MANPOWER DEVELOPMENT FOR
A HEALTH CARE TECHNICAL SERVICE

Report of the World Health Organization Interregional Meeting on
Manpower Development and Training for Health Care Equipment
Management, Maintenance and Repair

cosponsored by

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The report was prepared by:

Mr Hans Halbwachs, Technical Adviser/Project Coordinator, Health Care Technology, German Agency for Technical Cooperation (GTZ), Eschborn, Federal Republic of Germany

Dr Andrei Issakov, Medical Officer, Division of Strengthening of Health Services, World Health Organization, Geneva, Switzerland

Mr Thomas Judd, Division Manager, Biomedical Services, Hospital Corporation of America Management Company, Membership Chairman, American College of Clinical Engineering, Marietta, Georgia, USA

Dr Andreas Mallouppas, Head, WHO Collaborating Centre for Training and Research on Maintenance and Repair of Health Care Equipment/Eastern Mediterranean Regional Training Centre, Nicosia, Cyprus

Professor Joseph McKie, Director, Department of Clinical Physics and Bioengineering, West of Scotland Health Boards and University of Glasgow, Glasgow, Scotland, UK

Editors:

Dr Andrei Issakov
Dr Andreas Mallouppas
Professor Joseph McKie
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1. INTRODUCTION

The Interregional Meeting on Manpower Development and Training for Health Care Equipment Management, Maintenance and Repair was held in Campinas, Brazil, on 20-24 November 1989.

The meeting was organized by the World Health Organization, Division of Strengthening of Health Services, and was hosted by the Ministry of Health of Brazil, the Health Secretariat of the State of Sao Paulo, and the State University of Campinas. It was co-sponsored by the United Nations Industrial Development Organization (UNIDO), Commonwealth Secretariat/Commonwealth Association of Polytechnics in Africa (CAPA), German Agency for Technical Cooperation (GTZ), International Federation for Medical and Biological Engineering (IFMBE), and International Federation of Hospital Engineering (IFHE).

The meeting was attended by 22 participants from 16 countries and representatives of co-sponsoring agencies.

At the opening session chaired by Dr Alberto Cliquet, Assistant Professor, Centre of Biomedical Engineering, State University of Campinas, Dr Fernando Lopez, Director General of the University Hospital, on behalf of the President of the State University of Campinas welcomed the participants to Campinas and wished the meeting successful and fruitful work.

Dr Andrei Issakov, Division of Strengthening of Health Services, WHO, Geneva, on behalf of WHO thanked the Ministry of Health of Brazil, the Health Secretariat of the State of Sao Paulo and the State University of Campinas for hosting the meeting and welcomed the participants to the second WHO Interregional Meeting on the subject of management, maintenance and repair of health care equipment. He also thanked UNIDO, Commonwealth Secretariat, CAPA, GTZ, IFMBE and IFHE for co-sponsoring the meeting.

Dr Issakov noted that effective management and maintenance of health care equipment are vital prerequisites for the quality and efficiency of health care delivery in any country. However, most developing countries, where a wide variety of equipment at all levels of sophistication exists, seldom have more than half of it in usable condition. The underlying reasons for this situation, e.g. lack of awareness, specific policies, information support, and infrastructure including adequate facilities and qualified manpower, leading to an inadmissibly high wastage of limited resources and deterioration of quality of health care delivery, were highlighted at the first WHO Interregional Meeting held in Cyprus in November 1986 which also identified key areas for future action.

Since the Cyprus meeting considerable progress was achieved in strengthening international cooperation and coordination of related activities and important steps were made towards promoting a comprehensive approach at all levels to strengthening national capabilities in the field of management, maintenance and repair of health care equipment through developing health care technical service (HCTS) as an essential part of health systems based on primary health care. This became possible due to efforts within the WHO Global Action Plan developed on the basis of the recommendations of the Cyprus meeting and launched in 1987.

However, Dr Issakov observed that, although the Global Action Plan, being the first attempt to tackle the problem of health care equipment management, maintenance and repair in developing countries in a comprehensive, coherent and coordinated manner, is now widely recognised and referred to as the right path towards rectifying the present unsatisfactory situation, it is only the beginning of a long road and there are many unfulfilled needs worldwide. Successful experiences were developed in several countries of all WHO regions, close links were established with several international organizations, international professional federations, donor agencies and national institutions and a number of important initiatives were launched, but on a global scale progress is painfully slow.
Dr Issakov indicated that one of the most severe problems facing developing countries in this field is a general lack of awareness, management expertise and technical competence which does not allow effective management, maintenance and use of health care equipment. Many training programmes were usually focused only on the technician level, sometimes in quite narrow fields, disregarding the need for a wide spectrum of staff required for a HCTS, complexity and interdisciplinarity of training in question and were disconnected from the other components of manpower development process such as manpower planning and manpower utilization. This was compounded by lack of collaboration and coordination between the agencies planning and executing such programmes. Thus the results were far from anticipated.

As recommended at the Cyprus meeting manpower development is integrated into the Global Action Plan as one of its major priorities and is addressed as a comprehensive systematic process within HCTS involving manpower planning, training and utilization and catering for all levels and types of required personnel. In order to realise this it is necessary to review the experiences of various countries and agencies, to identify successful approaches as well as problems to be solved, to exchange information on crucial issues of manpower development for HCTS, to strengthen links amongst all those concerned making the further step towards an international training network for biomedical, clinical and hospital engineering.

Dr Issakov finally outlined the objectives of the meeting as follows:

- to discuss priority issues related to HCTS’s manpower requirements, planning, training and utilization;
- to outline specific features of the training programmes for various levels and types of required personnel;
- to exchange information concerning the work of existing training institutions and to identify future training needs and activities;
- to elaborate recommendations to countries, WHO, other international organizations and donor agencies for strengthening manpower development and training for HCTS particularly regarding the development of an international network of training institutions in this field.

He believed that this meeting would provide a unique opportunity for experts from selected countries, both developed and developing, as well as from several international and national agencies to exchange ideas and to work out recommendations for further action and thus achieve its objectives.

In opening the meeting, Dr Binseng Wang, Equipment Adviser to the Secretary of Health, Health Secretariat of the State of San Paulo, welcomed participants on behalf of the Ministry of Health and the Health Secretariat. He noted that recent efforts of WHO, particularly following-up the first Interregional Meeting in Cyprus in 1986, helped to bring the attention of health authorities around the globe to the problems related to the introduction of technology into health care with special emphasis on the need of qualified personnel to organize and manage the service, and to maintain and use equipment, as well as to motivate many developing countries to review their policies, or the lack of, towards management, maintenance and repair of health care equipment.

Unless developing countries establish effective HCTS including specific policy, planning process, physical infrastructure and well-trained manpower, it is useless making large investments into health care equipment using their precious limited resources. Instead of being the tool to expanding the coverage and improving the quality of health care, improperly managed equipment will only bring more problems and demand more money for maintenance and imported supplies and thus turn itself into a burden on the health care system monopolizing all available attention and resources.

