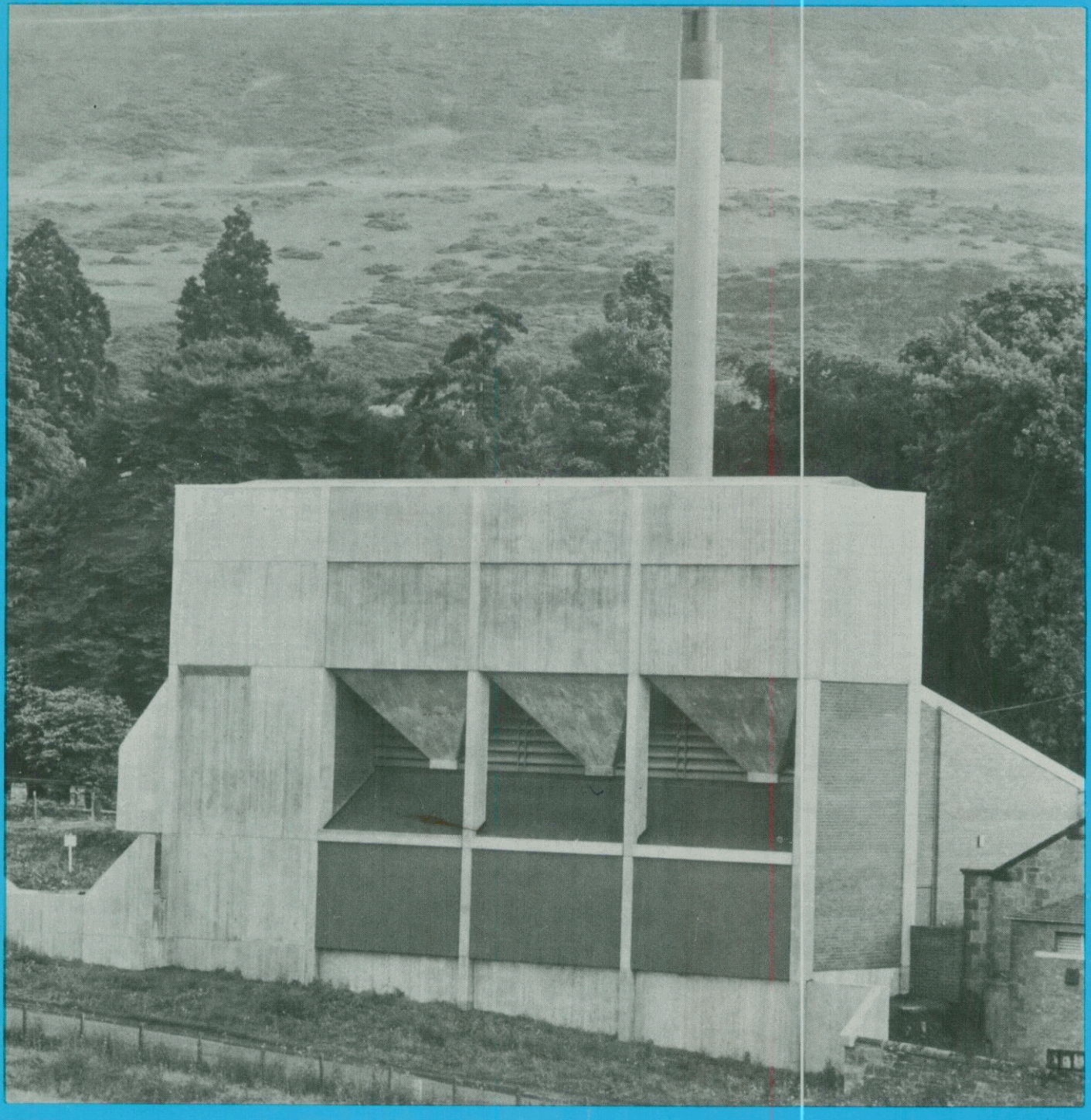
HOSPITAL ENGINEERING

January/ February 1979

The Journal of the Institute of Hospital Engineering



Hospital Boiler Plant Wins Architecture Award

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-REPAIRS?
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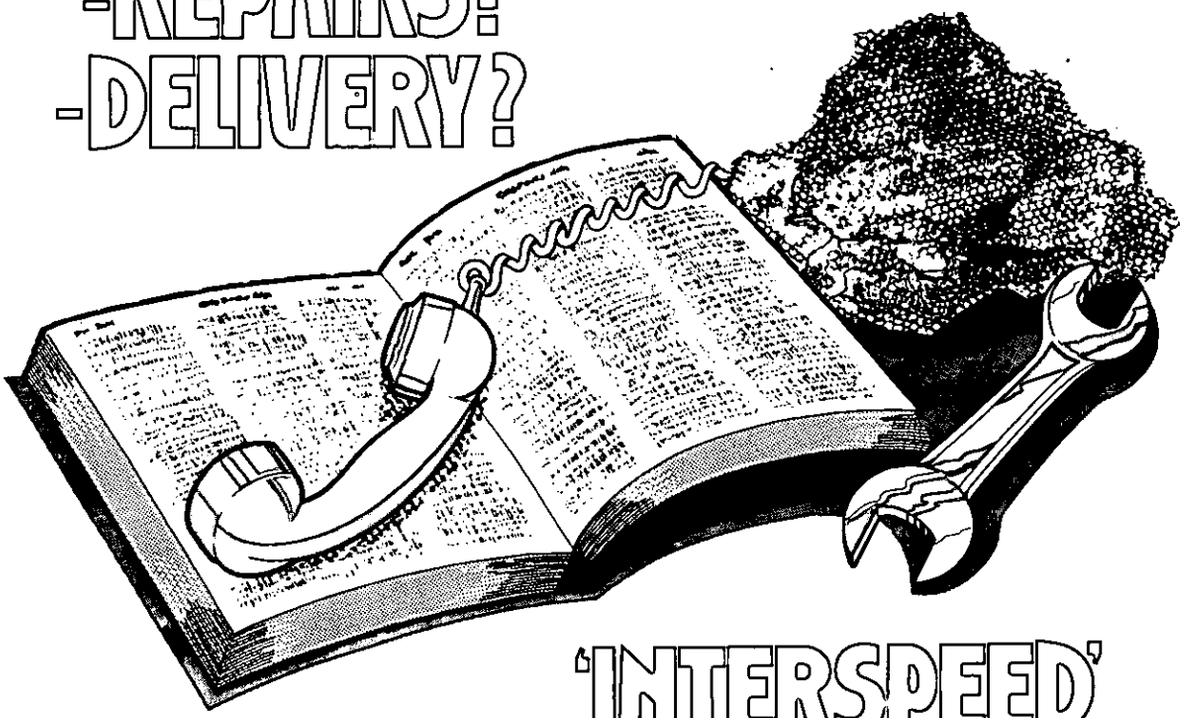

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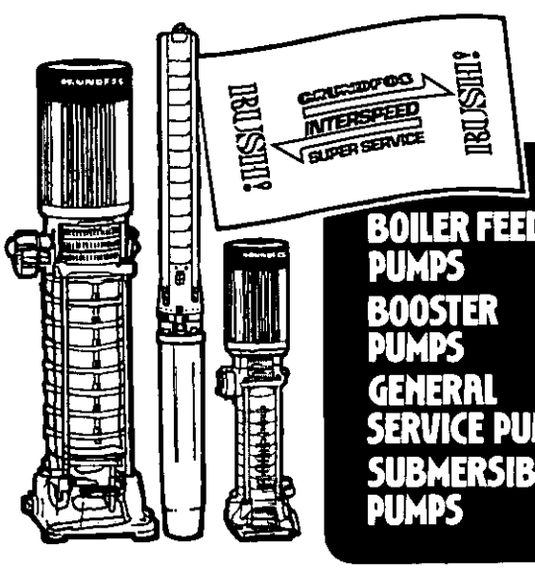

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Title	Author	Publishers
A guide to Current Practice	Institution of Heating and Ventilating Engineers	*Institution of Heating and Ventilating Engineers — 1959*
IHVE Guide Books A, B & C, 1970	Institution of Heating and Ventilating Engineers	*Institution of Heating and Ventilating Engineers (1970)*
Public Health Engineering for Hospitals	Institution of Public Health Engineers	*DHSS*
Photo-Electric Handbook	IVE, G. A. G.	*George Newnes Ltd*
Management of Industrial Maintenance	KELLY	*Newnes-Butterworth*
Methods of Waste Disposal in Hospitals	KENSETT, R. G.	*Institute of Hospital Engineering*
Principles of Management — An Analysis of Managerial Functions	KOONTZ, H.; O'DONNELL, C.	*McGraw-Hill Book Company — 1972*
Works Organisation	LAWLOR, A.	*Macmillan Handbooks in Industrial Management — 1973*
Electric Utility Rate Economics	LAYWOOD, R. E.	*McGraw-Hill Book Co*
Urban Estate Management Vol II — Third Edition	LEACH, W. A.	*The Estates Gazette Ltd*
Factory and Production Management	LOCKYER, K. G.	*Pitman Publishing*
Critical Path Analysis by Bar Chart	LOW, C. W.	*Business Publications*
The Efficient Use of Steam	LYLE, O.	*HMSO — 1947*
Basic Telecommunications for Emergency Medical Services	McCORKLE, J. E.; NAGEL, E. L.; PENTERMAN, D. G.; MASON, R. A.	*Ballinger Publishing Co, Cambridge, Mass*
Building Construction — Metric — Volumes 1 & 3	McKAY, W. B.	*Longman Group Limited*
Sunpower — An Introduction to the Application of Solar Energy	McVEIGH	*Pergamon Press*
Thermostatic Control	MILES, V. C.	*Newnes-Butterworths*
Electrical Installations	MOLLOY, E.	*George Newnes Ltd*
Introduction to Works Practice	MOLLOY, E.	*George Newnes Ltd*
Medical Electrical Equipment	MOLLOY, E.	*George Newnes Ltd*
Maintenance Engineering Handbook — Second Edition	MORROW, L. C.	*McGraw-Hill Book Co*
Heating Ventilation and Air Conditioning Plant (Planned maintenance & operation)	MULHOLLAND, J. R.	*Business Books Ltd*
Advanced Level Physics	NELKON	
Steam Trapping and Air Venting	NORTHCROFT, L. G.	*Hutchinsons Scientific and Technical Publications*
Steam Trapping & Air Ventilating—1968	NORTHCROFT, L. G.; BARBER, W.	*Hutchinsons*
The Energy Managers' Handbook	PAYNE	*IPC Science and Technology Press*
Sanitary Pipework and Drainage Systems for Health Buildings	PAYNE, Rolf	
Applications of Valves and Fittings	PEARSON, G. H.	*Sir Isaac Pitman & Sons Ltd*
Plant Layout and Materials Handling	PEMBERTON, A. W.	*Macmillan Handbooks in Industrial Management*
Techniques of Safety Management	PETERSON, D. C.	*McGraw-Hill Book Co*
Factory Plant and Works Services	POUCHER, G. H.	*Cassell (London)*
Noise and Vibration Control for Industrialists	PETRUSEWICZ, S. A.; LONGMORE, D. K.	*Paul-Elek (Scientific Books) Ltd*
Practical Boiler Water Treatment (Including Air Conditioning Systems)	PINCUS, L. I.	*McGraw-Hill Book Co*
Handbook of Heating Ventilating and Air Conditioning — Seventh Edition	PORGES, J. revised by PORGES, F.	*Newnes-Butterworths*
Industrial Gas Utilisation	PRITCHARD	*Bowker Pub Co Ltd*
Industrial Energy Conservation	REAY	*Pergamon Press*
Finance for the Non-Accountant	ROCKLEY, L. E.	*Business Books Ltd*
Managing Large Systems	SAYLES, L. R.; CHANDLER, M. K.	*Harper and Row*
The Commercial Management of Engineering Contracts	SCOTT, P.	*Gower Press*
Spon's Architects' and Builders' Price Book 1974 (99th Edition)		*E. and F. N. Spon Ltd*
Spon's Mechanical and Electrical Services Price Book 1974		*E. and F. N. Spon Ltd*
Plant Engineering Handbook, 2nd Edition	STANIAR, William	*McGraw-Hill Book Co*
Handbook of Environmental Control — Volume V	STRAUB, Conrad P.	*CRC Press Inc*
An introduction to Heat Pumps	SUMNER, J. A.	*Prism Press*
Electrics 72/73: Electrical Services in Buildings	The Electricity Council	*The Electricity Council*
Modern Oilhydraulic Engineering	THOMA, Jean	*Trade and Technical Press*
Design of Loadbearing Brickwork in SI and Imperial Units	THORLEY, W.	*William Heinemann Ltd*
Principles of Estate Management	THORNCROFT, M.	*The Estates Gazette Ltd*
A Guide to Sanitary Engineering Services	THOMSON, T. A.	*MacDonald and Evans Ltd*
Laboratory Manual of Physics	TYLER	
Basic Electronics in Six Parts (The New Model Illustrated Course of Elementary Technician Training)	Van VALKENBURGH: NOOGER and NEVILLE INC	*The Technical Press Ltd*
Industrial Boiler House Efficiency	WADE, Charles F.	*Crosby Lockwood & Son*
Electronic Equipment and Accessories	WALKER, R. C.	*George Newnes Limited*
Heat Engineering	WALSHAW, A. C.	*Longmans, Green & Co*
Boiler House Practice	WILLIAMS, S. N.	*George Allen & Unwin Ltd*
Costing Matters for Managers	WOOD, E. G.	*Business Books Ltd*
Materials of Construction for Steam Power Plant	WYATT, L. M.	*Applied Science Publishers Ltd*

The Institute of Hospital Engineering – Library 1979

A full index of books held in the Library was last published in the Journal in 1977, since which time there have been a number of additions made.

It is felt that rather than repeat the 1977 list it would be better to compile a fresh text giving details of additional publications plus those books which have been in greatest demand.

Members may obtain any of these books, normally for a one month loan period, on application to the Institute Honorary Librarian, R. G. Smith, Dryhill, Cold Slad, Crickley Hill, Witcombe, Glos., or his office address, Area Works Officer, Administrative Offices, New Cross Hospital, Wolverhampton.

Title	Author	Publishers
Hospital Planning Requirements	ALDIS, Garry	*Pitman, 1959*
Fire Safety Training in Health Care Institutions	American Hospital Association	
Boiler Management, Maintenance and Inspection	ARMSTRONG, H. C.; LEWIS C. V.	*Charles Griffiths & Co*
Practical Boiler Firing	ARMSTRONG, H. C.; LEWIS C. V.	*Charles Griffiths & Co*
Domestic Heating and Hot Water Supply	BARTON, J. J.	*MacLaren & Sons*
Estimating for Heating and Ventilating	BARTON, J. J.	*George Newnes Ltd (London)*
Fundamentals of Industrial Ventilation (Third enlarged edition)	BATURIN, V. V.	*N. S. Billington, E. Owner*
Evaluating New Hospital Buildings	BAYNES, Ken; LANGSLOW, Brian; WADE, Courtanay C.	*King Edward's Hospital Fund for London — 1969*
Transformation of Scientists and Engineers into Managers	BAYTON and CHAPMAN	*National Aeronautics and Space Admin*
Supervisory Studies — second edition	BETTS, P. W.	*MacDonald & Evans Ltd*
Lighting Design in Buildings	BOUD, John	*Peter Peregrinus Ltd*
Dismissals	BOWES, Egan	*The New Commercial Pub. Co Ltd*
Safety Inspection	BOWES, Egan	*The New Commercial Pub. Co Ltd*
Principles & Practice of Management	BRECH, E. F. L.	*Longman*
Pump Users' Handbook	British Pump Manufacturers' Association	*Trade and Technical Press Ltd*
Valves for the control of fluids, technical reference book — second edition	British Valve Manufacturers' Association	*Pergamon Press*
Building of Energy Conservation	BURBERRY	*Architectural Press Ltd*
A complete Public Speaking Course	CARSON, Herber N.	*The Efficiency Magazine*
Walmsley's Rural Estate Management	CHAPMAN, D. H.	*The Estates Gazette Ltd*
Workshop Technology	CHAPMAN, W. A. J.	*Edward Arnold & Co*
Part 1 — an Introductory Course Manual of Maintenance Engineering	CLEMENTS, Richard and PARKER, Dennis	*Business Publications Limited*
Landscape Design with Plants	CLOUSTON	*Heinemann*
Planning, Design and Construction of Hospital Buildings for the NHS	CRUIKSHANK, H. J.	*DHSS*
Work Study	CURRIE, R. M.	*Pitman Publishing — 1972*
Industrial Law and its Application in the Factory	DENYER, Roderick L.	*Macmillan Handbooks in Industrial Management — 1973*
The Industrial Manager's Guide to Personnel Practice	DICKINSON, A. W.	*Gower Press Limited — 1974*
The Effective Executive	DRUCKER, Peter F.	*Heinemann Ltd — 1969*
The Future of Industrial Man	DRUCKER, Peter F.	*The Mentor Executive Library — 1970*
Management: Tasks, Responsibilities, Practices	DRUCKER, Peter F.	*Heinemann, London*
The Principles of Switching Circuits	EDWARDS, Frederick H.	*The MTI Press*
Plant Operators' Manual	ELONKA, Stephen M.	*McGraw-Hill Book Company*
Oscar Faber's Reinforced Concrete	FABER, John and MEAD, Frank	*E. and F. N. Spon Ltd*
Heating and Air Conditioning of Bldgs	FABER, Oscar and KELLY, R.	*Architectural Press — 1951*
Hydraulic Systems and Maintenance	FAREL, Barbury	*Iliffe Books (London)*
Organisation and Management of Laundry Services for Hospitals and Local Authorities	FARNDALE, W. A. J.	*White's — 1968*
Computer Application in Architecture	GERO	*Applied Science*
Medical Gases, Their Properties & Uses	GRANT	*H. M. & M. Pub. Ltd*
Works Management in Practice	GILCHRIST, R. R.	*Heinemann Ltd — 1971*
Hospital Research and Briefing Problems	GREEN, J.; MOSS, R. and JACKSON, C.	*King Edward's Hospital Fund for London*
Mechanical Power Transmission (Component Selection and Application)	GREENWOOD, D. C.	*McGraw-Hill*
Your Factory and The Law	HART, Francis W.	*Seven Oaks Press Ltd — 1951*
Pump Operation and Maintenance	HICKS, Tyler G.	*McGraw-Hill Book Company*
Successful Engineering Management	HICKS, Tyler G.	*McGraw-Hill Book Company*
Medical Electronics — Monographs 7-12	HILL, D. W. and WATSON, B. W.	*Peter Peregrinus Ltd*
Medical Electronics — Monographs 13-17	HILL, D. W. and WATSON, B. W.	*Peter Peregrinus Ltd — 1975*
Real-time Computing in Patient Management	HILL, J. P. and HILL, D. W.	*Peter Peregrinus Ltd — 1976*
Lifts	HONEY, L. W.	*Marryat & Scott Ltd — 1949*
Lighting and Seeing	HOPKINSON, R. G.	*Wm Heinemann Ltd*
Tutor Text — Introduction to Electronics	HUGHES, Robert J. and PIPE, Peter	*The English Universities Press Ltd*
Building Energy Code, Part 1	Institute	*CIBS Pub*
Principles of Hydraulics		*Trade and Technical Press Ltd*
The Flow of Water in Metric Sized Copper Pipes (Supplement to Section C4 — The flow of fluids in pipes and Ducts of the IHVE Guide Book C, 1970)	*Institution of Heating and Ventilating* Engineers	*The Institution of Heating and Ventilating Engineers (London 1971)*

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HOSPITAL ENGINEERING

Vol. 33 No. 1

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Institute News

The Institute of Hospital Engineering One-Day Symposium

'Noise Pollution – Its Effect on the Health Service'

to be held at
The Institution of Civil Engineers, Great George Street, Westminster, London on Wednesday, March 21, 1979

Noise is unseen, many of its effects are intangible and so ignored. Noise pollution, perhaps, is growing at a faster rate than any other form of pollution yet, until the Control of Pollution Act in 1974, its effect on the environment was virtually uncontrolled.

There is a growing need to site health buildings at the centres of population and at places where there are good communications. Thus, the hospital is surrounded by noise which must be controlled if the building is to function effectively.

Health buildings are considered by the community, traditionally, to be havens of peace and quiet. However, the modern District General Hospital is a large industrial complex consuming vast quantities of energy. A proportion of this energy is emitted from the site as noise which, in turn, provokes complaints from the neighbourhood.

Dr. John Walker will consider the effects of noise pollution on patients, staff and the community. His particular research interest is community noise and he has undertaken a research commission for the DHSS which investigated the effects of noise on hospitals. Mr Leslie Minikin, in his paper, will unravel the mysteries of how to measure noise. Finally, Mr Terry Wagstaff will discuss noise control.

