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ACOUSTIC TESTING FACILITIES

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A Review of the Requirements for Sound and Vibration Measurement in Industry

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1. INTRODUCTION

When the acoustic problems of industry in general, and production engineering in particular are assessed, it will be found that they relate to one or more of the following:

1.1. People

1.2. Processes

1.3. Products

Measurements relating to Item 1.1, although of extreme importance, will be omitted from this discussion as the subjective effects of industrial acoustics are more closely aligned with the science of physiological and psychological acoustics.

Industrial measurement requirements in relation to sound and vibration generation by process installations will be directed towards tests of plant noise acceptability, the acquisition of design data for future plant extensions and diagnostic techniques directed towards process monitoring or the 'trouble-shooting' of actual or incipient failures.

Test facilities for sound and vibration measurements on the manufactured product will be required to undertake one or more of the following functions:

1.3.1. Fundamental Research and Product Development

Fundamental research and development will be undertaken where there is a requirement to optimise or improve the acoustic properties of the product. The design targets of such work would normally be set by existing National or International Standards; by direct instruction from the consumer; by national and international legislation against noise and by the company's competitive stance with regard to the products of alternative manufacturers. Such work could infer the provision of a full scale laboratory facility involving fixed and portable instrumentation, full scale on-site testing and the appropriate

calibration and ancilliary technical services.

1.3.2. Quality Checks and Failure Diagnosis

Quality checks and diagnostic analyses in general require a combination of fixed and portable instrumentation services with occasional use of full-scale laboratory installations.

1.3.3. Rating of Product Performance

Product performance ratification will normally be taken in accordance with recommendations laid down by International and National Standards organisations and will infer the provision of either full-scale laboratory installations of semi-reverberant and open-space test areas, or all three, backed by the appropriate instrumentation and technical personnel.

2. ACOUSTICAL PERFORMANCE OF MANUFACTURED PRODUCTS

The quantitative properties and performance parameters of manufactured products which require to be evaluated from an acoustic or vibrational standpoint will depend whether the test object is 'active', i.e., generating noise and vibration, or 'passive', i.e., absorbing or attenuating sound and vibration. Active products sub-divide into those which are emitters or converters of acoustical energy by design and those which are noise generators by default.

2.1. Sound Energy Generators

This category includes loudspeakers, audio apparatus, etc. As such it will be necessary to measure parameters associated with their output such as power handling capacity, percentage efficiency, frequency response, electrical and mechanical resonances, directivity of emitted radiation, etc. Acoustic energy converters such as microphones, vibration pick-ups, etc., will require properties associated with their input to be measured, such as sensitivity, frequency response, percentage energy conversion efficiency, power handling capacity, and resonances (electrical and mechanical), etc.

2.2. Noise Generators

This category embraces an immense field of potential noise sources including all sources of motive power; all mechanical assemblies involving rotating, reciprocating, impacting or translational movements; all assemblies involving non-laminar fluid flow, and innumerable others. Where the emission of acoustic or vibrational energy must be measured so that the unit may be assessed for its suitability in a given application, of where noise control equipment must be provided for it, the properties to be evaluated will include the frequency distribution of sound power output (related to operating conditions) within frequency bands or at given discrete frequencies determined by the operating characteristics;

radiation patterns and spatial distribution of emitted sound; amplitude and frequency response of continuously-generated vibration; characteristics of impulsive noise and vibration emitted by the test object, etc.

2.3. Noise-Controlling Products

The limited range of specialist materials and components for the control of noise and vibration include building materials and fittings which provide airborne sound absorption, impact sound isolation, airborne insulation, and surface noise control. Specialist assemblies will provide vibration isolation, vibration damping, attenuation of pipe-borne and ductborne noise, screening and absorption of free-field radiation, etc. Vibration damping will be obtained from specialist materials applied as continuous coatings, patches, or linear tapes to resonant assemblies and the performance of such treatments will require evaluation in terms of the reduction of the vibration response over a stated frequency range and given thermal and climatic conditions

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3. TEST LABORATORIES

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Any acoustic test laboratory must be designed to expedite measurements and observations on a pre-determined range of test objectives or materials. Since the primary function of most laboratories will be the direct measurement of sound and vibration, it is essential that the best possible signal to residual noise ratio is achieved by minimising external noise and vibration in the test area. This is normally achieved by constructing a test environment designed to exclude outside noise by the acoustic insulation provided by the structure and which is isolated from local and distant sources of vibration by decoupling the structure from its foundation. Since any built enclosure forms an acoustically-resonant system it is essential that the major dimensions of the installation shall be related to the wave-length of the low frequency limits of the desired measurements.

In general, there are four main types of standard purpose-built acoustic test environment:

3.1. Reverberant enclosure.

3.2. Semi-reverberant enclosure.

3.3. Anechoic enclosure.

3.4. Travelling-wave and standing-wave duct.

When the physical size of complexity of a test object precludes the measurement of noise generated by it within a building, or where an inexpensive test facility is required, a quiet open-space should be provided which is free from neighbouring buildings and reflecting surfaces and which has a flat continuous ground reference plane with a constant surface finish.

4. APPLICATIONS OF TEST LABORATORIES

The following break-down of the utilisation of acoustic test laboratories is not intended to be exhaustive but to give an indication of the variety of test work that can be undertaken by a given facility.

4.1. Open Space Environments - Measurements of hemi-spherical and spherical acoustic radiation by test objective. Evaluation of variations in sound pressure level and sound power level with frequency and directivity. (Low to moderate accuracy and repeatability.)

4.2. Semi-Reverberant Enclosure (Large) - Measurements of sound pressure levels in the near and transition fields for hemi-spherical radiation. Evaluation of sound power levels by substitution of standard source. (Moderate accuracy and repeatability.)

4.3. Semi-Reverberant Enclosure (Small) - Measurements of sound pressure level in the near field for hemi-spherical radiation. and sound power level evaluation by substitution with standard source. (Low to moderate accuracy and repeatability.)

4.4. Reverberant Enclosure (Diffuse Field) - Measurement of variation in sound power level radiation with frequency by unit source, either by direct observation or substitution with standard source; measurement of sound absorption coefficients by direct observation of variations in reverberation time. (High accuracy and repeatability.)

4.5. Anechoic Enclosure - Measurement of variation in sound pressure level with frequency and directivity over near and transition fields (far fields for small test objects) for sound sources and energy converters; measurement of sound power output by direct observation. (High repeatability and accuracy.) Physiological, psychological and audiometric testing.

4.6. Duct (Standing Wave) - Measurement of normal incidence sound absorption coefficients. (High repeatability and accuracy.)

4.7. Duct (Progressive Wave) - Measurement of unit attenuator performance (anechoic termination); measurement of aerodynamic regeneration and induct attenuator performance (reverberant/anechoic room termination). (High accuracy and repeatability.) High intensity acoustic fatigue testing.

4.8. Reverberant Enclosure to Reverberant Enclosure - Measurements of airborne sound insulation; airway attenuation. (High accuracy and repeatability.)

4.9. Anechoic Enclosure/Open Space to Reverberation Chamber - Measurement of variation in airborne sound insulation with angle of incidence. (Moderate or high repeatability and accuracy.)