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The Journal of the Institute of Hospital Engineering

Noise Control in Health Buildings

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HOSPITAL ENGINEERING

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October 1978

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Front cover: Mr T. Wagstaff, Principal Acoustics Engineer at the DHSS, presents his paper on *Noise Control in Health Buildings* at the 1978 Annual Conference of the Institute.

Institute News

Extraordinary General Meeting

Tuesday, November 28, 1978

It is necessary to amend the Memorandum and Articles of Association of the Institute to bring these into line with the requirements of the most recent Companies Acts. This will be effected at an Extraordinary General Meeting of the Institute and, accordingly, the requisite Notice of this meeting is given to members below:

NOTICE IS HEREBY GIVEN that an EXTRAORDINARY GENERAL MEETING of the Institute will be held at Committee Room 3, South West Thames Regional Health Authority, 40 Eastbourne Terrace, London W2 3QR on Tuesday, the 28th day of November, 1978, at 2 pm when the following Resolution will be proposed as a Special Resolution: —

Resolution

1. That the Memorandum of Association of the Institute (in this Resolution hereinafter referred to as 'the Memorandum') and the Articles of Association of the Institute (in this Resolution hereinafter referred to as 'the Articles' be altered in the following manner:—

(a) Proviso (ii) to Clause 3 of the Memorandum shall be deleted and there shall be substituted therefor:— 'The Objects of the Institute shall not extend to the regulation of relations between workers and employers or organisations of workers and organisations of employers'.

(b) In Proviso (iii) to Clause 3 of the Memorandum the words 'or the Secretary of State for Education and Science' shall be deleted from both places where those words appear and there shall be deleted the comma between the words 'the Chancery Division' and 'the Charity Commissioners' and there shall be substituted therefor the word 'or'.

(c) In the Proviso to Clause 4 of the Memorandum there shall be deleted the words '6 per centum per annum' and there shall be substituted therefor:— '2 per cent less than the minimum lending rate prescribed for the time being by the Bank of England, or 3 per cent whichever is the greater'.

(d) In Article 76 there shall be inserted between the words 'such conditions' and 'as the Council' the words 'consistent with the Provisions of Clause 4 of the Memorandum of Association'.

(e) In Article 78(E) there shall be deleted the full stop and there shall be added to the Article 'section 28 of the Companies Act, 1976 or section 9 of the Insolvency Act, 1976'.

(f) Article 94 shall be deleted and there shall be substituted therefor:— 'The Council shall cause accounting records to be kept in accordance with section 12 of the Companies Act, 1976'.

(g) In Article 95 the words 'books of account' shall be deleted and the words 'accounting records of the Institute' substituted therefor; the words 'section 147 (3) of the Act' shall be deleted and the words 'section 12(6) and (7) of the Companies Act, 1976' substituted therefor and the full stop at the end of the Article shall be deleted and there shall be added to the Article 'and the Secretary'.

(h) In Article 96 the words 'accounts and books' shall be deleted wherever they appear and the words 'accounting records' substituted therefor.

(i) In Article 97 the words '162 of the Act' shall be deleted and there shall be substituted therefor the words '14 of the Companies Act, 1967'.

(j) In Article 99 the words '159 to 162' shall be deleted and the words '161(1) to (4)' substituted therefor and immediately after the words 'of the Act' there shall be inserted the words 'section 14 of the Companies Act, 1967 and sections 13 to 18 of the Companies Act, 1976'.

By Order of the Council

J. E. FURNESS
Secretary

October 6, 1978

20 Landport Terrace,
SOUTHSEA, Hampshire, PO1 2RG.

NOTE. It is provided by Regulation 56 of the Articles of Association of the Institute that no Member may vote by proxy.

International Conference on Developments in Distribution Switchgear

Papers from Europe, America, Eastern Europe, Far East and the Middle East will be presented at the international conference entitled 'Developments in Distribution Switchgear' being organised by the Institution of Electrical Engineers to take place on November 20-22, 1978 at the IEE, Savoy Place, London WC2.

The aim of the conference is to promote discussion and interchange of information on developments in switchgear used on distribution systems from 1 kV to 150 kV and the programme will contain nine sessions which will include papers on arc interruption media: vacuum SF6 oil and air circuit breakers: design, testing, operational and safety aspects of switchgear: industrial applications; insulation materials; approval and service experience.

For further information, contact: Annemarie Cunningham - Swendell. Telephone: 01-240 1871, ext 280.

Southern Branch Programme

The Southern Branch programme for the coming winter is as follows:—

November 11, 1978 at Queen Alexandra Hospital (Cosham), a lecture on computerisation and communication. Speaker: Mr R. G. Jones of Cass Electronics.

December 2, 1978 at Cowes, Isle of Wight, a visit to Royal Hovercraft Establishment.

January 16, 1979 at Odiham, Hants,

a visit to the RAF Establishment.

March 10, 1979 at Southampton General Hospital, a lecture on 'New Concepts in Hot Water Heaters'. M. Maton of Beaumont Water Heaters.

London Branch visit

Mr A. M. Gower, the new correspondent for the London Branch, has sent in a very full and glowing report of the London Branch Members' visit to the Young & Co Brewery Ltd, of Wandsworth.

It seems that a very good time was had by all, and it is regretted that, because of a lack of space, we have not been able to print it.

Institute of Hospital Engineering

Bursary Competition

Council of the Institute is most pleased to give details of the Institute Bursary Award Competition for 1979.

The Institute is indebted, and would like to express its appreciation, to the Board of the King Edward's Hospital Fund for the financial support that makes this Bursary scheme possible.

The aims of the Institute of Hospital Engineering are the advancement, development and application of engineering science in health care and the management of engineering and allied staff employed in this work in Great Britain and abroad.

To achieve its aims the Institute co-operates with the Department of Health and Social Security and with industry in the promotion and organisation of training courses, symposia and seminars.

Papers are read at meetings of branches during the year and visits to health-care buildings and industrial establishments are arranged to broaden the knowledge of those working in hospital engineering.

The Institute is a Founder Member of the International Federation of Hospital Engineering, which was formed in Rome in 1970, and has expanded to take the Institutes or Associations right across the world from New Zealand to the United States of America. It is this involvement which has prompted the Institute to find means of promoting schemes whereby financial aid could be given to engineers to study hospital engineering in the United Kingdom and abroad and to encourage the younger members of the profession to widen their knowledge.

Details of membership and any other information about the Institute can be obtained from the Secretary.

Bursaries

The Council of the Institute of Hospital Engineering announce the offer of a Bursary to aid young British people in Great Britain and Northern Ireland who are engaged in health-care engineering. The Council's purpose in providing this Bursary is to enable successful candidates to broaden their knowledge and experience by overseas travel in order to study health-care engineering in other countries at first hand or, in certain cases, by obtaining training or industrial experience in this country at an approved college, institution or industrial establishment, and in these ways to equip themselves the better to improve their effectiveness and promotion potential in health-care engineering.

The conditions of entry to the Competition are given below. Further copies of these can be obtained from the Secretary of the Institute of Hospital Engineering.

A Certificate will be awarded to the successful candidates on completion of a satisfactory report of their tours or training taken through the aid of this Bursary.

The Council wishes to express its gratitude for the financial support the Competition will receive from King Edward's Hospital Fund for London which provides most of the Bursary, and for the co-operation of the candidates' employing authorities for permitting the candidates to enter the competition and to take up the Bursary. Thanks are also due to those authorities, companies and colleges who agree to co-operate to permit the successful candidate to follow the chosen study.

Conditions of Entry to the Bursary Competition

1. The Bursary is open to any British person practising or training to practice as an engineer in the fields of design, maintenance or manufacture of equipment or installations used in health-care establishments, who is over 17 years of age and under 35 years of age at the closing date of the competition. Candidates must demonstrate that they are seriously pursuing a career in health-care engineering.

2. Candidates must have studied, as full-time, part-time or evening students, for not less than one academic year, before the closing date of the competition, at a university, college or technical school approved by the Institute for this purpose.

3. Entry will be by paper submitted in accordance with these conditions, in which candidates should describe the study they wish to undertake, giving background information relative to the need for such study. Candidates, also, should indicate the places it is desired to visit, to further the study and indicate the way in which it is felt that the investigations will add to the development of health-care engineering, and to their own effectiveness.

4. Candidates should submit four copies of their entry which should be double-spaced and on one side of A4 paper only, the entry being signed and dated. Photographs and/or drawings of any size may be included in, or in support of, an entry.

5. Only one entry will be accepted from each candidate.

6. The entry must be received by the Secretary of the Institute of Hospital Engineering, 20 Landport Terrace, Southsea, Hampshire PO1 2RG, not later than the date stated at the foot hereof. Any entries received after this date may be disqualified.

7. Each candidate, when submitting an entry, must accompany it with evidence that, if successful, the requisite leave of absence will be granted

by his employer.

8. When considering to where they wish to travel in order to study their required subject, candidates should bear in mind the possibility that the Institute may choose to divide the Bursary. Candidates may, however, take into account any other financial contribution that may be available to them when estimating the cost of their studies.

9. Candidates selected for interview will be required to produce their proposed itinerary with estimated costs.

10. Successful candidates will be required to make their own travel arrangements within the limit of the Bursary and such other finances available to them.

Conditions for the Study or Project

1. Candidates must present, either as part of their entry or at the interview, the estimated time for travel and the preparation of the report on the study together with an estimate of the costs involved.

2. Successful candidates must arrange their own itinerary, make all contacts with those whom they wish to visit in order to seek assistance with their projects, and obtain all necessary approvals to enter premises and to have discussions, where necessary, with subordinates in organisations.

3. The Bursary will be paid to the successful candidate(s) as soon as the Institute is satisfied with their itineraries and that they are in a position to undertake their projects. Candidates shall pay for all expenses in connection with their projects and no accounts shall be paid by the Institute.

4. The Institute takes no responsibility for any of the candidates' actions in connection with their projects including obtaining documents which may be secret or have copyright protection, the taking of photographs, etc.

5. Candidates are expected to produce a comprehensive report at the completion of their studies or projects and to submit a copy for the Institute to retain and publish, if it requires.

6. The Institute reserves the right to:

a. require candidates to attend for interview;

b. publish entries, or reports submitted subsequent to a Bursary, without charge, in the Institute's Journal, retaining the copyright thereof;

c. withhold, or divide, the Award;

d. examine an applicant's birth certificate.

7. Whilst taking every reasonable precaution to safeguard entries and accompanying documents / materials submitted, the Institute accepts no responsibility for loss of, or damage to, material either on its premises, in transit, or elsewhere.

The 1979 Bursary

The total amount of the Bursary for 1979 is £500.

Entries for the competition should be submitted to the Secretary of the Institute by not later than April 30, 1979.

Application forms from:—

The Secretary,
The Institute of Hospital Engineering,
20 Landport Terrace,
Southsea,
Hampshire,
PO1 2RG (Tel: 0705 23186).

For new Entrants

The Spirax-Sarco organisation has a long history and widely acknowledged expertise in all aspects of steam utilisation. They offer an extensive range of information and study material available to any hospital engineer. Further details and applications to Spirax-Sarco Ltd, Cheltenham, Glos GL53 8ER.

Study Material For Hospital Engineers

During the last decade a whole new breed of young engineers have entered the engineering branch of the National Health Service. They bring with them knowledge and practices of new and developing technologies which will benefit the application and practice of hospital engineering for years to come.

However, there may be many instances where the young engineer, in his efforts to keep pace with the new advancing technologies, has created gaps in the process of knowledge and practice related to those aspects of hospital engineering, which although mundane to some, will remain an essential aspect of engineering knowledge and practice in the foreseeable future.

One such element of hospital engineering is the generation, distribution and process application of steam. To the mechanical and environmental engineer such knowledge in both theory and practice may present little difficulty. To those with other engineering backgrounds (and there are now many in the NHS), there may still be a gap which needs to be filled, and that need is amplified by the ever increasing importance of energy conservation.

The purpose of this article is to acquaint those who admit to knowledge gaps with one source of information about the use of process steam that is readily available and of proven worth, and Institute will be glad to publish articles like this, which give general or specialist information to those wishing to extend their knowledge in fields of hospital engineering. The Editor also will be pleased to receive letters of comment on this article to test its reception and usefulness.

The following information will give a selection of the study material required and how to obtain it: —

Information Books

- IB2 The Boiler House
- IB3 Fuel Oil Heating
- IB4 Steam Distribution
- IB5 Effective Separation
- IB7 Condensate Rates
- IB8 Air Removal from Steam Installations
- IB9 Calorifiers
- IB10 Condensate Recovery
- IB11 The Recovery of Flash Steam
- IB12 Compressed Air

Practical Studies

- PS1 Steam in the Oil and Chemical Industries
- PS2 Steam Heated Tracer Lines

PS4 Air Venting of Large Steam Spaces
PS5 Heating Coils for Marine Applications
PS7 Direct Steam Injection
PS8 Plating and Metal Treatment
PS11 Warm Air Heating Systems
PS18 Energy Conservation in Steam Systems

Correspondence Courses in Steam Utilisation Simplified and Advanced Instruction Schemes

The Simplified Scheme consists of ten folios covering the most essential details of Steam Utilisation and Heat Transfer. It is intended for those who have not had a technical training and it is written with this in mind. The Scheme is also suitable for those in need of an easy 'refresher' on steam subjects.

The Advanced Scheme consists of two specialist courses and a Primary section common to both. When the Primary section has been completed, students may enrol for the specialised course that best meets their requirements or if preferred, take both of them.

The Courses are entirely free of charge. The folios are sent out at monthly intervals, and provide a really useful series of reference papers.

Advanced Instructional Scheme

Synopsis of Courses on Steam Trapping and Air Venting Practice

Briefly, each course is conducted by correspondence and is accompanied by individual instruction which is also by correspondence.

The Primary Section is common to both courses and on its completion the course splits up into the two specialised groups.

PRIMARY

Comprising folios A B C and D. Answers to the questions set are sent with successive folios.

Steam characteristics	Group trapping
Steam usage	Steam locking
Condensation	Air binding
Removal of condensate	Dirt
The purpose of steam traps	Utilisation of condensate
Steam trap types	Flash steam
Waterlogging	Lifting condensate
The drainage point	Waterhammer
Steam trap selection	Air in steam
Condensation rates	Effect of air on temperature
Steam trap capacity	How to deal with air

COURSE 1 ADVANCED — STEAM FOR HEATING

Comprising folios E F and G. Answers to the questions set are sent with successive folios.