PROGRAMME

10.00 Coffee

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

CHAIRMAN for the day:
Professor J. LARGE BSc MS FIoA
Director of the Institute of Sound and Vibration Research
Professor of Applied Acoustics, University of Southampton

10.35 'NOISE POLLUTION — ITS EFFECT ON THE PATIENT, STAFF AND COMMUNITY'
Speaker: Dr J. WALKER BSc PhD FIoA
Institute of Sound and Vibration Research, University of Southampton

11.40 'NOISE MEASUREMENT'
Speaker: L. MINIKIN Esq BSc, B & K Laboratories

12.30 LUNCH

14.00 'NOISE CONTROL IN HEALTH BUILDINGS'
Speaker: T. WAGSTAFF Esq BSc(Eng) MSc CEng MIMechE FIHospE MIoA
Principal Acoustics Engineer, Department of Health and Social Security

15.15 OPEN FORUM

16.30 CLOSURE

Tickets (£13 each, including morning coffee and lunch) from the Secretary of the Institute.

IFHE Congress – Washington 1980

The International Federation of Hospital Engineering will conduct the 6th International Congress of Hospital Engineering to be held at the Sheraton Washington Hotel in Washington DC, on July 7-11, 1980. Sponsored by the American Society for Hospital Engineering of the American Hospital Association, the Congress will provide an opportunity to examine new developments and new technology in hospital engineering in areas of facilities, equipment and operations through selected papers, scheduled programmes and tours.

Technical papers will cover the following topic areas: Hospital Planning and Construction; Hospital Engineering Service and Systems; Safety, Environment and Infection Control; Plant Equipment and Maintenance; Telecommunications in Health Care; Hospital Medical Instrumentation Management (Clinical Engineering); Managing the Engineering Function; and Energy Systems and Conservation.

Persons desiring to present a paper at the Congress should submit a detailed summary of approximately 300 words (or the full paper) in duplicate for review to the International Federation of Hospital Engineering before June 1, 1979. Summaries may be submitted for review in either French or English. The final selected papers must be submitted in both French and English. We hope to publish selected papers in international issues of *Hospital Engineering*.

For further information, please contact: Judy Fowlkes, Society Director, American Society for Hospital Engineering, 840 North Lake Shore Drive, Chicago, Illinois 60611, USA. Telephone: 312/645-9439.

120 Nominations to new CEI Board

When the list was closed at noon on Monday, October 16, 1978, 120 Chartered Engineers had been nominated for the 16 individual seats on the Board of the CEI under the terms of its new Charter and By-Laws. Each nominee is supported by 15 fellow Chartered Engineers.

The successful candidates will take their places alongside the representatives of CEI's 16 'Corporation Member' institutions.

All Chartered Engineers are entitled to vote in the election which is being conducted on behalf of CEI by the Electoral Reform Society. The ballot papers provide a 150-word biography of each candidate. A member of the Institute, Mr K. G. Hanlon is standing. His 'official' biography appears below, with a letter in which he suggests that more information should have been allowed to be given about each candidate.

The names of those elected will be announced at the Annual General Meeting of CEI in March 1979.

Mr K. G. Hanlon — biography

Commencing with an engineering apprenticeship with the electricity supply industry at Crewe, Portishead and Stourport, transferring (1955) to the Atomic Energy Authority, initially commissioning Calder Hall and then a reactor engineer, Harwell. 1968, joined BOAC as a senior engineer specialising in large construction projects, then Project Manager, Parsons Brown & Partners before successively Chief Engineer, Technical

Mr K. G. Hanlon

Director and Regional Director, W. S. Atkins & Partners, Consulting Engineers. In 1976, aged 47, gave up most of his consultancy work to read full-time for the Bar, being awarded an LLB (University of Wales) 1978. Appointed August 1978 to the Boards of Astra Industrial Group Ltd and its subsidiary companies. Qualifying as an Electrical Engineer by way of HNC, went on (also by HNC) to qualify as a Mechanical Engineer before obtaining a BSc (Econ), London, and an MSc (Architecture), Bristol, all as the result of part-time study. Married, with three daughters, recreations include building his own house.

Letters to the Editor

Election of Individual Members to the Board of the CEI

Dear Sir,

I write as a candidate in the forthcoming election of corporate members to the Board of the CEI. The ballot list will give a short history of each candidate. It will not, however, despite an appeal to the President of the CEI and the obvious importance to the voters, give either the personal motivation or a declaration of the aims of each candidate.

I therefore seek the privilege of space in your Journal to enunciate briefly my claims to your Members' votes.

Firstly, after very many years of total commitment to work and study, I have found for the first time ever, the opportunity to offer myself for public office. I am young enough (49) yet sufficiently widely experienced to be able to contribute positively at this Board level position.

Secondly, I believe very firmly that these appointments must not mirror the establishment, but must reflect the average engineer. For this reason I have purposely avoided inviting Institution dignitaries (other than one who is a neighbour of mine) having instead invited a broad spectrum of members from most Institutions to support me. It is as an ordinary engineer that I offer myself to work for the streamlining of our otherwise disorientated profession.

Thirdly, I wish to emasculate completely the CEI from the learned society role which is more correctly held by the professional institutions. I believe above all the CEI should be an important force in politics (providing the Chief Engineer of Great Britain) with its corollary of a disciplining force over all members.

I am convinced that the committees and permanent staff of the Institutions are paying too great attention to academic qualifications at the expense of practical ability, and giving undue regard to bureaucratic measures (both national and international) all without either the necessary support from the individual members or in any way improving the image of the profession.

In short I see the new CEI as the moving force in our relationship as engineers with the public and with the Government. To do this the Board must be untrammelled by the often conflicting interest of safeguarding the role of each member Institution (recently illustrated by the action of the IEE in threatening to withdraw from the CEI).

Thus the forthcoming elections have more than usual importance. For the first time for a very long period of years the working engineer has the opportunity to select a completely new group of truly independent individuals who will have, ready-made, the necessary creditability to take up the case of the engineering profession at every level.

Yours faithfully,

K. G. HANLON, MSc(Arch) LLB BSc(Econ) CEng FIMechE FIHospE MIEE MCIBS

Financial Times Award — Dingleton Hospital commended

The Financial Times Industrial Architecture Award is presented for an outstanding work of Industrial Architecture, which makes a positive contribution towards encouraging a better industrial environment. During the 12 years in which the award has been made, almost 900 entries have been received. This year there were 64 applications and the *Financial Times* reported that the quality had remained high, adding that it was 'gratifying to find at this low ebb of building activity that the attraction of the award is so firmly established'. The award is open to all, both architects and engineers, concerned with the design of industrial works. It was notable that this year industrial works outside the normal category of factory building made a strong appearance.

The assessment panel comprised two architects, selected for their eminence in practice and their interest in industrial landscape, appointed with the co-operation of the Royal Institute of British Architects, together with one lay assessor. This year the architect assessors were Michael Manser RIBA, and Leonard Manasseh RIBA. The lay assessor was Sir Charles

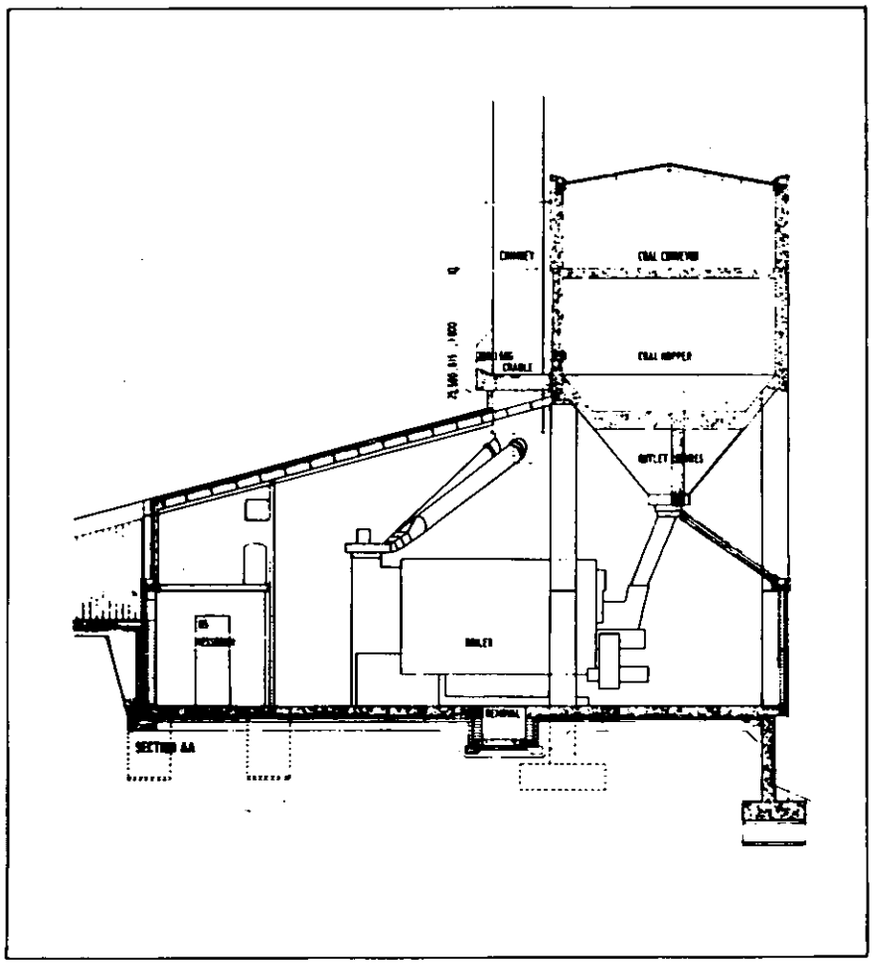
Troughton MC CVE (Chairman of the British Council). They specially commended the replacement boiler plant at Dingleton Hospital, Melrose, Scotland as:

"A small scale industrial building designed and executed with great confidence on the edge of magnificent countryside. It will be seen to better advantage when the old boiler building has been removed.

"This building is a model of how small and ancillary industrial buildings should be handled. Practical, economical, nothing superfluous and the working demands and materials of the building used to produce the visual interest".

Replacement Boiler Plant, Dingleton Hospital, Melrose

Designer: Peter Womersley RIBA.
Quantity Surveyors:
Iain Shaw & Partners.
Services Consultant:
Scottish Health Service.
Structural Consultants:
Fred Wilson & Partners.
Builder:
Melville, Dundas & Whitson Ltd.



Replacement Boiler Plant, Dingleton Hospital, Melrose.

An architect was appointed in October 1973 to design the replacement for an existing boiler house serving Dingleton, a psychiatric hospital. It was to be a new building to house three 2,500 kW boilers fired by coal. The building and engineering contracts were kept entirely separate. The contract was placed on May 24, 1976.

Since any new connection to existing heating mains had to be made in the vicinity of the existing boilerhouse, the only economical site available was a very small triangular site to the east of the old boilerhouse constructed in 1904, with this building as one boundary, a secondary public road to the north, and the existing hospital service entrance road to the south-west. A main hospital drain within the site added further complications, and the stepped plan shape of the new boilerhouse was ultimately evolved to fit — almost completely — a difficult site.

The basic structural material was reinforced concrete for both functional and economical reasons, and was also to express as fully as possible the different working parts of the process — coal delivery under a protective canopy into a ground hopper; mechanical conveyance to a platform above the three fifty-ton-capacity coal bunkers; storage in these bunkers, and subsequent gravity feeding into the three boilers below. Reinforced concrete has therefore been used in those sections of the building where heavy loads or movement occur. Weather protection and sound insulation of the boiler equipment itself has been expressed externally, by anodised aluminium cladding on concrete blockwork, supported by a reinforced concrete framework using the main bunker construction as the ridge. On the same principle, concrete has also been used to express the load-bearing function of the cantilevered cradle supporting the lighter free-standing aluminium chimney-shield cladding the three insulated internal flues.

Recessed joints were introduced into the design to isolate concrete pours, and the holes of bolts supporting shuttering expressed a relation to bolt patterning on the anodised aluminium cladding. All shuttering boards used were 150 mm wide and of rough-sawn whitewood, which was also used as the face of all external doors.

Serious Accident to Ken Eatwell

We are most sorry indeed to report that Mr K. J. Eatwell, Regional Engineer, South West Thames Regional Health Authority and Chairman of Council's Finance and General Purposes Committee was involved in an accident just one week before Christmas.

Mr Eatwell was knocked down by a motor car when crossing a pedestrian crossing. He suffered quite grievous injuries, the most serious of which was to a shoulder, where all three bones were broken. In addition, he suffered lacerations and cuts to the face and head and bruises to the body and, particularly, to the legs.

It is feared that Mr Eatwell will be away from duty for some little while; he will undergo regular physiotherapy to aid his recovery.

The good wishes of his many friends and colleagues throughout the Health Service will be with him and we wish him 'all speed' in his recovery to full health.

North Western Branch Meetings

On the evening of Wednesday, October 4, 1978, the North Western Branch visited the new Liverpool Teaching Hospital to hear a paper given on 'Commissioning' by Mr R. Chambers and Mr S. Carburn of R. W. Gregory & Partners. The visit was organised by Mr D. A. Footes, one of the Branch members.

Altogether 25 members and visitors attended the meeting where this most interesting paper was presented, and which resulted in a very lively discussion.

At the conclusion of the meeting the members were taken for a brief visit around the hospital to the various plant rooms. A further aspect which contributed to the success of the evening was the response in attending by members of the Liverpool area.

Another branch meeting took place on the evening of Wednesday, November 15, 1978, at Astley Hospital, New Leigh, where a paper was given on 'Waste Anæsthetic Pollution'. This paper was excellently presented by the Chairman of the Branch, Mr W. J. Smith, the NW RHA's Regional Engineer, and two of his staff, Mr D. Forrest and Mr F. White.

It was a most successful evening with an attendance of 49 members and visitors, which is the largest attendance at a branch meeting for a number of years. Some anæsthetists in the region had also been invited to the meeting and five attended. They contributed to the lively discussion which took place after the presentation of the paper.

On Thursday evening, December 7, 1978, the Branch held a meeting at the Bolton Medical Institute when a paper was given on 'Heat Recovery' by Fan Installation Ltd, of Farnworth near Bolton. The speakers were Messrs D. Barlow, I. Barlow and R. Burton.

This was a joint meeting, with this Branch acting as host to the local branches of The Chartered Institution of Building Services and the Institution of Plant Engineers.

The meeting was well attended with 41 present, of whom over 60% were branch members. The paper was on a very interesting and topical subject which was well received and promoted interesting discussions during and after the paper.

West of Scotland Branch

A branch meeting was held in the Conference Room, Greater Glasgow Health Board, 351 Sauchiehall Street, Glasgow, on Thursday, November 30, 1978.

Mr W. Jack, Chairman, welcomed members to the meeting and introduced Mr M. G. Rose of Houseman Burnham Limited, who spoke on the 'General Principles of Water Treatment'. He explained the composition of water, the universal solvent, and explained why its properties could be that of the strongest acid and the most aggressive alkali.

In showing how Boiler Feed water (dependent on its source) could contain varying quantities of different chemicals and other substances, he gave as an example how failure to control total hardness of a steam boiler could result in a drop of efficiency of 7% in one hour with subsequent wastage of fuel.

Mr Rose dealt with the wide range of treatments used in providing satisfactory water supplies for High Pressure Hot Water Boilers, Air Conditioning systems and cooling towers and introduced some humorous examples to illustrate the problems which can arise and the measures taken to correct them.

The Chairman welcomed 11 members and one visitor to the last meeting of 1978 on December 14. The speaker for the evening was Mr T. G. Brown of Messrs Sonicaid, Scanning Division, who spoke on 'Ultra-sound in Diagnosis'. As an engineer who had been involved for a number of years in the development of ultra-sonic diagnosis techniques, he found it particularly pleasing to talk to Hospital Engineers. He highlighted the importance of this comparatively recent development which now had something like £10m of international business per annum.

Slides were shown during his lecture which showed some spectacular results, particularly in the obstetric field where ultra-sonic diagnosis was now replacing or assisting in what is best known as 'Clinical Judgement'.

The speaker traced the development of ultra-sonics, which is a beam of sound, beyond the audible spectrum, which can be directed into the patient and through tissue. Much of the early development work was carried out in Glasgow and other parts of Scotland, initially using industrial ultra-sonic flaw detectors employed in the examination of the welding of boilers. When it was shown that some primitive medical results could be achieved, specialist equipment was subsequently devised and developed.

Ultra-sonic sound generation is principally a mechanical device, further introduction of electronic scanning methods have allowed an almost instantaneous picture to be built up into a recognisable form. Recent developments have allowed the scanning to move from showing a two-dimensional to a three-dimensional scan. Mr Brown showed how ultra-sonic diagnosis was complimentary to other forms of diagnosis, *eg* X-Rays.

During an active question session the speaker answered the many points raised. Mr Jack, Chairman, thanked him for an interesting lecture and the members responded to the Chairman's request for a hearty vote of thanks.

Book Review

Safety Inspections

Bowes Egan. Published by: The New Commercial Publishing Co Ltd. Price: £8.25.

There is no doubt this book is a major new text in its field. The Publishers claim that it provides a wholly new service for readers and that it is the only guidance on full systematic inspection of industrial and commercial premises that is available in the UK.

Well, you may say — 'Strong stuff'. It certainly gives expert guidance on legal matters in regard to defined safety inspections. It is broad in scope, practical in application, and in concise readable form.

I must admit that in reading this book I missed out by not noting in the preface Bowes Egan's acknowledgement to Robert Mackmurdo, the Editor of 'Industrial Relations Briefing'.

Once I had started it the book held me, maybe the sign of something good. However, I could not help thinking that I had travelled this road before. Then, too late, Robert Mackmurdo's name was there in cold print — of course, his excellent presentation at the Institute of Hospital Engineering Symposium on this very subject.

I speak for those engaged in the Health Service. Obtain a copy of this book, in our various roles we will surely benefit.

R. G. SMITH,
Hon Librarian

This paper was presented at the June 1978 Symposium of the Institute of Hospital Engineering on Recent Developments in Hospital Sterilizing Processes.

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Systems Reliability Assessment Applied to Steam Sterilizers

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Introduction

In June 1972 a committee of inquiry under the chairmanship of C. M. Clothier QC submitted a report to the Secretary of State for Social Services on its findings concerning the circumstances leading to incidents at the Devonport Section of Plymouth General Hospital arising from contaminated infusion fluid.

On February 29, 1972, a batch of 5% dextrose infusion fluid was taken into use at the Devonport Hospital which on March 1, 2 and 3 caused untoward reactions in patients. Subsequent bacteriological examination of the bottles from this same batch revealed that about one third were contaminated. The batch was produced on April 6, 1971, at the Evans Medical factory at Speke.

The Clothier Committee found that the batch had been produced without adequate sterilizing due to under-processing within an autoclave. As a result about one third of the bottles contained live bacteria which escaped detection at the factory. During the interval between production and use the surviving bacteria multiplied producing a dangerous degree of contamination. It was further determined by the committee that the reason for the sterilization failure was due to retention of air within the autoclave chamber throughout the sterilizing cycle. This condition was found to result from two simultaneous fault states, namely, blockage of the chamber drain, and the fact that no use was made of the vacuum line to remove air partially before admitting steam to the chamber.

As a result the Department of Health and Social Security in 1976 commissioned the Systems Reliability Service of The National Centre of Systems Reliability to conduct a detailed assessment, in terms of safety aspects, of two representative fluids sterilizer systems which were in operation at a large provincial teaching

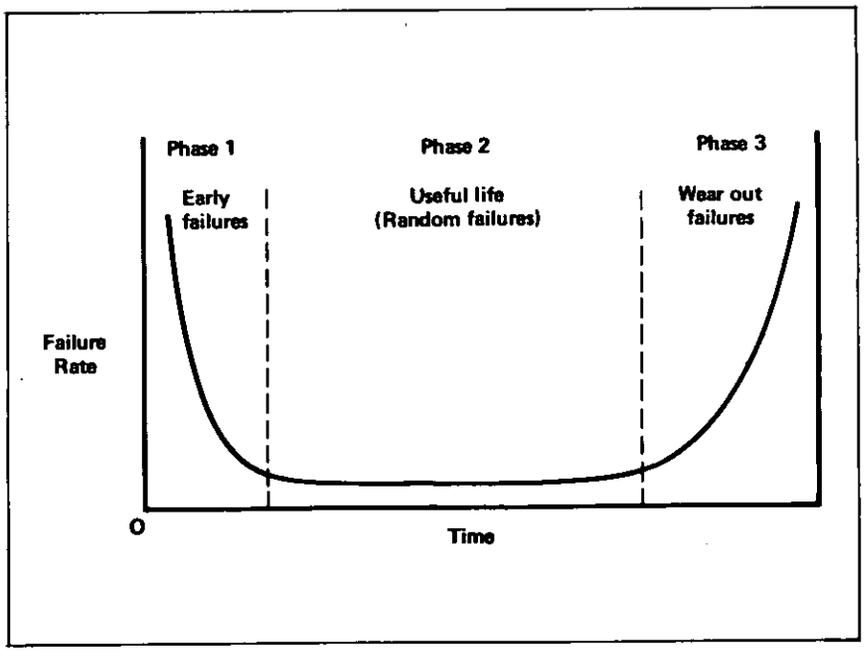


Figure 1. Typical failure rate characteristic for engineered items.

hospital. The SRS were instructed by the DHSS not to refer to the contents of the Clothier Report until completion of their assessment. This policy was adopted for two main reasons, to demonstrate the validity of the assessment techniques, and to establish a completely unbiased approach to the overall aspect of safety on fluids sterilizers.

