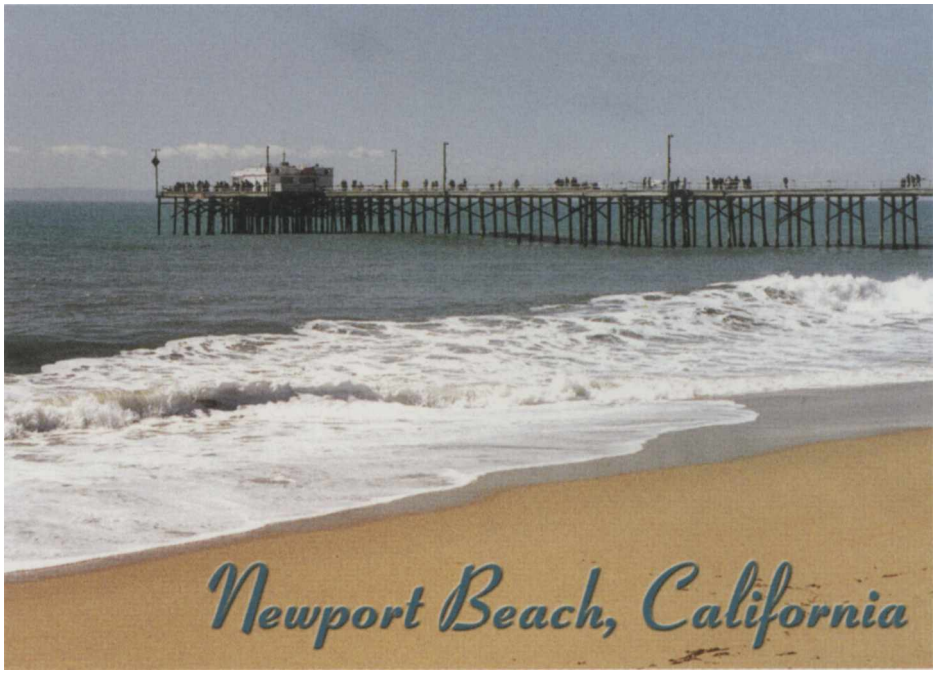
NOISE/NEWS INTERNATIONAL

Volume 8, Number 3
2000 September

A quarterly news magazine with an Internet supplement published by I-INCE and INCE/USA

Tocci:
Room Noise Criteria—State of the Art in the Year 2000



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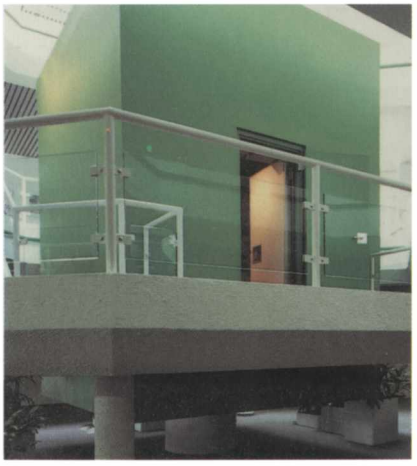

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Volume 8, Number 3 - 2000 September

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Noise/News International (ISSN 1021-643X) is a quarterly news magazine published jointly by the International Institute of Noise Control Engineering and the Institute of Noise Control Engineering of the USA., Inc. Noise/News International is distributed to the Member Societies of I-INCE and to the members of INCE/USA as a member benefit. Advertising services and production control are provided by the IEEE Periodicals-Magazines Department of the Institute of Electrical and Electronics Engineers, Inc. Editorial services are provided by Noise Control Foundation, Inc. Feature articles for Noise/News International are selected by the editors. Responsibility for the editorial content rests upon the authors and not upon I-INCE, INCE/USA, the IEEE, Noise Control Foundation, the societies or their members. Product information is provided as a reader service and does not constitute endorsement by the societies or their members. SUBSCRIPTIONS: In the USA, the annual subscription rate is USD 50.00, postpaid, which is included in the dues of Members and Associates of INCE/USA. Nonmember subscription rates available upon request. Single copy price is USD 12.50. Address correspondence concerning subscriptions to INCE/USA, P.O. Box 3206, Arlington Branch, Poughkeepsie, NY 12603-0206. In all other countries, the annual subscription rate is CHF 80 via surface mail; airmail delivery subject to additional charge. Single copy price is CHF 20. Address correspondence concerning subscriptions to I-INCE General Secretariat, Celestijnenlaan 200 D, B-3001, Heverlee-Leuven, Belgium. EDITORIAL CORRESPONDENCE: Address to George C. Maling, Jr., Managing Editor, NNI, c/o Noise Control Foundation, P.O. Box 2469, Arlington Branch, Poughkeepsie, NY 12603, USA; telephone +1 914 462 4006 or FAX +1 914 463 0201.

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ADVERTISING: For information about advertising, contact Susan Schneiderman, Advertising Sales Manager, IEEE Magazines, 445 Hoes Lane, Piscataway, NJ 08855-1331, USA; telephone: +1 732 562 3946; FAX: +1 732 981 1855.
Printed in the United States of America.

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The International Institute of Noise Control Engineering (I-INCE) is a worldwide consortium of societies concerned with noise control and acoustics. I-INCE, chartered in Zürich, Switzerland, is the sponsor of the INTER-NOISE Series of International Congresses on Noise Control Engineering, and, with the Institute of Noise Control Engineering of the USA, publishes this quarterly magazine and its Internet supplement. I-INCE has an active program of technical initiatives which are described in the Internet supplement to *NNI*. I-INCE currently has 45 Member Societies in 39 countries.

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The Institute of Noise Control Engineering of the USA (INCE/USA) is a non-profit professional organization incorporated in Washington, DC, USA. A primary purpose of the Institute is to promote engineering solutions to environmental noise problems. INCE/USA publishes the technical journal *Noise Control Engineering Journal* and, with I-INCE, publishes this quarterly magazine and its Internet supplement. INCE/USA sponsors the NOISE-CON series of national conferences on noise control engineering, and the INTER-NOISE Congress when it is held in North America. INCE/USA Members are professionals in the field of noise control engineering, and many offer consulting services in noise control. Any person interested in noise control may become an Associate of INCE/USA and receive both this magazine and *Noise Control Engineering Journal*.

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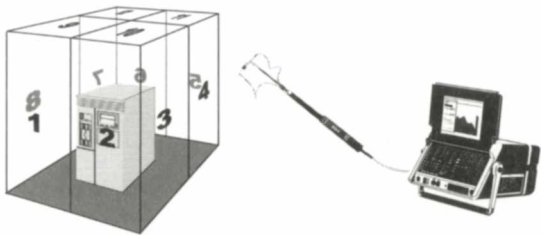

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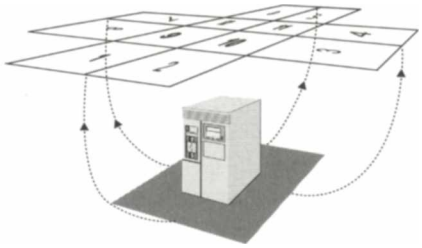

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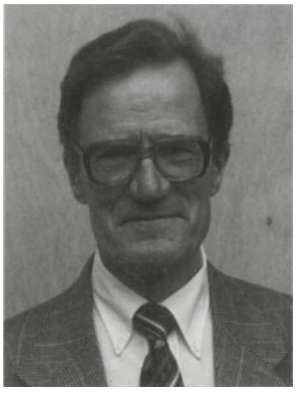
President's Column



The Costs of Noise are High—Long-Term Noise Abatement is Cheap

It is a superficial statement to say that noise abatement is expensive. It is not the high costs for noise abatement that have led to today's noisy workplaces and noisy communities—it is a lack of understanding of the problems and a failure to involve acoustic expertise at the right time.

Once a noise problem exists, the costs to solve it may become prohibitive. It is a totally different situation if the noise issue is considered at the correct time during the planning. Then the costs are typically a factor of 10 to 100 times less, or even zero. As our late colleague Professor Manfred Heckl said, "There is no law of nature that says that a silent machine must be more expensive than a noisy one!" He continued, "However, it is more difficult to construct a car that is quiet than to construct a car that can go fast!"

A society with a much-improved sound environment will not come about by itself but it can be obtained at low or even negligible cost if we work continuously on it and give it sufficient time. We who work in noise control have to improve our contacts with the public and their political representatives so that the level of understanding improves. Noise must be considered in each urban renewal project, each time a new building is planned, each time a new machine is designed, etc. One problem in the political world is that substantial improvements demand a much longer time than politicians typically stay in power. Therefore, noise is seldom the top priority on the political agenda—a situation that those in our field must change.

Another way to a quieter society is to use the market forces more effectively. One example is the Swedish standard by which the sound insulation and noise characteristics of new dwellings and row houses can be classified in steps of 4 or 5 dB. This standard was adopted a few years ago. The main contractors then made decisions not to build dwellings that comply with only the minimum requirements, but that are at least one or two classes better.

The contractors found that people were dissatisfied with the acoustic properties of new dwellings and moved out at a high rate. A willingness to pay (WTP) study, which was performed some years ago (*see the 1996 December issue of this magazine.—Ed.*) showed that the average WTP clearly exceeded the additional cost for really good sound insulation between dwellings or quiet ventilation or good sound insulation against traffic noise.

In the EU, work on a directive on ambient noise to be in force in 2002 involves noise mapping of urban areas. This mapping will be such that it can be used by the general public to check in detail the noise exposure of dwellings. This will greatly help the consumers in their choice of dwellings before they buy or rent. The cost for these noise maps is very small!

The I-INCE Technical Study Group on noise labels for consumer and industrial products will surely also help to improve the conditions for the market forces.

And the sooner we can eliminate the politicians' and the general public's misconception that noise abatement is expensive the better.

—Tor Kihlman
President, International INCE

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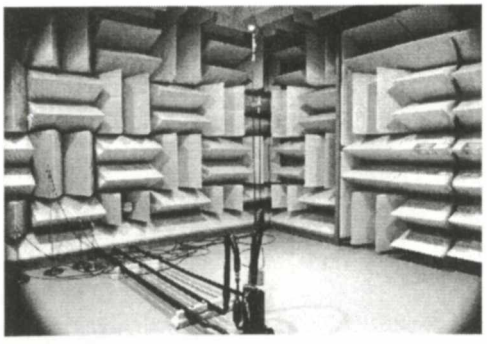

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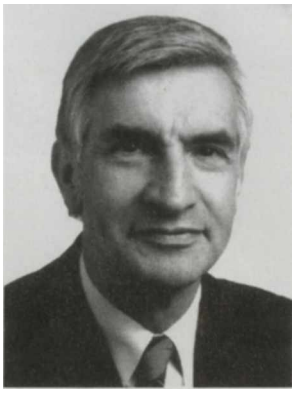
Editor's View



Aircraft Noise is a Serious Problem

Air traffic is growing all over the world, and this causes problems in the often densely-populated areas in the vicinity of airports. The problems are caused not only by air traffic itself, but also by activities generated by a growing airport. The extension of the road network around an airport, with increasing road traffic intensities, is an important example. Aircraft noise causes annoyance, communication disturbance, sleep disturbance, and, if the exposure levels are very high, reduced cognitive performance of children, high blood pressure, and ischaemic heart diseases. There is no doubt that annoyance, communication disturbance, and sleep disturbance occur as a consequence of the exposure to aircraft noise. For the other effects, it is not immediately evident whether aircraft noise contributes to these effects. The potential health effects of airport noise are still being debated.

One of the developments that can relieve the problem is the progress in new technology which enables the design of quieter aircraft. In both the United States and Europe, the aircraft industry is investing a great deal of effort in research on noise reducing techniques. In the last four decades, this has resulted in a significant decrease of more than 20 dB in the level of airplane noise. The question is: can new developments result in another significant gain of noise reduction in the next decades?

There is a worldwide organization, ICAO, of governments and aviation businesses in which the technical and political issues related to the noise problems are discussed and proposals are prepared for standardization and harmonization. The aviation sector, supported by governments, has succeeded in developing the noise control technology for aircraft. Nevertheless, this is an area with great problems—resulting in many conflicts between economic impact and environment at the local, national and worldwide levels. A major shortcoming of the ICAO is the fact that environmental stakeholders (citizens, environmental organizations, local authorities, environmental ministries) are not represented. Consequently the ICAO is not a suitable organization to propose measures that are balanced between economic impact and the environment. Another problem in the aviation sector is the fact that there are large differences in local measures . These differences, for example, concerning night flights, often result in a transfer of noisy traffic from one airport to other airports. Such a transfer is not advantageous for the aviation business as a whole and does generally not reduce the overall number of noise-affected people. Harmonization of legislation can improve this situation.

Aircraft noise is of great concern in the vicinity of major airports. Examples are Brussels National Airport, Zaventem, Belgium, and Schiphol Airport, The Netherlands. In Belgium, the Green Party is actually a member of the Government, and this party pressures the government to increase the acoustical comfort for the inhabitants near the airport, especially for night flights.

Considering the above, it is clear that there is very much room for improvement of the worldwide and continental approaches on aircraft noise. We should go to a situation in which the environmental stakeholders play a more direct role in the development of transport policy, and the local authorities and the public must be better informed about the actual situation than at present.

—André Cops
European Editor

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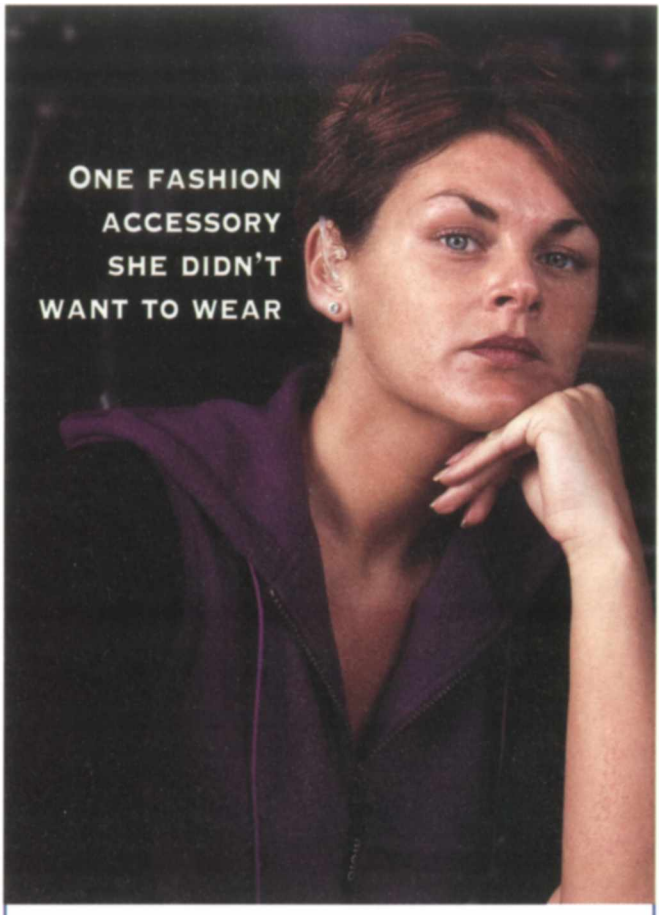

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Member Society Profile

The Portuguese Acoustical Society (SPA)

The Portuguese Acoustical Society (SPA) is an independent, non-profit and non-governmental organization. This society was conceived to be a specialized association intended to join together Portuguese acousticians and to promote and develop acoustics within the country—being simultaneously a forum to exchange information among its members.

Another purpose of the SPA is to serve as a link between several areas of different scientific fields that have acoustics as a common subject. It also aims at promoting technical and scientific advances in acoustics throughout the country and to facilitate the recognition—both in Portugal and abroad—of activities developed by those basically working in acoustics and by those who are simply interested in it.

The SPA was established in the 1970s. At the time, some important initiatives were taken by the initial group of SPA members with the purpose of encouraging technicians working in acoustics to join and work together with a view to promote acoustics in Portugal. Additionally, some relations at an international level were established in order to support the desired creation of SPA. Among all these contacts and supports, special reference must be made to SEA (Spanish Society of Acoustics) and to its President, Prof. Andrés Lara-Saenz, who, in collaboration with Prof. Pedro Martins da Silva—the first President of SPA—suggested the creation of a strong link between these two societies in order to co-operate within the administrative space of the Iberian Peninsula. This link has been implemented in various events that have been prepared in conjunction by the two societies throughout the years. In this context, mention must be made of the first international event promoted by SPA, which was held in Lisbon in 1978 with the theme *Environmental Acoustics: 1st Congresso Luso-Espanhol*. That event launched a continuous series of co-operating activities between the two societies, of which the latest one was the *Congresso Acústica 98*.

The SPA has organized various workshops and lectures on acoustics in a wide range of subjects. Within the scope of SPA activities, different monographs on acoustics have been published and an informative magazine has been issued whenever necessary.

Initially, environmental and building acoustics were the major fields dealt with by the Society. Nevertheless, other areas of interest have emerged as a result of the overall evolution. Nowadays, a wide variety of acoustical areas are covered, as well as the area of vibration.

The funding of SPA derives mainly from membership fees, seminars, and congresses.

The SPA is an affiliated society of EAA and of I-INCE. It is also a member of FIA (Ibero-American Federation of Acoustics).

SPA presently has 150 members, including individuals, students and associates. The SPA members come from all types of professions related with all areas of acoustics. Associate members are organizations that include consultants, manufacturers, engineering contractors, suppliers, designers and other companies.

It has been observed that the people are becoming increasingly aware of their surrounding environment. In this framework, the industry has recognized an increasing demand for quiet environments and reliable products to achieve such aims. In view of these challenges, acoustics will play an important part in the future, and the SPA will certainly play an important role in Portugal for all those who have the acoustics as their main concern.

This is the thirty first in a series of articles on the activities and history of the Member Societies of I-INCE.— Ed.

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Feature

Room Noise Criteria—The State of the Art in the Year 2000

Gregory C. Tocci, Cavanaugh Tocci Associates, Inc., 327 F Boston Post Road, Sudbury, MA 01776, USA

Gregory C. Tocci is president of Cavanaugh Tocci Associates, Inc., an acoustical consulting firm founded in 1975 with his partner, William J. Cavanaugh. He received a B.S. degree in Mechanical Engineering from Tufts University in 1970 and an M.S. degree from the Massachusetts Institute of Technology in 1973. He is a registered professional engineer in the Commonwealth of Massachusetts and the State of Rhode Island.

His professional career in acoustics began as a staff consultant with Cambridge Collaborative, Inc. in 1973, working on rail transportation, machine noise control, and architectural acoustics problems. In 1974 he joined Cavanaugh Copley Associates and there worked on a variety of highway and rail environmental impact statements as well as architectural acoustics problems.

He is a former chairman of the Greater Boston Chapter of the Acoustical Society of America, a past president of the National Council of Acoustical Consultants, and a member of their long-range planning committee. He is a fellow of the Acoustical Society of America (ASA), a member of its Membership Committee, and is a past member of the ASA Technical Committee on Noise. He currently serves as the Noise Control Engineering Journal associate editor for building noise control. He has also served INCE/USA as a director and as vice president for board certification. He is currently the president of INCE/USA.