Pipe heating installations	Canteen equipment
Steam radiators and convectors	Temperature control
Unit heaters	Use of exhaust steam
Heater batteries	Saturated or superheated steam
Calorifiers	Flash steam recovery
Hot water supply	Vacuum steam heating
Hospital equipment	Maintenance suggestions

COURSE 2 ADVANCED — STEAM FOR PROCESS

Comprising folios E F and G. Answers to the questions set are sent with successive folios.

Requirements for process heating	Hot air dryers
Steam for heating liquids	Contact dryers
Steam for space heating	Steam for cooking
Evaporation and distillation	Retorts and vulcanisers
Multiple-effect evaporation	Representative process installations
Steam for drying	Maintenance suggestions

Instructional Scheme

COMPRESSED AIR

The Course consists of eight folios which are available in either Imperial or SI Metric units. A synopsis of folios sent out at monthly intervals is set out below.

SYNOPSIS

Folio 1
Why use air
Properties of gases
Compressors

Folio 2
Compressor cooling
Control and safety
Compressor efficiency

Folio 3
Properties of water vapour
Coolers and dryers
Receivers
Automatic drain traps

Folio 4
Uses of compressed air:
direct
for linear power
for rotary power
for control and measurement

Folio 5
The Distribution System
Sizing mains
Conditioning the air (filters/regulators/lubricators)

Folio 6
Actuators:
mounting styles
construction
cushioning
speed control
positional control
torque characteristics

Folio 7
Valve: types/construction
Valve operating mechanisms
Use of electrics
Simple circuitry:
remote control
automatic cycling
sequential control

Folio 8
Time delay
Positional control
Quick exhaust valves
Safety
Silencers
Centralised control systems
Logic functions
Fluidics
Summary of course

This paper was presented on the final day of the 34th Annual Conference of the Institute, held at Cardiff earlier this year. The author is Principal Acoustics Engineer at the DHSS.

Noise Control in Health Buildings

T. WAGSTAFF MSc BFc(Eng) CEng MIMechE FIHospE MIoA

Until ten years ago acoustics was the province of the academic physicist. To unravel the complexities of the derived equations needed the mind of a mathematician. It was, therefore, convenient for the designer of building services to forget that noise could be a problem. If, at the completion of the project, complaints were received then an 'expert' could be consulted.

Those complaints could not be predicted. Sometimes, for no apparent reason, a single room in a building would provoke a multitude of complaints. Thus many researchers began work to assess the amount of reaction that could be expected for a given sound.

Noise and its control has filled many books. Obviously here the limitations of time must restrict us to a very small area. Here we examine what is noise control, why it is necessary, when and by whom it is carried out and how it is approached. The questions What, Why, When, Who and How form an excellent foundation for this introduction to noise control in health buildings.

Noise

The first problem is to identify the difference between sound and noise. Everyone can identify a pleasing sound from an unpleasant noise. However, generally no two people necessarily agree in this assessment.

The response to sound is a very personal one. It is this very subjectiveness that has led to great volumes of research to find out the relationship between the physical parameters of sound and the provoked response. For example, relationships have been derived for loudness, annoyance, fear and the noise source. It is further complicated by the fact that reaction to a given magnitude of sound differs for different sources of sound.

For instance the opening of Beethoven's 5th Symphony and a song bird are found tolerable and even desirable, but boiler house noise is unacceptable. A glance at *Figure 1* shows that the overall noise levels of the music and boiler house are not too dissimilar, and

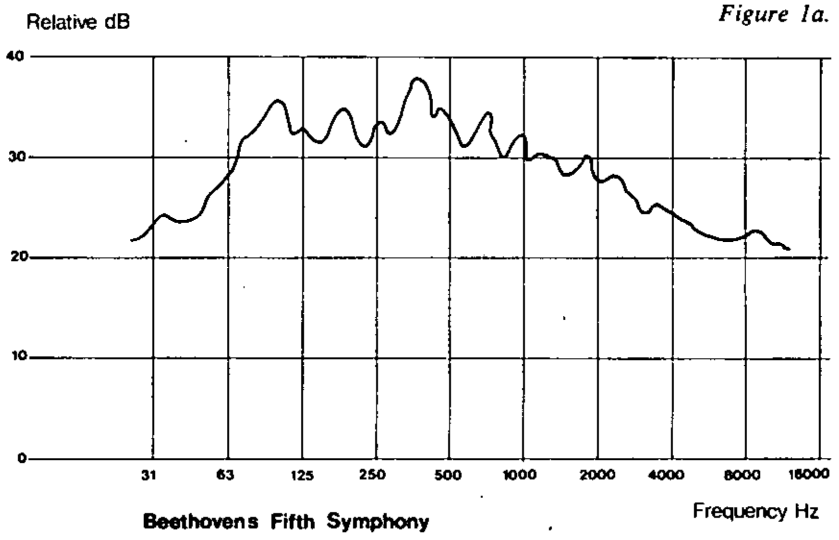


Figure 1a.

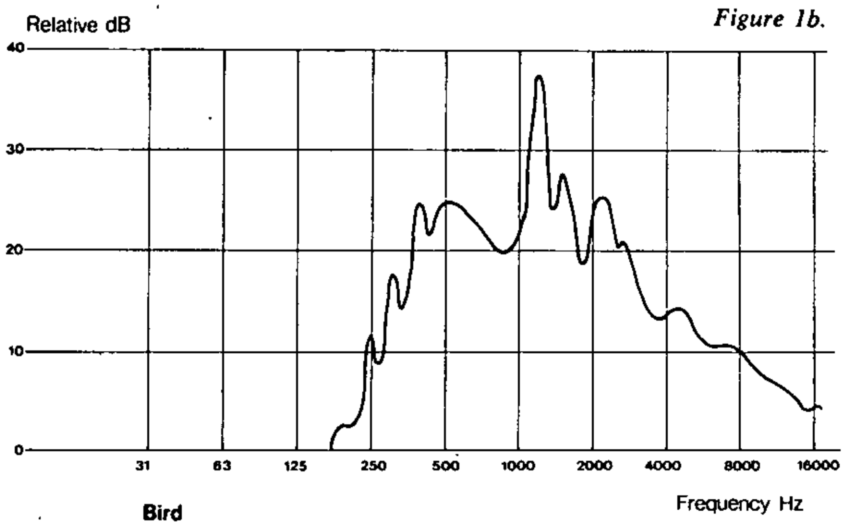


Figure 1b.

that all three have pure tone elements. So then what is noise? Perhaps this poem by a nine-year-old has the answer—

Noise is a thundering and clashing
of an express train,
Noise is the howling and screaming
of the wind,
Noise is the clanking and crashing
of the milk bottles,
Noise is the screaming and shouting
of people,
Noise is the wireless blaring out loud.

Apparently noise can be defined as unwanted and socially unacceptable sound. This then is the definition of noise control, *ie* to control the acoustic environment so that noise becomes acceptable sound. This immediately causes problems as this acceptability must be predicted from physical parameters, namely—

Magnitude	**Onset**	**Source**
Quality	**Duration**	**Sensitivity**

These parameters will be considered in more detail a little later.

To further confuse the situation there are different physiological reactions to noise. The ear is regarded as being able to detect notes from 20 to 20,000 Hz. The ear is not equally sensitive to all frequencies. *Figure 2* shows that the ear is much less sensitive to low and high frequencies, and that this sensitivity varies with sound intensity. The sensitivity is decreased with increasing age or exposure to excessive noise. Typically, engineers are virtually deaf to frequencies around 4,000 Hz. Most people reading this will not be able to hear over 15,000 Hz and few people of retirement age can hear frequencies above 12,000 Hz.

At the low frequency end, say below 50 Hz, the sound may be felt rather than heard. Car sickness is typically caused by a low frequency noise or vibration causing resonance in the ear and upsetting the balance organ. It is often alleged that high frequency sound is associated with physiological disturbances eg headaches, loss of drive. So both high and low frequencies cannot be ignored completely.

Objectives

So far the factors discussed apply to every situation. Now is the time to look at the particular noise control needs of health buildings. The designer generally has the objectives of providing an environment to ensure the

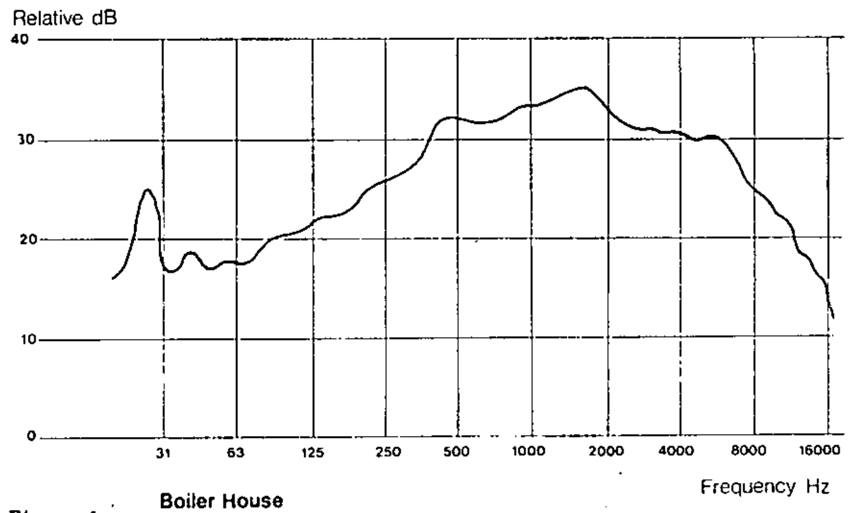


Figure 1c.

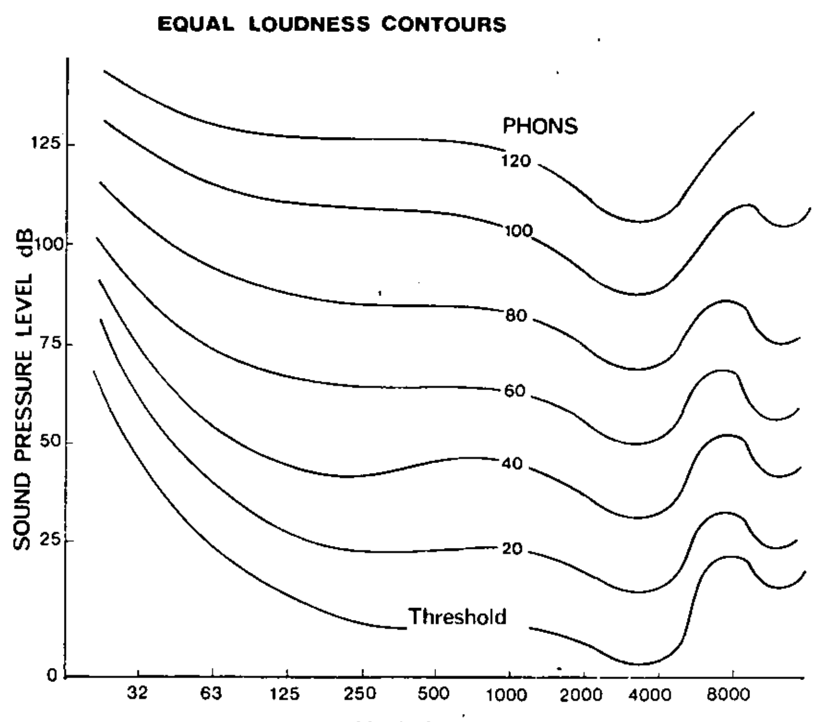
comfort and recovery of patients, and the provision of suitable conditions to enable staff to carry out their duties.

Noise control also has these two objectives. But there is an additional one. Wherever vast quantities of energy are produced, consumed or transformed there is a risk of generating high noise levels. The general public envisage hospitals as places of quiet and rest. Hospitals, of course, are very noisy and their noise emission can affect large areas of residential accommodation. So the third objective is to control the effect of the hospital noise on the surrounding community.

Why?

The layout of the building and the design of the building services must

Figure 2.



be undertaken from the standpoint of human requirements. It is relatively easy to specify the characteristics of the users and the task they perform. The difficulty in health buildings is the immense span of activities and uses. The patient may be long stay or only make one short visit as an outpatient. The staff perform a wide range of duties from the long operating sessions, through hotel and office functions to the industrial zones.

The environment is made up of spatial, visual, thermal and aural elements. Many people find the first three intangible, and in the event of the total environment being wrong, *noise gets the blame.*

This sets the first rule of noise control — check with the users what they think they want to do, what they are actually doing, and whether the other environmental factors are alright. This interaction makes the setting up of an integrated environmental specification for health buildings very desirable.

In health buildings one key factor which causes complaints about noise is overheating. To combat excess heat the windows are opened instead of the controls being adjusted. This immediately lets in dust, fumes and noise. Noise gets the blame. In mechanically ventilated areas conditions are different, both for staff and patients, to those experienced in their outside life. Typically there is some air movement noise. So again noise is the focus of the attention whereas the complainant is perhaps suffering discomfort due to some other intangible factor.

Clearly this is an over-simplification of the very complex reasoning that typifies the human animal. One thing is certain, once noise is the subject of a complaint it is very hard to satisfy the complaint. Even if the noise is reduced to what at the outset would have been considered reasonable, complaints will continue to be received.

Extrapolating research work into sources of complaint in other than health buildings it becomes apparent that—

People will complain even though the source is of direct benefit to them;

Adaptation occurs — they either grow to tolerate the noise or they continue to complain even when the noise no longer exists;

Quantity of noise (as measured on a sound level meter) is not fully correlated with the incidence of complaints;

The quality of the noise is an important factor;

Short duration sounds can cause as many problems as continuous noise;

Night time sounds appear twice as loud.

From this evidence one realises that early thought must be given to noise control and noise should be considered along with the other environmental factors. The inter-reaction of the six items above is highly subjective. Perhaps a few years ago the community accepted hospital noise emission since a hospital was for the greater good. This is no longer the case. The aim must be to ensure that the 'loudness' of an environment, either within the hospital or externally, is acceptable to most people for most of the time. (Loudness can be considered as an interaction of quantity and quality.) Never will the noise level satisfy all for the whole time. If in fact it does there will have been a serious over-design with the associated cost penalties.

