HOSPITAL ENGINEERING

August 1977

The Journal of the Institute of Hospital Engineering

Hugh Howorth's Design Award

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HOSPITAL ENGINEERING

August 1977 **Vol. 31 No. 6**

The Journal of the Institute of Hospital Engineering

Contents

Cover:
Hugh Howorth, immediate Past President of the Institute, receiving a coveted Design Council Award from the Duke of Edinburgh in May. Story page 5.

Due to an oversight, due credit was not given in our June 1977 issue to the source of the striking front cover picture. This was kindly provided by Thos. W. Ward Ltd., one of whose specialist asbestos stripping teams is shown.

Institute News

North Western Branch

At a meeting of the Branch held on May 4, 1977 the following programme was planned:

1977

September 17 — Saturday afternoon, Blackpool Victoria Hospital — talk and tour on Air Conditioning.

October 29 — Saturday afternoon — Mr. J. Sanderland talks on Boilerhouse Design, Hope Hospital.

November — A visit to a brewery, preferably a Friday evening.

1978

January 11 or 25 — Visit to Science Museum at Manchester.

January 20 — Annual Dinner Dance — details to be arranged.

February — Evening visit to Wolkes Fitters.

March 11 — A.G.M. Saturday afternoon — Ormskirk District General Hospital. Also talk on Energy Conservation by Mr. A. Schaffel.

April 18 — A talk and possible visit, on Sewage Disposal/Treatment.

May 18 — A talk on Water Distribution.

Southern Branch

At a meeting of the Branch held on May 11, 1977 the following programme was announced:

1977

September 10 — Visit to H.M.S. Alliance and Submarine Museum. H.M.S. Dolphin Gosport. Business meeting to be held at War Memorial Hospital.

November 12 — Work of the Commonwealth Secretariat in the Developments in Engineering in Health Departments of emerging African Nations. Grayling-Well Hospital.

1978

January 14 — Flooring types and preparation. Dorset County Hospital.

March 11 — Brain Scanner: also Annual General Meeting. Southampton General Hospital.

Brighton Sub-Branch meeting

A report was received on the meeting held on March 19, 1977 at the Royal Sussex County Hospital, Brighton.

Six persons were in attendance with Mr. A. J. Wavell in the chair. The business discussion was followed by a Technical paper entitled 'Development of the Vickers M300 Blood Sample Analyser' presented by Dr. C. Riley who developed this automatic analyser. The committee felt that Mr. Wavell should be applauded for his work in organising the meeting and hoped that the innovation of the Sub-Branch would develop greater interest within the Brighton area.

The Institute of Hospital Engineering One-day Symposium

'Major Hospital Building – Project Management'

to be held at The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, on Wednesday, 19th October, 1977

Large building projects often go wrong; in particular they are not completed on time or within budget. This is a world-wide experience and its cause requires further research. Meanwhile, pragmatic solutions have to be found and, no doubt, this accounts for the widespread interest, at home and overseas, in the use of project managers.

The Symposium will examine the way in which projects are managed from inception, through construction to handover; it will explore, also, the possible advantages of employing a project manager and his role, relationships and training will be examined.

PROGRAMME

CHAIRMAN for the day:
HERBERT J. CRUICKSHANK Esq, CBE CEng FIMechE FIOB FBIM
Member, South East Thames Regional Health Authority
Director, Property Service Agency Board of the Department of Environment
Formerly Deputy Chairman, Bovis Holdings Limited

10.00 Assembly and Coffee

10.30 OFFICIAL OPENING
J. R. HARRISON Esq, CBE CEng (Fellow)
President, The Institute of Hospital Engineering

10.45 'WHY CONSIDER THE NEED FOR BETTER MANAGEMENT OF HEALTH BUILDING PROJECTS?'
Speaker: W. D. PAGET Esq
Assistant Secretary, Department of Health and Social Security

11.30 'RELATING EXPERIENCE OF MANAGING THE NATIONAL EXHIBITION CENTRE AND OTHER PROJECTS WITH HEALTH BUILDING PROJECTS'
Speaker: FRANCIS C. GRAVES Esq, FRICS FIQS FRSH
Francis C. Graves & Partners
Chartered Quantity Surveyors and Project Controllers
Project Controller for the National Exhibition Centre, Birmingham

12.15 'PROJECT MANAGEMENT IN THE HEALTH SERVICE — THE PROBLEMS AND POSSIBLE SOLUTIONS'
Speaker: G. BROOKE Esq, MSc(Eng) CEng MICE
Regional Works Officer, Mersey Regional Health Authority

13.00 LUNCH

14.00 INVITED CONTRIBUTIONS AND OPEN FORUM

16.00 CLOSURE

Applications to: The Secretary, The Institute of Hospital Engineering, 20 Landport Terrace, Southsea PO1 2RG. Tickets £9 each (includes Morning Coffee and LUNCH).

George Grieve retires

George Grieve FIHospE TEng(CEI), retired as Hospital Engineer to Stirling Royal Infirmary on July 10, 1977. George has spent 36½ years at the Infirmary since he went there as Assistant Engineer to the then Chief Engineer.

He served an apprenticeship with J. Davie & Sons, Ironfounders and Engineers at Stirling as a mechanical engineer, while also obtaining his national certificate with the Glasgow Technical College. George has been a member of the Institute since the 1940s, and has served terms as Minute Secretary and Hon. Secretary of the West of Scotland branch. We wish him a long and happy retirement.

Association of Sterile Supply Administrators Annual Conference

September 18-21, 1977

The 10th Annual Conference of the Association is to be held at Lancaster University, and members of the Institute will be very welcome to attend. The conference will be opened formally by John Bolton, Chief Works Officer, DHSS, and will be addressed by distinguished speakers on a number of subjects, including Pressure Steam Sterilisers; Disinfection; Hot Air Sterilisers; Sub-atmospheric Steam and Formaldehyde Sterilisers; Area Stores; Disposable Drapes in a Laminar Flow Environment; the Sterile Supply Manager; a new Approach to Wound Dressing and the Development of Cardio-Thoracic Surgery.

Apart from the formal lecture programme there is also an exhibition of medical and surgical equipment, a Dinner and Dance, all in the attractive surroundings of Lancaster University, which is very well suited to such conferences. The closing date for applications is September 1. Application forms have been sent to all Regional Hospital Engineers, and can be obtained from Mr. B. L. Simmons, c/o Northwick Park Hospital, Watford Road, Harrow, Middlesex.

National Conference on Reliability

September 21-23, 1977

A conference on reliability technology and techniques, has been arranged by the National Centre of Systems Reliability, at the University of Nottingham.

The theme of the conference is to present the benefits of reliability technology as applied to savings in capital and operating costs; to discuss reliability techniques and their application; to examine data collection, analysis and interpretation; to discuss case histories and to consider problem areas and possible future developments.

A comprehensive leaflet giving full details of the conference, including the no less than 45 papers proposed to be presented, and full application details is available from Miss M. Sutton, National Centre for Systems Reliability, UKAEA, Wigshaw Lane, Culcheth, Warrington, Lancashire. Applications must be returned by August 22.

Letters to the Editor

Testing of low temperature steam/formaldehyde sterilisers with Bacillus stearothermophilus spores

Dear Sir,

We read with interest the timely paper[1] in the June issue of your journal in which attention was drawn to the need for the standardisation of spore preparations used for testing steam/formaldehyde sterilisers. The data which the authors presented in their accompanying table showed that the differences were greatest between commercially prepared Oxoid spore strips (all of which were sterilised in their experiments) and Southern Group Laboratories discs (none of which were sterilised).

These discrepancies could be accounted for by quantitative differences of the same extreme degree between the authors' own spore preparations). We have counted the spores recoverable from three batches of Oxoid spore strips and from one batch of Southern Group Laboratories discs, all of which have been stored at 4°C. The results obtained are shown in the table:

Oxoid spore strips (Code BR23) are produced "for testing the sterilising efficiency of autoclaves" and are standardised[2] by testing in steam at 121°C. Whether such tests have any validity in determining the usefulness of a spore preparation for testing the efficiency of a low temperature steam/formaldehyde steriliser must be open to question: that they produce different results when tested alongside the Southern Group Laboratories discs which contain at least 500 times more spores is not surprising..

Source	*Colony Forming Units* (Mean count, 10 discs/strips)	Range
Oxoid 1	2.3×10^3	$1.0 \times 10^3 - 3.5 \times 10^3$
2	2.7×10^3	$1.2 \times 10^3 - 4.6 \times 10^3$
3	1.9×10^3	$0.4 \times 10^3 - 3.9 \times 10^3$
Southern Group Laboratories	1.5×10^6	$0.6 \times 10^6 - 2.5 \times 10^6$

Yours sincerely,

P. H. Everall MIBiol FIMLS,
Technical Officer
C. A. Morris BSc MD DipBact,
Director
Public Health Laboratory,
Mytton Oak Road,
Shrewsbury SY3 8XH.

References

1. **Blake G. C., Cornick D. E. R., Vidic J.** (1977), *Hospital Engineering* — (22) 19-21.
2. **Kelsey J. C.** (1961), *Journal of Clinical Pathology*, **14** (3) 313-319.

The hazards of conferencing

Dear Sir,

Mr. J. L. Richardson's epic, telling of his journey to Pitlochry (Special Issue, July) must have caused the face of the bravest reader to blanch.

In this day and age when the very opening of a newspaper reveals a catalogue of disaster, actual and potential, it is most heartwarming to realise that the Institute — albeit unwittingly — created the circumstances which lead to such a display of heroism, fortitude and determination.

One wonders whether the Institute might inaugurate a special Annual Award, the winner to be considered to have suffered, or endured, the most in the cause of 'hospital enginering'.

Surely, there would be no shortage of eligible candidates. These might include anyone who:

a. volunteered to be a Branch Honorary Secretary;

b. did NOT write a thesis covering

further reorganisation of the National Health Service;
c. attended a course on 'management effectiveness';
d. worked for a Regional Health Authority and complimented someone who worked for an Area Health Authority;
e. worked for an Area Health Authority and complimented someone who worked for a Regional Health Authority;
f. actually said something complimentary about the DHSS;
g. moved home and when advising new address included postal code;
h. had a letter published in the Journal.

I am sure that you, Mr. Editor, would welcome further suggestions.

Meanwhile, I trust that, very soon, Mr. Richardson, and many others, will commence rigorous training in preparation for next year's conference in Cardiff on April 26, 27 and 28, 1978.

And Mr. Richardson — please do set off in good time with, perhaps, a sandwich and a flask.

Yours sincerely,
John Furness

20 Landport Terrace,
Southsea, Hampshire.

P.S. — For the benefit of any readers who may know nothing of:
(i) rugby union;
(ii) choir singing;
(iii) laver bread;
Cardiff is in South Wales.

An open letter

Training - What are our Chances and Opportunities ?

With 1979 looming closer, little appears to be moving on the training front for in-post Engineers below the sector level. The advent of the policy where chartered Engineer status will be required for posts above this level must be of concern to many engineers, who realise that their career prospects within the services are severely restricted. The obvious answer is to obtain at least the academic qualifications necessary to step onto the first rung of the chartership ladder.

In real terms one must now gain an Engineering Degree or equivalent qualification. To achieve this, what are the opportunities?

How to obtain a BSc

Leaving aside full-time degree courses run by the universities (one may assume that few opportunities will arise to undertake these) then part-time education is the only answer. Polytechnics oblige in this direction by running part-time degree courses, some of which have been accepted as exempting qualifications by the CEI. In general, entry qualifications to such a course are a good HNC and a successful formal interview. Alternatively an HND holder may be exempt from the first year of the four-year course. Unfortunately full technician certificates are generally unacceptable, therefore this candidate faces a six-year academic programme.

Some people may express concern as to the credibility of part-time degrees, and whether they are as complete as a full-time course. To obtain CEI approval it has to be. In fact it may be argued that the standard may need to look better to override any prejudices.

The format of the courses is one day and one evening per week of formal lectures, but it is obvious that a great deal of work must be undertaken outside these hours. As a general rule a minimum of ten hours per week are necessary to complete the work set.

It can be seen without much insight that the candidate must devote a large proportion of his spare time for four years in the hope of obtaining a degree, eventually facing high social and domestic pressures. It is then not surprising that one such course suffered a 'drop-out' rate of 50% in the first two years.

Is a degree necessary?

To cover all aspects of engineering a degree course, whose intake may vary from prospective Works Engineers to designers in every sphere of industry, must have an extremely varied scope. A good engineering appreciation of all facets of technical theory cannot be a bad thing. However I feel a degree course expands theories covered by the HNC/HND course to a level beyond that necessary for the Works Engineer. If he is to undertake further education beyond HNC it should be in a form which gives the specialist knowledge on matters technical, managerial, and financial, pertinent to Health Service Engineering. Unless it is anticipated that prospective District/Area level engineers shall in general not rise from Assistant Engineers, then the entrant to the Service holding an ONC will face a six-year day-release programme. The position for Hospital Engineers and above may be more oppressive; not many authorities may grant release for further education at this level.

Accepting that the student is willing and allowed to proceed, the Department must accept a day-release commitment of more than 200 days per student. From the student's angle, day release commitments result in a disrupted work programme.

Is there a solution?

One could argue that the immediate solution is to drop the CEng requirement, but many will agree that some form of distinguishing qualification above HNC is desirable.

Few other engineering environments can encompass the vast range of specialities the Hospital Engineer is required to be familiar with, together with the managerial and financial knowledge necessary. It would seem sensible to run a specialised course in Hospital Engineering.

This is not a new concept, many hospitals run their own individual courses, for example for pathology technicians. To proceed higher than technician level the Institute of Medical Laboratory Sciences sponsor a 'special examination', which on successful completion leads to Fellowship of the Institute, the recognised qualification for obtaining higher posts.

A similar qualification arrangement for engineers does seem sensible. The present CEng requirement does not specify the level of specialist skills mentioned above. Further to this, most engineers with a mechanical qualification have possibly only gained limited theoretical electrical training, and are lacking in practical knowledge or design. The opposite applies to engineers.

Structuring such courses

Introducing any new course is a mammoth task and day release at various centres would be virtually impossible. The solution to the problem may be met by structuring the course on a correspondence basis. The possibilities the syllabus may offer are exciting — design, maintenance, PPM

systems, technical papers on specialised aspects, Estmancode and budgetary control could all be covered. The possibilities are almost endless.

Assuming that basic engineering principles at HNC level are adequate, this level would form the basic requirements for entry to the course, with Thermodynamics as an endorsement, if not obtained with the certificate. The Hospital Engineering Training Centre at Falfield may arguably provide a good base from which the system may be run, with compulsory tutorials at the centre for one week sessions.

The advantages

One of the more indefinable advantages is the 'spin-off' from running the course, in the structure of design notes, etc. A level of uniformity would be reached throughout the service, particularly as a mechanical/electrical combination would avert the problems mentioned earlier. Feedback from hospital level to the DHSS should improve, as should communications in general.

Problems arising from day release for Hospital Engineers would be overcome, so would the loss of 200 days in the training of Assistant Engineers.

The raw materials for forming the course are readily available. Once they start, updating their content would be relatively simple. After overcoming teething troubles the system would almost run itself.

Conclusions

The concepts I have put forward should receive criticism, constructive or otherwise. Interest in any move to improve the prospects of the assistant/hospital engineer must be initiated from within. I sincerely hope this paper will arouse comment from all levels, I know that all engineers I have spoken to are deeply concerned about the present position, convinced that short of a miracle their fate has been sealed. Therefore gentlemen — put pen to paper!

