The Journal of the Institute of Hospital Engineering September 1981

HOSPITAL ENGINEERING

International Federation Issue

Underfloor Heating
Bursary Award Paper

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HOSPITAL ENGINEERING

The Journal of the Institute of Hospital Engineering

I.F.H.E.

International Federation Issue No. 39

Contents

Volume 35 No. 7 **September 1981**

Front Cover:
Underfloor plastic pipework for a heating system being laid, prior to receiving the screed — see page 4. (Photograph courtesy of Multibeton (UK) Ltd.)

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International Federation News

News from Spain Canadian Institute

The III Annual Meeting of the Spanish Association of Hospital Engineering and Architecture was held in Pamplona on 11th and 12th May, when the theme was 'Moderni' tion of Old Hospitals.

Nine papers were presented, five of which were concrete examples. Methodology of action was discussed along with the papers.

The IV Round Table Meeting of AEDIAH will be held in Madrid on 5th November, when the theme will be 'Laboratories'.

The President of IFHE, Mr Vinson Oviatt, will give a lecture on 'WHO Guidelines for Laboratory Biosafety: Design, Equipment and Operation'.

Subjects on general planification of laboratories, maintenance and installation will also be under discussion. At this meeting, there will be a simultaneous translation from Spanish into English.

The Spanish Association of Hospital Engineering and Architecture has recently issued a monography on *'Energy Saving in Hospitals'*, that contains the papers presented at its II Annual Meeting in 1980.
Language : Spanish
No. of Pages : 143
Graphics, schemes and tables : 46

ASINEL has published a book entitled *Application Guide for Maintenance of Electrical Installations of Surgeries.*

Its basic work was undertaken by a member of AEDIAH, Juan Muntasell, with the collaboration of the Maintenance Committee of AEDIAH.

This book is very useful for the control of security in surgeries, and it also has a series of 'control sheets' that makes its operation easy. It is available from AEDIAH, Diagonal 647, Barcelona 28, Spain.

Les jours il et 12 mai l'Association Espagnole de Génie et Architecture Hospitalière eue sa ill Réunion Annuelle à Pamplona sous la dewise "Actualisation d'Hopitaux existants". existants".

On developpa 9 rappots, 5 desquels fûrent exemples concrets et on y ajouta la méthodologie d'actuation.

Le 5 novembre on tiendra à Madrid la "IV Table Ronde d'AEDIAH" sur le thème LABORATOIRS.

Le président d'IFHE, Mr. Vinson Oviatt, tiendra une conférence "WHO Guidelines for Laboratory Biosafety: Design, Equipment, Operation.

D'autres questions à traiter seront planification générale du laboratoire, entretien, installations. Il y aura traduction simultanée espagnol-anglais.

L'Association Espagnole de Génie et Architecture Hospitalière, vient de publier une monographie sur *'L'Epargne d'Energie dans l'Hôpital'*, laquelle contient les rapports présentés en 1980 pendant sa II Réunion Annuelle.
Langue : Espagnol
No. de pages : 143
Graphiques, Schémes, tableaux : 46

ASINEL a publié le livre *Guide d'application pour l'entretien des installations èlectriques des salles d'opèrations,* dont le travail fondamental a été realisé par l'associé d'AEDIAH, ingénieur Juan Muntasell en collaboration avec la commission d'entretien d'AEDIAH.

Le livre, de grande utilité pour le control de la Surete dans les salles d'operations, a aussi une série de "feuilles de control" qui facilitent sa pour suite.

On peut l'acquérir a AEDIAH, Diagonal 647, Barcelona 28, Spain.

News from Denmark

In order to form a policy for our organisation, which has approximately 250 members, delegates from the whole of Denmark held a meeting in the spring of 1981.

The discussion dealt with:

which activities the association should carry out in the near future;
the association's relationship to the IFHE;
member activities in the local areas of Denmark;
further education policies.

The course activities planned in the Danish Association of Hospital Engineers are:

1. Patient and hospital staff hazards in the use of biomedical equipment.
The aim of this course is to give the participants knowledge of the requirements for services connected with biomedical equipment, and the various safety tests for equipment and electrical installations. The principles and the functions in the use of electromedical equipment will be described. The course will include an introduction to the IEC norms for biomedical equipment.

2. The maintenance of X-ray installations.
The aim of this course is:

to give information on the various types of X-ray installations and their use;
to acquire the knowledge necessary to evaluate the service requirements of X-ray installations;
to make the participants familiar with the national regulations for X-ray installations, and further to give information on radiation environment.

The function and the mode of operation of various types of installations will be described.

3. Installations and use of medical gases.
The aim of this course is to give the participants the basis knowledge required to understand:

the chemical and physical characteristics of medical gases;
the need to carry out quality tests of all medical gas installations.

Futhermore it is the aim to describe which elements make up installations for medical gases.

4. Energy saving in hospitals.
The increasing price of energy implies that the hospital's technical department must in the future implement various measures.

The aim of this course, to which we have invited our colleagues in Scandinavia, is:

to give information on which measures can save energy in hospitals;
to instruct the participants in how to evaluate the cost-benefit effect of typical measures in saving energy;
to make the participants familiar with the term 'energy management' in order to establish an energy organisation in their own hospital. For this subject the instructors will include a politician who will deal with political aspects.

Canadian Institute

The Canadian Hospital Engineering Society was formed on 30 May 1980. Less than a year later its membership exceeded two hundred.

Membership of the Society is open to 'any person who is active in the delivery of health care in the areas of administration, planning and design, construction, operation and maintenance and other related disciplines.'

It is noted that in the booklet issued by the Society, in a prominent and isolated position on the first page, there is the following message to members:

The measure of the success of our Society is not to determine by what you can get out of it, but rather by what you can contribute to fulfil its objectives.

Surely a proud 'motto' which has everything to commend it.

Our best wishes for growth and progress go to our Canadian colleagues.

Enquiries to: S. T. MORAWSKI PEng, Canadian Hospital Engineering Society, P.O. Box 5658, Station F, Ottawa, Ontario, Canada K2C 3M1.

Institute News

Developing Managers for Reconstruction

(The Keele Courses)

The October *Developing Management Effectiveness* course (formerly the Keele Course) comes at an appropriate time for Senior Works Staff. This will be held from October 11-16 and there are still a few placed available.

This course deals with man management, including industrial relations and multi-disciplinary working, and will be useful to consultants and overseas staff, as well as works staff at Region, Area and District.

Anyone wishing to book a place should complete a Falfield application form (included in the programme of courses), or apply to the Principal, the Hospital Estate and Management Centre, Falfield, Tel: 045 4260207.

2nd International Seminar

18th April-7th May 1982

Members are reminded that anyone wishing to enrol for the seminar on 'Focus on Appropriate Technology' should send in their application forms which were included in the literature distributed in June 1981.

MSc Degree for Institute Fellow

Mr W M Gillen, a Fellow of the Institute of Hospital Engineering, has recently gained an MSc in Energy Studies following a three year part-time course at the New University of Ulster, Coleraine.

Mr Gillen is District Works Officer of the Northern Health and Social Security Board, Coleraine, Ballymoney and Moyle District, Co Antrim, N Ireland.

The Institute would like to congratulate him on his success.

Annual Conference 1982

The Annual Conference for 1982 will be held at the Hilton International at Stratford upon Avon from 19th — 21st May.

The usual Conference literature will be distributed at the turn of the year.

Chartered Engineer

The Institute of Hospital Engineering has successfully sponsored Mr. R.J. Sear for registration as a Chartered Engineer.

Institute Member Retires

Stanley A Reynolds, a member of the IHE since 1949, is to retire from the Health Service in October 1981, coincidental with his 65th birthday.

Mr Reynolds started service in the NHS in 1935 as an Assistant Engineer, and after an interruption for war service, continued from 1946 as Hospital Engineer at Whixley Hospital, near York, going on to become a Senior Engineer for a group of hospitals in the York Health District.

New Hospitals from Old

A 2-day Conference

Following the reduction of major capital expenditure in the NHS, the emphasis in the future will be the refurbishment of existing building stock, rather than the provision of new. The purpose of this conference is to examine the problems and options available.

Sponsored by The Chartered Institute of Building, the conference is to be held at Birmingham Medical Institute, 34 Harbourne Road, Edgbaston, Birmingham B15 3AF, on 8 and 9 October, 1981.

The fee is £70 plus VAT and full details and application forms are available from:

Professional Services Officer, The Chartered Institute of Building, Englemere, Kings Ride, Ascot, Berks SL5 8BJ.

Diary Note

Water — the Economics of Plant Management is the subject of a symposium to be held in the Barbican, London on 3 November 1981.

Papers, presented by practical industrial engineers, will cover: ion exchange; boiler operation; effluent treatment; and cooling plant.

The cost, including lunch, refreshments and copies of papers is £55. Applications to: The Secretariat, The Industrial Water Society, 35 Broomfield Avenue, Fazeley, Tamworth, Staffs. B78 3QL. Tel: 0827 65089.

New CEI Affiliate

The Board of the Council of Engineering Institutions (CEI) today resolved to admit the Biological Engineering Society as an Affiliate of the CEI.

The Biological Engineering Society is a multi-disciplinary learned society which fosters professional partnership between engineers, scientists and technologists, and those engaged in medicine and the life sciences. It facilitates collaboration, not only within the National Health Service research institutions and universities, but also with the biomedical engineering industry for the advancement and improvement of health care.

The adress of the new affiliate is The Biological Engineering Society, c/o Royal College of Surgeons, Lincoln's Inn Field, London. WC2A 2PN.

Tel: 01-242 7750 — Hon. Secretary Mr. Keith Copeland.

Letters to the Editor

Clinical Gases
New Data

Dear Sir,
Thank you very much for publishing my paper *'Installation and Use of Clinical Anaesthetics — Safety Precautions'*, which I presented at the 6th International Congress in Washington in July 1980, in the June issue of this journal.

Presenting a paper in June 1980, however, means writing it in 1979, and during the last two years we have worked further with the subject. We have brought forward some new knowledge, which has made some of the statements in the article obsolete. Also some values stated in my article, put forward by other authorities, have been changed.