Acceptable Acoustic Environment

At this stage the definition of an acceptable acoustic environment ought to be considered. 'Acceptable' is used relatively. Obviously a very quiet environment is not needed for a typing pool in which the occupants themselves generate noise by their activities. Likewise the quality of their output will suffer if they are housed in acoustic conditions akin to the boiler house.

Above it was stated that the aim was to satisfy most people for most of the time. For example, 50% of a sample population suffer a sleep disturbance when they are subjected to a noise level of 45 dBA. This disturbance is not necessarily that they awake, maybe they change from one sleep state to another. In a bedroom the objective is to sleep and the design level is set accordingly. At this stage the dBA unit is used to develop the argument. Other units could have been used.

To say 45 dBA must never be exceeded is not only impracticable but also impossible to achieve. For instance the whole point of an alarm clock is to wake one up. So the alarm clock must exceed 45 dBA to achieve its objective. Similarly the design engineer cannot assess or design for the occupant's own noise eg snoring.

If one says the level in the room must average 45 dBA then sleep disturbance will occur statistically on average one second in every two. A high level of disturbance would result. This average level is called the L_{50}. The level L_x is the level which is exceeded for x of the time.

So generally the L_{10} would be set at 45 dBA. In other words for 90% of the time the noise level would be below 45 dBA, and over 50% of the population would suffer no disturbance. Immediately it is clear that some proportion of the population would suffer sleep disturbance. They may also be the vociferous proportion of the population who complain freely.

However one sets the criteria, there will always be some complaints. Most of these complaints will be from people who feel genuinely aggrieved. Whether or not further noise control measures are adopted must remain to be decided in the light of all other factors which may or may not be related to acoustics.

Having set the criteria for quantity of noise its quality must be considered. The ear is not equally sensitive to noise of all frequencies. A low or high frequency noise needs to be much greater than a middle frequency sound to be heard at the same loudness. The closer the noise follows one of these equal loudness contours of *Figure 2* then the more acceptable will be the quality of the sound.

Where an environment has a predominant tonal component the sound is assessed subjectively as being 5dB noisier than it is. Similarly stopping and starting noise, impulsive noise and other short duration sounds appear about 5 dB louder. Whereas during the day 55 dBA is acceptable, a night time sound of 10 dBA less would probably be judged to be as noisy.

When

Traditionally noise control measures are taken after a job has been completed, handed over, is in use, and complaints have been received. Noise control is synonymous for many designers with failure. The man whose project has noise problems is pitied.

Noise control should start at the outset of a project. Immediately from the client's brief areas sensitive to noise or those which emit noise can be identified. It is perhaps axiomatic that the final layout should not have these two types of area adjacent to one another.

Effective noise control requires the operational policies of the spaces to be

investigated. It is too easy to specify a general all embracing value of NR 35. Once commissioned, the user will find that the waiting areas are too quiet and consequently lack privacy. In other areas diagnostic work may be hindered because it is too noisy.

Even the ambient noise at the proposed site is important. A building can be orientated so that it is self-shielding. So noise control must come early into the discussions.

Cost

As a rough guide industry allocates approximately 2½% of the gross project costs to noise control. This allowance covers all fees to specialists as well as material and associated labour. No figures have been identified for health service buildings, where noise control appears to be treated as an abnormal and additional expense.

To attempt rectification after construction is expensive. Very little is achieved in the way of noise reduction for an expenditure of £7,500 once fees and disruption are taken into account.

Who

Those practising noise control must be part-time sociologists, so that they can predict the response of those subjected to noise. They must also be architects to preserve the æsthetic lines of buildings and rooms, engineers actually to measure and derive solutions, and statisticians to judge the probable success or failure on the 'average man'. Finally when all else fails and the person most affected is neither the reasonable or normal man in the street, one must resort to psychology.

The foregoing list of qualities is not too dissimilar from those needed by any good designer or project manager. Life is a compromise, so also is the end result of noise control. Unfortunately there are two major factors which so often frustrate the effectiveness of the final health building.

The first is a lack of financial resources. This inevitably results in space saving economics. Rooms become dual purpose, usually with conflicting acoustic requirements. This lack of money is restrictive, but, given goodwill is by no means insurmountable.

However, there is no substitute for the lack of inter-professional teamwork in the planning and design stages. Too often this co-operation is missing. At the very beginning the room's function and the operational policies should be specified. It is, perhaps, stating the obvious, but quiet rooms should be sited in quiet areas.

Design is not an end in itself. There is an important step before a health building is ready for its user, and that is commissioning. Plant and equipment are checked to see whether the design intent is met. However, no acoustic commissioning is undertaken except perhaps in specialist quiet areas.

The user occupies the room. At most times the acoustic conditions fulfil the user's needs or he can adapt to the deficiencies. Where the acoustic conditions are unacceptable and are only discovered to be so after the building is in use considerable disruption will occur in righting the mistake, if in fact it is possible to do so.

So the answer to 'Who' is responsible for noise control in health building?' is — everyone. There is little point in providing an ultra-quiet ventilation system in a typing pool where the noise generated far exceeds the ventilation noise. Similarly, to change at a late stage the function of a room say from a waiting room to a specialist diagnostic room can spell acoustic disaster.

These two examples are extreme cases, but similar situations do occur. The works professions must play a leading role in interpreting the needs of the user and ensuring that they are met. The user must be able at the outset to know their needs and to use the end result as it was designed.

Noise control is an ongoing function. Minor maintenance can cure major noise problems *eg* door closers correctly adjusted, bed screens/curtains kept from squeaking. Doors to noisy areas should be kept closed. These are elementary noise control measures which can easily be adopted.

How

Earlier the physical parameters of noise were discussed. Using a sound level meter the sound pressure level is measured. The direct meter reading gives either an overall sound pressure level, an 'A' weighted noise level, or if a filter set is fitted, readings in various bands of frequencies.

The 'A' weighted sound pressure level or the noise level in dBA is a powerful measure. If a receiver hears only one noise source, for instance traffic, aircraft or ventilation, then the Traffic Noise Index, Noise and Number Index and Noise Rating are available to judge a subjective response to that source. The actual subjective response judged by the measure will depend on how the particular research worker set up his project.

In health buildings the overall acoustic climate is important. Take for example a ward in a mechanically ventilated hospital. The noise sources will be from the external environment; from within the hospital but outside the ward, ventilation noise; and noise from activities within the ward.

The various indices mentioned earlier, not to mention the multitude of others which have been derived cannot be combined to give any meaningful measure of the acoustic environment.

The dBA noise levels from different sources can be combined. The result is a value which measures the type of acoustic environment achieved. Also in favour of the dBA unit is the fact that it is the best predictor of subjective reaction for single or combined noise sources. As a guide, the various noise level bands and the associated environments can be classified as follows:

Below 35 dBA — Very quiet, specialist areas,
35 to 45 dBA — Quiet,
45 to 55 dBA — Normal, suitable for most occupations,
Above 55 dBA — Noisy, industrial situations,
Above 85 dBA — Dangerous, risk of permanent hearing damage.

So the dBA is a convenient measure of noise magnitude. It gives no information about the quality or the frequency components in the noise. Hence the need for frequency analysis. Most acoustic data is quoted in octave bands. For many uses octave band sound pressure levels are adequate, though octave band values must be considered only as a very coarse attempt at defining the noise quality.

In *Figure 3* the octave band spectrum of a fan is shown. On the same figure are the predicted values using data given in the IHVE Guide. This would lead one to the conclusion that the noise would be acceptable. If a one-third octave band analysis is made, *Figure 4*, the picture is not so smooth.

For remedial measures even one-third octaves are too imprecise. With the filter sets now available one can easily measure the spectrum in 0.5 Hz or smaller steps. So in *Figure 5* some distinct features can be seen. The two major peaks represent the discreet frequencies associated with the shaft revolution and the blades.

The usual procedure is to add a

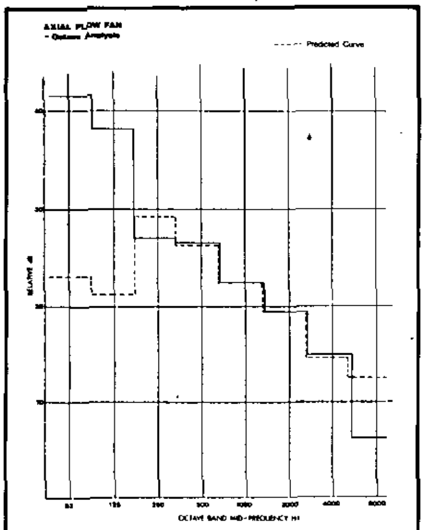


Figure 3.

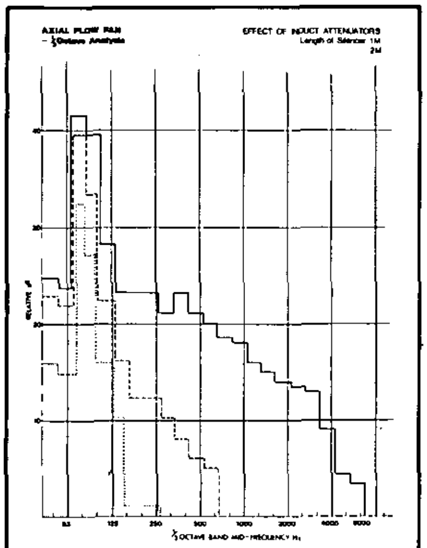


Figure 4.

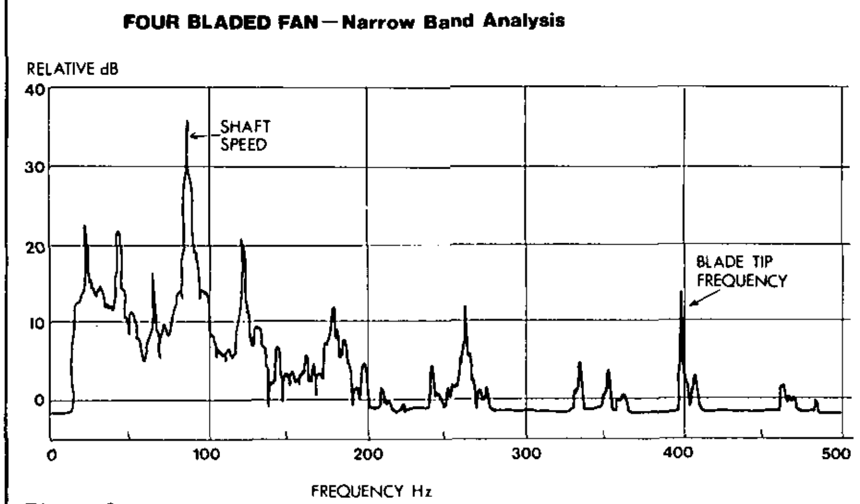


Figure 5.

silencer in the ductwork after the fan to ensure that the ventilated area does not have an unacceptably high noise level. Often a small silencer is used, say 1m in length. Although this will reduce the overall noise level a short silencer will have little effect on the low frequency content of the noise. In fact, as shown in *Figure 4*, there is only an attenuation of the high frequency content of the fan noise. The result is that the discreet low frequencies are relatively more pronounced.

The quality of the fan noise in the room is relatively more acceptable without the silencer. The only effect of a small silencer is to reduce the overall magnitude. Silencers of 2.5m or longer are required to have any measurable attenuation on frequencies down to 63 Hz.

There is another trap for the unwary when selecting a silencer. Most manufacturers quote their performance figures in terms of static insertion loss. This is determined in a laboratory by placing a noise source at one end of the silencer and a microphone at the other end. The difference in noise level is the static insertion loss.

In practice when a silencer is used there is an air flow. The very use of a silencer disturbs that flow. This turbulence generates noise; thus the effectiveness of the silencer is reduced. The attenuation achieved with an air flow is called the dynamic insertion loss. It is the dynamic insertion loss which is important, not the static insertion loss. The other factor to remember is that there will be a relatively large pressure drop across the silencer.

The silencers discussed above are all dissipative attenuators which work by absorbing the sound energy. The alternative where there is a very narrow band of noise is to use a reactive silencer. These variously are known as side-branch or Helmholtz resonators. In the case of a moving part there will always be a predominant frequency as shown in the case of the fan above. By the correct design of the resonator quite dramatic attenuations can be achieved.

There are, as always in noise control, some disadvantages. if the frequency is not steady, *eg* the moving part changes speed, then much of the resonator's effectiveness is lost. Continual fine tuning may be needed over a period of time. However, a cross between reactive and absorbative attenuation can be very effective.

Ventilation noise is just one of the noise sources which have to be considered. As outlined at the beginning of this section the total acoustic environment is the sum of many noise sources. Some of those noise sources may be acceptable on their own, others will be intolerable because of either quantity or quality. In this example the real situation has been simplified to two noise sources, both are taken as being steady.

One noise source is fairly broadband and of the two is predominant. The second has a tonal component but is somewhat less in magnitude. There is an immediate temptation to control the predominant noise. If this is done, then the resultant noise may be acceptable in quantity but will be unacceptable in quality. The broadband noise is said to mask the second noise source. This example is shown in *Figure 6*.

Often the treatment of one noise source leads to the discovery of another problem. If the overall acoustic environment is suspect before treatment the effect on the whole of each individual source must be investigated. This is a long and time-consuming process and needs sophisticated equipment. This is why it is far better to take the necessary noise control procedures at the design stage.