T. R. DIX

Hugh Howorth's Design Award

As announced in our May 1977 issue, Howorth Air Engineering Limited were awarded a Design Council Award in the Medical Equipment Section for the Charnley-Howorth Sterile Operating Unit. As our front cover shows, Hugh Howorth, Managing Director of the company and immediate Past President of the Institute, had the honour to receive the Award from His Royal Highness the Duke of Edinburgh at the presentation ceremony at Inverness in May.

The Charnley-Howorth Unit was designed by Mr. Howorth in association with Sir John Charnley CBE, Professor of Orthopædic Surgery and Director of Research at Wrightington Hospital, Wigan. This unit is the latest in a line of sterile air systems that Professor Charnley and Howorth Air Engineering have produced together since 1962 when their collaboration started. The company had been involved in the prevention of airborne infection since 1920, when they designed and manufactured the first sterile air systems for brewery fermenting rooms, where the infection of the pure strain of brewers' yeast could produce a major financial disaster. It is those studies over fifty years ago which produced the detailed knowledge of air-flow engineering which has been so successfully embodied in the Charnley-Howorth units since 1962.

The new sterile operating unit is a device to produce a substantial downward and outward flow pattern of contamination-free air over members of the surgical team and patient. Air is released from a ceiling-mounted diffuser system at a rate equivalent to 300 air changes an hour. Each member of the surgical team has a body exhaust system connected to a gown and mask designed by Professor Charnley. The patient also has a body exhaust to prevent self-infection as a result of body-vapour emissions. While the operating unit has no pretentions in its design, it was considered by the Design Council judges to be 'a good piece of British innovation simply executed. This operating theatre demonstrates outstanding successful collaboration between doctors and engineers'.

Records since these units were introduced in 1962 have shown that infection of wounds has fallen from a 3.7% rate before the equipment was introduced to between 0.3% and 0.5% since.

The Howorth family have been air engineers since Mr. Howorth's grandfather, James, founded a company in 1858 to make ventilation systems for the textile industry. He invented the multi-vane fan which stopped fog getting into the mills, where it so badly affected the yarn that work had to stop. Workers were normally sent home in such conditions, and when legislation was introduced to force mill owners to pay them even so, they very soon looked for other ways of dealing with the fog problem. Mr. Howorth obliged, and the company that he founded has ever since used its expertise in handling air-flow for the benefit of mankind.

It is indeed fitting that such an award should come to Hugh Howorth just after he has completed two most successful years as President of the Institute. Mr. Howorth is a striking man in every respect — particularly in view of his great height and fairly considerable bulk. He is however in no way slow moving, as indeed he proved in his younger days, when he was a most successful sports car racing driver. In those days the private entrant could still do well against the factory teams, and Hugh Howorth certainly did so in the years from the end of the war to the early fifties. He used his knowledge of air-flow to improve the breathing of the carburettors of his cars so much that they were considerably quicker on the straights. Hugh Howorth does not claim to have been particularly fast round the corners, but his engineering skills produced many wins, culminating in a dramatically successful season in 1951, when he entered 16 races with his XK-120 Jaguar winning ten outright and coming second in five more.

In 1952 Mr. Howorth raced only in the Jaguar Trophy Race which he had won the previous year. He won again and then retired from racing to concentrate on continuing the development of his company and its products. Since then Howorth Air Engineering and its other associated companies have been very successful, and have developed the life-saving systems which have given so much to so many people.

The most systematic attack on cross infection since sterilization itself

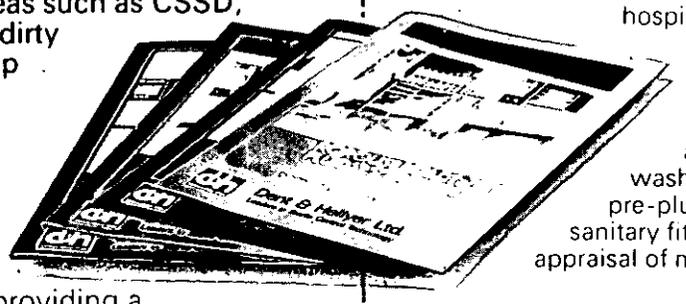
Nowadays, controlling cross infection is more than a hygiene problem.

With increasing demands on hospital resources it also presents a difficult management problem.

Sterile equipment must get into the right hands fast, involving as few "hands" as possible on the way, at the lowest possible cost.

At Dent & Hellyer we recognise what the real problems are. Quality equipment including sterilizers, bed pan washers and sanitary units are only part of our solution.

The essence of it is our ability to piece them all together into fully cost-effective packages for key areas such as CSSD, TSSU, sluice room, dirty utility room, scrub up area, pharmacy and laboratory.



For maximum efficiency you have to plan for efficiency. This is precisely what we can do for you, providing a comprehensive service including feasibility studies, planning, equipping, commissioning, staff training and worldwide after-sales support. You also reap the benefits of a Sterile Control Technology that's based on years of experience and backed up by a comprehensive research and development programme.

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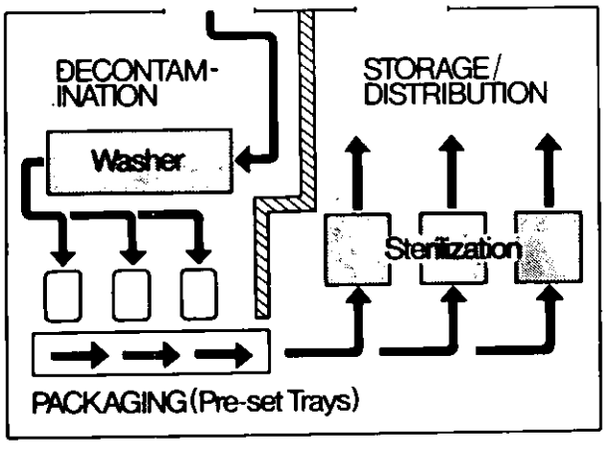

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Commissioning Building Services

The Institute held a one-day symposium on 'Commissioning Building Services in Hospitals' in London on 15 June, 1977. The following paper was among those given. Mr. Winning is Regional Works Officer of the Wessex RHA.

The author's interpretation of the brief for this paper is that an examination is required of the proposals contained on the Commissioning Document, bearing in mind the designer's role as a participant in both design and contract document administration. No attempt has been made to examine the technical detail of the designer's work, but rather to state ideal procedures at the design stage which are necessary to permit commissioning techniques when the design is later translated into a building services installation.

What Should the Designer Do?

J W WINNING BA CEng FIMechE FCIBS FIHospE

The commissioning document is intended to link together a number of associated functions, such as design and installation. The designer leads one of these. The designer, in this context, is seen as the person responsible for providing the design and administering the contract documentation.

To arrive at an adequate digest of what the designer should do, a small working group considered a sequence of activities carried out by the designer from the receipt of the service planning brief, in Capricode terms the 1A stage, to tender, that is to the 3J point of activities. This discussion therefore does not dwell on installation work, though it does acknowledge the need to specify and detail for this stage (*see Appendix 1 for Capricode procedures*).

The design and tender preparation stage is described in the commissioning document as associated activities. There is an argument that this is putting the cart before the horse, that designing and specifying what is required is the heart of the matter. Indeed it is in terms of producing engineering installations, but the document is about commissioning, therefore this is the paramount activity for discussion, others are associated with it.

The brief

Having received a service planning brief describing the client's requirements at Capricode Stage 1A, the designer must produce an engineering design brief. Here the designer must pause for thought and question whether or not what the client is asking for is justified, whether it can be achieved, and if it can, what is the cost of the end result, for the client's purse, and the standard cost limits. It is indeed the designer's ditions demanded may be well beyond duty to respond to the client in a positive way to prevent commissioning problems that can be foreseen, not the least in cost reduction exercises which, after receipt of tenders, necessitates paring back the engineering installations.

What is important for performance evaluation, which is a stage beyond commissioning, is the designer's clearly stated intention in terms of performance under specified conditions. In other words, the design intent. In reality the design intent stems from the client's brief and current practice and possible unique solutions to meet unusual circumstances (*see Appendix 2*).

It would be wrong, however, to assume that the designer only has to consider achieving the specified design parameters of the design intent, and that commissioning is a practical on-site way of testing whether or not this has been achieved, for there are other important aspects to consider. Safety, efficient operation of plant for energy conservation, satisfactory performance of plant to prevent premature wear in use and hence high maintenance costs are some other considerations. These aspects need to be borne in mind during specification writing, and indeed in the production of a cost analysis. Discounted cash flow techniques help in achieving a reasonable result in the comparison of initial cost with running costs.

There is a further point about the design intent and the technical brief. Very few design offices receive an effective feedback of information from sites about commissioning problems. There is also a difficulty of informing the designer even when a data bank of feedback information exists. One way of course is for the designer to attempt to avoid mistakes by visiting the most recently-completed installation of a similar type and learn first-hand of its faults. Probably a more effective way is for the commissioning adviser to report back personally to the designer in a debriefing meeting. This may be an educational process for the individual, but more needs to be done to inform the entire design office.

Project team work – commissioning input to the management control plan

At this stage the designer will be engaged most probably in project team work contributing to working up the design information and moving towards freezing the brief. He will be wise to note any intentions of accepting the building from the main contractor in phases, for this creates additional problems in providing completed services, and more particularly in commissioning them. With a planned phased take-over the contract documents must include this provision.

A phased take-over involves commissioning priorities for plant rooms and partial systems. This causes out of sequence work by the commissioning team, and also causes repetition when the entire systems are complete. This additional work must be paid for.

The management control plan required to be produced at the 2A stage under Capricode procedures should be structured to allow for engineering commissioning in Stage 4, the construction stage. It is an opportunity for an early warning that, ideally, practical completion should

not take place without engineering commissioning being accepted also.

The management control plan must make adequate allowance for commissioning (*see Appendix 3 for a schedule of activities*).

Design information, preparation and storage

An important information recording stage system for the designer is the room data sheet system, the basis for the room loading calculations. The sheets give information on environmental conditions, including lighting levels, control limits and data related to the provision of service outlets for a variety of services. On large projects, room data sheets form a great pile of paper which it is difficult to assess and criticise. There is therefore a sound argument for confirming with the client what he wants as a gradual process, not when all the sheets have been completed. The client must be pressed to specify exactly what he wants in terms of specialist equipment such as for laboratory or clinical applications. Lack of precise client information can both delay design and commissioning.

Technical activities such as design generate paper and it should be ordered efficiently. The recording, filing and the indexing of formal information must be systematically dealt with. For reference, papers should follow an agreed system of job numbering and colour coding, should use such standard forms as exist, be indexed and not include extraneous matter. For example, mixing a design file with general correspondence should be avoided.

Much can be written about design calculations. It is enough to say that, for the purpose of commissioning, it must be possible to establish by checking (possibly years later) that the methods applied and information sources are currently acceptable, and that calculations flow naturally through stages to an accurate result. A simple test is to assume that the design will no longer be with the organisation when a check is made. Can another experienced man make sense of the design file? This immediately cancels out the use of scrap paper for calculations, stored in a loose form without indexing, and almost certainly in a pocket file. Computer technology has assisted both with standardisation and legibility of records. Checking is certainly much simpler.

The quality of design information

The quality of design information is also critical for commissioning. Flow line diagrams (with quantity, direction of flow and temperature conditions) reference sources, diagrammatic representation of psychrometric conditions, the logic of control systems and similar evidence is needed to substantiate that the design is sound in the event of a systems performance dispute, and, more important, to ensure the plant is capable of being commissioned at all.

Pausing to consider for a moment the amount of guidance material available for the designer, the manuals issued by an informed client present a difficulty. It all depends on the quality of the information and its presentation. If things go wrong at the commissioning stage, the client will be inclined to enquire if his guidance material has been used. It is necessary therefore for the designer to be sure of himself, to know that his design is in accordance with current practice, and that the guidance material has been well tested.

The drawing programme has a variety of objectives, such as instructions to the contractor for installation and co-ordination of services within the building structure, and it has a particular significance for commissioning. Time must be allowed for the preparation of diagrammatic flowline representation of systems showing controls and outputs. Schedules of equipment and detailing on drawings are important in commissioning for locating and checking individual units. There must, for instance, be accord with the architect in numbering of rooms and other location references. Very little comprehensive information on the sequence of production, number and quality of drawings is usually available in drawing offices. The consequence of delay, or the cost of not producing information, is not apparent.

The client's commissioning adviser has been defined by the commissioning document as the person appointed by the Health Authority to advise whether the works meet the requirements specified by the Health Authority. The adviser can either be a specialist employee of the Health Authority or an appointed consultant. In either case he will be expected to be thoroughly experienced in design and commissioning techniques.

If a commissioning adviser is not employed then it is wise to provide the designer with a check list. This is to remind him of commissioning requirements. Alternatively and more effectively, a senior man can oversee the designer to see that allowance for commissioning is made.

Some clients particularly require frankness and an exchange of information between their designers and commissioning advisers, to ensure that sound design and maintenance facilities ensue from the ability to take second opinions. The results are not always beneficial, possibly due to a variety of reasons such as a reluctance to have open discussions, or overzealousness. In ideal circumstances a second opinion can be most useful in establishing that the designer has provided adequate quantified data about design parameters, has built into his systems the controls and capability of achieving these, and has allowed sufficient space planned for plant.

In theory the adviser should be appointed early in the design stage, before the design solution is set rigidly either by time or cost constraints, and defensive attitudes have been established.

The design comes together in pieces, either by departments or by service. The specification will also begin to take shape as contractual requirements are known and the plant is selected. The designer will need to recognise that it will not be possible to performance test a lot of items in situ. It will therefore be logical to require them to be works tested. These would include, for example, heater batteries, pumps, control panels and so on. This intelligence must be recorded in the specifications so that the contractor will be aware of his obligations.

All that is required from the contractor as a service must be listed, so that costs can be evaluated and submitted as tender prices. The information given to the contractor must relate to the adjustment and setting to work of systems and plant. Though a contractor can quite rightly be held to be accountable for installation and commissioning processes, he cannot be held responsible for the quality of the information on which he acts, or indeed the intention of a design.

It is important for the designer to register his requirements for time and service from the main contractor with the contract supervising officer who in the majority of cases will be the architect, so that provision can be made

in the contract documents. The main contractor may then price the cost consequences and acknowledge in his programme the time to be spent on commissioning activities. Previous mention has been made of the necessity for the client to agree to this and to allow for the commissioning time in the management control plan. This is translated into a calculation for the construction period, the end date being used as a reference point for the supervising officer to calculate extensions of time.

Commissioning has become as an activity late in the contract, a lively issue for debate in delay claim submissions. It is particularly related to the main contractor's programme, which in ideal circumstances is discussed and agreed with the sub-contractors.

For major contracts the wise client will specify that the main contractor must employ on site a mechanical and electrical liaison specialist who will be able to interpret the sub-contractor's requirements during the construction period. Needless delays and controversy about programming may be prevented by such an appointment.

Recording commissioning results for a large contract is a major task in itself. Not all good commissioning staff who are capable of trouble-shooting, that is sorting out a variety of electrical and mechanical faults, have the inclination to fill up forms to record results. This problem may be overcome by including in the contract documents examples of records, so that this task, one of technical administration, can be properly costed by the contractor at the time of tender, so that assistance may be provided if necessary and the commitment accepted.

