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FINAL RESULTS OF THE NPL DATA SHEET STUDY ON BS 4142:1990

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1. INTRODUCTION

A three year programme of research was set up at the National Physical Laboratory (NPL) to examine the objective and subjective assessment of industrial noise. This research was sponsored by the Department of the Environment and directed on their behalf by the Building Research Establishment. The project began in December 1990 with the overall aim of refining current methods for rating industrial noise. The work is divided into three parts.

(1) A systematic evaluation of BS 4142:1990 "Method for rating industrial noise affecting mixed residential and industrial areas" [1].
(2) Review of various national practices in the rating of industrial noise.
(3) Subjective listening tests on the judged annoyance of specific types of industrial noise.

This paper is only concerned with item (1) of this programme of work, a study of the application of the revised BS 4142:1990 by means of a data sheet study. Details of items (2) and (3) of this work are reported in other papers[2,3,4].

Development, implementation, review and revision of all standards is a continuous cycle. BS 4142 is no different from other standards in this evolutionary process. This study set out to examine the current part of this cycle, the implementation of the revised BS 4142:1990. The standard was first published in 1967. In 1990 the second edition of BS4142 was produced to bring it in line with ISO 1996 [5]. The main objectives of the revision were the conversion to L_{Aeq} and the tightening up of requirements on equipment, traceable calibration, and measurement procedures. In the absence of new data on noise complaints, it was difficult to justify major changes to the assessment procedure, and the overall aim was that the revised standard should give the same assessment as the previous standard for a given situation. Many changes were made to the standard during this revision, details of which can be found in references [6,7].

At the last IOA Autumn conference, an interim report [8] was presented based on 30 data sheets. This paper sets out to give the final results of the study. The main aims of the study are set out followed by a brief account of how the data were gathered and the response to the study. The main results are then summarised and some important findings of the study are highlighted. Conclusions, summary and recommendations are given at the end.

Since this conference paper is limited to 8 pages, this paper can only present a selection of the results. A full report on this study will be available early next year.

2. AIMS OF THE DATA SHEET STUDY

(1) To determine how well the assessment by the BS 4142:1990 rating method compares to the actual investigated noise complaints.
(2) To identify weaknesses in the revised 1990 version of the standard and to identify areas where investigating officers are having problems applying the measurement and rating procedure.
(3) To provide data on measurement values.
(4) To gather information on the various applications of the standard.

3. PREPARATION OF THE DATA SHEETS

In order to collate data on the application of the standard, data sheets were designed that could be completed when investigating a noise complaint in accordance with the standard. It was intended that the data sheets would assist the investigating officer in applying the revised standard by providing a guide through the assessment procedure. For this reason, the data sheets were designed to closely follow section 9 of the standard "Information to be Reported". The data sheet was divided into five sections:

general information
description of the noise sources
description of complaints
measurements
assessment

Extra questions were included in addition to the requirements of section 9 in order to gain further valuable information. These included questions relating to the opinion of the investigating officer on how the rating of complaint likelihood compared with the actual reported complaint occurrence. A space was provided at the end of the sections for additional comments.

Before the data sheet was printed in full, a small pilot study was conducted. Firstly, at the end of October 1990, the data sheet was sent to various members of the BSI Committee EPC 1/3 for comment, and various amendments were made. In January 1991, ten local authorities were chosen from information given in a previous NPL study[9] and the data sheets were sent for comments on layout, ease of use etc. Two months later the data sheet was approved by the Central Survey Unit of the Department of Environment. The main distribution commenced in April 1991.

4. RECRUITING VOLUNTEERS

The project was publicised in order to attract interest from those people who could assist in the collection of data. The sources of the 167 volunteers who offered to participate are shown in Table 1.

Table 1:

Recruiting Volunteers

Source	Number EHO's	Other
Letter in IOA Bulletin	25	16
Letter in Environmental Health News	48	5
BSI Seminar April 1991	10	14
IOA/Noise Council Seminar May 1991	7	4
Follow up letter in IOA Bulletin	1	2
IOA Autumn Conference	8	8
Other	10	10
Total	109	61

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113 data sheets were returned for analysis. These came from 44 different contributors, representing a 26 % return rate, with 41 % returning more than one data sheet, and including six planning cases. 87 % of the returned data sheets were received from local authority departments. In response to our request for information, in addition to returned data sheets, several letters and telephone calls were also received with comments on the standard. Information was entered into a computer database for analysis.

5. RESULTS

This section gives a summary of the some of the results in tabular and graphical form. A fuller discussion of the results will be given at the time of the conference.