Noise sources which are continuous, or which gradually increase and slowly decay are the most acceptable. Intermittent noise, especially if impulsive, is the most disturbing. Someone who is performing a complicated task is likely to be disturbed by a change in sound. The sensitivity of the recipient

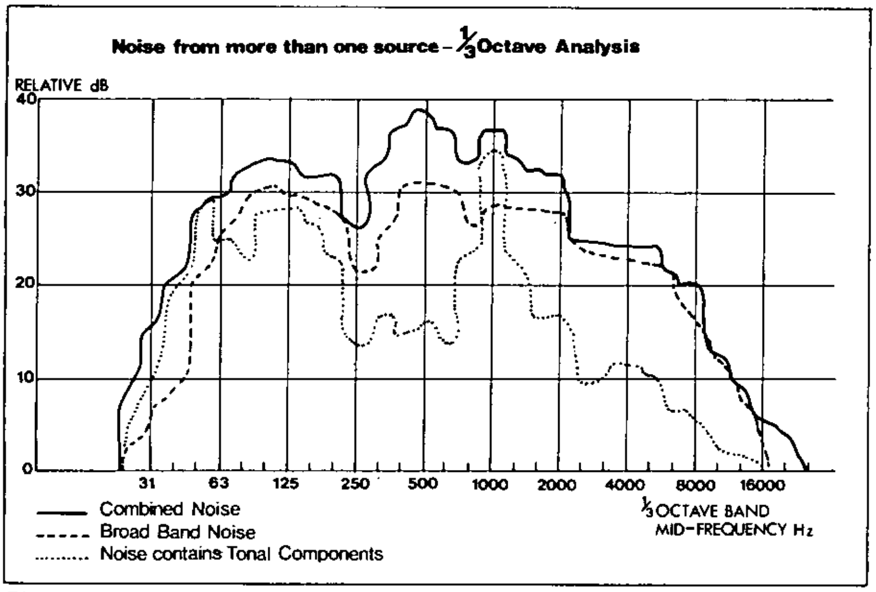


Figure 6.

to noise must be judged from the occupation or task which is being performed. It is an unfortunate fact that some noise sources cause fear, *eg* dentist's drill, or annoyance, and no amount of remedial measures will solve the problem.

Noise control is still an art, though the practitioners try to blind the recipients with science. The best way to cure a problem is to tackle it in easy stages, testing at each stage. Some simple steps can be outlined:

a. Treat at source — this removes the problem completely;
b. Contain the noise — usually only partially successful;
c. Remove recipient — which causes inconvenience or is impractical.

The silencer is an example of treatment at source. Often in the ventilation field the air movement velocity is too great. At the design stage larger terminal units could be selected or a low velocity system adopted.

Containing the Noise

In many instances it is impossible to treat the noise at source. Efforts must be made to contain the noise in a pre-selected area. It is an unfortunate characteristic of noise control that the result never comes up to expectation.

Consider, as an example, a standby generator. The measured noise level is found to be in the region of 89 dBA. Notionally, a 9in brick wall would provide a sound reduction index (SRI) of 50 dB. (The sound reduction index is the average of the attenuations in the 100 to 3150 Hz 1/3 octave bands. This value approximates to the attenuation in dBA.) In the wall will be a heavy access door with a sound reduction index of 38 dB.

If the door has an area which is 10% of the whole wall the effective sound reduction index will now be about 45 dB. This assumes that the door is a perfect fit. If, however, the door has a 1mm air gap down one side, the value will fall to 39 dB

So far the wall has been taken as perfect. It is presumed that there are no gaps in the mortar, and there is a perfect seal between the roof and wall. In practice the measured sound reduction may be as low as 15 dB. It is quite typical for the final 'on site' sound reduction to be between 33 and 50% of the laboratory value.

The cause of the difference is flanking transmissions. An extreme example is where a partition which is defined as a 40 dB SRI finishes at the false ceiling. The effective attenuation could be 13 to 15 dB.

Everyone is aware that increasing the mass of a partition increases its attenuation. Greater increases in sound insulation can be achieved if the partition has a discontinuous cross-section. At the design stage the theoretical sound reduction can be estimated from:

$SR = 15 \log M + 12 + K$

where M is the density kg/m^2

K is a factor for the air gap

K = 0 for no air gaps
K = 3 for 40mm air gap
K = 9 for 75mm air gap
K = 15 for 150mm air gap

From this relationship it may be seen that having a partition in at least two elements separated by air gaps is advantageous. The same principle applies to double glazing. If standard glass in a light-weight frame is installed its effective mass will be about 7.0 kg/m^2. Thus from the above a SRI of about 25 dB would be expected.

This expected value will be reduced if the glass is not fully sealed to the frame or if there are air gaps around the frame. Normally this will be an opening window construction, so the final SRI may be as little as 12 dB.

Thermal double glazing manufacturers extol the virtues of their product including its acoustic insulation properties. The air gap is too small to have any significant effect. The extra attenuation arises solely from the doubling of mass. However, if the air gap is increased to 200mm and acoustic absorbent material is used to line the reveals, a SRI up to 43 dB is achievable.

Conclusion

To identify the need for noise control at the outset of a project is not a sign of failure. If noise control is considered early, it can be implemented at the design and construction stages. Noise should not be considered in isolation but as something totally integrated with the spatial, visual and thermal environmental design. This integrated design will achieve:

an acceptable environment for patient and staff activities;
safe working conditions; and
harmony with the community.

Noise control in its simpler forms need not be expensive. Many commonsense approaches and good engineering practices automatically lead to the designing out of noise problems.

Institute of
Hospital Engineering

34th Annual Conference

Papers given at this conference which we hope to print in a future issue of *Hospital Engineering*, will include:

'Some Applications of Nucleus Solutions'
P. A. Tyler and P. Jones;

'Steam Sterilisers'
S. A. Gibbons.

A paper given at the 1978 Annual Conference of the Institute. The authors are, respectively, Assistant Regional Engineer and Main Grade Engineer in the West Midlands RHA.

Monitoring the Effects of NHS Investment in Energy Conservation
-a management task

E. J. BRETHERTON CEng MIMechE MCIBS
R. BRIGGS BSc

The NHS in England and Wales has now embarked on a £28m programme of investment in Energy Conservation announced in HN(77)192, as part of a government objective to bring public sector buildings up to a minimum standard of energy efficiency during the next ten years. £13.3m of this sum is to be funded by DHSS, and the balance of £14.7m is intended to be provided by means of savings diverted from revenue expenditure on energy, which accrue from 1979/80 onwards as investment measures begin to take effect. The aim is to stimulate investment over the next four years and to create a situation after 1980/81 in which £8m/annum is available, financed wholly from revenue expenditure, for energy conservation.

The period that this programme of investment will need to be sustained beyond 1981/82, will be determined by the extent to which savings for re-investment are realised over the initial three-year period, and the potential for saving which exists within present NHS expenditure on energy, currently running at about £120m/annum for England and Wales.

How realistic is this projected level of saving and re-investment? How is it to be demonstrated that investment has, or has not, achieved the desired results? Providing effective answers to these questions is a management task which faces the NHS Works professional, who will play the leading role in implementing the investment programme.

Four Essential Steps in Managing the Investment Programme

It is suggested that there are, as a minimum, four essential steps which need to be taken in order to establish effective management control of the investment programme: —

— Monitor energy consumption over the five year period 1977/78 to 1981/82, using 1977/78 as a reference year.

— Make allowance for the variable effects of weather and significant site changes which affect consumption over the period.

— Represent energy consumption in a form which enables the process of monitoring, and the changing situation it reveals over the period until 1980/81, to be generally and easily understood.

— Establish a routine procedure for analysing energy consumption, to highlight the effects of improvement measures (investment and housekeeping) and possible areas for further improvement.

Energy Monitoring Sheet

The means by which these four steps can be taken are embodied in an Energy Monitoring (EM) sheet produced by a Working Party in the West Midlands, consisting of Operational Works Managers and RHA specialists on energy matters. The EM sheet is based on the West Midlands Energy Audit system for health buildings, adapted to meet the circumstances of the investment programme.

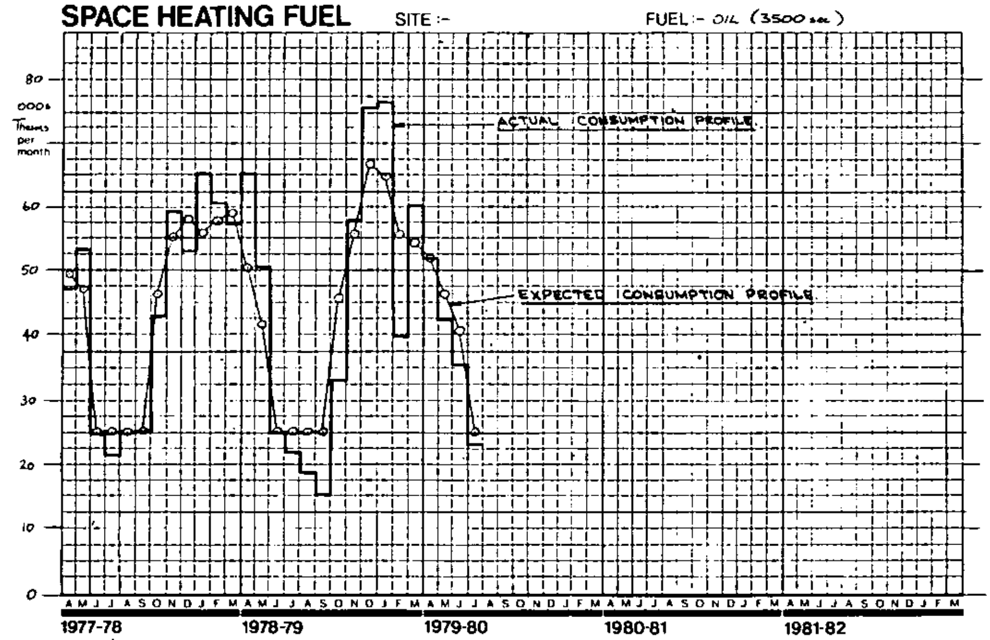
It is envisaged that the task of 'Monitoring' energy consumption over the four year period of the investment programme will be carried out at Unit or Sector level, with agreed arrangements for providing management information to District and Area. This will enable investment decisions to be taken, where necessary after energy survey(s) are carried out to identify the substance of possible energy saving measures. In this context, EM sheets, as illustrated on pages 14-15, have been designed (based on an A1 sheet size) to fulfil three functions. These are to serve as a complete working record for use by Unit/Sector staff to record energy consumption over the period 1977/78 to 1981/82; provide Works Management information for District/Area, both on the effects of conservation measures which have ben taken, and the need for further measures; provide a means of convey-

Energy Monitoring 1977-82

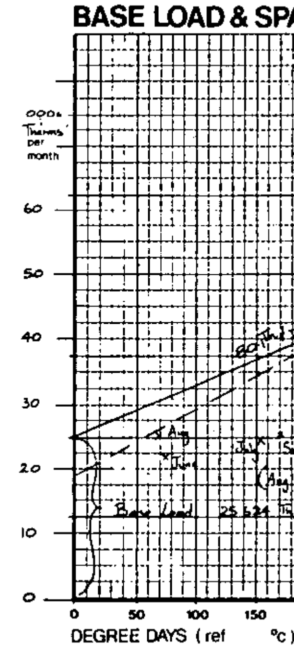
Produced by the Regi[...]
West Midlands Region[...]

SPACE HEATING FUEL

SITE :- FUEL :- OIL (3500 sec)

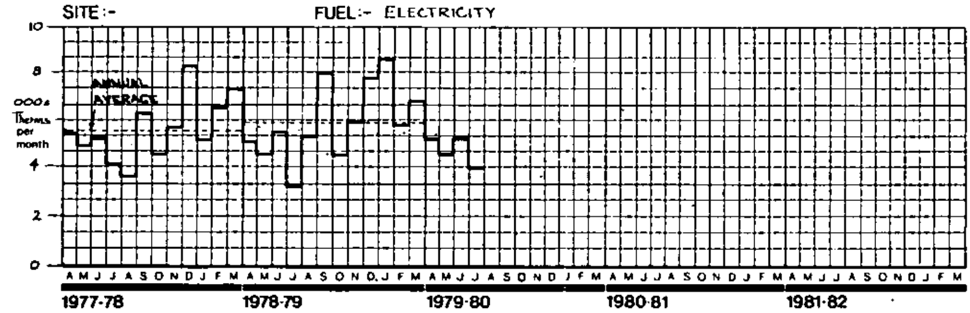


BASE LOAD & SPA[...]

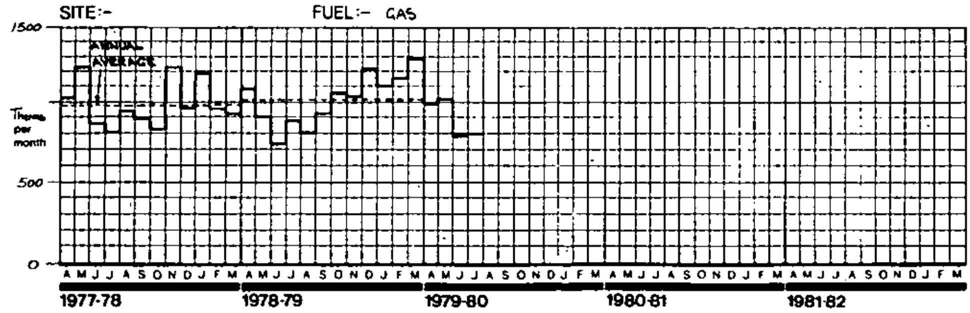


NON SPACE HEATING FUELS

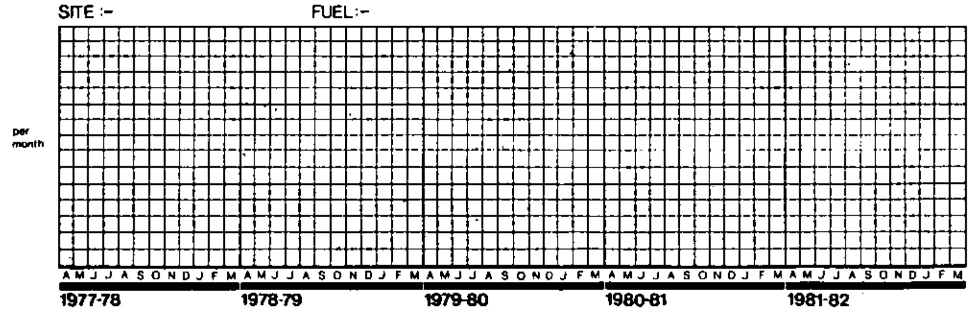
SITE :- FUEL :- ELECTRICITY



SITE :- FUEL :- GAS



SITE :- FUEL :-



RECORDED ENER[...]