Dr Wang described the efforts of the Health Secretariat of the State of San Paulo to formulate and implement a comprehensive and coordinated health care equipment policy for the public health system of San Paulo State, as well as similar programmes introduced in
other Brazilian states. He emphasized that along with certain successes achieved there are many problems and unfulfilled needs encountered within this process and noted that similar situations exist in other developing countries.

Dr Wang thanked WHO for holding the meeting in Brazil and particularly in Campinas which he considered to be a reflection of the high international standing of the Centre for Biomedical Engineering of the State University of Campinas and a unique opportunity for the Brazilian hospital engineers attending the 6th National Seminar on Hospital Maintenance being held simultaneously with the WHO Interregional Meeting to meet with the experts from other parts of the world.

Finally Dr Wang indicated that this meeting would help to maintain the momentum started three years ago in Cyprus and looked forward to its recommendations which will provide developing countries with new tools to find enduring solutions to improve management, maintenance and repair of their health care equipment in general and to ensure an adequate manpower development process for their HCTS in particular.

After the opening session Dr Andreas Mallouppas, Cyprus, was elected Chairman, Mr Hans Halbwachs, Federal Republic of Germany, Mr Thomas Judd, United States of America, and Professor Joseph McKie, United Kingdom, Rapporteurs. The participants were divided into three working groups and subsequently worked in plenary and in working groups.
2. BACKGROUND AND SITUATION ANALYSIS

2.1 Background

The first Interregional Meeting on the Maintenance and Repair of Health Care Equipment was held in Nicosia, Cyprus, in November 1986. It covered a wide range of topics and made an equally wide range of recommendations to deal with the problems which were identified.

This second interregional meeting held in Campinas, Brazil, from 20-24 November 1989, focused its attention on part of the problem of management of health care equipment, namely the development and training of the manpower necessary for equipment management. However, as many of the participants at Campinas were attending the first meeting on this broad subject, and because some wider issues continued to be matters of concern to all participants, this report will inevitably touch on a number of topics beyond the narrower scope and make recommendations on other related issues.

The extent to which equipment available to health care professionals in the developing countries fails to be useful because it is not adequately managed and maintained has been well documented in the Cyprus report and in subsequent publications. New country reports and updated experiences presented at this meeting show that this remains a severe problem, although certain progress was achieved in introducing a comprehensive approach to health equipment management and in strengthening international cooperation and coordination due to the efforts within the WHO Global Action Plan on Management, Maintenance and Repair of Health Care Equipment launched by WHO as a follow-up to the Cyprus meeting.

The Cyprus meeting emphasised the need for awareness of the importance of wise and efficient management of technology and associated equipment, if health services are to be efficient and cost-effective; it pointed out that mismanagement of this aspect of health care can waste resources on a scale greater than that due to mismanagement of drugs, which attracts greater attention. It underlined the need for countries to formulate and implement policies relating to the planning, requirements assessment, selection, procurement, standardisation, safety, efficiency and maintenance of equipment. It recommended that each country should establish a HCTS appropriate to its system of health care delivery and outlined a structure which could serve as a model for many developing countries. The Cyprus meeting then considered the manpower requirements for an HCTS, including that part of the service which, within the health ministry, would formulate the policies and would organise and manage the necessary infrastructure.

In many countries the development and training of the necessary manpower continues to present great difficulty. The principles underlying the required action were formulated in the Cyprus meeting and presented in its report but have remained difficult for many countries to understand, accept and especially to implement. For this reason, the subject of manpower development and training is the focus of this meeting.

2.2 Situation analysis

In most countries it is possible to train craftsmen who will perform technically simple tasks on equipment which is not exclusively used for health care - technical schools and craft-training institutions can do this training.

A higher level of technical comprehension and ability, and some understanding of specific mechanical usage is needed for basic and essential tasks of maintenance and repair of a wide range of simple clinical equipment and hospital plant: for this work it is common to employ polyvalent technicians. Here the training presents more difficulty since a typical college technical school will not have staff who have the necessary knowledge and experience of medical equipment and of the medical environment; it will not have the range of equipment needed for training purposes.
In some countries the programmes necessary for this training are being developed within existing education establishments with the help of international organizations and donor agencies from developed countries. Others send staff to the regional or interregional training centres supported by WHO and/or other organizations. Many of these centres also suffer from problems of shortage of training staff and facilities. There is often a language problem when staff at this level are sent for training out of their countries.

Most of the existing training programmes within developing countries attempt to train persons for duties across the craftsman-polyvalent technician range. Even when the training is successful, the contribution to the solution of the national problems is disappointing because the potential of such staff is realised only if they are managed by staff with superior technical and managerial knowledge and superior status who can establish working priorities, provide the required infrastructure to work in and relate to the other health care professionals as well as to other sectors.

A higher level of technical understanding and competence is needed not only for management of lower-grade staff but to maintain and repair the great variety of more complex equipment and plant; where detailed knowledge of electronic and mechanical engineering must be combined with fault-finding skills and the ability to devise innovative solutions, to communicate with manufacturer's engineers, to read and understand service manuals, etc. There are few countries which can give systematic training at this level; where this is done there is heavy reliance on expatriate trainers. A small number of staff receive training in developed countries but the knowledge gained is seldom transferred and the skills acquired are sometimes not practised after return because very often those programmes are not designed to meet specific needs of developing countries.

This training can be received in a few regional and interregional training centres, but not in all; even those centres which are capable of doing so are under-resourced.

Consequently there are very few staff capable of working at this intermediate level.

At the highest level of responsibility there are no systematic training programmes available which are tailored specifically to the needs of health care in developing countries. Few ministries have staff who have the appropriate standard of technical knowledge and of these few if any have management skills. Ministries may be able to recruit an expatriate or a person who has gained experience abroad, but systematic development of suitable staff is not yet possible.

Recently WHO, UNIDO and IAEA in collaboration with several donor agencies initiated a series of short courses on maintenance management for senior staff from developing countries. Also a project to establish an international school on management of health care equipment and technical support services is being planned by WHO.

Overall, there is a lack of understanding of the appropriate types of staff needed, of the priorities to be adopted, of the number of staff required, of the levels of training which should be provided in the country and the human and other resources needed for this training, of the duration and contents of courses, of methods of validation of training and of the value of continued in-service training and career development.

Amongst training centres there is insufficient exchange of information, staff and training materials. As a result there is a lack of sharing of experiences and expertise as well as unnecessary duplication in many efforts including the production of some materials whilst there is no effort being made to produce those at present unobtainable.
3. **KEY ISSUES IN MANPOWER DEVELOPMENT FOR HEALTH CARE TECHNICAL SERVICE**

3.1 Manpower Planning

To establish an effective HCTS, it is necessary to develop a wide range of staff who will be based at various levels of health care delivery, from the Ministry of Health to the first referral level. Through this range there will be a variation in the mix of technical and managerial components in the individual’s duties and responsibilities; for those working at Ministry level the managerial component will approach 100 percent whereas the craftsmen performing routine maintenance in a small, district hospital will have a technical component approaching 100 percent. Many key positions in the service will be filled by persons whose responsibilities are almost equally divided between technical and managerial duties.