Handicaps to commissioning

Having considered some of the things a designer should do, it is realistic to think of what often prevents him doing so in an ideal way. Difficulties can be defined under a number of headings such as:

(i) Management;
(ii) Cost;
(iii) Time;
(iv) Training.

Management

Clients may be unwilling to accept an extension of the construction period to allow for commissioning. For service or other reasons it may be necessary to specify a very short construction period. Commissioning in these circumstances may take place in a piecemeal manner and will be difficult for the designer to quantify as a requirement.

With a contract subject to delays the client may decide to have partial handovers, and allow for commissioning to be re-programmed with the objective of achieving practical completion as soon as possible in the circumstances.

The main contractor, the employer of the sub-contractors, may not allow adequate time in the construction programme for commissioning to be achieved.

Sub-contractors may not appreciate the complexity of installations and the time required for commissioning during programme discussions early in the life of the main contract.

The designer may be within a contractor's organisation and have a weak or non-existent link with the client before tender. This may possibly happen when tenders are produced against performance specifications.

Management may decide in response to an application by the main contractor to permit the heating installation to be used for drying or the lifts to be used. This will result in out of sequence commissioning of plant and may cause havoc with the specialists' programmes.

Cost

Like everyone else designers must have their output costed. It is an additional expense to provide design information for analysis by others. Drawings for commissioning are an added burden to a drawings programme. The designer is likely to be harried by the office accountant about his cost effectiveness, and the preparation of commissioning information may suffer.

The client should appoint a commissioning adviser. Over the years, however, more and more experts have been added to the list of consultants, which has grown through advanced technology and with the additional need to satisfy a variety of requirements such as safety, cost and co-ordination of services. The client may not therefore be able to afford an additional adviser and may rely solely on the designer and site staff. This is a legitimate decision, and is a normal practice for other than major projects.

Training

It is a comparatively recent requirement for building engineering services to be commissioned to agreed standards. The standards themselves have been subject to trial in use, and we are still moving towards more realistic requirements acceptable to clients, the design professions, commissioning consultants and contractors' associations. Though some training of engineering staff has been attempted there is much to be done. There is need for senior experienced people to contribute by on-the-job training in drawing offices and on site.

Summary

The main points to be made to be followed during the design stage are:

a. Plan for commissioning from the start of a project by obtaining the client's approval in terms of programming, and for the cost consequences of commissioning procedures;

b. Design with commissioning in mind, so that data is properly prepared as drawings, pictoral representation, calculations and specifications;

c. Consultation to be arranged between the designer and commissioning adviser. Both to understand and accept at the time of their appointments that the client will expect an early exchange of information to take place, and will require effective solving of disputes related to alternative design solutions;

d. Define in the contract documents which the sub-contractor uses to prepare his tender, what he is required to accept as obligations to be carried out as a commissioning service;

e. Make sure the main contract document includes a provision for commissioning to be shown in the construction programme and to be costed by the main contractor in his tender submission;

f. Make sure that the designer does not forget the information he must provide and that required by him from the contractor for those who must operate the installations through their many years of service;

g. Make sure that the sub-contractors and site staff understand what the designer specifies as a testing activity and what he requires as commissioning, particularly if other than standard definitions or procedures are used;

h. Train inexperienced staff to avoid if possible design and commissioning failures, contractual relay claims and similar difficulties. This is a responsibility of managers.

APPENDIX 1

Capricode health building procedure

Summary of stage headings

STAGE 1 Outline project intentions

1A Relationship to area and regional strategy
1B Briefing of project team
1C Outline management control plan
1D Assessment of functional content
1E Site appraisals
1F Cost and phasing
1G Approval

STAGE 2 Planning — project and first scheme

2A Management control plan
2B Site selection
2C Planning policies
2D Selection of building shape
2E Development control plan
2F Confirmation of functional content
2G Budget cost
2H Selection of contract method
2J Approval

STAGE 3

3A Notional cost plan
3B Detailed design brief
3C Sketch plans
3D Equipment schedules
3E Check design against brief
3F Detailed design
3G Pre-tender estimate and summary cost plan
3H Approval
3J Preparation of tender documents

STAGE 4 Contract and construction

4A Contract
4B Construction

STAGE 5 Commissioning

STAGE 6 Evaluation

Notes

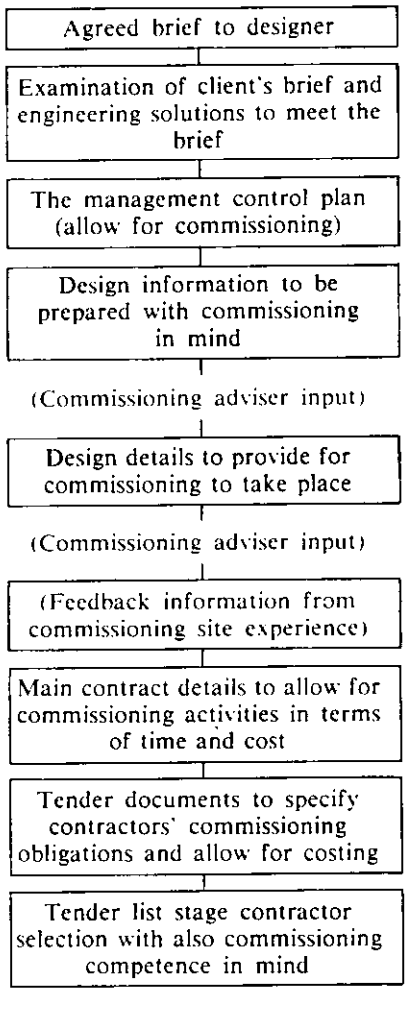
(i) Cost planning will be carried out as a continuous process throughout the design stage.
(ii) Finalisation of commissioning information will be necessary during Stages 5 to 8 of Document SG 12 6.

APPENDIX 2

Engineering design considerations

Site or shape factors.
Development control plan.
Fuel options.
Analysis of options and revenue consequences.
Notional cost plan.
Office organisation and management of design.
Production and presentation of design information.
Sketch plans.
Submission of sketch designs for approval.
Approval of sketch designs.
Detailed analysis of engineering brief.
Use of room data, consideration of guidance material, regulations and other design information.
Co-ordination with other disciplines and any other interested parties.
Flow-line-diagrams.
Appraisal and selection of major items of equipment.
Consult with equipment and other specialists and obtain preliminary data.
Prepare draft specification.
Finalise preliminary schematic and diagrammatic drawings.
Submit proposals for approval, with cost estimate.
Produce commissioning, testing and performance evaluation information.
Evaluation and selection of new materials.
Illumination levels and other electrical services information.
Carry out preliminary works inspection of major plant items, if necessary, to aid final design.
Consult with insurance companies.
Finalise designs including sizing of all mechanical and electrical systems.
Finalise all drawings and other tender documents.
Ensure documentation includes information on:
- Commissioning and testing procedures and programme.
- Construction standards and techniques.
- Procedures for remedial action if required.
- Acceptance testing.
- Commissioning and testing instruments.
- Builders-work implications.

APPENDIX 3



Commissioning Building Services

Another paper given at the Institute's symposium on 'Commissioning Building Services in Hospitals' on 15 June, 1977.

Mr. Wilkins is Senior Commissioning Engineer, Andrew Reid & partners.

Installation and Setting to Work

R D WILKINS MCIBS

Previous speakers have summarised the contents of the revised HTM 17 document and have explained the part that the designer has to play in the process of commissioning engineering services. It is intended in this paper to enlarge on further aspects of the document namely 'installation and setting to work'.

The specific responsibilities of both the client's commissioning adviser and the contractor's commissioning engineer have been clearly defined in the HTM 17 document. The client's adviser, although I hope he is involved in a contract from design inception to project completion, is essentially acting in an advisory and monitorial role and has little influence on the work of the contractor. The procedures described in this paper will therefore be those which are the responsibility of the contractor's commissioning engineer, from design inception to the conclusion of performance testing.

Pre-commissioning information requirements

Prior to any physical work proceeding at site level, a great deal of information needs to be analysed to enable the commissioning engineer to plan his order of works, familiarise himself with the system and pre-empt possible site problems. This information should include the following:

Functional schematic diagrams

These should be single line diagrams which convey to the reader the design intent, by indicating the interrelation between the various services. Flow rates, flow direction, desired temperatures and related permissible tolerances should be included. Such diagrams are not always self explanatory and, as such, should have a brief written explanation of the control functions of the plant. This information can be read in conjunction with the specification which normally goes into greater detail.

Plant specification drawings

On major projects, a drawing sheet can be produced giving a schedule of the duties and operating criteria for the individual items of plant. The tabulation of this information on one drawing obviously has advantages over the all too common collection of A4 sheets covering plant specifications, which invariably become separated on site.

Isometric drawings

Where particularly complex air and water distribution systems are installed, isometric single line drawings following the actual plant layout as faithfully as possible, are particularly useful. On the drawings items such as fire dampers and regulating valves can be indicated. Read in conjunction with the plant layout drawings, they enable the commissioning engineer to foresee possible problems in air and water distribution and greatly assist the familiarisation process once on site.

Schedules of equipment

'Up-to-date lists' of plant, such as fire dampers, grilles etc, need to be supplied. It is important to provide some means of cross referencing these schedules with all relevant drawings, using a common nomenclature, such as EF1 for 'East Face extract grille No. 1'.

Electrical drawings

The absence of the correct functional electrical diagrams is one of the commonest problems faced by the commissioning engineer. The diagrams required fall into the following categories:

Panel wiring diagrams

Schematic wiring diagrams
These diagrams convey the control logic to the reader and are especially useful when fault finding.

Co-ordinated wiring diagrams
Where several items of plant are electrically interconnected, eg a gas boiler, its automatic flue damper, the gas booster and the main control panel, a co-ordinated wiring diagram should be prepared indicating the specific terminals to be connected.

Pneumatic control diagrams (where applicable)

Planning of site works

From his study of the aforementioned information, the commissioning engineer can begin construction of a network logic diagram, detailing the order in which site works should be progressed to commission all major items of plant. Where as a prerequisite for the construction of a critical path diagram is a knowledge of manpower and equipment availability, the network logic diagram merely states the order in which

operations should be carried out without specific reference to the time involved.

From this network diagram a critical path analysis can be made through consultations with the main M and E contractors. An example of a network diagram relating to a boiler commission is given in *Figure 1*. The precise form which the final critical path diagram will take, will be determined by the order in which the two primary heat transfer devices ie the boilers and refrigeration plant, are to be commissioned. All too often the decision to commission one or other is left until site commissioning has commenced, by which time it is realised that the necessary support services are not available. In such cases the problem could have been obviated, if a critical path diagram had been prepared indicating the areas of site works that needed priority treatment. Determining which of these two items will be commissioned will normally be dictated by ambient conditions prevailing at the anticipated time of commissioning. The height of either summer or winter does not present one with any choice, but assuming that either the refrigeration plant or the boilers can be made available in, say, April or May when ambient loads are unlikely to be too demanding for either system, then the boilers would be the priority item for the following reason. In providing a false load for a boiler plant by overriding the space controls, one has the opportunity to raise the controlled space through a high differential from say, 10°C (50°F) to, say, 27°C (80°F) provided that the process is gradual and not damaging to the building structure. Once heated, the fabric will present a substantial false load for the refrigeration plant. The reverse principle does not apply. If the space is already at 10°C at commencement of commissioning then, because of the minimal differential between the chilled water and the return air space temperature, one cannot sub-cool the building any further.

Works testing

Control panel functional testing

The testing of complex control panels at works is desirable even at the expense of a minor delay in site delivery. If a panel is delivered to site un-tested, the availability of electrical power becomes critical. If power is not available early on in the site commissioning process, any panel faults which are eventually detected may take weeks to rectify due to the non-availability of components. If these faults can be detected at works, even long delivery components can be ordered and are often available once site commissioning commences.

In advocating panel testing, it is realised that these operations may necessitate bridging out in-built safety devices such as door switches and isolators, mechanically interlocked with the panel door. Sensible precautions to prevent any likelihood of accident must be taken. Rubber mats should be provided for testers to stand on, good earth and neutral link continuity should be established, and on no account should an unaccompanied individual carry out these tests. Panels should be tested on an item-by-item basis. All control and power fuses are removed whilst switches and isolators are positioned in the 'off' position. A single control fuse is installed and all functions associated with that fuse are tested, working wire by wire through the circuit. The success or failure of these functions can be noted on the panel and schematic wiring diagrams. This may seem a particularly time-consuming operation but it brings to light potentially dangerous faults such as control circuits fed from the wrong fuses, lack of neutral continuity, and loose cable terminations at power fuses. Having proved the correct sequential operation of each control circuit, attention should be turned to provisional setting of time delays on assisted start motor contactors, mechanical tripping of overloads to ensure de-energisation of starter coils, and the checking of wiring to such items as transformers on auto-transformer starters, and resistor banks on closed transition starters. Fuse ratings can also be checked to ensure that they are compatible with the equipment that they will serve on site.

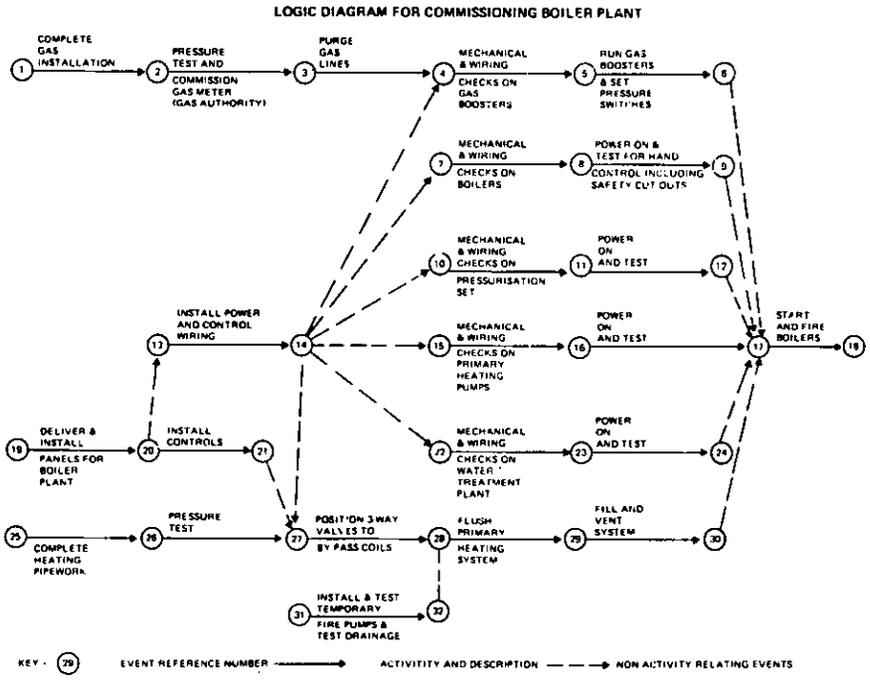


Figure 1.

Mechanical plant

Works testing of mechanical plant fulfils two basic functions which are of interest to the commissioning engineer and designer alike. Firstly the plant is proved to be mechanically sound and secondly it can be performance tested. There is a clear distinction to be made here between a works performance test carried out under ideal British Standard conditions, and so-called performance tests carried out on site. A high percentage of pro-forma test sheets within both the private and public sectors of the industry demand tabulation of data from which the performance of plant in absolute terms is supposed to be calculated. The chances of being able to provide the conditions and instrumentation on site for a performance test to British Standards are extremely remote. What is being advocated therefore is works

testing of equipment to determine that it falls within the manufacturer's production tolerances, followed up with accurate regulation of air and water services at site level. If this procedure is carried out it is highly unlikely that a shortfall in performance will be experienced.