FINANCIAL YEAR

Month	D day 18·5°C	Sp Htg Fuel OIL Unit Th.	Non Spac[...] Fuel ELEC Unit Th.	Fuel G[...] Unit T[...]
A	313	47 574	5 397	1 0
M	284	53 032	4 882	1 2
J	154	24 847	5 292	6
J	74	21 750	4 111	8
A	69	25 041	3 629	9
S	170	25 600	6 246	8
O	273	42 945	4 526	8
N	388	59 357	5 665	1 2
D	424	52 974	8 232	7
J	395	65 366	5 128	1 1
F	419	61 200	6 522	9
M	436	57 397	7 336	9
Total	3399	537 125	66 959	11 7
Av'ge	283	44 760	5 580	98

FINANCIAL YEAR

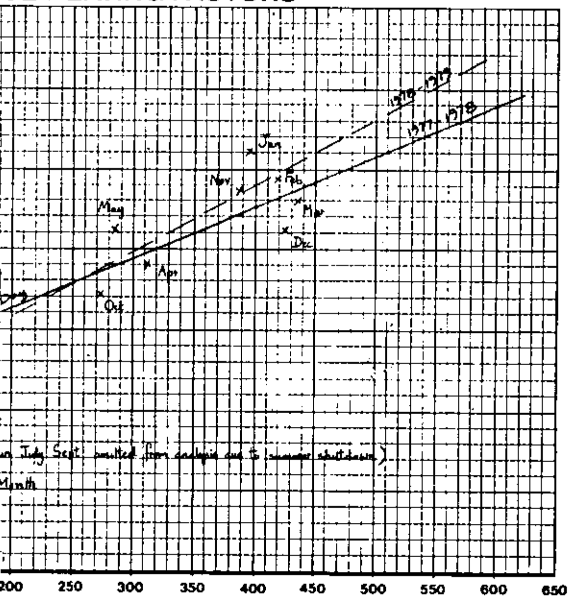
Month	D day 18·5°C	Sp Htg Fuel OIL Unit Th.	Non Space[...] Fuel ELEC Unit Th.	Fuel G[...] Unit T[...]
A	343	52 165	5 103	79
M	274	42 395	4 522	1 02
J	203	35 405	5 206	78
J	105	23 200	3 344	7
A				
S				
O				
N				
D				
J				
F				
M				
Total				
Av'ge				

FINANCIAL YEAR

Month	D day °C	Fuel Unit	Fuel Unit	Fuel Unit
A				
M				
J				
J				
A				
S				
O				
N				
D				
J				
F				
M				
Total				
Av'ge				

al Engineers Department,
Health Authority

CE HEATING FACTORS



GY CONSUMPTION

1977-78

...HEATING		
	Fuel Unit	Fuel Unit

FINANCIAL YEAR 1978-79

Month	D day 18·5°C	Sp Htg Fuel OIL Unit Th	Non Space Heating Fuel ELEC Unit Th	Fuel GAS Unit Th	Fuel Unit	Fuel Unit
A	326	65 471	5 020	1 091		
M	212	50 823	4 532	895		
J	106	25 149	5 408	735		
J	69	22 221	3 218	874		
A	97	18 808	5 285	803		
S	177	15 397	7 953	923		
O	266	33 164	4 502	1 057		
N	392	57 816	5 800	1 041		
D	530	76 062	7 723	1 216		
J	506	76 973	8 257	1 099		
F	393	39 667	5 680	1 149		
M	374	60 365	6 780	1 289		
Total	3448	541 911	70 158	12 162		
Av'ge	287	45 160	5 847	1 013		

1979-80

...HEATING		
	Fuel Unit	Fuel Unit

FINANCIAL YEAR 1980-81

Month	D day °C	Fuel Unit	Fuel Unit	Fuel Unit	Fuel Unit	Fuel Unit
A						
M						
J						
J						
A						
S						
O						
N						
D						
J						
F						
M						
Total						
Av'ge						

1981-82

Fuel Unit	Fuel Unit

SITE INFORMATION:

(Delete as necessary)

Type (use) – GENERAL & ACUTE / ~~GERIATRIC & PSYCHIATRIC~~ / ~~OTHERS~~

Building Period – ~~MODERN~~ / ~~TRADITIONAL~~ / MIXED

Site Layout – ~~SPREAD~~ / COMPACT

Boiler – ~~LANG~~ / ~~LANG & ECONOMISER~~ / ECONOMIC / ~~DECENTRALISED~~

Laundry – ~~YES~~ / NO

ANALYSIS OF ENERGY CONSUMPTION

FINANCIAL YEAR 1977-78

Fuel	Actual Cons (Therms)	Expected Cons ( )basis 19	Savings ( )	Unit Cost ( )	Savings £
OIL (3500s)	537 125				
ELEC	66 959				
GAS	11 784				
	615 868				

Heated Volume = 92 000 m³
Space Heating Fuel :–
Total Consumption = 58 383 Therms /Annum/10,000 m³
Space Heating Factor = 8·7 Therms /D day rel 18·5 °C/10,000 m³
Base Load = 2 785 Therms /Month/10,000 m³

FINANCIAL YEAR 1978-79

Fuel	Actual Cons (Therms)	Expected Cons. (77/78) basis 19	Savings (Therms)	Unit Cost (£/Therm)	Savings £
OIL (3500s)	541 911	547 780	+ 5 869	0·15	+ 880
ELEC	70 158	66 959	− 3 199	0·80	− 2 559
GAS	12 162	11 784	− 378	0·20	− 76
	624 231	626 523	+ 2 292		− 1 755

Heated Volume = 92 000 m³
Space Heating Fuel :–
Total Consumption = 58 703 Therms /Annum/10,000 m³
Space Heating Factor = 11·1 Therms /D day rel 18·5 °C/10,000 m³
Base Load = 2 086. Therms /Month/10,000 m³

FINANCIAL YEAR 1979-80

Fuel	Actual Cons ( )	Expected Cons ( )basis 19	Savings ( )	Unit Cost ( )	Savings £

Heated Volume = m³
Space Heating Fuel :–
Total Consumption = /Annum/10,000 m³
Space Heating Factor = /D day rel °C/10,000 m³
Base Load = /Month/10,000

FINANCIAL YEAR 1980-81

Fuel	Actual Cons ( )	Expected Cons. ( )basis 19	Savings ( )	Unit Cost ( )	Savings £

Heated Volume = m³
Space Heating Fuel :–
Total Consumption = /Annum/10,000 m³
Space Heating Factor = /D day ref °C/10,000 m³
Base Load = /Month/10,000 m³

FINANCIAL YEAR 1981-82

Fuel	Actual Cons. ( )	Expected Cons. ( )basis 19	Savings ( )	Unit Cost ( )	Savings £

Heated Volume = m³
Space Heating Fuel :–
Total Consumption = /Annum/10,000 m³
Space Heating Factor = /D day ref °C/10,000 m³
Base Load = /Month/10,000 m³

SITE:

HEALTH AUTHORITY:

ing information in a meaningful form to departmental managers, management teams and user groups, on energy consumption, costs and the effects of conservation measures.

The Concept of Energy Monitoring

The concept of 'Monitoring' as used on EM sheets is to identify shifts in the level and/or pattern of energy consumption for a site over the period 1978/9—1981/2, *when compared with 1977/78.* This will provide a means of judging the effects of investment in conservation measures over the next four years. Energy usage is represented in two forms on EM sheets: as it actually occurs, and in the case of fuel used for space heating—generally the principal site fuel, as it should occur — both throughout the year, and from year to year under the influence of weather variations. In the latter form, consumption is expressed in therms/degree day which permits a direct comparison of consumption to be made between different (equal) periods of time with allowance for weather variations.

Layout of EM Sheets

EM sheets include provision for
(i) Recording (monthly) energy consumption for the five year period 1977-1981.
(ii) Identifying the make-up of site load between that part which fluctuates with weather (Space Heating Factor) and that which does not (Base Load Factor).
(iii) Representing energy consumption in the form of visual profiles, and
(iv) Analysing annual energy consumption in comparison with 1977/78 as a reference year.
Consider each in more detail —

Recording Energy Consumption

Boxes are provided for recording energy consumption in each of the financial years from 1978/79 forward to 1980/81 and retrospectively for the reference year 1977/78. Consumption of each fuel per calendar month should be recorded, with corresponding hospital degree day information now issued by DHSS.

Where more than one fuel is used for space heating, monthly consumption figures should be aggregated in a single (space heating) column.

NB. The EM sheet can also be used for recording information on site water usage in one of the non-space heating columns of the recording boxes.

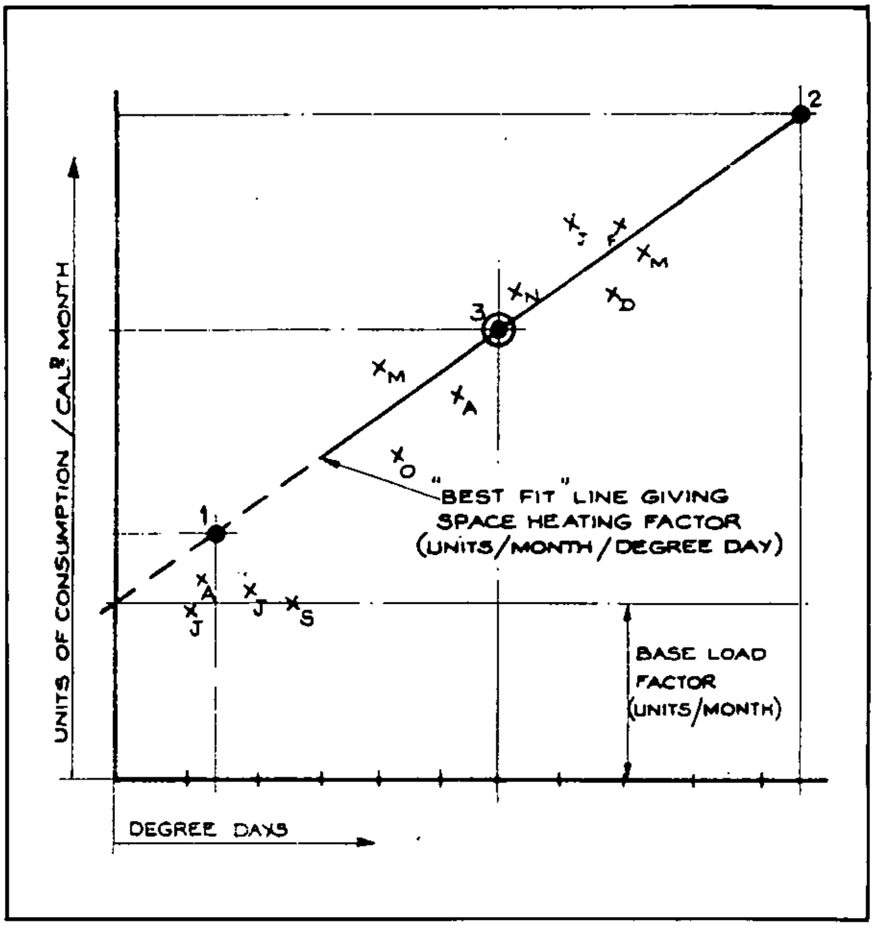


Figure 1.1.

Base Load and Space Heating Factors

This section of the EM Sheet is used to carry out a simple analysis of fuel used for space heating and other loads (column 3 of recording boxes), in order to identify that part of the load which fluctuates with outside temperature — the 'Space Heating Factor' and that which, nominally, remains constant throughout the year, the 'Base Load Factor'.

This can be done graphically, as can be seen from *Figure 1.1,* by plotting monthly figures of space heating fuel consumption (column 3 of recording box) against corresponding degree days for each calendar month (column 2). The slope of the 'best fit' line through the plots represents the variable Space Heating Factor in units of consumption/degree day. The intersect of the sloping line with the vertical ordinate of consumption identifies the Base Load factor corresponding to zero degree days. The accuracy of the graphical method is increased by pivoting the 'best fit line' on the arithmetic average point for degree days and therms, as illustrated in *Figure 1.1.*

The slope of the best fit line is established by taking two plots, one at either end of the line. The difference between the plots is used in the conventional way to calculate the slope, eg:

(i) 72,500 units = 600 degree days
(ii) 30,000 units = 60 degree days
difference
42,500 units = 540 degree days

rate of consumption

$$= \frac{42,500}{540} = 78.7 \text{ units of consumption/degree day}$$

The more accurate method of establishing Space Heating and Base Load factors for a site is by regression analysis. This is not as daunting as it sounds and is in fact a method by which — where the slope of variable consumption can be represented in the form $y=a+bx$ — the Space Heating factor 'b' and the Base Load factor 'a' can be calculated. Sufficient information on regression analysis for the purpose of calculating site load factors as part of energy Monitoring

is provided in *Figure 1.2*.

Using regression analysis to calculate the site factors for the example EM sheet produces a Space Heating factor of 80.1, compared with the result by the graphical method of 78.7. The error of approximately 1.5% in this case is small, but not insignificant remembering that the Space Heating factor is used as a multiplier (times degree days) to establish annual energy consumption levels. It should be noted that for both methods of establishing the site Space Heating factor, only consumption figures and corresponding degree days for those months when the heating system is taking significant load should be used.

Space Heating and Non-Space Heating Profiles

Provision is made on the EM sheet as illustrated in Appendix 1 for plotting profiles of energy consumption for Space Heating and Non-Space Heating fuels. Electricity consumption, and gas used for catering are examples of fuels which come under the latter heading.

The profiles are used to identify shifts in the level or pattern of energy consumption over the four year period, compared with the reference year 1977/78.

Two profiles should be drawn for space heating fuel(s) — the first being a histogram profile of actual monthly consumptions, for the second a profile of 'Expected' consumption is drawn using Base Load and Space Heating factors for the site, derived as above.

Expected consumption for the purpose of EM sheets is actual site consumption during the reference year 1977/78, adjusted for the difference caused by weather variations (degree days) in each of the subsequent years. As well as indicating a reference level of annual consumption based on 1977/78, the profile of Expected consumption also indicates the pattern of energy consumption which should occur through the year for space heating, as influenced by monthly degree day variations.

Profiles of Actual and Expected consumption should first of all be plotted retrospectively, for the reference year 1977/78. Histograms of actual consumption should be plotted for all fuels, (using monthly consumption figures tabulated in the recording boxes on the EM sheets). A profile of Expected consumption is then drawn for the space heating fuel(s) by plotting (the addition of) the Base Load factor and the Space Heating factor ×degree days (in a particular month). Individual monthly plots are joined to draw the profile.

Figure 1.2.

Regression Analysis

The position of a line through a scatter of points, representing plots of monthly fuel consumption and the corresponding degree day figures, is best determined by regression analysis. A full description of the technique is given in HSE 33-35 inclusive, but the mechanics of it can be explained quite briefly. The equation to a straight line is: —

$$y = a + bx$$

where, in this context, y is the monthly fuel consumption and x the monthly degree days. The constants a and b have to be evaluated to give the 'best fit' to the points. The first step is to table x, y, x^2, xy and y^2.

