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BUILDING SERVICES - A REVIEW OF DEVELOPMENTS IN NOISE CONTROL TECHNIQUES

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INTRODUCTION

During the past 15 years there have been major developments in Building Services Technology which require a re-appraisal of the traditional approaches to the control of noise and vibration. Recent designs for mechanical services systems tend towards:

- higher operating speeds and higher flow velocities,
- increased power ratings for a specific unit size,
- reduced equipment weight, and
- the use of unitary constructions and all-weather casings.

At the same time, developments in architectural design have also continued to evolve and now make extensive use of:

- lighter and more slender frames, slabs and partitions,
- longer spans for beams and floor slabs,
- increasing use of prefabricated and 'dry' constructions,
- open-plan layouts within buildings.

In other words there is an increasing tendency towards the use of high-speed, high-energy, compact equipment distributed throughout light-weight spacious buildings. As a result we get:

- higher levels of structure-borne noise and vibration,
- increased noise radiation to the building exterior,
- more flow-generated noise throughout the building,
- noise sources in juxtaposition with critical areas, but
- fewer low-frequency noise problems.

As building costs increase, greater pressure is put on the plant designer to use less of the valuable internal space. Plant is now frequently sited on roofs or sub-divided into small fan rooms close to the areas served, and duct space in ceiling voids and services shafts is reduced to the minimum volume possible.

The supply of noise control equipment for building services is now a major industry. The estimated annual value of the U.K. market is put at over £10m and world-wide the figure most likely exceeds £200m. But, of the steady stream of textbooks on noise control which have appeared in the last decade, few have tackled the subject of building services noise in any detail. Most contain out-of-date information and the purpose of this Paper is to review the current state of the art and to introduce some of the newer concepts and products which can be used in controlling noise and vibration from modern building services.

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HIGH-VELOCITY SYSTEMS

Possibly the most important development has been the evolution of high-velocity supply and extract systems. Previously, ventilation systems were based on low-pressure fans coupled to bulky rectangular ducts. High-velocity systems use narrow-bore, cylindrical hot and cold ducts linking a high-pressure fan to a distribution of terminal units which control the air volumes delivered to each zone, and which incorporate secondary silencers to control noise from the automatic dampers.

FANS

No significant changes in the design of ventilating fans have been introduced recently, but higher speeds (up to 3000 rev/min is now commonplace) are encountered in both centrifugal and axial configurations. High-pressure dual duct systems often operate at flow rates up to 20 m^3/s and at pressures in excess of 3 kPa. As a result, the SWL spectra of such fans are very 'flat' with octave band components of the order of 115 dBW. However, the primary attenuators for such systems are often smaller than would have been used for an equivalent low-velocity fan. This is because they can sustain higher pressure losses and therefore use higher airway velocities, with a consequent reduction in cross- sectional area. Furthermore, since such systems must use terminal units at the end of every duct run, the secondary attenuators can be selected to control not only the damper noise, but also any residual duct-borne noise from the fan.

ATTENUATORS

Recent developments in silencer design have been directed towards optimising the acoustic and aerodynamic performance of the units while keeping the bulk (and thereby the cost) to a minimum. Most dissipative silencers give an excess of high-frequency attenuation, with a corresponding short-fall at low frequencies (where the performance is always most needed). A recent new design incorporates membrane elements which give 40% more attenuation at 250 Hz at the expense of an acceptable fall-off at high frequencies. Acoustic louvres are a logical development from standard 'splitter' silencers, and are most useful in controlling noise breakout to the building exterior. Economy of space is achieved by locating the attenuation within the thickness of the plant room wall. They can also be used to form noise-controlling screens or enclosures around roof-mounted plant such as cooling towers and condensers

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AIR-HANDLING UNITS

Only the largest supply fans are now housed in builders-work fan chambers. It is commonplace for the standard sizes of fan to be combined with modular filters, heater and cooler coils, humidifiers, etc., to form a single unitary construction known as an 'air--handling unit'. By combining both inlet and outlet attenuators with the air handler, and by up-grading the sound insulation of the casing, it is possible to achieve good control of sound breakout from the assembly. Such units can be treated as 'wild' plant and located in voids above false ceilings or in lightweight plant rooms close to the zone to be served. In this way considerable economies in ducting and plant-room accomodation are often gained.

DUCTS

As noted above, the older design of rectangular low-velocity duct is giving way to circular or elliptical high-pressure ductwork. Velocities as high as 30 m/s can be used in certain circumstances and 10 m/s is normal. Noise induced by turbulent boundary layer flow must be allowed for in all designs for quiet systems but, because of the inherent rigidity of these sections, noise break--out through the duct walls is not necessarily a serious problem. Flexible ducts are now used extensively, particularly where it is necessary to couple the low-pressure side of a terminal unit to a supply diffuser. Some manufacturers now provide an optional sound-absorbent liner to give supplementary attenuation at this important part of the total system.

BOILERS

Modern boilers are now so light in weight that they can be installed at virtually any level in a building. Because of their increased thermal output (when compared with the same size of earlier designs) they are also liable to create more noise and vibration. Therefore it is most important to provide for adequate noise control if there is any likelihood that they will be sited near critical areas. New burner designs now incorporate noise attenuation and purpose--designed silencers are availble for inclusion in flues. It is also possible to specify vibration-isolating mounts, when needed.

GENERATORS

A development in building design, which was seldom considered ten years ago, is the provision of standby generators to maintain essential services in the event of an interruption of the public electricity supply. Units rated at up to 750 kVA are now being installed on roof-tops or even within office buildings. The prime mover is invariably a diesel or gas turbine, both of which are capable of generating very high levels of environmental noise. However, a range of specialist modular enclosures are now available to limit noise breakout from such installations by 60 dBA, or more.

SOUND CONDITIONING

The acceptance of open-plan accomodation in offices, schools and hospitals has given rise to a significant change in the philosophy of designing for mechanical services noise control. Hitherto, the objective was to ensure that a target criterion (usually expressed as an NC curve) was not exceeded, and invariably the resulting noise spectrum was well below the target over most of the audio-frequency band. The need for a precisely-defined masking spectrum in many buildings (often expressed as a PNC curve) has meant that much more consideration must be given to the noise contributed by grilles, diffusers, induction units, etc. It is now possible, by careful design, to ensure that a target spectrum is accurately achieved throughout a large open-plan area. But if a variable volume supply system is used, it is often necessary to supplement the masking sound with an electronic system.

FLOATING FLOORS

One of the most significant developments in noise control has been the introduction of floating-floor systems which provide guaranteed average sound insulation of the order of 80 dB or more. Before their arrival on the scene, designers were always warned that plant should never be located near noise-critical areas in a building. Now, although there would be a cost penalty, an architect is free to locate plant at any convenient site and, for example, one may now have a diesel generator immediately above guest rooms in a hotel without the occupants being aware of its presence.

THE FUTURE

New developments in building services design are almost certain to be governed by the need for energy conservation and fuel economy. Consequently, one may expect to see higher efficiencies and improved thermal claddings leading to perceptible reductions in plant noise. However, the most promising development in noise control technology has had to await the arrival of the microprocessor. New 'contrasound' systems are currently being evaluated whereby ductborne noise is controlled by the injection of an anti-phase component, and a bright future is seen for such systems in the control of noise from fans, turbines and reciprocating engines.