He has held adjunct teaching positions at both the New England School of Art and Design and the Harvard School of Public Health. He has lectured widely on a variety of topics in architectural acoustics to industrial and professional groups. In 2000, Mr. Tocci was given the Tufts University Mechanical Engineering Department Career Achievement Award. He is the author of the Solutia Acoustical Glazing Design Guide and several articles in professional magazines.

Introduction

Rating of noise in building spaces has a long history. To some extent, advances in methods for evaluating sound in buildings has paralleled the development of electronic sound measurement instrumentation. The first step in this evolution was simply to devise instruments that could repeatably measure sound. No sooner was this possible than electronic instrumentation advanced, further enabling the measurement of sound in frequency bands. The frequency discrimination of octave band sound measurements paved the way for advances in understanding the impact of noise on communication and hearing.

Though the ability to measure sound in frequency bands was a remarkable advance, it complicated the evaluation of the impact of noise on speech communication. However, researchers recognized an opportunity to combine methods for evaluating hearing acuity with methods for measuring background sound over the audible frequency range in order to developed single-number ratings for noise, particularly as it relates to speech interference. The first section of this paper briefly summarizes the evolution of methods for evaluating noise and for evaluating the interference of noise with speech.

Of the evolving methods for evaluating sound in rooms, three are in current use by engineers involved with the design of building mechanical systems. All three methods involve the use of sets of curves explained in this paper. These are Noise Criteria (NC) curves, Balanced Noise Criteria (NCB) curves, and Room Criteria (RC) curves. In addition, a fourth method called RC Mark II (Blazier, 1997) uses curves nearly identical to RC curves, but includes a different method for ascribing spectrum quality. Finally, a fifth set of curves, called RCN curves, recently published in the *Noise Control Engineering Journal* (Schomer, 2000), attempts to address cyclic variation of low frequency sound produced by large air ventilation systems—sometimes described as "surging."

As we enter the 21st century, it is clear that the acoustical consulting profession will continue to de-

velop criteria based on the experience of using these various methods. However, a single, simple, universal method for evaluating sound in buildings may remain elusive. Acoustical consultants, accustomed to using noise criteria (NC) curves, will likely continue to use them as appropriate, but will also explore the use of new rating methods for evaluating sound in buildings as they may be proposed. Mechanical engineers, architects, and building owners will continue to rely on acoustical consultants to implement these methods and to use them to achieve acceptably quiet buildings.

After briefly reviewing the history of room sound criteria, the use of these more recent criteria, i.e. NC, NCB. RC, RC Mark II, and RCN methods are described. The first four of these are compared using 238 measured spectra. Because the RCN method has been published recently, it is only discussed in general and is not implemented with the measured spectra.

A Historical Perspective

The history of acoustics is replete with attempts to develop useful single-number rating methods for evaluating noise in buildings and in the environment. These methods are aimed at accommodating the complexity of tonal and temporal characters of sound into a single-number descriptors. The following is a very brief synopsis of noise rating methods.

Equal Loudness Contours

The earliest reference to equal loudness contours appears to be by Fletcher and Steinberg in 1924 (Kryter, 1985). The benchmark work most widely recognized is by Fletcher and Munson in 1933 (Kryter, 1985). This later work, appearing in the *Journal of the Acoustical Society of America*, contains the now-famous equal loudness contours. A variety of investigators have recreated this work and arrived at equal loudness contours of equivalent shape. Indeed, the investigations continue, and generally tend to support the results of these earliest investigators.

Speech Interference Levels

To evaluate the interference of noise upon speech communication in passenger aircraft, Beranek (1947) introduced the speech interference level (SIL). The SIL was defined as the arithmetic average of the sound pressure levels in the 600 to 1200, 1200 to 2400, and 2400 to 4800 Hz octave bands. It also served as a convenient single-number rating for evaluating the interference of noise on speech communication in enclosed spaces and outdoors (Beranek, 1950). The use of the SIL has continued through the years and has been redefined in the currently used "preferred" octave bands as the arithmetic average of sound pressure levels in the 500, 1000, 2000, and 4000 Hz octave bands (Schultz, 1968) (ANSI 1977) (Harris, 1991).

A, B, C-Weighting Networks

The first of the measured single-number ratings appears to be the now very familiar A- and C-weightings and the less familiar B-weighting. These were first standardized in ASA Standard Z24.3-1944 (Beranek, 1949 and 1988).

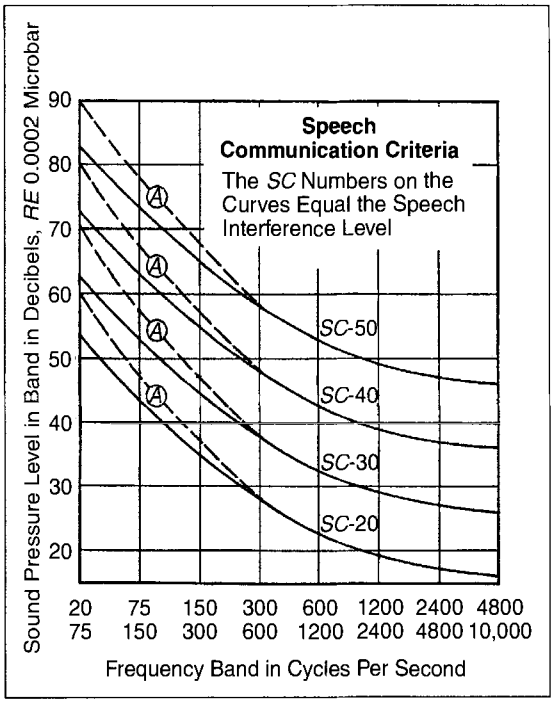

Fig. 1. SC curves (Beranek, 1954).

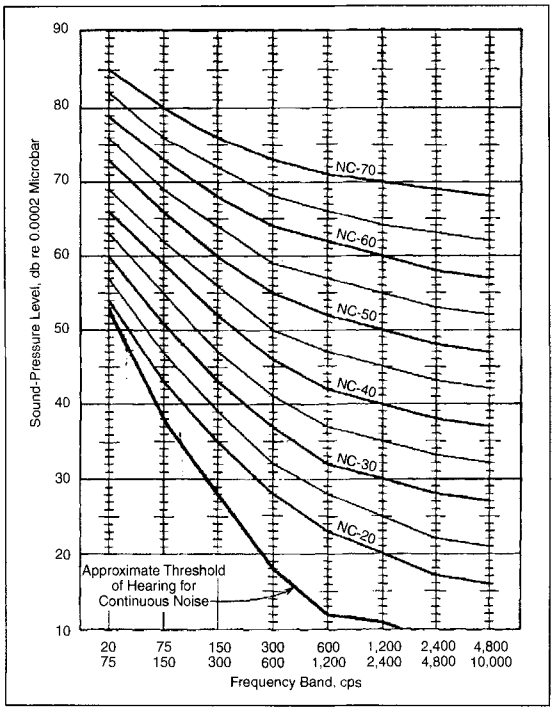

Fig. 2. NC curves (Beranek, 1960).

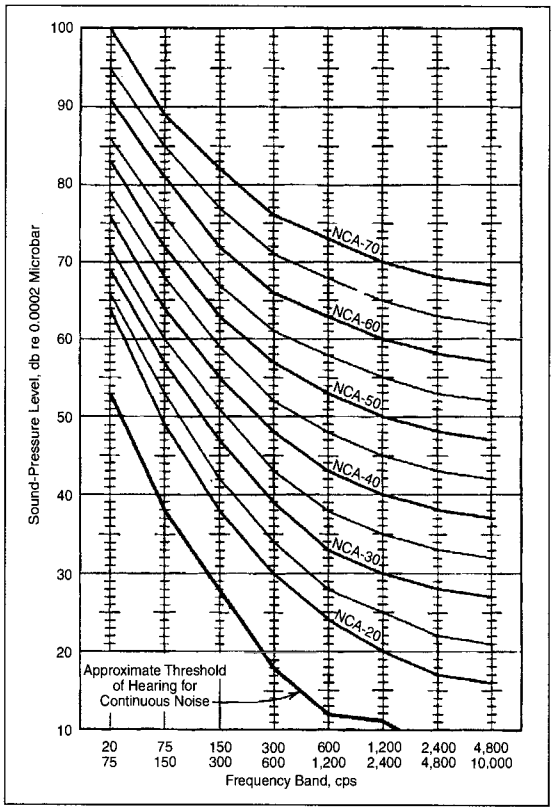

Fig. 3. NCA curves (Beranek, 1960).

SC Curves

The Sound Communication (SC) curves shown in Fig. 1 were first introduced in 1953 (Beranek *et al.*, 1953 and 1954). They are curves similar to the later, and more widely used, NC curves. SC curves were defined in the SIL octave bands (600 to 4800 Hz). Extension of these curves to lower frequencies was on the basis of annoyance. The SC curves were defined in 10 dB increments, but later interpolated to 5 dB and 1 dB increments. Each curve has an accompanying alternate curve that permitted more low frequency sound. These alternate curves permitted higher sound levels in the 20 to 300 Hz bands. In practice, a measured noise spectrum was overlaid on the SC curves. A criterion was met if all spectrum sound levels fell below the SC curve limit of the criterion. Accordingly, the SC rating of a spectrum was the highest curve reached by the spectrum, i.e., tangent to the curve.

NC Curves

The Noise Criteria curves of Fig. 2 were first published in 1957 (Beranek, 1957), and, like the SC curves that preceded them, are curves of approximate equal loudness. They were developed from a table of SIL values found to be acceptable in a survey of a persons working in a wide variety of office environments. The curve shapes were set to be monotonic in shape and to have loudness levels in phons that are 22 units above the corresponding SIL values. It is to be noted that the NC curves are not intended to be the most desirable noise spectrum shapes, but rather they are intended to be octave band noise levels that just permit satisfactory speech communication without being annoying (Beranek, 2000).

NC curves are customarily used with the tangency method for evaluating a sound pressure level spectrum. As with SC curves, the tangency method is a way to assign an NC rating to a spectrum. The wide use of NC curves is largely attributed to their publication by the American Society of Heating, Ventilating, and Airconditioning Engineers (ASHRAE) in their design handbooks used by most mechanical engineers.

NCA Curves

The NCA curves, or alternate NC curves, shown in Fig. 3, were published simultaneously with the NC curves, These curves permit higher amounts of sound in low frequencies for less sensitive applications, and are substantially the same as the NC curves at mid and high frequencies. The NCA curves were devised as a less restrictive method for limiting noise in building spaces where background noise is more tolerable, particularly at low frequencies. The NCA curves resemble SC curves in that they are alternate shapes to the NC curves and permit higher levels at low frequencies for less sensitive spaces. NCA curves, though published with the NC curves, never became widely used.

N, L, M, and H Contours

The first method for evaluating the spectral balance between low, mid, and high frequency sound, and to ascribe a neutral spectrum shape appears to be by Cavanaugh *et al.* (Cavanaugh, 1962). Four spectral shape curves were defined around the NC-30 curve as shown in Fig. 4. A spectrum that fairly well matched the shape of the NC-30 curve was defined as neutral in spectrum balance, i.e., having good relative proportions between low, mid, and high frequency sound. Such spectra are perceived as desirably innocuous, at least from the standpoint of background sound in buildings.

The L, M, and H curves were shaped in such a fashion as to permit predominance of noise in the low, mid, and high frequencies respectively. A measured spectrum shape that did not conform well to an NC curve, but conformed better to either of the L, M, or H curves, would be denoted as an L, M, or H spectrum, depending on the best subjective fit of the octave band data. No procedure was established for using these spectral balance curves, but they represent the first introduction of the notion that ratings alone are not sufficient and that some descriptor indicating predominance of sound energy in one range

or another was necessary for a more complete rating of sound in rooms.

PNC Curves

Because of observations that broad band sound electronically tailored to exactly match an NC curve tended to sound perceptibly "rumbly" and "hissy," and to adapt the "old octave band" NC curves to the new "preferred" octave bands, Preferred Noise Criteria (PNC) curves, shown in Fig. 5, were developed in 1971. These curves are less steep in the low frequencies and more steep in the high frequencies than the NC curves (Beranek, 1971). Although achieving a better balance between low, mid, and high frequency sound, the PNC curves were more stringent in the low frequencies. As a consequence, this required more extensive, and usually more costly, low frequency noise control in building mechanical systems than otherwise required using NC curves. Furthermore, experienced consultants found the more stringent low frequency limits of PNC curves to be unnecessary and impractical in most building applications. For these reasons and the fact that they were never incorporated into any standards or practice guidelines, the PNC curves never became widely used.

RC curves

In an attempt to better understand the implication of spectrum shape on the suitability of background sound in buildings produced by building mechanical systems, ASHRAE, in the mid 1970s, undertook a survey of background sound in building spaces. Blazier used this survey to develop a method for evaluating the suitability of background sound in building spaces based on space use (Blazier, 1981). The result was a set of Room Criteria (RC) curves that are straight, parallel lines of constant –5 dB/octave slope. This shape was described as being perceptually neutral, i.e. not have tonal dominance in any one frequency range. As explained below, the RC method involves determining an RC rating and a spectrum quality descriptor that denotes any imbalances or predominance of sound in a particular frequency range and causes a sound spectrum to be perceived as either "rumbly" or "hissy." RC curves and methods for rating room sound spectra are defined by American National Standard S12.2-1995, "Criteria for Evaluating Room Noise."

NCB Curves

These are a refinement of NC curves. NCB curves have somewhat greater negative slopes in the high frequencies to overcome the hissy quality of NC curves, and extend down to the 16 Hz octave band (Beranek, 1989). Like the RC method, the NCB method has a rating procedure and a method for ascribing a spectrum quality descriptor indicating any spectrum imbalance. NCB curves are inherently different from RC curves. NCB curves are based on curves of equal loudness, whereas RC curves are of perceived optimum spectrum shape. NCB curves are also defined in ANSI S12.2-1995.

RC Mark II

This method uses curves nearly identical to those of the RC method and its means for rating a spectrum is the same. The method differs, however, in the way a sound quality descriptor is determined for a spectrum. The RC Mark II method defines a quality assessment index (QAI) that is calculated using the differences between the spectrum values

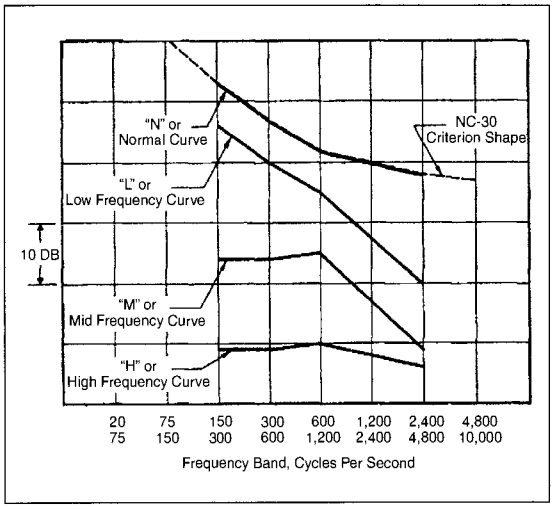

Fig. 4. N, L, M, and H characteristic noise curves (Cavanaugh, 1962).

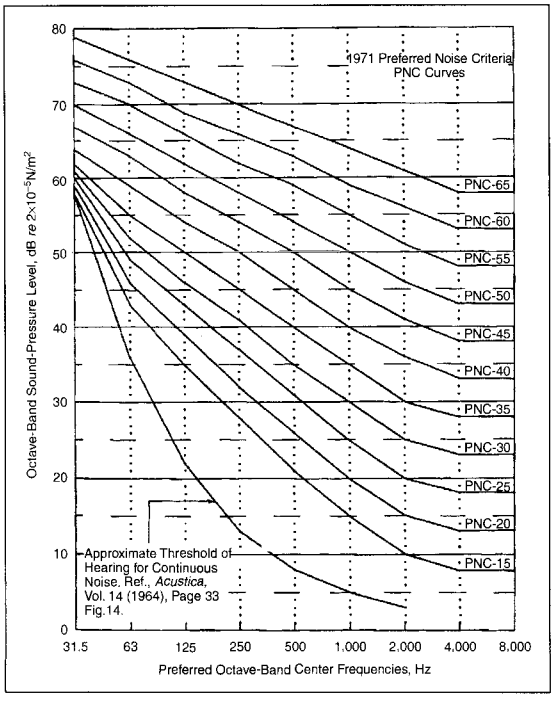

Fig. 5. PNC curves (Beranek, 1971).

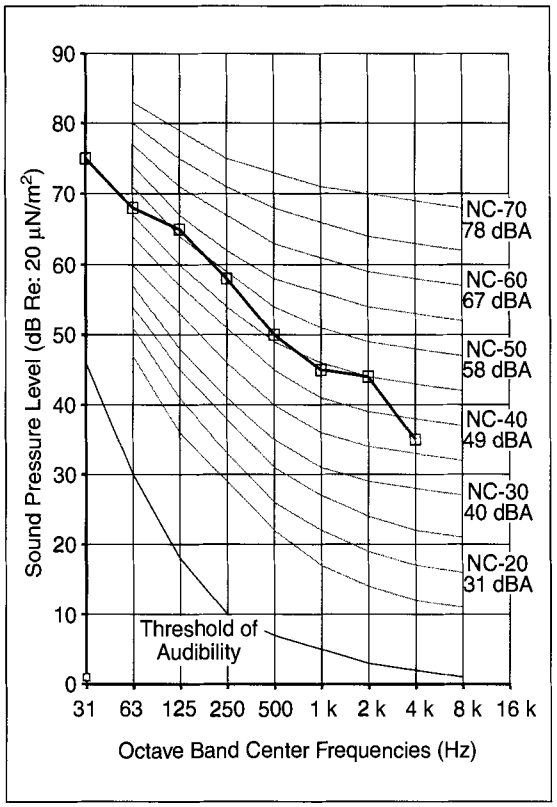

Fig.6. Noise Criteria (NC) curves.