	Degree days	Consumption			
n	x	y	x^2	xy	y^2
1					
2					
.					
.					
n					
	Σx	Σy	Σx^2	Σxy	Σy^2

and add the columns. These summated figures are used in three calculations: —

$$\int x^2 = \Sigma(x^2) - \frac{(\Sigma x)^2}{n}$$

$$\int y^2 = \Sigma(y^2) - \frac{(\Sigma y)^2}{n}$$

$$\int xy = \Sigma xy - \frac{\Sigma x \Sigma y}{n}$$

and then $b = \frac{\int xy}{\int x^2}$ and $a = \frac{\Sigma y - b\Sigma x}{n}$

To give the equation

$$y = a + bx$$

If y is then calculated for low and high value of x, this gives two points on the graph between which a straight line may be drawn. One further calculation: —

$$r = \frac{\rho xy}{\sqrt{\rho x^2 \, x\rho y^2}}$$

gives the correlation coefficient which is a numeric indication of the degree of scatter (unity if all points are on the line, zero if the points are wholly random, a figure above 0.9 being generally satisfactory).

The point where the line cuts the fuel consumption axis, *ie* at zero degree days, is a measure of the base load, and should approximate to the July/August consumption figure, when space heating is minimal.

An arithmetic average line should be drawn for non-space heating fuels as this provides a useful year to year comparison of consumption levels.

Large industrial type loads (laundries, CSSDs etc) are likely to have a distorting effect on the space heating profile, where the load is fed from a central site boiler plant. It is recommended therefore that they should be plotted separately on the EM sheet using a histogram profile related to throughput.

Analysis of Energy Consumption

Analysis boxes are provided on EM sheets as a means of identifying, in tabular form, the difference in annual consumption and cost for each of the four years 1978-81 compared with the reference year 1977/78. Consumption in 1977/78, when weighted for the difference in weather in each of the subsequent years (degree days), is identified as Expected consumption in the analysis boxes.

Expected consumption figures for the space heating fuel in 1978/79, and similarly for other subsequent years, is established from the addition of the Base Load factor per 10,000m³ for 1977/78 (×12), and the Space Heating factor per 10,000m³ for 1977/78 × degree days *in the current year* during the period the heating system is taking significant load), after each has been multiplied by the volume factor (9.2 in the example).

Illustrating this numerically:

Expected Consumption for 1978/79 is:

	Therms/Annum
Base Load Factor:	
2,785 × 12 × 9.2 =	307,464
Space Heating Factor:	
8.71 × 2,999 × 9.2 =	240,316
	547,780

NB. It is important to note that only degree days during the period the heating plant is taking significant load should be used in conjunction with the Space Heating factor in deriving Expected annual load. For the example illustrated, this includes the months of October to May in which there are 2,999 degree days. Expected consumption for non-space heating fuels, are the actual consumption figures for the reference year 1977/78.

In addition to total Actual and Expected annual consumption and related cost figures, Total Consumption, Space Heating and Base Load factors should be established for each year as illustrated, as a means of identifying what should be a progressive improvement linked with investment, or 'good housekeeping', measures.

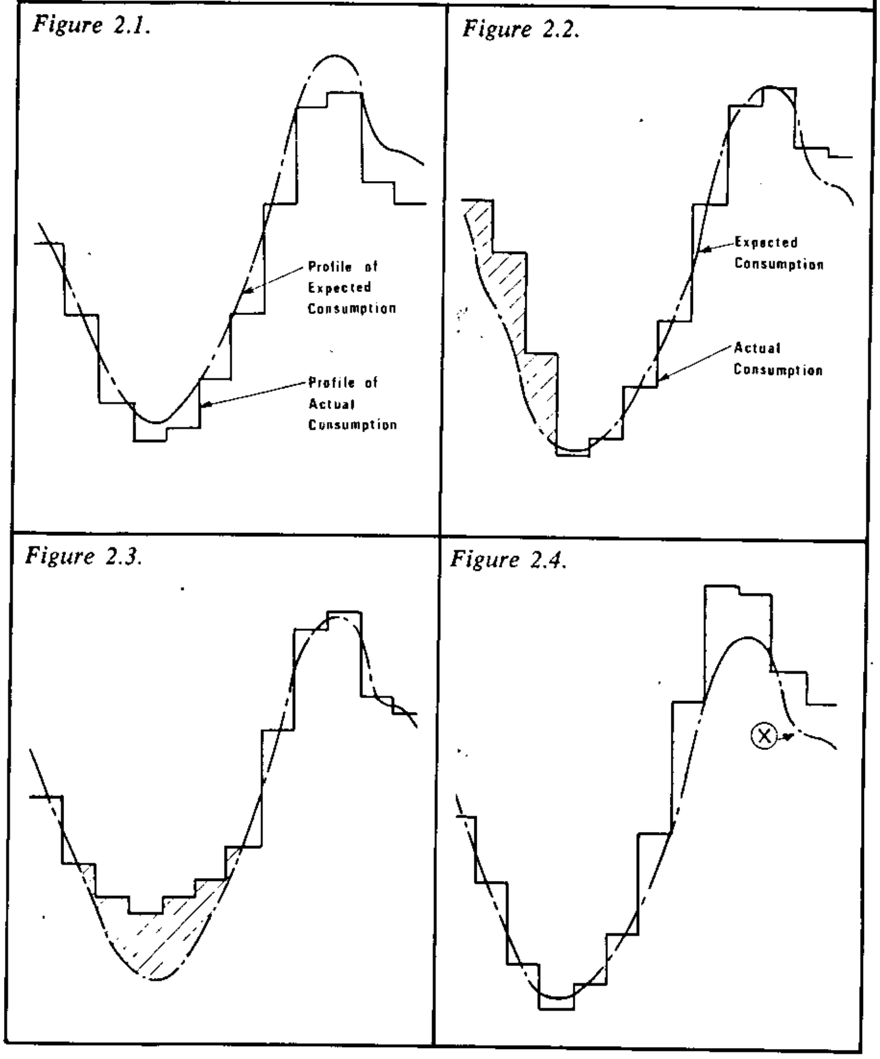
The example illustrates in the analysis boxes a situation in which there has been a reduction in Actual consumption during 1978/79, compared with Expected consumption based on the reference year 1977/78. However, the Space Heating Factor has increased by some 25%. Observing the relationship between Actual and Expected profiles for 1978/79 shows that actual consumption varies a great deal from the pattern of 'expected' consumption and at the (December) peak substantially exceeds it. As a result a substantially higher *rate* of energy demand is indicated. Actual consumption on the other hand appears, superficially, to be comparable with Expected consumption.

It can be seen, however, that there are periods of substantial underheating which have been compensated by increases in electricity consumption. This situation has been created for the purpose of illustration only. If revealed in practice, it would give grounds for concern and should stimulate action to improve the situation. Further general comment is made below on interpreting monitoring profiles.

Increase in Accommodation

Any significant increase in accommodation in real terms, or in equivalent terms by increasing the standard of existing accommodation will disrup the 'Monitoring'. procedure if allowance is not made for this when recording annual energy consumption. Provision is made for recording a nett heated building volume in the analysis box for each of the four financial years covered by the EM sheet. Changes in heated volume (addition or reduction), or changes which have a, similar effect, should be noted so that a compensating allowance can be made when judging the results of investment on energy consumption.

Interpreting Monitoring Profiles



Interpreting Monitoring Profiles

As indicated earlier, Monitoring profiles provide a valuable insight into site energy usage. Three noteworthy aspects of interpreting Monitoring profiles are what they reveal on:

(i) **The Stability of the Heating System.** In the context of Monitoring, stability is used to describe good or poor performance in responding to load changes. Regular and large deviations in the pattern of actual consumption shown by the histogram, from the profile of the Expected consumption indicates that the system is unstable in that it does not respond effectively to load change. Where there is underheating as a result, there is likely to be a related increase in electricity consumption.

(ii) **Heating System Characteristics.** Heating systems may be stable but display, from the profile, characteristics which indicate that they are inefficient. The more easily recognisable of these characteristics are Spring over consumption, Summer overheating and Winter overheating.

These characteristics are illustrated as hatched areas in *Figures 2.1-2.4.*

(iii) **Progressive Changes in Site Consumption.** The trend in consumption shown by the profiles should be one in which the histogram profile of actual consumption progressively falls below the Expected consumption profile, where conservation measures are being implemented.

A blank master of the EM Sheet and the accompanying notes are available from the West Midlands RHA, from Mrs. K. James, on Birmingham (021) 454 4828, extension 137, for £3 each to cover production, postage, etc.

The author is a project engineer with Robinsons Developments Ltd, Solar Heating Engineers, of Winchester. This article makes an interesting contrast to that by Mr J. R. Fielding, 'Solar Energy for the Boiler House', in our April, 1978 issue.

Pre-heating Steam Boiler Feed Water

– a practical application for solar heating

R. HILEY

The growing need for energy conservation is apparent to all of us. The first consideration is the reduction of energy consumption. By improving the efficiency of energy producing plant, such as centralised steam raising plants, energy consumption can be reduced at its source. There are many methods for conserving and economising on fuel consumption. One possibility which is being considered more and more is the use of alternative energy sources such as wind power, wave power and solar energy. In many applications it is impossible to completely dispense with the use of conventional fuels and alternative sources can only be regarded as a means of reducing fuel consumption. Such a case is the pre-heating of steam boiler feed water. This paper indicates that the installation of a solar pre-heating system can be both practical and economically viable.

The Pre-Heating Concept

The best potential for solar heating use exists when a fluid has to be heated from cold. For at low temperatures a solar heating panel is operating at relatively high efficiency levels.

In the case of a steam raising boiler a certain amount of 'cold' make-up water is required to replenish any losses in the distribution system or through equipment using direct injection of live steam. The quantity of make-up water required is, therefore, dependent on the individual characteristics of each installation.

Generally, if the system is providing steam for space heating coils and domestic hot water calorifier coils only, the volume of condensate return is high. This condensate can represent approximately 90% of the total feed water to the boiler, the remaining 10% being provided by treated water from a cold water supply.

In many hospital services applications such as cooking, sterilising and laundry provisions, a combination of heating through coils and direct injection of live steam is often implemented. The quantity of condensate returned to the boiler house is, therefore, greatly reduced whilst, conversely, the treated water feed is increased to maintain the required volume flow of feed water to the boiler. So is would be an advantage if the treated feed water could be pre-heated from the mains water temperature of 9°C. Generally speaking there will be 1% less fuel used in the boiler for every 6°C increase in the temperature of the feed water to the boiler.

Glazed or Unglazed Solar Collector?

Many types of solar panels are currently manufactured or imported into the United Kingdom. Various materials, design and configurations of collectors have been produced, intended mainly for domestic hot water heating and are generally too expensive to be considered for a cost effective industrial or commercial 'pre-heating' system. Such panels which are single or double glazed can certainly heat small volumes of water up to high temperatures. However, for low temperature applications they are generally no more efficient than a simple unglazed collector which may conveniently be manufactured from relatively low cost materials such as plastics (polypropylene). This may appear confusing when considering the 'greenhouse effect' which suggests that glazing should improve the performance. With low temperature systems operating close to ambient temperature the potential heat losses are small and thus the greenhouse effect has little relevance.

Additionally, the glass adversely effects the quantity of solar radiation reaching the collector because it reflects away a significant proportion of the sun's rays, particularly at low sun angles. On balance it is found that during reasonably favourable conditions the addition of glazing and rear insulation increases the panel cost considerably without affording any performance improvement.

A Simple Pre-Heating System

The pre-heating of boiler feed water is an ideal low temperature application for solar heating. *Figure 1* shows a typical solar pre-heating system for a steam raising boiler plant. The supply of raw mains water is fed through a softening plant in cases where the water does not meet the required standards, and then into a make-up tank. The capacity of the make-up tank will depend on the make-up requirements of the Hotwell tank, ie the quantity of condensate being returned. The make-up tank is piped directly to the solar heating system as there is no contamination or corrosion problem when using polypropylene solar panels. An indirect system using a heat exchange coil is not necessary. The make-up water is circulated through the solar system by means of a standard inline circulating pump which operates only when the differential control system indicates that useful heat can be gained from the solar collectors.

The system is designed to be self draining so that when the circulating pump is not operating, the water in the solar panels will drain down into the make-up water tank. The solar panels can be mounted on a roof (pitched or flat) with a suitable orientation within 15° East or West of South. To calculate the surface area of collector required the amount of solar energy available and how efficiently this energy can be collected must be established.

How much Heat Can an Unglazed Collector Provide?

Water heating is the most efficient way of harnessing solar energy, particularly when considering low temperature applications.

High temperatures are not required for a pre-heating system as it is not intended to heat the treated make-up water to the same temperature as the condensate being returned by the distribution system. The unglazed collector is designed to heat relatively large quantities of water through a small temperature rise of say 9°C to 30°C. Operating in this temperature range means that the temperature difference between the ambient air and the water flowing through the collector is very low. A high proportion of solar radiation is received during the Summer months from April to September, whilst a low level of useful radiation is available during the winter months.

From data published by the Building Research Establishment, approximately 2.75 GJ (765 kWh) of solar radiation falls on each square metre of solar panel when set at an angle of 30° to horizontal during the 'solar season' (April-September) in the United Kingdom. Using an unglazed polypropylene solar panel for pre-heating, the average collection efficiency will be about 75% during this period. Therefore each square metre of solar collector should provide approximately 575 kWh of useful heat. During the Winter months the system will generally only function on days when direct solar radiation is available although in Spring and Autumn there will be some useful benefit. The total energy which can be usefully collected outside the summer period is estimated at 65 kWh.