In the article, it was recommended to install ventilation and scavenging systems in all rooms where anaesthetic gases and vapours are used. We recommended 10 air changes per hours in induction rooms; 17 air changes per hour, or at least 2000 cubic metres per hour, in operating theatres; and at least 6 air changes per hour, or at least 500 cubic metres per patient per hour, in recovery rooms.

Unfortunately, further studies have shown that the recommended values, not in all cases, have brought the pollution rates down to these low figures. That in its turn necessitated the Danish authorities not to fix the low limits (25 ppm for Nitrous Oxide and 1 ppm for Halothane) as had been expected, but instead to fix the values at 100 ppm for Nitrous Oxide and 5 ppm for Halothane, i.e. the same values that are valid in Sweden.

There were, of course, special cases where the limits could not be reached, such as deliveries, certain examinations of the throat, and especially anaesthesia on children. Also many cases where masks of not perfect fit were used, e.g. on patients with beards or moustaches.

The newest studies carried out in Norway, Sweden and Denmark focus on a vacuum cleaner-like principle, where a rather thick tubing (5-10cm diameter) is placed near the patient's head, while 100-200 cubic metres of air per hour are sucked through the tube. This is the same principle which is used in industry, for sucking away welding smoke for example.

These studies are by far not finished, but initial results seem promising. Hopefully, they will lead to a reduction in pollution rates to such an extent, that the recommended figures for air changes per hour could even be lowered, so that some energy savings could be achieved. We shall be happy to report on this when the study is finished.

Jan Fialla, MSc.
Danish Hospital Institute.

NHS Incentive Scheme

Dear Sir,

With reference to the letter from Mr. Howie in the July/August 1981 issue, may I give him the following advice? Firstly, to read the letter from Mr. Shand which was printed alongside his own, and which contains an exemplary description of the value of the NHS Craftsmens Incentive Scheme.

Secondly, Mr. Howie should then aim to introduce this Scheme in his own district whereupon, whether he likes it or not, he will discover very quickly how many craftsmen he needs.

B.J.F. Reilly, District Works Officer, Leicestershire AHA (East).

Book Review: 'Preventing Hospital Infection'

This book is a report by a committee set up by the Dutch Health Council. The original Dutch report has now been produced in a very well-translated English version and published last year (1980). It is a soft-back book of A4 size, 410 pages long. It is of interest to the engineer owing to the fact that almost one-third of the written text is concerned with ventilation of hospital areas in order to prevent infection.

The bulk of the book is concerned with how nurses and doctors would set about reducing infection in hospitals. The topics covered include: the problem, scope and consequences of hospital infection; hygiene of hospital staff and patients; general nursing care; isolation nursing; antibiotics; dispersers and sources of infection; operating room design and use; sterilisation; infections in other departments.

This part of the book is written in an easy-to-read style, and each section starts off with the committee recommendations for preventing infection, then followed by the reasons and justification for such recommendations. The subjects covered in this part of the book are treated in such a way, that although the book is not bedtime reading (although the reviewer read most of it on holiday), it is certainly more easy to assimilate than many engineering books.

What may be of greater interest to the hospital engineer, is the section concerned with ventilation of hospital areas to prevent infection. This is written as a separate appendix of considerable length and scope. The subjects covered are: recirculation of air and heat recovery, possible sources of bacteria from the air conditioning plant; air filtration; air movement control for isolation rooms, and requirements for isolation; ventilation of operating rooms, including considerable discussion about laminar-flow systems; and finally, air movement control in the operating department.

I should like to recommend to hospital engineers that they read this book. Those that do will be very much more aware of the reasons and causes of hospital infection. This information is of undoubted interest, but when used with that contained in the section on hospital ventilation, they will be well equipped with the reasons and means to assist in reducing hospital infection.

It is available from: Government Publicity Office, PO Box 20014, 2500 EA, The Hague, Netherlands. The cost is 60 Dutch Florins (which is approximately £11.80 at today's rate of exchange). No doubt it can also be purchased, as they say, 'through a reputable bookseller'.

W Whyte,
Building Services Research Unit,
University of Glasgow.

The author is the recipient of the 1980 Bursary Award presented by the Institute of Hospital Engineering, and this paper is in fulfilment of that award. Mr Stoneham is a Senior Mechanical Engineer with Messrs Trevor Crocker & Partners, Consulting Engineers, Mitcham, Surrey.

Underfloor Heating using Plastic Pipes

A survey of principles and current European practice

H G STONEHAM BSc(Hons) CEng MIMechE MIMarE MIHospE MInstR

Introduction

Underfloor heating is not new, its origins can be traced back as early as 1200 BC. It was, however, in the second century AD that the technique was adopted by the Romans. Until then open fires having small, high temperature radiant surfaces, with the serious disadvantage of uneven distribution of heat, were common. The Romans were quick to realise that if the products of combustion of the fire were circulated in ducts underneath the floor, a much more even distribution of heat could be obtained throughout the rooms. The technique was so successful that the 'hypocaust' became a feature of all the better Roman villas.

Flue gas or warm air remained the only method of heating floors until the early 1900s, when the first pipe-coils carrying hot water were embedded in structures. By the 1920s underfloor heating was being applied to many buildings, including hospitals and schools. This period of development and acceptance was overtaken by serious shortcomings in the systems, such as corrosion of the pipework, structural cracking and the inability to supply sufficient heat to the room from the heated floor, necessitating additional heating surface in the form of traditional radiators.

As these problems were not resolved, the use of embedded metal pipe-coils gradually died out, but there was a resurgence of interest in underfloor heating in the 1960s.

However, these systems used electric cables, either in ducts to facilitate withdrawal, or directly embedded in the screed. The systems, although comparatively cheap to install, had the major diasadvantage of high running costs. In an effort to reduce the running costs, a 'storage' system was adopted where the screed was heated by off-peak electricity during the night and gradually released during the day. Despite the use of cheaper electricity, the systems did not prove popular and suffered from two major disadvantages.

Firstly, sufficient heat had to be stored in the floor to meet the heating requirement for the whole day, resulting in excessively hot floors for part of the day. Secondly, as with all night storage systems, the following day's heating requirements must be determined in advance — or the floor will store either too little or too much heat, resulting in under or overheating of the space.

Some twenty years ago the chemical industry began to develop plastic pipe that would remain stable when carrying warm water. A period of rapid development soon resulted in pipes that would carry water at temperatures of up to 60°C with a predicted life of hundreds of years. Heating engineers in Germany and Switzerland were quick to adopt these pipes for underfloor heating, as the major disadvantage of pipe corrosion and its attendant

Sommaire Francais

Des canalisations en plastique pour le chauffage par le sol

Le principe du chauffage par le sol n'est pas nouveau. De nombreux systèmes ont été essayées par le passé, chacun d'entre eux tombant progressivement dans le discrédit. Récemment, avec le développement de matières plastiques adaptées, on a pu voir une relance du chauffage par le sol en Europe, où ces systèms se sont acquis une part prépondérante du marché.

Les principes de base du transfert et de la régulation de la chaleur sont analysés, et une étude critique est faite des systémes et des techniques modernes.

En conclusion, l'article constate que les canalisations en plastique procurent un moyen viable de chauffer les édifices et qu'elles triomphent des arguments traditionnellement avancés contre ce systèm de chauffage. Les systémes modernes présentent des avantages par rapport aux systèmes de chauffage plus conventionnels à radiateurs et circulation d'eau, notamment quand ils fonctionnent avec des sources de chaleur telles que les pompes à chaleur ou les panneaux solaires.

high repair costs had been overcome. Coincidentally the improvement of insulation techniques, and the better thermal properties of modern building materials, meant that the heat emissions required from floors to meet the space heating needs were reduced to such an extent that additional heating surfaces were no longer necessary.

The rate of growth of the underfloor heating industry in Northern Europe is quite staggering, rising from taking 1% of the market for heating systems in 1973 to some 13% in 1978. In Germany in 1979, $9.6 \times 10^6 m^2$ of underfloor heating utilising warm water[1] was installed, representing 16% of the total market for space heating systems. *Figure 1*[2] gives predictions for the German market to the year 1982, and is broken down into the various market segments. It can be seen that the domestic market is predominant. This trend is confirmed by *Neururer*[3], who estimates the Swiss market to be divided as roughly 60% domestic and 40% public buildings.

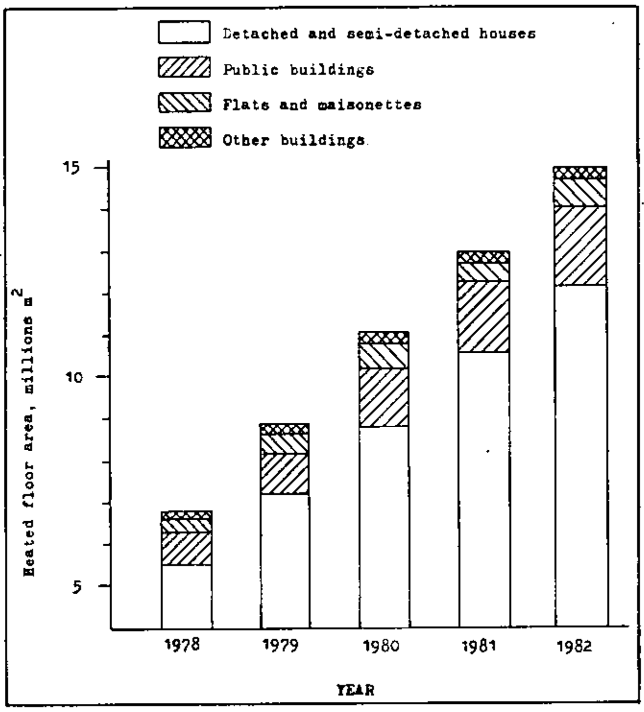


Figure 1: Warm water underfloor heating, German market and forecast to 1982.