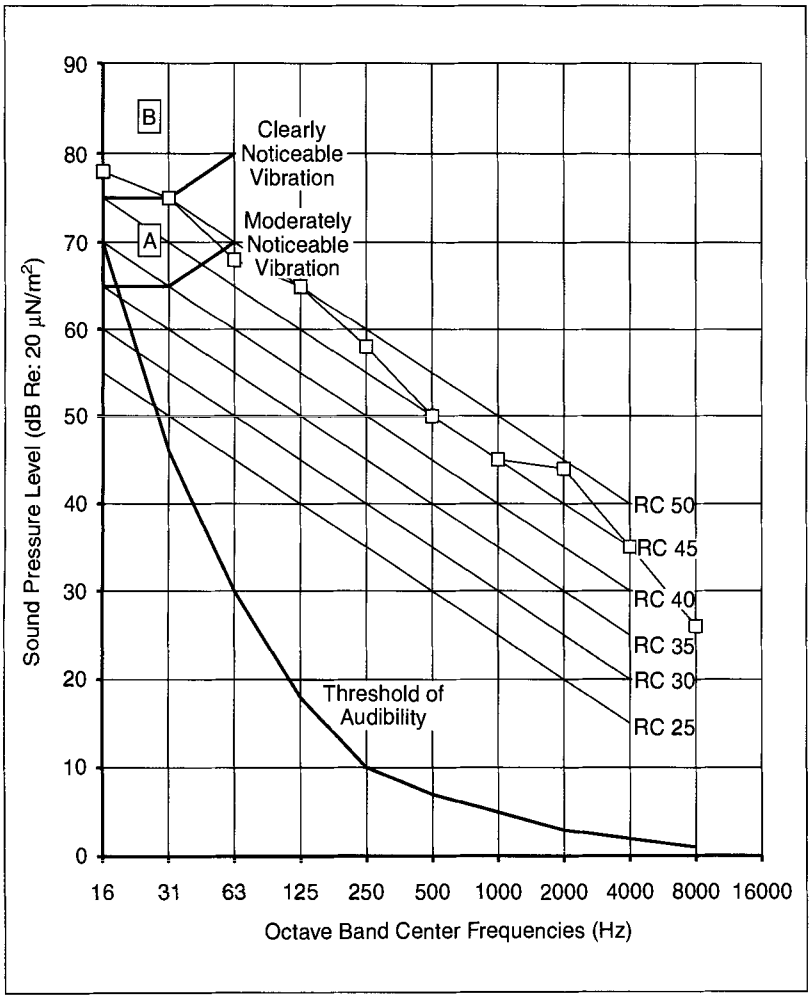

Fig.7. Room Criteria (RC) curves. ANSI S12.2 Criteria for Evaluating Room Noise.

and the neutral RC curve corresponding to the spectrum. This method is the outgrowth of experience by Blazier and others. It was published in 1997 (Blazier, 1997), and is expected to be published in the ASHRAE Fundamentals Handbook (ASHRAE, 2001).

RNC Curves

Finally, in an attempt to reach a technical compromise between NC, NCB, and RC curves, RNC curves have been developed that can be used with a tangency method for determining an RNC rating of a room sound pressure level spectrum (Schomer, 2000). Unlike other spectrum evaluation methods, the RNC method can be used to evaluate temporal variations in low frequency sound often observed in large ventilation systems.

Current Rating Methods

NC Tangency Method

NC curves were first described by Beranek (Beranek, 1957), and were developed as described earlier. It was originally presumed that an octave band spectrum that generally follows an NC curve shape would be perceived as equally balanced in low, mid, and high frequency energy. Although this was shown not quite to be the case, leading to the development of other curve sets, NC curves have continued to be used as the chief means for evaluating background sound in buildings.

The tangency method is the simplest and most commonly used method for rating octave band sound pressure level spectra in rooms using NC curves. Using the tangency method, the NC rating of a spectrum is designated as the value of the highest NC curve reached. Figure 6 contains a set of NC curves overlaid with a typical room sound pressure level spectrum. The rating of the spectrum shown is approximately NC-51. The tangency method does not attempt to evaluate the tonal character of an octave band spectrum.

NC curves were originally defined in the old octave bands. The NC curves shown in Fig. 6 are an interpolation of the original curves into the preferred octave bands, as published by Schultz (Schultz, 1968).

RC Rating Method

The Room Criteria rating method was first proposed by Blazier (Blazier, 1981) and is now standardized in ANSI S12.2-1995, "Criteria for Evaluating Room Noise." Figure 7 presents a set of RC curves together with the typical sound pressure level spectrum shown in Fig. 6. RC curves are defined from RC-25 to RC-50, and are intended to cover the typical range of background sound in buildings over the fre-

quency range 16 Hz to 4000 Hz. RC curves are parallel lines of constant –5 dB per octave slope. Their shape was defined on the basis of Blazier's observation that this was the average spectrum shape found in offices surveyed in earlier work by ASHRAE.

The rating of a sound pressure level spectrum follows the general form RC XX(YY), where XX is the RC rating and YY is one or more descriptors indicating spectral balance—as discussed below.

Rating a sound pressure level spectrum using the RC method involves two steps. The first step is to determine the mid-frequency average level (L_{MF}) defined as follows:

$$L_{MF} = (L_{500} + L_{1000} + L_{2000})/3.$$

The RC rating of a spectrum is equal to the mid-frequency average level: L_{MF}. For the spectrum shown in Fig. 7, the RC rating is 46.

The second step involves determining the perceived balance between low and high frequency sound. A spectrum rich in low frequency sound (16 Hz to 500 Hz) is defined as "rumbly." A spectrum rich in high frequency sound (1000 Hz to 8000 Hz) is defined as "hissy."

The rumble criterion is defined as the RC curve that is 5 dB higher than the neutral curve determined from the L_{MF} and extends from 16 Hz to 500 Hz. If low frequency sound levels exceed the rumble criterion curve, the spectrum is judged to be rumbly.

The hiss criterion is the RC curve that is 3 dB higher than the neutral criterion and extends from 1000 Hz to 4000 Hz. Spectra that have values that exceed the hiss criterion would be perceived as hissy.

In addition, two criteria curves are also provided for determining the likelihood that low frequency sound will produce audible rattling in lightweight building elements such as suspended ceilings, light fixtures, doors, windows, ductwork, etc. These are shown in Fig. 8, one for "moderately noticeable vibration" and a second for "clearly noticeable vibration."

To express the balance of a spectrum, one of the following is used for the YY descriptor: (N), (R), (RV), or (H). Spectra found not to exceed rumble, hiss, nor noticeable vibration criteria are considered to be "neutral," i.e., having relatively good balance between low, mid, and high frequency sound energy. These spectra are followed by the quality descriptor (N). Since the spectrum in Fig. 8 exceeds the "clearly noticeable vibration" criterion curve, it would be designated an RC 46(RV) spectrum.

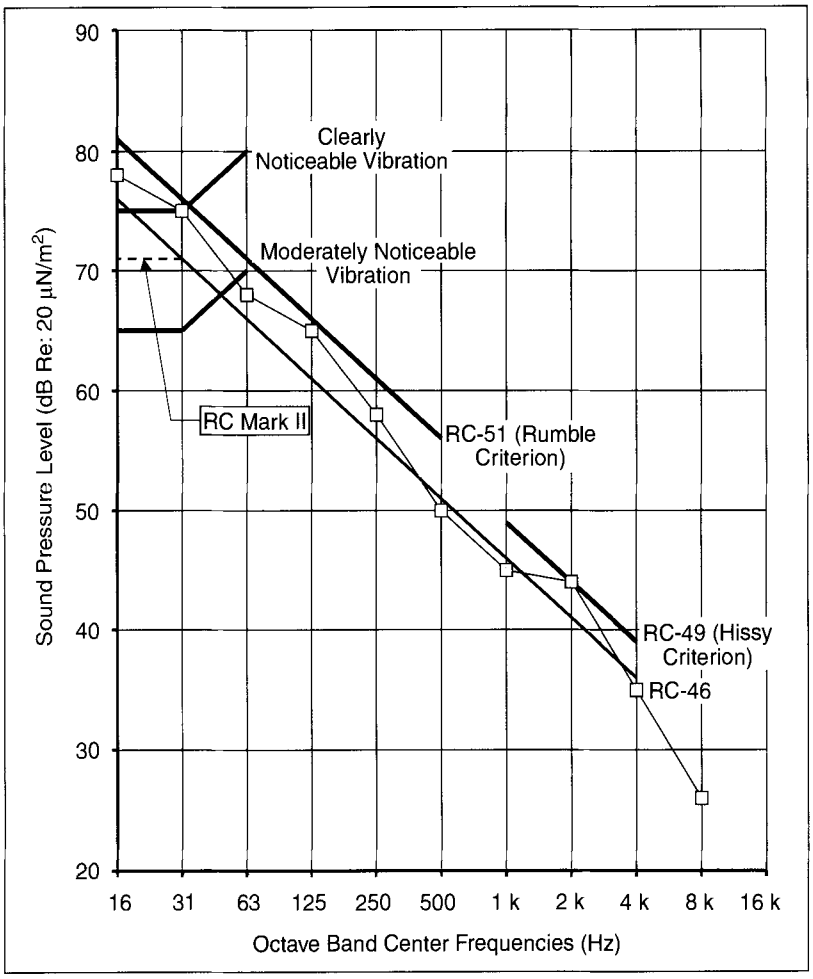

Fig. 8. Room Criterion Curves (RC) example spectrum evaluation.

NCB Rating Method

ANSI S12.2 provides a table defining balanced noise criteria curves in 1-dB increments. These curves are shown graphically in Fig. 9. These curves extend from the 16 Hz to the 8000 Hz octave band. The standard defines the values for each individual curve from NCB-10 to NCB-65. In addition, the NCB-0 curve is defined as the threshold of audibility for continuous sound in a diffuse field and is derived from the ANSI threshold of audibility for pure-tones.

The NCB curves were derived by a different procedure from that used to define NC curves (Beranek, 1989). NCB curves use the 4-band SIL. The NCB number of each curve is equal to the corresponding 4-band SIL. The shape of each curve was determined by making the loudness level in each octave band the same as determined using Stevens' Mark VII procedure for calculating loudness in critical bands. Where only part of a critical band falls in an octave band, the loudness was reduced proportionately. Conversely, when more than one critical band fell in an octave band, the loudness was increased. NCB curves also meet the same annoyance test as the NC curves, that is the loudness at low frequencies in phons does not exceed the SIL by more than 24 units.

As with the RC rating, the NCB rating takes the form of NCB XX(YY), where XX is the NCB rating and YY is a spectral balance descriptor.

Also as with the RC rating, the NCB method involves two steps. The first step is to compute the speech interference level (SIL) for the spectrum being evaluated. The SIL is defined as follows:

$$SIL = (L_{500} + L_{1000} + L_{2000} + L_{4000})/4.$$

The NCB rating of a spectrum is equal to the SIL rounded to the nearest decibel. For example, the spectrum shown in Fig. 9 has an SIL of 44 dB, and is therefore an NCB 44 spectrum.

The second step involves a determination of the perceived balance between low and high frequency sound. A spectrum rich in low frequency sound (16 Hz to 500 Hz) is defined as "rumbly." A spectrum rich in high frequency sound (1000 Hz to 8000 Hz) is defined as "hissy." The previously-described criteria for moderately and clearly noticeable vibration are also used with the NCB rating method. As with the RC method, spectra found not to exceed rumble, hiss, nor noticeable vibration criteria are considered to be "neutral" spectra, i.e., having relatively good balance between low, mid, and high frequency sound energy.

The rumble criterion is defined as the NCB curve with a value 3 dB higher than the curve determined on the basis of SIL. The rumble criterion curve extends only between 16 Hz and 500 Hz. Figure 10 presents the rumble criterion curve corresponding to the NCB-44 spectrum shown. Note that the spectrum exceeds the NCB-47 rumble criterion, therefore the spectrum shown would be characterized as "rumbly." It also exceeds the "moderately noticeable vibration" criterion curve.

The hiss criterion is somewhat more complicated to determine as illustrated in Fig. 11. The hiss criterion curve is the arithmetic average of the three NCB curve values intersecting the spectrum at 125, 250, and 500 Hz—in this case NCB-49. Note that the spectrum does not fall above the NCB-49 hiss criterion curve, therefore the spectrum is not "hissy" according to ANSI S12.2.

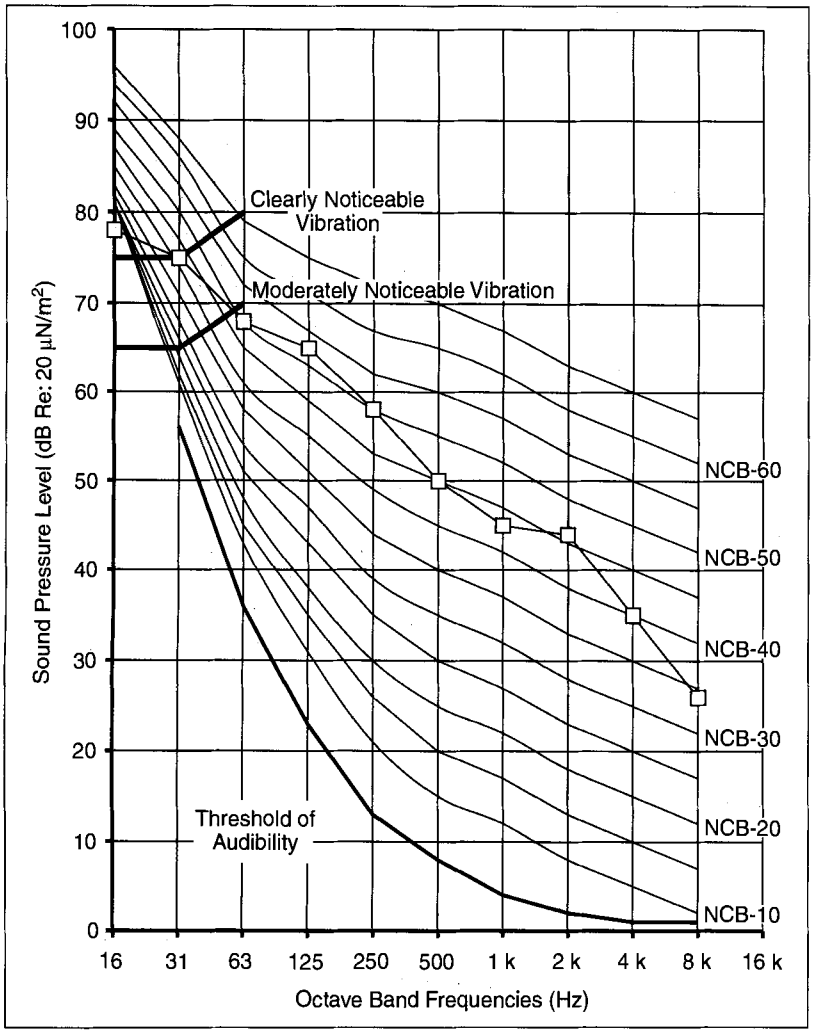

Fig. 9. Balanced Noise Criteria curves (NCB).

RC Mark II Rating Method

This rating method is similar to the RC rating method in that the L_{MF} value is used as the rating value. It has been developed and published by Blazier (1997), and is expected to be included in the forthcoming ASHRAE *2001 Fundamentals Handbook* (ASHRAE, 2001). The method differs from the RC rating method principally in two respects.

First, the RC curves used in the RC Mark II method differ slightly in that they are flat, rather than sloped, in the 16 to 31 Hz bands as noted in Fig. 12 and as also shown for the RC 46 curve in Fig. 8.

Second, the RC Mark II rating method differs in how qualitative characteristics of sound are computed. This new method uses two new quantities for computing qualitative characteristics of sound. These are the "energy-average spectral deviation factors" and the "quality assessment index." As seen in Fig. 12, the RC Mark II rating method divides the audible frequency range into three regions— low (16 to 63 Hz), middle (125 to 500 Hz), and high (1000 to 4000 Hz). Excess sound in these ranges are indicated as being perceived respectively as "rumble," "roar," and "hiss." The RC Mark II qualitative rating method can be divided into three steps as follows:

Step 1 is to determine the RC rating using the L_{MF} as previously discussed. For convenience, this curve should be plotted together with the spectrum or listed in a table as discussed below.

Step 2 is to calculate the energy-average spectral deviations in each of the three previously mentioned frequency regions. These are as follows:

$$\Delta LF = 10\log\left(\frac{10^{\Delta L_{16}/10} + 10^{\Delta L_{31}/10} + 10^{\Delta L_{63}/10}}{3}\right)$$

$$\Delta MF = 10\log\left(\frac{10^{\Delta L_{125}/10} + 10^{\Delta L_{250}/10} + 10^{L_{500}/10}}{3}\right)$$

$$\Delta HF = 10\log\left(\frac{10^{\Delta L_{1000}/10} + 10^{\Delta L_{2000}/10} + 10^{\Delta L_{4000}/10}}{3}\right).$$

In the above relationships, the ΔL_f values are the differences between the spectrum value and the RC curve value at that frequency.

Step 3 is to determine the quality assessment index (QAI). The QAI is the difference between the highest and lowest energy-average spectral deviations. If the QAI is less than or equal to 5 dB, the spectrum is presumed to be neutral, i.e., exhibiting proper balance between low, mid, and high frequency ranges. Accordingly, the qualitative descriptor following the RC rating would be (N). If the QAI is greater than 5 dB, then the qualitative descriptor would be determined by the maximum energy-average spectral deviation and signified (LF), (MF), or (HF). If the spectrum exceeds the moderate or clearly noticeable criteria, the qualitative descriptors (LV_A) or (LV_B) would also be used. It is possible that two descriptors would be needed, i.e., one of (N), (LF), (MF), or (HF) and one of (LV_A) or (LV_B).

Figure 13 includes the previously considered spectrum and the neutral RC Mark II curve. The qualitative descriptor can be computed using the above three-step process. Figure 13 contains a table presenting the qualitative descriptor computation method.

The following is a brief explanation of the worksheet in Fig. 13.

Line 3 is the measured or calculated sound pressure level spectrum.

Line 4 is the L_{MF}, the arithmetic average of sound pressure levels at 500, 1000, and 2000 Hz and is also the RC Mark II rating of the spectrum.

Line 5 is the corresponding neutral RC curve.

Line 6 includes the three band groupings centered in each three-band set.

Line 7 lists the arithmetic differences between the spectrum and the RC curve values in each frequency.

Line 8 includes the energy-average spectral deviation factors.

Line 9 is the arithmetic difference between the highest and lowest energy-average spectral deviation factors.

Line 13 is the clearly noticeable vibration criterion

Line 14 is the arithmetic difference between the measured spectrum levels of line 3 and the clearly noticeable vibration criterion of line 13.

Line 18 is the moderately noticeable vibration criterion

Line 19 is the arithmetic difference between the measured spectrum levels of line 3 and the clearly noticeable vibration criterion of line 18.