Some systems demand works testing. Packaged boiler, refrigeration and diesel generator sets for export are best proved prior to shipment. The Arabian Desert is not the place to discover that a compressor cylinder head gasket has not been fitted. Other systems warranting works testing are those which due to their complexity or unusual configuration need to be analysed by the manufacturers who are equipped with the sophisticated instruments necessary for plant performance analysis. An example is a prefabricated air handling unit manufactured in sections to suit the structure into which it will be placed. Space restrictions may mean that undesirable air turbulence is created within the plant airways, affecting the performance of the fan and the heat transfer efficiency of cooler and heater batteries. The system can be constructed, often in model form, and tests carried out to determine whether modifications will need to be made to ensure optimum performance of all components.

These works tests, be they mechanical or electrical, are often carried out long before the contractor's commissioning engineer becomes involved with the project. Therefore the onus lies with the designer and the client's commissioning advisor to determine which tests are necessary and at what time they are to be carried out. The results of the tests should then be provided as part of the commissioning brief documentation.

Pre-commissioning site visits

One of the less agreeable aspects of commissioning major plant is having to modify a system which a site operative has just completed, having spent many hours on its construction. It must be remembered that fitters and electricians are carrying out their work to approved drawings. They should not be expected to foresee possible problems in commissioning, although it is always refreshing when an operative takes enough interest in his work to raise queries on his own behalf if he has misgivings about some aspect of plant design.

One way to prevent this problem is to organise pre-commissioning site visits during which the mechanical and electrical services can be inspected. Low standards of workmanship on a particular service will give an early warning that particular attention should be paid to that item during the remaining construction and commissioning period. Queries that arise relating to such items as the positioning of test points can also be dealt with. Under normal circumstances the client's site engineer will be witnessing the pressure testing of pipework, ductwork and electrical tests on cabling and motors as the construction progresses. The commissioning engineer has a responsibility to keep himself informed regarding these tests, if he is not permanently on site. On the subject of pressure testing, one recurrent problem is the failure to remove blanking plates used to isolate sections under test. Forgotten blanks can result in some initially mystifying readings being obtained during the regulation process. If such a blank is in a builder's work duct where no such duct existed during the pressure test, it can prove a time-consuming process both finding the blank and removing it.

Another item requiring attention during early site visits is the flushing of pipework. No longer should drain down after pressure testing be regarded as adequate, as it is invariably done through a 12 mm drain cock which quickly becomes blocked with mill scale and welding slag. The specific procedures and design recommendations regarding flushing are adequately described in the IHVE Commissioning Code Series W. In this publication great emphasis is laid on installing generously sized drain connections and providing full bore flushing facilities where practicable. The author never fails to be amazed at the amount and diversity of articles revealed during these flushing exercises. Over the years, nuts, bolts, washers and plugs burnt out for test points have been commonplace but the discovery of a pair of rubber gloves in a condenser header and a welder's mask in a large steam main had to be seen to be believed.

Site commissioning

The precise time at which short term pre-commissioning visits end and permanent residence on site commences, will be dictated by the critical path diagram. If it has been adhered to all major items of plant will have been installed, and electrical power and mains water will be available, whilst pipework, ductwork and wiring will be substantially complete.

Informal defects or snag lists should be drawn up at this stage, derived from a close examination of both mechanical and electrical plant. To some extent the contractor is looking to the experienced commissioning engineer to anticipate problems which will arise once the plant is operational but which are not necessarily apparent to the untrained eye during construction. The presence of both fitters and electricians during this period is essential. Not only will they be available to carry out any plant modifications necessary but also their intimate knowledge of the systems is invaluable to the commissioning engineer during his first couple of weeks of site familiarisation.

The types of site installation problems one might expect to pick up during this inspection are many and varied but they are typified by the following:

Heating systems

The failure to install expansion bellows with adequate cold draw and in correct axial alignment.

Cooling systems

The installation of water traps on condense lines from cooling coils which fail to take account of the high negative pressure inside the unit which is capable of holding back the condense, causing flooding of the drip tray and excessive carry over.

Air handling plant

The occasional failure to remove transit packing on the volume regulating device in a variable or constant volume terminal unit.

Having drawn up an informal comprehensive list of works outstanding and system defects, the commissioning engineer should supply a copy to the main contractor stressing the items which are likely to cause any disruption of the critical path.

The commissioning engineer should not involve himself with contractual problems: these are the main contractor's responsibility. He should, however, influence the day-to-day progress of the mechanical and electrical works, as it is his responsibility to ensure that the commissioning of major plant is carried out in accord-

ance with the pre-planned network diagram.

Setting to work

Plant alignment

Safe in the knowledge that the system's defects are being attended to, the commissioning engineer can commence the practical task of plant alignment prior to running. Belt driven systems when compared with direct drives, although requiring care, do not demand the same degree of accuracy in the alignment between motor and driven apparatus, but special attention should be paid to obtaining the correct belt tension. The various types of belt at present on the market require different degrees of tensioning, and it is not satisfactory to use rule of thumb methods.

Direct driven equipment requires expert attention. Not only should it be checked for parallel and angular alignment, but also that the correct end float has been allowed on the bearings. Some base plates are designed to be filled with concrete, an activity which is easily overlooked. Failure to infill the base can allow flexing and vibration which will eventually damage the machine bearings.

Lubrication of the bearings needs to be checked. Almost all equipment with ball races are pre-packed with grease by the manufacturers, but some continental manufactured motors are delivered with dry bearings. Oil slip ring bearings will need filling as they are invariably delivered dry, and on some bearings vent plugs will need to be removed.

In any event the information relating to both alignment and lubrication must be obtained from the manufacturers. It is the commissioning engineer's responsibility to ensure that this information has been obtained by the contractor and that the correct lubricants are available.

Switchgear

Without power and functional switchgear, progress on all fronts is severely hampered. If works panel tests have been carried out, the burden is immediately lightened. The testing is then confined to equipment associated with the external wiring. The same simplistic approach should be adopted as has been described previously for works panel testing. All power and control fuses should be removed. One control circuit can be livened up at a time. The safety interlocks associated with the equipment served can be tested prior to energising the main contactors. Fire switches, stop-locks and overloads can be proved, ensuring complete safety during the running-in process.

When commissioning three-phase motors, it should be ensured that the motor and cabling have been insulation tested by the electrical contractor and duly witnessed by the superintending officer's representative. Where several pumps or fans are involved it is prudent to ring out power cabling to ensure that the correct motor is being served by the cabling indicated at the panel.

Mis-routed power wiring between either duty and stand-by or, say, primary and secondary chilled water pumps is a common fault experienced on site. A second line of defence is to break circuit at local isolators and stop-locks on all items of equipment not being tested. The wiring at terminal blocks should be examined. Some manufacturers supply dual voltage motors suitable for connection to either 240 volt or 415 volt three-phase supplies. These motors are star wound on 415 volt three-phase supplies. Other manufacturers supply motors suitable for delta connection on 415 volts. The wiring of star-delta, auto-transformer and closed transition-started motors require special attention if second stage direction reversal and blown phase fuses are to be avoided.

Having fully checked a particular starter circuit and its associated safety interlocks, the power fuses can be installed. Rotation checks should be treated with great caution, and on no account should electricians 'flick over' equipment immediately after completion of the wiring installation. During the mechanical alignment process the driven equipment and motor will have been checked, to ensure that there are no obstructions to prevent rotation but a last-minute inspection should be made, just prior to rotating the equipment to extricate the odd scaffold pole that inevitably finds its way into fan impellers!

Belt-driven equipment should be detached from the drive motor by belt removal for the following reason. If, despite checking, a wiring fault exists on a two-stage starter, the rotation can be reversed on the second stage. By removing the belts, both the mechanical and electrical stresses will be reduced. Direct driven equipment, apart from pumps and axial flow fans, will probably be detached from the motor awaiting the attention of the specialist supplier's commissioning engineer and will therefore present no problems. Direct driven pumps and their associated pipework should have been flushed clear to prevent the ingress of mill scale and welding slag during the rotation check.

Support services for major plant

The necessary support services for major plant items will vary from plant to plant but in any event they are clearly defined in both Health Authority and the IHVE codes of practice covering commissioning.

The critical path diagram will have determined which operations are likely to be demanding the majority of the commissioning engineer's attention at this stage in providing these services, but he must not forget to progress the many parallel works which will have to be substantially complete before the major heat transfer equipment can be commissioned. One of these items is the provision of a false load.

Provision of false loads

Brief reference has already been made at the planning stage to the necessity to provide false loads for both boiler and refrigeration plants. Hence, to commission a refrigeration plant during the winter for example, the boilers and primary fan systems will have been run, and both chilled and heating water will have been flushed. Correct absolute flow rates are not essential at the air to water heat exchangers but they must be correct at the boilers, condensers and evaporators.

If the means of heat transfer to the conditioned space is via water to air heat exchangers the control devices serving the exchangers will have to be in the full flow mode. On electric valves there is usually a provision for manual overide. Pneumatic valves will either need functional controllers, which can be set to extreme set points to motor the valves open, or alternatively the valves can be pumped open and the pneumatic lines feeding the valve head plugged off.

Boiler plant

The burner engineer will require certain measuring facilities to obtain

maximum operating efficiencies across the load range. These facilities should be calibrated by the commissioning engineer prior to the burner engineer's arrival on site. They should include: metering of gas and oil fuel supplies, pressure and temperature tappings in both the burner and the smoke box at exit from the boiler, a pressure gauge on the boiler flow header plus temperature gauges on flow and return mains, and feed water to steam generators plus metering of the feed water flow rate. With these measuring facilities available the commissioning engineer working in conjunction with the burner engineer can put the boiler through its paces. The commissioning engineer should always be in attendance during these trials to provide loads to match the heat input at any specific loading. If the load is not modified accordingly, all readings will be transient and cyclic, being of little use as records of burner efficiency. Stability is the keyword.

Refrigeration plant

The specialist refrigeration commissioning engineer will require similar facilities to be made available, such as pre-tested safety controls, temperature measuring facilities across the condensers and evaporators, and accurately regulated water flow rates. Interminable arguments over whether the manufacturer's quoted resistance for the water side of a condenser or evaporator are accurate, have arisen through the false economy of not fitting an orifice plate or venturi device to the water services. If the pressure loss of such a device is prohibitive in terms of available pump head, the measuring device can be used to calibrate the condenser or evaporator being tested. The measuring device can then be removed, to be replaced by a stool piece, and a second reading taken across the pressure vessel. The, new pressure drop and associated flow rate will be related by the square law relationship for fixed resistance devices.

Performance testing

It has been established previously that, provided an item of equipment has been performance tested at works, a site test will not only be superfluous but in any case is unlikely to be accurate. The commissioning and site engineers will be more concerned with the overall plant's ability to maintain the desired space conditions than with analysing specific items of equipment. What the commissioning engineer will be expected to do is to demonstrate to the site engineer that the air and water flow rates are in accordance with the design specification and that the complete system is maintaining space conditions consistent with ambient conditions prevailing at the time of testing.

Maximum load performance

The provision of a maximum load, be it false or real, on refrigeration and boiler plant is not made solely to prove that the plant is capable of its rated output. In order to commission both items of equipment the specialist manufacturer's commissioning engineer requires a maximum load in order to set up his equipment for normal operation. On large centrifugal refrigeration compressors, for example, the maximum current limiter control module which prevents motor overload can only be set under maximum load conditions. Similarly boiler burners need to be set up under maximum load to obtain optimum firing efficiency.

Minimum load performance

If a machine is to be relied upon after hand-over it must be reliable across its entire load range, and it is the capability of a system to operate under minimum rather than maximum load conditions which is normally the most troublesome.

On boiler plants the light load problems to look for include maintaining a high enough flue gas temperature to prevent condensation, ensuring efficient fuel to air mixing at the burner diffuser on modulating burners, and determining the amount of over-fire necessary on the lead boiler of a multiple set of parallel piped boilers.

Light load performance on refrigeration plant is rarely examined closely enough during the commissioning period but is often the reason for continued call-backs after hand-over. A machine's ability to continue running under minimum load without either cycling on and off or cutting out on low temperature will depend on its turn-down ratio. Packaged chillers containing reciprocating multi-cylinder compressors are often step loaded via return water thermostats. In theory the maximum deviation in chilled water flow temperature under full load conditions may be in the order of only 1°C. If, however, one imposes on that same machine a load of between 10 and 15% of design maximum, and compounds the problem by taking account of the thermostat's slow response and its inherent hysteresis, then the true variation in outflow temperature is not uncommonly between 1.5°C and 2°C. If under these light load conditions, one cooler battery in a multi-battery system is calling for maximum cooling this drift of up to 2°C above design flow temperature can represent a reduction of 20% in battery output. Lowering the control set point, in an effort to limit the maximum flow temperature to an acceptable level, usually results in nuisance trips on the low water thermostat. Solutions to this problem will depend on the application, but where stability is required under light load, hot gassing between steps on a reciprocating machine and below 20% duty on centrifugal machines may be the answer.

Heater and cooling batteries

Battery performance testing is fraught with difficulties relating to one's ability accurately to measure the heat content of the mediums involved. The accuracy of air and water flow rate measurements are dictated by the tolerances the commissioning engineer applies while air and water balancing. Hopefully the air may have been measured within an accuracy of ±5% of design and the water ±10% design. If one percentage is high and the other low it is easy to see why any data obtained is of somewhat academic interest and should not be used as an accurate record of battery performance. Better to concentrate one's efforts on obtaining stable flow temperatures, stable valve control, an even air flow pattern across heating and cooling coils and a low by-pass factor with good 'wetting' on sprayed coils.

Conclusions

This paper has served to illustrate the fact that major plant commissioning is a complex process requiring meticulous planning. It is hoped that by highlighting this fact a greater exchange of ideas and feed-back will be encouraged between all disciplines concerned. Only in this way, building on past experiences, will a more coherent plan emerge which recognises the equal importance of all three disciplines in designing, constructing and setting a system to work.

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Clean Air in Hospitals

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What is clean air?

The phrase 'clean air' is one which tends to have emotive overtones. It is put in the same category as 'free speech', 'right of assembly', 'free press' as representing some sort of practical aim that we expect in life. But it is as well to remember that (perhaps like the other ideals) 'clean air' is a relative term. We think of country air as being clean air, but in summer, the pollen count can be very high in the country to the great suffering of asthmatics. In the country sanitary inspectors are much concerned about pigsties and farmyard effluents.

We think of sea air as being clean, but that so-called ozone smell is probably decaying seaweed. In the towns, the air that is available to the hospitals, as well as the normal population, can be as clean as anywhere, with dust concentration of the order of 2×10^{-5} g/m^3, but in industrial districts it can be as high as 5×10^{-3} g/m^3. It used to be much higher until the legislation concerning smokeless fuel and cleaner effluents was enacted and enforced.

Of interest is one particular occurrence of extreme smog in London in 1952. A plot of smoke and sulphur dioxide gas in the atmosphere against the incidence of deaths showed that, as the dust level rose from 0.2 mgs/m^3 to about 2 mgs/m^3, and the sulphur dioxide rose from 0.1 ppm to 0.7 ppm, the death rate following a few days after rose from 250 deaths to over 800 deaths per day, and fell just as dramatically after the smog had abated (*Ref. 1*). Some work followed by a Dr. Keeping at St. Charles' Hospital in London, where he treated patients with severe respiratory diseases in a ward whose air supply had been cleaned with high efficient filters. He obtained dramatic improvements in successful treatment. This must have been one of the first instances of the studied use of clean air in hospitals greatly to improve treatment success rate.