This division of the market is opposite to that which prevailed in the 1950s in the United Kingdom, when underfloor heating was common in the public sector — banks, churches, hospitals, etc. This may possibly be explained by the relative cheapness of modern systems making them more attractive to the domestic market.

Industry in England has been slow to take up the challenge of these new underfloor heating methods. *Field*[4] has surveyed the English market and finds that currently only three continental manufacturers are represented in the U.K.

Heating and Thermal Comfort

There are two principal reasons for heating buildings:

First, to maintain conditions which prevent condensation within the space or building fabric;
second, to meet the physiological needs of the building's occupants.

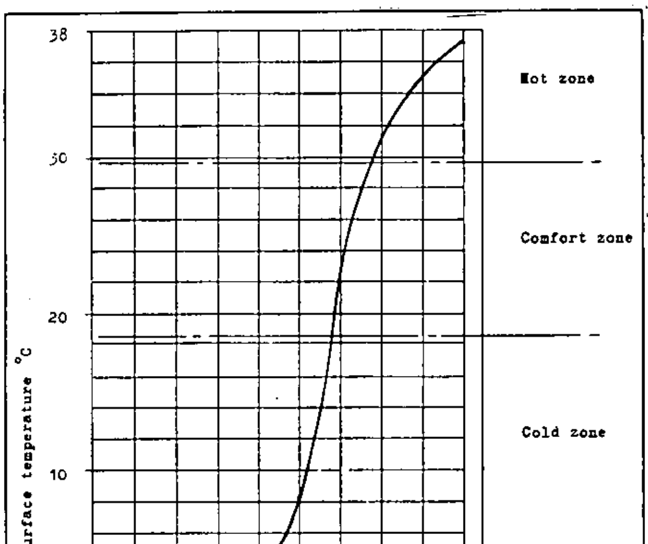
With modern well-insulated buildings, the conditions necessary to satisfy the first can be maintained with air temperatures of around 12°C. If condensation occurs, considerable damage can be caused to the building fabric or contents, or both.

The physiological needs of man are complex and require further analysis. It is an important requirement that man maintains a constant internal body temperature of around 37°C. In order to do this, the body regulates itself to ensure that there is a balance between the rate of heat production within and the rate of heat loss from its surface. However, the range of ambient temperature over which the body can maintain this balance is small, and below this range the rate of heat loss must be balanced by external means — such as layers of clothing, or raising the ambient temperature by the use of a heating system.

Whilst raising the ambient temperature may ensure that a heat balance is maintained between the body and its surroundings, it will not always ensure comfort. This is because the body can differentiate between the effect of varying temperatures on different parts of the body. It would be possible for the body to be in thermal equilibrium with its surroundings yet having some part, possibly the feet, feeling cold and giving rise to discomfort. It is therefore important that a heating system be provided that takes account of this, and does not just simply liberate heat into the space in a haphazard manner.

Bedford[5] carried out experiments on a group of subjects and found that complaints of discomfort to the feet ceased when the air temperature 150mm above the floor was between 21.1°C and 23.3°C; yet these same subjects preferred an air temperature of 18.3°C at head level. *Chrenko*[6] has confirmed the observations of *Bedford* and concludes that a non-uniform thermal environment, with the highest temperature at floor level, is necessary in the

Figure 2: Variation of sole temperature with different floor surface temperatures.



interests of thermal comfort of the occupants of a building.

Despite the need for higher temperatures at floor level it is possible to cause discomfort by overheating the foot. *Fanger*[7] has produced a graph relating to floor temperature and foot temperature, measured on the sole, to the sensation of discomfort.

From this graph, shown in *Figure 2*, we can conclude that for ideal comfort conditions the floor temperature should lie between 18.5°C and 29.5°C. *Chrenko*[8] also carried out experiments on the effect of floor temperature on thermal comfort, and concluded that floor surface temperatures should not exceed 25°C. Incidencies of discomfort were particularly pronounced for walking subjects, both men and women, when the floor surface temperature exceeded 25°C.

It has so far been established that for ideal thermal comfort the body requires higher temperatures at the feet than at head level.

There are many heating systems available, ranging from underfloor heating to ceiling heating, warm air, convectors, radiators, etc. Each of these different systems provide differing characteristic thermal gradients within the space they heat. *Kollmar*[9] has measured variations of space temperature for different types of heating systems in both the horizontal and vertical planes. These results are summarised graphically in *Figures 3 and 4*. In *Figure 3* vertical temperature distributions are plotted against an 'ideal' temperature profile. It is clear that the vertical temperature variations which most nearly coincide with the ideal profile are those of the underfloor heating system.

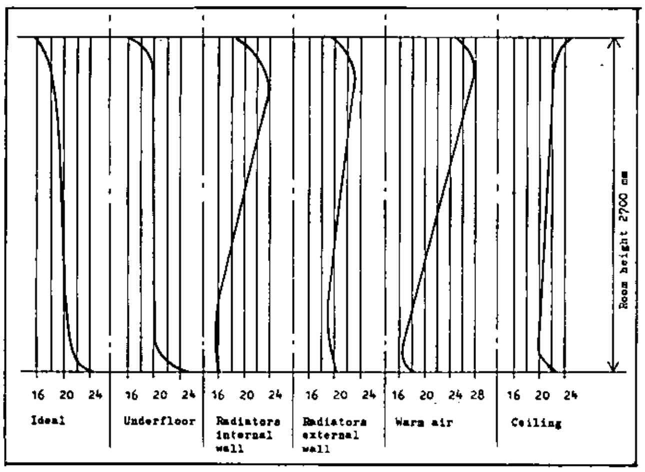


Figure 3: Vertical temperature distributions (degrees centigrade) in enclosed spaces due to various heat emitters.

Figure 4 shows horizontal temperature distributions measured at head height. It can be clearly seen that for most systems quite large horizontal temperature variations can be expected, whereas in the case of underfloor heating the variations are quite small. We can therefore conclude that conditions of equal comfort exist throughout the space heated with this type of system.

Heat Transfer and Basic Principles

For any heating system to be effective, it must supply sufficient heat to a space to balance any losses which may

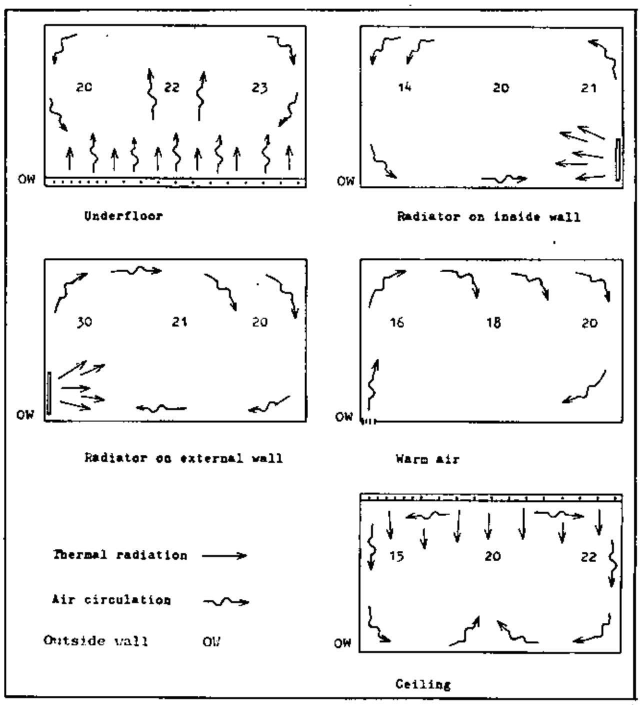


Figure 4: Horizontal temperature distributions (degrees centigrade) and symbolic representation of radiation and convection in enclosed spaces due to various heat emitters.

occur. In buildings, the usual losses are due to;

Heat conduction through the structure, and;
convective heat transfer to the ventilation air.

In underfloor heating, heat is transferred to the space by means of convection and radiation, which we will consider separately. The general equation for purely convective heat transfer from a floor may be written as:

$$\phi c = c(tf - tr)^n$$

where:

ϕc = heat transfer due to convection;
c = a constant;
tf = temperature of the floor surface;
tr = temperature of the room air;
n = an exponent.

It is not easy, if at all possible, to evaluate c and n from first principles and it is usual to derive values from experiments. A considerable number of experiments have been carried out in the past and a number of different values have been published.

Similarly the general equation for purely radiant heat transfer may be written as:

$$\phi R = \sigma \varepsilon (T_1^4 - T_2^4)$$

where:

ϕR = heat transfer due to radiation exchange;
σ = Stefan Boltzmann constant;
ε = emissivity factor;
T_1 = absolute temperature of the floor;
T_2 = absolute temperature of the surroundings.

Heat transfer due to radiation can be much more precisely analysed. In the case of an enclosure or room, the walls, ceiling, etc. all receive radiation from the heated floor and then re-radiate some of this back into the room; the quantity re-radiated depending upon the emissivity, temperature, shape and geometric relationship of the surface to the floor. Graphs and tables are available in most heat transfer textbooks, which enable engineers to calculate the magnitude of these radiated components, and therefore arrive at the overall radiant heat transfer from the floor.

Because of the complex nature of evaluating the convective and radiant heat transfer components separately from basic principles, many researchers have concentrated on producing equations which combine the two components in a simple and easily evaluated form. These equations are typically:

$\phi f = \alpha A\ (tf - tr)$ watts

where:

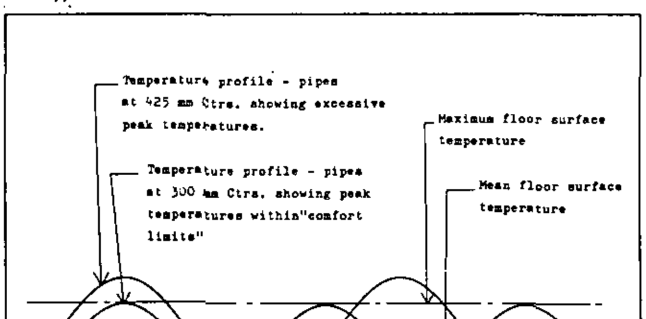
ϕf = combined radiant and convective heat transfer from the floor - w;
α = a heat transfer coefficient - $W\ m^{-2} k^{-1}$;
A = heated floor area - m^2;
tf = mean floor temperature - °c;
tr = mean room temperature - °c.