It was gratifying to find on completion that the findings of the Clothier Report on the technical circumstances of the incident were identified independently in the assessment, and were quantified in terms of probability of occurrence.

General Considerations and Definitions

Reliability Concepts

Reliability is defined as 'the probability of a device performing in the manner desired for a specified period of time under the relevant environmental conditions'. Unreliability or failure probability is the converse of the above definition.

In order to predict failure probability over a given period of time, some knowledge of the equipment's failure rate and failure distribution with respect to time is necessary. For most practical cases engineering components (and also human beings) exhibit the typical failure rate characteristic as shown in *Figure 1* which is widely known as the 'bathtub curve'.

In order to maintain a given reliability rating of an engineering system or component it is necessary to operate the equipment in the random failure phase of its life. Therefore initial soak testing is necessary in order to eliminate those components which may have those manufacturing or systematic faults which account for the higher failure rates experienced over phase 1 of the life cycle. Over the random failure phase the equipment exhibits a constant failure rate and therefore has what is known as an 'exponential failure distribution'.

The failure probability of a component with an exponential failure distribution with respect to time is shown in *Figure 2*.

From *Figure 2* it will be seen that failure probability is dependent on the time variable in that, as the time interval increases, failure probability increases so that in an extended interval $P \rightarrow 1.0$.

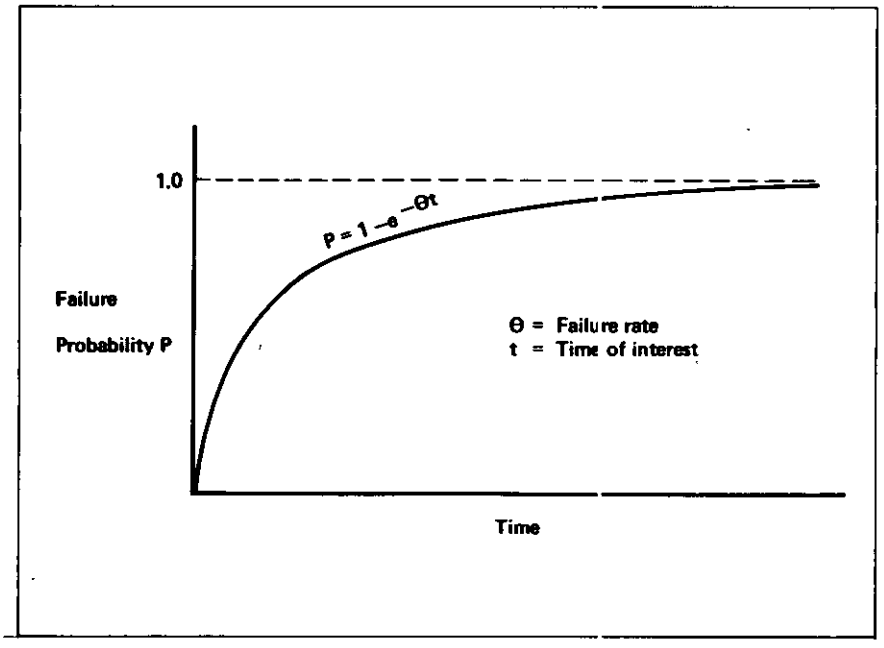


Figure 2. Failure probability characteristic for exponential failure distribution.

Success is the complement of failure hence success probability $= 1 - P$.

In order to maintain a system within a desired reliability rating it is necessary to limit the failure probability P to some maximum value. It therefore follows that if a proof test be applied at successive but equal intervals, and provided that faulty components are replaced with those already cleared of manufacturing faults, then the system can be restored to its initial state which existed at $t = 0$.

In practical terms this procedure means that the failure probability immediately preceding the proof test will be at some finite value dependent on the time interval τ. Immediately following the proof test and any necessary renewal the failure probability will be almost zero *ie*, $P \rightarrow 0$.

Figure 3 illustrates the effect of successive proof testing.

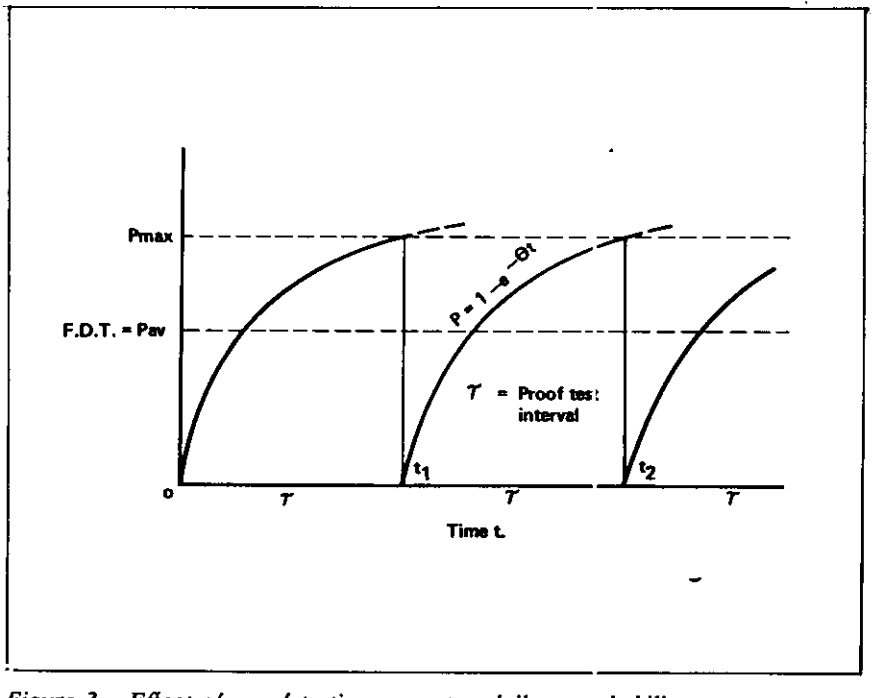


Figure 3. Effect of proof testing on system failure probability.

Proof testing produces a 'saw-toothed' failure probability characteristic with an upper limit of P_{max}. The characteristic shows that the value of P_{max} can be reduced or increased by varying the test interval τ. *Figure 3* leads to an important probability failure concept which is termed 'mean fractional dead time'. The quantity of real interest is that of average failure probability P_{av} over the time interval τ. This represents the failure probability on demand of the system from the point of view of dangerous or unrevealed equipment failures.

P_{av} is the average height of the probability function over the interval τ and may be expressed as follows:

$$P_{av} = \frac{1}{t_1}\int_0^{t_1} P\,dt = \frac{1}{t_1}\int_0^{t_1} 1 - e^{-\theta t}\,dt$$

If θt is very small, *ie*, $\theta t < 0.1$, then $P \triangleq \theta t$.

Mean fractional dead time

$$(FDT) = P_{av} = \frac{1}{t_1}\int_0^{t_1} \theta t\,dt = \frac{\theta t_1}{2}$$

(for a single system).

Since FDT is the average failure probability of the system at all times, it follows that it represents the fraction of total time that the system would be expected to be in a failed state due to unrevealed failures, hence the terminology 'mean fractional dead time'.

From the above discussions it will be seen that in order to quantify reliability it is necessary to have knowledge of the relevant failure rate data. Failures may be expressed broadly in terms of two states — namely unrevealed and revealed failures. Generally, unrevealed failures are viewed as potentially dangerous in that a protective device, although apparently in a working state, may have a failure condition which would prevent it responding to a random demand. Such failures can only be found by proof tests carried out at scheduled intervals.

Revealed failures become immediately obvious in that the equipment changes its state in an observable mode. In a protective system a revealed fault may cause the equipment to initiate an alarm or shut down action even though a demand is absent. So for these failures immediate remedial action can be commenced causing repair times to become of prominent interest.

The collection of representative failure rate data is essential for the quantification of reliability both in safety and availability considerations. Criteria for reliable data relies on field information from as large a population as possible, along with knowledge of the failure distribution. The National Centre of Systems Reliability through its Systems Reliability Service operate a computerised data bank at Risley, primarily as a service to its Associate Members, of which the DHSS is one, and for carrying out reliability assessments on behalf of such members.

Autoclave Definitions

Autoclave Types

At the hospital where the study was undertaken three types of sterilizing process are in use, namely:

a. Fluids
b. Porous loads
c. Non-porous loads.

The first type processes bottled fluids and operates on a batch system basis. The hospital sterile products unit houses two examples of this type of autoclave, and it is upon these that the detailed assessments described later have been carried out. For the purpose of this paper they will be referred to as machine A and machine B. The other two types process porous items, *eg* gowns, and non-porous items such as surgical instruments.

Types of Fluids Sterilized

Fluids sterilizers process a range of fluids which are used for different purposes, *eg*, intravenous, irrigation, non-injectable topical and oral small injectable. Typical fluids are those of water, saline solutions, dextrose, lævulose, chlorhexidine, glycine and sodium citrate.

The Hospital Sterile Products Unit

Hospital District

The district served by the hospital sterile products unit covers about thirty hospitals in the region concerned. These hospitals were, at the time of the study, supplied principally with products which were not commercially available.

Work Throughput

Over a period of one year the sterile products unit has manufactured up to 100,000 items consisting of ampules and bottles of assorted sizes from 1 ml up to 1 litre.

Pharmacy Staff

The pharmacy is under the direct control of a District Pharmaceutical Officer with delegated responsibilities invested in a Staff Pharmacist who is immediately responsible for the operation of the sterile products unit. For the day-to-day running of the unit the Staff Pharmacist has a work force of approximately ten persons who include a pharmacist, technicians, pharmacy assistants and glass washers.

Hospital Type

The hospital, which is in the suburbs of a large provincial city, is a large District General Teaching Hospital of some 1,200 beds. In addition to the usual specialities there are large Acute Psychiatry, Maternity and Geriatric units and Regional Centres for Plastic Surgery and Burns, Maxillo-Facial and Artificial Kidney Units. New units for the Younger Disabled and Alcoholism are currently being commissioned. Over 3,000 people work in the hospital, and there is a budget of over £9 million. In 1975 the number of out-patients and in-patients approached 150,000 and 17,000 respectively.

Pre-Assessment Problems

Personnel Relationships

It was appreciated at the outset that the success of the study would largely depend on establishing good relationships between the assessors and local hospital officers. Meetings held at the commencement of and during the study between officers of the DHSS, SRS and the hospital ensured that there were no unnecessary misunderstandings concerning the intent of the assessment which proceeded with the complete co-operation of all concerned.

The machines were made by different manufacturers and hence relationships were confined to two sterilizer manufacturing organisations. The first manufacturer did not in fact manufacture the sterilizer under study (machine A) but had absorbed into its organisation its original manufacturer. Noting that this sterilizer was built in the early years of the 1960s the manufacturer was not able to find any documented information and it was thus necessary to derive all such details from the machine itself which considerably lengthened the time scale of the project. The second manufacturer readily provided information in the form of drawings and specifications as well as putting at our disposal one of two engineers on all the occasions when such assistance became necessary.

Defining of Sterilizer Systems

Sterilizer A

This system was manufactured in 1963 and since its installation had been considerably modified. An instruction manual existed for the original system but was no longer applicable due to modifications which were never documented. Details of the wiring logic were not available and certain systems were not operational. Most indicator lamps on the control panel were in a failed state, the audible alarm system was out of operation and a wiring fault was present on the steam valve 'open' limit switch. It was therefore necessary before any assessment could commence to fully define the system to the satisfaction of all interested parties. This necessitated the rectification of all long-term faults followed by extensive test running in order to observe the action of the interlocks and controls. During this period the hospital bacteriologist who had overall responsibility for bacteriological safeguards called for a modification to the cooling water system which then had to be brought into the system definition.

Sterilizer B

This sterilizer was manufactured in 1971 and in its period of service had not been modified. There was an absence of documented technical information but this was supplied in full after three meetings with the manufacturer's representatives. As a result of the discussions the manufacturer found that a drain temperature interlock, namly T2, was not operational due to incorrect adjustment. This interlock should have initiated closure of two steam ejector valves SV1 and SV2 when the drain temperature achieved 100°C in order to promote pressurisation of the sterilizer chamber. The fault had not become apparent since pressurisation had in fact occurred even though these valves were open. The manufacturer corrected the condition.

A further major obstacle to system definition concerned the draining philosophy of the condensate tank. This vessel stored condensate on the basis of its sterility and recycled it as a coolant during the pressurised cooling phase. The system definition called for a drain-off frequency. The manufacturer stated that it should never be drained whereas the hospital authorities had specified a daily draining routine which was not strictly observed to an extent of six-week periods. In order to resolve the situation samples of long-term condensate were taken from the vessel for chemical analysis. The analysis showed unacceptably high levels of lead and cadmium and as a result a weekly drain-off routine was established.

A 12-point temperature survey was conducted on a representative load in order to verify the capability of the stimulated bottle temperature interlock TI8. It was found that bottles were attaining 130°C with the interlock set at 121°C. This condition was corrected to the relevant standard by re-adjustments of the interlock and steam reducing valve settings. This survey led to the permanent installation of a six-point temperature recorder in order to improve the overall temperature monitoring of the system. Finally, due to poor recording quality and inadequate chart size, the single-point recorder TR1 was replaced by a recorder having a larger ten-inch chart. This is an important chart in that it is used in the later quality control procedures.

Sterilizer 'A' Assessment

System Description

The sterilizer which is illustrated in *Figure 4* consisted of a single chamber with manually operated door into which bottled fluid loads could be batch introduced by means of a wheeled trolley. The system was operated in either an automatic or manual mode, and was selected by means of an unguarded switch on the front control panel. This panel also housed all the necessary operator controls including the temperature chart recorder. The automatic process cycle commenced with a period of steam heating and purging at atmospheric conditions until the drain temperature achieved 100°C. At this point a drain temperature interlock initiated the pressurised sterilization phase by closing the chamber drain and activating a timer. Expiration of sterilising time initiated the rapid pressurised cooling phase by closing off the steam supply, and admitting cooling water and pressurising air. A second timer was also then activated in order to control the duration of the cooling phase. When cooling time had expired the pressurising air and cooling water services were shut off and the chamber depressurised. At this point the system went into the process end phase and the chamber could then be opened and the contents discharged, providing simulated bottle temperature and chamber pressure conditions were satisfied.

Steam and air pressure control was achieved by means of a shared single-term proportional pneumatic controller operating into a single control valve. Cooling water was pumped from an open cooling water tank via a line pressure operated valve to a system of 12 spray nozzles in the head of the sterilization chamber. The cooling water tank took in untreated towns water via a float-operated valve. The tank also featured a steam-heated coil to pre-condition initial cooling water to 80°C for sterility purposes.

Temperature, pressure and timing interlocks provided process phase initiations and in addition similar interlocks were provided to ensure safe operating conditions for the operators. In the manual mode of operation safety interlocks were retained and steam and air pressure control remained automatic. Transfer into operational phases became entirely at the discretion of the operator and timing was carried out on the basis of observed temperature chart recordings.

Hazardous Product Modes

The use of a hazard logic approach showed that there were four hazards which could have adverse effects on patients. These hazards, which are defined as follows, apply equally to both the automatic and manual modes of operation (*Figure 5*).

a. **Over-processed product.** Whereby principally three products, chlorhexidine, dextrose, lævulose can become hazardous if subjected to either excessive sterilization times or temperatures. As an example chlorhexidine can have formed ppm quantities of p Chloroaniline which is carcinogenic.

b. **Particulates in product.** Whereby particles of glass or other material could be present in the sterilized product and which would be hazardous to a patient.

c. **Chemical contamination.** Whereby harmful chemicals may enter a bottle which is being sterilized through a leaking seal. The sources of chemical contamination were identified as follows:
   (i) oil in pressurising air
   (ii) chemicals in the towns cooling water.

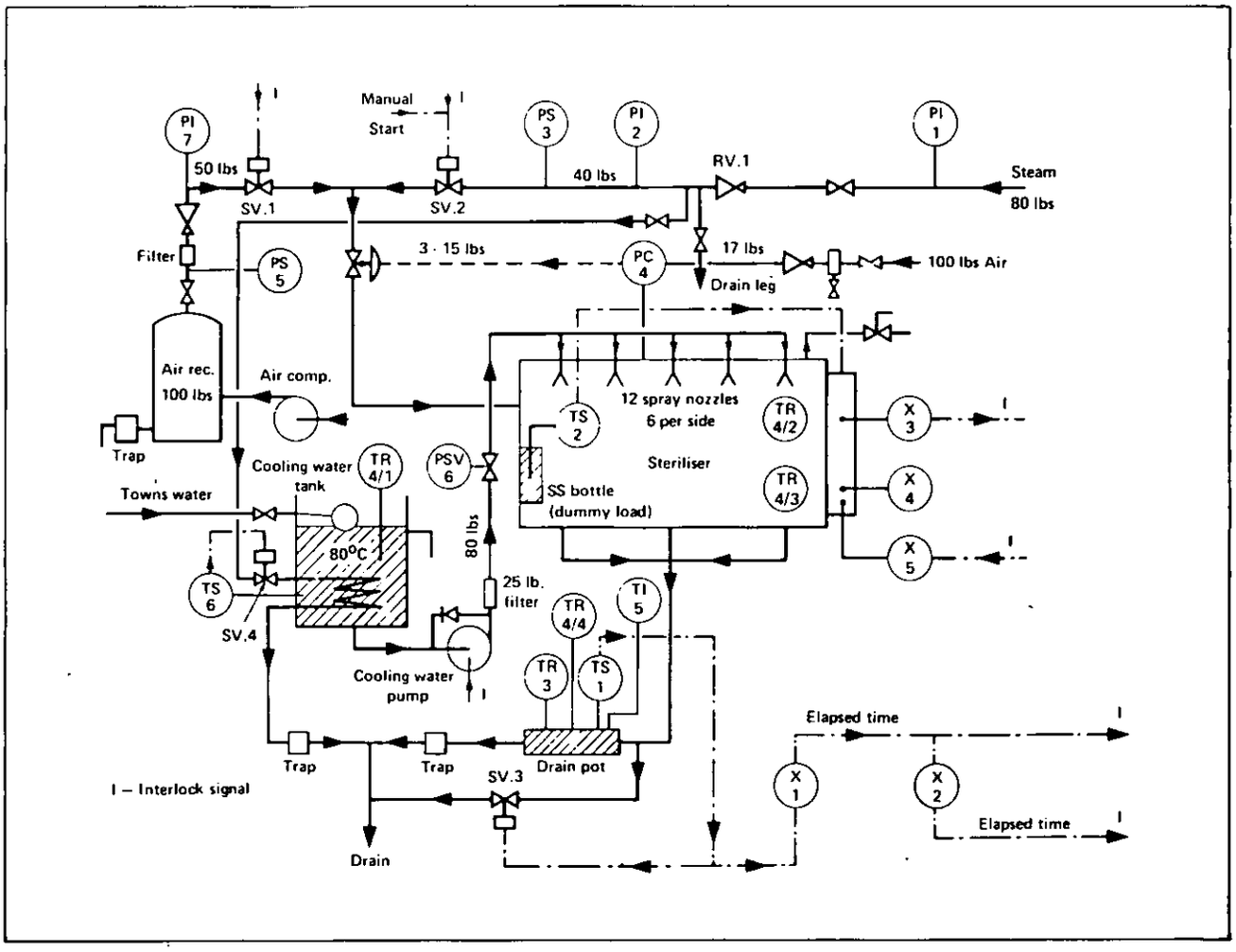


Figure 4 Sterilizer 'A'.

