for the first time (82). Future work topics were identified and included comparisons of existing guidelines and recommendations on national and international criterion levels, and the present review is a contribution to this effort. More generally, this review has provided valuable information to support the future development of national and international standards and noise policy.

9 ACKNOWLEDGMENTS

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