Figure 14 presents a summary of the RC Mark II rating for the spectrum shown in Fig. 12 and entered

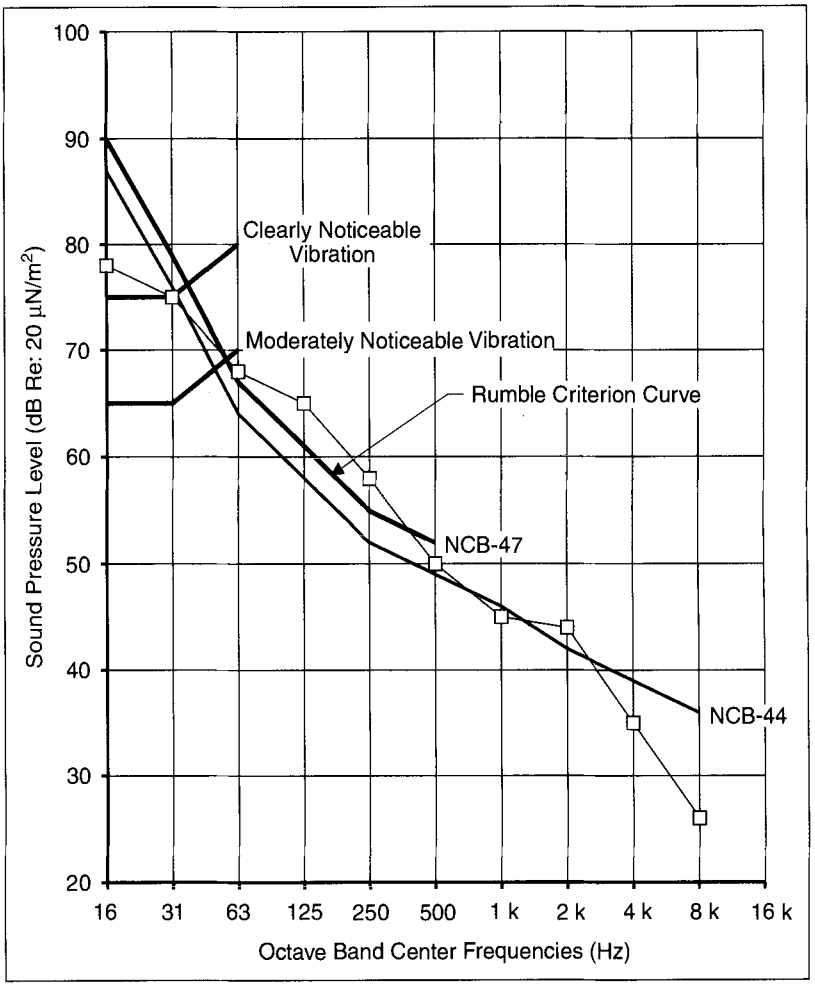

Fig. 10. Balanced Noise Criteria Curves (NCB) rumble criterion.

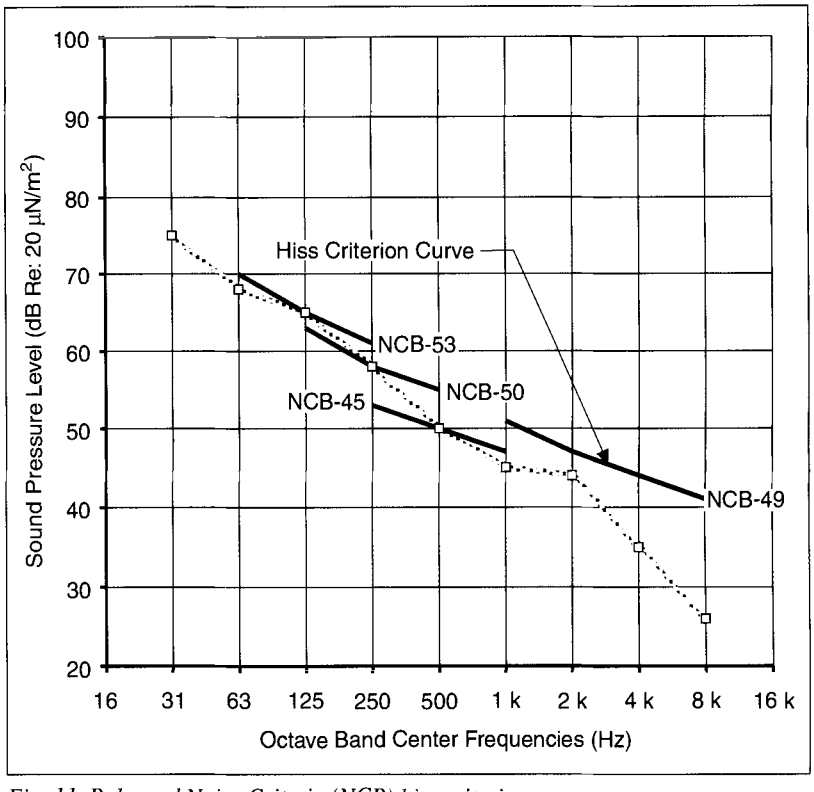

Fig. 11. Balanced Noise Criteria (NCB) hiss criterion curve.

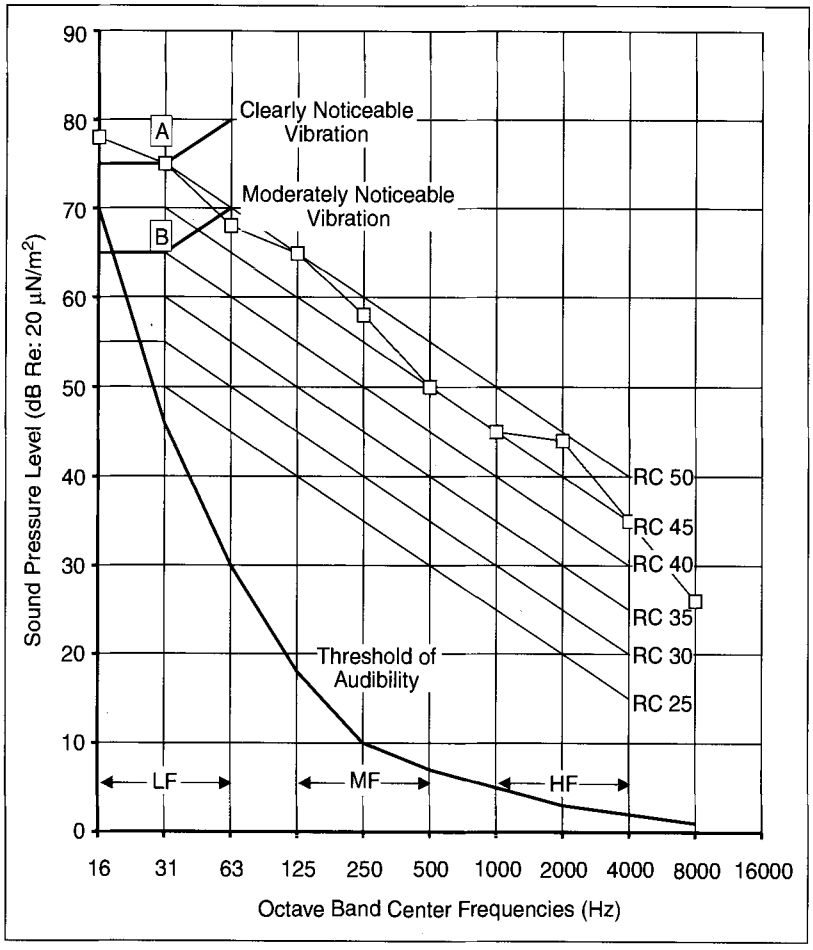

Fig. 12. Room Criteria (RC) Mark II curves (Blazier, 1997).

into the table of Fig. 13. A copy of a Microsoft Excel spreadsheet to perform the RC Mark II computations for a given spectrum is available from the ASHRAE technical committee on sound and vibration (TC 2.6) and from the author of this article.

Having determined an RC Mark II rating, Blazier provides a means to determine how a room occupant might respond to a given spectrum. Occupant subjective responses are indicated as: "acceptable," "marginal," and "objectionable." These responses presume that the RC rating (which is the L_{MF}) is consistent with recommendations for such ratings on the basis of space use. The subjective responses are provided in Fig. 15 (Blazier, 1997).

Proposed RNC Rating Method

American National Standards Institute Working Group 18 is the technical entity charged with updating ANSI S12.2-1995, Criteria for Evaluating Room Noise. Currently, the standard is under the usual review process associated with periodic reaffirmation. During this review process, a new method for evaluating room noise has been submitted for working group

	1	2	3	4	5	6	7	8	9	10
1					**Octave Band Frequencies (Hz)**					
2		**16**	**31**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**
3	L_p	78	75	68	65	58	50	45	44	35
4	L_{MF}							46		
5	RC curve	71	71	66	61	56	51	46	41	36
6			LF			MF			HF	
7	ΔL_f	7	4	2	4	2	-1	-1	3	-1
8	ΔLF, ΔMF, ΔHF		4.8			2.1			0.8	
9	QAI					4.1				
10										
11		**1/1 Freq. (Hz)**								
12		**16**	**31**	**63**	**Max**					
13	LFV_A	75	75	80						
14	$Lp - LFV_A$	3	0	-12	3					
15										
16		**1/1 Freq. (Hz)**								
17		**16**	**31**	**63**	**Max**					
18	LFV_B	65	65	70						
19	$Lp - LFV_B$	13	10	-2	13					

Fig. 13. RC Mark II rating and QAI worksheet.

consideration. The method known as the Room Noise Criteria (RNC) rating method (Schomer, 2000) is a consolidation of the NCB and RC curves. The new set of curves, known as RNC curves, is shown in Fig. 16. Spectra are normally rated using the tangency method with RNC curves. The method does not currently have a spectral balance assessment means; however, the method considers the impact of variations in low frequency sound with time. Such variations are often described as a "surging" sound associated with variations in airflow in large duct systems. The new method includes a means to compute an adjustment to the tangency rating to account for time variations in low frequency sound that may be present that exacerbate the perceived impact of background sound.

Highlights of the proposed method are:

- A new set of curves representing an "averaging" of NCB and RC curves.
- Use of a tangency method for determining a spectrum RNC rating.
- Use of measured (or calculated) peak-to-peak variation and standard deviation of sound pressure level with time in the 16, 31, 63, and 125 Hz octave bands.
- Weighting and combining of the 16, 31, and 63 Hz octave band levels to determine a lowest frequency band closely matching the critical band of human hearing in the low frequencies.

	1	2
2	**RC MARK II EVALUATION SUMMARY**	
3	RC Neutral Curve	46
4		
5	LFVA or LFVB or neither?	LFV_A
6		
7	Energy-average spectral deviations	
8	LF	4.8
9	MF	2.1
10	HF	0.8
11	Quality Assessment Index	
12	QAI	4.1
13		
14	Qualitative descriptor	N
15		
16	Spectrum RC Mark II Rating	**RC 46(N,LFV_A)**

Fig. 14. Summary of Qualitative Descriptor Computation for Spectrum of Fig. 12.

Case Histories

In order to examine the differences between the use of NCB and RC rating methods, 238 measured sound pressure level spectra were obtained from

Sound-Quality Descriptor	Subjective Perception	QAI	Occupant Response
(N) Neutral	Balanced, no one frequency range dominates	QAI ≤ 5 dB (L_{16}, $L_{31.5}$ ≤ 65 dB)	Acceptable
		≤ 5 dB (L_{16}, $L_{31.5}$ > 65 dB)	Marginal
(LF) Rumble	Low-frequency range dominant (16-63 Hz)	5 dB < QAI ≤ 10 dB	Marginal
		QAI > 10 dB	Objectionable
(LFV_A) Rumble, perceptible surface vibration	Low-frequency range dominant (16-63 Hz)	QAI ≤ 5 dB (L_{16}, $L_{31.5}$ > 75 dB)	Marginal
		5 dB < QAI ≤ 10 dB	Marginal
		QAI > 10 dB	Objectionable
(LFV_B) Rumble, perceptible surface vibration	Low-frequency range dominant (16-63 Hz)	QAI ≤ 5 dB (L_{16}, $L_{31.5}$ > 65 dB)	Marginal
		5 dB < QAI ≤ 10 dB	Marginal
		QAI > 10 dB	Objectionable
(MF) Roar	Mid-frequency range dominant (125-500 Hz)	5 dB < QAI ≤ 10 dB	Marginal
		QAI > 10 dB	Objectionable
(HF) Hiss	High-frequency range dominant (1000-4000 Hz)	5 dB < QAI ≤ 10 dB	Marginal
		QAI > 10 dB	Objectionable

Fig. 15. Interpretation of RC Mark II ratings presuming spectra are appropriate for space use.

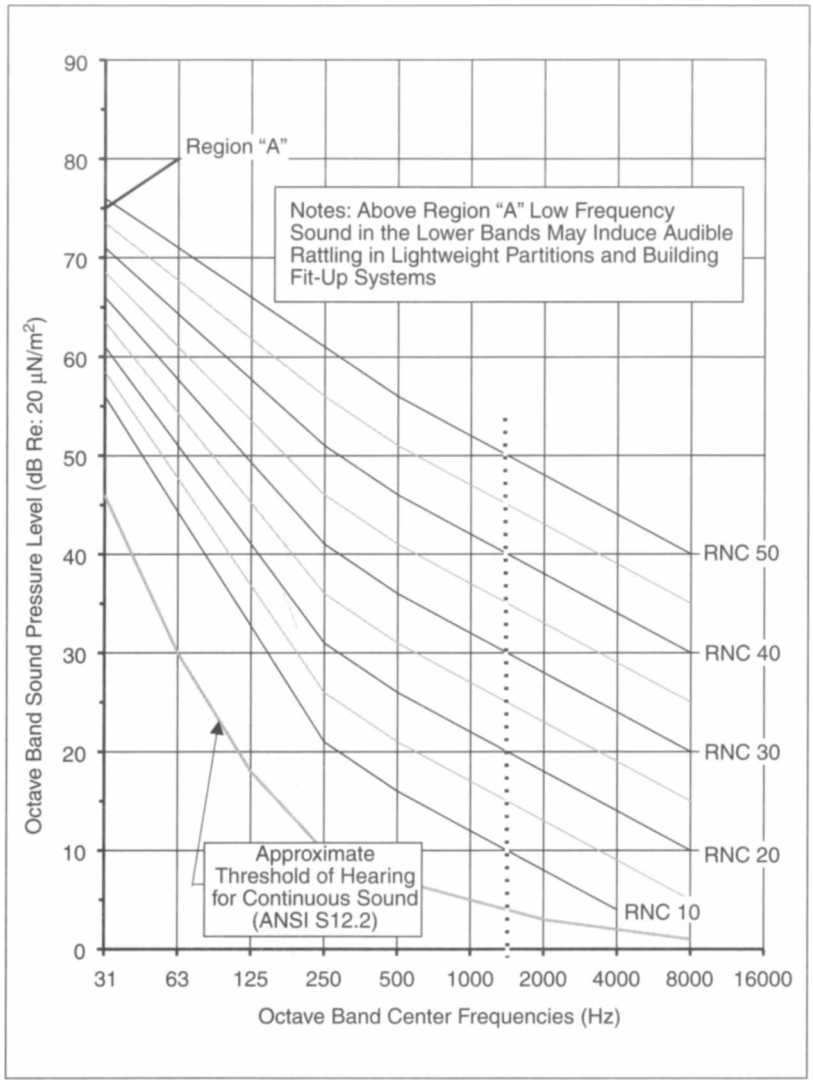

Fig. 16. RNC curves (Schomer, 2000).

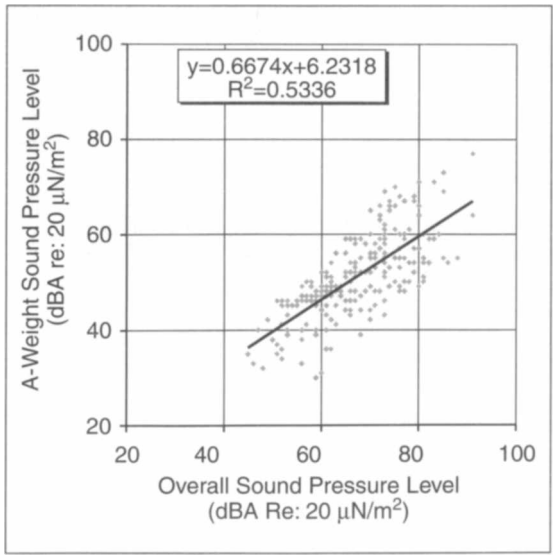

Fig. 17. A-weighted SPL as a function of overall (linear) SPL.

consulting project files of Cavanaugh Tocci Associates, Inc. These represent a variety of spaces including offices, hotel guestrooms, hospital patient rooms, classrooms, laboratories, etc. Most represent at least minor problems to the users, either by sound levels being too high and/or containing pure-tone components.

Figures 17 through 20 present relationships between measured sound levels; and NC, NCB, and RC ratings for the 238 measured spectra. Figure 17 presents the relationship between linear (overall) and A-weighted sound pressure level. Also provided is the linear regression relating linear and A-weighted sound levels and the coefficient of determination. In Fig. 17, A-weighted sound pressure levels are, as expected, consistently lower than unweighted levels, but not in a fashion that produces a regression line that has a slope of 1.0.

Figure 18 presents the relationship between NC (tangency) and NCB ratings for the 238 spectra analyzed. It is seen in this figure that the NC (tangency) rating is consistently higher than the NCB rating. Again, this is as expected since the NC tangency method seeks the highest curve value reached by the spectrum. By the very nature of the NCB rating method, the NC tangency rating method will almost always produce higher values than will the NCB rating method.

In Fig. 19, the relationship between NCB and RC and RC Mark II ratings is shown to be very consistent—following a regression slope of approximately 1.0 and with only a small y-intercept. This suggests that, statistically, the NCB and RC ratings of spectra will be very nearly the same. Hence, NCB and RC criteria values used to establish acceptable sound levels in building spaces should be very nearly the same as well, or at most RC ratings should be set about 2 dB higher than NCB ratings for identical spaces. This is as expected since RC and NCB ratings are based on averages of sound pressure levels over nearly identical frequency ranges.

Figure 20 presents the relationship between NCB tangency and NC tangency ratings. As these sets of curves are very nearly identical, the corresponding ratings are also very nearly identical. Note that only spectra with tangency points falling within the frequency range covered by the NC curves (63 Hz to 8000 Hz) have been included.

Figure 21 presents correlations between the determinations of rumble and hiss criteria using NCB and RC methods for the 238 spectra evaluated in this study. The figure presents four correlations covering combinations of agreement and disagreement between the two methods for ascribing rumble and hiss characteristics to measured criteria.

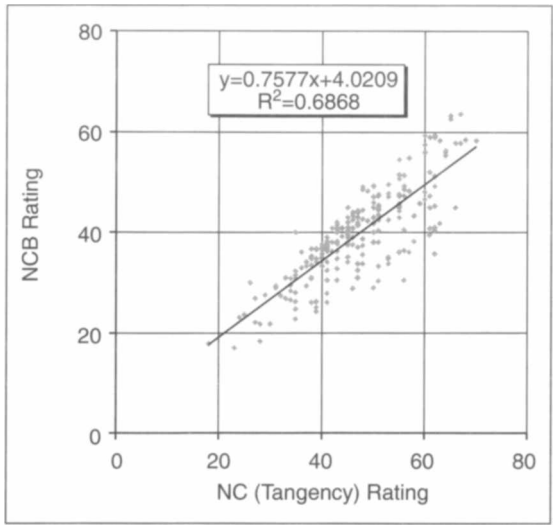

Fig. 18. Relationship between NCB and NC (tangency) ratings.