In a service which is well-established and highly developed it is possible to identify many different levels of healthcare engineering staff and to distinguish between the knowledge, skills and abilities required. By classifying the medical devices according to the annual hours of servicing needed and surveying a country’s inventory of equipment, it is possible to utilize a matrix which matches people and their expected productive outputs, and a matrix which identifies the preventive maintenance times and repair times of different classes of devices, and to derive the manpower needs of the country. Having established the appropriate occupational classifications and surveyed the pool of technical labour available in the country, plans can be formulated to get these to the required levels to meet the determined needs. A model for such calculations is presented in Working Paper No. 2 prepared by Y. David, T. Judd, R. Morris and F. Painter.

The meeting recognized that it will not be possible to survey the available equipment, apply standard servicing times, establish appropriate occupational classifications and calculate realistic manpower needs in a country which is at an early stage in the development of a HCTS, which lacks even the skeleton of an infrastructure for the service and which has too few technically-experienced persons to assess the inventory of usable or potentially usable (i.e., economically repairable) equipment, the pool of available technical manpower and the technical classification levels which will be attainable in the short-term.

At this early stage of development of an HCTS - and without any desire to limit the future development of more sophisticated and more detailed classifications - the meeting recognised that the spectrum of abilities and of mixtures of managerial/technical responsibilities could be usefully simplified into three broad ranges which were designated A, B and C in order to avoid confusion due to differences in national understandings of terms such as engineer, technician, etc. Countries will have their specific terms for categories of staff which may overlap these ranges, but the important requirement is that a country’s HCTS must allow for the presence of staff with abilities and responsibilities which cover each of these broad ranges.

Staff range A have duties which are predominantly technical, ranging from 100 percent technical, 0 percent managerial to around 60 percent technical, 40 percent managerial. The level of technical complexity remains comparatively low throughout the range. In most countries this range will include many grades of craftsmen, craftsmen supervisors, and polyvalent technicians who are limited in skills and/or experience.

Staff range B have duties in which the managerial responsibilities are more important, ranging from about 20 percent to 80 percent, and whose technical responsibilities are considerably more complex than those of range A. Some of the more experienced and/or more able of the polyvalent technicians in developing countries will enter this range. It will include most of the technicians or BMETs of developed countries and some of the less experienced engineers. Most in this range will have had substantial technical education in college or university since leaving school, with specific training in health care technology.
Staff range C will have duties which are predominantly managerial, the technical component will be demanding and complex. There will be staff in this range who are responsible for policy decisions at ministry level, for managing the HCTS at national, regional and hospital level; it will include senior engineer grades (or equivalent scientific grades) and possibly a few of the most senior EMETS.

The responsibilities and attributes of these three ranges of staff are suggested in more detail in working paper 1, prepared by J. McKie, and also in the report of the Cyprus Meeting, working paper 2, paragraphs 142-150.

The meeting emphasised the importance of giving attention to the staff in range B at the commencement of an HCTS, as these persons can undertake a wide range of technical tasks and manage much of the work of the service.

In many countries there is a sharp division between responsibilities for equipment or plant such as heating, ventilation, refrigeration, sterilisation, power-supply, water, lighting, kitchen, laundry, transport, etc., and responsibilities for clinical equipment such as imaging, laboratory, theatre, intensive care monitoring, anaesthetic, etc. The former is often the responsibility of hospital engineers and the latter of clinical engineers. This division, which is common in developed countries, has been transferred to some developing countries, particularly in the establishment of training schemes for entrants to the HCTS which concentrate on clinical equipment rather than hospital equipment.

The meeting recognised that this distinction was not helpful to most developing countries where it was equally important to improve the management, maintenance and repair of both types of equipment. For example, a high level of maintenance of clinical electrical equipment is not sufficient if the electrical supply is unreliable and of poor quality. When a HCTS is well-established, it may be efficient to develop two distinct, specialised streams but in the early stages of development the staff should be trained to accept responsibilities for all types of equipment and services.

Although it is not useful to attempt to specify the final number of staff needed for full development of a HCTS, it is possible to suggest levels of staffing which should be achieved during the first stage. Although they are based on personal experiences, the recommendations of several advisers are broadly similar (H. Halbwachs, Federal Republic of Germany report, see page 29, A. Malloupas, Guidelines on Development of National Health Care Technical Services, 1988, Report of the Cyprus Interregional Meeting, J. McKie, Working Paper No. 3, page 84). For a 100-bed district hospital six staff (two in range B and four in range A) should be employed: if there are satellite health centres or hospitals, the numbers may be doubled. Numbers do not increase in simple proportion for larger institutions, e.g., 200 beds might be served by 3B + 6A.

Staffing levels will also depend on the level of support from manufacturers or other commercial sources; the number suggested are for an in-house service. Even where there is heavy reliance on commercial contracts it is essential to employ staff in the B range to specify contracts and monitor contractors' performance.

If a developing HCTS is staffed to the suggested level and the infrastructure is developed during the initial phase, any need for further development should become evident. At this stage careful manpower planning process should be established with the targets for future development calculated from knowledge of the equipment requirements and inventory, the maintenance needs and the staff productivity (using models of the type described in Working Paper No. 2).

Although the majority of resources should be applied to the development of staff in the B range, the meeting strongly endorsed the imperative need for competent and knowledgeable staff at ministry level (C range staff) to formulate policy and to plan and manage its implementation (working paper No. 1, paragraphs 4.2-4.8). Experience showed that country programmes were ineffectual where such expertise was not available in the ministry.
Such staff should be appointed as head of the service at a high level in the Ministry of Health with supporting personnel at the commencement of development of an HCTS. Where practicable, this should preferably be a senior and experienced engineer, the individual should have had, or should be given, appropriate training in the management of health care technology.

Problems were encountered in countries where senior officials changed when political parties gained or lost power; it was desirable to maintain continuity but necessary that the senior HCTS manager should be able to influence health policies.

3.2 Manpower Training

Detailed discussions on manpower requirements for various levels of HCTS and on the content of the job responsibilities for A, B and C ranges of staff as described above have lead the meeting to thorough consideration of the required training programmes.

The meeting dealt with curriculum content and development, organization of training centres, training materials requirements, continuing education, user training and training of trainers.

The meeting emphasized that within the general similarities of the job responsibilities for each range of staff they might vary according to country specific circumstances and personnel capabilities. Thus any national training programme catering for such personnel will have to be tailored to local conditions, attitudes and cultural influences. Consideration must always be given of the effects of a basic non-technological culture which usually exists in developing countries.

Another problem to consider is that university engineering graduates who enter the HCTS usually have a narrow specialised education which does not cover the wider engineering branches and sciences that are encountered in health care equipment management. Thus extra training courses covering such topics as human biology, medical practice, health management, etc., would be required in order to facilitate communication between the technical and health/medical/para-medical staff.

It has been found necessary to link any training school to a service workshop in order to complement the training of the school with real-life hospital situation exposure. However, the difficulty encountered in realising this is the availability of suitable, qualified and experienced tutors at a hospital level.

Endorsement type courses should be given to existing personnel in order to improve their technical, managerial and teaching skills (paragraphs 5.14 and 5.15 of the working paper No 1).

Due to financial as well as educational constraints many existing national courses have commenced with A type of training. Such personnel are needed but if they are the only personnel available they usually do not have the status and influence that is necessary to produce effective management of equipment.