The predilection of many of the medical profession for opening the windows and letting in free passage of the air that nature provided is, therefore, suspect.

As engineers, we should regard the air in hospitals as a raw material which can be controlled, processed, and conditioned to an appropriate cleanliness for the job required. This is a facility which modern technology gives us, and it should be fully exploited. But processing to the appropriate cleanliness is an important qualification. If we want to remove dust and sulphur dioxide, then that is what we should remove: if we want to remove bacteria, but are not too worried about the amount of dust, then that is another 'cleaning' problem. The pharmaceutical industry, and the industry which makes space components, have reached a high degree of sophistication about providing appropriate clean conditions for the work in hand. Similar techniques are gradually being brought to bear on the hospital situation.

The hospital environment

There are few places which carry as many hazards associated with the cleanliness of air as hospitals. They contain pathogenic micro-organisms, radioactive materials (both gases and aerosols) and many types of chemicals and solvents which are toxic, explosive, carcinogenic or odorous. All these, released into the air that could be breathed by staff, patients or people outside the hospital, are dangerous and steps must be taken to maintain clean air against all these hazards. We have to remember that the staff in the hospital is continuously exposed to these hazards if they are not adequately controlled, and many of these hazardous materials, particularly chemical and radioactive, are cumulative in nature — that is, harmful effects can be produced by the accumulation of small amounts over long periods. We have also to remember that the patients are a specially susceptible population because their resistance is low, they may have open wounds, or for special reasons of the nature of their illnesses

or the type of treatment they are receiving, they may be particularly susceptible to infection which may be airborne. Also, we must never forget that, if dangerous elements are allowed to escape from the hospital, they can affect people who live or work in neighbouring buildings, or are just passing by.

The hazards I have mentioned in general are all associated with air cleanliness because the agents concerned can be in gaseous, vapour or aerosol form, thus polluting the air which can be inhaled or from which solids can be deposited on the skin. If we maintain the air at the appropriate cleanliness by removing or adequately diluting the pollutant the hazard is eliminated. I have repeated the phrase 'appropriate cleanliness', with intent. Clean air is expensive. and the more clean it is the more expensive it is. But our knowledge of how clean the air needs to be in relation to the various objectional materials and circumstances is inadequate, and this is a field of study or research which deserves increased attention.

Where is clean air required?

I will now consider the different parts of, and activities in, hospitals where the cleanliness of air needs careful considerations. I shall do this in a general way first; afterwards I shall deal with each one in turn in a little more detail.

Laboratories

The place where most different hazardous substances occur is in the laboratories. The hazards may be microbiological, chemical, carcinogenic, radioactive or explosive (as where solvents are used).

Where aerosols, vapours or gases are the natural form of hazardous materials, or where such can be created by manipulation, they may form a serious inhalation problem.

The problem is dealt with by carrying out the process from which the hazards arise in protective air enclosures like fume hoods, safety cabinets, fume cupboards and laminar air flow units.

The principle involved in all these types of air enclosure is largely the same — the undesirable material is contained by suspending it within an enclosure in a current of air directed away from the operator and then ducted away.

In this way, if the protective air enclosures are properly designed and operated, the laboratory air is kept free of obnoxious substances. It is desirable, however, that the laboratory should be adequately ventilated also to deal with undesirable substances that, to a lesser extent might be disseminated other than in the protective enclosure, or which leak back into the laboratory because the protective enclosure is not working satisfactorily. Also the air that is ducted away from the protective enclosure must be dealt with in some way so that it does not re-enter the hospital or pollute the air outside the hospital to the detriment of people outside. Devices which can be used here are filtration, to trap hazardous particles, dissemination by ducting and, if necessary, a chimney to a point high enough for dispersal to give adequate dilution.

A special type of protective air enclosure is where work is being carried out, such as the preparation of radiopharmaceuticals, and where it is necessary to maintain clean air, free from micro-organisms or, maybe, pyrogenous dusts, to avoid the preparation being infected or the work being affected. A clean air unit such as a laminar flow unit, would then be used. It can be designed to provide protection for the operator against leakage of harmful material, such as radioactivity, out of the enclosure, as well as protection of the work, but the adequacy of some present designs has recently been queried.

Operating theatres

The risk of infection in surgical operating theatres is a very serious one. This would appear to be particularly serious in operations to do with bones and joints, such as hip replacement, and figures as high as infection rates of 7-9% have been quoted.

The infecting bacteria can arise from many sources — the air, the patient, the operating staff, the equipment, but it is becoming increasingly recognised that arrangements for maintaining clean air in the operating theatre are of paramount importance as one of the major factors in supplying a safe environment for operating. The problem of maintaining a clean atmosphere is one that will be discussed later, but it has been recorded that, in the USA, the number of hospitals employing the 'clean room' principle had risen from 23 in 1970 to well over 300 in 1972.

Results which have encouraged this development are exemplified by those at an investigation at Indiana, USA, where a figure of 6.5% infection rate before laminar flow air conditions were introduced had dropped to 1.07% after its introduction. While the most frequent approach in the operating theatre is to make the whole theatre into a clean room, there have been other attempts which amount to providing a mini-environment of clean air around the patient.

The provision of clean air in the operating theatre, as I have said, is not the only barrier against infection. The usual meticulous attention to scrubbing, sterilisation, masks, clothing etc, all have an essential part to play.

Special care wards

In Intensive Care Units and other special wards, notably burns units, the patient may be highly susceptible to infection. Other cases may be leukæmia patients or those being treated with immuno-suppressive drugs. A clean air environment to the patient is highly desirable and this may be provided by nursing the patient beneath ceiling canopies supplying a laminar flow of sterile air over and around him, and arranging for pressures to be such that no air can enter the ward from outside other than through the canopy.

Isolation rooms

In the case of a patient with an infectious disease, it is necessary to ensure that airborne micro-organisms do not escape from the area of the patient and contaminate the surroundings. What we are ensuring is that clean air leaves the isolation room. For such isolation, known as source isolation, one solution is to have the isolation room at a negative pressure so that outside air is drawn past the patient, and exhausted from the room through appropriate filters.

Ultra Special Care Units

In some cases related either to isolation for very highly dangerous infective diseases or abnormal susceptibility to infection, a clean air environment needs to be maintained with no direct contact with the patient. In such cases the patient has to be nursed in a glove-box type of compartment with nursing operations carried out through gloves and essential materials passed in and out through transfer locks. Proper air flow

with high efficiency filters, either to provide a clean air supply into the unit or to clean the air extracted, are the essential elements for maintaining such systems.

General wards

Patients and staff shed micro-organisms in the general wards and other rooms in the hospital, and the problem of maintaining sterility in any general ward is a difficult one. It has been agreed that contact cross-infection is more important than air-borne cross-infection. It has also been argued that mechanical ventilation with relatively clean air, provided in such a way that clean air is likely to be maintained, as well as producing a thermally and humidity controlled atmosphere, is desirable to produce a comfortable and safer environment for patients.

These, then, are the main situations in hospitals where clean air is either essential or highly desirable.

I want next to consider a little more closely the engineering and technology that are involved in providing these clean air environments.

High efficiency filters, laminar flow and air flow control

Firstly there are some elements that occur and re-occur in clean air engineering to the standards required in most hospital situations. The most important are high efficiency filters, laminar flow and air flow control.

High efficiency filters

Only about thirty years ago did the technology of high efficiency filtration begin to be developed in a manner which enabled large scale installations to deal with the problem of cleaning air, full of minute particles of highly toxic materials, down to levels acceptable for release of air to atmosphere.

Materials suitable for the sort of efficiencies required were originally developed in relation to service respirators in defence against chemical and bacteriological warfare particles both in the UK and the USA. They were first used for industrial filtration purposes towards the end of the 1939-45 war, by collaboration between the chemical defence authorities and industrial firms, using more modern materials and designs. But up to the early 1950s, a high efficiency filter was a cumbersome affair, and large scale installations required space and power larger than the industrial processes themselves. This was true of the early installations in the Porton Microbiological Laboratories and the Atomic Energy Authority installations, who were the major users at that time.

It was the development of the pleated glass paper medium which brought the technology down to manageable proportions, with comparatively small units processing comparatively large volumes of air. I was closely involved, as an engineering scientist, at both Porton and the UKAEA and, with some colleagues, produced a book on *High Efficiency Air Filtration* in 1964 after the main elements of the technology had been laid down.

Glass paper, which was exceedingly difficult to manufacture and process, was a very good material for making filters. It could be made to give low penetration combined with low pressure drop and high air capacity, it was non-inflammable and did not begin to deteriorate until about 500°C, and it had good chemical and humidity resistance. It is made up by pleating the paper around corrugated spacers to give a larger surface area in a small compass, but care has to be taken with edge sealing.

The efficiency and capacity can be varied in relation to the particle size of the material to be removed, by varying the glass fibre diameter, and density and thickness of the paper.

The standard high efficiency particulate air (HEPA) filter has an efficiency of 99.997% (or it may be expressed as a penetration of .003% of ½-micron sized particles). Filtration of small particles depends on three mechanisms (*Ref. 1*).

Particle inertia

Air flows in a flow pattern, and the particle sails along in that flow pattern in general, but if the air flow line distorts appreciably, as when it approaches a glass fibre, the particle's inertia gives it a more direct path and it collides with the fibre. The larger the particle the easier it will be removed by this mechanism.

Interception

As the particle passes through a mat of glass fibres, some will impinge directly onto the fibre directly in its path. Here again the larger the particle, the more likely it is to be intercepted by this mechanism.

Diffusion

Very small particles of matter are subject to what is called Brownian movement due to collision with randomly moving air molecules (like particles in a sun beam). This causes them to deviate from a smooth air flow line, and they are then more likely to collide with a glass fibre. This effect is greater with smaller particles. It follows, surprisingly enough, when those three mechanisms are acting together that very large particles and very small particles are the easiest to filter, and the most difficult size to filter is around ½-micron. People sometimes worry that while bacteria, whose size is usually about 1.5 microns might be filterable, viruses which might be as small as .01 microns might not. But as we have just seen viruses would, in fact, be more easily filtered in HEPA filters.

Installed, as they are, in heavy engineering complexes, HEPA filters are very delicate items. The paper is easily breached mechanically or by heat (as by bunsen burners in fume cupboards), the sealing can age and crack and so allow leaks around the edge. If they are not mounted carefully into their housing, this can lead to further leaks.

They can clog (and a prefilter is always desirable to take the major load of dust) and if they do, the pressure drop goes up and, therefore, the volume of air they pass goes down.

They, therefore, need to be carefully tested about every three or six months for both penetration and pressure drop.

Laminar flow

The technique of laminar flow has been mentioned in relation to certain types of protective air enclosure and in relation to operating theatres; perhaps this needs a little explanation. There are, generally, two ways of supplying clean air to a room. The first is to have air passed through a set of filters and then allowed to mix rapidly — indeed encouraged to do so — with the air already in the room, to give a turbulent ventilation system. The other system, known as the displacement system or the laminar flow system, involved introducing air over a wide area with a minimum of turbulence then passing it uniformly to its outflow point, in straight lines, as it were, so that there is a sort of piston of air which displaces the air already in the room. The air may be introduced from the ceiling area or

from the side walls, to produce either vertical or horizontal laminar air flow.

Laminar air flow will provide the cleaner air conditions, but the laminar flow will be upset by the existence of obstacles in the air part or by adventitious entry of secondary air.

Air flow control

All systems which attempt to provide a clean air environment are highly dependent on a properly designed air flow control system. A fume cupboard in a laboratory will not work properly unless there is an ample supply of air free to flow uniformly to it without major obstacles or major deviation, as by blasts from opening doors or windows. Equally the extract from a fume cupboard must pull smoothly, adequately and continuously to maintain the passage of air into the fume cupboard required.

External wind conditions can cause dangerous blow backs and where fume cupboards are grouped together with common ducting and fans, incorrect sizing of duct branches and incorrect adjustment of dampers can produce the wrong flow of air to individual fume cupboards.

Engineers need to check their whole air systems in relation to maintaining the correct flows in the correct direction.

These are just three of the elements — HEPA filters, laminar flow and air flow control that are involved in the engineering of clean air systems of all types.

Fume cupboards, etc.

The most important feature of a fume cabinet, safety cabinet or air hood, is that the flow of air passing into the enclosure through its opening should be sufficient to prevent the air in the fume cupboard, which contains the toxic material, from leaking out. There has been a lot of investigation on this point, but it now appears to be generally agreed that, to achieve this, the air must move into the opening at a uniform velocity of between 100 and 200 ft/min over the whole of the opening. If the velocity is lower than this at any point in the opening, material is liable to leak out. If it is much higher, undue turbulence may be created in the fume cupboard, and this will swirl material about and get it deposited on the operators' hands or upset the work. It is not enough to take the size of the maximum opening, and calculate the air required on the basis of this opening combined with 100 ft/min. This is because variations in velocity over the face can easily occur because of turbulence, eddy currents and vortices and can easily produce a back flow, particularly at the edges, although the main air flow is at 100 ft/min. Turbulence which produces back flow can be caused by correct design of the fume cupboard, because of movement in the laboratory such as doors opening and closing, or operators walking rapidly close to the fume cupboard, and because apparatus and operations within the fume cupboard cause turbulence and convection currents.

There are a number of ways in which the design of the fume cupboard can be made to help.

Firstly, the opening face of the fume cupboard should be of aerodynamic shape to produce a streamline air flow. The placing of an air foil along the front edge of the base, to create a gap of about 25 mm between it and the base, reduces eddy formation, improves containment in cross-draughts, and ensures that heavy vapours are sufficiently scavenged. A substantial shaping of the side entrances should also be included to reduce eddy formation (*Ref. 2*). Turbulence within the cupboard is reduced, and heavy vapours or aerosols much more effectively scavenged, if a back baffle is fitted, so that there is a low level, as well as a high level, extract slot.

If the air extraction rate is sufficient to provide an adequate velocity over the maximum working aperture of the fume cupboard, excessive air velocities will result when the sash is lowered to reduce the aperture. An air flow compensating device should be provided to maintain the correct air velocity at all aperture openings. One way of doing this is to incorporate a simple by-pass which is uncovered as the sash is lowered. (*Ref. 2*).

If the width of the fume cupboard is greater than 4 ft, two off-take ducts are advisable to assist in obtaining a uniform air flow over the whole width. It is desirable to arrange that, if the fume cupboard is switched off (and it is better that a fume cupboard should never be switched off), there should be a time delay at the switch of about ten minutes thoroughly to scour out the remaining toxic materials.

An instrument that tells the operator the **correct** air flow is being maintained, should be fitted to each fume cupboard or other protective air enclosure. It is important to maintain smooth air flow conditions in the fume cupboard, and to see that the inside of the fume cupboard should not be cluttered up with any more apparatus, bottles, etc, than is necessary for the work in hand. Also it is desirable that large equipment should not be situated near to the fume cupboard. This is to avoid turbulence conditions on the outside of the fume cupboard, and it is important to realise that no fume cupboard will work satisfactorily unless the air conditions in the laboratory are correct. That is, that there should be an ample, smooth uninterrupted flow of air to the fume cupboard. It is not enough to rely on normal ventilation, and open windows cause draughts which can pull air out of the fume cupboard. The air that goes into the fume cupboard should provide ventilation of the laboratory (which, by the way, should be at a rate of eight to ten changes of air per hour), and therefore the supply of the air and the positioning of the inlet grilles should be related to the fume cupboards so that the air is swept smoothly through the whole of the room before it reaches the fume cupboard. If the air supply is ample and well arranged, the problem of opening doors and movement of people is minimised, although it is always important to site fume cupboards as far away from doors and normal traffic routes as possible.

