THE NATIONAL LIBRARY OF SCOTLAND BUILDING - SERVICES DESIGN

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INTRODUCTION

During November 1987, the first phase of the new National Library of Scotland was formally opened at Causewayside in Edinburgh. The new building represents a £16m extension to the existing, overcrowded and much less functional library located in the city centre. As one of the two national archives, the other being the British Library, with a statutory requirement to hold all documents published in the United Kingdom, the building was heavily serviced in order to provide a controlled environment for the long term storage of books.

A common feature throughout the seven storey building was the use of hexagonal air conditioning ductwork, chosen partly for aesthetic and partly for functional reasons by the design team. The investigation described here involved a study of the possible reduction in the sound insulation of division walls at the point where the duct passed through the wall.

DUCT IN WALL

The basis of any study involving the sound insulation of a duct-in-wall situation is essentially that of correctly estimating the break-in and break-out from the duct itself. Once the duct calculations have been carried out the remainder is a fairly straightforward exercise in resolving the sound transmission through composite panels. The system has been modelled (Refs. 1,2) using statistical energy analysis (S.E.A.) and a design guide based on a mathematical model has been produced (Ref. 3).

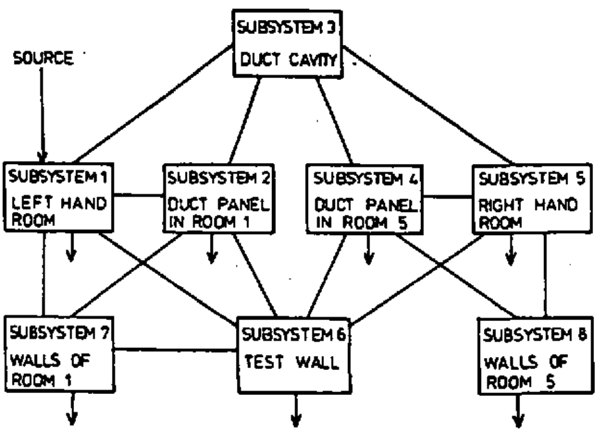

Fig. 1 - S.E.A. model of duct-in-wall (Ref. 2)

The unknown factor was whether or not a hexagonal duct behaved acoustically similar to a rectangular duct or to a circular duct.

ACOUSTIC BEHAVIOUR OF A HEXAGONAL DUCT

A. 4.0 m long hexagonal duct, with dimensions as shown in Figure 2 was suspended by wires in the Reverberation Chamber of the Heriot-Watt University. The side and end panels were constructed using 22 g galvanised steel.

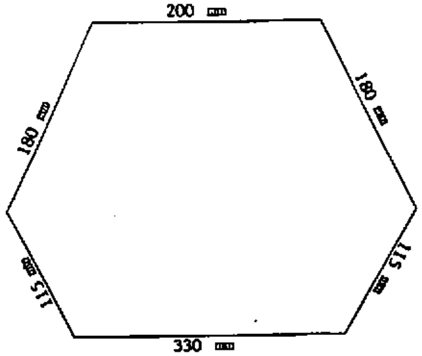

FIG. 2 - HEXAGONAL DUCT

RESULTS

The sound reduction index was measured in both directions and the arithmetic average calculated as shown below in Figure 3. The results indicate that below the fundamental resonance of the largest panel, the hexagonal duct behaves more like a circular duct than a rectangular one. Above the $f_{1,1}$ region the hexagonal duct gives a result similar to the rectangular duct. At higher frequencies, the strong resonance which occurs on the circular duct at the 'ring' frequency, does not occur in the hexagonal duct.

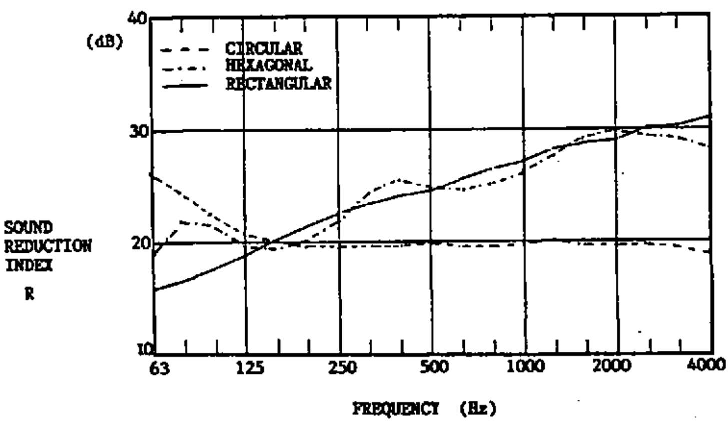

FIG. 3 - SOUND REDUCTION INDEX OF DUCTS

References:

1. MACKENZIE, R.K. "The Transmission of Sound via Ventilation Ducts", Ph.D. Thesis 1974 (Heriot-Watt Univ.)

2. CRAIK, R.J.M. "Noise Reduction of the Acoustic Paths between Two Rooms" - Appl. Acoust. (12) 1979, 161-179.

3. CRAIK, R.J.M. & MACKENZIE, R.K. "The Transmission of Sound by Ventilation Ducts" - Applied Acoustics (14) 1981, 1-5.

THE ANALYSIS OF AIR HANDLING UNIT CASEWORK INSERTION LOSS AND SITE MEASUREMENT TECHNIQUES.