Thus at first priority should be given to the training of staff in the B range whose potential for both managerial and technical responsibilities makes them most adaptable and useful.

However, as indicated above care should be given on a global scale to ensure that all three broad ranges of staff (A, B, C) were developed simultaneously.

The meeting agreed with a scheme outlined in the WHO Global Action Plan which foresees the development of a network of training centres at national, subregional, regional and interregional level. It is targeted that most of the developing countries will have national training centres catering for A and lower-B range training. As training complexity increases, broadens and becomes more demanding and expensive, as for the full B range training, this will be covered by the training centres at the
subregional, regional and interregional levels, though, at a national level in some countries. Finally, the most sophisticated higher level engineering and technology management training (C range) will be available at the global and interregional level.

The outline syllabus for a three-year course for the staff in the B range should contain:

**Hospital engineering**
- Mechanical engineering  
- Electrical engineering  
- Technical drawing  
- Workshop skills  
- Plants and installations

**Clinical engineering**
- Electronics  
- Medical equipment/instrumentation  

**Non-technical subjects**
- Anatomy/Physiology  
- Safety  
- Planned preventive maintenance  
- Health organization and management  
- Basic tuition skills

**Basic subjects**
- Mathematics  
- Physics  
- Languages

The syllabus for the A range of staff can be derived from type B, basically by shifting the proportions of training time towards hospital engineering and by reducing highly sophisticated elements. A duration of two years may then be sufficient.

Developing countries are urged to start A and B range national training programmes with secondary school leavers preferably from technical secondary schools of six years' duration.

The C-range type of staff, primarily charged with policy and management tasks at the level of ministry, provincial, district and hospital administration, requires the following basic qualifications:

- M.Sc. in engineering, natural sciences/physics, architecture or equivalent;
- Several years of practical professional and executive management experience;
- Leadership potential.

Additional training is required in:

- Health environment, policy and management;
- Management of human resources;
- Operational management of technical services (including equipment management);
Management of information systems and technology;
- Strategic management;
- Current development in health care technology.

When developing a training centre at a national level for A/B range training, it was recommended to preferably identify an existing technical training institution which can usually provide capacities for the basic skills training and can facilitate national certification. A training facility should be located close enough to a reasonably-sized hospital and offer a sufficient (building) space for the establishment of an additional course (department).

A capability of a training institution to serve intercountry needs should always be carefully assessed and used whenever possible. WHO should compile and continuously update a list of suitable training centres for every level of training, particularly those which can be subregionally, regionally or interregionally used (Directory of Training Institutions in Biomedical, Clinical and Hospital Engineering). This is of special importance for countries too small to develop their own full training schemes in terms of economy.

Use should be made of the general guidelines of indicators required to develop national curricula which are given in the background papers. A typical course content for clinical and hospital engineering training classified as upper-B to C range level (staff in charge of provincial and/or central maintenance workshops) is given in the background paper by A. Mallouppas.

The meeting recommended that entry requirements for national training should be based on existing regulations of the host training institutions. Success in an entrance exam and aptitude test should be a prerequisite. It was also emphasized that for subregional, regional and interregional training centres, entrance exams were also desirable. The international language of a particular country should be a prerequisite for B-range level training and the language should be taught at technical level during the course.

While discussing the issue of training materials, the meeting pointed out that many highly important and relevant materials are available in existing training institutions worldwide. However, the lack of information makes them almost unaccessible for the centres in developing countries. It was recommended that every effort should be made to ensure effective information exchange and sharing of available training materials. It was emphasized that WHO has a crucial role to play in this respect through encouraging, promoting and facilitating the networking of training centres at a global scale. WHO was requested to:

- Compile an Annotated Bibliography of available training materials;
- Identify existing relevant written materials such as syllabi, training manuals, etc., in order to reprint and distribute them to the countries and institutions concerned;
- Promote the production of handbooks for various levels of training based on the materials used at existing well-established training centres for distribution to the new institutions;
- Encourage national trainers to produce their own training materials or to modify existing ones in order to reflect their specific requirements;
- Promote the production of user manuals in order to enhance better equipment utilization.

It was recommended that training institutions should cooperate with medical and nursing schools in obtaining teaching materials for medically orientated subjects. The need for unusable equipment available in developed countries, which is useful for training, to be made available to national training institutions in developing countries, possibly using donor support to cover transport costs, was pointed out.
The importance of continuing education was strongly emphasized by the meeting. The availability of continuing education schemes was recognized as a main means of upgrading knowledge and skills as well as of raising motivation and self-respect of staff. It was recommended that continuing training should become a policy of manpower development of HCTS and should be linked to career structures. Such training should be offered by existing training institutions. Continuing training by manufacturers for service and user personnel should be foreseen at the contract specification stage by both recipient countries and donors. The role of professional societies as a channel for continuing training was pointed out.

The training of equipment users was another issue dealt with (paragraph 7 of the working paper No 1 gives more details). As an obvious fact it was noted that good user practice prolongs the lifetime of equipment and results in their full and safe potential use. Such training should be given by suitably qualified HCTS staff. It was felt that this responsibility should be included in the job description of HCTS staff. The meeting recommended that service staff should regularly carry out individual familiarisation instruction to users. User training by service staff should be strongly supported at district hospital level which should include users from rural centres and should ideally bring together all the members of the user team from doctors to nurses. As part of this type of training awareness seminars should be held on equipment management for administration and management personnel including those at hospital, district, provincial and central levels. The development of audio-visual training aids and other self-learning materials for nurses and doctors is also very important for the effectiveness of such training. Finally, it was emphasized that equipment management modules should be included in medical, paramedical and nursing school curricula, as well as in hospital administration programmes.

Lastly the issue of training the trainers (paragraph 8 of the working paper No 1) was discussed. In this respect few people are needed in every country who should, however, be adequately trained and experienced. Given the availability of such personnel in developing countries, it has been found that the best solution may be to use former students, with an aptitude for teaching to train a lower grade of trainee (for example, B range staff to train A range staff and C range staff to train B range staff). Special training in methodology of teaching, curriculum planning and development should be given to trainers assigned to train personnel at the training centres in developing countries. In cases where national requirements demand it, attention is drawn to the fact that formal teacher training may be required for trainers.

Efforts in training of trainers by existing training institutions should be strengthened and promoted. Collaboration with training centres in developed countries as well as with the most experienced centres in developing ones, particularly those operating at a regional basis, in the form of staff and information exchanges is a means of improving trainer capability. A suggested procedure would be for trainers from developed centres to visit developing country schools and assist by having the reality of the local situation clearly at hand. In this way the training content would be designed to match the capabilities and realities available in the country. Following this, exercise trainers from the developing country may visit centres abroad for further experience. This is obviously a process that requires a longer period of time.

3.3 Manpower Utilisation

Proper utilisation of manpower can only be realised if a committed national policy is available and effective HCTS is established. In the report of the Cyprus meeting as well as in other background papers the required actions and necessary approach to formulate and implement the relevant policies are discussed in detail.