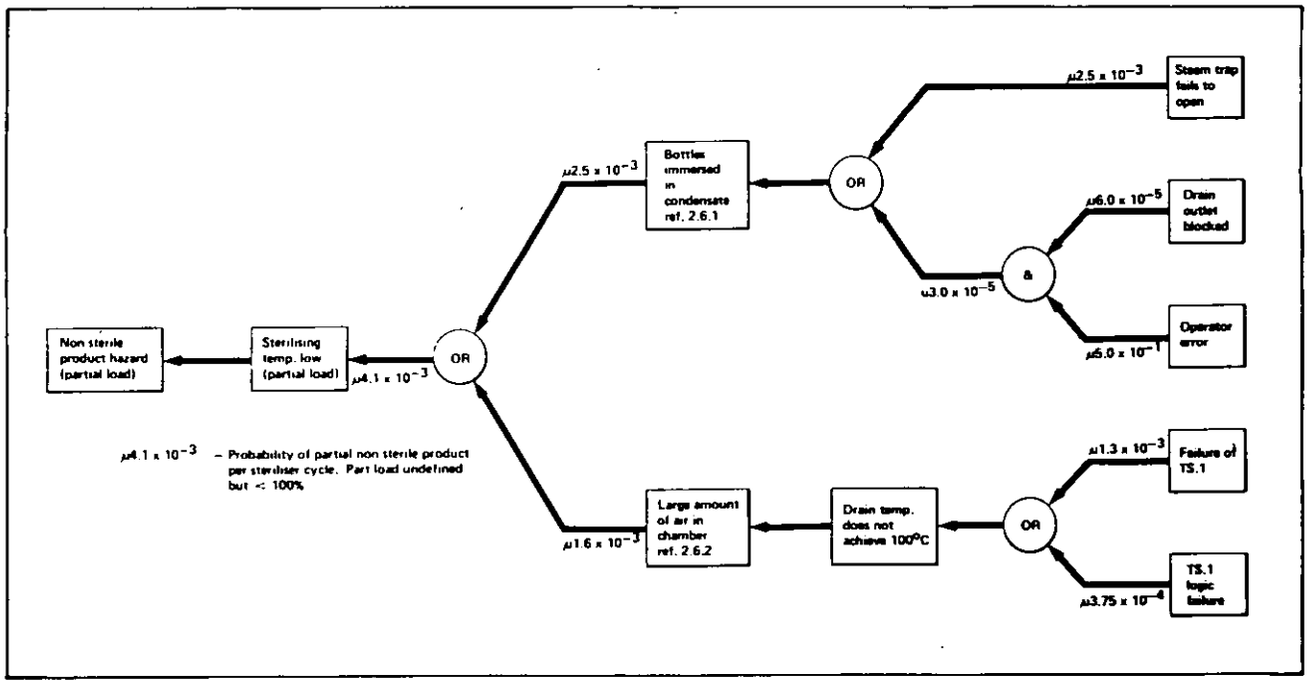


Figure 5. Sterilizer 'A' auto operational mode — part load non-sterile hazardous product logic.

d. **Non-sterile product.** Whereby the contents of the load or part load may leave the sterilizer chamber in a non-sterile condition. This condition was seen to arise from five system failures, namely:
   (i) insufficient sterilizing time
   (ii) inleakage of non-sterile pressurising air
   (iii) inleakage of non-sterile coolant
   (iv) low sterilizing temperature
   (v) bacteria contamination, post sterilizing.

Specimen Case Study

This study is of particular interest in that it identifies and quantifies the failures given in the Clothier Report which led to the incident at the Devonport Hospital in 1972. In the SRS assessment the hazard mode was considered in both the automatic and manual modes of operation. For convenience, only the auto mode is discussed here.

This case study considers the hazard of 'Part Load Non-Sterile' in the auto mode and is given by the hazard logic of *Figure 5*. The hazard may arise due to either of two system fault conditions, namely:

a. bottles immersed in condensate
b. large amounts of air in the sterilizing chamber.

The first of these fault states arises through either the steam trap failing to open or the combinational failures of blocked drain outlet and of the operator failing to observe abnormal decay of chamber pressure at the 'Process End' phase.

The latter fault state is due either to the failure of the drain temperature interlock which initiates pressurised sterilization or its associated relay logic.

Failure probabilities throughout the *Figure 5* hazard logic model are given as mean fractional dead times, *ie* failure probabilities on demand, and hence apply to any single sterilizer cycle.

The 'OR' and '&' gates indicate the ways in which the probabilities are to be combined in order to determine the overall mean fractional dead time μ_0.

The model concludes that on the basis of three monthly proof testing of components and daily checking of drain outlets in the chamber that the probability of the hazard is 4×10^{-3}. It is also concluded from the model that the significant contributions are due to two system components, namely the steam trap and the temperature interlock TS1.

Finally it is of some interest to show, in general terms only, the way in which an overall mean fractional dead time might be calculated for a logic model of this typical type. In those cases where the proof test frequency is the same for each of the sub-elements (in *Figure 5* this is not actually true) an overall probability function can be derived from which an overall fractional dead time can be expressed. Hence from *Figure 5* let μ_1 correspond to maximum failure probability P_1 etc.

Max failure probability P for a single sub-element

$$P = 1 - e^{-\theta t} \quad \text{where } \theta = \text{failure rate}, \; t = \text{test frequency}$$

then if

$$\theta t < 0.1 \qquad P \simeq \theta t.$$

Hence the overall probability expression

$$\begin{aligned} P_0 &= P_5 + P_8 \\ &= (P_4 + P_1) + (P_6 + P_7) \\ &= (P_2 P_3 + P_1) + (P_6 + P_7) \\ &= \theta_2 t \theta_3 t + \theta_1 t + \theta_6 t + \theta_7 t \\ &= \theta_2 \theta_3 t^2 + t(\theta_1 + \theta_6 + \theta_7) \end{aligned}$$

Now

$$\text{FDT} = \mu = \frac{1}{t}\int_0^t P \, dt$$

$$\therefore \quad \mu_0 = \frac{1}{t}\int_0^t P_0 \, dt$$

$$\mu_0 = \frac{1}{t}\int_0^t \theta_2\theta_3 t^2 + t(\theta_1 + \theta_6 + \theta_7) \, dt$$

$$\mu_0 = \frac{1}{t}\left[\frac{\theta_2\theta_3 t^3}{3} + \frac{(\theta_1 + \theta_6 + \theta_7)t^2}{2}\right]_0^t$$

$$\mu_0 = \frac{\theta_2\theta_3 t^2}{3} + \frac{(\theta_1 + \theta_6 + \theta_7)t}{2}$$

The Sterilizer 'B' Assessment

System Description

This sterilizer system represented by Figure 6 was basically similar to sterilizer 'A' in that it consisted of a single chamber with facilities for wheeled trolleys to be directly introduced. This unit also used steam for sterilizing and compressed air for rapid cooling under pressure. The sterilizer had certain features which differed from sterilizer 'A' in that the system could only be operated in an automatic mode. The access door was power operated, a vacuum cycle was present, and cooling was done by recirculating steam condensate via a heat exchanger which used towns' water as a cooling medium. Safety interlocks were present which prevented the door from being opened should the chamber conditions be unsafe to the operator. These interlocks, both mechanical and electrical, were essentially pressure sensitive but with the addition of a cycle phase electrical interlock which allowed opening only in the 'Not Sterile' position.

In operation, the system commenced with a vacuum cycle which used a steam ejector system in order to remove air from the chamber, ensuring an even temperature distribution within the load when sterilizing. At the required degree of vacuum the system advanced to the sterilizing phase and steam was admitted to the chamber, the drain system remaining open. A drain temperature interlock T2 closed the drain valves at 100°C and pressurisation of the chamber commenced. A second temperature interlock TI8 initiated the sterilizing timer at 121°C noting that this timer could be automatically reset to zero time should TI8 fall below 121°C. At the end of the time cycle the system advanced into the cooling phase at which the steam was cut off and pressurising air applied with condensate coolant. This phase was terminated at 80°C by a third temperature interlock TI7 in the drain tank and the system then advanced into 'Process End' indicating that a door open demand could be made. On receipt of the manual demand the system advanced into the Not Sterile position and the door automatically opened.

Hazardous Product Modes

There are four hazard modes which are identical to those of sterilizer 'A'. These are discussed as follows:

a. **Over-processed product.** Whereby those products previously discussed under *Hazardous Product Modes (a)*, above, are over-processed in terms of time or temperature and as a result develop hazardous properties.
b. **Particulates in product.** As discussed previously in *Hazardous Product Modes (b)*.
c. **Chemical contamination.** Whereby harmful chemicals may enter a bottle which is being sterilized through a leaking seal. The sources of contamination in this system were identified as follows:
   (i) chemicals arising from the sterilizer system;
   (ii) chemicals in the public water supply;

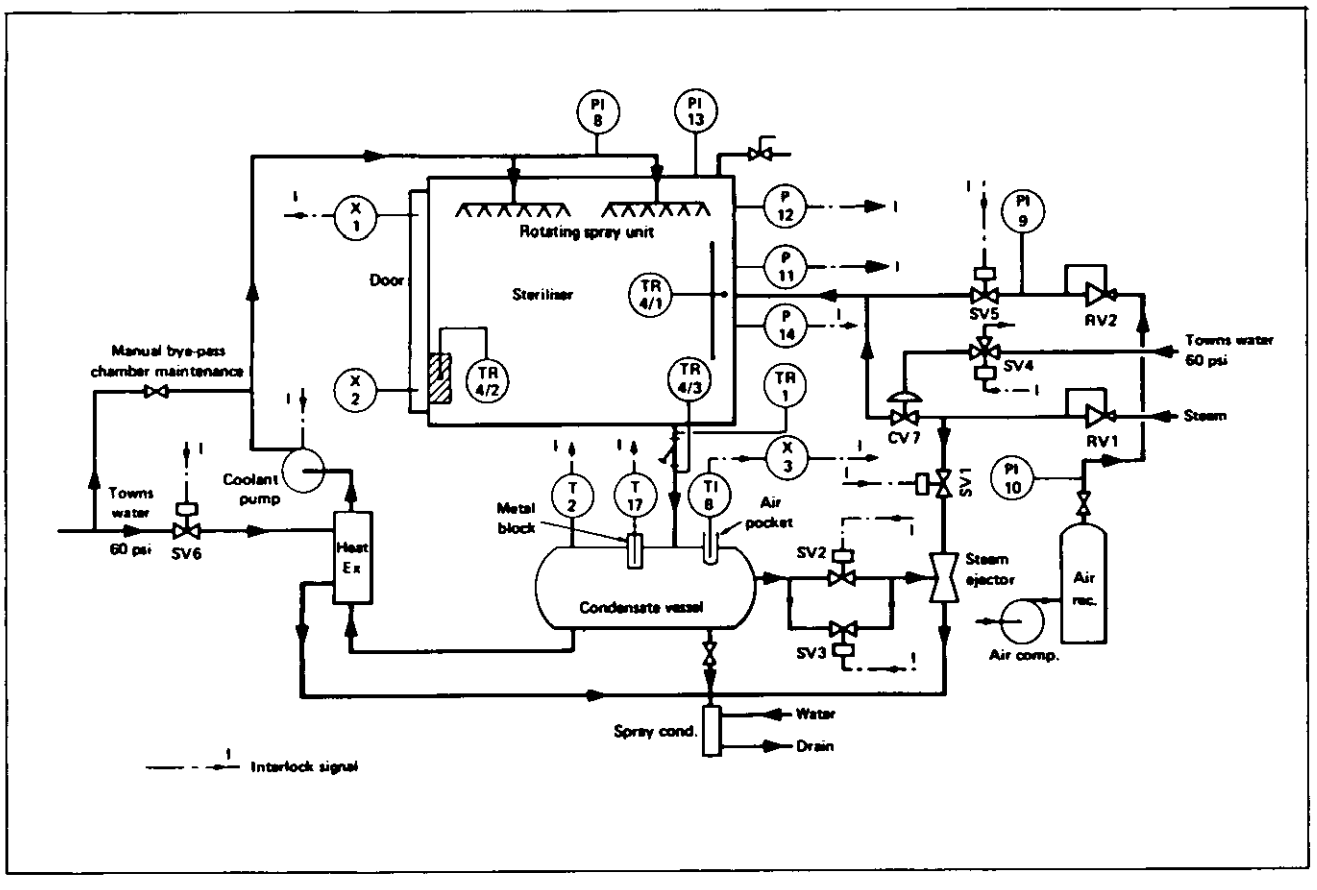


Figure 6. Sterilizer 'B'.

(iii) chemicals in the steam supply;
(iv) chemicals from previous loads.

With the exception of (ii), the above sources of contamination were not present in sterilizer 'A'.

d. **Non-sterile product.** Whereby the contents of the load or part load may leave the sterilizer chamber in a non-sterile condition. The system failures which led to this hazard were identified as follows:
(i) insufficient sterilizing time;
(ii) inleakage of non-sterile pressurising air;
(iii) inleakage of non-sterile coolant;
(iv) low sterilizing temperature;
(v) bacteria contamination, post sterilizing.

The above failures were also present in the sterilizer 'A' system.

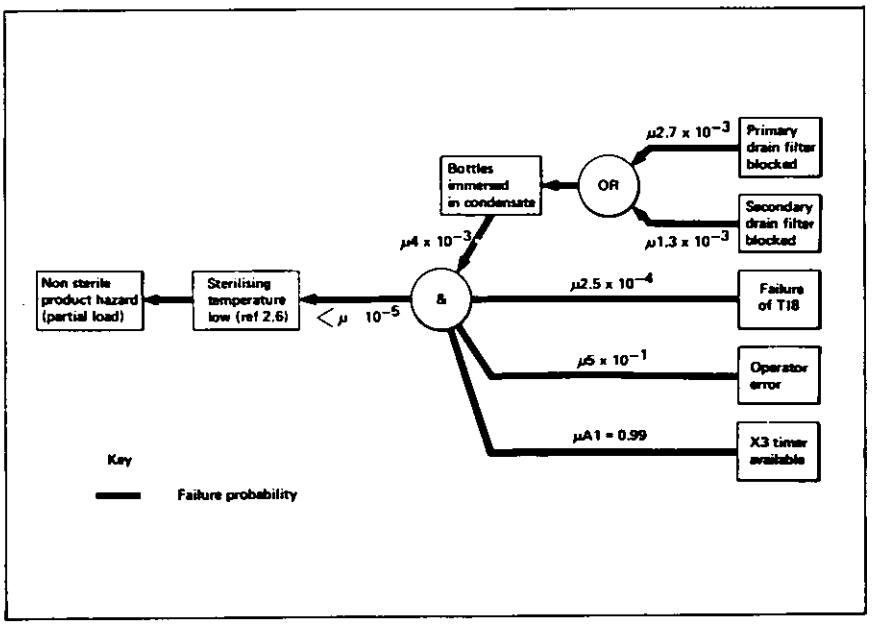
Specimen Case Study

This again considers the failure modes which led to the Devonport Hospital incident and which has previously been discussed under *Specimen Case Study*, above, for sterilizer 'A'. This case study again considers the hazard of 'Part Load Non-Sterile' and is given by the hazard logic of *Figure 7*. The model shows that there had to be four conditions present in order to produce the hazard, namely:

a. blocked drain filter;
b. failure of sterilizing temperature controller TI8;
c. human error;
d. sterilizing timer fully available.

The first failure could be caused by blockage of either the primary or secondary drain filter. The second failure considered those faults in TI8 which would cause it to initiate and

Figure 7. Sterilizer 'B' part load non-sterile hazardous product logic.



maintain the sterilizing timer even though the true temperature had not attained 121°C.

The third failure was due to the sterilizer operator failing to note the significance of an abnormal slow decay of chamber pressure at 'Process End'. The final condition was not a failure but was dependent on the scheduled operation of the sterilizing timer X3 when demanded by TI8.

The model shows that on the basis of three monthly proof testing of TI8 and daily checking of the drain outlet that the probability of the hazard is less than 10^{-5}. The model also shows that the hazard is independent of the human operator and the sterilizer timer.

Operator Hazards

Hazard to Operator Modes

The hazard logic shown in *Figure 8* which refers to sterilizer 'A' system shows that there are two basic ways by which the operator could be injured due to system failures. The two hazards apply to sterilizer 'A' in both the auto and manual modes, and also to sterilizer 'B'. It is important to note that although the main hazards are identical in both sterilizer systems, the sub-system failures which lead to the hazards are not similar. The two hazards are defined as follows:

Chamber at pressure hazard. Whereby the operator could be at risk due to pressure conditions within the sterilizing chamber. At higher pressures above the operating level the protection was provided by a single relief valve, whilst at normal or lower pressures, interlocks and pressure indication were intended to prevent the operator from opening the chamber door.

Bottle fracture hazard. Whereby the operator could be injured by breaking glass bottles. Here the hazard logics indicate either part or total load being at temperatures greater than 80°C consequently such bottles having internal pressures which could initiate disintegration when the load was being handled by the operator at the process end.

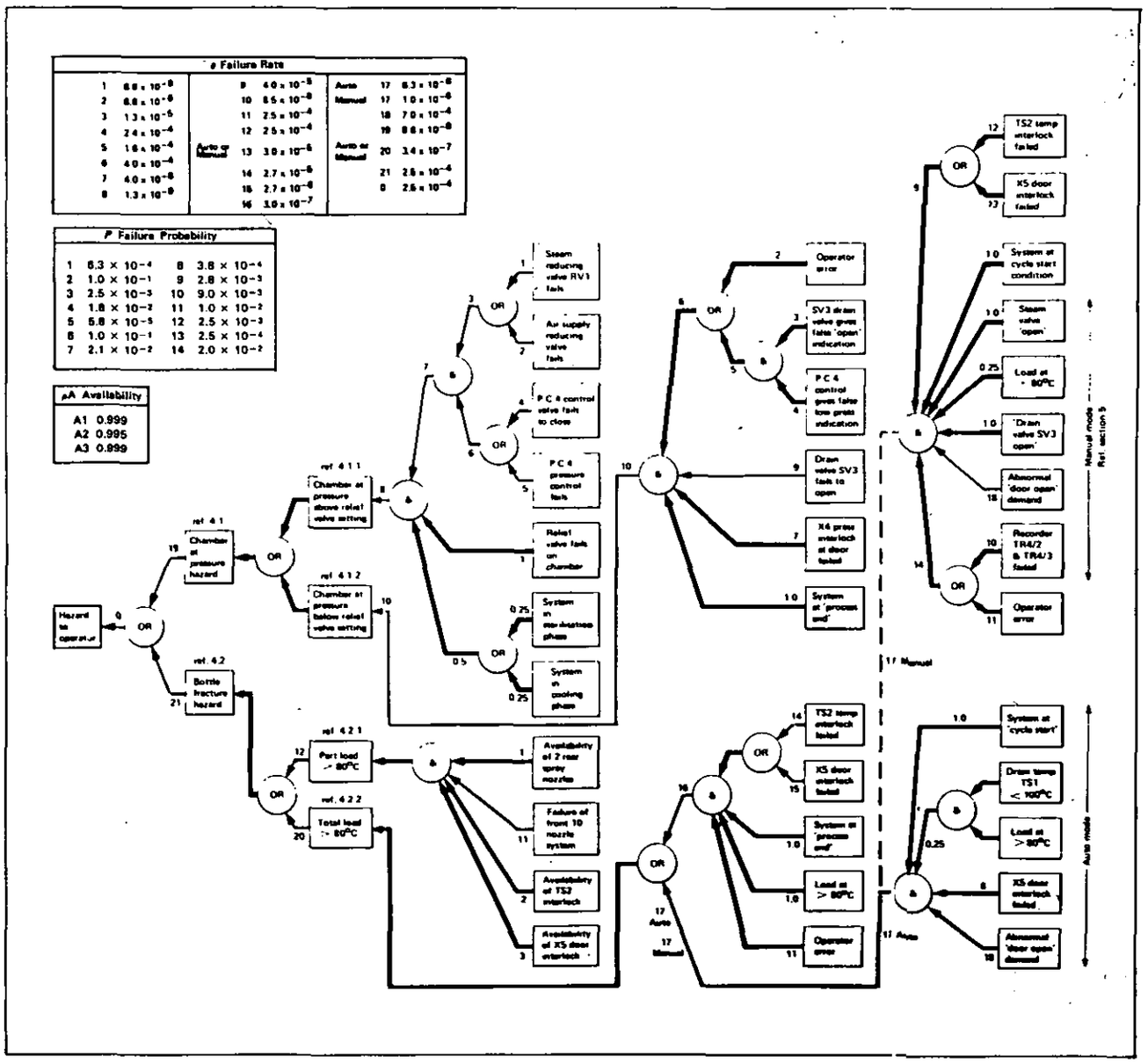


Figure 8. Sterilizer 'A' hazard logic — hazard to operator — auto mode and manual mode.

Comparisons of Sterilizer Systems

For convenience the following *Figure 9* is reproduced from the two system assessments. The table shows the relative failure probabilities for each of the sterilizer systems in each of the hazard modes which include risks to operators.

Figure 9.

Comparisons of Sterilizer Systems

Hazard	Sterilizer 'B' System	Sterilizer 'A' System Auto	Sterilizer 'A' System Manual
Total load non-sterile	1.9×10^{-3}	4.1×10^{-2}	5×10^{-2}
Part load non-sterile	$< 10^{-5}$	4.1×10^{-3}	1.3×10^{-2}
Non-sterile product Bottles per cycle	7×10^{-2}	7×10^{-2}	7×10^{-2}
Particulates in product Bottles per cycle	6×10^{-3}	6×10^{-3}	6×10^{-3}
Chemicals in product Bottles per cycle	1.6×10^{-2}	10^{-3}	10^{-3}
Total load over-processed	1.5×10^{-3}	1.8×10^{-2}	2.3×10^{-2}
Hazard to operator per cycle Pressure mode	9×10^{-9}	8.6×10^{-8}	8.6×10^{-8}
Hazard to operator per cycle Bottle fracture mode	3.1×10^{-5}	2.5×10^{-4}	2.5×10^{-4}

Comparison of Sterilizer 'A' Auto/Manual Modes

The 'Part Load Non-Sterile' hazard is seen to be the only hazard state whereby the system is significantly improved when automation is present by amount equal to a single order of magnitude. This improvement in the auto mode is due to the feature of the drain temperature interlock TS1, which initiated pressurised sterilization when the temperature achieved 100°C. In the manual mode the operator called for pressurised sterilization by reference to a temperature chart recording.