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Noise in the building enviroment can be suppressed by enclosing noise sources with densely clad enclosures. Air handling units are a major contributor to the noise level in the building enviroment and utilisation of their surrounding casework for acoustic purposes is the obvious way to cut down on the breakout noise.
The authors have previously looked in detail at the breakout noise levels from air handling units and realised that a gap in knowledge existed concerning measurement of true insertion loss of acoustic enclosures. This paper highlights the areas where conventional theory and empirical measurement techniques break down and the remedies sought after to develop a consistent on site measurement method.
Theory and data are drawn from their two previous papers which concentrated on developing a wider understanding of insertion loss, sound reduction due to the enclosure's insulating properties and sound intensification when a sound source is placed in an enclosure. Sound theory was at all times compared against empirical results achieved after exhaustive testing and the ramifications added to previous knowledge to develop a reliable site test technique to highlight the enclosures true performance vis sound reduction index.
This logically led to an experiment in an actual site situation. The test integrated the techniques prefered from results gained in the laboratory.

Test Environment.

A plantroom chamber approximate dimensions being, 4.56m High x 13.4m Wide x 25.0m Long. The chamber contained a typical selection of supply and exhaust ductwork and water/steam pipes connected to 3 Metair air handling units sited as plantroom drawing. All surfaces were metallic or painted brick/concrete and thus gave quite a harsh reverberant test environment.

Measurement Technique.

This included a probe of the fan enclosure and the Walkaway measurement technique used in previous experiments. The Walkaway measurement technique was prefered to reverberation tests when trying to evaluate room effect in a semi-reverberant environment.

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Test Procedure

For the purposes of the test all possible noise external to the air handling unit to be measured was eliminated. This entailed shutdown of air handling units 1 & 2 and the close-down of the moving public escalator, leaving a tolerable background noise level for the tests.
The fan enclosure was probed from the top using a 2m length of 1/4" dowel to which the 1/2" condenser microphone was attached. The dowel was marked off at 200mm intervals so that the vertical probe could be plotted on the certified drawings.
At a depth of 1200mm the probe microphone was directly opposite the fan inlet eye 1000mm away from the centre of the sound source, a good reference point for the comparison with the duty point of the fan and the theoretical sound pressure level spectrum in free field conditions (see calculations in Mathematical Appendix 1).
The probe measurements started at 400mm away from the inner ceiling skin of the fan enclosure and carried on in 200mm steps to 1800mm from the inner ceiling skin giving 8 measurement positions in all (see fig 1.), see table in Mathematical Appendix 1. During the 20 minute long probe experiment the fan was kept running at a constant 100% VAV duty of 1387rpm.
The fan was run at 100% VAV duty for the Walkaway measurement experiments which fell into 2 categories,(see fig 2.)
i) Doors open.
ii) Doors closed.

i) Doors Open.

There were 4 measurement positions: 0m, i.e. at the interface with the inner skin of the casework panel, 0.5m, 1m and 1.5m. The distance of the fan outlet from the inner face of the door panel was approximately 1.5m, see table in Mathematical Appendix 1.

ii) Door Closed.

The 0m measurement position was at the panels outer face: all other positions used the casework panels inner face as their reference point, the difference being only 25mm. This minor difference in measurement position did not affect the comparison of measurements, see table in Mathematical Appendix 1.

All measurements for door open and closed tests took place 1m from the plantroom floor along the same linear path.

Results.

Starting with the probe test and the 48 different measurements

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which took place in the box. A log average was taken as can be seen in the table Internal Dynamic Traverse of Casework, Mathematical Appendix 3, this was compared with the theoretical fan sound pressure level. A summary table is shown below.

Mid-Frequency Hz	125	250	500	1K	2K	4K
$PROBE_{log\ ave}$	81.5	86.5	89.1	91.8	88.8	85.5
SPL_{theory}	91.0	90.0	88.0	86.0	82.0	78.0
Difference	-9.5	-3.5	+1.1	+5.8	+6.8	+7.5

The figures in the table are sound pressure levels in dB.