The value of α is derived from measurements made in test rooms, and therefore many different values have been published depending on the exact nature of the experimental chambers. However, it is generally accepted that α has a value of 9 - 10 $W\ m^{-2}\ k^{-1}$. In certain circumstances, where the rooms have a large re-radiating effect, values as high at 13 $W\ m^{-2}\ k^{-1}$ have been reported.

Suter and Nilsson[10] working at Lausanne University have carried out experimental work to determine combined heat transfer coefficients from floor, and have published values in the order of 16 $Wm^2\ K^1$ for ordinary rooms. These values have caused great controversy throughout the underfloor heating industry.

Using such high values, some 60% higher than those generally accepted, designers could reduce the quantity of pipe in the screed — hence increasing the spaces between the coils, and reducing the cost of a given installation and still expect to obtain the same heating effect. The industry in Europe has challenged the validity of the experiments and also states that if the higher values of heat transfer coefficients, together with increased pipe-coil spacing, were adopted, uneven floor temperatures would result. *Figure 5* illustrates the result of the assumption of

Figure 5. Floor surface temperature profiles for pipe coils at different centres.



a high value for heat transfer coefficient and the consequence of increased pipe spacing. It can be seen that some areas of the floor would become sufficiently hot to cause discomfort to the feet of people standing on them. Because of the nature of the system — warm floors — there is a considerable downward heat flow from the floor to the soil beneath the floor and surrounding the building. *Figure 6* illustrates the principal paths of heat flow associated with a floor in contact with the earth.

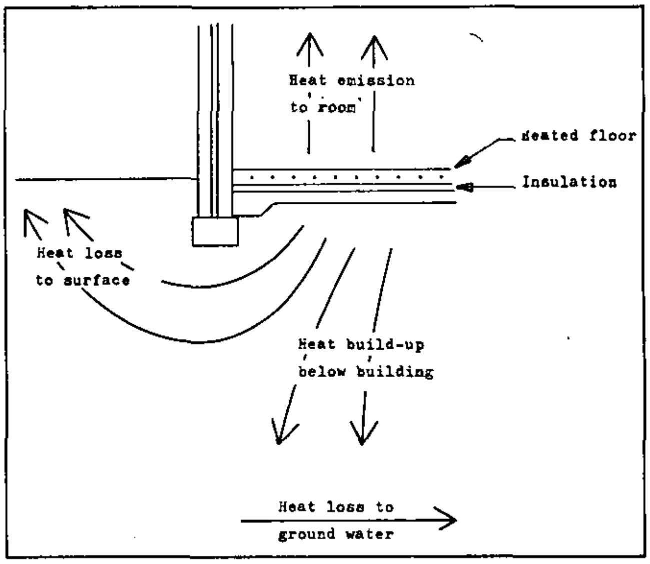


Figure 6: Heat flows from floor in contact with earth.

In Europe the great majority of buildings have basements, and therefore the problem of downward heat flow has not received great attention. The estimation of downward heat flow is a complex problem, and depends on several important factors. The nature of the heat flow is conductive, and whilst the conductivity of soil remains fairly constant at 1.0 — 1.4 $W\ m^{-1}\ k^{-1}$, the presence of a high water-table or running water in the soil can significantly increase the heat loss. When a building is erected there is a steady rise in ground temperature beneath the building over a period of years, this is particularly pronounced in the case of underfloor heating systems and may then act as a thermal fly-wheel.

The effect of ground water on the downward heat loss is recognised in Europe, and in Germany the DIN standards, to which all designs must comply, publish values of water temperatures to be assumed under buildings. However, such information is not available in this country, and therefore another approach must be adopted to evaluate the downward heat flow. As previously stated, the estimations of downward heat flow from a floor is a complex problem; much research work has been carried out in the past and some results can be found in the *C.I.B.S. Guidebook A3*[11]. Table A3-15 and A3-16 give 'U' values for different configurations of floor. Whilst the 'U' values given are not directly suitable for our purpose, they may be modified as follows. 'U' values are calculated as the sum of a series of resistances of the various elements of a composite structure, and in the case of 'U', values for a floor may be written as:

$$Uf = \frac{1}{Re + Rs}$$

where:

Uf = 'U' value of the floor — $W\ m^{-2}\ k^{-1}$;

Dimensions of Floor	'U' values for calculating downwards heat flow from underfloor heating for various thicknesses of insulation.		
	Insulation 0.025m	Insulation 0.05m	Insulation 0.075m
Very long x30 m broad	0.15	0.14	0.12
" x15 "	0.25	0.21	0.19
" x1.5 m "	0.39	0.31	0.26
150m x60 m "	0.10	0.09	0.09
" x30 m "	0.17	0.15	0.14
60m x60 m "	0.14	0.13	0.12
" x30 m "	0.19	0.17	0.15
" x15 m "	0.28	0.24	0.21
30m x30 m "	0.23	0.20	0.18
" x15 m "	0.31	0.26	0.22
" x7.5 m "	0.44	0.34	0.28
15m x15 m "	0.37	0.30	0.25
" x7.5 m "	0.48	0.37	0.30
7.5m x 7.5m "	0.56	0.41	0.33
3m x 3 m "	0.87	0.56	0.42

Figure 7: 'U' Values, for underfloor heating calculations, for solid floors in contact with the earth having four exposed edges.

Dimensions of Floor	'U' values for calculating downward heat flow from underfloor heating for various thicknesses of insulation.		
	Insulation 0.025m	Insulation 0.05m	Insulation 0.075m
Very long x30 m broad	0.09	0.08	0.08
" x15 m "	0.15	0.14	0.13
" x7.5 m "	0.25	0.21	0.19
150m x60 m "	0.06	0.06	0.05
" x30 m "	0.09	0.09	0.08
60m x60 m "	0.08	0.07	0.07
" x30 m "	0.11	0.10	0.09
" x15 m "	0.17	0.15	0.14
30m x30 m "	0.14	0.13	0.12
" x15 m "	0.19	0.17	0.15
" x7.5 m "	0.28	0.24	0.21
15m x15 m "	0.23	0.20	0.18
" x7.5 m "	0.31	0.26	0.22
7.5m x7.5 m "	0.37	0.30	0.25
3m x 3 m "	0.71	0.49	0.37

Figure 8: 'U' Values, for underfloor heating calculations, for solid floors in contact with the earth having two exposed edges at right angles.

Re = resistance of the earth — $m^2\,k\,W^{-1}$;
Rs = resistance of the air layer directly above the floor — $m^2\,k\,W^{-1}$.

With underfloor heating the hottest part of the floor is at the plane of the pipe coils, and heat flows both upward and downward from this level. Therefore, when considering downward heat flow we may discount the value of Rs. However, to reduce the heat loss from the floor, it is essential to include a layer of insulation between the pipe coils and the slab. This resistance of this layer of insulation may be calculated as:

$$R_i = \frac{L^i}{K_i}$$

where:

R_i = resistance of the insulation material — $m^2\,K\,W^{-1}$;
L_i = thickness of the layer of insulation — m;
K_i = thermal conductivity of the insulation material — $W\,m^{-2}\,K^{-1}$.

Using values given in the *C.I.B.S. Guidebook A3*, modified versions of tables A3-15 and A3-16 are given in *Figures 7 and 8* respectively. The modified values have been calculated by the following method:

$$U_f = \frac{1}{\frac{1}{U} - Rs^1 + Ri^1}$$

where:

U_f = 'U' value for estimating downward heat flow from the pipe coil plane — $W\,m^{-2}\,K^{-1}$;
U = 'U' value given in table A3.15 or A3.16 — $W\,m^{-2}\,K^{-1}$;
Rs^1 = value given in table A3.4 for surface resistance of floor — $m^2\,K\,W^{-1}$;
Ri^1 = resistance of various thicknesses of insulation material — $m^2\,K\,W^{-1}$.

Using these modified 'U' values the downward heat flow may be calculated from:

$$\phi d = U_f A_f (tp - to)$$

where:

ϕd = downwards heat flow — W;
U_f = modified 'U' value — $W\,m^{-2}\,K^{-1}$;
A_f = area of heated floor — m^2;
tp = mean temperature of the pipe coil plane — °C;
to = outside air temperature — °C.

Control Systems

The purpose of controls is to vary the output of a heating system to balance the energy loss from the space which is being heated. With a system utilising water as the heat transport medium, the change of output is effected by varying the water flow temperature.

Underfloor heating systems, because of the mass of screed that is heated, are slow to respond to changes in water flow temperature. Typically, underfloor heating systems respond three to four times more slowly than a conventional steel panel radiator system.

Changes in the heating system output are needed to meet changes in heating requirement caused by variations of outside climate. Sunlight shining through windows, or the introduction of a heat source into a room, may also require a reduction in output from the heating system if the space is not to be overheated. Changes in the outside climate are not usually felt immediately within the space, as the structure both reduces the magnitude of any changes and also delays them. The exact delay and degree of moderation are dependent upon the thermal and physical characteristics of the building. 'Heavyweight' buildings, i.e. those that have heavy walls and insulation on the outer surfaces, have a greater moderating effect than 'lightweight' buildings, i.e. those that have heavy walls and insulation on the outer surfaces, have a greater moderating effect than 'lightweight' buildings, i.e. those that have light walls and insulation on the inside of the structure.

An important feature, therefore, of all controls for underfloor heating systems is that changes in the outside climate are relayed to the heating system as soon as they occur, so that the system may begin to respond before the delayed effect of the external changes are felt within the space. The most common system uses the familiar external compensation of flow temperature, where an outside thermostat is used to vary the flow water temperature of the system.