Table 2:

Description of Noise Sources	% of Total
Fans	35%
Compressor units, generators and air conditioning units	19%
Metal handling operations	11%
Refrigeration plant	10%
Car wash	6%
Activities related to paint spray booths	5%
Continuous	47%
Intermittent	34%
Cyclic	18%
Fluctuates at random	11%
Specific characteristics	61%
Tonal	50%
Irregular enough to attract attention	28%
Impulsive	21%

Groups are not necessarily mutually exclusive

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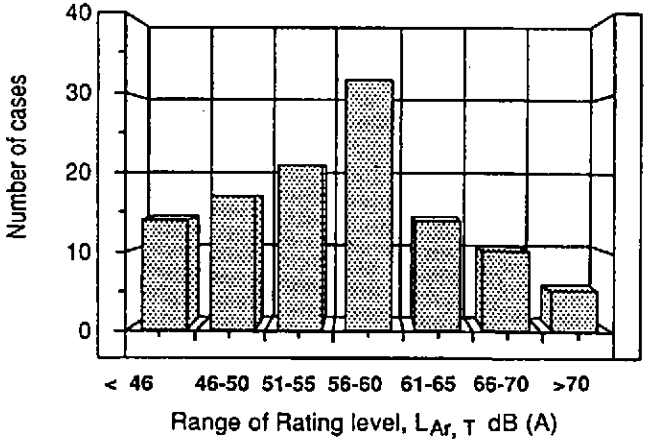
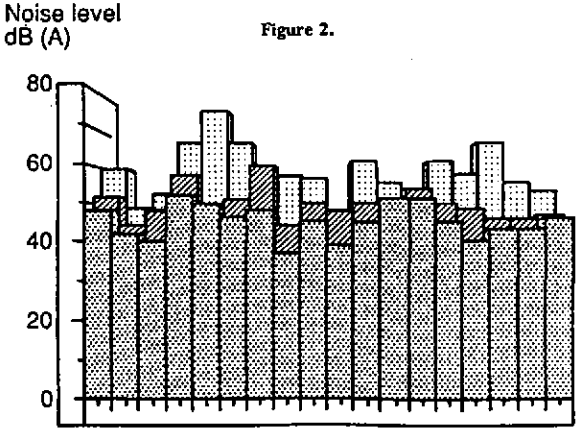
Figure 1.



Distribution of Rating Levels

Figure 2.



Comparison of Rating Level with L_{Aeq} and L_{A90} of the Residual Noise: Daytime

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Figure 3: Assessment of likelihood of complaints for daytime

(Based on total responding to question)

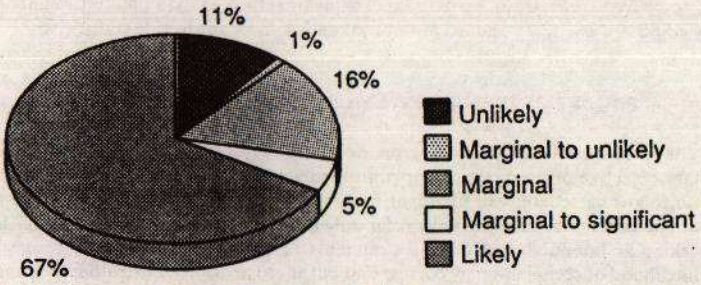


Figure 4: Assessment of likelihood of complaints for night-time

(Based on total responding to question)

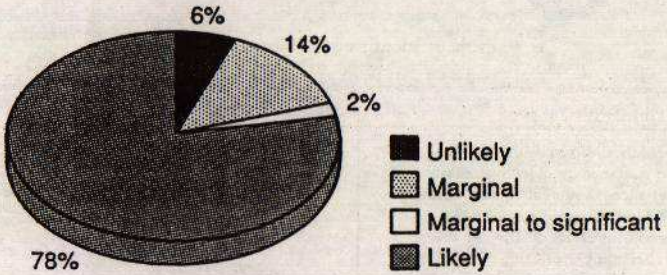
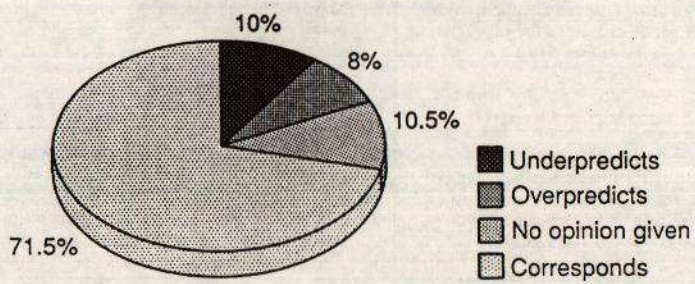


Figure 5: Comparison of the BS 4142: 1990 assessment of the likelihood of complaints with the actual reported occurence



It is worth emphasising here that the BS 4142:1990 rating procedure was reported to be meeting its objective of predicting the complaint likelihood in over 80 % of the cases where an opinion was given. On the other hand, it should be taken into account that these data reflect the experience only of those who have indeed used the standard and have taken part in the data sheet study by returning data sheets. Comments from those who felt that they could not use the standard are not taken into account in this statistic.