Sterilizer Comparisons

Total Load Non-Sterile

Sterilizer 'B' shows a hazard probability which is a factor of twenty better than the corresponding figure for that of sterilizer 'A' when operating in the auto mode. System analysis shows that the hazard could only arise in the sterilizer 'B' system as a result of insufficient sterilizing time. In the sterilizer 'A' system the hazard could arise also as a result of low sterilizing temperature.

Part Load Non-Sterile

This is the significant hazard related to the Clothier Report.

The sterilizer 'B' system yielded a hazard probability which was at least two orders of magnitude better than the sterilizer 'A' auto system, and three orders of magnitude better than the sterilizer 'A' manual system.

Considering the auto modes of both sterilizers the improvement in the sterilizer 'B' system was due to the presence of drain and simulated bottle temperature interlocks, both of which had to fail before a large amount of air could be left in the chamber. The sterilizer 'A' system had a single drain temperature interlock which, if in a faulty state, could initiate sterilization with large amounts of air left in the chamber.

Non-Sterile Product. Bottles/Cycle

The analysis concluded that in all modes of operation in both sterilizer systems the pressurising air would not be free of bacteria and hence the hazard probability would be entirely dependent on the incidence of leaking bottle seals.

Particulates in Product

The assessment considered that although particulates could arise as a result of the sterilizing process, *eg*, particles of glass, the probability of this hazard was always due to two factors, namely — the incidence of particulates, and failure of the operator to observe the particles when carrying out visual examinations with a light source. There was no evidence of increased particulate incidence in either machine and it was therefore concluded that this hazard is independent of sterilizer system.

Chemicals in Product. Bottles/Cycle

This hazard was shown to be worse by a factor of ten in the sterilizer 'B' system, this being due to the system of cooling by recycled steam condensate. The sources of contamination which are not present in the sterilizer 'A' system were those of:

a. Chemicals arising from steam;
b. Chemicals arising from the sterilizer system;
c. Chemicals arising from previous chemical-based loads.

Total Load Over-Processed

In sterilizer 'B' the predominant system elements were those of the steam reducing valve RV1 and the MKVIII controller. The combined failure probability of these items was an order of magnitude more favourable than that of the pressure control system in sterilizer 'A', when viewed in the auto mode.

Hazard to Operator per Cycle Pressure Mode

The analysis showed that the sterilizer 'B' system exhibited an order of magnitude improved hazard rate due to the system of two pressure interlocks, one mechanical and one electrical on the door opening mechanism. The sterilizer 'A' system featured only a single mechanical interlock.

Hazard to Operator per Cycle Bottle Fracture Mode

The part load, >80°C, was the hazard of significance in the overall bottle fracture hazard for both sterilizer 'A' and 'B' systems. The sterilizer 'B' system exhibited a hazard rate more favourable by an order of magnitude, due to the lower failure rate of its coolant rotating spray head system when compared with the static spray nozzle system of the sterilizer 'A'.

Summary

The study has indicated areas where improvements in reliability could be made when designing new fluids sterilizer systems. These aspects are discussed in the following sub-sections which refer to the hazardous states given in *Figure 9*.

Total Load Non-Sterile

The studies revealed an order of magnitude improvement in sterilizer 'B' system over that of sterilizer 'A'.

This was due to sterilizer 'B' being sensitive only to sterilizing time whereas sterilizer 'A' was sensitive to both sterilizing time *and* temperature.

Sterilizer 'B' was seen to have the combined advantages of a pre-sterilizing vacuum phase with two drain temperature interlocks T2 and TI8 which respectively initiated the pressurised sterilization phase and the desired timing interval.

Failure of interlock TI8 in a low temperature switching mode would, if steam input conditions were met, always directly result in an insufficient sterilizing time interval, irrespective of the fact that the chamber load would ultimately reach the desired sterilizing temperature. Low sterilizing temperature could not be directly caused by failure of TI8 but would be conditional on other failures in the steam input system *eg*, steam reducing valve or automatic steam inlet valve CV7.

The sterilizer 'B' system could be further improved in reliability terms for this hazard if:

a. The system always operated on a fixed sterilizing time interval; and/or

b. the sterilizing cycle timer reliability could be improved.

Part Load Non-Sterile

Sterilizer 'B' exhibited a very low probability, namely $<10^{-5}$ for this hazard whereas sterilizer 'A' yielded a hazard probability which was at least two orders of magnitude worse.

Although both machines were equally susceptible to outlet drain blockages leading to immersion of lower bottles in condensate, sterilizer 'B' was sensitive solely to this condition for this hazard whereas Sterilizer 'A' was *also* sensitive to large amounts of air being left inside the chamber during sterilizing. This result again indicated the advantages in sterilizer 'B' sytem of a pre-sterilizing vacuum phase with two drain temperature interlocks. These are referred to as T2 and TI8 in the section 'Total Load Non-Sterile', above.

Non-Sterile Product Bottles/Cycle

Both sterilizer systems yielded an incidence of 7×10^{-2} bottles per cycle which were expected to be non-sterile due to contamination arising from the sterilization process. In either sterilizer system three sources of bacteria contamination were identified namely:

(i) pressurising air;
(ii) coolant;
(iii) post-sterilizing conditions at the respective sterilizer.

Bacteria was seen to be always present in pressurising air. In the coolant the study revealed a negligible probability of bacteria for both systems whilst at the post-sterilization phase the system was entirely dependent on the integrity of the operator in removing the load immediately on completion of a cycle.

Significant improvements for this hazard when designing new sterilizer systems could be realised if:

a. pressurising air could be made sterile;

b. system safeguards could be implemented at the end of sterilization, to prevent contamination of loads awaiting discharge by possible atmospheric conditions within the sterilizer chamber. The elimination of the human operator factors is recommended;

c. improvements in the design of containers and associated seals, noting that in the reliability studies the hazard rate was seen to be dominated by the incidence of bottle seal failure.

Particulates in Product Bottles/Cycle

This hazard was found to be independent of sterilizer system. Its incidence was dependent entirely on two factors — human error, and incidence of particulates. In order to improve this hazard, consideration could be given to the replacement of a human operator with an automatic system to detect particulates after sterilization.

Chemicals in Product Bottles/Cycle

Sterilizer 'A' exhibited a more favourable hazard rate by an order of magnitude when compared with sterilizer 'B'. This was seen to be due to the sterilizer 'B' system of using stored steam condensate as a cooling medium on the basis that it would be sterile. Initial chemical analyses of condensate from machine 'B' revealed levels of 22 μgms/ml of lead and 6 μgms/ml of cadmium. Machine 'A' yielded negligible levels of these chemicals. Further analyses taken over a period showed that retention time of condensate in machine 'B' was an important factor in the degree of lead and cadmium build-up.

Sterilizer 'A' yielded a hazard rate of 10^{-3} bottles/cycle whilst system 'B' showed a rate of 1.6×10^{-2} and in both systems the incidence of defective bottle seals was a significant factor and this again emphasised the need to improve bottle sealing. Sterilizer 'A' system could be further improved by:

a. reducing the probability of oil contamination in the pressurising air supply;

b. conducting a more detailed and longer term survey of the public water supply in order to refine the probability figure used in the assessment.

In addition to a. and b. above, sterilizer 'B' system could also be improved with respect to this hazard by:

c. redesign of the coolant system to reduce the probability of its chemical contamination by the long-term leaching out of chemicals from the sterilizer itself, and chemicals arising from previous chemical-based loads;

d. chemicals in the steam supply could be reduced by local generation of steam at the sterilizer itself if a stored condensate system was being employed.

Total Load Over-Processed

Sterilizer 'B' yielded a hazard probability for this condition which was an order of magnitude better than that of sterilizer 'A'. An over-processed load is defined as a sensitive load which is exposed to excess sterilizing temperature or time. In sterilizer 'B' the predominant system elements which contributed to the hazard were those of a steam reducing valve RV1 and a sequence controller. The combined failure probability of these two items was an order of magnitude more favourable than that of the pneumatic single-term steam pressure controller PC4 in machine 'A'.

The study showed that temperature controlled through the medium of a steam reducing valve was more reliable by an order of magnitude than a pressure control system consisting of a pneumatic controller and diaphragm operated modulating valve.

Hazard to Operator per Cycle Pressure Mode

Sterilizer 'B' showed an improved hazard rate for this mode of an order of magnitude over sterilizer 'A'. Hazards due to pressure may arise due to operation of the system above

the relief valve setting or at lower normal operating pressures. At the higher abnormal pressures both sterilizer systems yielded a very low hazard rate of 10^{-9} per cycle. At normal operating pressures safeguards consisted of interlocks on the door opening mechanisms, arranged in such a way that the doors were prevented from opening if the chamber pressure conditions were unsafe for the operator. In this aspect sterilizer 'B' yielded an improved hazard rate by a single order of magnitude, this being due to the presence of two interlocks one electrical and the other mechanical. Sterilizer 'A' had only a single mechanical pressure sensitive interlock. For this mode hazard rates per cycle were again of a low order, namely 8.5×10^{-8} for machine 'A' and 7×10^{-9} for machine 'B'. The results indicate that redundancy with diversity on door opening safety interlocks result in a significantly lower hazard rate.

Hazards to Operator per Cycle

Bottle Fracture Mode

Bottle fracture hazards are referred to the Total Load $> 80°C$ and the Part Load $> 80°C$. For the Total Load mode both systems yielded a lower hazard rate of 10^{-7}.

In the Part Load mode sterilizer 'A' yielded a hazard rate per cycle of 2.5×10^{-4} whilst sterilizer 'B' showed a rate of 3.1×10^{-5}. The improvement in system 'B' was due to the lower failure rate of its rotating spray head cooling system over that of the static nozzle system in system 'A'.

The study indicated that improvements in hazard rate at the Part Load mode are dependent solely on the reliability of the spray cooling system within the chamber.

General Observations

Sterilizer 'A' was the only system which could be operated in either the manual or automatic mode. The studies showed that advantages in reliability terms were only realised for the Part Load Non-Sterile hazardous product mode and here the improvement was by a single order of magnitude.

Sterilizer 'B' was generally shown to be superior to system 'A' except for the chemical contamination hazard. Here the study showed that the recycling of stored condensate on the basis of its sterility raised other hazards in that the system became more susceptible to chemical contamination.

Economic Considerations

Reliability of new sterilizer systems is reflected by the failure rates, by testing periodically, and by the maintenance of equipment used in their subsystems. The establishment of reliability criteria enables equipment with more favourable failure rates to be specified consistent with optimum testing frequencies. Studies would indicate those items which require less frequent testing. Lower failure rate items also result in less frequent maintenance and hence the establishment of optimum levels of spares. Reliability also leads to higher system availabilities with consequent higher production levels over a given period.

Overall Conclusions

The study clearly demonstrates the advantages of using this system of logical approach to problems of safety and equipment availability. The use of this technique in the study described has identified problem areas in the two machine systems. In particular it has independently identified the failures which led to the accident which was the subject of the Clothier Report.

Where probabilities in absolute terms may be in dispute due to difficulties of data collection the probabilities in relative terms remain a valid conclusion in any assessment hence the identification of strong and weak areas. The method of assessment using the logical approach may be applied to any system of sterilizer and can also be extended to other fields of hospital engineering.

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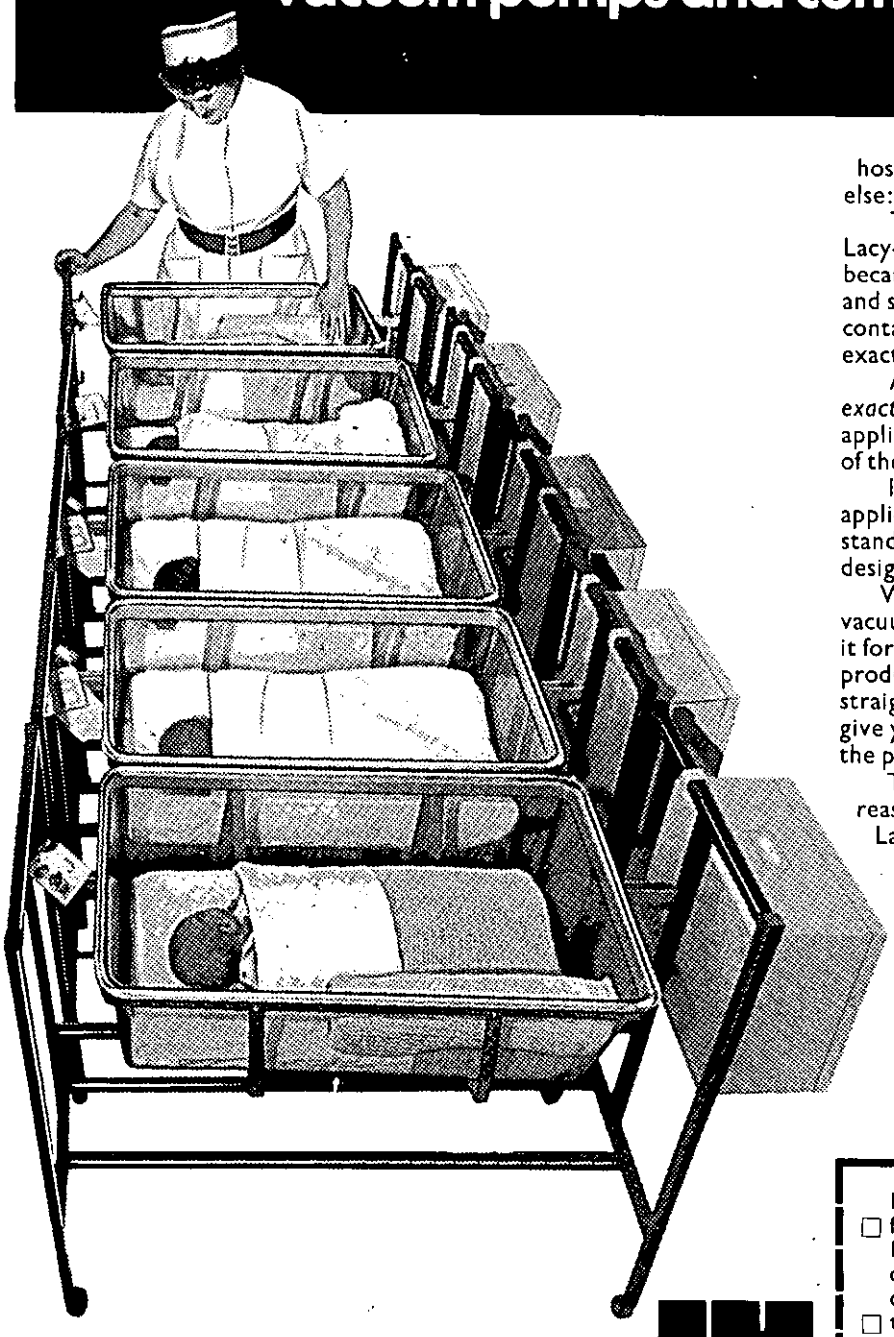

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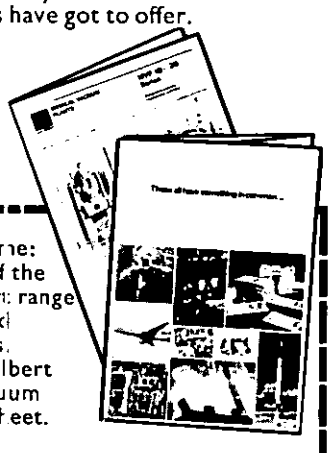

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This paper was presented at the June 1978 Symposium organised by The Institute of Hospital Engineering in London on 'Recent Developments in Hospital Sterilizing Processes'. The author works in the Engineering Division of the DHSS.

Recent Developments in Hospital Sterilizing Processes.

Revision to Health Technical Memorandum 10

L. W. M. ARROWSMITH BSc(Eng) CEng MIMechE

Without doubt, the new edition of Health Technical Memorandum 10 will be a much thicker document than that of the 1968 edition, basically because we have chosen to include information of interest to a much broader readership. Even so, much of the additional matter, only implicit in the old edition, was substantiated by the much quoted document HM 67/13, so we have merely set down the detail.

Other forces also have been at work, namely the application of the Medicines Act to the NHS. This alone influenced the decision to include a whole *Appendix 4* covering management of not only fluids sterilizers, but all sterilizers used in the Health Service.

From the outset it was felt that the TM should cover all types of sterilizer. There is a new section to cover hot-air sterilizers and their testing — and the eventual objective is to publish additional sections or supplements on LT steam and formaldehyde sterilizers, laboratory sterilizers, possibly an outline of the use of ethylene oxide sterilizers, although these units have a specialised role, rather than general Health Service application.

The publication of some standard documentation, plant history records — sterilizer processing logs *etc* is also proposed.

The revision has been undertaken at a time when the BS3970 itself is in the process of review and naturally it has taken a great deal of effort to harmonise the two documents. The objectives here are quite distinct. HTM10 represents the Health Service buyers' guide, whilst BS3970 represents the basic standard with which the customer may expect a sterilizer to comply.

As far as Departmental policy is concerned, the views expressed in the 1968 edition still hold. We remain committed to the use of central sources of supply for sterile products either from the CSSD, TSSU or eventually HSDU. This is the only way to ensure optimum use of resources, equipment, the management of the department and the maintenance and testing of sterilizers.

We reiterate, as firmly as ever, the condemnation of boiling water sterilizers which, believe it or not, are occasionally requested. We deprecate the use of dual cycle machines as before, meaning fluids and porous load cycles, porous loads and low temperature steam cycles. We retain an aversion to double door sterilizers, not merely because of the problem of ensuring the air tightness of porous load machines, but also because of the associated installation problem.

The majority of sterilizers installed in the Health Service are 14 or 21 cubic foot capacity machines. This results in the enclosed width of the plant space being probably no more than three feet. Clearly, this severely hampers maintenance and access becomes more difficult, necessitating entry to the plant space through the facia at several points. Additionally, at least one outside wall for a plant room is preferred. This way the effect of heat gain from the machines can be minimised.

There are apparent attractions to a through-the-wall installation, segregation of processed from non-processed products, but if it is used for this reason alone it is quite likely that the cramped maintenance area will prejudice maintenance and lead to other problems. There are other ways of ensuring segregation of loads, their progress through the department necessitating batch documentation to assist in segregation. They may be necessary for certain special applications, *eg* in SPF Laboratories.

The fluids sterilizers referred to in the TM are those intended for processing fluids in sealed rigid containers. Usually these will incorporate rapid cooling.

No attempt to accommodate the problems of bottle closure or to suggest ways whereby this problem can be ameliorated has been made. It is suggested, in any case, that the so-called sterile cooling cycles create additional problems, the corollary being that bacterial contamination from non-sterile cooling can often be seen, whereas chemical contamination from so-called sterile cooling probably will not be detected.

It is also suggested that natural cooling may not be the answer, because the more gradual stabilisation of pressure within the container during

cooling will not seal the bottles so firmly and can lead, eventually, to additional contamination on the shelf. This may be the case in a spray cooled machine.

Our presumption has been that the closure will remain effective. Engineers can ensure a high level of maintenance and perform tests on sterilizers against physical parameters which can be defined, and hopefully the development of the 'Eurobottle' will solve the problem of contamination.

There has been some progress with sterilizers with non-rigid containers, but since they are still at the development stage we have not incorporated much advice on these units in the TM except to say that where they can be justified in terms of their size and their complexity, an approach should be made to STB who will assist in development and commissioning.

An attempt to dispel the myth of the so called 'dropped instrument' sterilizer has been included. These do NOT comply with British Standards and in any case, when used the instruments emerge from them at a temperature at which they are unusable. Subsequently, time is lost waiting for the temperature to fall or the items are dunked in water, neither of which seems to be particularly satisfactory.

The main section of the TM has been altered to reflect current thinking. In particular we have had to recognise the impact of the Health and Safety at Work Act. It is important today to be more specific about the noise levels permitted from all equipment. Both the Health and Safety at Work Act and Energy Conservation measures have encouraged us to look for an improvement in thermal insulation of sterilizers.

Water Boards are becoming more concerned with the way in which water is used, particularly with the problems of back syphonage. In future all new installations will have to be supplied from a suitable brake tank. Eventually we expect existing installations to be so provided, particularly the water for ejectors, vacuum pumps and condensers. In large installations it may also be worthwhile to consider the use of the secondary recirculatory water cooling systems.