According to our previous experiments with fans placed in enclosures the sound field was intensified at all frequencies when the enclosure was in place but in this case the findings at the lower frequencies suggest that quite a substantial amount of internal attenuation is derived from the MTR 1500 enclosure being in place. If a standing wave was present in the enclosure at these frequencies the figures for the nodal and anti-nodal measurements should have averaged out over the probe's traverse of the fan enclosure. Bearing this in mind there are circumstances that may contribute an explanation to this phenomenon.
Firstly the actual fan itself: sound data published in catalogues tends to be extrapolated from a series of tests done on example fans which are used as a basis for the calculation of fan data for the whole range of fans. Errors are almost certain to happen here, predicting the errors is difficult. Also the fan construction and installation in the air handling unit can not always be classed as a totally uniform operation, with the fluctuation in the grades of metals used for manufacture, the simple tightness of the screws belts and pulleys all could have an effect on the sound field the fan produces.
Secondly the environment the fan was tested in: it can not be directly compared with the previous experiments that took place in the semi-reverberant environment because in that case the enclosure was practically a uniform construction completely surrounding the noise source. In the New Century House site test the casework was only uniform on three sides of the enclosure. As can be seen from the certified drawings, the fan section is partly covered on its upper part by the double decked arrangement of the extract unit (see fig 1.). We also have no proper casework behind and in front of the fan due to the simple fact that air has to flow through the unit for it to carry out its air conditioning job. The sections that precede the fan section are

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the humidifier and the cooling coil sections and the sections after the fan are the spreader plenum and attenuator sections. In both cases it is easy for sound to diffuse and travel up both these airways.
From the comparison of the sound pressure spectrum difference it is plain that the lower the frequency the less the sound field appears to intensify with the addition of the enclosure i.e. the sound pressure levels tend to intensify as frequency increases, suggesting that lower frequency intensification is non-responsive to the partially enclosed environment.
We have observed that this was not the case in the enclosed environment when we dynamically traversed the cube enclosure in the semi-reverberant environment. See table below;

Mid-Frequency Hz	125	250	500	1K	2K	4K
$PROBE_{dynamic}$	89.1	98.2	97.7	114.4	101.2	95.7
$SPL_{measured}$	66.2	78.9	80.1	91.3	81.6	76.0
Difference	+22.9	+19.3	+17.6	+23.1	+19.6	+19.7

The figures in the table are sound pressure levels in dB.

The response of the lower frequencies here shows that intensification of the sound field takes place at approximately the same levels right across the spectrum.
The realisation of the anomaly at lower frequencies means that any rogue statistics can be quickly eliminated from our calculations thereby allowing a valid mathematical analysis to continue and the comparison between the predicted and calculated/measured Sound Reduction Index (SRI) to take place.
The Walkaway tests with the doors open and closed gave us the additional data required to perform the SRI comparison tests for the New Century House Units (see Mathematical Appendix 1).
The calculations in Mathematical Appendix 1 show that the theoretical and calculated Sound Reduction Index are even closer than before. This result can be verified by explaining the logical calculation procedure and the mathematical assumptions enforced.

Measurement Method and Calculation Procedure

This was developed from the previous anechoic and semi-reverberant environment experiments.

All the Walkaway data for the doors open test was arranged in tables with the theoretical Sound Power Level of the fan to

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determine R from the equation;

$$SPL = PWL + 10 \log_{10} [Q/4\pi r^2 + 4/R]$$

R is the room effect on the generated sound pressure level.

The measurement is taken from four different distances away from the unit which are then averaged to give an average room effect. In this test the lower frequencies of 125Hz and 250Hz provided us with figures which were not consistent with the experiment. As a result of this they were eliminated from the analysis.
The calculated/measured figures for the Sound Reduction Index were then derived from the equation;

$$SRI = SPL_1 + RC - SPL_2$$

These were kept for future comparison with the theoretical figures.

The next stage took the method of Kinsler & Frey to calculate the predicted Sound Reduction Index.
It was necessary at this stage to examine the site test situation in greater detail and draw a contrasting picture to that of the 104A semi-reverberant room tests.
We had a situation at the New Century House site where the fan section of the unit did not sit in the centre of the room, it was positioned far to one side. The position and the size of the unit and the size of the plantroom meant that this test did not lend itself to the same assumption used in the 104A test where S in the equation;

$$TL = NR + 10 \log_{10} S/A$$

S = Total surface area of "wall"

S was assumed to be the total surface area of the cube enclosure able to radiate sound i.e. approximately 5m². It was ideally situated for this to be the case.
Due to the size of the New Century House air handling unit fan enclosure it was assumed that the fan section panel measured would be the only significant contributory source of sound due to the fact that the sound radiating from the top and other side of the unit would have to travel many metres even for the shortest path. The drop in sound level over this distance would mean the other two radiating faces would have no significant effect on the microphone reading. Using this assumption the surface area of the fan casework side panel is 3.8m². By making this equal to S the predicted levels of Sound Reduction Index can be found.
All these calculations can be found in Mathematical Appendix 1.

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Conclusion.

From the results given in Mathematical Appendix 1. we can see that the predicted Sound Reduction Index is extremely close to the calculated Sound Reduction Index across the 4 frequencies. The lower frequencies were eliminated from the analysis due to inconsistent readings. This shows that the method developed for acoustic analysis on site can produce results which are consistent with present theoretical findings.