The effect of direct sunlight, or of changes in room occupancy, are normally dealt with by thermostatic radiator valves in the conventional steel panel system. These valves are not required for underfloor heating systems however, as such systems have a considerable degree of self-regulation. We have seen above that the heat output of underfloor heating is dependent upon a temperature difference between the floor and the space. If we consider a room as having a temperature of 20° C with a floor temperature of 25°C, i.e. a difference of 5K, then a rise of 1°C in the room temperature will cause the temperature difference to fall to 4K, and as the heat output is proportional to the temperature difference, it will fall by 20% of its original value.

In this way, utilising a combination of an externally compensated flow temperature and the inherent properties of self-regulation, good control of underfloor heating systems can be obtained. Measurements made in hospital wards show that room temperatures can consistently be held to a variation of 1.5K about the design point.

Where underfloor heating systems are used in buildings requiring intermittent heating, careful attention must be paid to the control system. Because of the low rate of response, the pre-heating time required for the floor is longer than that of a comparable radiator system. However, there is a similarly long cooling time at the end of the day. To take advantage of this extra cooling time, and to minimize the long warm-up time, an optimum on-off controller is best used. It is now possible to obtain such controllers especially designed to cope with the flat heating and cooling areas of underfloor systems. A particular advantage that may be gained from the long cooling time is that of reduced chance of room condensation. Research has shown that intermittent heating is a major cause of condensation problems in modern buildings.

Clearly, underfloor systems would not be suitable for intermittent heating of very lightweight buildings as these require a system that can respond rapidly to changes in the external environment.

System Design and Practice

When designing underfloor heating systems, the heating duty for each space is calculated in the same manner as that for any other heating system — except that heat losses through the floor are not taken into account at this stage. If the calculated heating duty is divided by the floor area, the required heat emission per unit area of floor is arrived at. By application of the previously discussed principles of heat transfer, and limiting the floor surface temperature to a figure low enough to ensure adequate thermal comfort, we may conclude that for a typical space with design internal temperature of 20°C, the extreme maximum emission obtainable from the floor is 123W m^2.

If the required emission from the floor is in excess of this figure, additional measures must be considered. These are commonly:

a. *raise the floor temperature to above comfort level* over the whole surface:

b. create a high floor temperature zone—usually on the external perimeter;

c. the use of additional heat emitters such as radiators or convectors.

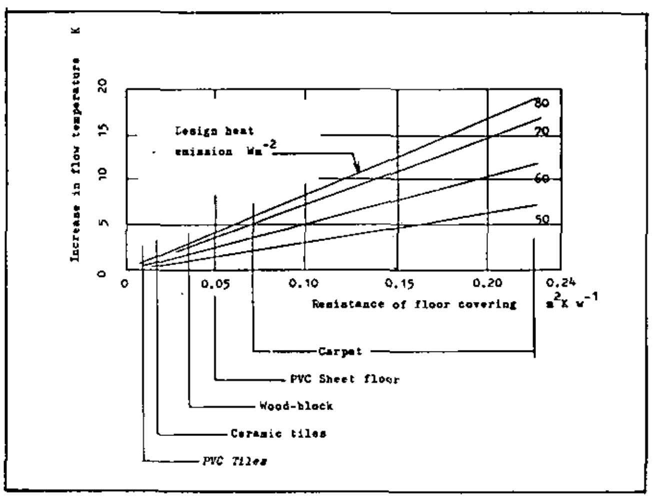
The use of solution (a) should be avoided at all costs. It may only be permissible where the area of floor is trodden on for short periods of time, such as entrance halls or corridors. Alternative (b) is more acceptable, as room occupants, in general, rarely utilise the perimeter zone. However, the method is not very efficient. Typically, increasing the temperature of some 25% of the floor to say 35°C will result in only a 12% increase in overall heat output. If additional heating surface is introduced, as in (c), a comfortable thermal environment may be maintained, but the major advantages of underfloor heating, namely lack of intrusion on the occupied space and the fuel saving room temperature gradients, are sacrificed.

As a further alternative for increasing the heat output from the floor, one German manufacturer has patented a flow-reversing valve where the flow and return connections to the coils are periodically reversed. This has the effect of raising the mean temperature of the floor, and therefore the heat output — without increasing the maximum temperature of any part of the floor.

After calculating the heating necessary for each space, the downward heat flow must also be estimated before the required boiler power can be arrived at. The quantity of downward heat flow depends principally, for a given room and external temperature, upon the thickness and type of material used for the underfloor insulation. Expanded polystyrene is the most commonly used insulation material in Europe and its thickness varies from 25mm to 75mm. The exact thickness of insulation is usually selected on financial criteria. Where floors are directly in contact with the ground, the 'U' values outlined in *Figures 7 and 8* may be used to estimate the downwards heat flow.

For other situations where intermediate floors are concerned, 'U' values may be calculated using the methods outlined in the *C.I.B.S Guide Book A3.* By adding the fabric and ventilation losses calculated for each space to the estimated downward heat losses (it is usual to ignore gains from other spaces) we may determine the boiler power required.

Figure 9: Increase in water temperature necessary to compensate for the increased resistance due to the presence of different floor coverings.



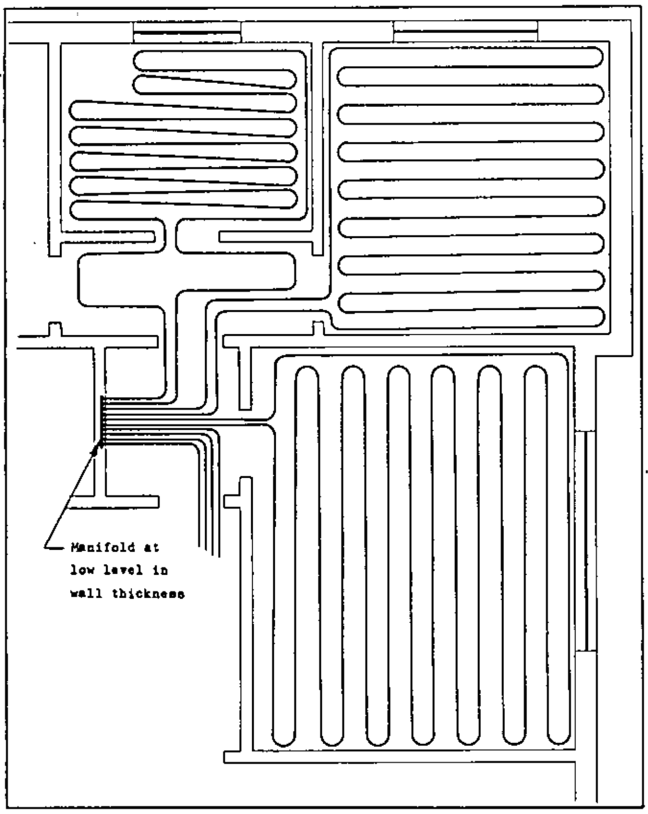
When calculating the heat emission from the floor to the space, consideration should be given to the type of floor covering to be laid. This is important, as the type of covering has a major effect on the heat emission. In. *Figure 9, Lage*[12] shows the increase necessary in flow water temperature to compensate for the resistance to heat transfer of various forms of floor covering. It is clear that the use of carpet will require flow water temperatures up to 15K higher than for plain floors, with other types of coverings requiring lesser increases.

It is usual, as in the case of radiator and convector heating systems, to allow some additional boiler power for rapid heat-up from cold. Typically, these allowances vary from 7% for heavyweight buildings with long hours of occupation, to, say, 30% for lightweight buildings occupied for shorter periods.

When the heat loads for each room have been determined, the spacing of the pipe coils must be selected. The exact spacing is usually between 240mm and 300mm, depending on the heat emission required from the floor. Each coil obtains its hot water from a series of distribution manifolds, located at strategic positions throughout the building. *Figure 10* shows a typical system. The manifolds are usually provided with flow isolating and return regulating valves, and can very often feed up to six separate coils.

Some manufacturers, in an attempt to obtain a more even distribution of heat over the floor surface, provided thin aluminium plates, known as lamellas that clip over the pipes and therefore act as heat distribution fins. Before the pipes are buried in the screed they must be securely fixed so that they are not displaced when the screed laying operating is commenced. There are two common methods of pipe fixing:

Figure 10: Typical layout of pipe coils and connections to distribution manifold.



Property	Tube Type			
	Polythene PE	Cross-linked V-PE	Polybutylene PB	Polypropylene PP
Density	0.95g/cm³	0.94	0.92	0.91
Axial stress	24 N/mm²	20	18	29
Bursting pressure	35 N/mm²	23-25	33	45
Extension	800%	400-500	300	1000
Modulus of elasticity	900 N/mm²	450-600	400	900
Linear coefficient of	2.0 10⁻⁴/K	2.0	1.5	1.8

Figure 11: Comparison of physical properties of tubes.

The insulation boards are supplied with grooves at the correct centres to suit the pipe spacing, and the pipes are pushed into these slots;

Or pipe-clips are fixed to the floor at the correct centres and the pipes are attached to these.

In order to reduce the number of fixings, metal rails are provided in which the pipe-clips slide, the rails being fixed at each end only. The rails are very often marked with typical pipe centres to speed up the process of laying the coils. The range of materials available for the plastic pipe is quite large, the raw materials being provided by the large chemical companies. *Figure 11*[13] sets out a summary of the common types available. The most common material in current use, say 80% of all installations, is the polypropylene material (PP) which has excellent life and handling characteristics. It can easily be joined by welding and is cheap.

The next most popular material is the crosslinked polythene (V-PE) though this material, despite its increasing popularity, has two drawbacks:

It cannot normally be joined by welding and compression fillings must be used;

and pipe remains 'fluid', and leaks will develop at the compression joints unless these are periodically tightened.

This second drawback means that if some time after the installation the pipe coil is punctured, it will be almost impossible to make a repair that can be re-buried in the screed. The V-PE tube, however, has one advantage in that if it is damaged during installation, the application of light heat will cause the tube to recover its original shape again. The other two types, polythene and polybutylene are rarely used. Polybutylene, despite having the best theoretical life of all the tubes, tends to lose its elasticity after ten years or so and may therefore crack at the expansion joints in the building in later years. All the types of pipe have expected lives of several hundred years. Most installers give long guarantees — say up to thirty years — and include cover for any consequential loss in addition to replacing the defective tubes.