In the plenary session the main points that are a prerequisite to good manpower utilisation were highlighted. The key issues that were raised related to motivation and incentives, development of national professional societies and certification. Also the role of international organisations in the whole process of manpower development for HCTS was discussed.
It has been recognised that clearly defined career structures and interrelationships of roles across the entire manpower spectrum of a HCTS are necessary in order that individuals can map out their career ladder and determine the available opportunities and their personal development. This is a very important criterion in retaining staff and offering job satisfaction.

To enable service staff to carry out their work effectively and efficiently they must have at their disposal the necessary tools and physical facilities to do so. Thus it is necessary to create a conducive working environment by improving or establishing suitably designed and furnished service workshop facilities at central, provincial and district levels.

The loss of good and experienced staff mainly to the private sector is another detrimental factor preventing the establishment of an effective HCTS. Measures have to be taken to create competitive salaries and appropriate secure appointments in order to retain personnel. If salaries are not competitive, supplement earnings by facilitating the use of service workshops for private work during non-working hours have to be allowed.

Other factors that would contribute to job satisfaction and retainment of staff are the availability of incentive schemes and continuing education. Various methods to mainly supplement salaries including the availability of transport and housing were discussed as well as various forms of continuing training to upgrade skills and knowledge of staff and to be the basis for possible promotion. A recognition of good performance should be ensured within the incentive schemes in order to promote the status and respect of personnel at every level of HCTS.

The development of professional societies and associations should be encouraged at a national level, if a critical mass of personnel is available, or subregional level, if this is not the case. This would develop the means for promoting the status of and respect for the engineering profession within the health sector, facilitate the career development of members as well as act as a source or channel for continuing training and information support and a forum for the exchange of ideas and expertise. The affiliation of such societies and associations with existing national engineering and health bodies as well as with registration authorities should be promoted. Their linkage with corresponding international organizations should be established. The crucial role of WHO, other International organizations such as IAEA and UNIDO, and international professional federations such as IFMBE, IFMS and IOMP in providing technical support and advice, in promoting and facilitating this process was emphasized.

The idea of certification or the verification of the competence of service personnel at different levels of career development was also presented. It was however recognised that with the current weak infrastructures in most of the developing countries this should be a long-term goal and that a necessary precondition to this would be the formation of professional societies. Any certification process being developed should be tailored to the country's specific needs utilising, but not copying, the models and information from other countries.

Lastly the role of international organisations was considered. Their unique position and ability to promote, coordinate and support various efforts at all levels aiming at strengthening national capabilities for management, maintenance and repair of health care equipment in general and manpower development in particular was emphasized and stressed. The role of the WHO Global Action Plan on Management, Maintenance and Repair of Health Care Equipment initiated as a follow-up to the Cyprus Interregional Meeting was pointed out by the meeting as a first attempt to tackle the problem in a comprehensive way and as a mechanism to promote international cooperation and coordination in this area. The networking process amongst international organisations, donor agencies, NGOs and national institutions started with the launching of the Plan was noted as a most gratifying development in recent years.
However, it was emphasized that, although the WHO Global Action Plan presents a right path towards solving the problems of equipment management in developing countries, this is only the beginning of the long road and there are many unfulfilled needs worldwide and the overall progress is painfully slow. It was pointed out that greater priority and visibility including funding and human resources should be given to the programme by WHO if the objectives of the Plan are to be reached and activities foreseen are to be implemented.

As immediate goals, further strengthening of coordination at a global scale in order to avoid wasteful overlapping and duplication of efforts, promotion of collaboration and networking between centres for transfer of information, experiences and expertise, establishment of an international information clearing house supported by a network of reference centres located at strategic points around the globe, development of mechanisms for access and use of computerized databases, were considered.
4. GENERAL CONCLUSIONS

It is recognised that training alone cannot solve the problems related to management of health care equipment and thus an engineering manpower development process should be an essential part of the national health care equipment programme integrated into the overall health system development. Moreover training itself should be carefully planned and cater for the whole range of staff involved and not just for any one level.

In developing a HCTS particular attention should be directed to policy formulation, manpower development, physical infrastructure strengthening and information support. Efforts to improve each of these areas of need should occur simultaneously and not serially. It is only with such a coordinated and comprehensive effort that equipment management will be improved and as a result health care delivery enhanced.

The initial efforts towards HCTS development should focus on creating awareness of its need. Then the manpower and physical facility requirements should be determined through thorough country situation analysis, the necessary funding secured and a policy commitment made to establish a service with an adequate infrastructure and a career structure for staff.

It was generally agreed that countries should have the whole range of competent staff and that training programmes should be established to produce suitable graduates for each and every level. Such training network, depending on the level of training and national capabilities, has to be established at national, subregional, regional and global levels.

The basic level training, and in some cases specialised training, may commence at country level, and examples of this are already available. The more complex and expensive training may, for the near future, remain at subregional, regional or interregional level. For the top level technical manager training, where the numbers of required personnel are few and the training syllabus is novel and highly specialised, a training programme should be made available at global level in the immediate future, with the possibility of regional programmes in the longer term.

National training programmes should be encouraged to commence or existing programmes should be strengthened. Training centres should always be linked to a service workshop in a nearby hospital for practical exposure for trainees.

Securing and retaining adequately experienced trainers is a serious problem that needs to be addressed urgently and train the trainers programmes be established. Collaboration and networking between existing centres in developed countries and schools in developing countries should be actively promoted by WHO and other international organizations in order to facilitate information and staff exchange and thus transfer the necessary technology to country level.

There is a serious gap in availability of training materials in developing countries, thus WHO should place an increased emphasis on this problem and ensure production or sharing of relevant materials for all levels of training using the expertise of existing institutions, particularly those currently operating at the regional and interregional levels.

Special audio-visual materials and self-learning programmes should be developed to assist with special courses on user training. It has been shown that many breakdowns of equipment, which result in reduced lifetime and thus wastage of limited resources, are due to misuse. Particular attention should therefore be paid to this type of training.

Schemes for continuing education and training should be developed as an essential part of the manpower development process to provide a channel for upgrading professional knowledge and skills of staff as well as for their career development. In this respect
the establishment of professional societies in developing countries should be encouraged and promoted. They will also help to raise the respect and recognition of the profession.

Given the reality of the situation in many developing countries and the fact that time would be needed to develop a fully effective HCTs, as an intermediate measure, various incentive schemes should be established in order to improve salaries and make them competitive, thus ensuring that engineering staff are not lost from the health sector.

Special attention should be paid to promoting the awareness and strengthening managerial capacities in the health care equipment field. Thus maintenance management courses and awareness seminars initiated by WHO in collaboration with several other organizations and agencies should be further promoted and organized on a regular basis in all WHO regions.

It is essential to have available adequate and easily accessible information support both for manpower training and equipment servicing. It was, however, recognized that in order to realize this, WHO had to take the initiative to establish an agreed hardware and software system which would then be used by all concerned.

Finally, the international organizations, professional federations, and donor agencies should further strengthen their collaboration and coordination of activities aiming at promoting awareness and strengthening national capabilities for management, maintenance, and repair of health care equipment. Steps undertaken in this direction within the WHO Global Action Plan should be actively encouraged and promoted. Expanding support for various projects in this field at global, regional, and country levels is a matter of urgent need since most developing countries do not have the technical and financial means to realize this by themselves.
5. **RECOMMENDATIONS**

The general recommendations of the meeting are:

1. Countries should formulate policies and strategies which aim at developing effective and efficient HCTS having the required manpower expertise and physical infrastructure at all levels from the health ministry to district hospitals which provide technical support to primary level facilities.