Whilst we normally advocate the use of open drainage, the conventional tun-dish — which still holds good for sterilizers used for clinical and pharmaceutical products — there are exceptions where this is not appropriate. Where a microbiological hazard is likely to arise, the drain should be sealed with the vent taken out externally from the plant room. This type of arrangement will also be necessary with low temperature steam and formaldehyde sterilizers in order to prevent a build-up of formaldehyde in the plant room.

The commissioning of sterilizers may be considered now as a tripartite involvement. The client first has the responsibility of demonstrating the adequacy of the services — steam, air etc; the manufacturer or installer has the responsibility of demonstrating that the machine is performing satisfactorily in respect of the mechanical function of the machine — safety devices, interlocks and for carrying out performance of the standard tests, for example, the Bowie/Dick and full load test. And finally the sterilizer engineer will be responsible for carrying out the various tests to produce master temperature records.

Of the various types of sterilizers, the porous load machine is perhaps more susceptible than any to problems associated with steam supply. There has been remarkable accommodation within the NHS and, indeed, in industry over the last 10-15 years in techniques of fuel conservation. Many manufacturers themselves have championed this but, I think more than that, the energy crisis has spurred people into a further rush of activity. This has mostly eliminated problems with wet loads; the majority of difficulties now result from problems with packaging. This is covered at some length in *Appendix 1* and represents part of the advice intended for users.

Whilst improvement in steam supply has reduced the problem with wet loads, difficulties still remain with non-condensable gases.

Sterilizer installations cannot be planned in isolation and the steam supply, venting and trapping arrangements must all be considered. Even further, the boiler plant itself must be properly controlled with the hot well maintained at temperature and the correct water treatment dosage applied. For this reason alone the use of small steam boilers should be considered as a last resort. They rely almost totally on raw water for make-up, there being virtually no condensate returned to them and their proximity to the sterilizer means that there is little opportunity for venting out non-condensable gases.

Whilst hospitals have steadily improved their boiler plant and process steam quality, manufacturers have also been improving the air removal stages of porous load sterilizers. Most modern sterilizers have a fairly active air removal stage, while the steam is fed into the chamber during a series of rapid pulses.

When the chamber is lightly loaded, there is a very small heat sink, and because the chamber is jacketed virtually no heat loss. We are seeing, therefore, on several sites evidence of super heating which may be modest or severe. This phenomenon is demonstrated by means of a thermo-couple installed in the free chamber space.

This overheating is causing concern so steps are being taken to review the design of sterilizers. It is recognised that there is a current problem to be accommodated and as a palliative guidance to acceptable levels of superheat has been issued. We consider a 5° centigrade transient decaying after the first minute of the sterilization hold time to be acceptable until we develop a solution. All cases exceeding these limits should be investigated and we suggest that they are referred to the Department. Although we do not have a general solution so far, we have had some success in resolving the problem at specific sites.

The satisfactory monitoring of the sterilizer process still relies on appropriate instrumentation. *Appendix 2* sets down standards for instrumentation fitted to the sterilizer both during the maintenance checks and commissioning tests. The guidance is based on the standards provided by the appropriate British Standards for the various classes and types of instrumentation. In addition, we do say and expect that instruments will be calibrated at the actual test site in order to improve the accuracy for the temperature at which we are intending to use the machines. It is insufficient merely to install an instrument which forms part of a monitoring system without first carrying out a check on calibration. It is the effect of the prevailing site condition upon calibration which interests the user and not the conditions in the manufacturer's calibration laboratory.

We have covered the entire range of instruments including the indicating thermometer, which may be either mechanical, *eg* vapour pressure, liquid expansion, and for hot air sterilizer bi-metallic or electronic instruments using thermo-couple or resistance elements. We have permitted the inclusion of combined

indicating thermometers and controllers, where the control function does not affect indications. For example, a contact head on a mechanical instrument system may arrest the pointer by 3% of the scale span.

We have, incidentally, permitted their use in hot air sterilizers where a depression of temperature reading does not exceed 1½° of 1½% of scale span. For steam sterilizers, the problem can be overcome by the use of electronic instruments.

The chart recorder is, of course, the most important instrument providing an essential part of the process record. We state these to be essential on all fluids sterilizers, porous load sterilizers and hot air sterilizers. They may very rarely be required for bowl and instrument sterilizers if they are installed in a theatre complex and a record is required, but we feel that the theatre should be supplied from a TSSU or HSDU.

The thermometric systems for recorders may be bourdon tube or electronic and we have no particular preference for circular or strip chart recorder. Strip chart recorders do provide a more manageable record and perhaps if incorporating a tear-off facility, probably reduce wear and tear from handling. Certainly once loaded, the pointers are subject to much less manipulation.

The circular recorder is the only one which will accept a bourdon tube pressure measuring system and consequently a pressure recording. Electronic pressure systems compatible with stripchart recorders are available but are considerably more expensive for the same degree of accuracy and therefore we would normally expect to see a pressure recording on a combined circular instrument. In any event, we require a pressure recording for sub-atmospheric sterilizers only.

We have asked for single pen recorders only. The recorded temperature may not represent the lowest temperature of the load at all times during the process, but it will be an analogue corroborated during the thermo-couple tests to establish the master temperature record.

Portable instrumentation is required for the various tests. At least a three-channel machine for porous load sterilizers and quarterly tests on fluids sterilizers and a 12-channel machine for commissioning fluids sterilizers are necessary.

The instruments are not really meant to be handled and carried around, so it is essential to carry out calibration checks on site before performing tests using an oil bath, potentiometer or milli-volt source. At the moment the most appropriate system for testing is by means of thermocouples which can be readily inserted into bottles or porous load packs. They do not have the same bulk as resistance elements. Thermo-couple wires are reasonably manageable and only one joint, the hot junction itself, has to be made, apart from the connection to the recorder.

We have given advice on thermocouples which may vary considerably not merely from batch to batch but from reel to reel. We suggest using selected wire which is a reel upon which tests have been carried out, where the variation in EMF output is much smaller. Nevertheless the output will differ from the actual figures quoted in the British Standard table. For type T, the one we recommend as being the most versatile, the selected wire is probably within 0.3°C at 134°. The standard's accuracy is ±1.3°C. Even so it is essential to calibrate test instruments for a given set of thermo-couple wires.

There is some concern, probably more imagined than real, over the possibility of controversy between two parties on site — perhaps between the commissioning engineer of the manufacturer and the sterilizer engineer regarding the accuracy of the two sets of instrumentation. We cannot guide people on good working relations, but it is perhaps worth reviewing what is, in fact, required.

The best possible accuracy of the instrumentation system for testing is about ½° if suitable calibration checks are undertaken. With the problem of readability of the scale and the variation of the paper chart itself, the actual reading may be expected to be within 1°C of the true temperature. The second instrument may similarly be within 1° of the true temperature, so that a possible difference of 2°C exists The importance of site calibration is clearly evident, but it is essential that the recordings of the individual thermo-couples are the same, when exposed to, say, the free chamber space steam, and moreover that the readings are consistent. This is an essential feature of pre-test calibration and instrument checks.

In an attempt to set down a protocol for management of sterilizing departments and sterilizers, *Appendix 4* was written. This lists the various duties of the staff involved, the User, Maintenance Engineer and Sterilizer Engineer. The user could be the CSSD manager under the guidance of the Consultant Microbiologist, or the Production Pharmacist. The whole Appendix was, in the main, directed towards the Medicines Inspectorate to publish an individual inspector's guide on the control and use of sterilizers.

It defines the documentation required, process logs, plant history records and draws attention to the maintenance procedures laid down in Estmancode and PMG12 and 13 on the maintenance of sterilizers. The importance of adequate maintenance, effected by trained staff cannot be emphasised too strongly. Much of the Appendix deals with commissioning data and records of commissioning tests, which, apart from ensuring that contractual obligations have been met by the manufacturer, are concerned with the setting down of the various data for subsequent checking the performance of the sterilizers.

Of paramount importance here is the master temperature record covered in *Appendix 12*. This we define as the record obtained from the chart recorder fitted to the sterilizer produced whilst the sterilizer is being checked by means of the separate test instrument. If a satisfactory test recording is obtained we can then accept the chart recording as being an acceptable analogue. This will not necessarily be the temperature in, for instance, actual bottles, but will reflect the overall temperature of the load. All subsequent temperature recording charts for production loads may be compared with this MTR.

We anticipate that a MTR will be required for typical loads, fully specified regarding container-size and contents. Where possible and when thermal degradation of the product will not be a problem the worst case load will suffice, but the user and sterilizer engineer must agree on the range of MTRs required.

MTRs are required for fluid sterilizers for production control purposes and Hot Air Sterilizers. A form of Master record for porous load sterilizers obtained during commissioning will be of use to engineering staff to check on the sterilizers as a reference for test recordings, but it will not form part of the production record because of the variety of loads processed.

The key to this procedure lies with the Sterilizer Engineer. We would prefer to see a Regional appointment where the necessary degree of special-

isation can be achieved. Apart from specialisation, and active involvement with the testing of sterilizers, this arrangement permits close contact with the pharmaceutical QC (Pharmacist), which is a regionally based role, and indeed the Consultant Microbiologist working at a particular hospital may be regionally appointed.

The day-to-day maintenance will be the responsibility of the maintenance engineer, possibly based at a hospital, and it is essential that a certain amount of training is undertaken to ensure familiarity with the sterilizer under his control. He will be responsible for reviewing with the user the previous week's production records and detecting any anomaly in the cycle or deterioration in performance.

The user will be responsible for the day-to-day checks on instrumentation readings, performing the Bowie/Dick test and notifying the maintenance engineer in the event of a failure or malfunction. It is clear that for the protocol to work satisfactorily, reliance must be placed on mutual trust, confidence and clear communication.

At the beginning, I said we had decided to include all types of sterilizers in this document, the first being the hot air sterilizer. Much concern has been expressed over the apparent lack of control of the hot air sterilizer which appears to be the Cinderella of them all, but none the less important in view of the variety of sterile goods it processes.

Steam sterilizers present much more of a hazard to operators and the process is less easily understood, consequently they have received a great deal of attention, particularly with regard to automation of the cycle, door interlocking and fail safe controls.

In trying to redress the balance, we first considered the technical feasibility of achieving some similarity between the two types.

Firstly, the hot-air process relies on sensible heat transfer which takes much longer than latent transfer, so that the heating time of individual loads must be established from the outset. Perhaps a total process time, heat-up time and sterilizing would take up to four hours. They are used for medicinal production purposes and for a variety of products, all of which have differing heat up times. We would consider a chart recorder essential, therefore, with appropriate MTRs.

Some form of door locking arrangement, preferably an automatic interlock but at least a key lock, is really essential. There is no reason why a greater degree of automation could not be applied to this type of cycle. Certainly the timers and the thermostats could all be pre-set, the whole being initiated by a single control operation. We have indicated in the TM the features considered essential, and we would expect all hot air sterilizers eventually to have some form of automatic control. A further provision to assist cooling down would also be desirable.

Our aim has been to draw attention to the problems which have been overlooked with this process. We say that the sterilizer should not be used as a drying oven, and if a drying oven only is required, then it should conform with the relevant British Standard (BS 2548). This is altogether a different type of machine.

In laying down tests for hot air sterilizers, we have based our tests on those in BS 3421, although we are more concerned with tests on actual production loads. The British Standards tests are not strictly relevant and they would be undertaken only if there was some doubt concerning the performance of the sterilizer.

Lastly, all the tests necessary for the various types of sterilizer have to be specified and set out in detail. These include the Bowie/Dick test for porous loads, the pre-production load instrument checks, using the information supplied during commissioning and the weekly leak rate test for porous load sterilizer. In addition, all the tests using separate test instrumentation, those undertaken by the Maintenance Engineer at quarterly and half-yearly intervals, and those undertaken during commissioning or recommissioning by the Sterilizer Engineer. These tests were all inferred in the 1968 edition, but the details are now specified in full.

This paper was presented to the London Branch at a meeting devoted to practical energy conservation.

The author is marketing manager in the Cooling Products Division at Dunham-Bush Ltd, of Portsmouth.

Aspects of Heat Recovery and Energy Conservation

J. L. BOWEN AMInstR

Increased fuel costs have made us all energy conscious, so it is hardly surprising that the emphasis is currently being placed on heat pumps and heat reclaim systems throughout Europe. Obviously, it has become essential to make every saving in our natural resources that can economically be achieved. Recovering rejected heat from essential refrigeration or air conditioning plant is an attractive method of power saving, especially in these days of large air conditioned structures such as hospitals, public buildings, libraries and other applications.

This idea is not an entirely new one and, even before the energy crisis developed, many far sighted people were already looking at the savings that could be achieved over the course of a year by using rejected heat within buildings to provide a low grade heat source for heat deficient areas. In fact, prior to the crisis Dunham-Bush had orders for some 12,000 hp of heat reclaim plants of the screw compressor type, either in operation or ordered for buildings in the United Kingdom and at the time of writing this has increased to some 14,000 hp.

At the same time, quite a number of smaller plants using conventional

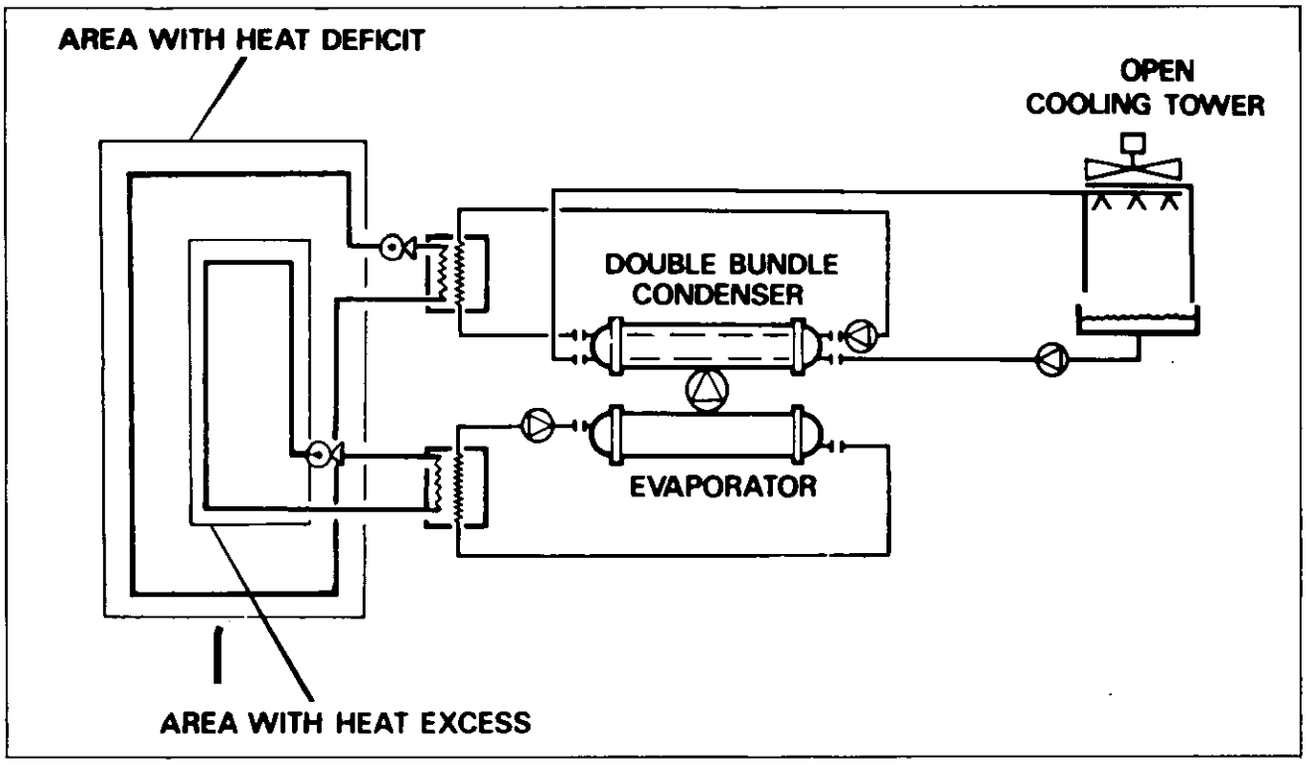

Figure 1. A typical, basic heat recovery system.

reciprocating compressors were being used in a single bundle condenser configuration on heat reclaim projects in this country, with the equipment operating in conjunction with closed circuit cooling towers. Although the coefficient of performance (COP) achieved in reciprocating machines does not generally reach the higher limits attained by the screw compressor packages, the utilisation of waste heat still makes this concept worthwhile. The development of standard ranges of heat reclaim reciprocating packaged water chilling equipment was an inevitable step, so a range of single and double bundle equipment (or alternatively, twin condenser packages) were produced in an effort to have equipment available for the lower horsepower applications. The development of the double bundle configuration of screw compressor packaged water chillers continued, to complete a range which could be utilised for this purpose from 25 hp to 750 hp.

This environmental comfort is recognised as an essential requirement in both industry and commerce if optimum employee productivity is to be maintained. However, the environmental conditioning of modern commercial buildings poses many problems for energy conscious designers and engineers and, contrary to the traditional brick and stone buildings technique, modern lightweight structures having a low thermal mass are being constructed.

In buildings where high heat gain equipment such as computers are installed, air conditioning plant is often required to operate continuously to maintain adequate temperature control within fairly fine limits — most buildings require a balance of both heating and cooling to compensate for solar, body and machinery heat gains in given areas and lower temperatures in exposed wings, lobbies and perimeter areas. The reduction in glass areas down to as low as 15-20% of a building surface, as against the previously accepted norm of 50-70%, has done much to alleviate heat losses from the perimeter of the actual building structure thus making the air conditioning engineer's job that much easier.

Heat reclamation and redistribution techniques have been evolved to reduce energy usage and running costs by making optimum use of secondary heat supplies. At the heart of such a system is the packaged refrigeration unit, slightly modified and fitted with heat reclaim facilities.

In a typical basic heat recovery system — as shown in *Figure 1* — the heat resources are grouped in the central core of the building. Heat extraction, *eg* for air conditioning, will therefore be required in this area during both summer and winter. Localisation of the excess heat area also enables the necessary cooling load to be centralised, so that during winter operation the refrigeration plant is provided with sufficient evaporator load. Heat is reclaimed at the refrigeration plant via the condenser cooling water and recirculated through a heating circuit serving all areas with a heating deficiency.

During summer operation the system would reject reclaimed heat from the condenser water through an open type cooling tower, using either the double bundle (*Figure 2*) or two separate condensers (*Figure 3*) techniques. In winter operation, the second section of the double bundle condenser (or second condenser) would provide a low grade heat source via a closed circuit heating system interlinked with the fan coil units, or through heat exchange batteries in supply air ducts. Once the building's heat demand is satisfied, any excess heat can then be rejected to atmosphere through the cooling tower.

An alternative is to use a single condenser with a closed circuit cooling tower operating as the heat reject facility. When heat is required, condenser cooling water is diverted from

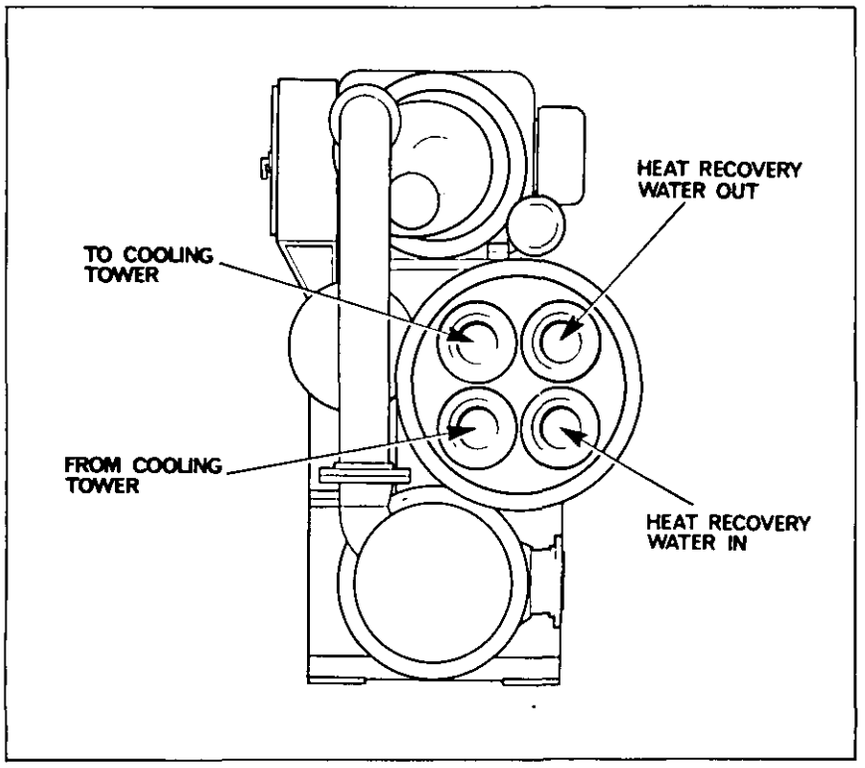

Figure 2. A packaged water chilling unit fitted with double bundle condenser.