The pipes, when delivered on site in coils, tend to be fairly rigid, especially if the weather is cold. To make installation easier, the fitters prefer to have the heating source commissioned so that hot water may be circulated through the pipes to make them more flexible. If the permanent heat source is not available, it is common for the installer to use a portable electrically heated hot water heater which may be coupled to the pipes. Because of the very large areas of underfloor heating being laid in Europe, installers have, over the years, developed a variety of special tools to aid quick installation of the pipe, thus reducing labour costs.

When the pipe coils have been installed and tested, the screeding operation may begin. The screeds used are similar to those in all normal buildings; however, some important rules must be observed. Firstly an impervious layer, usually polythene sheet, must be interposed between the screed and the insulation layer to prevent the latter from absorbing moisture from the screed, thus causing rapid drying and eventual cracking. Secondly, it is usual to add to the screed special chemicals which promote flow and thus ensure that the screed grips the pipework tightly when dry. The adhesion between the screed and the pipe is used to restrain pipe movement due to expansion. The pipe material, being flexible, will deform inwards under expansion conditions, the pipe wall thickness increasing slightly.

In order to ensure that the screed has sufficient strength to restrain the pipe, it should have at least 10mm cover above the highest part of the pipe coil. If this thickness is reduced the screed may eventually crack. Where large areas of screed are laid it is usual to incorporate expansion channels filled with mastic. The pipe coils may safely pass through these joints without protection. However, where building expansion joints occur, it is usual to slip an oversize tube over the pipe coil, extending for some 150mm each side of the joint, to

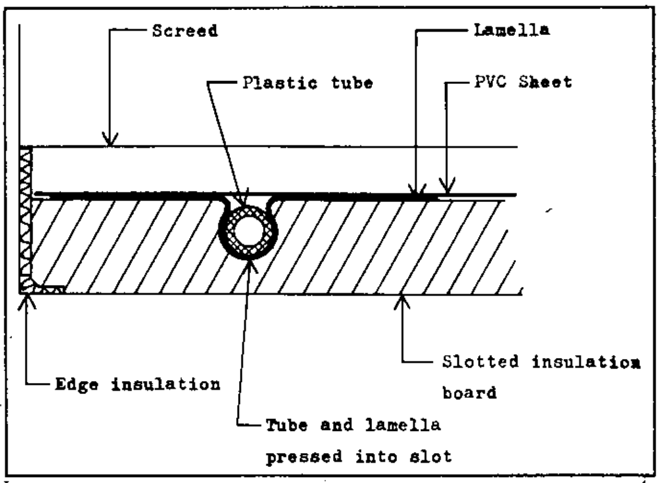
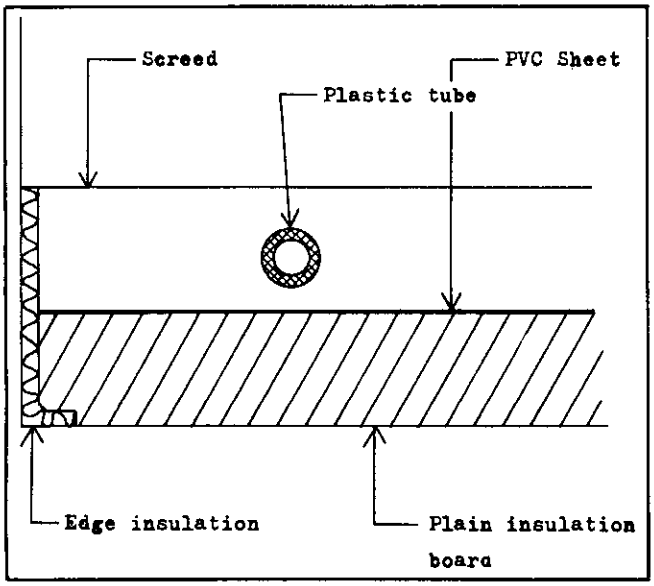


Figure 12: Typical section through floor showing slotted insulation board.

Figure 13: Typical section through floor showing plain insulation board.



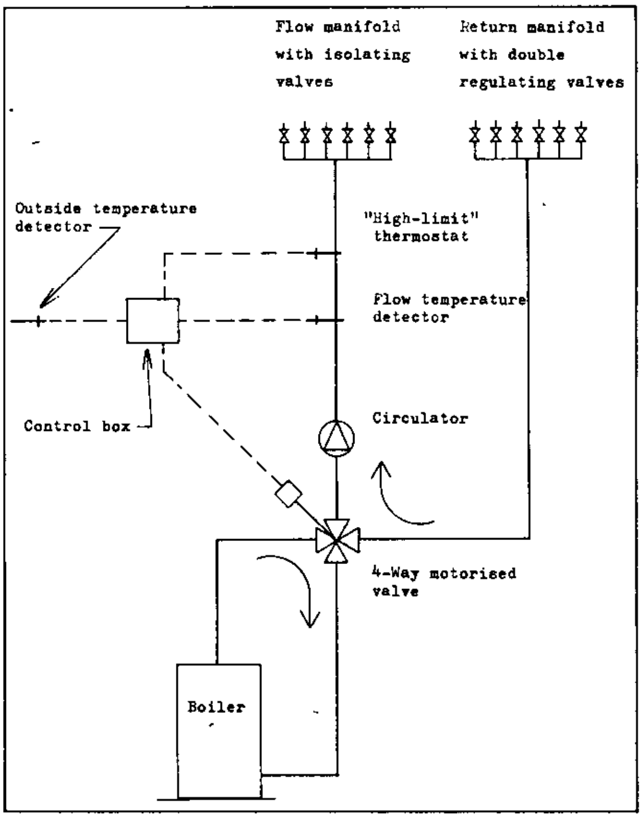


Figure 14: Schematic diagram of controls showing essential components.

provide additional reinforcement. Most underfloor heating installers provide and install edge insulation for each screeded area, this commonly taking the form of a corrugated paper strip. *Figures 12 and 13* show typical sections of floor constructions.

The hot water supply to the distribution manifolds usually takes the form of a mixing circuit. In Europe, A 4-way valve is commonly used on small installations. *Figure 14* shows a typical control circuit. The flow water temperture is controlled by the outside sensor, the 4-way valve mixes sufficient hot water from the boiler to the return water from the heating circuit; the remainder of the hot water being mixed with the return water to the boiler, so that the 'Back-End' temperature is kept up. The circulation from the boiler is by gravity and in the heating circuit by pump. The only other control item is the high-limit thermostat, which cuts off the flow to the heating circuit should the temperature rise to excessive levels. This is essential to prevent damage to the pipe coils and the building fabric.

Economic Considerations

Cost is an important consideration when choosing any heating system: In addition to the capital outlay, major areas of expenditure are fuel and maintenance costs.

Because of the lack of underfloor heating installations conforming to modern practice in England, available cost data is not all that reliable. In Europe the capital cost of underfloor heating systems is said to be in the order of 10-20% higher than for a conventional radiator system. However, this cost includes a much higher standard of insulation than would normally be applied to the floors, and also does not take into account the extra costs of a radiator system — such as painting — which are traditionally part of the main contractors' work in England.

In the other areas positive cost savings can be made. Because of the reduced temperatures and thermal gradients in rooms, and the improved standard of floor insulation, reductions in energy consumption of at least 10% over other systems can be expected. *Olesen et. al.* [14] have reported that in their test rooms, the underfloor heating system has the lowest heat losses; energy consumption of other systems was found to be 10-20% higher.

Maintenance costs should be almost zero with underfloor heating systems, provided treated water is used to prevent the pipes scaling up. The system being corrosion-resistant will not need any other maintenance, apart from the occasional tightening-up of the compression fittings if a cross-linked polythene pipe is used. Whereas a radiator system will probably be painted several times in its life and, being surface mounted, is susceptible to accidental damage by furniture and deliberate vandalism.

Another major cost-saving feature of underfloor heating systems is that they use 'low-grade' energy, and are thus ideal for combining with heat pumps or solar heating. In Northern Europe, heat pumps are popular and are being used in conjunction with underfloor heating systems to provide substantial fuel cost savings. In England, *British Telecom*[15] have installed a heat-pump combined with underfloor heating in a computer centre. This recovers the heat rejected from the computers, and is used instead of a 150kW boiler plant and radiator system, to heat the offices and stores associated with the computers. The installation costs were found to be similar to those for a conventional radiator system, but saving expenditure on a boiler and running costs.

Conclusions

Over the past eighty years many underfloor heating systems have been tried, and generally these have fallen into disrepute. Since the 1960s underfloor heating systems have been developed in Europe using plastic materials. These systems are now extremely popular and can be found in a wide range of buildings varying from domestic housing, offices, shops, factories and churches to hospitals.

The systems now in use have overcome the disadvantages of the previously tried systems such as:

high installation and running costs;
increased building costs;
poor control leading to energy wastage;
excessively hot floors;
corrosion and leakage problems;
inability to cope with the problems of intermittent heating;
high maintenance and repair costs, etc.

Modern underfloor heating systems offer the installer many advantages, the most important of which may be summarised as:

Thermal comfort — underfloor heating systems offer the building occupier a high degree of thermal comfort with the ability to give warm feet and a cool head.

Improved aesthetics and use of space — because the system does not intrude on the space and is hidden from view, the building designer is less constrained. Floor-to-ceiling windows may be used freely, and furniture may be positioned without regard to heating appliances.

Reduced maintenance and freedom from interference — the system, because of its corrosion-free materials, does not require maintenance apart from attention to the pump and control valve which are part of all wet systems.

Because the system is hidden it is vandal-proof and does not require periodic repainting, and cannot be damaged by furniture or misuses.

Reduced costs — whilst the installation cost of underfloor heating systems is a little higher than that of a radiator system, the cost saving that occurs by virtue of reduced energy consumption soon outweighs the initial extra expenditure.

Ability to utilise sources of low grade heat — underfloor heating, because of its requirement for low water temperatures, is ideal for combining with energy-saving devices such as solar panels and heat pumps. In Northern Europe and England heat pumps have been shown to be particularly effective, affording their users substantial cost benefits.