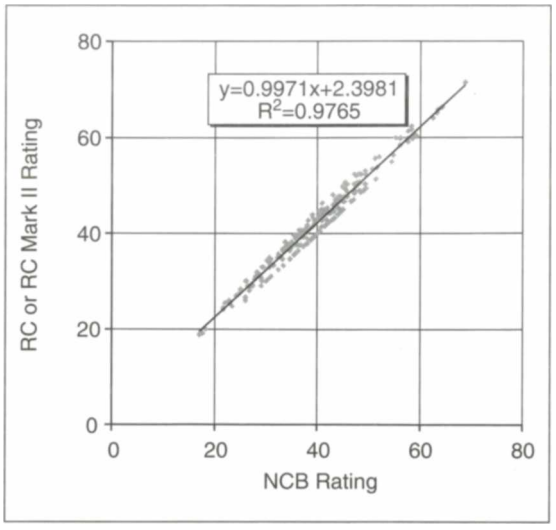

Fig. 19. Relationship between NCB and RC and RC Mark II ratings.

In Fig. 21, "NCB only" means only the NCB rating determined the spectrum to be rumbly, but not the RC rating, etc.

Of the 238 spectra, all excluded data in the 16 Hz band. In addition, a few had no data in the 31 Hz band, and several had no data at high frequencies because levels were low and of little interest to the evaluation of the problem at hand. Missing data in the 31 Hz band were approximated by setting the 31 Hz band sound pressure level equal to the 63 Hz sound pressure level. The missing high frequency data were approximated by continuing the spectrum from the highest band for which data was reported at a negative 5-dB slope. In addition, 42 spectra had L_{MF} values outside of the RC 25 to 50 range.

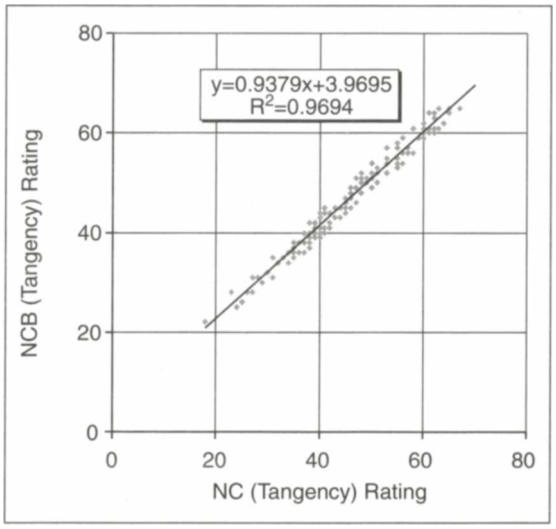

Fig. 20. Relationship between NCB (tangency) and NC (tangency) ratings.

Conclusions

The approximately 70-year history of noise criteria has been briefly reviewed with detailed descriptions provided for noise rating methods in current use. Currently-used methods in the literature for rating room sound level spectra include the Noise Criteria (NC), Room Criteria (RC), Balanced Noise Criteria (NCB), and RC Mark II curves. Of these, only the RC and NCB curves are defined in American standards, in this case, ANSI S12.2 (ANSI, 1995). Both methods provide a means for rating spectra on the basis of an octave band arithmetic average of sound levels. As discussed, these are the L_{MF} and the SIL; the former is used with RC ratings and the later with NCB ratings. In addition, both methods have a quality descriptor that indicates perceived spectrum balance between low and high frequencies.

The older, more widely used, NC curves are standardized through the technical literature and have no fixed method of use to determine the NC rating of a spectrum, except that the "tangency" method has come into wide use for this purpose.

The RC Mark II method is a further development of the RC method and uses curves nearly identical to the RC curves defined in ANSI S12.2. The RC Mark II method differs considerably from the RC method in the way it ascribes a spectrum quality descriptor to a sound pressure level spectrum.

Finally, a new rating method, the Room Noise Criteria (RNC) method, has been discussed briefly. It has recently been published in the *Noise Control Engineering Journal*. The method attempts to combine the favored attributes of the NC, RC, and NCB rating methods by using curves that represent a compromise between RC and NCB shapes, and by using a tangency method for determining spectrum rating.

In order to investigate differences between NC, NCB, RC and RC Mark II rating methods, each

Rumble Correlation	Number of Spectra	Hiss Correlation	Number of Spectra
NCB only	73	NCB only	28
Both rumble	84	Both hiss	13
RC only	1	RC only	10
Neither rumble	38	Neither hiss	145
SUB TOTAL	196	SUB TOTAL	196
Spectra out of criteria range	42	Spectra out of criteria range	42
TOTAL	238	TOTAL	238

Fig. 21. Correlation between NCB and RC Determinations of Rumble and Hiss for Measured Spectra.

Rumble Correlation	Number of Spectra	Hiss Correlation	Number of Spectra
RC only	26	RC only	20
Both rumble	59	Both hiss	3
RC Mark II only	68	RC Mark II only	41
Neither rumble	43	Neither hiss	132
SUB TOTAL	196	SUB TOTAL	196
Spectra out of criteria range	42	Spectra out of criteria range	42
TOTAL	238	TOTAL	238

Fig. 22. Correlation between RC and RC Mark II Determinations of Rumble and Hiss for Measured Spectra.

Rumble Correlation	Number of Spectra	Hiss Correlation	Number of Spectra
NCB only	52	NCB only	29
Both rumble	105	Both hiss	12
RC Mark II only	22	RC Mark II only	32
Neither rumble	17	Neither hiss	123
SUB TOTAL	196	SUB TOTAL	196
Spectra out of criteria range	42	Spectra out of criteria range	42
TOTAL	238	TOTAL	238

Fig. 23. Correlation between NCB and RC Mark II determinations of rumble and hiss for measured spectra.

method has been implemented on a series of 238 measured spectra. The resulting NC, NCB, RC, and RC Mark II ratings have been correlated using regression methods. General observations on the similarities and differences between these methods are as follows:

1. On the basis of the 238 spectra studied, the RC rating of a spectrum tends to be about 2 dB higher than NCB rating of the same spectrum. This is logical since the NCB method uses a four band (SIL) average and the RC method uses only the three lower (500, 1000, 2000 Hz) of the these four bands (L_{MF}, mid-frequency average). Since the sound level in the fourth band (4000 Hz band) is usually lower than the sound level in the three lower frequency bands (500, 1000, 2000 Hz), the four band average will usually be lower than the three band mid-frequency average.

2. Generally speaking, the NCB method tends to be more sensitive to evaluating rumble characteristics than the RC method, at least on the basis of the spectra evaluated. It is believed that this observation is a result of measured spectra having low frequency peaks at 63 Hz or higher. It is believed that the RC method is more sensitive than the NCB method to low frequency rumble sound at 16 and 31 Hz. Hence, it is believed that spectra having significant amounts of sound energy in these lowest bands, it would more likely be determined to be rumbly by the RC method than by the NCB method.

3. The RC method appears to be somewhat less sensitive to hiss than the NCB method. Of the 51 spectra identified as being hissy, only 13 of the spectra were determined to be hissy by both methods.

4. The RC and RC Mark II methods are identical in the way spectra are rated, but differ significantly

in they way the spectrum balance quality is evaluated. It is apparent that the RC Mark II method is more sensitive to rumble and hiss than is the RC method. In addition, there is a wide disparity between spectra indicated as being hissy using the two methods.

5. There appears to be good agreement between the NCB and RC Mark II methods for determining the presence of rumble. However, this is not true for the evaluation of spectrum hiss.

Acknowledgments

The author wishes to thank his partner, William J. Cavanaugh, for his comments and suggestions, and the author's colleague Timothy J. Foulkes for the bulk of the measured data used in this analysis. The author also wishes to thank Leo Beranek for his helpful suggestions and recounting the history of the ratings discussed.

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- **Noise from domestic appliances**
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05 Publications (other than technical articles)
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07 Education
08 Noise programs
09 Definitions and descriptors

EMISSION: NOISE SOURCES (noise generation and control)

10 General
11 Noise-generating devices (including components and subassemblies)
12 Stationary noise sources (noise generation and control)
13 Moving noise sources including aircraft (noise generation and control)
14 Specialized industrial machinery and equipment

PHYSICAL PHENOMENA

20 General
21 Physical mechanisms of noise generation
22 Natural sources of noise
23 Propagation, transmission & scattering of sound (general wave equation)
24 Sound propagation in the atmosphere
25 Sound propagation in enclosed spaces
26 Sound propagation in ducts

NOISE CONTROL ELEMENTS (for path noise control)

30 General
31 Barriers and screens, shielding
32 Enclosures for noise sources
33 Sound isolating elements (including panels, partitions and curtains)
34 Filters, mufflers, silencers and resonators (conventional types)
35 Absorptive materials
36 Hearing protective devices
37 Noise attenuation and transmission in ducts
38 Special treatments (including active noise control)

VIBRATION AND SHOCK: GENERATION, TRANSMISSION, ISOLATION AND REDUCTION

40 General
41 Characteristics of sources of vibration and shock
42 Vibrating surfaces and structures (beams, plates, shells)
43 Propagation in structures (solid-borne noise)
44 Balancing of rotating and reciprocating machines
45 Reduction of impact forces; shock isolation and absorption
46 Vibration isolators and attenuators
47 Vibration-damping materials and structures
48 Vibration generators, shake tables
49 Effects of vibration and mechanical shock (on man, on structures)

IMMISSION: PHYSICAL ASPECTS OF ENVIRONMENTAL NOISE (multiple sources and multiple paths)

50 General
51 Building noise control
52 Community noise control
53 In-plant noise control
54 Shipboard and offshore platform noise control
55 Outdoor plant noise control design and construction
56 Noise surveys

IMMISSION: EFFECTS OF NOISE

60 General
61 Perception of sound
62 Physiological effects
63 Psychological effects
64 Effects of noise on physical structures
65 Effects of noise on domesticated and wild animals
66 Sociological effects; community reaction to noise
67 Economic effects
68 Environmental impact statements
69 Criteria and rating of noise

ANALYSIS

70 General
71 Instruments for noise and vibration measurements
72 Measurement techniques
73 Test facilities (design and qualification)
74 Signal processing
75 Analytical methods
76 Modeling, prediction and simulation
77 Sampling and quality control procedures
78 Audiometry, dosimetry and hearing measurements
79 Psychoacoustical evaluations and testing

REQUIREMENTS

80 General
81 Standards
82 Federal government legislation and regulations
83 State and local legislation and regulations
84 Other legislation and regulations
85 Ordinances, including zoning requirements
86 Building codes
87 Specifications
88 Auditing, enforcement and certification
89 Labeling

NOISE-CON 2000 PAPER LISTING

This is a listing of the papers to be presented at the joint meeting of NOISE-CON 2000 and the 140th meeting of the Acoustical Society of America (ASA) in Newport Beach, California on 2000 December 03-05.The ASA paper numbering system has been adopted for this meeting. For example, 0pNSa1: 0 = Dec. 03 (1 = Dec. 04, 2 = Dec. 05), p = afternoon (a = morning), NS means Noise, a = Session a (b, c,...), 1 = paper number in session (2, 3, 4, ...). A registration form for the meeting is on page 128. Travel planning information and a hotel reservation form appeared in the 2000 June issue of this magazine. This information can be also found on the Internet as a link of the INCE/USA home page, http://ince.org.

Plenary Sessions

0pNSe1 Global players in acoustic standardization, *Klaus Brinkmann*

1aNSa1 Noise control engineering for the airport railway in Hong Kong, *Glenn H. Frommer*

1pNSa1 Product sound quality: From perception to design, *Richard H. Lyon*

Theoretical and Experimental Noise Control

0pNSa1 Case study evaluation of the Rayleigh integral method, *D. W. Herrin, T. W. Wu, A. F. Seybert*

0pNSa2 Forcing function models for structures excited by low-speed flow, *Y. F. Hwang, S. A. Hambric*

0pNSa3 A computational approach for flow-acoustic coupling in deep cavities, *Paul M. Radavich, Ahmet Selamet, James M. Novak*

0pNSa4 Wall pressure fluctuations due to boundary-layer transition, *Gerald C. Lauchle, Sewon Park*

0pNSa5 Prediction of power injected into and absorbed from a turbulent boundary layer excited flat plate with an attached dashpot, *Michael J. Daley, Stephen A. Hambric*

0pNSa6 Hybrid active/passive control of sound radiation from panels with constrained layer damping and model predictive feedback control, *Randolph Cabell*

0pNSa7 Rigid rotor control via sliding mode: theory and experiments, *Scott Lewis*

0pNSa8 The efficiency of ultrasonic systems in the case of piezoceramic transducers supplied with rectangular signal, *Odobescu G. Liviu*

Active Control of Noise and Vibration

0pNSb1 Active increase of sound transmission loss of partitions based on utilizing EMFi panel actuators, *Hannu Nykanen, Marko Antila, Seppo Uosukainen, Jukka Lekkala*

0pNSb2 Robust active control of a vibrating plate, *Stephen Prajna, Oliver Kaiser, Stanislaw Pietrzko, Manfred Morari*

0pNSb3 Active control of rotating shafts using modal separation, *D. C. Swanson, B. Kim*

0pNSb4 Robust control of sound in an active acoustic grillage, *Kalev Sepp, Juris Vagners*

Aircraft Noise

0pNSc1 Modeling the normal modes and acoustics of a jet engine, *Laralee G. Ireland, Scott D. Sommerfeldt*

0pNSc2 Survey of human response to control of low-frequency tiltrotor interior noise, *Scott M. Hirsch*

0pNSc3 Correlations in fuselage response and sound field in aircraft cabin during flight, *Gopal P. Mathur, Boi N. Tran, Myles A. Simpson*

0pNSc4 Evaluation of efficient passive damping treatments for aircraft cabin noise control, *Gopal P. Mathur, Joshua T. Lee, Myles A. Simpson*

Community Noise

0pNSd1 The community impact of rogue transportation sources, *Ithan Zimmer, Charles Wilson, Robert Dresnack*

0pNSd2 Pump station noise and vibration in a residential development, *David A. Towers*

0pNSd3 Mitigation of structureborne noise nuisance, *Wing P. Ko, P.E.*

0pNSd4 Strategies to evaluate aircraft routing plans at Newark International Airport, *Robert Dresnack, Ithan Zimmer, Charles Wilson*

0pNSd5 Assessing the community impact of aircraft noise, *Charles E. Wilson, Robert Dresnack, Ithan Zimmer*

0pNSd6 Low-frequency aircraft noise and its effects on residential land use, *Andrew Harris*

0pNSd7 The noise produced by harbour infrastructures, *Salvatore Curcuruto, Alberto de Leo, Concetta Fabozzi*

0pNSd8 30 years of traffic noise problems and countermeasures taken in greater Cairo, Egypt, *S. A. Ali, A. Tamura*

HVAC Noise

1aNSb1 Air handler sound power prediction method based on ARI Standard 260, *Stephen J. Lind*

1aNSb2 Condenser fan noise reduction solutions, *Michael Bobeczko*

1aNSb3 Sound attenuation of dual-wall fiberglass-lined, circular ducts with and without air flow, *Douglas D. Reynolds*

1aNSb4 A procedure for measuring background sound levels in rooms, *Jerry G. Lilly, Mark E. Schaffer*

1aNSb5 On HVAC duct acoustical end reflection, *Emanuel Mouratidis, Richard J. Peppin*

1aNSb6 Estimating community noise levels from outdoor condensing units, *Gary W. Siebein, Hyeong-seok Kim*

1aNSb7 Tips for specifying active duct silencers, *Steve Wise, Christian Carme, Dwight Shackleford*

Classroom Acoustics

1aNSc1 Progress report on I-INCE technical initiative for schoolroom acoustics, *David Lubman, Louis C. Sutherland, Zerhan Karibiber*

1aNSc2 Determination of insertion loss for classrooms at a high school, *Michael Greene*

1aNSc3 Rating and ranking university classrooms by acoustical quality, *Murray Hodgson*

1aNSc4 A resource for creating learning environments with desirable listening conditions, *Robin Glosemeyer, Benjamin Seep, Robert C. Coffeen*

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1aNSd1 **A finite element analysis of a smart foam system for passive/active noise control,** *Cliff L. Chin, Joshua T. Lee, Gopal P. Mathur*

1aNSd2 **Properties and applications of novel acoustical foams,** *Suresh Subramonian, Mae Drzyzga, Sandrine Gilg, Laurent Remy, Chung Park*

1aNSd3 **Elimination of structure-borne noise using an insulating material made from recycled rubber,** *Paul Downey*

1aNSd4 **Geometric sound absorbers,** *Glenn E. Warnaka*

1aNSd5 **Broad-band structural acoustic silencers,** *Sripriya Ramamoorthy, Karl Grosh*

1aNSd6 **Wide-band transmission noise reduction of smart panels featuring piezoelectric shunt circuits and sound absorbing material,** *Jaehwan Kim, Joong-Kuen Lee, Jin-Young Choi*

1aNSd7 **Active control of sounds with large dynamic range,** *Anthony J. Brammer, George J. Pan*

Performance Assessment of Acoustical Test Rooms

1pNSb1 **Qualifying a reverberation room for sound absorption measurements,** *Alf Warnock*

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1pNSb3 **Anechoic wedge design and development/Anechoic chamber qualification testing,** *Alan Eckel, Istvan Ver*

1pNSb4 **Experiences with anechoic chamber qualification per ISO 3745 and ASA/ANSI S12.35,** *Kenneth A. Cunefare*

1pNSb5 **On sound power determination: The uncertainty in sound power determined in a reverberation room based on a round-robin,** *Richard J. Peppin*

1pNSb6 **Research into quality assessment methods for anechoic chambers,** *Francis Babineau, Jr., Brandon Tinianow*

1pNSb7 **Design and construction of a convertible hemi/anechoic acoustical laboratory for testing space flight hardware at the NASA Glenn Research Center,** *Beth A. Cooper*

1pNSb8 **Noise and vibration isolation design for a vibration testing laboratory,** *David A. Nelson, Thomas Stewart*

Noise Standards - Challenges to Quieter Products

1pNSc1 **Noise labeling for consumer products,** *Paul Schomer*

1pNSc2 **The cylindrical microphone array: a proposal for use in international standards on sound power level measurement,** *Matthew A. Nobile, Jennifer A. Shaw, Brian Donald*

1pNSc3 **Method for evaluating the attenuation of acoustical covers used in high-end computer systems,** *Jennifer A. Shaw, Matthew A. Nobile, Brian Donald*

1pNSc4 **A comparison of two methods for the evaluation of prominent discrete tones Phase 3,** *Anne C. Balant, Robert D. Hellweg, Jr., Matthew Nobile*

1pNSc5 **Computer sound quality: Masking, loudness and prominence,** *David A. Nelson*

1pNSc6 **Sound quality of contemporary personal-computers,** *Ya-Wen Chou, Ming-San Cheng*

1pNSc7 **Noise radiation from a riding mower,** *Christian M. Skinner, Courtney B. Burroughs*

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Community Noise and Community Noise Barriers

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1pNSd2 **Analysis of the performance of a weapons noise monitoring system located along the shores of a bay,** *George Luz*

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1pNSd4 **Noise produced by religious pilgrimages in Monterrey, Mexico,** *Fernando J. Elizondo-Garza, Jose de J. Villalobos-Luna*