If you have an opening 3 ft × 2 ft, this, combined with an air flow of 120 ft/min, will give 43,200 cft of air per hour as the air requirement for one fume cupboard. This is about the equivalent of ten air changes per hour in a room 22 × 22 × 10 ft, and one would not normally have more than one fume cupboard in a room that size.

It is only by careful attention to the design and maintenance of fume cupboards and other protective air enclosures, that clean air conditions will be maintained in hospital laboratories.

While correct air flow will only be obtained if satisfactory air flow conditions are maintained to the laboratory, it is also true that correct air flow will only be obtained if the extraction from the fume cupboard is adequately designed and maintained.

There are a number of elements involved in this:

Filters. The possibility of installing high efficiency filters at the outlet of the fume cupboard has first to be considered. This is essential where pathogenic bacteria or viruses might be handled and HEPA filters should,

therefore, always be fitted to safety cabinets, but an area which requires much closer study is whether the materials used in chemical and radiological laboratories are not also sufficiently toxic to deserve the installation of high efficiency filters.

The ducting must be designed so that the combined pressure drop of the fume cupboard and ducting, related to the air flow required, is adequately overcome by the fan provided.

The ducting must also be carefully installed and periodically inspected to ensure that in-leakage of air does not impair the air flow to the fume cupboard.

With ducting systems in which whole groups of fume cupboards are all connected to a common ducting and fan, it is most important that the ducting is sized and balanced with dampers so that the correct air flow goes through each branch. Otherwise too much air will go through one fume cupboard and too little (or even reverse flow) in another. To guard against reverse flow (which, of course, would push the toxic materials back into the laboratory), arising from faulty extract conditions, it is desirable to fit an automatic anti-blow back at each fume cupboard. This would consist of a sensitive, well balanced and closely fitting damper.

The setting of air flow control dampers and the operation of non-return dampers should be checked regularly.

The fan should preferably be centrifugal with the impeller constructed of material resistant to the chemical conditions obtaining. Above all, it must be adequately sized. It is also important, however, that the air which goes into the fume cupboard, where it becomes mixed with the more hazardous materials which are handled there, should not be carefully extracted from the fume cupboard only to be thrown into a position where it can be harmful to people outside the laboratory. In particular, it is important that it should not be discharged to a point near to the inlets of the hospital's ventilation system, or near to openable windows. Indeed the extraction and dispersal of contaminated air from protective air enclosures in hospitals is undergoing a lot of re-thinking at the moment.

The trouble is that just passing air through the wall of the laboratory in the belief that it will be dispersed and adequately diluted in the open air is false.

Wind conditions can easily be such that a dead zone of virtually trapped air can be formed to the leeward of a building, and fumes released into this zone are not carried clear, nor substantially diluted and can, therefore, cause an unclean air hazard outside the hospital. Indeed, wind conditions can easily be such that the extract fan is overcome, and a blow back into the fume cupboard occurs.

If the ducting is carried to roof level we are still not safe, because meteorological conditions can produce down draughts which will blow the plume back down the wall of the hospital, past air intakes and open windows. It is becoming inescapable that, if we have toxic materials possibly released into the fume cupboard extract, the only satisfactory answer is to have a chimney. This must be high enough for the plume to be dispersed free of the effects of air turbulence produced by the building, or of wind blowing the plume down from the chimney.

The calculations required to establish the degree of dilution required, and height of stack necessary to obtain this dilution, relative to the topography of the surroundings are very complicated, and should be referred to experts. Probably stack heights of about 30 ft above roof level will generally be required.

I have dwelt at some length on the complicated engineering problem involved in maintaining clean air conditions in and around hospital laboratories. The same principles apply to the design of isolation wards for infectious diseases, where the requirement is to establish a protective air enclosure for the patient, and to pass air towards and over the patient to a bank of efficiency filters, from which it is extracted and disposed. A clean air environment is then provided in the ward, and the microbiological organisms are prevented from reaching people in the ward. Also the same principles apply to the autopsy unit in the mortuary. Here we are concerned that infectious organisms, or perhaps radioactivity, are contained. One solution is to have a canopy over the autopsy table. Both canopy and table should be aerodynamically designed, the table being a perforated plate. A current of air is fed down through the canopy, passes over and around the body and is collected below the table and ducted, preferably through filters, and adequately dispersed.

Operating suites

There are two basic requirements in the provision of ventilation to an operating room. The air should reach a specified level of cleanliness, and it should have adequate temperature and humidity control for the comfort of patient and operating staff.

What is meant by clean air in the operating theatre is not fully established. The most significant factor, of course, is the necessity of removing bacteria. Bacteria may have diameters as low as 0.5 microns but they rarely exist in the air as unattached particles and generally are associated with dust or skin particles which have diameters of 5 — 14 microns. Because of this, many ventilation systems have filters 99.9% efficient down to 5 microns. These will give air at their outflow having less than 35 contaminated particles per m^3 (1 per ft^3), and this is the standard laid down for operating suites by a Joint Medical Council and Department of Health and Social Security working party in 1972. However, where large volumes of air are concerned, particles of 0.5 to 5 microns can lead to a visible build-up of dust on surfaces which would be undesirable because bacteria could collect there. Also it is now recognised that even inert particles, smaller than 5 microns can produce a cellular response in wounds and so, in more modern operating theatres, it is becoming customary to install filters with 99.9% efficiency down to 0.5 microns.

The fact that all the air pumped into a theatre goes through high efficiency filters does not, of itself, guarantee that the air around the patient and operating staff is clean. There are other things to be considered:

1. Air may leak in from surrounding rooms in an unclean state. This should be dealt with by having the operating room at a higher pressure than its surroundings, so that at any leakage point, air leaks out rather than in, even when doors are open. Also the pressures in the operating suite should be maintained so that air flows from the cleanest area (the operating area) to the less clean area moving from operating theatre to scrub room and anæsthetic room, then to entrance lobby and changing rooms and, finally, to sluice and dirty movement areas.
2. Bacteria and other particles are given off by operating staff and, indeed, by the patient, and to deal with this it is desirable that the air flow within the operating theatre is

such that clean air flows past the patient towards the sources of bacteria, thus carrying bacteria away from the patient, and as it passes, collecting other bacteria from all sources on its way out. In one case the floor is marked to give a position beyond which operating staff shall not go, unless it is essential.

Another way of dealing with the bacteria given off in the theatre is to remove the air quickly, which is done by having a rapid air change. There is much debate on this, but it is reported that in America the latest tendency is to have as many as 600 changes per hour, and this is said to have given very good results such as on infected tissue or transplants.

In this country we do not seem to have got beyond about fifty changes per hour.

It should be noted that, with large numbers of air changes, a system would be too costly unless re-circulation of some of the air were used. This is only satisfactory if HEPA filters are used. Then both power and heat can be brought down to manageable levels.

We have previously discussed the principle of laminar air flow, and there is still much debate about whether turbulent or laminar air flow is the better in the operating theatre. There are protagonists for both methods.

Studies of the two systems indicates that laminar flow was more effective at clearing general contamination of a whole room, and may give the same rate of clearance as a turbulent system supplying up to four times as much air. However, this advantage is difficult to maintain in an occupied room due to currents caused by staff and their movements without a large increase in ventilation rates to overcome the disturbances (*Refs. 3 and 4*).

A large, multi-centred clinical trial, sponsored by the DHSS and the MRC, has recently started to test the effectiveness of high-flow ultra-clean air systems. Sepsis rates in some 17,500 total hip replacement operations over two and a half years will be assessed.

There can be no doubt that clean air in the operating theatre is a most important factor in reducing sepsis at the operation. It is a duty of the hospital engineer to understand the principles upon which his particular operating theatre has been designed, and to examine it frequently to see that the best is being got out of it. All designs should incorporate gauges and/or flow meters and warning lights that can indicate directly that the air flows and pressures are adequate to prevent contaminated air from entering the room, and to remove contamination within the room. Regular inspection of the filters and ductwork should be made by engineers, and tests of filter efficiency and bacterial counts should be arranged.

The principles relating to the design of operating theatres are also the basis of design of sterile wards and sterile isolation units for all nursing where it is necessary to keep the patient free of bacteria.

The engineer has the same duty to understand how these units are designed, to get the maximum sterile effect possible with the installation he has, and regularly to check that air flows are correct and filters are functioning efficiently.

Clean air – sophisticated technology

In conclusion, I would emphasise that all these considerations of supplying clean air to hospitals, to a level not met with even 15 years ago, are the fruit of a developing, sophisticated engineering technology. But like all sophisticated technology they require a high level of understanding and attention to make them work effectively, and if they are not working properly they can produce situations more dangerous than if they had not been used at all.

The engineer has a very special and firm responsibility towards the effective use of this technology. He must be heavily involved with design, installation, commissioning and maintenance with technical understanding of the systems used, and concern for the health and safety of all who are affected if they do not function satisfactorily.

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Medical Engineering– Who Does What

Report by A. M. Gower

Approximately 50 members and visitors attended the London Branch Meeting at the Middlesex Hospital Medical School on 10th May for a discussion on *Medical Engineering – Who does what?* under the chairmanship of Mr. R. D. Buckley.

In welcoming members of the Hospital Physicists' Association, and in particular their President, Mr. John Clifton, Mr. Buckley stated that the London Branch had been fortunate indeed to have secured three excellent speakers who were well aware of the existing problems of maintenance. He looked forward to their contributions which would undoubtedly lead to a greater understanding, and create additional interest and enthusiasm, on a subject which was generally regarded as a 'grey' area.

Expressing a personal view, the first speaker, Mr. J. Huelin, Principal Assistant, Medical Engineering, Oxford Regional Health Authority (T), considered that there was a lack of liaison and unanimity between the different engineering facilities such as bio-engineering and medical engineering on subjects such as electronics, and on laboratory, X-Ray and other medical equipment. This wasted a lot of time. It was generally accepted regretfully that there was a rift between hospital engineers and physicists, and to some extent also bio-engineers. Better allocation of responsibilities and greater management efficiency was essential.

The Oxford Regional Health Authority spent approximately £5 million per annum on capital medical engineering equipment, equivalent, Mr. Huelin suggested to £200 million annually in the U.K. The annual maintenance bill would be £20 million. Mr. Huelin considered that the maintenance figure could be reduced by 50% by increased efficiency, particularly in in-house maintenance departments. Although the safety of the patient was obviously paramount, and should never be forgotten, economies in maintenance were perfectly possible, with good product information. The Department's maintenance leaflet EY10 had received criticism but Mr. Huelin considered it was basically acceptable. Physicists generally believed that maintenance on all research buildings and equipment should be their responsibility. In the Oxford Region however, this problem had not been experienced. Existing in-house maintenance staff co-operate closely with all engineering disciplines. Medical equipment was basically maintained by regular visits from the manufacturers. Day-to-day maintenance and observations were made by the engineering technician, with the physicists 'standing by', readily available with their expertise and specialised knowledge if required.

The Zuckerman Report had not been welcomed by the physicists, who would prefer to work in small groups with a Professor, or similar person leading whatever research or other project the team was engaged in.

Mr. Huelin suggested that the Area Health Authorities should encourage the Regions to get involved to resolve the existing problems, otherwise within five years there would be a serious decline in service facilities and standards.

The second speaker was Dr. D. Whelpton from the Department of Medical Physics, University Hospital, Nottingham. He referred to the many aspects of medical maintenance engineering, including general maintenance, calibration, safety checks, evaluation, staff training and liaison, equipment modification and development, and the acceptability of new equipment. He considered it vital to have good technical support with reliable equipment and servicing facilities. Guidance and assistance in new applications, logging of observations, and technical advice in the use and interpretation of scientific equipment was fundamental. Several alternative maintenance schemes were available. In one, all services should be the responsibility of the engineering department, with all development work being the responsibility of the physicist; the engineering department and the physicist operating as a joint unit. Other alternatives suggested that the engineering department should accept prime responsibility, or that the physicist act as an agent for the engineer. Dr. Whelpton's opinion was that physical locations generally dictated the system of liaison to be used. The patient was always the main concern, with teamwork being essential.

The third speaker Mr. R. Rodgers, Superintending Engineer DHSS explained that his duties included responsibility for ensuring that all medical equipment supplied was technically satisfactory and acceptable, and that any defects were reported to the appropriate authority. Regular and rigorous maintenance was fundamental, and it was essential to have an excellent filing system with a supporting management team for maximum efficiency. The individual should be utterly committed to his work and completely reliable. Good technical skills over a wide range would be highly desirable. Knowledge of the Health and Safety Act was very advantageous. Equipment calibration required special skills and good electrical knowledge, and it was essential for the individual to recognise his own skills and limitations. In the DHSS many disciplines of engineering were brought together in solving problems. In equipment development all skills are necessary to be successful, and Mr. Rodgers stressed that, unless engineering modification was well documented, it would be very dangerous indeed to proceed with a project. In his opinion there was no room for people who could not recognize others' special skills, or their own limitations.

Discussing a £20 million annual maintenance bill Mr. R. Parkin had calculated that between 4/5000 engineers of various skills would be required. He asked whether the Health Service could really afford them. In reply Mr. Huelin indicated that his own authority had no difficulty in attracting staff, but appreciated that London had special problems, and suggested that perhaps the grading system should be reviewed in selective areas. The number of teams were growing, specialists were being trained in other skills, and he suggested that area authorities wanted to get involved in this work.

Dr. Whelpton mentioned the enormous work load of the X-Ray Units and recommended employing a greater number of technicians to gain experience.

In reply to Mr. J. F. Sancroft who asked about the different values across the country on grading, as distinct from research, and the cost of running the hospital service, Dr. Whelpton replied that Regional Areas were underfunded. He suggested that management was possibly the most important factor, essential for cost evaluation and values.

Answering a question on maintenance costs per staff member, Mr. Huelin was of the opinion that twice the individual's hourly rate was a fair costing, although he realized many engineers would consider this estimate too low.

In reply to Mr. J. C. Brown, concerning the responsibilities of National Health Officers as compared with Contracting Engineers, Mr. Huelin agreed that a problem did exist between what could be classified as repair as distinct from maintenance.

Mr. Rodgers stressed that with any suspected radiation leak the Health and Safety Executive should be consulted immediately.

Mr. J. C. F. Peake of the Physics Department at Guildford Hospital stated that it was practically impossible to calibrate gamma scanners and similar types of electronic equipment properly and keep sufficient spares, and suggested that the manufacturers should always be brought in to do the work. Mr. Huelin agreed it was a difficult situation and although the manufacturers are normally helpful, spares are not always available at short notice – careful selection of the supplier was therefore most essential.

Mr. Buckley stated that the meeting had successfully brought together those who knew about the problems of maintenance; those who cared about the problem; and those well qualified to resolve the problems, and considered that it had achieved an important contribution towards a better understanding and appreciation regarding the problems of medical maintenance.

In concluding the meeting the Branch Chairman, Mr. D. L. Davies warmly congratulated Mr. Buckley for having arranged the meeting programme, and thanked the Speakers and all those who had contributed in the discussion, in what had proved to be a most excellent and helpful exchange of views.