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The authors of this paper are from the Hospital Infection Research Laboratory, Dudley Road Hospital, Birmingham. Professor Ayliffe is the Honorary Director, Mr Babb is Senior Research Officer and Jean Davies is the Scientific Officer.

Removal of Pipework from Vacuum Plant Installations

Handling Hazards

G A J AYLIFFE MD FRCPath J R BABB FIMLS JEAN G DAVIES AIMLS

Introduction

The risk of infection to personnel working on medical vacuum systems is unknown, but thought to be minimal. In collaboration with British Oxygen Company (BOC), an investigation was therefore made in which swabs and samples of pipework were taken, following vacuum-line break-ins, at specific hospitals during a period of twelve months.

In the early stages of the study, samples were confined to selected hospitals in the southern half of England — but it was later decided to extend the study to other regions. In all, 17 hospitals were investigated, and these included vacuum systems from theatres, intensive and special care units, renal units and from isolation facilities, including tuberculosis.

Sommaire Francais

Les risques résultant de la manutention des canalisations des installations de vide

Le risque d'infection que court le personnel travaillant sur des systèms de vide médicaux, bien qu'inconnu, est estimé minimal. En collaboration avec la *British Oxygen Company (BOC)*, une étude fut menée récemment qui comportait des prélèvements et des échantillons de canalisations, sur des installations de vide de certains hôpitaux et sur une période de douze mois.

Alors que dans les premiers temps de l'étude, des échantillons furent prélevés dans des hôpitaux sélectionnés au sud de l'Angleterre, il fut décidé plus tard d'étendre l'étude à d'autres régions. En tout, l'étude a porté sur 17 hôpitaux et elle a examiné les systèmes de vide des salles d'opération, des unités de soins intensifs et spéciaux, des unités rénales et des locaux d'isolement, y compris des tuberculeux.

Figure 1: Contamination of pipework removed from vacuum plant installations in 17 hospitals.

	Number of Samples	Samples Yielding (%)				
		no growth	handling* contaminants only	other isolates (including T.B.)		
				scanty	moderate	heavy
Pipe sections	27	25	2	0	0	0
Swabs	65	58	5	0	1 *Ps. fluorescens* (1.5%)	1 *Ps. aeruginosa* *Micrococci* *Candida* (not albicans) Sarcina (1.5%)

* Scanty growth of skin organisms, e.g. coagulase-negative staphylococci and airborne aerobic sporing bacilli.

Methods and Materials

Where possible, employees of BOC were asked to take three swabs and two sections of pipe from each break-in. Instruction as to how this could be done without handling contamination, and without reducing the numbers of viable bacteria in the pipework, were given.

Swabs were despatched to the laboratory in transport medium where, on arrival, they were cultured directly on blood agar and *MacConkey* agar plates and put into nutrient broth. Plates were incubated at 37°C for 18 hours and examined for growth. Nutrient broths were similarly treated after incubation. Isolates were Gram stained and identified using conventional biochemical tests.

Using a 20ml syringe and needle, pipe sections with sealed ends were pierced through the seal and inoculated with *Ringers Solution.* One ml of *Ringers Solution* was added per 20mm of pipe. Pipe sections were thoroughly rinsed, using a rotary mixer, and the washings removed for culture. Using a dropping technique, 1ml of these washings was plated onto the surface of a blood agar and *MacConkey* agar plate.

These plates were incubated and the bacterial count and identity established. One ml of the washings was cultured in nutrient broth and the remainder examined for *Mycobacterium tuberculosis,* by inoculating *Lowenstein* and *Jensen* slopes. This is a slow-growing organism and may take up to six weeks to grow and identify. It was suggested that the sites chosen for culture should include:-

A swab from a wall outlet-point, not necessarily in current use, but one that had been used within 48 hours.

A section of pipe (150-200mm), after pipe feeding outlets have merged from the ward where the outlet point was sampled.

A section of pipe after all sections have merged to form a single line to the plant room.

Swabs from the inner surfaces of the filter bowls, and outer surfaces of the filter candles.

The facility to sample other pipework not specified was given, providing the location could be clearly established and samples taken in the described manner. An instruction leaflet was provided by the laboratory, indicating the correct sampling and despatch procedures; also a questionnaire to be returned with the samples, identifying the hospital, sample locations and the state of the pipework, i.e. wet/dry, presence of biological material, etc.

BOC employees were instructed that it was essential that samples, particularly swabs, were despatched with minimum delay. Sterile plastic seals of an appropriate diameter were supplied for sealing pipe section after removal.

Results

The results of bacteriological investigations in 17 hospitals are shown in *Figure 1.* In these hospitals, 27 sections of pipe were taken from the plant. No potentially pathogenic bacteria were recovered. Sixty-five swabs were cultured from the block, filter and bowl. Potential pathogens were recovered from two samples only — one from the block in a theatre 40 metres from the main pipe, *Pseudomonas aeruginosa;* candida (not albicans); and sarcina. The second *Pseudomonas fluorescens,* from the block in a special care baby unit. Both outlets had been used within the previous 24 hours.

Contaminants due to handling, e.g. coagulase-negative staphylococci and aerobic spore-bearing bacilli, were recovered from two pipes and five swabs. These organisms are normally found in the air or on skin, and are therefore difficult to avoid when taking and putting up samples.

All pipe sections were examined thoroughly and found to be dry and free of biological material; two pipe sections contained a chemical deposit. M. tuberculosis (T.B.) was not recovered from any of the pipe washings, in spite of a fairly vigorous wash-out procedure.

The majority of samples (pipes 23/27, swabs 60/65) were received within 3-4 days of being taken.

Discussion

From these results, it would seem that the bacteriological hazard to employees removing the pipework from vacuum systems in minimal. Bacteria were recovered from only two locations, and were not of a type likely to infect healthy persons. They can sometimes cause respiratory infection in patients undergoing mechanical ventilation, in immunologically compromised patients or those with open surgical wounds. Similar bacteria commonly live in the normal human gut without causing harm.

All pipework sampled was free of biological material and dry. Aerosols are extremely unlikely as there was no evidence of bacterial survival in the pipework, and proliferation does not occur in dry tubing. The wearing of face-masks is therefore unnecessary for work on vacuum systems. Removal of the waste pipe from a domestic sink is theoretically a far greater hazard, as numerous Gram-negative bacilli are present but infection does not occur.

Although pipework was investigated for T.B., none were found. A tuberculosis isolation unit was included in the study, as M. tuberculosis is likely to remain viable for longer periods than other vegetative bacteria.

Although there was inevitably some delay between collection of samples and culture, the pipes were immediately sealed on removal to prevent any further evaporation of moisture, and swabs were transferred and despatched in transport medium.

Pipework was not examined for viruses, but it is unlikely that viruses would survive in conditions where bacteria do not.

Vacuum plant installations are not used in units for the isolation of patients infected with Group A pathogens. In the unlikely event of such an infection occurring in a general hospital, the Environmental Health Medical Officer will provide advice.

In view of these findings, and provided that basic hygenic practices are followed, removal of unheated pipework from vacuum systems does not appear to be a dangerous practice.

Recommendations

Cover open cuts and areas of broken skin with a waterproof dressing before break-in.

Thoroughly wash hands after completing the work.

Take precautions to avoid injury from the sharp ends of cut pipes. If cuts do occur, they should be cleaned and covered before return to work.

Non-immune employees should be offered immunisation against T.B. and tetanus, as is advised for all hospital staff.

Acknowledgement

We wish to thank the British Oxygen Company and the Engineering Branch of the DHSS for their collaboration.

Product News

£150m Hospital Package from Saudi Arabia

Two years of negotiation with Saudi Arabia have resulted in a contract worth £150m over the next two years for British firms.

The prime contractor is a London company established to co-ordinate British bids for major contracts, and the sub-contractors involved are to provide a range of services from accountancy and architecture to specialised consultancy work.

Since diplomatic relations with Saudi Arabia were tainted over the showing of the TV film 'Death of a Princess' early in 1980, this is the largest single piece of business won *by the UK in Saudi Arabia.*

After the initial stage of the contract, opportunities for further business are expected to emerge, but the first part of the contract is to commission and operate a 500-bed hospital in Jeddah for the National Guard. The hospital is to be built by Belgian firms.

The UK will be substantially involved in the modernisation and development of the Guard's medical services, which will mean orders for goods and services stretching far beyond the first stage of the Jeddah Hospital.

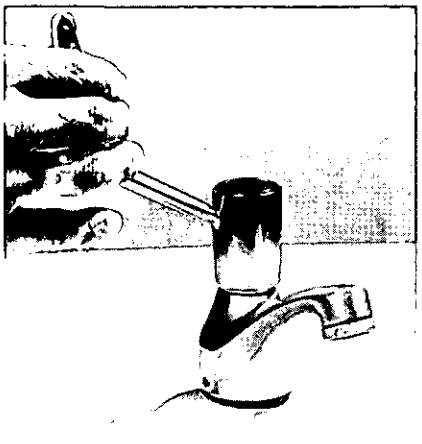
Ten companies involved are: International Aeradio; Grand Metropolitan; Wellcome Foundation; IHG (Medical Services); PA Management Consultants; Peat Marwick and Mitchell International; International Laboratory Services; Cusden Burden and Howitt; Hanscomb International; and Donald Smith, Seymour and Rooley. The last named firm is that of Mr George Rooley, a Past President of the International Federation of Hospital Engineering.

Spray Mixer Tap

A new feature for Economy Spray Mixer Taps — Mintap, is a special knurled metal orifice plate which screws on to the tap outlet.

The function of Mintap is to mix together hot and cold water to produce the desired temperature by rotation of an acrylic or metal control knob with an alternative of lever operation.

Lever operated Mintap is ideal for hospital use or for elderly or disabled persons who find that a single tap which is lever operated can be considerably easier to use than normal taps because the lever can be moved by the wrist or elbow.



'Mintap" mixer tap.