1pNSd5 **Regulation of amplified sound sources,** *Eric M. Zwerling*

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1pNSd7 **Creating noise sources for rotorcraft and aircraft noise simulation models,** *Kenneth J. Plotkin*

1pNSd8 **Rotorcraft Noise Model (RNM) and Acoustic Repropagation Technique (ART2) validation and application using CH-146 (Bell 412) measurement data,** *Juliet A. Page, J. Micah Downing*

1pNSd9 **Investigation of noise reflections using test signals,** *Lloyd Herman, Jeff Giesey, Jeremy Ghent*

1pNSd10 **Field measurements of a reduced-scale noise barrier's insertion loss and absorption coefficients,** *Todd A. Busch, Ramon E. Nugent*

1pNSd11 **A correction to Maekawa's curve for the insertion loss behind noise barriers,** *Penelope Menounou*

1pNSd12 **Random and periodic square wave barriers in noise control,** *Nesrin Sarigul-Klijn, Dean Karnopp*

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2aNSa2 **Soundscapes in American mainstream films,** *Barbara Flueckiger*

2aNSa3 **Sound quality of exterior vehicle noise,** *Klaus Genuit*

2aNSa4 **Soundscapegraphy of old town of Kyoto with Gion festival,** *Kozo Hiramatsu*

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2aNSa6 **Quiet areas and quiet facades important elements in the EU Noise policy,** *Tor Kihlman*

2aNSa7 **Measurement of the natural soundscape in national parks,** *J. Micah Downing, Eric Stusnick*

2aNSa8 **Measurement and modeling of snowmobile noise and audibility at Yellowstone and Grand Teton National Parks,** *Christopher Menge, Jason Ross*

2aNSa9 **The application of a noise-rating scale composed of hue-scale and L_{Aeq} on various kinds of noise sources for noise map,** *Kenji Furihata, Takesaburo Yanagisawa*

2aNSa10 **Methodology for analysing perceptual criteria of urban soundscape,** *Raimbault Manon*

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2aNSb2 **Using a prediction model to allocate allowable noise between sources and establish equipment noise limits,** *David J. Parzych*

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2aNSb4 **Noise control engineering interacting with the design process of a power plant,** *Marlund E. Hale*
2aNSb5 **Risks in designing power plants to meet noise limits and how to manage them,** *Frank Brittain*

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2aNSb8 **Active control of low frequency turbine exhaust noise,** *Bruce Walker, Alan Hersh, Joseph Celano, Eldon Ray*
2aNSb9 **Certifying noise emissions from heat recovery steam generators (HRSG) in complex power plant environments,** *George F. Hessler Jr.*
2aNSb10 **Determination of sound pressure levels *in situ* using sound intensity measurements,** *Stephen E. Keith, G. Krishnappa, Vincent Chiu*
2aNSb11 **Diagnostics of vibration excitation mechanisms for complex hydro-mechanical systems,** *Andrei B. Prokofiev, Valeri V. Lenchine, Evgeniy V. Shakhmatov*
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International Noise Standards

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2aNSc2 **Work programmes and interrelations of IEC/TC29, ISO/TC43, and ISO/TC43/SC1,** *Klaus Brinkmann*
2aNSc3 **Current trends in the international standardization of mechanical vibration and shock,** *Bruce E. Douglas*
2aNSc4 **Noise control and the machinery safety standardization programme of CEN (European Standardization Committee),** *Jean R. Jacques, Roger P. Higginson, Patrick Kurtz*
2aNSc5 **Building acoustic ISO standards and European legal metrology,** *Hans Goydke*
2aNSc6 **ASTM Committee E-33 and its role in acoustical and noise standardization,** *Steven M. Brown*
2aNSc7 **SAE transportation noise activities,** *Richard F. Schumacher, Paul R. Donavan*
2aNSc8 **Standards in Acoustics of the American Society of Heating Ventilating and Air-conditioning Engineers (ASHRAE),** *Richard J. Peppin*
2aNSc9 **Environmental noise: From guidelines to standards,** *Dietrich Schwela*
2aNSc10 **Noise impact from motor racing events,** *Alberto de Leo, Franco Giuliani, Concetta Fabozzi*
2aNSc11 **Problems of evaluation of long-term levels for corona noise**
Tadeusz Wszolek

Environmental Noise Focused on Combined Noise Sources

2pNSa1 **How many meta-analyses fit on the head of a pin?,** *Sanford Fidell*
2pNSa2 **The acceptor principle in German regulations for environmental noise,** *Dieter Gottlob, Jens Ortscheid*
2pNSa3 **Assessment of annoyance in a multi-source environment,** *Truls Gjestland, H. M. E. Miedema*
2pNSa4 **The importance of loudness functions in assessing noise annoyance,** *Paul Schomer*
2pNSa5 **How to define synergetic effects of combined noises,** *Brigitte Schulte-Fortkamp*
2pNSa6 **What can classical and fuzzy concepts contribute to the analysis of masking effects in environmental noise surveys?,** *Dick Botteldooren, Andy Verkeyn, Peter Lercher*
2pNSa7 **Development of line-based noise pollution reduction programs,** *Andrew Wearne, Richard Heggie, Suzanne Stuart, Donald MacLeod*
2pNSa8 **A statistical method for the evaluation of discrete noise sources submerged in background,** *Alois Heiss, Robin T. Harrison*

Construction Machinery Noise Limits and Means of Compliance

2pNSb1 **Recent developments in European legislation concerning construction equipment,** *Volker K.P. Irmer*
2pNSb2 **Railway construction in Hong Kong: How to make it work,** *Glenn H. Frommer*
2pNSb3 **Noise control for a vacuum excavator - a mutually beneficial solution,** *Erich Thalheimer*
2pNSb4 **Noise monitoring, control and compliance practices at several construction sites in Southern California,** *Douglas K. Eilar*
2pNSb5 **Survey of worldwide legislation on the control of construction noise,** *Kai Ming Li*
2pNSb6 **Legislation concerning construction noise in Germany,** *Eberhard Fischer-Sheik Ali, Volker K.P. Irmer*
2pNSb7 **Noise and vibration control for the Los Angeles Metro Rail construction project,** *Thanh T. Luc*
2pNSb8 **Demonstration hearing conservation program for construction workers in Washington State,** *Alice H. Suter*

Vehicle Noise and Vehicle Noise Tests

2pNSc1 **Rolling noise ANC system: an experimental facility test,** *Federico Rossi*
2pNSc2 **Indoor moving passby test - a feasibility study,** *Paul N. Liang*
2pNSc3 **High temperature quiet-flow test facility,** *Jim R. Cummins, Jr., Jim B. Causey, David Kapsos*
2pNSc4 **Sound transmission characteristics of bulb seals,** *Junhong Park, Luc G. Mongeau, Thomas Siegmund*
2pNSc5 **Vehicle door seal modeller for wind noise,** *Yuksel Gur*
2pNSc6 **Maglev - a super fast train,** *Areg Gharabegian*
2pNSc7 **Relation between noise emission, friction and rolling resistance of car tires - Summary of final results,** *Ulf S. I. Sandberg, Jerzy A. Ejsmont*
2pNSc8 **The effect of damping of the disc brake squeal noise,** *Kihong Shin, Jae-Eung Oh, Wootaek Kim, Mike Brennan*

Power Plant Acoustics Roundtable

A panel made up of invited speakers from Session 2aNSb: Power Plant Noise Control and Prediction will discuss issues confronting the accurate determination of emissions and immissions from power plants. Panelists will introduce issues including prediction, noise control techniques, and measurements and encourage questions and comments from the audience.

NOISE-CON 2000/ASA Advance Registration Form

NEWPORT BEACH, CALIFORNIA - 3–8 DECEMBER 2000

NOISE-CON 2000 Attendees Note: Registration for the meeting of the Acoustical Society of America includes admission to all ASA/NOISE-CON sessions at the joint meeting. There is no separate NOISE-CON 2000 registration fee.

However, at the bottom of the form, you will see a $60 line item for the **NOISE-CON supplement**. This optional charge includes a drink ticket at the exposition reception AND a CD-ROM which will contain the Proceedings of NOISE-CON 96, NOISE-CON 97, NOISE-CON 98, the 1998 Sound Quality Symposium, and the NOISE-CON 2000 Proceedings. It is expected that there will be approximately 600 technical papers related to noise control engineering on the CD-ROM.

Please type or print clearly: ASA/INCE member: ☐ Yes ☐ No

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If your registration is not received at the ASA headquarters by 24 November you must register on-site.

REGISTRATION

	BEFORE 6 NOV.	AFTER 6 NOV.	
ASA/INCE Members	$200	$275	$_____
ASA/INCE Member One-Day Circle Day of Attendance: M T W T F	$100	$140	$_____
Nonmembers	$245	$320	$_____
Nonmembers One-Day Circle Day of Attendance: M T W T F	$125	$160	$_____
Nonmember Invited Speakers	$200	$275	$_____
Nonmember Invited Speakers (one day registration) Circle Day of Attendance: M T W T F	$0	$0	$_____
Students (attach student ID)	$0	$0	$_____
ASA Emeritus Members (pre-approved by ASA)	$35	$45	$_____
Accompanying Persons (For registrants who will not participate in technical sessions)	$35	$45	$_____

OPTIONS

A/V Computer Projection: # papers _____ @$50 ea. $_____

Fellows' Luncheon: # tickets_____ @$25 ea. $_____
(For ASA Fellows Only)

NOISE-CON Supplement (includes CD-ROM)	$60	$60	$_____
ASA Short Course	$200	$250	$_____
Tutorial Lecture:			
Students	$7	$12	
Non-Students	$15	$25	$_____

TOTAL REMITTANCE (U.S. Dollars) $_____

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Card Number_____ Expiration Date (MM/YY)_____

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To help us in planning for the meeting please let us know which of the following events you plan to attend:

☐ **Sun, 3 Dec., Exhibit Reception** ☐ **Tues., 5 Dec., Social Hour** ☐ **Thurs., 7 Dec., Social Hour**

Asia-Pacific News

Anita Lawrence, *Asia-Pacific Editor*

AUSTRALIA

Aircraft Noise Continues to be a Problem in Australia. Aircraft noise is still making the front-page headlines in the Sydney broadsheet newspaper. In order to increase aircraft movements at Sydney Airport in conditions of poor visibility (using parallel runways), a new radar system is being installed. This causes increased movements over the affluent northern suburbs. It also means that the number of dwellings eligible for improved aircraft noise insulation has increased. The Federal Government is still deliberating about when and where the second Sydney Airport will be built!

The inadequacies of internal noise insulation (although built in compliance with the building construction regulations) have also been highlighted. The minimum requirement between two occupancies can be satisfied by a single brick wall (STC 45), which is certainly insufficient. This has been highlighted recently, as there has been a boom in the construction of very expensive, high-rise, CBD apartments, and the new owners are complaining vigorously.

Managing editor's note: There is also a great deal of activity on aircraft noise in Europe—as evidenced by the information in the "Editor's View" and "European News" departments in this issue. Readers interested in this subject may also be interested in an article that appeared in the 2000 April issue of *Acoustics Australia* (Vol. 28, pages 11-14). The article concerns the Australian Noise Exposure Forecast (ANEF) system, and is titled "Rethinking Our Approach to Aircraft Noise Information—Going beyond the ANEF," by D. Southgate, Airport Operations, Commonwealth Department of Transport and Regional Services, Canberra, Australia.

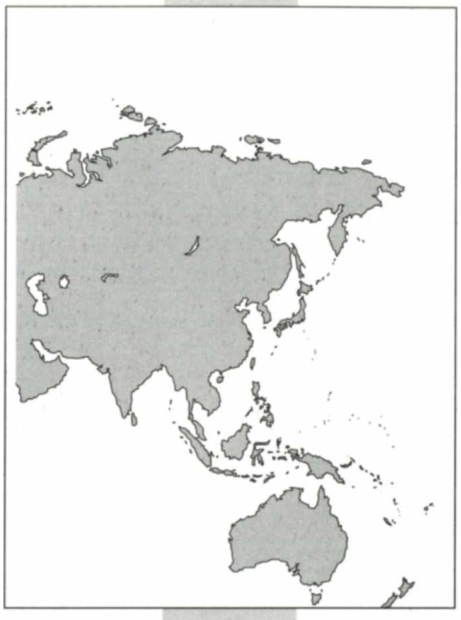
JAPAN

New Officers of INCE/JAPAN. New officers and directors of INCE/JAPAN have been installed with terms beginning in 2000. The president is Dr. Koichi Takagi, the honorary professor of Kyoto University. Vice presidents are Dr. Masazumi Shiota of the Research Institute of Technology, Tobishima Corporation and Prof. Kyoji Fujiwara of Kyushu Institute of Design.

New Address of the Acoustical Society of Japan. In 2000 June, the Office of the Secretariat of the Acoustical Society of Japan moved to the following address:

The Acoustical Society of Japan
Nakaura 5th-Bldg., 2-18-20 Sotokanda
Chiyoda-ku, Tokyo 101-0021, Japan
Telephone: +81 3 5256 1020
FAX: +81 3 5256 1022
URL http://wwwsoc.nacsis.ac.jp/asj/
e-mail: KYM05145@nifty.ne.jp

This information from Japan was contributed by Kohei Yamamoto.—Ed.



Recreational Noise Symposium Proceedings

In November, 1998 a Recreational Noise Symposium was held in Queenstown, New Zealand in conjunction with NOISE-CON 98. Twenty three papers from the symposium were published in Noise Control Engineering Journal in 1999 and then published as hard cover book for distribution to Symposium attendees.

A limited number of copies of this book are still available for 135 New Zealand dollars. For more details contact Philip Dickinson, INCE New Zealand, P.O. Box 57032, Mana 6230, Wellington, New Zealand. E-mail: philip_d@iconz.co.nz

Pan-American News

George Maling, *Pan-American Editor*

Concerns on the Current Draft IEC Sound Level Meter Standard That Changes the A-weighting Tolerances. (*Reprinted by permission from the Standards News Department of the* Journal of the Acoustical Society of America, ***107****(5), 2319, 2000.—Ed.*) During the meeting of Accredited Standards Committee S1: Acoustics, in Columbus, Ohio, in 1999 November Dr. G. Wong, Chair of S1, expressed the concern that in the draft document, IEC/CD 61672-1 Electroacoustics—Sound level meters—Part 1: Specifications, there are proposed changes to the tolerances of the A-weighting for acoustical measurements. To clarify the above changes, the table below on the A-weighting tolerances is included for comparison:

From the above table, by comparing the ANSI S1.4 Type 1 with the proposed IEC Class 1 in the boldfaced tolerances, one can see that in the above IEC proposal, because of the negative infinity tolerances at 12.5 Hz and 20 kHz, an IEC Class 1 sound level meter will have *a limited operating range from 16 Hz to approximately 16 kHz.* In the ANSI S1.4 Type 2 and the proposed IEC Class 2 comparison, there is a general of widening of A-weighting tolerances for the IEC instrument.

With the new IEC proposal, even with a Class 1 instrument, it may not be possible to ensure meaningful measurement to frequencies higher than 16 kHz, and yet currently, there are scientists working on high frequency audiometry to assess human hearing beyond 16 kHz. The widening of the IEC Class 2 A-weighting tolerances will not help the hearing conservation effort by the acoustics community. The existing ANSI S1.4-1983 (R1997) tolerances have been used in North America for many years, by changing the tolerances one may not be able to compare future measurements with previous databases that are based on the existing ANSI S1.4 A-weighting tolerances. If anyone has concern on the pending changes, you may send your comment to George Wong, Tel.: (613) 993-6159; Fax: (613) 990-8765; email: george.wongnrc.ca.

Participation Wanted to Measure Sound Impact of Floors. A task group of the American Society for Testing and Materials (ASTM) Subcommittee E33.03 on Sound Transmission within Committee E33 on Environmental Acoustics is at work on test methods that measure the effectiveness of floor coverings such as carpet, vinyl and composite toppings to reduce impact noise. Currently, a new test method is close to completion that is based on an ISO (International Organization for Standardization) standard.

Participation is sought to develop an extension of this test method that will measure sound impact of joist floors with wood subfloors, instead of concrete. Toppings are not as effective on such floors as they are on concrete. A reference floor has to be defined and modifications to the test procedures may need to be developed. These new test procedures will allow designers to select among floor coverings and toppings free of any contribution from the supporting floor or influences of the laboratory design.

Persons willing to participate should contact the task group chairman, Alf Warnock, NRC Canada, M59 Montreal Road, Ottawa, Ontario1 KIA ORL, Canada. Telephone: +1 613 993 9370; FAX:

(continued on page 131)

ANSI S1.4-1983 (R1997) with Amendment ANSI S1.4A (A-weighting tolerances (dB)			Proposed IEC 61672-1 (A-weighting tolerances, dB)	
FrequencyHz	**Type 1**	**Type 2**	**Class 1**	**Class 2**
10	**±4**	**+5, -∞**	**+3.4, -∞**	**+5.4, -∞**
12.5	**±3.5**	**+5, -∞**	**+2.9, -∞**	**+5.4, -∞**
16	±3	**+5, -∞**	+2.4, -4.4	**+5.4, -∞**
20	±2.5	±3	±2.4	±3.4
25	±2	±3	+2.4, -1.9	±3.4
6.3k	+1.5, -2	±4.5	+2.1, -2.6	±5.1
8.0k	+1.5, -3	±5	+2.1, -3.1	±5.6
10k	+2, -4	**+5, -∞**	+2.6, -3.6	**+5.6, -∞**
12.5k	+3, -6	**+5, -∞**	+3, -6	**+6, -∞**
16k	+3, -7.4	**+5, -∞**	**+3.5**, -17.0	**+6, -∞**
20k	+3, -8.7	**+5, -∞**	**+4, -∞**	**+6, -∞**

European News

A. Cops, *European Editor*

BELGIUM

There is a great deal of activity on aircraft noise in Belgium. (*See the Editor's View in this issue.—Ed.*) This is true not only for the Brussels National Airport Zaventem but also for the regional airports Antwerp, Ostend, Liège and Charleroi. Since 1999, a new government has been established, and one of the six parties in the government is the Green Party. Of course, one of the items of great importance for this party is the improvement of the acoustical environment near airports. During the past several months, the media have been filled with articles related to the measures which have been taken by the government.

This has resulted in three meetings on airplane noise and regulation, held recently in the country. The first meeting was organized by the Belgian Acoustical Society, ABAV, on 2000 April 06 in Brussels. (*See NNI, 2000 June, page 83.—Ed.*)

A second meeting was organized by the Brussels Environmental Institute on 2000 May 15. The theme of the meeting was *Local authorities faced with aircraft noise.* The objective of this meeting was to review the methods that can be used to control noise around airports and to compare experiments organized all over Europe.

The morning session was chaired by J. Nemerlin, President of the Belgian Acoustical Society. The conference was opened by D. Gosuin, Minister of the Environment of the Brussels Capital Region. Then followed a speech by I. Durant, Federal Minister of Transport, on measures taken by the Government related to Zaventem Airport.