2. Countries should develop a broad spectrum of staff for their HCTS ranging from staff whose responsibilities are mainly managerial with a content of complex technology to those whose tasks are mainly technical and relatively simple. Care should be taken to ensure that all three ranges of staff (A, B, C) were developed.

3. Countries should determine their manpower and training requirements bearing in mind many factors including suggested levels of staffing for the first stage of HCTS development. When the initial level of staffing is achieved and infrastructure is in place a careful manpower planning process should be established with the targets calculated from equipment requirements and inventory, maintenance needs and staff productivity.

4. At first countries should give high priority to the development of staff in the B range whose potential for both managerial and technical responsibilities makes them most adaptable and useful.

5. In the early stages of HCTS development, training in both clinical and hospital engineering should be given to all personnel and no division between specializations should occur in order to ensure that medical equipment as well as hospital plants have adequately trained staff to service them.

6. Each country should ensure that there is within its ministry and, where appropriate, within the health authorities of its states, provinces and districts, staff in the C range who have received training in the management of health care technology or who have had substantial experience in a successful HCTS.

7. As a matter of urgent need WHO should arrange the provision of a training programme in the management of health care technology and technical support services, suitable for staff at the ministry of health level as well as at other levels of health administration, accessible to all countries, as recommended in the position paper prepared by WHO. Short courses and seminars on this subject initiated recently by WHO, UNIDO and IAEA in collaboration with several donor agencies and national institutions should be continued in all WHO regions.

8. Efforts should be strengthened at a global scale to develop a network of training institutions catering for all levels of personnel. All countries should be encouraged and supported to commence national training programmes for the A and lower-B ranges or full B range in some cases. Most capable training centres in terms of experience and resources, particularly those for the full B range training, should operate at subregional, regional and interregional level. Most sophisticated training as for the C range should be available at the interregional level.

9. WHO should urgently prepare the World Directory of Training Institutions for Biomedical, Clinical and Hospital Engineering and make it available for countries.

10. When developing a national training programme at any level use should be made of general guidelines for curriculum content and development given in this report, the report of the Cyprus meeting and this meeting's background papers. New technician training programmes should preferably commence from the basic and polyvalent levels.
11. Entry requirements for national training should be based on existing regulations of the host training institutions. Success in an entrance exam and aptitude test should be a prerequisite. Subregional, regional and interregional training centres should also have entrance exams.

12. To a extent possible training programmes should be established at the existing technical training institutions which have necessary capacities and can facilitate certification.

13. Such training centres should be linked to a nearby reasonably-sized hospital with a service workshop and have a strong practical orientation within national specific conditions and capabilities. Programmes which are mainly concluded in classrooms and academically biased should be avoided.

14. High priority should be given to train the trainers for national training centres by developing special schemes using expertise of most experienced existing WHO training centres and institutions in developed countries.

15. WHO in collaboration with other international organizations should identify available relevant training materials and when possible reprint them, promote publication of training materials used by the existing experienced training centres and make them available to national schools, encourage national trainers to produce their own materials or modify existing ones to make them relevant for their specific needs.

16. WHO should urgently prepare an Annotated Bibliography of Training Materials available worldwide with a reference to their possible source for use by the national training schools.

17. Unusable equipment available in developed countries which could be used for training purposes should be identified and made available to the training institutions in developing countries with donor support to cover transport costs.

18. User training should be promoted as one the main means of effective equipment utilization and should be included in the job description of service staff who should carry out regular familiarization seminars and individual instructions to the medical and paramedical personnel. It should be strongly supported at the district level involving users from rural health centres and bringing together all members of the user team from doctors to nurses. User training should also include equipment management awareness seminars for hospital administration staff.

19. Production of user manuals, audio-visual materials and self-learning training programmes should be promoted to assist with the user training.

20. Equipment management modules should be included in medical, paramedical and nursing schools' curricula as well as in hospital administration training programmes.

21. Continuing education and training should become an essential part of manpower development for HCTS as a main means of upgrading knowledge and skills of staff, their motivation and career development. Such training should be offered by existing training institutions, professional societies and manufacturers. The latter should be foreseen at the contract specification stage by both recipient countries and donors.

22. The formation of professional societies at national and/or subregional level should be encouraged and supported by WHO, other international organizations and international professional federations as a channel for continuing education, exchange of information as well as raising respect and recognition of the engineering profession in the health sector in developing countries. Such societies should be
affiliated with relevant national and/or subregional health and engineering bodies and registration authorities as well as with corresponding international organizations.

23. In order to retain staff and promote job satisfaction HCTS should have a conducive working environment with suitably designed and furnished service workshops, clear career structure and competitive salaries, opportunities for continuing education and career development, various incentives schemes, etc.

24. As a long-term goal establishing a certification process should be foreseen. However, given the current weak status of HCTS in most developing countries this is a matter of slow and careful development and a necessary precondition to this is the formation of professional societies. Any certification process being developed should be tailored to the country's specific needs utilising, but not copying, the models from other countries.

25. WHO should facilitate and promote the transfer of information, experiences and expertise pertinent to management and maintenance of equipment including manpower development for HCTS encouraging direct contacts between those who need information and those who can provide it. In this respect the networking process initiated by the WHO Global Action Plan should be further strengthened.

26. As a matter of urgency, steps should be taken by WHO to establish an international information clearing house, supported by a network of reference centres located at strategic points around the globe with mechanisms for access and use of computerized databases, and for direct communication with each other. Such an information clearing house should also collect, analyse and make available information on country situations as well as on ongoing and planned projects in order to support coordination of international action in this field, and thus avoid overlapping and wasteful duplication of efforts.

27. Collaboration and coordination between the international organizations, international professional federations and donor agencies should be further developed and strengthened. They have a unique position and ability to promote, coordinate and support various efforts at all levels aiming at strengthening national capabilities for management, maintenance and repair of health care equipment in general and manpower development in particular. Expanding support for various projects in this field at a global, regional and country level is a matter of urgent need since most developing countries do not have the technical and financial means to realise this by themselves.

28. The WHO Global Action Plan on Management, Maintenance and Repair of Health Care Equipment is a first attempt to tackle the problem of health care equipment management, maintenance and repair in a comprehensive way and is an effective mechanism to promote international cooperation and coordination in this area through the networking process amongst international organizations, donor agencies, NGOs, national institutions and countries. However, greater priority and visibility including funding and human resources should be given to the programme by WHO if the objectives of the Plan are to be reached and activities foreseen are to be implemented as a significant contribution to the progress towards Health for All by the Year 2000.
Figure 1. Ranges of HCITS staff
Figure 2: Spectrum of NTS manpower development

WHO IS WHO
IN NTS

Polyvalent Technician
Examples: Carpenter, Plumber

Craftsmen

Specialized Technician

Advanced Technician

Troubleshooting, advanced maintenance

Polytechnic: 2-3 years technical program

Bachelor of Engineering/B.Sc., 4-5 years

Postgraduate: Diploma, Master's, PhD

Advanced technical work, eng. work, central or provincial workshop

Managing district workshop, advanced troubleshooting,sec. tech., purch. spec.