6. PROBLEMS IDENTIFIED BY USERS OF THE STANDARD

Although the results have shown that the rating method of BS4142:1990 is actually working very well at achieving its primary objective of predicting complaint likelihood, there are some problem areas that have been reported. The following section will highlight some of the difficulties the users of the standard are having, but it should be noted that these actually refer only to a small number of cases where the prediction method is not working as intended. Indeed, the comments in this section may refer to cases where the prediction of the likelihood of complaint may correspond but there are other difficulties with the application of the standard.

Table 3 is a summary of the problems commonly reported by users of the standard. My own observations are given in the third column. Again, due to space limitations, it is not possible to give a full discussion of the various areas of the standard which have given rise to problems. A full discussion will be given in the comprehensive report.

Table 3: Identified Problems

TOPIC	IDENTIFIED PROBLEMS	OBSERVATIONS
Tonal character	1. Definition of tonal No guidance on objective measurement Reliance on subjective identification Addition of penalty can have a significant effect on BS4142 rating 2. Underrating/overrating of subjective impression 3. Indoor noise and effects Low frequency hums	1. Could lead to inconsistent decision making 2. Heightened response is level dependent 3. Standard does not address indoor noise measurement
Impulsive character	1. Definition of impulse No guidance on objective measurement 2. Underrating of subjective impression	1. Could lead to inconsistent decision making 2. Heightened response is level dependent
Intermittent noise	1. Often attracts added attention which may not be accounted for adequately 2. On-time sometimes difficult to determine accurately 3. On-time "effective penalty" reported both as too large and too small	1. May lead to underrating of subjective impression of noise
Combined features or effects	1. Noise may contain more than one acoustic feature e.g tonal and impulsive etc, 2. Noise may be accompanied by other stimuli, e.g odour, vibration	1. BS4142 allows for only a single 5 dB penalty, (inconsistent with ISO 1996), may lead to underrating of subjective impression 2. BS4142 only deals with predicting complaint likelihood due to noise, therefore forms only part of a complete complaint investigation.

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TOPIC	IDENTIFIED PROBLEMS	OBSERVATIONS
Multiple noise sources	1. Sometimes difficult to establish specific source Sometimes difficult to measure background noise level Shutting off one source often reveals another problem 2. Creeping background	1. One must decide whether to examine multiple sources as one complete source or whether to investigate each source separately with other sources contributing to residual of the other. 2. Decisions must be made about choice of background noise level in case of modifications or addition of new installations to existing industrial premises
Assessment procedure	1. Too coarse Addition of penalty can have significant effect on outcome 2. Use of other procedures for night-time noise or boundary levels based on absolute noise level limits. 3. Comparison of L_{Aeq} with L_{A90} - particular reference to fluctuating residual noise - where difference may be greater than 10 dB before specific noise is introduced	1. Could lead to inconsistent decision making 2. BS 4142 only addresses margin by which specific noise exceeds background noise level although foreword points out that complaint likelihood may also depend on attaining a certain level. BS 4142 is therefore only part of the story in a noise complaint investigation. 3. 5.4.4 (b) should be applied in all cases for good measurement practice and to minimise uncertainty in approximation in table 1 - rewording required.
Uses outside existing scope	1. Standard often applied outside scope since no alternatives available 2. Applicability to assessment of nuisance and justifiability of a complaint.	1. Use outside scope decreases probability that standard would meet its objective at predicting complaint likelihood. 2. The likelihood that an individual will complain depends on individual attitudes and perceptions, in addition to the noise levels and acoustic features present. BS 4142 makes no recommendations in respect of the extent to which such non acoustic factors should be taken into account. Since noise rating is only one of the factors used for deciding justifiability and nuisance, any decision must be based on all relevant factors and BS 4142 can only form a component part of the evidence.
Noise inside dwellings	1. More representative of real problem ? Structure borne noise Shared party walls Low frequency hums	1. BS4142 does not address measurements inside dwellings, and if used as such, often leads to underrating of complaint likelihood.
Low background noise levels	1. Applicabllity of rating procedure in low noise environments e.g quiet rural areas 2. Applicability to windy rural areas e.g windfarms	1. BS 4142 at present not intended for use where background noise level is below 30 dB(A), but is the use of rating procedure legitimate if specific noise level is high ? 2. Alternative procedures/guidance may be required for specific applications.
Complaint likelihood predicted as of marginal significance.	1. 88 % of marginal cases had specific characteristics 2. For marginal cases, significant increase in probability that BS4142 will not work as intended.	1. Application/non-application of 5 dB penalty will have a significant effect on rating of marginal cases - may lead to inconsistent decision making. 2. If rating method can be made to work for marginal cases, it follows that it should work for more extreme cases.
Instrument-ation requirements	1. Calibration/verification requirements Cost considerations of above Required accuracy for more extreme cases	1. Although section is about good measurement practice, difficulties are experienced with meeting requirements in terms of how, cost of calibration, and necessity of such accuracy for a standard measuring to 1 dB.

