inter•noise 96
25th Anniversary Congress - Liverpool

INCE: 07

# IN RESIDENCE AND DISTANCE EDUCATION IN NOISE CONTROL

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## 1. INTRODUCTION

Today's rapidly developing technology requires engineers and scientists to extend their knowledge beyond fundamental areas of education into new subfields. A common feature of these subfields is their interdisciplinary scope and, therefore, adequate mastering of the material may require professionals to seek extensive education in several disciplines. Education in industrial acoustics and noise control is not an exception to this common feature. Due to an abstract nature of sound, engineers who possess a good background in field physics usually adopt more rapidly the basic concepts of sound generation, radiation, and methods of sound reduction than those who have a fundamental education based on mechanical disciplines only.

In the past, industries solved their need to address noise control issues by simply assigning, often arbitrarily, an engineer to be in charge of a particular project. Due to the restructuring which occurred in many industries and the redistribution of basic (mostly mechanical) design, the opportunities for engineers with specialized education have increased and noise control engineers are now in demand, particularly by large companies. Therefore, a dialogue concerning the breadth and depth of noise control education is of ultimate importance in order to proceed most effectively in establishing or modifying specialized education in noise control and other industrial applications of acoustics and vibration.

## 2. DEVELOPMENT OF NOISE CONTROL EDUCATION

An important session devoted to many aspects of general education in acoustics and specialization in noise control was held at Inter-Noise 87 [1-5]. In the United States the coordinated efforts to offer general as well as specialized education in acoustics goes back to the 1960s. The teaching of

noise control was boosted by the upsurge of interest in environmental control and environmental protection, and particularly hearing protection. At least ten major universities have developed programs to offer sizable education in acoustics and noise control at the undergraduate level [2]. A total of 86 universities have been involved in teaching acoustics. Table 1 provides information on the number of universities involved in fourteen different subject areas of acoustics.

| Subject Area | Number of Universities Involved |
|---|---|
| Noise Control | 54 |
| Vibration and Shock | 47 |
| Psychological Acoustics | 47 |
| Acoustical Instrumentation | 43 |
| Physiological Acoustics | 40 |
| Speech Communication | 37 |
| Acoustical Signal Processing | 34 |
| Bioacoustics | 34 |
| Underwater Acoustics | 33 |
| Ultrasonics | 30 |
| Architectural Acoustics | 30 |
| Radiation and Scattering | 29 |
| Aeroacoustics | 26 |
| Musical Acoustics | 17 |

**Table 1**

Table 1 shows that the peak course offering in engineering areas is in noise control, and vibration and shock. Available data reveals that such courses are offered by the Departments of Mechanical Engineering, Engineering Mechanics, Aerospace Engineering, and Civil Engineering, as well as Physics.

Other statistical data shows how many universities are involved in a given number of the fourteen listed subject areas found in Table 1 [2]. The peak of this reference distribution lies at three subject areas (14 universities) and as the number of total subject areas increases there is a gradual decrease in the number of universities involved.

The inclusion of three or four courses into an undergraduate curriculum can provide an introduction into the solutions of noise control problems on a simplified platform, but it cannot educate students in the substantive areas of acoustics such as the physics of sound generation, radiation, and propagation, which are needed to address complicated practical problems of noise control.

Practicing noise control engineering obviously requires a complete education in an engineering area linked to design of products or systems. Therefore, it is generally accepted that acoustics and noise control should

be taught as a graduate level specialization, providing the student intensive interaction with an advisor and sufficient time for thesis research. In the United States there are several universities which offer acoustics and noise control as a graduate specialization within a traditional department, usually mechanical engineering. However, this organizational structure may not permit the establishment of a truly interdisciplinary program. The student is required to take courses and pass large examinations specific to the department. These requirements may contribute very little to the overall education in acoustics and may be of a very little interest to the student. The government institutions, which often define national priorities and set research trends, consistently emphasize the need for interdisciplinary education. However, the response of academic institutions is very slow and few academic institutions have the wisdom or the courage to adopt structural changes that would better serve the needs of interdisciplinary education.

Currently there is only one graduate department in the United States, at The Pennsylvania State University that offers a graduate degree in acoustics. Since its inception in 1965 the Acoustics Department has produced 149 M.S. and 100 Ph.D. graduates in acoustics. Current enrollment is over one-hundred students. The department offers twenty-seven graduate courses in acoustics and vibration. The students may also take courses in mathematics, physics and other engineering fields which are relevant to the completion of their thesis research.

The principle advantage of specialized education at the graduate level consists of its capability to be systematic, cover completely fundamentals, provide a good overview of subfields, and permit in depth specialization. Graduates from this type of program are usually immediately productive, an experience confirmed by the feedback from industry.

As indicated earlier, the United States job market for engineering graduates with specialized education is excellent and the demand for graduates in acoustics is very strong. Increasing competition and environmental regulations are forcing industry to react quickly to meet this demand. Therefore, there is a growing need to develop continuous professional education for industrial personnel. A variety of short courses offered on a customized or university platform have been developed. This task is generally difficult if the goal is to provide education along with training.

## 3. REQUIREMENTS AND QUALIFICATIONS FOR A NOISE CONTROL ENGINEER

Before the currently available education is analyzed in terms of its adequacy and quality an "ideal" curriculum for education in noise control should be defined. It is often believed that industry should be a principle source to formulate requirements on noise control education. Although industrial input is certainly valuable it usually has a very narrow scope linked to particular

products and services. Most often industry seeks training rather than education, which reflects the quick fix attitude. On the other hand industrial input if correctly interpreted may provide good information on the extent and depth to which specific subjects need to be taught.