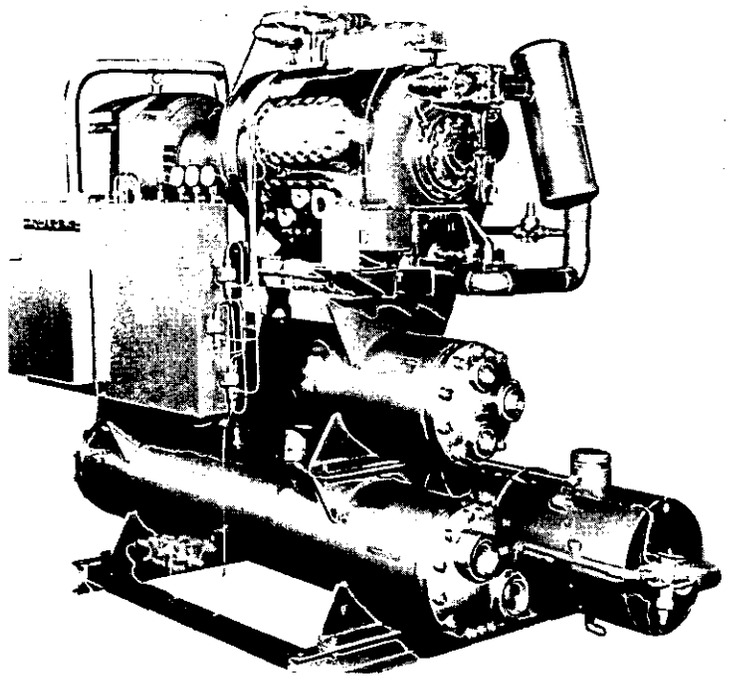

Figure 3. A Dunham-Bush packaged water chiller designed with two separate condensers for heat reclaim duties.

the cooling tower and introduced into a closed circuit heating loop.

However, selection of a particular system is dependent on the design parameters of each project, *ie* space savings, piping runs and other normal considerations which can only be assessed on a job-to-job basis.

One of the main factors to be thoroughly investigated when designing a heat reclaim scheme is the temperature to be applied on the reclaim side of the system. It is common knowledge that, as the condenser leaving water temperature (CLWT) is increased, the condensing temperature will rise to give a relative increase in absorbed hp on the motor side of the packaged chilling unit. The table illustrates these effects when using a typical screw package. However, it should be noted that manufacturers of hermetic packages prefer to limit the CLWT to 105°F with a condensing temperature in the region of 115°F at full load. Reference to the table shows that a small rise in CLWT creates substantial increases in bhp; for example, at 105°F CLWT, the absorbed bhp is 1.09 bhp/ton refrigeration, whereas a 10°F increase in CLWT (115°F) results in a rise in bhp to 1.41 bhp/ton refrigeration. The designer should therefore look closely at the economic selection of CLWT and absorbed bhp before making a final decision as to the heating system water supply temperature. Research has shown that the most economical design temperature, when considering duty and bhp, is between 105°F and 110°F, when using a screw or reciprocating-type packaged water chiller.

At this temperature the water will be suitable for the majority of systems, although more heat exchange surface will normally be required in the central station air handling units or fan coil units. If an economic CLWT/bhp balance cannot be achieved, a 'boost heat' type calorifier (operating in conjunction with a small boiler unit) can be added to the system. Although the capital cost of the installation would be slightly increased, this method of achieving an optimum temperature balance would require less energy expenditure than that used by increasing the motor size of the refrigeration plant beyond economic limits. Alternatively, a 'heat sink', fitted with immersion heaters, could prove advantageous in resolving these problems.

When operating this type of system

Figure 4. Two Dunham-Bush PCX helical axial (screw) compressor packaged water chillers for the heart of an extensive heat reclaim installation at the Simon Engineering building, Stockport, Manchester.

under summer conditions, it should be remembered that reject heat is still available, often in large quantities, which could be used either for domestic or, in the case of industrial users, process purposes, instead of being rejected to the atmosphere. In fact, in some process plant applications it may be possible to use all of the heat at all times and even consider the elimination of a cooling tower, with subsequent cost savings.

Finding extensive applications in heat reclamation installations are the reciprocating type packaged water chilling plant and helical axial (screw) compressor refrigeration equipment.

Dunham-Bush has supplied some 200 hermetic and open screw type compressor packaged water chillers (*Figure 4*) in operation in the UK, on projects ranging from 100 tons of refrigeration up to 5,000 tons. A large number of these machines are being used for heat recovery, using either single or double bundle condensers to provide a heat source for the building during winter operation. There is no doubt whatsoever that, with the inherent stability of this type of equipment, and its constant volume method of compression, it is ideally suited for heat recovery applications.

Helical axial screw compressor water chilling plant is not usually specified for air conditioning applications rated at less than 100 tons of refrigeration. Below this limit the reciprocating compressor type plant is generally selected since, at the present time, it is a more economical proposition.

Research into the use of screw compressors for the lower tonnage installations is taking place, with a view to competitive pricing in line with the reciprocating machines. It must be remembered that in certain low tonnage applications, the advantages of a screw type packaged chilling unit can outweigh those of the reciprocating machine if quietness of operation and vibration-free characteristics are called for. These factors must be considered at the design stage, especially if low load performance advantage and high coefficients of performance are required.

Condenser leaving water temp °F	*Condensing temp °F*	*Tons refrig*	*BHP*	*BHP TR*
85	95	202	167	0.83
'H' 95	105	195	182	0.93
105	115	186	204	1.09
'O' 110	120	173	222	1.28
115	125	167	236	1.41

'H' = hermetically sealed motor unit.
'O' = Open type motor unit.

In order to obtain maximum energy utilisation in the form of both heat reclamation and cooling from reciprocating chilling machines, it is necessary to reconsider traditional design temperature parameters in consideration of improved operating economy.

To make the most of a standard packaged chiller in terms of bhp, systems should be designed with chilled water entering the machine at 54° to 55°F and leaving at 44° to 45°F. Although larger heat transfer coils could be required to achieve room temperatures of 68° to 70°F, the extra cost of the coils would soon be absorbed in savings on running costs and reduction of package chiller size.

The initial extra cost incurred by larger units can of course be obviated if the user accepts an air conditioning scheme with an internal/external dry bulb differential of 10° to 15°F maximum — thus, room temperature tolerance would be increased to provide a maximum condition of 75°F instead of the present 70°F. An increase in internal design temperature can often be compensated by lowering the relative humidity without noticeable discomfort to the occupiers.

Critical sizing of the equipment is therefore of utmost importance if optimum running efficiency is required. In some cases, it may be necessary to undersize reciprocating equipment to ensure maximum full load operation and economy of horsepower. Screw chillers, on the other hand, do not require such critical selection owing to their better part load/power input curve. The common practice of continually adding safety factors is therefore quite futile, since it will only result in the continual part load operation of the plant, thus giving uneconomical performance as far as absorbed bhp is concerned.

Research into the application of low tonnage packaged water chillers in heat reclamation schemes has revealed that, with very slight modifications to existing standard equipment, such designs have become an economically viable proposition.

Such a project (*Figure 5*) would involve the use of a conventional water cooled packaged chiller or condensing unit with a single condenser. After circulating through the standard condenser, the condenser water is either diverted to a secondary heating circuit serving the building or, when heat is not required, passed through a closed circuit cooling tower to reject the heat to atmosphere. Although this scheme would involve additional costs in the form of a closed circuit cooling tower, as well as a possible increase in heat transfer coil size to provide optimum reclamation of low grade heat, operating economies would offset the additional expenditure.

A second project has also been considered, involving Dunham-Bush's Series 70 range of reciprocating compressor type water chillers. In this

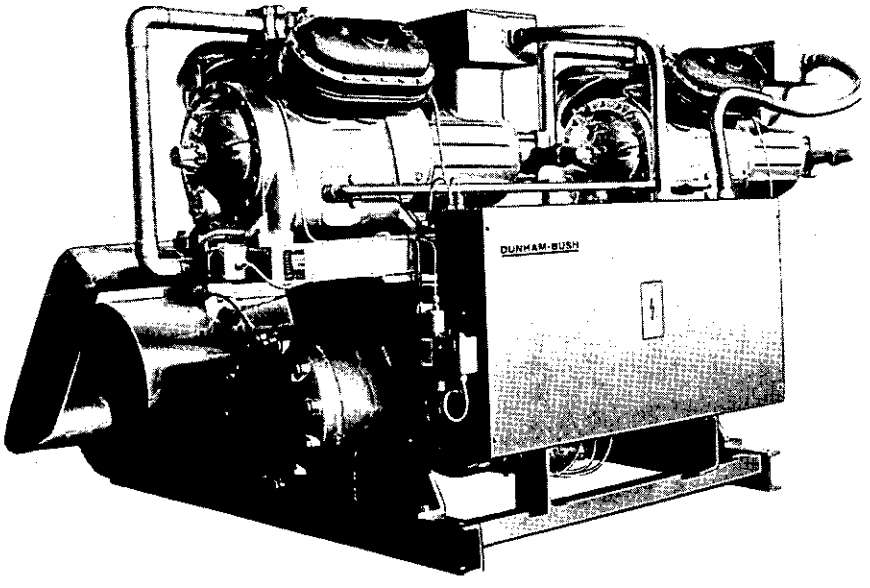

Figure 5. A conventional water cooler packaged chiller with a single condenser.

scheme, an additional condenser is fitted to the package, so that one condenser is used for heat rejection to a cooling tower of the open circuit type and the other is used as the heat reclaim condenser to provide a source of low grade heat. The second condenser would simply be mounted pick-a-back style on the standard unit (*Figure 3*).

There is little doubt that, with the increasing emphasis on plant efficiency, specifying authorities will be reviewing the application of this type of equipment to optimise energy usage instead of rejecting low grade heat to atmosphere. However, if maximum energy conservation and utilisation is to be achieved, it is increasingly apparent that closer co-operation between the consultant, refrigeration and air conditioning contractor, and the equipment manufacturer is required during the design stages to ensure the correct selection of plant and machinery. It is only at this stage that the major economies can be recognised.

It is obvious when designing that considerable thought must be given to the effect on plant size and performance during the greater part of the year of absolute maximum and minimum ambient temperatures. Heat reclamation systems of one type or another are not only viable but are absolutely essential if we are to conserve oil and other fuel resources. It should be realised that there are great advantages in using a manufacturer's range of standard equipment rather than custom built plant, operating at normal air conditioning temperatures (*ie* with condenser water leaving at 105°F to 110°F) in order to maintain a high COP and low equipment prime cost. There will always be occasions when equipment is required for an individual application, and providing the manufacturer has a large enough range of standard models these can usually be easily modified for a particular operating condition. The cost of building special units must be in excess of that involved in simple changes to standard equipment, thus achieving a worthwhile saving in capital investment.

In order to make the best possible use of energy within the building it is essential that all facets of the scheme are considered at the commencement of the project. This will mean close liaison between all those concerned with the design, not only of the structure, but of such items as glazing, lighting, occupancy and heat balance as well as the basic air conditioning/heat recovery plant and its associated controls. Providing these features are considered at this stage and full attention is given to them during the progress of the project, there is no reason why the principal of heat recovery should not be successfully applied irrespective of the size of the scheme involved.

This paper, by HM Senior Principal Inspector of Factories, was presented at a November 1978 Symposium organised by the Institute of Hospital Engineering.

The Work of the HSE as it Relates to Hospitals

R. J. ATKINS

The work of the Health and Safety Executive in relation to hospitals is a rapidly changing activity and in many ways the real development is only just beginning. On the other hand, limited contact between the Factory Inspectorate and the hospital authorities goes back many years.

It may help to give perspective to the subject if we regard recent developments as yet another stage in the application of Health and Safety

legislation to the occupational field. For example. the Factory Inspectorate has been engaged in monitoring standards and enforcing legal requirements at workplaces for almost 150 years. During that period the number and complexity of premises visited and legislation administered, has constantly increased with each successive major piece of legislation. In a very real sense the Health and Safety at Work Act is not only the latest of the series, it is the culmination, in the sense that it embraces all those premises not previously covered, of which health service premises are a very significant proportion. It is true, of course, that hospitals in this regard present some new problems, most particularly the risk of infection and the special consideration of patient care, but it is still useful to see the service in the wider context and also appreciate there are other large areas of activity brought under the legislation for the first time with not altogether dissimilar considerations, such as the field of education.

In addition to the Health and Safety at Work Act, the relationship between the Inspector and the hospital has been significantly changed by the domestic reorganisation of the Factory Inspectorate itself. In the first place in October 1974 the Health and Safety Commission was set up, followed by the Health and Safety Executive in January 1975. The Commission decides the policy for the Executive, which is its operational arm in the field. The Executive itself was formed from the various Inspectorates, such as HMFI and the Mines and Quarries, Alkali and Clean Air Inspectorates, each maintaining a large degree of autonomy as the members of each had their own expertise and were not interchangeable.

Secondly, the Factory Inspectorate was reorganised so that, instead of a District being looked after by a District Inspector and his staff who visited practically all types of premises subject to the legislation, his equivalent, a Principal Inspector and his Group of Inspectors, although covering a larger area, will now only be concerned with a limited occupational field. Consequently one group of Inspectors will now be responsible for all Health Service premises in their Area of the Executive.

One further innovation was the allocation of a co-ordinating role for a particular industry or field of activity to the Area Director and his Deputy, in each of the HSE areas *eg* Education in Scotland, the steel industry in Wales and the Health Services in the South West based around Bristol. Although the full implications have yet to be realised, its potential should not be underestimated, particularly when considering one of the fundamental problems of any national law enforcement body — how to ensure consistent standards of enforcement — and also the formulation of appropriate standards. I shall be returning to this topic later on.

Although the Factory Inspectorate was involved with hospitals prior to the HSW Act, to the extent of visiting those parts subject to the Factories Act and OSRP Act (which are, of course, still in force), the significance and the problems of extending this activity to the whole field of the health services, both public and private sectors, were not underestimated. In order to chart a way forward a pilot survey was set up in the NW Thames Region to examine the nature and extent of the problems likely to be encountered. This was undertaken with the close co-operation of the Department of Health and the resulting report, sometimes referred to as the Wood Report, was distributed to employing Health Authorities and employee national representatives during the summer, and its significance and HSE's approach to inspection were later explained and discussed in meetings with management representatives at centres across the country. Considerable comment has since been made by numerous bodies, including Institute of Hospital Engineering, and this will be digested by HSE and where necessary discussed with DHSS.

I do not propose to deal in detail with the Survey Report, but certain broad generalisations can be made:

— Many of the problems encountered by the Inspectors were familiar ones, although perhaps met in unfamiliar surroundings: mechanical risks, hazards connected with steam plant, highly flammable liquids and gases, toxic chemicals, problems arising from the use of ionising radiations in radiology and radiotherapy and the more everyday problems of lifting, handling, storage and good house-keeping.

— On the other hand there were hazards outside the experience of the average Inspector, being predominantly microbiological ones *ie* risks of infection.

— The team were very conscious of the unusual management structure in the Health Service and the degree to which the vital patient/doctor or nurse relationship affects employees and the work they are doing.

— Lastly, it was found that there was often what appeared to be a dearth of statistical information about accidents and cases of occupational disease. There, however, was a considerable quantity of information and advice on health and safety at work, available through the DHSS — although, because of the nature of the organisation there was no compulsion on the employers to follow it.

These, and numerous other considerations were taken into account by the Executive earlier this year when framing their programme for inspection and enforcement which was explained in a document entitled 'The Approach of the Health and Safety Executive to the Inspection of Hospitals and Health Services'. This has been given wide circulation within the Health Service and appeared in *Hospital Engineering* Vol 32 No. 7.

As I am sure you all read your journal assiduously, I shall not attempt to reproduce what is given in that document, but I should like to enlarge on certain of the matters referred to and also to speculate on the direction likely to be taken; for instance, how will inspectors approach their task? They will first need to meet the administration at various levels. Contact with the Regions will be necessary as they are, in certain contexts, employers — but for the most part the Inspector will be primarily concerned with the Areas and then the Districts.

Firstly, it is essential that the foundations be properly laid and there are certain basic requirements before progress can be made:

(i) There must be an Area policy for the health and safety of employees, which is not just a pious statement of intent, but also giving details of the organisation and arrangements for implementing that policy. It should set out the levels of responsibility and the degrees of delegation, the functional expertise available to advise management, a policy on training and supervision, the identification of the main hazards and the formulation of procedures for dealing with them.

This is not a paper exercise and we could well bear in mind the comment of the Robens Committee on this point:

'We have no doubt that the existence

of a clear and explicit statement of an employer's policy and arrangements for safety and health can be of genuine practical value. If all employees are to participate, they must know what the basic policy is and what arrangements exist for implementing it; and employers should be clear enough about their policy objectives to be able to set them down in writing. For those employers who have not already done so, the process of drawing up such a statement might be a salutory exercise'.

(ii) Another matter which the inspector will be interested is in the setting up of a system to record accidents and cases of occupational ill health, the investigation of these where appropriate and the use of this information in a constructive manner.

(iii) The inspector will also wish to see some arrangement, such as the appointment of a senior member of management, whereby the performance of the Area in this field is monitored to ensure that suitable progress is being made and that there is compliance with the employer's legal obligations.

Only after this initial approach has been made will hospital inspection, as such, proceed.

As much of this inspection, although not concerned specifically with workshops, will involve hospital engineers, it may be helpful if I refer to the question of standards.

Those parts of hospitals where the Factories Act applies should present no or few serious problems. There is a history of past inspection and the standards required in the Factories Act are usually adequate for the purpose.

In other parts of hospitals where only the HSW Act applies the situation is different. This Act does not set out detailed requirements, only broad duties placed on various groups of people, such as employers, employees etc. Consequently we need to look elsewhere for guidance as to what those duties entail — in effect, guidance on standards of good practice. This can be of various kinds:

a. It may be statute such as the Factories Act or the OSRP Act.

b. It may be BSI standards — a good example BS 5304 : 1975 Code of Practice on Safeguarding of Machinery.

c. In many cases DHSS technical guidance may be acceptable — although I will refer to this again later.

d. There may be a Code of Practice drawn up by a profession or an officially appointed committee. The Report of the Working Party under Sir James Howie on the Prevention of Infection in Clinical Laboratories is a good example. This Working Party was set up by DHSS from within the professions concerned. Its draft Code of Practice has been adopted by DHSS and, although not given the status of an Approved Code of Practice under the HSW Act, it has also been accepted by HSE as the standard to be enforced by Inspectors.

e. On the other hand there may appear to be no appropriate standard available and the HSE may have to draw up a standard after consultation with DHSS, manufacturers, our own specialists etc. An example of this is the guidance put out to Inspectors on standards of safety for laboratory centrifuges.

Inspection has been in progress now for several months but it is still too soon for the NIG to be aware of all the problems which are cropping up and it is probably premature to talk in terms of priorities. There are, however, certain areas which are likely to be of major concern. Examples of these are:

— Pathology laboratories. The Howie Report makes clear that there is much to be done. It also suggests a system of priorities based on degrees of risk and DHSS themselves are drawing up a programme for implementation, which they will recommend to AHAs. This may or may not be acceptable to HSE, who are likely to maintain a flexible approach according to the problems encountered. In certain cases major capital expenditure may be involved, but equally a number of matters are procedural, relating to methods of work or use of protective clothing and are in the 'no cost' or 'low cost' categories.

— Operating theatres. The DHSS has already put out guidance on the purging of anæsthetic gases. *Hospital Engineering* has contributed to the discussion, including an interesting article in the October 1977 issue on Waste Gas Systems (Vol 31 No. 8). However, it appears that probably no more than 33% of operating theatres are provided with scavenging systems. In addition further enquiries in this field may well be necessary, and this is of interest to the HSE.

Similarly problems exist with the general ventilation of operating theatres. For example, we have had HBN 26 since 1967, the Lidwell Report since 1972, but probably acceptable standards are reached in a minority of cases.

However, I should not like to leave you with the impression that all the problems are sophisticated, technical ones — there are numerous more mundane problems such as waste disposal, from the point where the item is discarded to the time it enters the incinerator, together with the need for segregation and identification. Not only your own staff, but various ancillary workers and porters can be exposed to risks of infection and various mechanical hazards. There are also long standing problems of lifting and carrying and patient violence.

It must be remembered that the inspector is not the only one who will be approaching you on matters of health and safety. For some time the Safety Representatives and Safety Committees Regulations have been in force, whether or not trade unions have availed themselves of their rights to appoint such representatives. I will not deal with the regulations in detail, if only because HSE has a limited involvement — most of the problems which are likely to arise will be in the field of industrial relations and be a matter for ACAS. But I should like to stress that from the very beginning these regulations have been seen as essential to the working of the HSW Act. Many if not most problems should be solved at the place of work and the intended system of self regulation will not be effective unless this machinery is made to work, and be seen to work. To encourage this the inspector will be increasingly reluctant to involve himself in approaches by employees until the existing machinery has been used to the full.