7. CONCLUSIONS

The purpose of the rating method of BS4142 is to predict the complaint likelihood. This study has shown that the rating method generally gives a good indication of the likelihood of complaint (in over 80 % of the cases reported). However, there are problem areas and ambiguities that need attention and clarification which should be taken into account in subsequent reviews leading to any future revisions of the standard.

Many of the investigated noise sources had specific characteristics. In fact over half of the noise sources were tonal. This highlights the need for measuring and assessing the impact of noise with certain characteristics which give rise to a heightened response. In particular, we need more accurate and reliable objective procedures for identifying these characteristics and methods for assessing their impact on the listener. Furthermore, the reliance on the somewhat subjective judgment of the presence of these characteristics depends on personal judgment and the experience of the investigating officer. This may lead to a lack of consistency in the decision making process particularly with cases which may be judged as of marginal significance. In conclusion, the study has shown that the assessment of noise with specific characteristics needs improvement.

The study has also shown that there are many applications outside the scope of BS 4142, e.g the various types of sources, indoor noise measurements and low background noise levels. The study has indicated that using the standard outside its scope reduces its efficacy at predicting the complaint likelihood.

The study has re-affirmed the importance of the experience of the user especially where individual interpretation and personal judgement is required. As pointed out in the foreword of BS 4142, noise assessment is a skilled operation and should only be undertaken by persons who are competent in the procedures.

BS 4142 can be refined in the light of new experiences but one should not expect it to answer all of our noise problems or lay down definitive rules. It is primarily an objective procedure assessing a subjective effect and therefore can only be used as a tool for use with noise complaint investigations. Furthermore, response to noise is affected by many factors (acoustic and non-acoustic). Assessing the impact of a noise is a complex process and assessments according to this standard can only form part of a complete investigation.

8. SUMMARY AND RECOMMENDATIONS

Most of the paper has been restricted to comments and observations reported in the data sheets and telephone calls and letters received at NPL. This section will attempt to focus on the author's opinion of the underlying reasons for problems with the standard:

(1) There are procedural difficulties with applying the standard. These include ambiguities, wording, difficulties in interpretation and the application of the actual measurement procedure.

(2) One is attempting to measure objectively a subjective response. Subjective response to noise is variable between both individuals and situations and therefore perhaps we can never succeed in getting such a standard to work 100 % of the time. However, the standard is a valuable tool and should be improved with the aim of consistent decision making and providing an accurate description of the noise environment.

(3) BS 4142 is often used outside its scope due to the absence of other standards or guidelines to rate the impact of noise.

(4) BS 4142 if often followed as a "rule book" and not as part of a complete study taking into account all factors (acoustic and non-acoustic)

(5) Too much significance is given to noise level comparisons, and insufficient account is taken of the actual acoustic features of the noise which may be the main cause for complaint in the first instance. More account should be taken of the "noise quality" and not just levels of the noise.

The possible ways forward to address these problems include the following:

(1) Refinement of current standard to address short term problem of ambiguities, wording, clarifications, greater emphasis on statements in the foreword etc.
(2) Modifications to procedures for identifying and rating noises with various acoustic features.
(3) Improvement of the assessment procedure.
(4) Development of a more general framework document to reference BS 4142 and provide guidance on alternative approaches to assessments outside the scope of BS4142. This might take the form of DoE guidelines.
(5) Environmental Impact Assessment (EIA) approach to industrial noise [7] to take into account all the factors (acoustic and non-acoustic) and to use the rating method of BS 4142 as intended as part of the process of analysis.

Item (1) is currently in hand and addresses some of the issues raised in this study. In the next paper in the conference, Berry [10] reports on the work of the BSI Working Group dealing with this. However, to refine the standard further in the longer term, items (2) to (5) would require a significantly greater amount of time and research. Work is currently in hand to address item (2), including work at ISVR into tonal and impulsive noise descriptors [11 12] and at NPL on combined features [4]. Work is also progressing at NPL and ISVR into the development of an assessment procedure based on the acoustic features in the noise [13].

Finally let us go back a step and consider the requirements of a general noise assessment procedure. A noise assessment procedure should provide a means to:

* adequately describe the noise including all those significant acoustic features which are actually present,
* encourage fair treatment and lead to consistency in decision making,
* target cost-effective noise control and aim for an equitable trade-off between lowest cost and maximum benefit to the community.

Although BS 4142 has the specific objective of predicting the complaint likelihood, we need to ask the more general question, how can we improve the standard to better meet these more general requirements ?

9. ACKNOWLEDGEMENTS

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