An Appraisal of the Findings.

Each of the stages of development in this project has provided a basis for the next. It was the aim to logically progress from an intense analysis of the enclosures casework panels and pentapost in a sterile experimental environment, to testing the findings in a less perfect more realistic environment and then progress to the everyday site situation.
Taking first the anechoic experiments. The objective was to examine the panels infill materials and the difference pentapost insulation made to the insertion loss of the enclosure. The insertion losses were recorded for both fibreglass and Rockwool panel insulation with and without the insulated pentapost. It was clear from these early tests that more was going on in the enclosure than the simple test methods used could detect.
The next step took the enclosure out of the sterile test environment into the more complex and realistic semi-reverberant world. This confirmed early on that it was a difficult environment in which to take readings using the simple methods used in the anechoic chamber. Further testing was required to estimate the effects of the external and the internal environment on the Sound Pressure readings. The test to do this had to measure the reverberation times of the room and the enclosure and it was planned to backup these tests with theoretical data to support the test procedure. The results of the reverberation time measurements of the enclosure were very encouraging. They were used to predict the Sound Pressure Level in the enclosure which was confirmed when a probe microphone did a dynamic traverse of the unit. Unfortunately the results of the room reverberation time measures were totally inconclusive as can be seen from the tables and graphs, it seemed that the complex sound field set up in the semi-reverberant environment could not be accurately measured in this way. A more rudimentary method to give the room effect was tried, the Walkaway method. This gave the room effect data for appreciably consistent results and appeared to confirm the theoretical data with comfortably close measured readings. It was to form the basis of the test technique for site measurements along with the probe microphone dynamic traverse of the air

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handling unit's fan enclosure.
Using the information gleaned from the previous steps the site test was set up to confirm if possible the previous findings and to investigate the true Sound Reduction Index of the air handling unit enclosure. Difficulty was found when performing the probe test of the fan enclosure in that the lower frequencies provided us with inconsistent readings, however progress was made by concentrating on the more consistent figures and it was noted that the intensification of the Sound Pressure level had a peculiar tendency to increase with frequency, a phenomenon not experienced in the other tests.
Further modifications were made to the Kinsler & Frey calculations in that the size of the site air handling unit provided us with a "wall" to measure rather than a three dimensional, almost omnidirectional sound source, as in the 104A semi-reverberant environment tests. This proved to be a good assumption to make as the figures from the site experiment were in favour of all the developments made in the previous research.

References.

Kinsler,Frey,Coppins & Saunders: Fundementals of Acoustics 3rd Ed (1983.)

Whitfield W.A.,Colgrave P.,Fairhall D.M.: Measurement of Sound Insulating Properties of Air Handling Units. Proceedings of Institute of Acoustics Conference, University of Cambridge 1988.

Whitfield W.A., Fairhall D.M.: Noise Breakout From Air Handling Units. Proceedings of Institute of Acoustics Conference Volume 9 Part 7.

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MATHEMATICAL APPENDIX 1.

SITE TEST: NEW CENTURY HOUSE PLANTROOM

Calculation of Sound Reduction Index Using Walkaway Experiment Results.

All measurements taken in New Century house Plantroom.

Calculation for 0m or 1.5m from fan. (no panels)

$SPL = PWL + 10 \log_{10} [Q/4\pi r^2 + 4/R]$

$Q/4\pi r^2 = 1/4\pi(1.5)^2 = 0.035$

$SPL = PWL + 10 \log_{10}(0.035 + 4/R)$

$SPL - PWL = 10 \log_{10}(0.035 + 4/R)$

$10^{(SPL - PWL)/10} = 0.035 + 4/R$

$R = 4/(10^x - 0.035)$ (1) R = Room Constant

dB/Hz	125	250	500	1K	2K	4K
$SPL_{1.5}$	82.0	85.1	87.6	89.2	85.5	81.2
PWL_{theory}	97.0	96.0	94.0	92.0	88.0	84.0
DIFF	-15.0	-10.9	-6.4	-2.8	-2.5	-2.8
R from eqn (1)	-1184	86.4	20.6	8.2	7.6	8.2

Calculation 2m from fan (Doors open)

$Q/4\pi r^2 = 1/16\pi = 0.02$

$R = 4/(10^x - 0.02)$ (2)

dB/Hz	125	250	500	1K	2K	4K
$SPL_{2.0}$	80.8	85.6	83.7	86.0	83.7	79.9
PWL_{theory}	97.0	96.0	94.0	92.0	88.0	84.0
DIFF	-16.2	-10.4	-10.3	-6.0	-4.3	-4.1
R from eqn (2)	1002	56.2	54.6	17.3	11.4	10.8

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Calculation 2.5m from fan (Doors open)