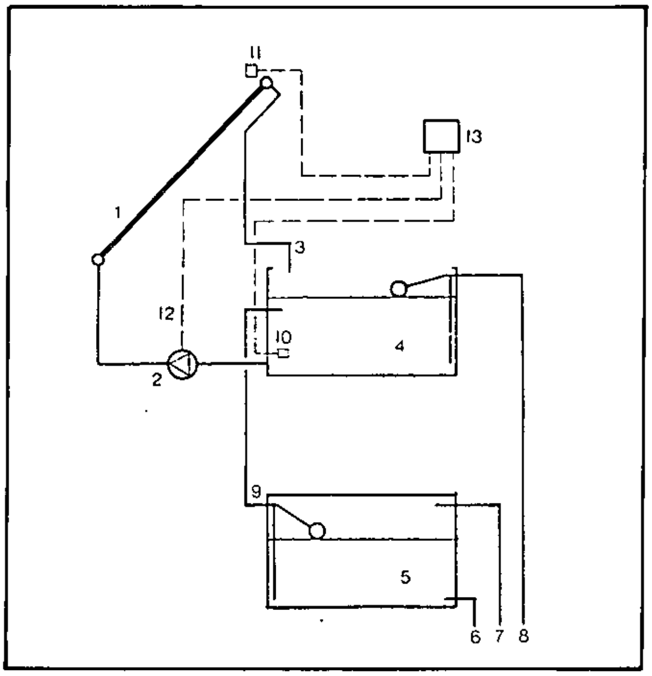


Figure 1. Suncell Oasis Solar Pre-Heating System.

1, Solar Collectors (unglazed); 2, Circulating Pump; 3, Return Pipe to Solar Tank; 4, Solar Storage/Make-up Tank; 5, Boiler Feed Tank; 6, Boiler Feed Pipe; 7, Condensate Return Pipe; 8, Cold Feed Pipe; 9, Pre-Heated Feed to Boiler Feed Tank; 10, Solar Tank Temperature Sensor; 11, Collector Temperature Sensor; 12, Electrical Supply to Pump; 13, Differential Controller.

Pre-Heating System Analysis

The proof of a system can only be judged by applying it to a specific boiler plant and evaluating how much can be saved and at what cost?. Consider the following typical boiler plant which consists of:

— 4 No. Economic Boilers rated 7MW
— Typical load 8,500 kg/hr at 8 bar
— Fuel: Natural Gas/35 sec oil standby
— 2 No. Hotwell tanks with a capacity of 7,000 litres retained at 78°C
— 1 No. Raw Water Tank with a capacity of 2,000 litres recorded at 9°C
— Condensate returned to Hotwell tank at 65% at a temperature of 80°C.

i. **Boiler Steam Heat Content**
Heat content of 8,500 kg/hr steam at 8 bar.
From the formula,
Specific Enthalpy of Saturated liquid × kg/hr condensate = energy available.
∴ 2,771 kJ/kg × 8,500 kg/hr = MJ.
Using a conversion factor of 3.60 to convert MJ to kWh

$$\frac{2{,}771 \times 8{,}500}{3.6} = 6{,}543 \text{ kWh}$$

ii. **Condense Heat Content**
Quantity of condensate returned

$$= 8{,}500 \times \frac{65}{100} = 5{,}525 \text{ kg/hr at } 80°\text{C}$$

From the formula,
Specific Enthalpy of Saturated liquid × kg/hr water = energy available.

$$\frac{336 \text{ kJ/kg} \times 5{,}525 \text{ kg/hr}}{3.6} = 515 \text{ kWh}$$

iii. **Raw Water Heat Content**
Steam production − condensate returned = raw water required.
8,500 kg/hr − 5,525 kg/hr = 2,975 kg/hr at 9°C
Specific Enthalpy of Saturated liquid × kg/hr water = energy available.

$$\frac{37.8 \text{ kJ/kg} \times 2{,}975 \text{ kg/hr}}{3.6} = 31 \text{ kWh}$$

iv. **Fuel Energy Requirement**
Heat Content of Steam − heat content of feed water (condensate + raw water).
6,543 kWh − 546 kWh = 5,997 kWh
5,997 kWh = 204 Therms at 100% efficiency
∴ At 75% efficiency = 7,995 kWh or 273 therms
∴ Fuel costs 273 therms at 10p × 8,760 hrs.
(*NB* 10p per therm is an industrial tariff)
= £239,148.00 (if plant runs continuously).

v. **Heat Content Available to Feed Water**
Condensate + Raw Water (from 2 and 3)
= 31 kWh + 515 kWh = 546 kWh

vi. **Heat Required to Feed Water**
Specific Enthalpy of Saturated liquid × kg/hr water = heat available.

$$\frac{(327 \text{ kJ/kg} \times 8{,}500)}{3.6} - 546 = 226 \text{ kWh}$$

226 kWh = 350 kg/hr steam to hotwell.

vii. **Potential Output from Solar System**
Output of panel per square metre (April-September) =

Radiation × efficiency.

$$= 766\,\text{kWh/m}^2 \times \frac{75}{100} = 575\,\text{kWh per m}^2$$

Output of panel per square metre (October-March) = Radiation available × efficiency.

$$= 162\,\text{kWh/m}^2 \times \frac{40}{100} = 65\,\text{kWh per m}^2$$

viii. **Potential Solar Heat Input into Make-up System**

Quantity of heat available from solar panels to heat make-up water from 9°C to 30°C.

From the formula,

a. Specific Enthalpy of Saturated liquid × kg of water at 9°C. Subtracted from,

b. Specific Enthalpy of Saturated liquid × kg of water at 30°C. Is equal to,

Total heat available from solar panels.

a. $\frac{37.8\,\text{kJ/kg} \times 2{,}975\,\text{kg}}{3.6} = 32\,\text{kW}$

b. $\frac{125.66\,\text{kJ/kg} \times 2{,}975\,\text{kg}}{3.6} = 104\,\text{kW}$

∴ 104 kW − 32 kW = 72 kW.

To establish what the likely average energy input is going to be per square metre of solar collector one must take into account the solar radiation available during various times of the year. The Building Research Establishment and The International Solar Energy Society have produced information based on records from Kew (1959 to 1968) giving average solar radiation on 1m² of collector at different angles to the horizontal.

Using this information and the expected efficiency levels of an unglazed and uninsulated solar panel the energy input into the pre-heat system will be 320 W/m².

$$\therefore \text{Collector area} = \frac{72\,\text{kW}}{.32\,\text{kW/m}^2} = 225\text{m}^2$$

∴ Using an unglazed polypropylene panel with an area of 3.6m²,

$$\text{Number of panels required} = \frac{225\text{m}^2}{3.6\text{m}^2}$$

Number of panels required = 62.

ix. **Solar Savings — Cost Analysis**

From the annual output of 640 kWh per m² for the solar system can be used to calculate the total annual savings.

640 kWh/m² × 225m² = 144,000 kWh per annum.

The costs of pre-heating feed water by conventional means in dependent on the type of fuel used in the boiler and how efficiently the boiler plant can be managed. This means that steam raising costs can vary between .55p and 1.5p per kW.

∴ If an average cost of 1p per kW is used then the cost savings using a solar pre-heat system are:

144,000 kW × 1p per kW = £1,440 per annum.

Installations costs for a 62 panel system should not exceed £30 per m².

∴ Say total installation cost = £7,000.

∴ Allowing for an increase in the costs of conventional fuels of 5% per annum the total savings per annum for the solar system would increase as follows:

1st year	144,000 kWh @ 1p =	£1,440.00
2nd year	144,000 kWh @ 1.05p =	£1,512.00
3rd year	144,000 kWh @ 1.10p =	£1,587.00
4th year	144,000 kWh @ 1.15p =	£1,666.00
5th year	144,000 kWh @ 1.20p =	£1,749.00
		£7,954.00

∴ 'Pay-back' period for this particular installation is under five years.

This paper was presented at the Institute Symposium 'Recent Developments in Hospital Sterilising Process', held at Imperial College of Science and Technology, on June 14. Dr Sprake is Principal Pharmacist, Quality Control for the Trent RHA.

The Medicines Act 1968 –its impact on the hospital pharmacist in relation to sterile products

DR J. M. SPRAKE BPharm PhD FRIC CChem MPS

Most sterile products prepared in the hospital Pharmacy are aqueous bottled fluids, and include large volume intravenous infusion fluids, small volume injections, eye-drops, topical solutions and water, bladder washouts, and antiseptics. The majority of these preparations are sterilised by heating in a bottled fluids steriliser, although some are heat labile and must be sterilised by filtration through a sterile bacteria-proof filter. Other, non-aqueous, products are also prepared, such as sterile liquid paraffin and arachis oil, and certain oily solutions. Where these are heat sterilised, a hot air steriliser must be used, since due to the absence of moisture in the product it is necessary to achieve a temperature of 150°C for one hour for sterilisation.

Whilst sterilisation is clearly a very important aspect of the preparation of sterile products, it is only one of many, and the impact of the Medicines Act on the whole system has been considerable. Nor is the Engineering input confined to the sterilisation step. Thus whilst this Symposium is concerned mainly with hospital sterilising processes, and sterilisers in particular, the object of this paper is to present a broader picture of the manufacture of sterile products, although it will still be necessary to be selective in dealing with the very many changes which have been brought about.

The Medicines Act 1968

In Great Britain, standards for raw materials and finished pharmaceutical products have been laid down for many years in a succession of Pharmacopœias, commencing with the British Pharmacopœia in 1864. However, it was not until the advent of the Medicines Act 1968 that the actual process of manufacture was brought under legal control. This Act contains in effect a requirement for a proper system of quality assurance, and detailed guidance on various aspects of manufacturing and quality control was published in 1971 in the 'Guide to Good Pharmaceutical Manufacturing Practice',[1] commonly known as the 'Orange Guide'. The second edition was published in 1977.

The 'Orange Guide' has no statutory force. Nevertheless, it is on the basis of the Guide that the Medicines Inspectors carry out their assessments of pharmaceutical manufacturing. Where a hospital has a Sterile Products Unit, the Engineers involved with it should therefore possess a copy of the Guide, and be familiar with the provisions in it which have implications for them.

Shortly after the first appearance of the Guide, an incident occurred which demonstrated very clearly the need for a proper system of quality control. A batch of 5% dextrose intravenous infusion fluid made by a commercial manufacturer contained a number of bottles which were not sterile. These were not detected at the factory, and in the interval between production and use the bacteria present multiplied, producing a dangerous degree of contamination. The batch only came under suspicion when a succession of untoward reactions occurred in patients to whom they were administered.

On investigation, it was found that the contaminated bottles all came from one particular autoclave load, and that about one-third of the bottles from the load were contaminated. The bottles had been loaded in three layers, and it was concluded that air had been retained in the autoclave throughout the sterilising cycle, resulting in the bottom layer of bottles failing to reach sterilising temperature. How this came about, and why the contaminated bottles were not detected, is described in the Clothier report,[2] which should be read by every Pharmacist and Engineer connected with the production of sterile fluids.

Originally, the requirements of the Medicines Act with regard to manufacturing applied only to the pharmaceutical industry, but it soon became apparent that it would be inconsistent to permit manufacturing in hospital pharmacy to continue without applying similar standards. The necessary hospital circular HSC(IS)128 entitled 'Application of Medicines Act to Health Authorities' was eventually issued in April 1975, by which time members of the Medicines Inspectorate had already paid informal visits to many of the larger manufacturing hospitals to advise on manufacturing conditions and procedures, and quality control systems. Formal visits and reports followed the appearance of the circular.

The Quality Control Pharmacist

One of the results of applying the Medicines Act to hospital pharmacy has been the advent of Quality Control Pharmacists, and the development of Quality Control Laboratories. The Quality Control Pharmacist exercises his function independently of the Production Pharmacist, so that neither is responsible to the other, and one of his most important duties is to take the final decision on whether a particular batch of product is satisfactory, and can be released for use.

The Impact of the Medicines Act in relation to Sterile Products

Raw Materials

The first step in the manufacture of a satisfactory product is to ensure that the raw materials are of suitable quality. Thus raw materials, when received are placed in bond until they have been sampled and tested by Quality Control staff. If found to be satisfactory, they are released for use by the Quality Control Pharmacist, and only then do they become available to the Production Unit.

One very important raw material which is actually produced within the hospital is distilled water, and it is necessary to monitor the quality of this, with in-line conductivity meters, and periodical chemical and microbiological tests. Distilled water, and any products made from it, should be sterilised within four hours of collection of the water, unless special precautions are taken to prevent the growth of bacteria, such as storage above 65°C.

Premises

A major result of the application of the Medicines Act to hospital pharmacy has been the wholesale upgrading of Sterile Products Units. Products which are sterilised by heat in their final containers must be manufactured in what the 'Orange Guide' terms a 'Clean Area', whilst products to be sterilised by filtration should be manufactured in a clean area until sterilisation, after which further processing, including filling and sealing of the final containers, must be carried out under aseptic conditions. BS 5295, published in three parts in 1976, is entitled 'Environmental cleanliness in enclosed spaces', and in Part 1 four classes of environment are designated. Aseptic and Clean Areas in the 'Orange Guide' correspond to Class 1 and Class 2 Environments in the British Standard, and these are defined in terms of size and number of airborne particles as follows:

Class 1
The particle count shall not exceed a total of 3,000 particles/m^3 of a size of 0.5 micron or greater. The greatest particle present in any sample shall not exceed 5 micron.

Class 2
The particle count shall not exceed a total of:
300,000 particles/m^3 of a size of 0.5 micron or greater;
2,000 particles/m^3 of a size 5 micron or greater;
30 particles/m^3 of a size 10 micron or greater.

The 'Orange Guide', and Part 2 of the British Standard, also provide guidance on the design of Clean and Aseptic Areas. The object here is to minimise the shedding or accumulation of particulate matter, and to facilitate cleaning and disinfection. Thus the internal surfaces, that is the walls, floors and ceilings, of these areas should be smooth, impervious and unbroken, and there should be no uncleanable recesses, such as might be created by pipes or ducts, and a minimum of projecting ledges, shelves or cupboards. Equipment, both fixed and movable, must be kept to a minimum.

The clean and aseptic areas must be supplied with filtered air of suitable quality, with the final filter at, or as close as possible to, the point of input to the Area. There must be at least twenty air changes in the room per hour. Even so, extra protection is afforded to the product by the situation in the processing areas of laminar flow cabinets providing Class I air. The air flow in these cabinets carries any particles shed by the operator horizontally away from the product and out of the cabinet. Thus products to be sterilised by heating are filled into their final containers under laminar flow, and the processing of products which have been sterilised by filtration is also completed in these cabinets.

Access to clean and aseptic areas is through changing rooms, where personnel don suitable protective clothing, including footwear and headgear. Requirements are particularly stringent for aseptic areas, where gloves and face masks should also be worn, and fresh, sterile garments provided at least once a day.