The following papers were presented in the morning:

- Environmental questions associated with the problem of aircraft noise
- Impact on health and the living environment of noise pollution generated by aircraft, M. Vallet
- Instruments for controlling noise nuisance around airports, V. Trefois
- European policies in the fight against noise, T. Ten Wolde
- European experiments in sustainable management of airports
  - Heathrow (London), R. Norman
  - Orly (Paris) , G. Paque
  - Schiphol (Amsterdam), R. Wever

The afternoon session was chaired by F. Roelants du Vivier, Chairman of the Environmental Committee of the Brussels Parliament.

The following papers were presented in the afternoon:

- What strategies, what type of noise management and monitoring around Brussels-National airport?
- The standards and the aircraft monitoring system set up in the Brussels-Capital Region, G. Clerfayt
- Presentation of the noise management and monitoring system proposed by federal government for Brussels-National Airports, E. Monami
- What local policies can be envisaged to reconcile interests and environmental constraints?

Then followed a Round Table discussion. Participants were:

J.P. Blazy, President du Conseil National du Bruit, France; M. Henry, Maire de Ville-le-Roi, Paris, France; - K. Koehler, Flügläermschutschbeauftrage des Senats der Freien und Hansastadt, Hamburg, Germany; J. Montfort, Alcalde de Viladecans, Barcelona, Spain; A. Wildekamp, Chair of the Commission Geluidhinder, Netherlands.

The discussion leader was J. Cech, chief editor of Eco-Manager. The final conclusions of the meeting were presented by J.-P. Hannequart, General Director of the Brussels Environmental Institute. The day closed with a call for creation of a European network of cities as a platform for exchanges on managing urban noise.

On 2000 June 14, a third meeting on aircraft noise was organized in Antwerp. This meeting was set-up by the Association for Acoustics and Vibration together with the Association for Building Physics of the Royal Flemish Society of Engineers. The theme was: *Aircraft noise in the vicinity of Brussels-National Airport Zaventem—A general and building technical approach.*

On 2000 February 11, decisions were made by the Belgian Government in order to achieve a durable development at Brussels-National Airport Zaventem. This agreement results in further economic development of the airport but from the other side, measures have been taken to reduce the noise pollution near the airport. Measures have been taken, e.g. to decrease aircraft noise at night and include for example a policy of subsidizing for the renovation of houses. During this meeting, attention was focussed from the acoustical viewpoint. The emphasis was on what the building sector can do in order to realize the necessary acoustical comfort at least inside homes. The morning session was chaired by B. Ingelaere, Belgian Building Research Institute. The following papers were presented:

- Principles and indicators related to the perception of aircraft noise, G. Vermeir
- Aircraft noise: Impact in the vicinity of Zaventem airport, noise-effect calculations and measures, J. Caerels, W. Lauriks, J. Thoen
- Measures at Brussels-National Airport Zaventem (1): Decisions taken by the Federal Government, G. Pauwels
- Measures at Brussels-National Airport Zaventem (2): Initiatives from the Belgian International Aircraft Corporation BIAC and Regional Authorities, E. Peeters
- Building physical comfort, minimal requirements (1): edge conditions, P. Wouters

The afternoon session was chaired by G. Vermeir, Laboratory for Building Physics and Laboratory for Acoustics and Thermal Physics, K.U.Leuven. This session proceeded as follows:

- Building physical comfort, minimal requirements (2): annoyance and medical aspects, L. Neyt
- Building acoustical measures (1): introduction, M. Blasco

- Building acoustical measures (2): solutions: insulation of windows, J. Lecompte
- Building acoustical measures (3): solutions: other building elements, B. Irgelaere
- Building acoustical experiments at Bierset-Liège Airport, V. Trefois.

After a question and discussion period, the chairman G. Vermeir presented final conclusions on the papers presented.

RUSSIA

The fifth International Symposium on Transport Noise and Vibration. The 5th International Symposium Transport Noise and Vibration was held by the East-European Acoustical Association (EEAA) in Saint-Petersburg (Russia) on 2000 June 6-8.

The Symposium was dedicated to the 300th Anniversary of St. Petersburg and the 10th Anniversary of the EEAA. The Symposium was held in the Mansion of Duke Kochubey that is one of the oldest sights of Pushkin City located in a beautiful suburb of St. Petersburg.

Professor Alexei Nikiforov (Russia), the President of the EEAA was the Chairman of the Symposium. Professor Nikolay Ivanov (Russia), the First Vice-President of the EEAA was the Chairman of the Symposium Organizing Committee. Professor Zbigniew Engel (Poland) was the Chairman of the Symposium Scientific Advisory Committee.

One hundred and thirty specialists from 22 countries were participants of the Symposium. More than 100 papers were presented. Prof. Engel (Poland), Prof. Myshinsky (Russia), Prof. Nilsson (Sweden), Prof. Munin (Russia), Prof. Crocker (USA), Prof. Osipov (Russia), Dr. Ryu (Denmark) and Prof. Ivanov (Russia) presented plenary and invited lectures.

The Proceedings of the Symposium in CD-ROM format were given to the participants.

The 6th International Symposium Transport Noise and Vibration will be held in St. Petersburg on 2001 June 4-6.

European Directive on Equipment Used Outdoors

A new directive relating to the noise emissions of equipment used outdoors was published in the Official Journal of the European Union on 2000 July 03. The directive is part of a new approach to reduce noise and to protect the health and well being of citizens by reducing overall noise exposure and noise nuisance. This approach was announced in the European Commission's Green Paper "Future Noise Policy" published in 1996, and reported in NNI (1997 June, pp. 74-94).

To provide information to consumers and public authorities who are the major users, all such equipment is to be marked with the guaranteed maximum level of the noise it emits. The directive covers 55 different types of equipment which are normally used in open air. These include construction machines (compressors, hammers, tower cranes, mobile cranes, excavators, and loaders), garden equipment (all kinds of lawnmowers, chain saws, leaf blowers, and shredder/chippers), and equipment mounted on municipal vehicles (for example, domestic refuse collection vehicles).

Limits on the noise emissions are prescribed for an additional nineteen (19) different types of equipment that are either extremely noisy or annoying. In setting the noise limits, account has been taken of the technical possibilities for reducing the noise emissions, as well as the influence of the noise limits on the industry concerned. The noise limits are to be implemented in two steps. The first step involves the elimination of the noisiest equipment and the second step takes into account the advances in technology.

The second step, to be introduced in four years' time, will coincide with the entry in force of the proposed directive on gaseous and particulate pollutants from the engines identified as "non-road mobile machinery." Manufacturers are expected to take both tighter air pollution and noise emission requirements into account during the design phase of a product. The setting of limits is a process that will continue in the future based on the experience gained from the planned collection of noise emission data.

The directive also defines noise test codes as the values of the noise limits are dependent on the way the noise emission is measured. Different conformity assessment procedures are to be applied to:

- equipment subject to specific noise limits, manufacturers accredited by a quality assurance procedure may use equivalent assessment procedures,
- equipment not subject to specific noise limits, self-certification with monitoring by the EU Member States is permitted.

In line with the general requirement of the EU to simplify procedures, the new directive replaces nine (9) current directives covering separate machines.

Pan-American News

(continued from page 129)

+1 613 954 0483. Committee E33 meets Dec. 12-15 in Newport Beach, Calif.

New American National Standard is Published. American National Standard Microphone Windscreens—Part 1: Measurements and Specifications of Insertion Loss in Still or Slightly Moving Air, a new American National Standard, developed by Accredited Standards Committee S1, Acoustics, has just been published.

This Standard specifies a test to use to determine the insertion loss of windscreens for measuring microphones over a defined frequency range. The insertion loss is determined in conditions that reflect performance in still or slightly moving air.

ANSI S1.17-2000/Part 1 can be purchased for 90 USD per copy. Contact the ASA Standards Secretariat, 120 Wall Street, 32nd Floor, New York, NY 10005-3993, USA for more details. E-mail:asastds@aip.org.

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Product News

For more information about the products in this department, go to

http://noisenewsinternational.net

and take the link to IEEE DirectAccess. Additional links to these manufacturers' web sites are also available at the above URL.

Larson Davis Unveils a New Sound & Vibration Analysis Platform. Emerging from the fusion of the successful Model 2900B real time analyzer (RTA) and DNA™software, the ViRTé™ 3000 is said to be the superlative solution for a host of sound and vibration applications. It offers a wholly visual real time environment, with DNA™ software controlling a powerful, expandable analysis pod.

This new LD analyzer family is said to be ideal for rapid, PC controlled acoustic and vibration data acquisition and transfer. It is said to benefit from an existing, powerful application base developed along with DNA™: sound power, acoustic intensity and mapping, materials testing, transient analysis, building acoustics, environmental noise measurement, etc. ViRTé™ 3000 platforms include the low-cost 3000 remote pod, and the 3000+ RTA, which features a proven user interface for autonomous measurements. Both versions offer rapid parallel communication (RS232 also available) with DNA™ PC software.

Further information can be obtained from Larson Davis Inc., 1681 West 820 North, Provo, Utah 84601 Telephone: +1 801 375 0177; FAX: +1 801 375 0182. E-mail: mktg@larsondavis.com; Web site: http://www.larsondavis.com.

High Performance Sound-Absorbing Panel Systems from Eckel Industries. Installation of the Eckoustic® Functional Panels (EFPs) on walls and/or ceilings is said to offer an effective, economic method for reducing background noise and reverberation in recreational and sports facilities such as gyms, indoor swimming pool areas, weight/exercise rooms, aerobic studios, health clubs, and spas. The applications, design, and sound control features of these acoustical panels are discussed in a bulletin (#200042) issued by Eckel Industries, Inc., Acoustic Division, Cambridge, Massachusetts. In addition, model architects' specifications are provided.

A case history is detailed which illustrates how EFPs were utilized to correct the acoustic environment of a school/community athletic facility, changing it from a facility with excessive reverberation and high background sound levels to one with a comfortable environment. Reverberation time and sound level measurements made before and after the acoustic upgrading with EFPs show the effectiveness of the treatment. Prior to the installation of the EFPs, reverberation time was from 9.6 to 9.98 seconds; after treatment the measured reverberation time was under 2 seconds at 500 Hz.

In addition to the improvement in acoustic environment obtained by using EFPs, the data sheet describes other advantages of the panels. For instance, since the EFP sound-absorbing unit panel system does not require full wall or ceiling coverage to achieve the desired noise control, existing lighting, ventilation, and similar systems can remain as is when panels are put in place. Installation of EFPs does not require relocation of existing utilities or any structural alterations, and, therefore, acoustic treatment can be carried out with little disruption in the normal operations of a facility. Another advantage of the EFPs, particularly important for swimming pool facilities, is in the construction - the panels' alloy aluminum facings and sealed acoustic insulation prevent corrosion-induced deterioration, thereby helping to ensure reliable, long-term acoustic performance. And, EFPs are available not only in the standard white polyurethane enamel finish, but also in a wide selection of optional colors, allowing EFPs to

blend in with a room's decor or to be used as a design statement.

The sound-absorbing Eckoustic® Functional Panels (EFPs) system also offers a convenient, cost-effective method for correcting noise problems in industrial facilities. The use of these EFPs in wastewater and water treatment plants to reduce background noise in these operations and provide a quieter workplace environment is detailed in an illustrated bulletin. Also contained in this data sheet (#200043) are condensed specifications for EFPs.

A detailed case history is presented which illustrates how the EFP unit panel system can be installed in engine generator, gas mixing, blower, and pump rooms to bring noise levels down to OSHA requirements. Installation was a simple procedure. And since the EFPs could achieve the desired noise reduction in an area with only 40-50% coverage of wall and/or ceiling surfaces, existing utilities were not disturbed or relocated, and plant operations continued uninterrupted while the panels were put in place.

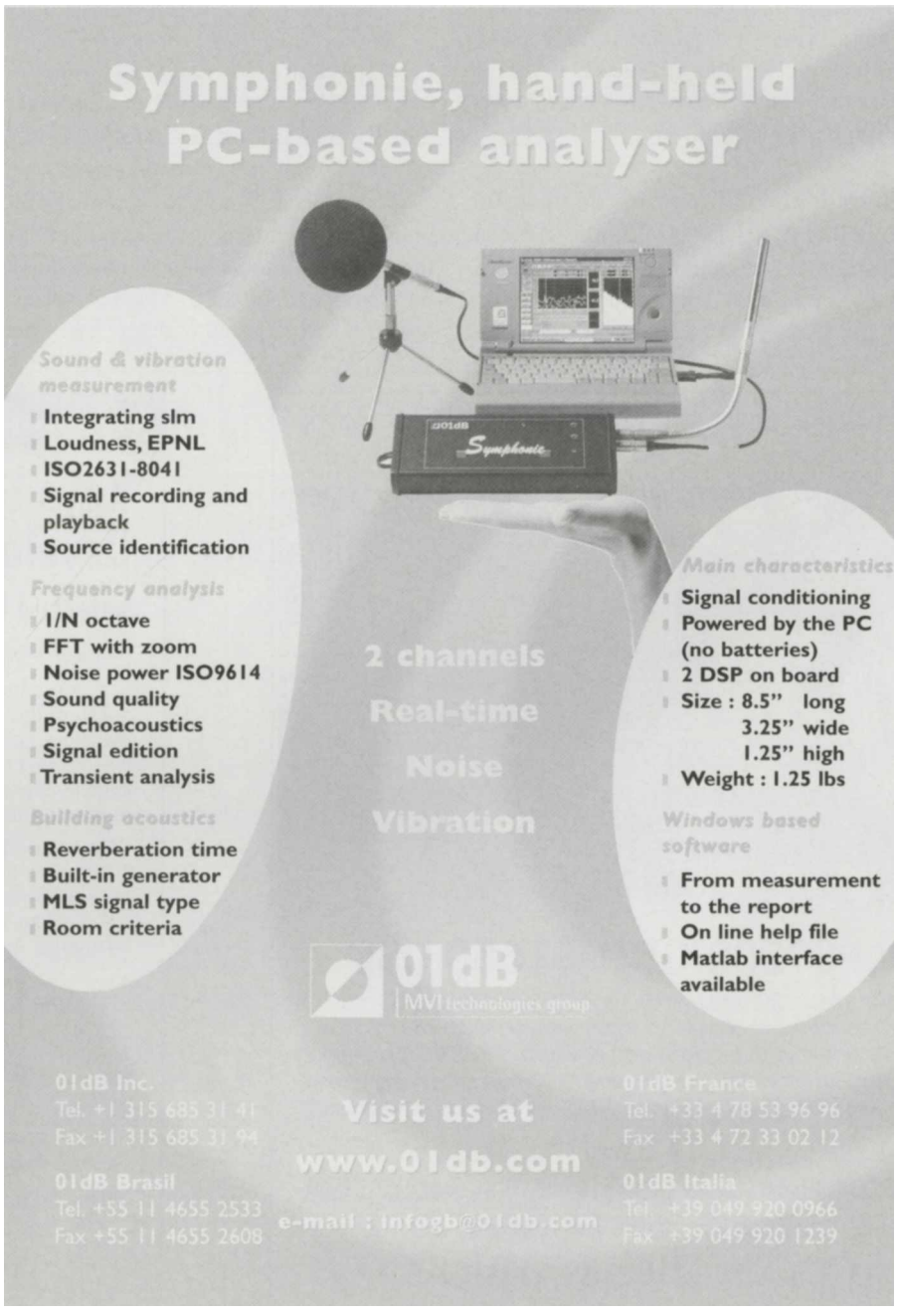
For the wastewater/sludge treatment facility discussed, sound level measurements, before and after EFP treatment, are given for several of the rooms that were acoustically upgraded. For example, for one of the gas generator rooms, with one engine set and three pumps running, the background noise level was reduced to 82.7 dBA, a reduction of almost 10 dBA. With two sets of engine generators and four pumps running, the overall noise level was brought down to below 85 dBA. Similar results were obtained for the blower rooms. Here too, noise levels are said to have been brought down to OSHA-acceptable levels for areas where people are working.

In addition to their efficiency in improving the acoustic environment, other advantages of EFPs are mentioned.

For a free copy of "Noise Control Systems for Recreational Facilities," or "Noise Control Systems for Wastewater and Water Treatment Plants" contact Eckel Industries, Inc., Acoustic Division, 155 Fawcett Street, Cambridge, MA 02138. Telephone: +1 617 491 3221. e-mail: eckel@eckelacoustic.com.

SONEXcurtain Enclosure System Absorbs and Contains Noise from Machinery. The SONEXcurtain Enclosure System™ from illbruck, inc. is said to help to absorb and contain noise produced by loud machinery such as routers and dust collectors. Depending on the application, SONEX® Curtains can reduce hazardous noise to OSHA-specified levels and help provide a safe and comfortable work environment. The system can be configured to create barriers, independent walls and partitions, and portable acoustical screens in manufacturing facilities or high-traffic areas.

The SONEXcurtain Enclosure System is made from any combination of SONEX curtain products, including SONEXcurtain Barrier Backed™, SONEXcurtain Barrier Septum™, and SONEXcurtain Quilted Absorber™. The curtains are designed to absorb machinery noise and contain sound waves within an enclosure. They feature FIBER-FREE willtec® acoustical foam, which is said to be Class-I fire-rated for low flammability. A washable vinyl facing, available in gray, white, tan or black, withstands dirt, dust, oil, welding spatter and general industrial abuse.



The system is available with a number of options, including roof-top panels, valances, corner treatments, view windows, ventilation baffles, exhaust fans and various curtain support frames. The curtain track and hardware systems are manufactured from heavy gauge galvanized steel that provide sturdy and economical support. The curtain track can be mounted to ceilings, walls, beams or floors in a wide array of configurations to suit the application.

illbruck, inc. makes noise control products for a wide variety of industrial applications. For more information on SONEXcurtain Enclosures and materials, contact: illbruck, inc., 3800 Washington Ave. N., Minneapolis, MN 55412. Telephone +1 800 662 0032; FAX: +1 612 521 5639. Web site: http://www.illbruck-sonex.com.

Sound and Vibration Toolset for LabVIEW™ Now Available. National Instruments has announced the release of the Sound and Vibration Toolset for LabVIEW™. With this software and other tools from National Instruments, a user can build and distribute custom sound and vibration test systems for Windows NT/9x PCs or Macintosh platforms. By leveraging the personal computer, it is said that the user gains greater flexibility and cost savings over traditional sound and vibration setups that employ custom hardware or standalone instruments.

The Sound and Vibration Toolset offers functions and visualization tools for fractional octave analysis, sound level measurements, frequency analysis, transient analysis, handling engineering units, and calibration. The software is an extension to the LabVIEW software for PC-based test and measurement. LabVIEW offers a graphical programming environment in which you can automate the acquisition, analysis, and presentation of your measurements.

To build a test setup for sound and vibration applications, you can combine these software tools with signal acquisition hardware and a PC. The Toolset can analyze data acquired with any hardware supported by LabVIEW. Examples include a GPIB-bus connected external instrument, National Instruments' E-series line of plug-in data acquisition boards or our PCI-445x series of PCI-bus plug-in dynamic signal analyzer instruments. When used with the PCI-445x series, the software offers ANSI and IEC standards compliant measurements. The Toolset can also perform post-acquisition analysis; you can load and analyze data from a wave (.wav) or a text file.