$Q/4\pi r^2 = 1/25\pi = 0.013$

$R = 4/(10^x - 0.013)$ (3)

dB/Hz	125	250	500	1K	2K	4K
$SPL_{2.5}$	78.2	84.0	83.7	84.8	84.0	78.7
PWL_{theory}	97.0	96.0	94.0	92.0	88.0	84.0
DIFF	-18.8	-12.0	-10.3	-7.2	-4.0	-5.3
R from eqn (3)	21909	79.8	49.8	22.5	10.4	14.2

Calculation 3m from fan (Doors open)

$Q/4\pi r^2 = 1/36\pi = 0.009$

$R = 4/(10^x - 0.009)$ (4)

dB/Hz	125	250	500	1K	2K	4K
$SPL_{3.0}$	74.6	80.0	82.7	82.9	78.8	75.6
PWL_{theory}	97.0	96.0	94.0	92.0	88.0	84.0
DIFF	-22.4	-16.0	-11.3	-9.1	-9.2	-8.4
R from eqn (4)	-1232	248.2	61.4	35.1	35.9	29.5

Summary Table:

dB/Hz	125	250	500	1K	2K	4K
$R_{1.5}$	-1184	86.4	20.6	8.2	7.6	8.2
$R_{2.0}$	1002	56.2	54.6	17.3	11.4	10.8
$R_{2.5}$	21909	79.8	49.8	22.5	10.4	14.2
$R_{3.0}$	-1232	248.2	61.4	35.1	35.9	29.5
R_{ave}	?	?	36.6	20.8	16.3	15.7

10Log4/R = Room Constant

There are rogue figures over all distances measured in the 125Hz frequency band and one for the $R_{3.0}$ measurement in the 250 Hz band these caused concern enough to eliminate the calculations for R at these frequencies from our mathematical analysis.

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$SPL_2 = SPL_1 - RC - SRI$

$SRI = SPL_1 + RC - SPL_2$ (i)

The calculated/measured figures for SRI come from eqn (i)

SPL_1 = Level in closed box.
SRI = dB drop due to room.
SPL_2 = Measured at 1m.

dB/Hz	125	250	500	1K	2K	4K
SPL_1	81.5	86.5	89.1	91.8	88.8	85.8
RC	-	-	-9.6	-7.2	-8.4	-5.9
SPL_2	60.1	62.5	60.0	58.0	55.2	47.8
SRI_{CALC}	-	-	19.5	26.6	25.2	32.1
IL	17.1	20.5	22.7	25.8	27.8	29.9

IL = Insertion Loss , it is measured at 1 metre.

Method from Kinsler & Frey.

$TL = NR + 10 \log_{10} S/A$

Transmission Loss = TL = SRI

$NR = L_1 - L_2$ ie $SPL_{BOX} - SPL_{104A}$

A = Absorption of room.
S = area of "wall" ie the side panel of the fan section
= 1.7m long x 2.25m high
= 3.8m²

$A = S\alpha \approx R$

$SRI = (SPL_{BOX} - SPL_{104A}) + 10 \log_{10}(s/r)$

We can derive the first half of the right hand side of the equation.

dB/Hz	125	250	500	1K	2K	4K	8K
box-104A	28.2	38.4	39.4	42.4	35.3	34.1	30.2

$SPL_2 = SPL_1 + 10 \log_{10} \tau + 10 \log_{10} S - 10 \log_{10} A$

$SPL_2 = SPL_1 - 10 \log_{10} 1/\tau + 10 \log_{10} S - 10 \log_{10} A$

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$$SRI = SPL_1 - SPL_2 + 10 \, Log_{10} \, S - 10 \, Log_{10} \, A \quad (ii)$$

The SRI predicted figures are derived from the eqn (ii) above.

S = 3.8, A = R;

S is the principle surface area of the fan section that transmits sound to the surrounding room. In this case the side panel is assumed to be the "wall".

R is the available averaged figure at each frequency taken from the walkaway tests performed in 104A.

dB/Hz	125	250	500	1K	2K	4K
box-104A	21.4	24.0	29.1	33.8	33.6	38.0
10LogsS/R	-	-	-9.8	-7.4	-6.3	-6.1
SRI_{THEORY}	-	-	19.3	26.4	27.3	31.9
SRI_{CALC}	-	-	19.5	26.6	25.2	32.1