Considerable economy is obtained because Mintap is designed to discharge only 2 litres per minute under normal operating conditions and this leads to great saving of water and energy.

Details from: Meynell Valves Ltd., Bushbury, Wolverhampton WV10 9LB. Tel: 0902-28621.

Heat Recovery Unit

The latest addition to the Beltran range of heat recovery and pollution control equipment is a new stack mounted, circular heat recovery unit.

This spiral finned tube heat exchanger enables waste heat from boiler or process exhaust gases to be successfully and continuously recovered.

This unit is mounted 'in-duct' and features an integral bypass system. It is available in a range of sizes to suit most heat recovery situations and is easily fitted into boiler flue ductwork or process stacks.

In-situ cleaning of the unit, either manually or automatically, is simplified by the inclusion of a removable two piece housing. Provision for the installation of soot blowers is included.

The benefits of no ductwork transistors or bypass ducting and extremely low exhaust side pressure drops enable capital pay-back periods of 1-2 years to be frequently obtained. The new Beltran unit is available on an ex-works or turnkey basis.

For further information contact: Beltran Limited, Sunderland House, Sunderland Street, Macclesfield, Cheshire. SK11 6JF, Tel: 0625 615529. Telex: 668150.

Axial Flow Fan

Thelcastle Ltd. of Eccles, Manchester have introduced a new 'Economy Range' of Axial Flow Fans from 330mm. (13ins.) dia. to 762mm. (30ins.) dia. inclusive.

The new range has a revised specification and is being offered at substantial savings on current prices for standard Axial Flow Fans but maintains the same performance and overall dimensions. The standard range of Axial Flow Fans is still available.

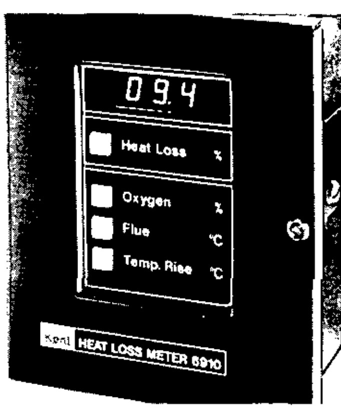
For further details contact: Thelcastle Ltd., PV Works, Montonfields Road, Monton, Eccles, Manchester, M30 8AW. Tel: 061 788 0345 or 061 707 3165.

Heat Loss Meter

The aim of good boilerhouse practice is to ensure that there is sufficient excess air for the maintenance of efficient combustion with very low levels of combustibles in the flue gas, whilst avoiding excessive heat loss via the chimney or flue.

The Heat Loss Meter Model 6910 which, when coupled with a continuously operating oxygen in flue gas analyser and two thermocouples, provides a continuous and direct measurement of boiler combustion performance. The unit is housed within a robust steel case

Heat loss meter, Model 6910.



suitable for wall or panel mounting and is fitted with a hinged door with a window through which the display and controls may be viewed. Its purpose is to present the operator with a value for the percentage of available heat which is lost up the chimney or stack and to indicate the combustion conditions from which this results. Any empirical adjustment made in these conditions can be monitored together with its effect on the percentage heat loss.

The heat loss meter accepts the electrical inputs form two thermocouples and an oxygen analyser and from these signals performs all the necessary calculations to give direct indication of:
Heat loss (%); percentage of oxygen in flue gas; flue gas temperature (°C); Temperature rise (°C).

Any of these parameters may be chosen for indication on the instruments' digital display upon operation of the appropriate push button located on the front panel. Indicator lamps show the selected function. In addition an electrical signal (mV), proportional to percentage heat loss is available for the operation of external recording/indicating/alarm equipment.

D. J. Barker, GKEP Analytical Instruments, 4 Rosemary Lane, Coldhams Lane, Cambridge, CB1 3QL. Tel: 0223 49121.

Braille Control Panels Free offer

For some 12 years, Philips Major Appliances have made available special Braille control panels for their appliances.

They now propose to make available Braille panels (converted by the Royal Institute for the Blind) to all interested customers, free of charge. All a customer has to do is to contact the Consumer Relations Department and give details of the model number of their Philips major appliance and an engineer will be sent to fit the panel at no cost.

Philips, Lightcliffe Works, Hipperholme, Halifax, West Yorks. Tel: 0422 20351.

Wall Cladding

A high impact acrylic/PVC alloy sheet material recently introduced into Europe by Rohm and Haas, has obtained a class 'O' fire rating for wall cladding applications when tested to the British Building Regulation Fire Test BS 476.

Already widely used to protect problem surfaces, KYDEX is employed as wall corner guards, corridor linings, door kick plates and wall linings in a variety of areas ranging from hotel kitchens to sports centres.

In addition to its class 'O' fire rating, it is said to offer exceptional resistance to denting, gouging and chipping and be resistant to chemical, and day-to-day, staining.

KYDEX provides an effective and attractive solution to high-abuse wall surface applications and is available in sheet or roll form in a range of standard colours with one surface pretextured with a fine hair-cell grain effect.

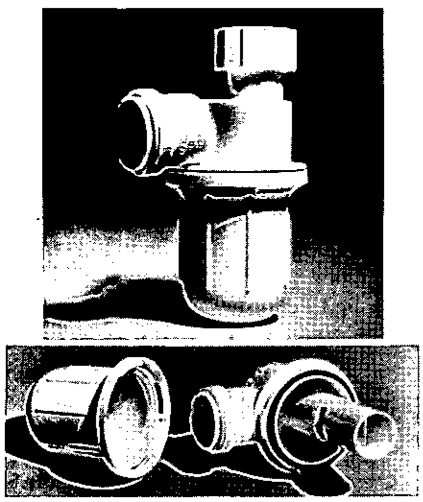
For further information contact: Rohm and Haas (UK) Ltd., Lenning House, 2 Mason's Avenue, Croydon CR9 3NB. Tel: 686 8844.

Anti-syphon Trap

Marley Extrusions Ltd has further refined its Monitor anti-syphon trap so that the anti-syphonic action is provided by air being drawn through a central by-pass tube.

It is now more compact, enabling it to fit behind the wash basin pedestal, and also not project so far below the basin. Minor internal modifications have improved the flow of water through the trap (while still maintaining the BS 5572 minimum 25mm. water seal), increasing the self-cleansing action.

Anti-syphon trap



The Monitor performs to the requirements of BS 3943; its inlet accepts British Standard waste outlet fittings, and the outlet has a new pre-fitted ring seal to suit small diameter mupvc or pp discharge pipes to BS 5255 : 76. There is also an adaptor ring option to connect light gauge copper to BS 2871 : 71 Part 1.

Details from: Marley Extrusions Ltd., Lenham, Maidstone, Kent. Tel: 0622 858888.

Boiler House Renewal

The existing coal-fired boiler house and plant at St. John's Hospital, Lincoln, is being completely replaced at a cost of £336,097.

The contract has been awarded to Eccleshare Ltd., 108/116 Dixon Street, Lincoln, by Trent Regional Health Authority and the work is expected to take 18 months.

When it has been completed the new boiler house and plant, which will also be fired by coal, will provide improved services to both the wards and the hospital in general, including the kitchens and laundry.

Energy Saving Kit

A new energy saving kit being offered by Stanbridge for their MW1/SG hospital bed pan and bottle washing machine will provide energy savings, and other benefits, and has the advantage of being available for both new machines and units already installed.

The kit mainly involves special insulation casings for the hot water tanks and steam generators and, say the makers, will not cause any obstructions for routine maintenance. The energy saving value of this insulation would, of course, depend very much on operating circumstances. Additional lagging on the washing canister will improve the disinfection cycle.

Apart from improving heater efficiency, another important benefit derived is sound reduction. Quieter operation of the machine will encourage, in some environments, late night or off peak use to further increase economy and avoid the early morning queue of pans.

Contact: John Beaumont, Stanbridge Ltd, 53 Hastings Road, Bromley, Kent. Tel: 01-462 1496.

Classified Advertisements

APPOINTMENTS AND SITUATIONS VACANT

WOLVERHAMPTON AREA HEALTH AUTHORITY

ENGINEER required for the Engineering Department in the Wolverhampton Group of Hospitals.

Applicants must have served an apprenticeship in Mechanical or Electrical Engineering and had at least two years further experience in the maintenance of engineering plant and/or environmental services, including knowledge of steam, gas, water, electrical and heating and ventilation services and be capable of designing heating and ventilating schemes.

Minimum qualifications — ONC Electrical and Mechanical or Part II City and Guilds Technical Certificate in Plant Engineering.

Salary Scale — £6201 - £7005 + 15% bonus.

A job description and application form may be obtained from Area Personnel Officer, Wolverhampton Area health Authority, Administrative Offices, New Cross Hospital, Wolverhampton, WV10 0QP. Telephone Wolverhampton 737221 Ext. 35/36.

Further information regarding the post may be obtained from Mr J A Simpson, Area Engineer at New Cross Hospital. Telephone Wolverhampton 732255, Ext. 2735.

Closing date 18 September 1981.

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Engineer

Area Works Department

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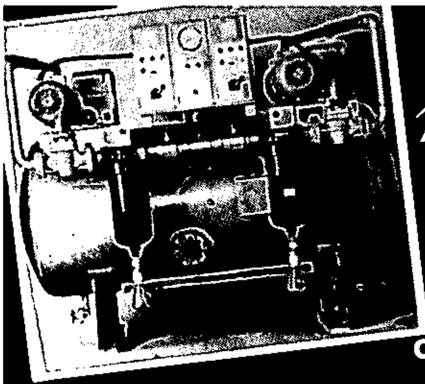
We need a man or woman who has an enthusiastic and professional approach and is technically competent. Previous Hospital experience an advantage.

You should have ONC Engineering, or equivalent, and have completed an apprenticeship in mechanical or electrical engineering. Day release facilities and training within the service in specialised subjects available. You will be encouraged to develop your career within the NHS.

Application form and job description from the Area Personnel Department, Croydon General Hospital, London Road, Croydon, CR9 2RH. Tel: 01-688 7755 ext 29/31.



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