CLINICAL ENGINEER

CLINICAL ENGINEER MANAGER

Clinical engineering

Advanced clinical work, advanced technical work, eng. work, central or provincial workshop

Managing district workshop, advanced troubleshooting, sec. tech., purch. spec.

Engineering Technician

Making policy, in charge of NTS in Ministry or other level admin.

H.Sc., advanced management training, Fellow of Professional Engineering Organization

Chartered eng., Registered Prof. eng., Certified Clin. eng., member of professional eng. organization

Education timeline

A

B

Range of NTS staff
Pyramid 1 - numbers and level of required personnel (A, B, C ranges)
Pyramid 2 - level and breadth of required training
Pyramid 3 - numbers and level (national, regional, interregional) of training centres

Figure 3. Correlation between HCTS staff ranges, required training and training institutions needed
Annex 2

Summaries of Reports from Countries, Participating Institutions and Organisations

Argentina

The Centre for Research and Planning of Physical Resources for Health (Centro de Investigación en Planeamiento del Recurso Físico en Salud, CIRPS), was established ten years ago at the University of Buenos Aires with the purpose of the development of research, teaching, information and technical cooperation. Its character is imminently interdisciplinary and interinstitutional. Amongst its activities the development of Guidelines for the Health Facilities Planning Process and Technical Records on Health Facilities - Space, Equipment and Engineering Systems being carried out in collaboration with institutions from Brazil, Colombia and Mexico are of particular importance. This project promotes a comprehensive, integrated and systematic approach to the process of planning of physical resources for the health care system and presents methodological tools for the selection and use of the most appropriate technology.

Training activities of the Centre are closely linked with the above mentioned approach and include such long and short courses of particular relevance and interest to the meeting as on health facilities planning, preservation of health facilities, administration of health services and teachers' improvement. The courses involve undergraduate and postgraduate levels as well as continuing education programmes and cater for both the national and regional needs.

Brazil

a. Centre for Biomedical Engineering (CEB)

The CEB was established in 1982 as a separate entity within the structure of the State University of Campinas (UNICAMP), drawing its personnel from the Schools of Engineering and Medicine. Currently the Centre has a staff of five engineers, four medical physicists and 35 technicians as well as 15 researchers.

The CEB's activities may be classified into the following five broad areas: Clinical (Hospital) Engineering, Medical Engineering, Bioengineering, Medical Physics and Support Services. Its facilities include laboratories for hardware and software development, ultrasound and bioengineering, mechanical and electronic workshops, darkroom for printed circuit development and a small library. Its objectives are to provide the following:

Clinical engineering: management, maintenance and repair of health care equipment which belongs to UNICAMP. Carry out manpower training of the hospital personnel in the field of effective utilisation of equipment. Design and construction of mechanical parts or small mechanical devices required by UNICAMP or its hospitals.

Medical Engineering: biomedical equipment development and evaluation, design of required instrumentation for preventive maintenance, participation in training of technicians.

Bioengineering: quantitative research on biological phenomena, and systems and participation in training graduate level personnel of the university hospital and associated centres.

Medical physics: quality assurance of X-ray and nuclear medicine equipment, pre-purchase evaluation and implementation of radiation protection procedures to safeguard personnel and patients.
Due to the Centre's activities a considerable amount of savings were incurred by UNICAMP due to reduced downtime and better utilisation of equipment, as well as development of prototypes which led to their industrial design. CEB is also funded by research grants and has carried out a number of masters and doctorate level theses.

b. State of Sao Paulo

Since 1987 all public and philanthropic health institutions were organised into a single integrated system with decentralised administration. The private institutions which were previously linked to the Federal Social Security System are also under its supervision. At present the system is composed of 550 hospitals (with 85,000 bed capacity), 1,100 outpatient clinics and health centres and ten research and manufacturing facilities. Together with the private sector they provide health care for about 33 million people.

It was immediately realised that one of the main issues needing urgent attention was health equipment management, since this is an expensive area and requires highly qualified personnel and its effective performance is essential to the provision of adequate health delivery.

The new system has three major roles with respect to technology, as a: (i) major consumer, (ii) public health authority, (iii) main service provider. As a result its policy tries to integrate all relevant issues in all phases of the life cycle of equipment, namely in: planning, procurement, acceptance testing, utilisation, maintenance and repair, refitting and obsolescence.

In order to implement the above policy the technical group of the Office of Equipment Advisor (ASEQ) was set up staffed with professionals with backgrounds in medicine, public health, nursing, nutrition, clinical and biomedical engineering, architecture and computer sciences. ASEQ reports directly to the Secretary for Health.

ASEQ's main responsibilities are: planning procurement, management and maintenance and regulation, research and development. Through these three areas it promotes equipment management by making available advice and expertise on tenders, minimum technical specifications requirements, assisting in establishing hospital/clinical engineering teams providing a database information system and coordinating actions and advising the state government on major issues of policy.

Colombia

The National Hospital Foundation (Fondo Nacional Hospitalario) of the Ministry of Health of the Republic of Colombia includes amongst its functions advising on hospital engineering, studies on the procurement of equipment, preventative and corrective maintenance, contracting for maintenance, the planning and implementation of training programmes for engineers and maintenance technicians, mediating national budget allocations, research on appropriate technology, guidance on maintenance administration and standards, advice and assistance to hospitals on equipment management, procurement and training.

A series of seminars organised in 1988 for heads of maintenance in 150 institutions examined the factors hindering the development of a network of adequate engineering services. These included:

- poor administration in divisional health services and hospitals;
- lack of physical and material resources;
- inadequate training of staff;

Many hospitals do not have a chief of maintenance and there is urgent need for all types of engineers and technicians but especially in electronics, where functions need to be reviewed. Some chiefs of maintenance have too many technical duties which detract from their ability to manage. Few hospitals have adequate technical documentation and
there is a general lack of specialised test equipment and tools. Budgets for maintenance need to be increased and all salaries require to be improved. Arrangements for continuing education are needed.

There is urgent need for advice on setting up and implementing maintenance programmes, on administrative structures for record-keeping, with data-processing equipment, on programmes for continuous renewal of stock of equipment, and for stable working conditions for hospital directors and managers.

Since 1975, Colombia has recognised the need for the training of competent people to ensure the optimal contribution from the increasingly complex and costly technology, especially as most has been developed outside the country. Its experience in training can be made available to other Latin American countries. Courses are available in:

- Maintenance of basic hospital equipment (water, sanitation, heating and refrigeration, air-conditioning, etc.);
- Maintenance of hospital electromechanical equipment (hydraulic, lighting, heating, suction, centrifuges, incubators, dental, pressure, anaesthesia, etc.);
- Precision mechanics (including microscopes, endoscopes, hearing, ophthalmological, microtones);
- Clinical laboratory equipment;
- Electromedical equipment (including ECG, EGC, monitoring, ultrasound, etc.);
- X-ray diagnostic equipment;
- Management of maintenance of physical resources in health care (theories, concepts, procedures, costings, documentation and recording, computer software, management of human resources, etc.);
- Technical teacher training for instructors in maintenance (teaching methods, preparation of instructional material, etc.).