Students' pages

Mr. Fletcher is Area Engineer, Cleveland Area Health Authority. This is the second of his series of lectures aimed at new entrants — the first was published in our April 1977 issue.

Fire Preventions and Precautions

J R FLETCHER BA CEng MIMechE MIMarE AMBIM FIHE

At the moment hospitals do not come within the legislation of the Fire Prevention Act 1971, and do not require a fire certificate. Nevertheless, this should not be used as an excuse to avoid one's responsibilities. It is recommended that all premises be surveyed by the Local Fire Prevention Officer.

The Fire Services Act 1947 requires fire authorities to give advice upon request on fire prevention and means of escape, in respect of buildings in their own areas. Hospital Engineers should avail themselves fully of this service and its specialist advice. It is good practice to carry out an annual survey of all premises in conjunction with the Fire Prevention Officer and the Hospital Fire Officer. This survey ensures that an independent specialist assessment is made of the buildings and fire prevention systems. Any shortcomings can be discovered, and remedial action taken, before they become an embarrassment, sometimes with disastrous results. Remember, complacency can creep into any organisation, familiarity breeds contempt, and everyone to varying degrees can end up 'not seeing the wood for the trees'.

It is good practice for a Hospital Engineer, particularly for new entrants into the N.H.S., to carry out a fire survey of a hospital. Although the provision and requirements vary between buildings and their usage, a survey should include the following:-

(a) Adequate means of escape for patients and staff in an emergency,
(b) Are fire compartments included in the building? Ensure that all openings through the fire compartment walls comply with current requirements,
(c) What type of fire detection is used?
(d) What type of fire alarm is used; automatic, break-glass, telephone, etc. Is it linked directly to the Local Fire Brigade?
(e) Is there an adequate supply of suitable fire extinguishers?
(f) Is there an adequate water supply to all fire hoses and hydrants?
(g) Are all escape routes, exits, and stairways adequately illuminated?
(h) Are all means of escape clearly indicated?
(i) Check if good housekeeping with regards to storage of inflammable materials and 'No Smoking' signs, etc., is being enforced,
(j) Ensure there exists a plan of action in case of fire. Is everyone aware of this plan?

The Secretary of State expects each hospital authority to have a carefully prepared programme for dealing with fire prevention, fire fighting, and the movement of, or evacuation of patients in an emergency, including staff training in this matter, at all premises under their control.

There is often doubt in a Hospital Engineer's mind as to his responsibilities regarding fire precautions and prevention. Engineers readily accept responsibility for the maintenance and testing of electrical fire alarms, (indeed these should be included in the P.P.M. scheme) but since the introduction of Fire Officers into the N.H.S. there sometimes exists confusion as to who is responsible for the periodic testing of portable extinguishers, fire hoses, hydrants, dry risers, etc.

The Fire Officer is invariably attached to the Hospital Administrator's staff, and, through lack of co-ordination there is the possibility of duplication or contradiction of action. It is imperative that the Fire Officer and the Engineer should know each other's exact responsibilities with respect to fire precautions and prevention. Their functions may be easier to control and co-ordinate if both were responsible to a senior works officer, but that is an engineer's opinion that may not find favour with other disciplines!

To avoid any confusion, duplication, or what is worse, omissions of responsibilities, it is essential that the Hospital Engineer should obtain from his superior clear instructions as to his responsibilities with respect to fire precautions and prevention. It is essential that a log book be maintained by a responsible person, where details of false alarms, fire call-outs, tests, inspections, complaints and comments, etc., are recorded. This log book must be inspected and signed at regular intervals by a Senior Works Officer and the Fire Officer, and must be available for inspection by the Health and Safety Executive.

Hospital Authorities should notify the D.H.S.S. through the Regional Health Authorities within 48 hours of all fires which result in loss of life or injury or disturbance to patients, or damage to hospital property, and should forward a copy of any report on a fire received from the Fire Brigade.

To assist the new entrant into the N.H.S. I have compiled some guidelines as follows:-

Do ensure that

1. All recognised means of escape, including special emergency exits, are clearly and indelibly indicated;
2. Lighting fittings in exitways are group controlled, and so located that they are not readily available to unauthorised persons;
3. You are familiar with your hospital fire alarm system;
4. You are familiar with portable and fixed fire extinguishers, ensure that there are sufficient to meet an emergency;
5. There is an adequate water supply to all fire hoses and hydrants;
6. All non-smoking areas are conspicuously marked;
7. The storage of highly flammable liquids and materials is satisfactory, preferably in a special store;
8. The storage of medical gas cylinders are to the requirements of H.T.M.22.

Do you know where all medical gas cylinders are stored, so that the Fire Brigade can be informed in the case of a fire?

9. The collection and disposal of combustible waste is adequate. Is the disposal of aerosol spray cylinders satisfactory? What precautions are you taking to ensure that none are thrown into incinerators?

10. The storage of petrol complies with the requirements of the local licensing authority;

11. The hard standing around the liquid oxygen plant is adequate in construction and area. Are prohibitive notices displayed? Is the site railed off to prevent unauthorised access?

12. Service ducts containing piped gases have adequate ventilation;

13. Medical gas pipelines are bonded to earth and are protected against mechanical damage;

14. All medical gas isolating valves are clearly marked, indicating type of gas and area controlled;

15. Low temperature heating is used in areas in the vicinity of highly inflammable materials, etc.;

16. The storage of X-Ray films is adequate;

17. Fish fryers are fully maintained, that thermostats are regularly tested, and all results are recorded;

18. All of your gas appliances comply with BS1250 and BS2512 as appropriate;

19. All roof spaces and other confined spaces are checked periodically to ensure that they are clear of combustible materials;

20. Controls of engineering installations are clearly marked as to what areas they control or isolate;

21. Switch and fuse gear is housed in non-combustible enclosures, are readily accessible at all times, and all switches and fuse ways are marked with the circuits controlled;

22. Switchrooms are not used as storerooms and are free from items not needed in an emergency;

23. Neon type indicators are used on equipment in regular use;

24. Electric irons are thermostatically controlled;

25. Accurate and reliable temperature control is used on electric pads, blankets, etc.;

26. Emergency lighting complies with H.T.M. 11;

27. The emergency generator is tested regularly to ensure that it will automatically start and carry an electrical load within 15 seconds. (See procedure laid down in circular ED 75/38);

28. Regular testing and servicing of electrical installations is carried out. Ensure that all wiring associated with fire alarms and emergency lighting is either M.I.C.S. or encased in steel conduit;

29. Lightning conductors are tested and examined regularly;

30. Fresh air intakes are correctly positioned to avoid the intake of smoke, etc.;

31. Disused ventilation shafts and ducts are dismantled or sealed;

32. All fusible links on ventilation systems are fitted correctly;

33. Laundry drying machines are regularly checked and cleaned to prevent 'fluff' build up. These are potentially a high fire risk;

34. Full details of raising a fire alarm are available to all staff;

35. Your staff are familiar with the location and use of the main controls for the electrical, oil, water, and gas installations, including medical gases. Are your record drawings factual, are they readily and easily available?

36. The existing fire precautions and system within your hospital are constantly monitored. Are there any improvements that can easily be incorporated?

37. That all lighting on primary escape routes is classified as safety lighting, independent of other circuits and fed on an essential circuit.

Do not

1. Allow inflammable liquids or materials to accumulate unnecessarily;

2. Install medical gas pipework in rooms or areas with a significant fire risk;

3. Allow temporary or improvised electrical wiring, except in an emergency;

4. 'Over-fuse' electrical circuits;

5. Use radiant type heaters, except in fully controlled circumstances;

6. Use portable space heaters, except in an emergency and then under supervision;

7. Allow naked flames near to batteries whilst they are being charged. Battery rooms should have adequate ventilation, and 'No Smoking' signs must be displayed;

8. Under any circumstances allow lamps of higher wattage to be used in fittings than design rating;

9. Allow the use of privately owned electrical equipment, except in locations specially set aside for the purpose. Unauthorised electrical extensions should be forbidden;

10. Walk past fire doors which have been wedged open;

11. Allow dangerous or hazardous practices to continue;

12. Implement any alterations to buildings or services without considering the full fire implications of the proposed alterations. Discuss the matter with your building and fire prevention colleagues;

13. Use portable ladders as means of escape, all means of escape must be permanent;

14. Use chutes as a means of escape, except in exceptional cases, and then only after full discussion;

15. Use lifts as a means of escape, unless there is no satisfactory alternative, and then only after discussion with all concerned.

Definitions

High Life-Risk Areas

(a) Area in which non-ambulant people may reside who would require assistance to move from a fire into an adjacent fire compartment.

(b) Areas in which more than 50 people would normally congregate.

Low Life-Risk Areas

Areas in which all occupants are ambulant and are able to move away from a fire to a safe area.

High Fire-Risk Areas

Areas which, due to their function and/or contents are not subject to continuous surveillance, are inherently susceptible to an outbreak or rapid spread of fire, e.g. laboratories, boiler houses, kitchens, etc.

High Fire-Load Areas

Those parts of a hospital which because of their construction and/or contents contain large amounts of combustible material, e.g. X-Ray film stores, linen stores, central stores, etc.

Fire Compartments

This is where a building is segregated into fire compartments, and so designed as to retard or contain a fire. All hospital areas should be divided into fire compartments which will provide not less than one hour fire resistance. Where there are areas of high fire load or risk within that compartment, a sub-compartment of not less than ½ hour fire resistance may be necessary around that particular area. The integrity of a fire compartment is of paramount importance. All openings through the fire compartment walls should be capable of automatic closure on the outbreak of fire.

Closed Circuits
Circuits in which all call point contacts are normally closed and are connected in series. This system has the advantage of allowing a continuous monitoring current to be passed through the wiring and call points to indicate circuit failure.

Open Circuits
Circuits in which call point contacts are normally open and are connected in parallel. Failure or closure of a call point (short circuit) completes the circuit, hence sounding an alarm.

Heat Sensitive Detectors
There are several different types of heat sensitive detectors available, using differing methods of operation, e.g. bi-metallic devices, fusible elements, thermocouples, expansion of fluids or thermistors. All heat sensitive detectors are designed to operate at a specified maximum temperature, but some also incorporate a rate of rise of temperature element. These operate at temperatures lower than the maximum if the rate of rise of temperature is abnormally high. Engineers should ask themselves as to why both types are required, and where they should be installed.

Smoke Detectors
There are two types of smoke detector. One utilises the effect of smoke particles in an open ionisation chamber and the other relies on the clouding effect of smoke in a photo-electric device. Smoke detectors are normally more sensitive than heat detectors, but are more prone to false alarms through fine dust, heavy pipe smoke, etc. They are also relatively insensitive to fires involving alcohol, ether, etc., which produce very little smoke when burning.

Final Exit
Means the terminal point of an escape route beyond which people are no longer in danger from fire.

Fire Resisting Construction
Means construction of a type which if tested in a prescribed manner would give a minimum of 30 minutes resistance to fire, or longer as may be required for that type of construction. For greater detail see Building Regulations 1977.

Protected Area
Means an area giving an adequate degree of protection from fire in another area and from which there is means of escape.

Protected Lobby
Means a lobby having an adequate degree of protection and forming part or whole of the horizontal component of an escape route.

Protected Route
Means a route having an adequate degree of fire protection including walls, partitions and floors and ceilings of fire resisting construction, which separate the route from the remainder of the building.

These guidance notes, etc., are not intended to be a comprehensive list, and I must emphasise that any Hospital Engineer, before specifying, installing, or modifying a fire alarm/prevention system, must make himself fully aware of current requirements with regard to fire prevention, etc.

It is perhaps unfair to expect Hospital Engineers to be completely familiar with all requirements. I would, nevertheless, expect them to be familiar with the requirements of H.T.M. 16, H.T.M. 11, Design Note 2, and Dear Secretary Letter L/H45/25.

There are undoubtably some glaring omissions from the above guidance notes, particularly from the point of view of a Fire Officer and Architect/Building Supervisor. Might I suggest that a similar paper from one of those disciplines would be beneficial to everyone.
(Editor's note: We are always delighted to receive papers for consideration.)

One area in which the Works Department can make a positive contribution to fire prevention is during minor capital works involving alterations and extensions to existing services and buildings. Sufficient precautions are seldom taken during this type of work and the controlled disciplines considered necessary on major capital works are frequently ignored. Where minor/major capital work is to be carried out in a fire risk area an Authorised Person should ensure the following:-

1. Work is carried out only with written authority;
2. Adequate inspection, before, during and after work;
3. Area has been cleared of all combustible materials. Where this is not possible a fire insulating screen should be erected around the place of work;
4. Adjoining areas must be inspected to ensure that there is no danger of ignition by radiation, conduction or convection;
5. Portable extinguishers are readily to hand;
6. The proposed work has been discussed with the Fire Officer or someone trained in fire prevention;
7. Care is being taken to ensure that sparks cannot fall into concealed spaces;
8. Fire hoses, etc., have been tested prior to commencing work;
9. All cutting equipment, hoses and cylinders have been checked for safety. Where possible the oxygen and acetylene cylinders should be remote from the fire risk, great care should be taken to protect the hoses from mechanical damage, etc.

Whilst accepting that the installation of a fully automatic and monitored alarm system is beneficial to the safety of patients and staff, and assists in the prevention of fire spread, one has to balance the overall fire and life risks against the economic facts of life. H.T.M. 16 must be used for guidance on the choice of alarms. Automatic systems are usually restricted to high life and risk areas, and where supervision cannot ensure that the unattended period is limited to approximately 5 minutes. They are sometimes justified in unstaffed areas, which constitute a high fire risk, or where protection is justified due to the valuable and essential nature of the contents. Fire doors should be automatically controlled by detectors. The highest life risk is in wards housing patients suffering from mental illness or disability, and the highest priority should be given to these areas, particularly where they are isolated from main circulation areas of hospitals.

Manual operation is, at present, deemed satisfactory in ward areas which are staffed throughout the 24 hours. Where manual break points are used, they should be positioned at escape points, exits from departments, plantrooms, and centrally manned positions, e.g. nurses' stations. A considerable number of hospitals use the telephone system as a manual alarm, i.e. a number, say 222, designates a fire call. Manual break points and telephone alarms should not be integrated. Manual break points should switch off any mechanical ventilation plant serving that particular area.

Whatever fire alarm system is finally installed, a compromise is often required between what is recommended by the Fire Prevention Officer and what is feasible due to design, user requirements, economic cost, public interest and the building function.

Uniformity in precautions is often difficult to achieve, as each building invariably has individual problems, through type of design and construction, and through usage. Also, the interpretation of regulations by Fire Prevention Officers tends to vary somewhat.

Some basic rules

1. Escape routes should be free of flammable materials or other possible fire risks;
2. Ensure there is an effective fire resisting separation between escape routes and any potential fire risk;
3. Remember that the vast majority of fires have a small beginning, usually through some careless human action;
4. It is essential that all staff should be trained to recognise potential fire hazards and risks, and should receive instruction as to what action is required from them to eliminate hazards or bring them to the attention of a responsible person;
5. Hospital Engineers should ensure that their 'Engineering Emergency Services Plan' contains sufficient equipment and facilities, and their staff have received adequate instruction to deal with an emergency situation such as FIRE.