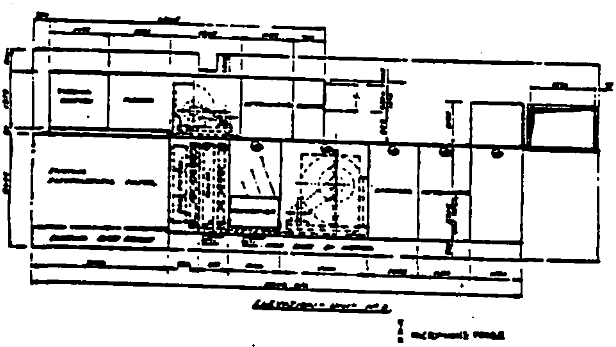

FIGURE 1

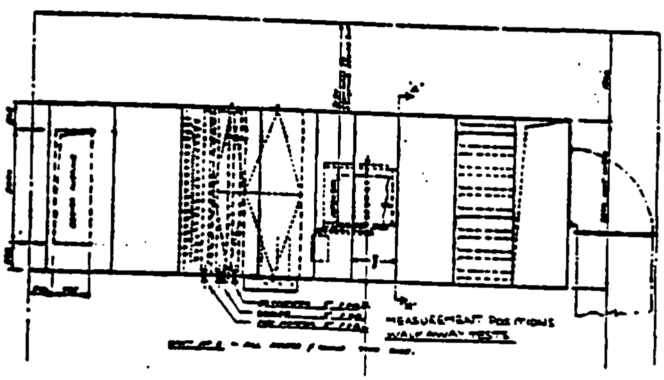

FIGURE 2

NEW PRINTING BUILDING : SURREY DOCKS

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NEW PRINTING BUILDING : SURREY DOCKS

Background

A number of the national newspapers have progressively vacated Fleet Street to establish the new technology in London's Docklands. The London Docklands Development Corporation (LDDC) planned for the mixed development of the docklands areas, with sites given over to residential, commercial and industrial uses. In the event, private 'yuppie' housing has proved very popular and this has resulted in a particular challenge for the industrial sites to be good neighbours. As press activity is at its peak between mid-night and 3am, printing complexes are noisy when ambient levels are at a minimum.

The £130m new Mail Newspapers printing complex is located in the heart of the Surrey Quays redevelopment, with housing areas all around at nearest distances from 137m to 465m.

Noise Surveys

BDP were initially appointed by Mail Newspapers to carry out an exhaustively detailed site noise levels survey and measure noise levels around different press activities. The first survey covered three 24 hour periods in order to cover typical weekdays, Saturday and Sunday, and a further survey extended the area covered by the monitoring positions. The survey recorded L90 daytime levels of typically 50-55 dBA on Sunday and 55-60 dBA on other days. Between 2am and 4am L90 levels fell to a minimum of typically 38dBA.

The press processes examined were as follows :

* presses
* folding (publicity inserts) - bundle strapping machines
* tray sorters (not used in the project as built)
* platemaking
* waste compactors

'Flexo Courier' Koenig and Bauer printing presses in the premises of The Darmstadt Echo, Frankfurt were measured as presses of this type were to be installed at the Daily Mail. The measured noise levels in the vicinity of two print units operating was 91-98 dBA (sound power level for 2 print units and one folder 112 dBA). Factored up for the number of presses and folders in Mail's print hall, a reverberant level of 96 dBA was implied, even if a sound absorbing ceiling was included.

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The publishing department houses machinery including 'Ferag multicell' devices which stack newspapers and bundle them. These were measured at an existing installation as 88 dBA at close range (SWL 98 dBA).

The publishing department was to house tray sorters for which the 'Daverio' units at the new Daily Telegraph premises in Manchester were looked at as precedent. The sound levels at that 68-tray arrangement were 68 dBA in the vicinity of the tray sorters, or 78 dBA close to the drive units. The sound power of a large tray sorter with two drive units was 91 dBA. At Mail Newspapers only the conveyors were installed.

APR Platemaking machines in the existing Daily Mail Northcliffe House building indicated sound levels of 72-80 dBA at 1m during the platemaking process, each plate taking 20 seconds to make. This corresponds to an SWL of 85-89 dBA. Whilst general levels are determined by ventilation noise, there are also short duration 'hiss' impact sound which measured 83-86 dBA.

'Thetford' industrial waste compactors were measured at two local retail premises; set within the building these range from 70-79 dBA, or outside 60-74 dBA (SWL 90 dBA).

Noise data for the HVAC plant components of noise and other building services equipment was obtained from vendors or estimated from data available for similar load equipment.

Planning Conditions

The outcome of negotiations with the LDDC and their consultants was the control of noise by planning conditions relating to the following :

* vehicular traffic on site access roads and within site.
* printing presses and associated production equipment
* building services equipment, particularly ventilation plant with inlet and exhaust connections to atmosphere.

The condition applied to control emission from fixed plant was for the Corrected Noise Level as defined in BS4142 outside reference residential properties to be demonstrably within 40 dBA.

The initial design intent was to control emission to achieve levels not exceeding 35 dBA, to allow for BS4142 corrections on tone or intermittency. However, it was judged that the large number of sources contributing to noise emission ironed out tonal character and a design working limit of 37dBA was used.

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Buildings

The printing complex comprises a main building holding a press hall and platemaking, with HVAC plantroom at roof level. The ancillary building houses plant, offices, stores and service areas. Conveyors connect these areas to Publishing and a covered vanway. An automated paper store building completes the complex.