The Inspectors who will undertake this work will be HM Inspectors of Factories, but they may equally answer to the title of HM Inspectors of the Health and Safety Executive and in fact spend relatively little of their time on factory premises. In any case they will be specifically nominated to visit hospitals and other health service premises and have received special training for the work. In each HSE area there will be two and, perhaps later, three such inspectors. Their powers, which are set out in detail in s20 of the HSW Act, include the right of entry at any reasonable time — a right which it is essential to retain, but which in the hospital context will obviously need to be used with suitable discretion. It is likely that most or all of the initial

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round of visits will be made by appointment and, although this may well become less formal as the inspector establishes his contacts, there are obviously a number of departments where prior arrangements will always be necessary *eg* operating theatres, post-mortem rooms, probably pharmacies and treatment areas. In those areas where there has been periodic inspection for many years past, such as workshops and laundries, it is likely that existing procedures will be retained.

Although the inspector will be interested in all parts of the hospital, he will restrict his activities in certain respects:

(i) He will not be responsible for the enforcement of general fire precautions under the Fire Precautions Act 1971 which will be the concern of the Home Office and Scottish Home and Health Department. If a fire matter of serious concern comes to his attention which he cannot overlook, he will bring it to the attention of the management and the employees' representatives. He will, however, retain responsibility for enforcement in relation to 'process' fire risks *eg* the handling and use of highly flammable liquids.

(ii) The survey of plant, equipment and structures used for radiology and radiotherapy will be undertaken not by the inspector but by the National Radiological Protection Board, although he will be concerned with procedural systems and safety organisation in these fields and the NRPB survey report will be submitted to the Principal Inspector who will have responsibility for enforcing the recommendations.

(iii) The other limitation on the inspectors' activity will be that they will not concern themselves with the professional or nursing care of patients, nor the professional judgement involved. This is an area where further discussion is needed, but this is not likely to limit the inspectors' existing concern with systems of work or the fitness and maintenance of plant and equipment.

There is an important area where the inspector has an obligation which is particularly relevant to this subject, and that relates to the disclosure of information required by section 28(8) of the HSW Act.

Inspectors have always acknowledged a need to make contact with employees' representatives during the course of inspection, but this has now been made a legal requirement and formalised not only by the HSW Act, but by the Safety Representatives and Safety Committees Regulations 1978 which came into force on October 1, 1978.

Section 28(8) should be read in connection with section 2(2)(c) which places the duty on the employer to provide 'such information as is necessary to ensure so far as is reasonably practicable, the health and safety at work of his employees'. Also, of course, we must bear in mind section 2(6) which requires the employee to consult with the safety representatives appointed under the Regulations. Section 28(8) requires that the Inspector shall:

> 'in circumstances in which it is necessary to do so, for the purpose of assisting in keeping persons employed — or their representatives — adequately informed about matters affecting their health, safety and welfare, give to such persons, or their representatives, the following descriptions of information:
> a. factual information obtained by him which relates to those premises or anything which was or is therein, or was or is being done therein; and
> b. information with respect to any action which he has taken or proposes to take, in or in connection with those premises, in the performance of his functions'.

This information will most frequently be provided through discussion at the time of the visit and, where matters of serious concern are involved, this verbal advice could well be confirmed in writing, probably to a representative who has been chosen by his fellow representatives to receive written communications from the enforcing authority. The safety representatives will also be consulted when certain enforcement procedures are followed.

You will, I am sure, already be aware that the normal procedures of enforcement through the courts or by the service of Improvement or Prohibition Notices is not available to the inspector in relation to hospitals in the public sector, as these are deemed to be Crown Premises* and exempt from this form of enforcement. However, for the time being at least, a 'Crown Notice' procedure will be available to the inspector in those situations where a Notice under sections 21 and 22 of the HSW Act would otherwise have been used. Such a notice can only be served on an employing Authority and not on an employed person. In the case of a failure to comply with the terms of a notice the matter will be referred to a higher level in the respective organisations in order for the matter to be resolved. When the notice has been served on the employer a copy will be supplied to the appropriate Safety Representative.

I referred earlier to the new concept in the HSE of the National Industry Group (NIG). Since its inception the NIG for the Health Services has become increasingly involved in preparing the ground for the routine inspection of hospitals, which finally started a few months ago. For instance, it has been concerned with the training of inspectors for hospital inspection and the drafting of guidance to inspectors on a variety of matters. More recently it has been involved in discussions with professional associations and trade unions, with manufacturers of equipment and various branches of the DHSS. In particular it has been consulted by the Department on guidance issued to the Health Authorities relating to safety, health and welfare, on interpretation of statutory requirements and in order to resolve specific problems which have arisen during visits to hospitals by inspectors.

It is not necessary to stress here the volume and scope of technical guidance issued to Health Authorities by the Department and the fact that much of this — although fortunately not all — is relevant to matters that will concern inspectors during the course of their visits. It will thus be necessary to consider whether there is any disparity between the standards embodied in these publications, on the one hand, and the standards envisaged by statute, on the other. In order that this assessment may be made in an orderly fashion it has been agreed that these standards will not be contested by the inspector in the field, but that any doubts or misgivings will be referred to the NIG for discussion with the appropriate Technical Branch of the Department. At the same time we have been invited to comment on new or reissued publications and those already in existence will gradually be scrutinised as the occasion arises.

This *ad hoc* arrangement for consultation with the Department must be regarded as an interim measure which has distinct limitations, and some more formal and more representative machinery is both desirable

*Except in Scotland.

and necessary. The form this will take has yet to be decided, but if we look at other fields of activity where this form of consultation is more advanced, it is clear that one possibility would be the setting up of an Industry Advisory Committee, on which both employers' and employees' representatives would sit, and would meet to discuss their problems jointly, with the participation of HSE. This still lies some way ahead and for the present the Inspectorate's main concern is to progress with a programme of work which aims to complete an initial round of inspections to health service premises, in both the public and the private sectors, over a period of five years.

Problems will, of course, arise and many of these will have to be solved by consultation and discussion with members of the Institute. There can be no doubt that the aim of the inspector, to improve the standard of health, safety and welfare in the service, will be shared by yourselves, and this aim must always be kept in the foreground. The question of resources is obviously one which everyone must take into account and, inevitably, priorities will have to be decided. However, this will not be new to the inspector — his training and work in the field will have accustomed him to a practical approach to such problems. At the same time we must remember that there are now — and have been since April 1975 — legal requirements with which to comply and ample evidence that standards in health and safety in the service are not always at a satisfactory level, in spite of the considerable effort and resources put into this field. It is clearly in the interest of no-one to perpetuate this state of affairs. It is also clear that much will depend on the close liaison between yourselves as hospital engineers and the inspector in the field. It is hoped this paper will help to consolidate the existing relationship and make for a mutual appreciation of each others' problems.

Product News

The Manchurian Waste Compactor

The Manchurian Compactor is of robust steel construction producing bales 54 inches × 30 inches × 42 inches. It measures 13 feet 6 inches long × 46 inches wide × 71 inches high including the loading hopper. The Compactor consists of a hydraulic power pack which supplies pressure to a hydraulic cylinder positioned horizontally on the machine. The cylinder is attached to the baling head which compresses the waste material into bales. The density of the bales are determined by a pressure relief valve built into the hydraulic circuit which can be adjusted to suit various densities. Control is manual/automatic to the electric motor, which is coupled to the hydraulic power pack. The sequence of operation is to feed waste material into the hopper which is mounted on top of the baling chamber. The level of this material is controlled via photo cells positioned each side of the hopper. When the baling chamber is full the photo cells signal the baling head to compress the waste material into the end chamber. The baling head then returns from the partly filled end chamber to await further waste material from the hopper so that the operation can be repeated until the end chamber is full. When the baling is complete, wires can be passed through pre-determined slots and tied. The front hinge door is released so that the bale can gradually be pushed out.

The Waste Compactor easily compresses and bales bulky chunks of paper, computer tape, plastic, cellophane, cardboard, newspaper and polythene film.

Further details from FHD Construction Ltd, 124a/130 Edinburgh Avenue, Trading Estate, Slough, Berks. Tel: Slough 28321.

A bale ready for disposal.

Engineers' Hypodermic Probes

A range of four hypodermic probes, with thermocouple or platinum resistance thermometer (RTD) elements, is now available from Ancom Ltd, the Cheltenham-based temperature measurement specialist company. These instruments are designed for industrial, laboratory, manufacturing and research use.

Three of the four probes — HYP-1, HYP-2 and HYP-4 may be used with steam autoclaves.

HYP-1 is a very delicate instrument used primarily in research to obtain instant readings in plants, other semi-solids, and liquids. It has a very fine needle, 30 gauge (0.12 inch outside diameter), which is only ¼ inch long, attached to a copper/constantan (type T) thermocouple element. The measurable temperature range is cryogenic to +400°F.

HYP-2 incorporates the same type of thermocouple, but it is provided with a more robust — 21 gauge (0.032 inch outside diameter) — and longer — 1½ inches needle.

HYP-3, the only model which must not be used with steam autoclaves, is designed for heavy duty and so has an even stronger needle, 16 gauge (0.072 inches outside diameter), which is also 1½ inches long. A choice of iron/constantan (J), cromel/alumel (K), and cromel/constantan (E), as well as copper/constantan (T), thermocouples to cover different applications and ranges of temperature, is available.

HYP-4 employs, not a thermocouple, but a platinum resistance thermometer (RTD) as the sensing device, associated with the same 16 gauge 1½-inch needle used for HYP-3. The advantages of an RTD sensor is that it does not require a reference junction which is essential when a thermocouple is employed.

For further information, please contact: Mr N. MacDonald. Tel: 0242 53861/24690.

Portable Accommodation Brochure

Presco International Ltd, of Newtown, Mid-Wales, manufacturers of a range of factory-built accommodation,

has published a new colour broadsheet showing the Steelclad range of instantly portable accommodation units.

A large section of the publication shows detailed layouts of the 29 standard models which include chassis mounted mobile offices and Health and Welfare units, toilets for accommodating 50-200 persons, shower units, canteen/kitchen units and partitioned and open plan offices up to 48 ft × 12 ft (14.3 m × 3.66 m) floor area.

Details of the Presco Steelclad service and regional sales and hire depots covering the British Isles are also included.

The brochure is available from: Presco International Ltd, Mochdre Estate, Newtown, Powys SY16 4LD. Tel: 0686 25698.

Glass Fibre Sectional Tanks

Harvey Fabrication offer a wide range of glass fibre tanks, including sectional tanks constructed from rectangular GRP panels which are bolted together on site to form the required size of tank. The panels have a flat, smooth surface and are coloured black on the inside of the tank. The exterior surface incorporates a grey diagonal cruciform rib. The panels are supplied pre-drilled and complete with nuts and bolts and sealant ready for erection on site.

Nuts and bolts are zinc plated, and other metal fittings are suitably protected against corrosion where necessary. A butyl rubber-based sealant, which is odourless and non-toxic to drinking water, is used.

A wide standard range is available — from a nominal capacity of 3.56 gallons up to 14,080 gallons. Special tanks can also be made to suit individual requirements.

For further information, please contact: Tim Eldridge, Harvey Fabrication Ltd, Woolwich Road, London SE7. Tel: 01-858 3232.

Auto Temperature Controller

A new Automatic Temperature Controller for minimising power consumed by evaporation cooling towers is being marketed by Hamon-Sobelco Ltd.

Their automatic temperature controller automatically compensates for variations in cooling water temperatures by switching cooling fans on and off as required by controls on the auto controller. At night, or during winter, for example, as ambient temperatures fall, the auto controller will progressively shut down cooling fans to maintain a pre-selected cooled water temperature. Thus, not only is power consumption reduced without impairing cooling tower efficiency, but noise levels are also lowered.

In the event of a fan malfunction, the auto controller can be set to switch on a standby unit.

Because it harmonises the operation of cooling fans for even distribution of operation, there is a parallel gain in minimising unequal motor wear.

The Hamon-Sobelco automatic temperature controller is a totally enclosed, free standing unit, occupying small floor space. Internally, the functions performed by the auto controller are effected by purpose designed interchangeable solid-state printed circuits on pull-out cards.

For further information contact: Mr R. Butler, Regency House, 1/4 Warwick Street, London W1. Tel: 01-434 1273/6.

Classified Advertisements

APPOINTMENTS AND SITUATIONS VACANT

Hertfordshire AREA HEALTH AUTHORITY

NORTH WEST DISTRICT

DISTRICT ENGINEER

Salary Scale: £6,858-£8,160 pa plus Outer London Allowance £141 pa.

This post has fallen vacant due to the promotion of the present post holder. Applicants must have a sound knowledge of the maintenance of engineering services and equipment in buildings, and preferably have hospital experience.

The district includes Hemel Hempstead and St. Albans and has a wide range of hospital buildings. The total number of hospital beds is approximately 3,600.

Only suitably qualified and experienced engineers will be considered and the essential and appropriate and minimum qualifications are specified in relevant circulars.

Those seriously considering applying may obtain further details by ringing the Area Works Officer, Mr A. J. Barrett, on Hemel Hempstead 61663, ext. 270.

Application forms and job description available from Area Personnel Officer, Hertfordshire Area Health Authority, Hamilton House, 111 Marlowes, Hemel Hempstead, Herts. Tel. 61663, ext. 278.

Closing date: March 2, 1979.

SEFTON AREA HEALTH AUTHORITY
(Northern District)

DISTRICT WORKS OFFICER
£7,113-£8,463 per annum

Applications are invited for the above post which is based in Southport. The successful candidate will be responsible for the management of the District Works Department involving maintenance of building and engineering services in seven hospitals, plus Health Centres and Clinics. A Nucleus hospital is projected for Southport in the 1980's.

Experience in the maintenance of large buildings essential, preferably in the NHS.

Applicants must hold a qualification in accordance with paragraph 2541 of the PT'B' Handbook which is basically an HNC or HND in building or engineering with various additional subjects.

Application forms and job descriptions from Area Personnel Officer, Sefton Area Health Authority, Merton House, Stanley Road, Bootle, Merseyside L20 3BA (Tel: 051-922 7252, Ext. 37), to whom they should be returned by February 16, 1979.

Closing dates

Recruitment advertisers are requested to set closing dates no earlier than three weeks after publication date of the Journal.

Monthly publications do not receive preferential treatment by the Post Office and circulation lists in hospitals also delay receipt of the Journal by many potential applicants.

SANDWELL AREA HEALTH AUTHORITY

Assistant Area Engineer

Salary: £5,328-£6,309 pa

This newly created post will offer a challenging opening for a professional engineer with a sound knowledge of engineering design, construction and maintenance.

The person appointed (male/female) will be required to assist the Area Engineer in his full range of duties, with particular responsibility for the engineering design and management of capital schemes.

Sandwell is a single district Area Health Authority comprising seven hospitals, 22 clinics and four health centres, and is situated between Birmingham and Wolverhampton, close to the Midland motorway network, providing easy access to many areas.

Applicants should have a minimum of HNC in mechanical or electrical engineering with industrial administrative endorsements. A list of alternative qualifications will be provided with the job description on application.

Job description and application form may be obtained from the Area Personnel Officer, Sandwell Area Health Authority, Shaftesbury House, High Street, West Bromwich. Tel: 021-553 6151, Ext. 292.

Closing date for applications: February 16, 1979.

CUMBRIA AREA HEALTH AUTHORITY
EAST CUMBRIA HEALTH DISTRICT

SENIOR ELECTRONIC TECHNICIAN II

(£4,470-£5,610 pa)

Due to promotion we require an Electronic Technician who is qualified to HNC standard and has more than three years' Health Service experience. He/she will lead a team providing an electronics service to the East Cumbria Health District and will assist in the maintenance of specialist equipment throughout the area as required.

The post is based at the Cumberland Infirmary, Carlisle, which is situated in a rural area near the Scottish Border, Solway Coast and Lake District. Car driver essential. Temporary single/married accommodation is available.

Further particulars and application forms from the Personnel Officer, District Offices, Cumberland Infirmary, Carlisle. Tel Carlisle (0228) 23444, Ext 469.

Closing date: February 19, 1979.

SOUTH WESTERN REGIONAL HEALTH AUTHORITY

Re-Advertisement

STERILIZER TEST ENGINEER
Technical Assistant — Grade 1
Salary Scale: £4,641-£5,478

Post based at Derriford, Plymouth, to cover work in Southern part of the South West Region. Duties include commissioning and testing of Hospital Sterilizers.

Experience in sterilizer maintenance required, but further training available.

Relevant ONC or acceptable alternative qualification essential; HNC preferred.

Application form and job description available from Regional Personnel Officer, Establishment Section, UTF House, 26 King Square, Bristol BS2 8HY.

Closing date: February 19, 1979.

REGIONAL ENGINEER

Salary Scale £11,022-£13,335

Applications for this post are invited from Chartered Engineers, who are corporate members of one of the following: ICE, IMechE, IEE, IERE, CIBS.

The post carries responsibility for the engineering content of a major building programme, and for monitoring the operation and maintenance of existing engineering services.

Applicants should have considerable experience of the design of building services, preferably including hospitals. An age range range of 35 to 50 is preferred.

Further details and application form from: The RHA Section, Personnel Division, Cumberland House, 200 Broad Street, Birmingham (021-643 5781, Ext. 69) to whom completed application forms should be submitted by: February 28, 1979. In all correspondence please quote reference G76/HE.

West Midlands Regional Health Authority

To place an advertisement in the next issue of **HOSPITAL ENGINEERING,** appearing in **March, 1979,** please contact:

EARLSPORT PUBLICATIONS, 17 St. Swithin's Lane, London, EC4, 01-623 2235/8, by **February 20,** latest.

MOUNT VERNON HOSPITAL
NORTHWOOD, MIDDLESEX
Tel. Northwood 26111

ENGINEERING CRAFTSMAN GRADE 5

Applications are invited for the above vacancy from experienced engineers who have completed an apprenticeship and possess a recognised trade certificate, preferably the City and Guilds Electrical Technician's Certificate No 57 Part 1 or the Mechanical Engineering Technician's Certificate No 293 Part 1.

Basic Wage: £76.02 plus £6.68 per week London Weighting.

Application forms available from Personnel Department, ext. 388.

SHEFFIELD AREA HEALTH AUTHORITY (TEACHING)

National Self-Financing Incentive Bonus Scheme for NHS Maintenance Departments

PLANNER MANAGERS

(2 posts)

Salary: £4,497 to £5,073 pa, plus bonus payments (current maximum 15%)

Negotiations are proceeding with staff side bodies to secure the implementation of the National Incentive Bonus Scheme. A Planner Manager is now required for each of the two Districts that constitute the Sheffield Area Health Authority (T).

The successful candidates will be accountable to the District Works Officer (or his nominated officer) and will assist with the local implementation of the National Incentive Bonus Scheme and manage a team of planners/estimators. It is anticipated that experience as a Planner Manager will be useful in career progression to a post of Senior Engineer.

Training will be given and attendance will be arranged at courses organised nationally by the DHSS at Slough and the Hospital Engineering Centre, Falfield.

Candidates must hold an ONC in Engineering or a higher qualification (alternative qualifications, as determined by the Secretary of State, may be acceptable).

An apprenticeship in mechanical or electrical engineering and five years' relevant experience should also have been completed.

Application forms and job descriptions (both posts) are available from Acting District Personnel Officer, Northern General Hospital, Sheffield S5 8AU. Telephone 387253, Ext. 760.

Closing date: February 14, 1979.

AREA ENGINEER

Applications are invited for the post of Area Engineer to the Redbridge and Waltham Forest Area Health Authority.

Candidates must be Corporate Members of the Institutions of Civil, Mechanical, Electrical or Electronic and Radio Engineers, and able to demonstrate —

(a) Sound knowledge of engineering design and construction — preferably in a large undertaking concerned with construction, operation and maintenance of sophisticated engineering plant, equipment and services in a health and social services context; and a good working knowledge of engineering techniques and standards. Detailed knowledge over part of this field desirable.

(b) Managerial experience with an ability to understand and work in close co-operation with building interests and needs; and an ability to communicate and work with officers of other disciplines and at other levels.

Salary Scale: £8,370 rising to £9,882 per annum inclusive. Single accommodation may be available.

Application form and job description obtainable from the Area Personnel Department, PO Box 13, Claybury Hall, Woodford Green, Essex IG8 IDB. Tel: 01-505 6241, Ext. 27.

Closing date: February 16, 1979.

Informal enquiries to Mr P. E. Somers, BA, CEng, MIMechE, MIMarE, Area Works Officer. Tel: 01-505 6241.

Redbridge and Waltham Forest AREA HEALTH AUTHORITY

Sterilizing Equipment Co. Ltd.

Do your Autoclaves meet today's standards?

We offer a comprehensive programme for carrying out a survey of your autoclaves, advising on any modifications which are required and upgrading and testing them to conform to the latest standards.

Our consultation and advisory services are available to determine sterilization processes and systems best suited to the needs of the Health Services.

Contact us to discuss methods of improving your present sterilizing facilities.

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