For further information, contact Sam Shearman, Signal Processing and Analysis Software, National Instruments Corporation, 11500 N. Mopac Expwy., Austin, TX 78759-3504, USA. Telephone: +1 512 794 0100; Fax: +1 512 683 8411; e-mail: info@natinst.com; Internet: www.natinst.com.

Low-Profile ICP® Ring Accelerometer. Model 355B02 from SVS, the Shock and Vibration Sensors Division of PCB Piezotronics, Inc., features a low-profile ring configuration with through-bolt mounting. This permits installation into

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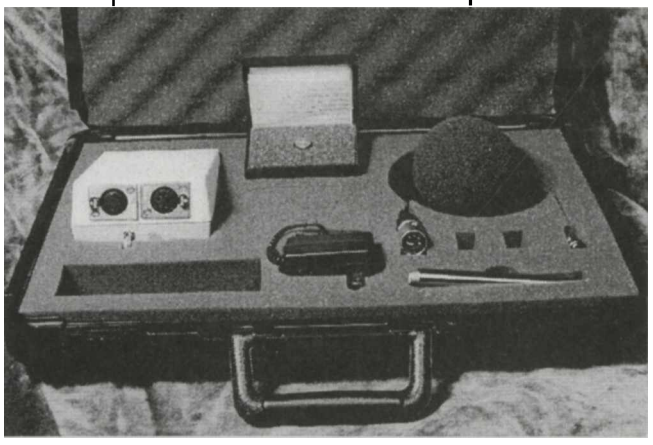

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The high output, shear mode, piezo-ceramic sensing element generates 10 mV/g through a wide frequency range of 0.6 to 12,000 Hz. Built-in, low noise electronics allow use of ordinary cables and operation from low-cost, constant current, ICP® sensor signal conditioners. The unit possesses a measurement resolution of 0.0005 g rms and is an excellent choice for general-purpose shock and vibration testing requirements to ±500 g pk.

For additional information on this accelerometer, contact the Shock and Vibration Sensors (SVS) Division of PCB Piezotronics, Inc., (toll-free in the USA) at 888 684 0013; e-mail: svs@pcb.com; or Fax at +1 716 685 3886. For other PCB products, contact PCB directly at +1 716 684 0001 or visit our website at www.pcb.com.

Triaxial Capacitive Accelerometers Provide DC Frequency Response. Satisfy low frequency, low level, triaxial acceleration measurements with the Series 3703 capacitive accelerometers from DCS, the DC Sensors Division of PCB Piezotronics, Inc. These rugged units combine three orthogonal capacitive sensing elements into a lightweight, hermetically sealed, 1-inch titanium cube. Applications include vehicular ride quality studies and structural testing applications of buildings, civil structures, and space objects. In addition, they are capable of providing tilt and orientation data of structural members and platforms.

The Series 3703 is available in a variety of sensitivities and full-scale ranges to accommodate specific measurement requirements. Measurements from 20 micro-g to 200 g and frequency ranges from 0 to 1000 Hz are accommodated. In addition, units are available for portable operation from low voltage power sources such as automotive batteries and laptop data acquisition power sources. The designs utilize on-board voltage regulators to insure constant sensitivity values, regardless of supply voltage, and are protected against accidental shock overloads of up to 3000 g.

For additional information, contact the DC Sensors (DCS) Division of PCB Piezotronics, Inc., (toll-free in the USA) at 888 684 0014; e-mail: dcs@pcb.com; or Fax at +1 716 685 3886. For other PCB products, contact PCB directly at +1 716 684 0001 or visit our website at www.pcb.com.

Miniature, Lightweight, High Sensitivity, Triaxial ICP® Accelerometer. The triaxial ICP® accelerometer, Model 356A17 from the Shock and Vibration Sensors (SVS) Division of PCB Piezotronics, features a strong, 500 mV/g output signal and a small lightweight aluminum housing. In addition, a 4-pin, electrical connector, with positive key-way, achieves the convenience of a removable cable without risk of bent pins. The unit is ideally suited for modal and structural vibration analysis as well as multi-point modal measurements on automotive and aerospace structures.

The unit's miniature size occupies only a 14-mm cubic envelope and weighs just 9.3 grams. Shear mode, piezo-ceramic sensing elements account for the high sensitivity and accuracy through a frequency range of 0.3 to 4000 Hz (+/- 10%). Built-in microelectronic signal conditioning circuitry offers a low-noise, low impedance output signal while permitting long distance signal transmission and simplicity of operation. The durable design can be stud or adhesive mounted and survives accidental shock inputs to 5000 g.

For additional information on this accelerometer, contact the Shock and Vibration Sensors (SVS) Division of PCB Piezotronics, Inc. Telephone: +1 888 684 0013; Fax: +1 716 685 3886; E-mail: svs@pcb.com. For other PCB products, contact PCB by telephone at+1 716 684 0001. Internet: http://www.pcb.com.

New Brochure Focuses on E-A-R's VersaDamp™ Molding Materials Line. A new free booklet has been published especially for design engineers grappling with complex vibration and

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shock problems in electronics devices. Upon request, E-A-R Specialty Composites will send a copy of the brochure, Introducing VersaDamp™ 2000 TPE System, which focuses on E-A-R's newest family of moldable elastomers.

The booklet outlines the features and benefits of the VersaDamp product line, which includes 10 standard formulations and a range of durometers and damping capabilities. It explains how the materials can address both vibration and unpredictable shock, and thereby provide better reliability and equipment life. It also contains a chart comparing a standard VersaDamp formulation with other E-A-R damped materials and competitive alternatives, and a complete grommet and mount design spec guide as well.

A VersaDamp 2000 brochure can be obtained by contacting E-A-R Specialty Composites at 7911 Zionsville Road, Indianapolis, IN 44626, or by phoning toll-free +1 877 327 4332 or by faxing +1 317 692 3111. The company's Website address is www.earsc.com and the e-mail address is solutions@earsc.com.

VersaDamp™ 2000 Molding Materials Perform in Broad Temperature Range. VersaDamp 2000 thermoplastic elastomers from E-A-R Specialty Composites are ideal as anti-shock and anti-vibration mounts for compactly designed devices with limited isolator sway space, such as pagers, cellular phones, laptop and hand-held computers, and other miniaturized mechanical and electronic components. VersaDamp formulations can be adjusted to optimize damping performance or durometer or both.

VersaDamp materials are olefinic dynamic vulcanizates with a patent pending. They feature durometers ranging from 35 Shore A to 75 Shore A and have broad energy-absorption capabilities (peak loss factors ranging from 0.75 to 0.15) as well. They are easily and economically injection-molded into vibration, noise and shock isolators, gaskets, and other equipment components. The materials contain no free sulfur, carbon, or plasticizer.

E-A-R Specialty Composites manufactures what is said to be the most complete line of noise, vibration, shock, and motion control products available from one source. The company's proprietary urethane and vinyl materials are used to control unwanted mechanical energy in OEM product designs, including aircraft, vehicles of all types, electronic and electromechanical equipment, appliances, precision equipment, and industrial machinery.

More information about the VersaDamp 2000 family of materials is available by contacting E-A-R Specialty Composites, 7911 Zionsville Road, Indianapolis, IN 46268, USA. Telephone: +1 877 327 4332; FAX: +1 317 692 3111. E-mail: solutions@earsc.com. Web site: http://www.earsc.com.

Dalloz Safety Introduces Bilsom® 777 Transceiver and 799 Electo FM Stereo Radio Earmuffs. Dalloz Safety, formerly Willson Safety, has introduced two new communication earmuffs.

Dalloz Safety offers the Bilsom 777 muff with a detachable cord and also offers users the opportunity to purchase specific adapters to match their two-way radio brand. It has also introduced a 799 Com model that combines the Bilsom 799 Electo FM stereo radio benefit with adaptability to two-way communications.

Both muffs are part of the lightweight Bilsom 700 Series that includes over-the-head, cap-mounted and electronic models engineered with broad ear cushions and large, asymmetrical ear cups. The "Quick Click" adjustment ensures a snug fit and secure seal for any head size.

The Bilsom 777 muff is designed for environments where two-way communication is not possible without reducing or attenuating the noise. It replaces the microphone and speaker in a portable radio and has a built-in dynamic receiver and a goose neck noise canceling boom microphone that permits clear communication even in high-noise situations.

The Bilsom 799 Electo muff, rated at NRR 23, is said to be the only muff available that combines quality FM stereo reception with electronic impact and voice amplification. The new 799 Com model offers that in addition to the two-way communication option.

Dalloz Safety offers a complete line of Bilsom hearing protection equipment from disposable earplugs to reusables to all-purpose, specialty and electronic earmuffs. The line includes another innovation—the recently introduced unique, versatile and multi-position reusable Bilsom PerCap™ hearing protector that can cut hearing protection costs by as much as 60 percent.

For more information on the enhanced Bilsom 777 Transceiver and 799 Electo FM stereo radio earmuffs, or information on other Dalloz Safety products and services, contact Elizabeth A. Antry, Director of Marketing Communications. Telephone: +1 800 345 4112; Fax: +1 610 371 7874. Internet: http://www.cdalloz.com.

Acquisition Positions Aearo Company for European Growth. Aearo Company has announced that it has acquired Norway based Livax A/S. The acquisition will enable Aearo to increase its share in the rapidly growing European market for products that allow for communication in noisy environments.

Livax A/S, based in Norway, had 1999 sales of approximately $1.2 million. Livax A/S services the offshore industry with communication headsets, and to a lesser extent services the motorsport and general industrial marketplace. Livax A/S has been a distributor of Aearo's Peltor® brand name products for over 20 years and also provides after-sales service and support.

For more information on products, go to
http://noisenewsinternational.net
and take the link to IEEE Direct Access.

NOISE-CON 2000 Exhibitors

As of 2000 August, the following exhibitors planned to participate in the joint NOISE-CON 2000/ASA 140th Meeting Exposition on 2000 December 3-5 in Newport Beach, California. The list of papers to be presented at the meeting begins on page 124, and a registration form appears on page 127.

- Dura Undercushions
- Scantek, Inc.
- Casella CEL
- Müller-BBM Vibroakustik Systeme, Inc.
- 01dB Inc.
- ACO Pacific, Inc,
- Eckel Industries Acoustic Division
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- Kinetics Noise Control
- Naval Undersea Warfare Center-Underwater Sound Reference Division

INCE/USA Membership Information

Individuals having professional responsibilities or an interest in noise control engineering at any level may participate in the activities of the Institute of Noise Control Engineering of the USA. One of th goals of the Institute is to include within the organization a broad representation of individuals in the United States of America who have a professional interest in research, in teaching, and in engineering applications involving all aspects of noise control. The roster of the Institute includes INCE Members, INCE Distinguished International Members and INCE Associates. An individual interested in full INCE membership first enrolls as an INCE Associate, and then makes applicatio to become an INCE Member. An INCE Member may also be Board Certified in Noise Control Engineering by the Board of Directors of the Institute. INCE Distinguished International Members are elected from among distinguished noise control engineers who reside outside the U.S.A. INCE Associates may remain in that status if they do not choose to apply for full INCE membership. The three basic requirements for an individual to advance from INCE Associate status to full membership in INCE/USA are that the applicant: (1) have earned a baccalaureate (or equivalent four-year academic degree), or higher degree, from a qualified program in engineering, physics, or architecture offered by an accredited university or college, (2) have instructed, or have enrolled in and successfully passed as part of a degree program, at least one full-semester course of instruction at the undergraduate or graduate level covering the physical principles and fundamentals of acoustics and (3) have demonstrated academic or professional experience in acoustics and noise control. Al three requirements must be satisfied.

A membership application appears on pages 140-141 of this issue.

International Advertising Contacts

Below is a list of international contacts for the advertisers in this issue. The telephone number is given first, and is followed by the FAX number where available. In cases where there are several telephone numbers per location, or several locations within a country, a colon (:) separates the telephone number(s) from its respective FAX number. Advertisers, please e-mail updates to Lynn Guarente at lguarente@ieee.org.

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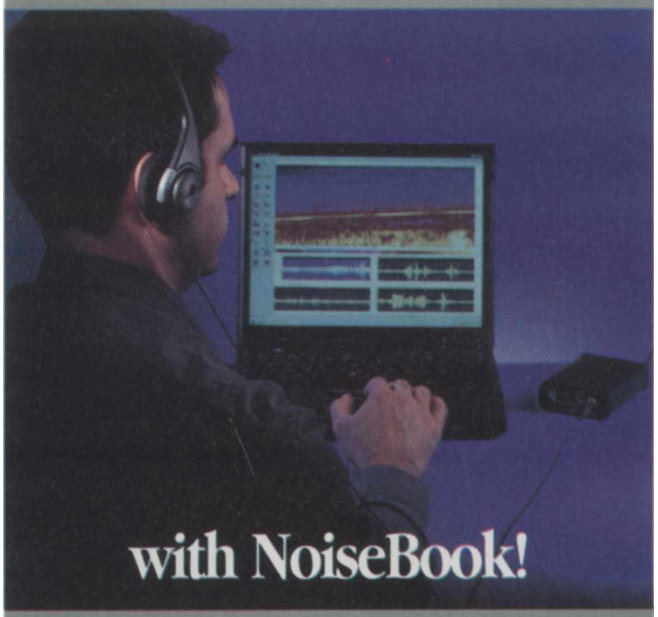

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2000 December 3-5
NOISE-CON 2000, the 2000 National Conference on Noise Control Engineering, Newport Beach, California, USA. Held as a joint meeting with the 140th meeting of the Acoustical Society of America. Contact: Institute of Noise Control Engineering, P.O. Box 3206 Arlington Branch, Poughkeepsie, NY 12603, USA. Telephone: +1 914 462 4006: FAX: +1 914 463 0201. *e-mail: hq@ince.org.*

2001 August 28-30
INTER-NOISE 2001, the 2001 International Congress on Noise Control Engineering, The Hague, The Netherlands. Contact: W.F. Druyvesteyn. *e-mail: secretary@internoise2001.tudelft.nl.* Home page: http://internoise 2001.tudelft.nl.

2001 October 29-31
NOISE-CON 01, The 2001 National Conference and Exposition on Noise Control Engineering, Portland, Maine, USA. Contact: Institute of Noise Control Engineering, P.O. Box 3206 Arlington Branch, Poughkeepsie, NY 12603, USA. Telephone: +1 914 462 4006: FAX: +1 914 463 0201. *e-mail: hq@ince.org.*

2002 August 19-21
INTER-NOISE 02, The 2002 International Congress and Exposition on Noise Control Engineering, Dearborn, Michigan, USA. Contact: Institute of Noise Control Engineering, P.O. Box 3206 Arlington Branch, Poughkeepsie, NY 12603, USA. Telephone: +1 914 462 4006: FAX: +1 914 463 0201. *e-mail: hq@ince.org.*

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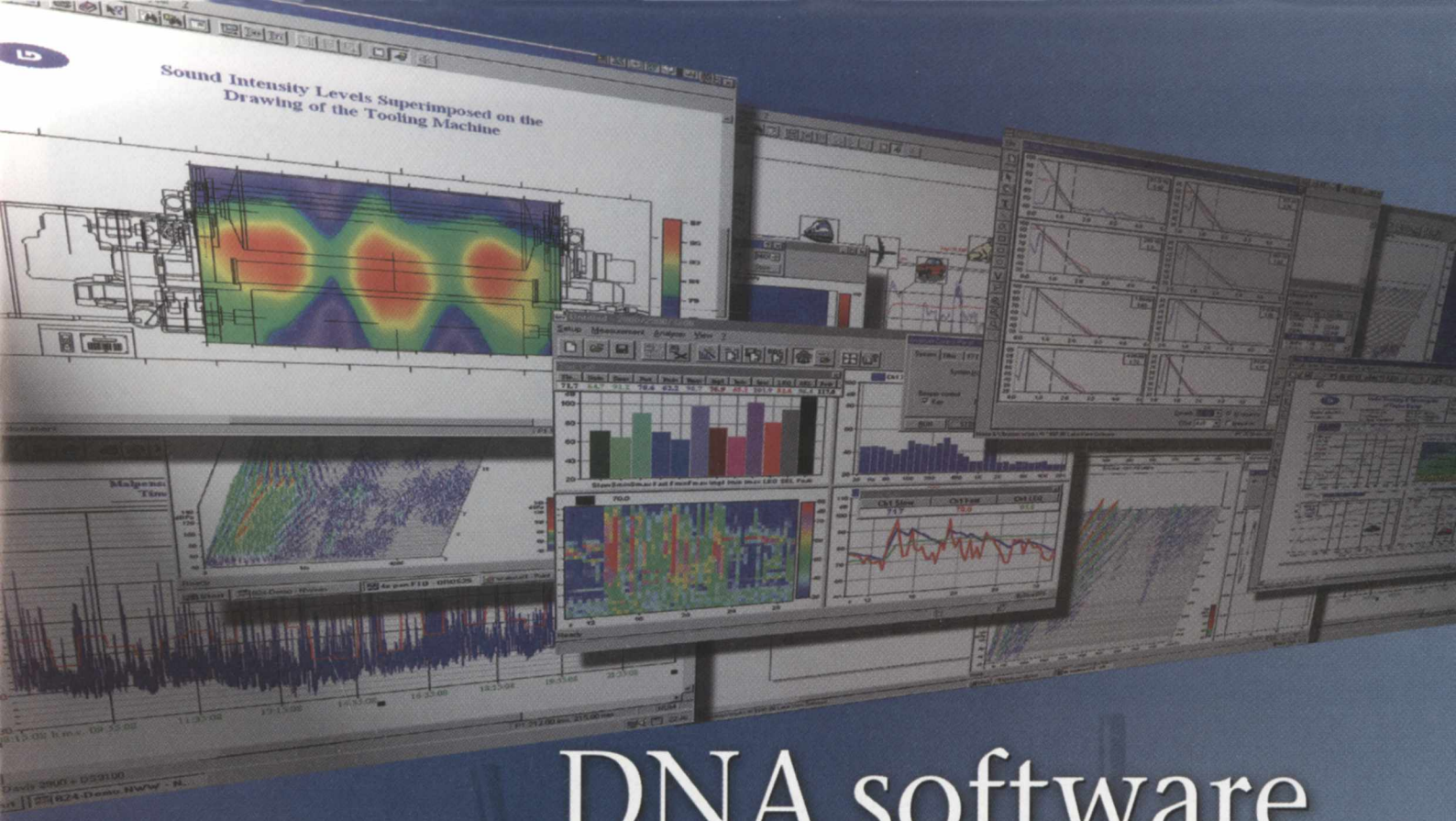

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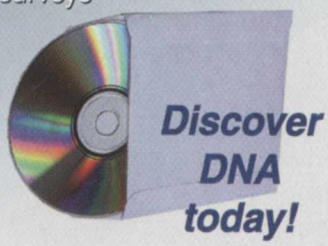

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