The Production and Quality Control Pharmacists generally undertake jointly the monitoring of clean and aseptic areas for levels of particulate and microbial contamination.

Procedures and Documentation

All of the Production and Quality Control procedures must be fully documented, and adequate records must be kept of all batches prepared and all testing and monitoring carried out. Thus in the Production Unit a master sheet is produced for each type of product which is made, and a photocopy of this sheet is used with each batch prepared. On this batch sheet are spaces to be completed at various stages, with information such as the batch number and date; initials of the person measuring the ingredients, and of the checker; details of sterilising cycle; number of final containers passed and rejected on visual inspection; numbers of labels issued, used and destroyed; a sample of the labels for that particular batch.

Heat Sterilisation

Most of the products from a Sterile Products Unit are aqueous solutions which are sterilised in a bottled fluids steriliser, although some non-aqueous preparations are sterilised in a hot air steriliser. It is the responsibility of the Production Pharmacist to be assured that the sterilisation is both effective and safe, and that of the Quality Control Pharmacist to confirm these points by quality audits. The way in which these duties are to be discharged are described in Appendix 4 of the new HTM 10, together with the duties and responsibilities of the Steriliser Engineer and Maintenance Engineer. This Appendix clearly demands close liaison between all of these persons.

Each sterilising cycle must be recorded on a temperature-time chart, and this chart forms a part of the batch records. The new HTM 10 describes the preparation of Master Temperature Records (MTRs), against which the individual Temperature Record Charts (TRCs) are to be compared.

Bonding and Release of Finished Products

After sterilisation, the products are inspected as appropriate, labelled, and placed in bond whilst tests are carried out on samples. The Quality Control Laboratory carries out chemical tests to ensure that the right ingredients are present in the correct quantities. Sterility testing may be carried out either by the Quality Control Laboratory or by another department such as a Pathology or Public Health Laboratory. Finally, the Quality Control Pharmacist considers the batch sheet and temperature record chart, together with the results of chemical analysis and sterility testing, before deciding whether the batch is satisfactory to be released for use.

From the above it will be clear that the impact of the Medicines Act on the preparation of sterile products has been enormous. It is not long since these products were made in premises which would now be considered greatly substandard, with inadequate documentation, and with no testing of the raw materials or finished products, and no involvement by a Quality Control Pharmacist.

Engineering Considerations

So far, four points have been mentioned where the Engineering input is particularly important.

First, there is the necessity to ensure a good supply of distilled water. Problems with stills are not uncommon. Certain hospitals have experienced considerable difficulties with thermocompressor stills, although the evidence would suggest that these perform satisfactorily provided that the water supply is suitably pretreated, and the still is run continuously rather than being closed down nightly. In a recent instance of a thermocompressor still with a long and troubled history, it was eventually found on close investigation that although the water supply was being pretreated, there was actually a bypass of the pretreatment plant which was partly open, and allowing raw water to reach the still. The existence of this bypass had escaped the notice of both Pharmacists and Engineers.

Second, clean and aseptic areas must be supplied with filtered air of appropriate quality. In another recent instance, the presence of a greyish patch at an air inlet led to an investigation of the air filtration plant. The final filtration should be at, or as close as possible to, the point of input to the area, but in fact not only was the final filter several yards from this point, it was actually upstream of the fan unit. When a small door in the ducting between the filter and the fan unit was opened, it was found that the base of the inside of the ducting was covered with dust and dirt, partly no doubt because the wrong type of filter was also being used. It is only recently that Pharmacists have begun to acquire air particle counters with which to check the quality of air being supplied to clean and aseptic areas, and it seems unlikely that this will prove to be an isolated incident.

Thirdly, it is important that laminar flow cabinets function satisfactorily. Again, the performance of these is checked most easily with an air particle counter. Whilst leaks through the filter itself usually occur only where there is visible damage, leaks around the edge of the filter are by no means uncommon. In some cases, filters in laminar flow cabinets are changed by the Hospital Engineers, in others by manufacturers under service contracts. It is disconcerting that leaks are sometimes detected in the latter case even when the contractor has purported to test the cabinet himself with a particle counter, and has issued a certificate to the effect that the performance is satisfactory.

Finally it is important that sterilisers perform satisfactorily, and be regularly and thoroughly maintained, and that all instruments be properly calibrated. In a recent instance coolers which had been fitted to the spray cooling system of a bottled fluids steriliser some years ago had gradually become corroded and ceased to function. Over a period of time, the cooling part of the sterilising cycle had gradually lengthened from approximately half an hour to two-and-a-half hours. This had passed unnoticed due to changes of staff, and the lack of a master temperature record. Two main disadvantages of this were that the sterilising cycle was taking about twice as long as necessary, thus constricting production, and the products were remaining hot for much longer than necessary, which in some cases could produce deleterious effects.

There is thus a very important Engineering input to the Pharmacy Sterile Products Unit in a number of ways, and nowhere does this come over more clearly than in the new HTM 10, which was in part the reason for the Symposium at which this paper was presented.

[1]Guide to Good Pharmaceutical Manufacturing Practice 1977, HMSO, 1977.

[2]Report of the Committee appointed to inquire into the circumstances, including the production, which led to the use of contaminated infusion fluids in the Devonport Section of Plymouth General Hospital. C. M. Clothier (Chairman). HMSO. Cmnd 5035, July 1972.

Product News

Pipe Freezing Demo by BCB at Interflow '78

The BCB Pipe Freezing Services exhibit at the Interflow '78 Exhibition, Harrogate, on November 7-9, is demonstrating pipe freezing applications on 6 in and 9 in diameter pipe work with static displays on the freezing of oil and glycol. BCB is backed by the BOC Cryospeed Service.

Jetfreeze Ltd, also a member of the BCB Group, who offer a radio-controlled mobile round-the-clock small bore pipe freezing service, is demonstrating the 'Jetfreezer' technique for freezing ½ in and 1¼ in diameter pipe work.

By reducing maintenance and replacement time to a minimum, pipe freezing has many advantages including the ability to prevent the complete closedown of systems, saving large quantities of valuable liquid that would otherwise be contaminated or lost, or preventing a potentially dangerous situation arising when a sprinkler system is completely drained for maintenance purposes.

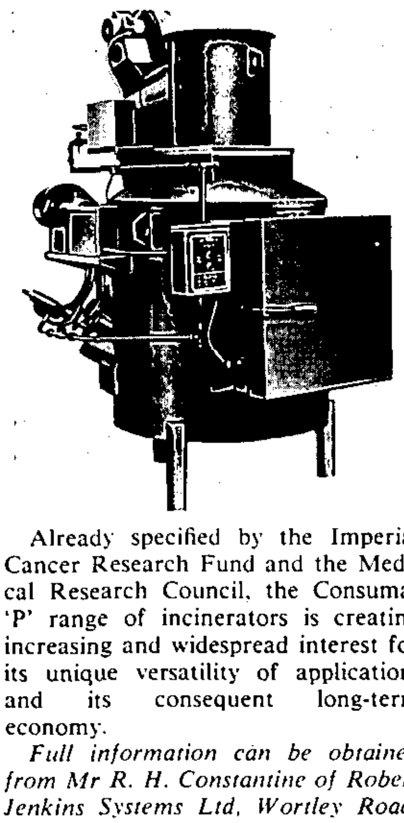
Further details from BCB Group of Companies, Boswell Road, Thornton Heath, Croydon, Surrey. Tel: 01-689 6911.

New Incinerator For Waste Disposal Problems

Robert Jenkins Systems Limited, of Rotherham, have produced an extremely versatile incinerator.

Consumat 'P' is a new type of solid waste incinerator which will dispose of almost any type of waste without adjustment of any kind, including: plastics, nylon gloves, petri dishes, clothing, cardboard, pathological/animal carcasses, etc — well within the required legal limits of emission.

Irrespective of the relative proportions of waste material fed into the unit, everything is reduced to a sterile ash in a controlled and consistent manner.



Already specified by the Imperial Cancer Research Fund and the Medical Research Council, the Consumat 'P' range of incinerators is creating increasing and widespread interest for its unique versatility of application, and its consequent long-term economy.

Full information can be obtained from Mr R. H. Constantine of Robert Jenkins Systems Ltd, Wortley Road, Rotherham, South Yorkshire.

Insulation Fault Detector for Medical Rooms

A Dutch company, B. V. Nieaf, is marketing an insulation fault detector designed for use in power circuits in medical rooms. The growing use of electronic equipment for diagnosis and treatment in hospitals has resulted in an increased risk of patients or staff coming into accidental contact with electricity. This has led to safety specifications and standards being drawn up by committees and laid down in such regulations as IEC-SC62A and NEN 3134. One of the subjects of these regulations is a separation transformer. In accordance with standard NEN 3134 the detector indicates whether the transformer gives an adequate guarantee of protection to the patient and staff.

The detector measures the impedance between the phases and earth on the secondary side of the transformer. The secondary side of the transformer is not earthed. An artificial mid-point is created with the aid of relatively low impedances, on which an alternating pulse is superimposed via a high resistance. With this measuring method (parallel resistance measurement) the current at this mid-point decreases as soon as there is a leakage current to earth. The current is then rectified by means of synchronous detection, making the measuring current a direct current. This direct current is fed into a trigger circuit with an adjustable switch point. If the pre-set value is exceeded an alarm is given via a relay, for example. Because of the high input impedance, the detector can be connected permanently to the unearthed network to keep all appliances connected to this network under constant supervision for insulation defects.

Technical Data

Model: designed to be built-in;

Input voltage: 220 V, 50 Hz (unearthed);

Alarm limit: continuously adjustable up to 0.5 Mohm;

Type of alarm: optional, by relay, TTL or analog output;

Internal safety device: 32 mA (delayed).

Further enquiries from: B. V. Nieaf, Vrieslantlaan 6, Utrecht, Holland.

Classified Advertisements

APPOINTMENTS AND SITUATIONS VACANT

Closing Dates

Recruitment advertisers are requested to set closing dates no earlier than three weeks after publication date of the Journal
Monthly publications do not receive preferential treatment by the Post Office and circulation lists in hospitals also delay receipt of the Journal by many potential applicants.

LANCASHIRE AREA HEALTH AUTHORITY

Blackpool Health District

HOSPITAL ENGINEER

(Over 24½ Points)

required for Victoria Hospital, Blackpool, due to the promotion of the present holder.
Salary scale: £4,497 × 5 to £5,073 plus £183 responsibility allowance, plus bonus allowance.

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Applicants should be appropriately qualified and have sound experience in all aspects of mechanical and electrical engineering, and be able to demonstrate managerial and supervisory ability.

Qualifications shall be HNC in mechanical or electrical engineering or an equivalent approved qualification, with endorsements in management.

Application forms and further details can be obtained from the District Personnel Officer, District Offices, Victoria Hospital, Whinney Heys Road, Blackpool FY3 8NR. Tel. Blackpool 34151. Ext. 206, to be returned November 30, 1978.

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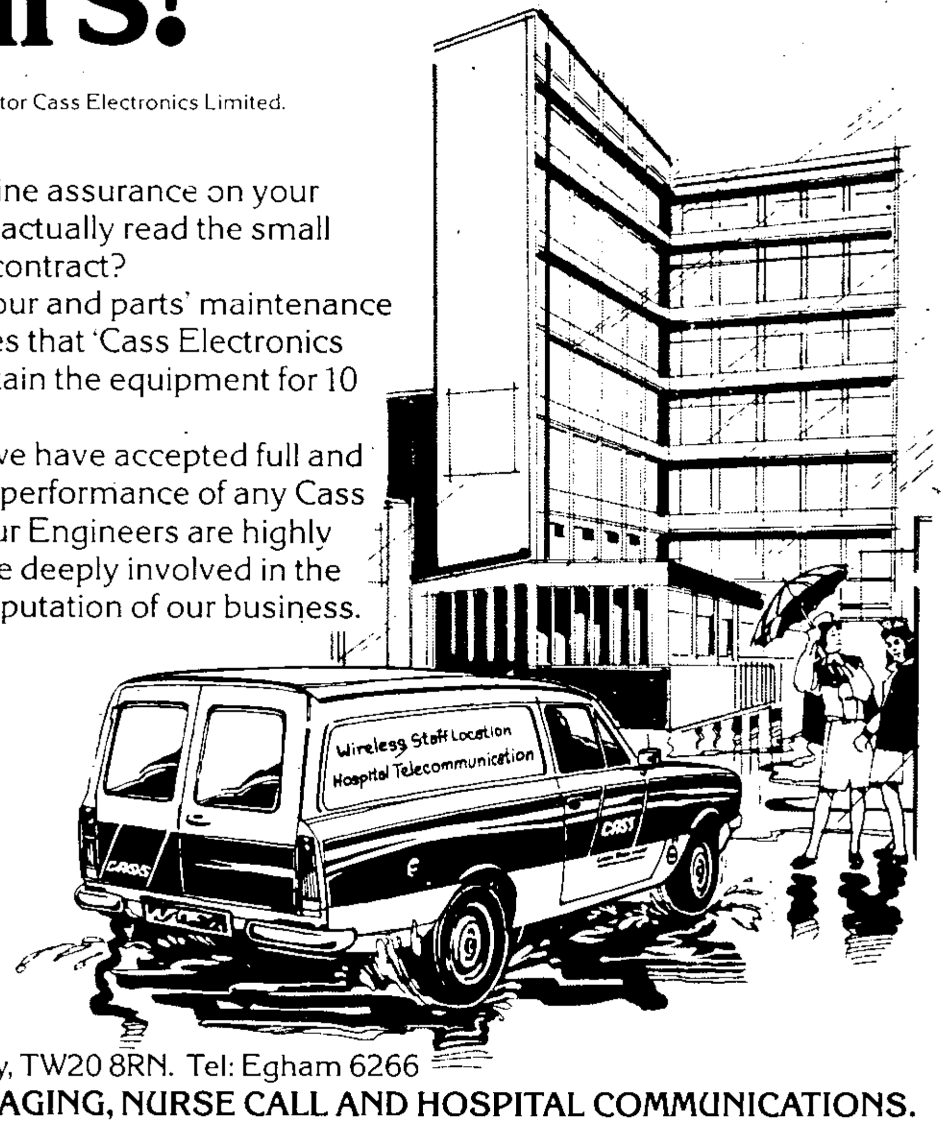

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