The buildings are steel framed, with metal cladding external face. The press hall alone is 90m long by 30m high. The wall cladding incorporates continuous louvre sections to provide connections for HVAC inlets and exhausts, and smoke louvres. Roof decks are penetrated by ventilation openings terminated by louvre turrets, and smoke vents.

Design Measures

BDP received a separate appointment directly to the management contract design team to implement design ingredients to meet the planning requirements. Following the studies establishing the likely internal noise levels, performance specifications were issued giving minimum permissible values of sound reduction index for all significant external building elements - cladding, glazing, doors, and smoke ventilators. Performance specifications were also provided for noise radiation from intake and exhaust louvres and from external plant, to assist in the selection of plant and design of attenuators.

The following features were incorporated in the building to limit external noise emission :

* in high noise areas like the press hall, the walls are internally lined with 140mm dense blockwork, with an airspace of 400-520mm behind external cladding containing a sound absorbent quilt.

* roofs are generally steel decking, 100mm cavity with quilt, and inner decking. In high noise areas, the lining is uprated with 1 or 2 sheets of dense mineral boarding.

* sound-absorbing ceilings are provided in the Press Hall, main HVAC plantroom, and Publishing to reduce internal reverberant noise levels.

* non active louvre areas are blanked off with blockwork, plasterboard or dense mineral board, depending on location.

* smoke louvres in walls (set behind weather louvres) consist of multiple hinged blades with edge seals. In high noise areas, additional louvres in tandem uprate the sound insulation.

* horizontal smoke vents on the roof are closed by hinged smoke flaps. In high noise areas the flaps are externally clad with a steel tray over mineral wool, and have uprated edge seals.

* all smoke vents are normally closed and remote indication of open vents is provided. Smoke louvres and flaps have been subjected to laboratory tests to prove the sound insulation performance.

* air inlet and exhaust openings incorporate rectangular splitter attenuators or acoustically lined duct sections to control the emission of plant and fan noise.

Calculation Techniques
A computer program was used to enable noise emission from building surfaces and equipment to be calculated, and readily updated as the design proceeded.

The external surfaces of the buildings are grouped into building elements of common construction and internal noise level. Data for each element was recorded on noise analysis forms, areas of low internal noise level were generally excluded from the analysis.

The program calculates the noise level at each reference position due to noise emission from each building element. The sound power radiated by each element is calculated from input data on internal SPL, sound reduction index, and element area. The SPL at each reference position due to each element is calculated from the element SWL by applying corrections for distance (calculated from the element coordinates), atmospheric absorption, and source directivity. The simplified directivity corrections described in VDI 2571 have been used for building elements.

A similar method was used for noise emission from each HVAC element. The SWL from each opening is calculated from manufacturers' data for fan-connected openings, or from internal SPL and opening area for non-ducted openings; the insertion loss of any attenuator is subtracted from the calculated SWL. The SPL at each reference position is calculated as for building elements. In all, 685 elements have been tabulated.

Because of the complexity of the building and large number of elements, the calculation methods are necessarily simplified. However, the simplifying assumptions are conservative and will generally lead to an over-estimate of overall noise levels. This tendency towards over-prediction provides an additional margin of safety in the acoustic design. The 'rank order' listing drew attention to priority items for improvement, and gave a logic to the acoustic design advice given to the project team throughout the realisation of the scheme.

NEW PRINTING BUILDING : SURREY DOCKS

Interior
£.5m alone was spent on the acoustic glazing separating the noise havens and control room core from the press hall. The glazing was designed to give levels not exceeding 65 dBA in the protected areas.

Commissioning
The presses have largely been installed and initial runs are in hand. Hand-over of the building envelope is on target for the end of the year, so commissioning acoustic tests will be undertaken soon.

MAIL NEWSPAPERS SURREY DOCKS DEVELOPMENT EXTERNAL NOISE ANALYSIS

ELEMENT NO 233.0

Description LOUVRE - TO HVAC PLANT ROOM

Elevation SE Level 3 Grid Ref. J26

Coordinates X= 47 Y= 92 Z= 14 Size 6.0 x 2.5 = 15.0 m2

Associated Elements 552.1/552.2/233.1

NOISE EMISSION	63	125	250	500	1k	2k	4k	8k Hz
Internal SPL	87	84	82	78	75	73	71	69
SRI	20	27	31	32	36	37	38	41
PWLout	72.8	62.8	56.8	51.8	44.8	41.8	38.8	33.8