Professional associations may also contribute to formulation of educational standards; the membership in INCE USA is based on proof of sufficient knowledge of noise control fields. An INCE certified member must pass both a fundamental and professional examination. These examinations were created by a team of practicing engineers and educators who made a tremendous effort to define the range and extent of knowledge which a noise control engineer should master.

The ultimate educational goal is the ability to master a wide spectrum of applications which range from building acoustics to hearing damage. Although training courses can be designed to cover any narrow application area the goal of education must be to cover the principles common to all application areas first and, depending on the extent of the curriculum, provide in depth education in application areas.

Recently Penn State has analyzed, in the context of developing a series of continuing education courses, the curriculum for noise control engineering and selected the following topics:

1. Noise sources
   - Vibration of systems with lumped parameters
   - Structural waves and modes on strings, membranes, beams, plates and complex structures
   - Radiation from simple and complex vibrating bodies
   - Properties of radiated sound fields. Source coupling
   - Aerodynamic sources
   - Sound generation by impacting bodies
2. Sound propagation
   - Wave propagation in fluids and solids
   - Reflection, absorption , and scattering
   - Propagation in open space and environment with random reflection
   - Diffraction and propagation over barriers
   - Propagation and attenuation in ducts
   - Propagation in rooms and transmission through partitions
3. Sound reception
   - Basic hearing properties, loudness, masking
   - Damage risk criteria, hearing loss
   - Noise exposure criteria
   - Annoyance, speech interference
   - Concepts of sound quality
4. Signal processing
   - Signal representation in time and frequency domain
   - Data analysis: spectra, cross-spectra, coherence, statistical representations

Digital signal processing
Data acquisition and processing
Sound measurement equipment, sound level meters, analyzers

5. Measurement technique
Sound pressure levels, $L_{eq}$
Sound power, intensity
Sound absorption and transmission
Special facilities, anechoic and reverberation rooms
National and international standards
Governmental and local regulations and ordinances

In addition to the listed fundamentals, noise control education should cover several specific application areas such as: noise in buildings, community noise, transportation noise, noise in industry, vibration isolation, consumer noise products and issues linked to sound quality.

## 4. ROLE OF CONTINUING EDUCATION

As discussed earlier the best way of becoming educated in the interdisciplinary noise control field is to attend graduate school or a well structured undergraduate option. The principal reason for this preference is the coverage of fundamental principles which is needed for a creative approach to noise control solution. Because acoustics is, in essence, an abstract discipline the comprehension of the basic principles is time demanding.

Industry and government laboratories have a growing need to educate their employees in acoustics and noise control and it is fortunate that many employees are seeking the completion of a masters degree to advance their job position. Penn State's Acoustics Department responded about ten years ago to this need and developed a continuing education program leading to M.Eng in acoustics. The program consists of the same courses which are taught in-residence students. The courses are taught in a customized studio/classroom and transmitted to the host site classrooms via satellite or telephone lines using picture compressing equipment. Participants receive a complete and well rounded education in acoustics. To establish a direct contact with the students the instructor visits the delivery sites at least twice a semester. The M.Eng. program is structured to allow for completion in two and one half years although students may take longer. The majority of the participants are very enthusiastic about the opportunity to receive a graduate education, whether they seek a graduate degree or merely wish to increase their knowledge by a single course. They also feel that their job performance improves with each course completed; the element of self-satisfaction becomes an important driving force to complete the program.

Another educational program developed by Penn State to provide continuing education is the Summer Program in Acoustics. To accommodate the work schedule of professionals the program is structured into two

sessions each lasting two weeks. Courses, offered for credit or audit, include fundamentals of acoustics, a group of courses in underwater acoustics and signal processing and seven noise control engineering courses including: noise control engineering, active control of sound and vibration, experimental modal analysis, aerodynamic noise, flow-induced noise, architectural acoustics and sound quality. The program is very popular particularly because the credits can be used for the completion of a graduate degree at Penn State or another university.

The arrival of new media technologies provides new opportunities and challenges to continuing education. Interactive programs recorded either on computer hard disk and available via Internet or recorded on CD-ROM and thus available for wide distribution are currently being tested for improved mode of presentation.

At least two CD-ROM projects are currently in progress in the U.S. The American Institute of Physics initiated a collective effort to produce a Handbook of Acoustics. The second project was recently started at Penn State in collaboration with the Sloan Foundation. The plan is to develop a curriculum in noise control engineering consisting of five courses. Four courses will be recorded on CD-ROM and will cover fundamentals as well as application areas. The fifth course will be developed to teach material linked to specific needs of a particular industry. The program participants will pass examinations and upon successful completion of the program will receive a certificate.

The Penn State program participants are expected to work together in small teams and an instructor will be available to provide necessary guidance and answer questions. It is important to note that a participant take the courses in sequence so that mastery of the fundamentals of sound physics will be secured.

## 5. CONCLUSION

Noise control is a well defined subfield of acoustics. The best way to educate noise control engineers is to create a graduate program or to establish an extended option of a suitable undergraduate major. Continuing education programs may also be suitable if they are not limited to short narrow oriented training sessions.

## 6. REFERENCES

[1] E. L. Hixson, Inter-Noise 77, p. B 1.
[2] J. C. Johnson, J. Tichy, Inter-Noise77, p. B 6.
[3] E. J. Richards, M. J. Shelton, Inter-Noise77, p. B 15.
[4] J. Biederbick, Inter-Noise77, p. B 20.
[5] M. Oldman, Inter-Noise77, p. B 26.