Conclusion

Considering the large number of buildings within the N.H.S., the varying age, different types of usage, and construction of these buildings, and the millions of people (patients, staff, and visitors) who use these buildings, the N.H.S. has a remarkably good record of safety, particularly when it is considered that the majority of fires are invariably caused by the careless or unthinking action of people. Unfortunately, when loss of life does occur, it is usually the mentally or physically infirm who perish, so one should never be complacent about fire; there is always room for improvement in any system.

One life lost through fire is one too many. It is the responsibility of everyone within the N.H.S. to keep an ever-watchful look out for fire hazards and careless practices.

Perhaps the greatest single contribution towards this is the education of all staff on fire prevention and precautions. This is, I feel, the responsibility of the Fire Officer, with suitable assistance from members of other disciplines.

With the high human element involved, it will never be possible to eliminate all fire risks from the N.H.S. Nevertheless, it is essential that fire precautions are maintained at a high standard, particularly in areas associated with non-ambulant patients.

Finally, under the Health & Safety at Work Act 1964, everyone has a responsibility to himself and his fellow man to **THINK SAFETY, ACT SAFELY.**

Product News

New Sterilisers

New LTSF Steriliser

A new low temperature steam and formaldehyde steriliser which features an automatic formalin dose meter fitted with adjustable controls has been introduced by Dent and Hellyer Limited of Andover.

The LTSF steriliser is available in a variety of sizes, and has been designed for processing heat sensitive materials and equipment that will withstand moisture and temperatures only up to 80°C. Suitable articles for sterilisation by this method could include electrical and electronic equipment, various plastic and rubber items, Cystoscopes, fibre-illuminated telescopes and cables and anaesthetic equipment.

The new automatic dose meter ensures that the correct quantity of formalin solution is admitted to the steriliser with each pulse of steam and therefore effectively monitors the formaldehyde concentration. In previous sterilisers of this type, formalin was manually induced for each sterilisation cycle.

Other features of the machine include Dent and Hellyer Slidelock controls with solid state components. Full instrumentation with stage indicators are located on a large panel adjoining the machine ensuring totally effective operation. The unit incorporates an advanced system of air evacuation by vacuum pumping, combined with low temperature steam and formaldehyde pulsing, to effectively achieve air removal, with temperature and gas penetration. Although all stages in this sterilisation cycle are automatic, an override key switch can be used if necessary.

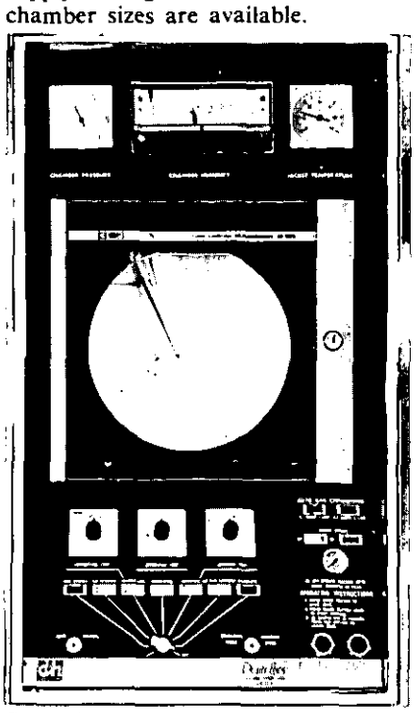
A detailed leaflet giving full specifications for the new LTSF Sterilisers with Slidelock controls is available from: *Dent and Hellyer Limited, Walworth Road, Andover SP10 5AA. Telephone: 0264 62111, Telex: 47430.*

New Ethylene Oxide Gas Steriliser

Dent and Hellyer have also introduced a new ethylene oxide gas steriliser for the sterilisation of items that cannot withstand moisture and heat in excess of 55°C.

The new ethylene oxide gas steriliser, called 'Dentethox', is being manufactured to meet the needs of modern hospitals, laboratories and similar manufacturing facilities which require effective sterilisation of heat sensitive items such as heart lung units, electrical and electronic apparatus, pre-packaged disposables, rubber and plastic items, bedding, clothing and powders.

Features of the new machine include a series of fail-safe devices to ensure efficient operation, easily serviceable or replaceable solid state components, a comprehensive operator control panel and an automatic gas supply changeover control. Various chamber sizes are available.



Control Panel for Dent & Hellyer Slidelock Mk IV.

A detailed leaflet containing full specifications of the new Dentethox Ethylene Oxide Gas Steriliser with Slidelock Mk IV controls is obtainable from *Dent and Hellyer Limited, Walworth Road, Andover SP10 5AA. Telephone: 0264 62111, Telex: 47430.*

A selection of Dent and Hellyer equipment is on display at the British Hospital Equipment Display Centre, 22 Newman Street, London W1P 3HP.

Air Conditioning Unit equipped for thermal recovery

The recently introduced Bahco ABC series of air handlers incorporates heat recovery sections, use of which can reduce fuel costs by up to 85%.

The main cost of heating a building is concerned with warming the incoming air. Recirculation can sometimes be used, but the actual gain is often minimal. Frequently air cannot be re-used owing to contamination.

The Bahco ABC enthalpy heat recovery section incorporates a device with many thousands of small axial passages which have thermal storage capability. Heat from exhausting building air is absorbed and transferred to the supply side of the air handler — the amount of energy required being considerably reduced.

Another device available as part of the modular ABC system takes advantage of recuperative exchange. Instead of using a solid body to transfer the heat from the exhaust to the supply air, a liquid is employed. The exchanger located in the extract duct absorbs heat, the liquid continually circulating is pumped to the air handler where energy is liberated. The incoming outdoor air is pre-heated by the recovered energy before being admitted to the heater battery in the supply duct.

One of the advantages of this run around system over others is that supply and exhaust air units do not have to be in close proximity to each other. They can be installed in a manner most suitable for the construction aspects and system layout.

Further information from: *Bahco Ventilation Ltd., Bahco House, Beaumont Road, Banbury, Oxon. OX16 7TB. Telephone: Banbury (0295) 57461.*

Emergency Lighting

A six-page A4 leaflet gives full details of the range of Central Emergency Lighting Systems offered by Automat.

Comprehensive three-hour rating tables are included listing units suitable for providing safety lighting in hotels, cinemas, public buildings, offices, dance halls, etc., including those for DC applications or incorporating relays in accordance with BS764.

Free on request: *Sales, Automat, Moorside Road, Swinton, Lancashire M27 3PW, England. Telephone: 061 794 4747, Telex: 669058.*

Classified Advertisements

APPOINTMENTS AND SITUATIONS VACANT

HEREFORD HEALTH DISTRICT
GENERAL AND RURAL HOSPITALS

ASSISTANT HOSPITAL ENGINEER

Salary: £3,063 per annum rising to £3,507 per annum plus £291 per annum plus 5%.

To assist the Hospital Engineer with the works services for Hospitals, Clinics and Ambulance Stations situated within the Central and Rural Sectors of the Hereford Health District. To be based initially, at the General Hospital, Hereford.

Qualifications — ONC in Engineering or an alternative qualification acceptable to the Secretary of State.

Practical Training and Experience — must have completed an apprenticeship in Mechanical or Electrical Engineering, experience in the management of Mechanical/Electrical Engineering plant, including maintenance planning; control and deployment of maintenance and operational staff, preparation of maintenance estimates and reports.

Application forms and job description from: Mr. C. W. Sheldrake, District Works Officer, 24 St. James Road, Hereford.

Applications to be returned by 26th August, 1977. Please quote reference 2/PT/HE.

MAINTENANCE MANAGER

Madame Tussaud's and The London Planetarium, which form a unique family entertainment and attract over two million visitors a year, now wish to create a new appointment of Maintenance Manager. The Company has a considerable amount of mechanical, electrical and optical equipment, and it is Company policy to maintain its own building. The Company directly employs the necessary skilled people, including electricians, carpenters and painters.

It is envisaged that the new Maintenance Manager will have had mechanical engineering or technical building experience, and probably be qualified to HNC standard or equivalent, although management qualities and the ability to get on with people are more important than technical qualifications. Someone who has been employed in Hospital, Hotel or Theatre Maintenance may be suitable. Although a major concern will be the mechanical aspects of maintenance, the man or woman appointed will be responsible for planning and supervising the electrical and building aspects of maintenance, and experience in these fields would be useful.

In the autumn of 1977, a major project is the replacement of the present air-conditioning system, together with redevelopment of part of the building interior, and during this period the post will be more of a project management one.

This is a senior permanent appointment for which a salary of £5,500 is offered, together with generous benefits, including subsidised staff restaurant, non-contributory pension and life assurance scheme, and an assisted car scheme. It is not thought that someone under 40 years of age would have the necessary experience.

Suitable applicants are invited to write in confidence to Mr. B. Worthing-Smith, General Manager, Madame Tussaud's Limited, Marylebone Road, London NW1 5LR, enclosing a curriculum vitae.

THE ROYAL NATIONAL THROAT, NOSE and EAR HOSPITAL

Gray's Inn Road, London WC1

ASSISTANT ENGINEER

Salary: £3,838-£4,282 p.a. (inclusive)

Responsible to the Hospital Engineer for the day-to-day management function including PPM system of the above hospital and associated properties. Applicants must have completed a mechanical or electrical engineering apprenticeship or have acquired a thorough practical training appropriate to the duties and responsibilities of the post, and hold an ONC in electrical or mechanical engineering or acceptable alternative.

Application form and job description from: Hospital Engineer. Tel. 01-837 8855, Ext. 315.

(Closing date: August 26, 1977).

Cambridgeshire Area Health Authority (Teaching)

Area Works Organisation

DISTRICT ENGINEER

PETERBOROUGH HEALTH DISTRICT

Salary Scale: £5,763-£6,945 p.a. plus Stage I and II pay supplements.

The successful applicant should have had wide experience at senior level in the management, planning, design, operation and maintenance of building services, preferably in the Health Service.

He will be expected to make a significant contribution to the Area engineering maintenance and operational policies now being developed at Peterborough District and to influence directly the function of an efficient Works Organisation.

Minimum qualifications: HNC in Mechanical and/or Electrical Engineering or equivalent with approved endorsements. PTB circular 261, paragraph 1(c).

Application form, job description and further details obtainable from the: Area Personnel Officer, Cambridgeshire Area Health Authority (Teaching), Purbeck House, Purbeck Road, Cambridge CB2 2PF. Tel. Cambridge 42841, ext. 234.

Closing date: August 19, 1977.

CENTRAL PUBLIC HEALTH LABORATORY

ENGINEER

required for the operation and maintenance of the engineering services and related building maintenance. Applicants must be experienced maintenance engineers and have a practical knowledge of boilers and mechanical and associated electrical equipment and a knowledge of plumbing installations an advantage. HNC or City and Guilds in engineering or equivalent qualifications, desirable.

Whitley Council salary scale for Hospital Engineers, at present £4,195 rising by five annual increments to £4,795 *per annum inclusive of pay supplement* and London Weighting. In the event of an unqualified, but experienced person applying, the salary would be abated by £150 per annum at all points.

Application form and outline of responsibilities from Personnel Officer, Central Public Health Laboratory, Colindale Avenue, London NW9 5HT. Tel. 01-205 7041.

HAREFIELD HOSPITAL, HAREFIELD, MIDDX.
Telephone: Harefield 3737

HOSPITAL ENGINEER

required, to be responsible for all major Engineering Services at this 350-bed hospital.

The post involves the maintenance and control of Electrical and *Mechanical Services* for the hospital and the management and co-ordination of support staff.

Minimum qualifications are an apprenticeship in Electrical or Mechanical Engineering and HNC or equivalent DHSS approved qualifications. Practical experience in the operation of coal-fired steam-raising plant would be an advantage and National Health Service experience would be helpful.

Housing will be available if required.

Application form and job description available from: Miss P. Durand, Sector Personnel Officer.

Closing date: August 19, 1977.

LANCASHIRE AREA HEALTH AUTHORITY
BLACKPOOL HEALTH DISTRICT

HOSPITAL ENGINEER

(Over 24½ Points)

required for Victoria Hospital, Blackpool.

Salary Scale: £3,615 X 5-£4,140 plus £291 flat rate addition plus variable pay supplement plus £183 p.a. responsibility. Bonus payments are also made.

The successful candidate will be responsible to the District Engineer for the management of the engineering section of the Works Department of this 765 bedded acute hospital.

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. Telephone Blackpool 34151 Ext. 206, to be returned by 19th August.

To place an advertisement *in the next issue of*
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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.

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Every year the number of fires increase. Many are small, but many cause loss of life, severe equipment and structural damage and irretrievable loss of production. This fact has increased compulsory legislation and indeed personal awareness with regard to fire protection that it is now an integral part of any property.

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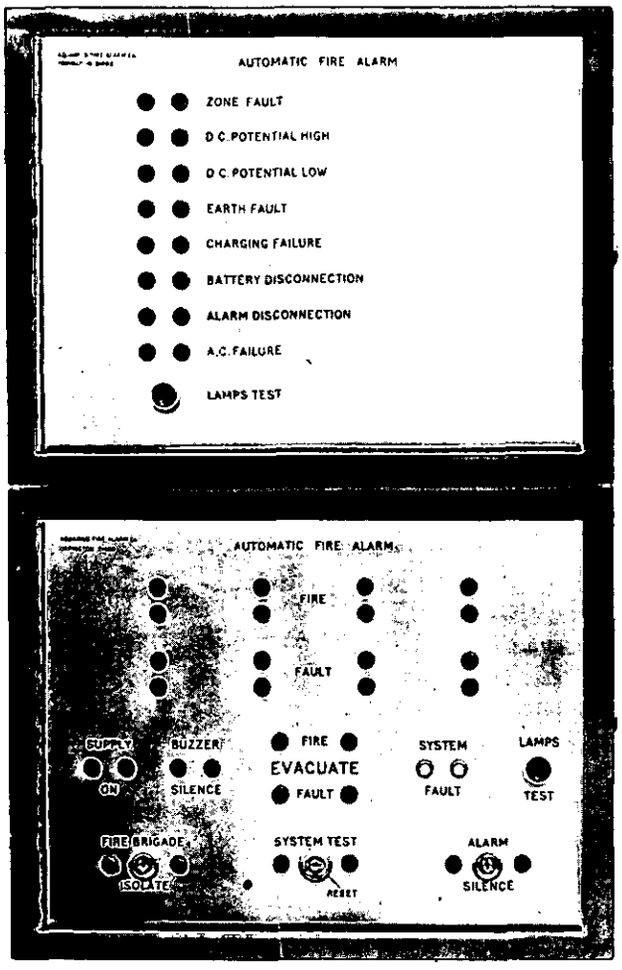

Performance

Zonal detection wiring, Detector head removal, Audible alarm wiring or short circuit, Visual alarm wiring or short circuit, Alarm fuses, Alarm relays, D.C. Potential high (29 volts), D.C. Potential low (21 volts), Earth fault, Battery disconnection, Charging failure, Insertion of plug-in modules, A.C. Failure and all associated fuses. Should a fault or break develop within the system immediate visual and audible warning would be indicated at the master control and fault indication panels. Plug-in modules are incorporated within the panels which gives facilities for ease of servicing and maintenance. Ionisation smoke detectors, Infra-red detectors, Fixed temperature and rate-of-rise heat detectors and manual break glass contacts may be incorporated on any zone while still requiring only a two core cable.

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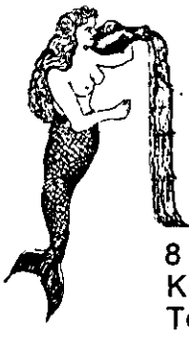

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