CALCULATION OF SPL AT REFERENCE POSITIONS A B C D

A	Distance 273 m	-56.7	-56.7	-56.7	-56.7	-56.7	-58.9	-61.6	-68.2
	Directivity	3	3	3	3	3	3	3	3
	Screening								
	SPL at A	19.1	9.1	3.1	-1.9	-8.9	-14.1	-19.8	-31.4
	A-Weighted SPL at A	-7.1	-7.0	-5.5	-5.1	-8.9	-12.9	-18.8	-32.5
	TOTAL= 0.7 dBA								
B	Distance 480 m.	-61.6	-61.6	-61.6	-61.6	-61.6	-65.4	-70.3	-81.8
	Directivity	-10	-10	-10	-10	-10	-10	-10	-10
	Screening								
	SPL at A	1.2	-8.8	-14.8	-19.8	-26.8	-33.6	-41.5	-58.0
	A-Weighted SPL at A	-25.0	-24.9	-23.4	-23.0	-26.8	-32.4	-40.5	-59.1
	TOTAL= -17.3 dBA								
C	Distance 183 m.	-53.2	-53.2	-53.2	-53.2	-53.2	-55.4	-58.2	-64.7
	Directivity	-20	-20	-20	-20	-20	-20	-20	-20
	Screening								
	SPL at C	-0.4	-10.4	-16.4	-21.4	-28.4	-33.6	-39.4	-50.9
	A-Weighted SPL at C	-26.6	-26.5	-25.0	-24.6	-28.4	-32.4	-38.4	-52.0
	TOTAL=-18.8dBA								
D	Distance 282 m.	-57.0	-57.0	-57.0	-57.0	-57.0	-59.2	-61.9	-68.5
	Directivity	3	3	3	3	3	3	3	3
	Screening								
	SPL at C	18.8	8.8	2.8	-2.2	-9.2	-14.4	-20.1	-31.7
	A-Weighted SPL at D	-7.4	-7.3	-5.8	-5.4	-9.2	-13.2	-19.1	-32.8
	TOTAL= 0.4dBA								

Notes

Blanked-off smoke louvre.

Table : Sample analysis sheet for noise break out model

BDP ACOUSTICS

M.7172 1988

ELEMENT NO. 233.0

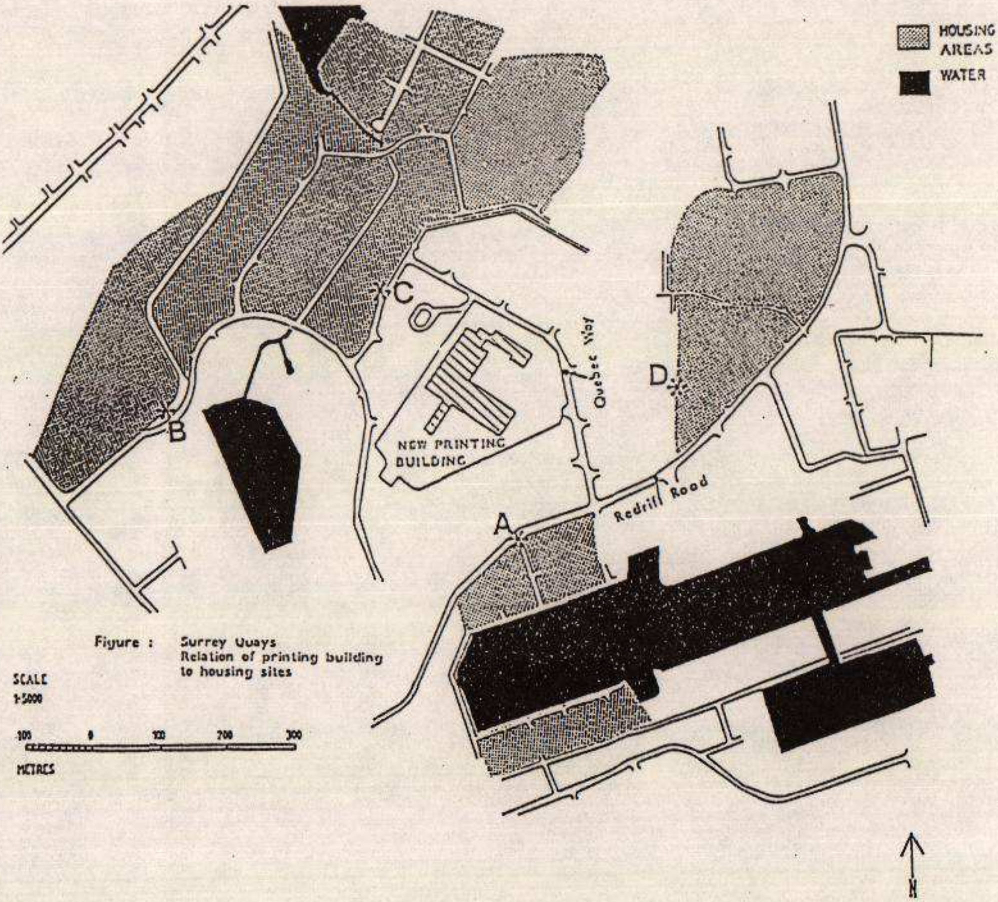

Figure : Surrey Quays
Relation of printing building to housing sites