The Commonwealth Association of Polytechnics in Africa (CAPA)

CAPA, founded in 1978, currently consists of 99 post secondary technical institutions distributed throughout the 15 countries of Commonwealth Africa, namely: Botswana, The Gambia, Ghana, Kenya, Lesotho, Malawi, Mauritius, Nigeria, Sierra Leone, Swaziland, Seychelles, Tanzania, Uganda, Zambia and Zimbabwe. The aim of the association is to foster cooperation among its member institutions for the improvement of technical education and in particular to promote the exchange of experiences and ideas; improvement of teaching, organisation and management; dissemination of information; facilitation of movement of staff and students between member institutions; research on training needs for rapid national development and provision of common services to CAPA institutions.

CAPA's activities include a wide range of programmes ranging from conferences, seminars, staff development and training workshops, research surveys and publications all directed at addressing identified needs. Its administrative funding is through members' subscriptions and grants while programme funding comes primarily from donor and international organisation support.

A programme that is currently receiving attention is that of training medical engineering technicians in Commonwealth African polytechnics. The need for such a project arose due to the substantial proportion of scarce national resources that have been invested by CAPA member states in establishing national health care delivery systems including health care equipment. However, the lack of adequately trained manpower in its maintenance and repair results in inadequate outputs. Thus an urgent need to produce well trained staff has been recognised by the regional meetings of ministers of health and experts.

Through this project CAPA seeks to provide to its member institutions the required prerequisite to stimulate their active involvement in the design and implementation of the necessary training programmes for medical engineering technicians in the region. Various activities are foreseen by the proposed project, which includes consultations
with national authorities with the aim of establishing national training, carrying out surveys to determine manpower requirements, organisation of workshops to sensitize polytechnics to the issues involved, organisation of group training of trainers.

The project on its completion anticipates having at least one polytechnic in each member state carrying national training for medical engineering technicians; a report containing the estimates of manpower training requirements in each country; a core group of about 15-20 trained medical engineering technician trainers.

Costa Rica

Health care to a population of 2,647,890 is provided by 29 hospitals, 237 clinics and 844 health posts integrated under Caja Costarricense de Seguro Social (CCSS) since 1985. The same year the Integrated Maintenance System for Health Care Services (SIMSS) was established by the Ministry of Health and CCSS with support from PAHO/WHO and the Interamerican Development Bank.

SIMSS operates at three levels: central, regional and local, and has 844 employees. It covers the following areas of activities: management and administration, information system including maintenance indicators, development of safety norms and regulations, strengthening of maintenance capabilities at the local health systems (SILOS), training including continuing education, production of technical manuals and training materials.

The SIMSS training programme includes 30 short courses per year varying in duration from 40 to 200 hours and attended each year by 450 people including engineers, technicians and users. It also serves subregional needs receiving 40 students annually from Central American countries. The programme has a faculty of 40 qualified engineers and technicians working mainly part time as professors.

The courses are usually programmed a year in advance based on a necessity study carried out for the whole country each year as well as on the other information available at SIMSS. Curriculum and training materials are developed by the programme faculty.

Training covers three broad areas: maintenance management and administration, technical training in various fields and for various levels of personnel, and user training. Establishing a proper relationship between those who operate the equipment and those who serve it is one of the objectives of the training.

The SIMSS training programme is officially recognized by the relevant authorities and thus the certificate received after training facilitates career development and is an important incentive. The other incentive used by the programme is the provision of tool kits to the participants which entices hospital maintenance units to send their staff to the courses and helps to fulfill the need of personnel in having their own tools to perform their job properly.

The other area which is covered by the SIMSS programme is the promotion of continuing education through organizing seminars, conferences, etc. at the national level as well as participating in the relevant activities at the international level.

Cyprus

The Eastern Mediterranean Regional Training Centre (RTC) at the Higher Technical Institute in Nicosia, Cyprus, began its operation in 1978 as a joint project of the WHO Eastern Mediterranean Regional Office (WHO/EMRO) and the Cyprus Government in the training of medical and hospital equipment technicians.

The RTC participated in country surveys for WHO/EMRO and hosted in 1981 a regional meeting of training centre directors and managers. In 1985, the WHO Headquarters’ Division of Strengthening of Health Services requested that the RTC assist in formulating and promoting the programme on equipment management, maintenance and repair by providing specialised reports, meetings and country surveys. Within this context, the RTC hosted
the first Interregional Meeting on Maintenance and Repair of Health Care Equipment in November 1986. WHO designated the RTC as a WHO Collaborating Centre for Training and Research in Health Care Equipment Maintenance and Repair in July 1987. As such, the RTC's objectives are:

- to assist WHO in holding training courses on maintenance and repair of health care equipment;
- to provide consultative services;
- to develop and apply appropriate technology in relation to health and medical equipment services; and
- to assist WHO in the collection and dissemination of information in the field of health care equipment.

In the area of training, the centre currently offers the following 10-month (two semesters) courses:

- Medical electronics specialised technician;
- Electro-medical and clinical laboratory equipment advanced technician;
- Operating theatre and dental equipment advanced technician;
- X-ray and nuclear medicine equipment advanced technician.

The advanced technician courses mentioned above include modules on: electrical and electronic technology, instrumentation, transducers and measurements, basic human biology and an overview of medical equipment not covered in the particular specialisation of each course. The second semester deals with the equipment specialisation of each course, which also included project work and practical training.

The medical electronics course includes analogue and digital electronics, instrumentation, transducers, microprocessors and practical electronic projects.

The RTC has also carried out EPI technician short courses on solar and conventional refrigerator repair.

Up to November 1989 there were 386 graduates from its various courses from 41 different countries, mainly sponsored by WHO or the Commonwealth Fund for Technical Cooperation. The current fees are US$ 2,200 per semester which exclude living expenses, books, travel and accommodation. Students with six years' technical school, preferably with some practical experience, are eligible for entry to the courses which are in English.

The RTC has also been involved in consultancy work for WHO and the Commonwealth at the global, regional and country level as well as in research and development activities on the use of solar panels for powering BRS X-ray units.

El Salvador

El Salvador has a population of 5,907,000. The country is divided into 14 provinces and 261 municipalities. Health services are provided by the Ministry of Health and Social Security which has 15 general and specialized hospitals ranging from 300 to 600 beds, 15 health centres having 50 beds each and 300 health posts, with total bed capacity of 5,920; the El Salvador Institute of Social Security which has seven hospitals and 21 out-patients units with 1,000 beds; the Ministry of Defence which has two hospitals with 600 beds; the Ministry of Interior which has one hospital with 70 beds, and the private sector which has hospitals, clinics and laboratories, however, its bed capacity is unknown.

The public health services belonging to the Ministry of Health are catering mainly for the poorer portion of the population. Human and physical resources including those for hospital maintenance are not adequate to meet the existing demand.
The importance of hospital maintenance in overall health services function is poorly understood. There is no system for HCTS. Maintenance is not taken into account at the planning stage so no budget provision exists as well as there are no regulations and standardization for acquisition process. Maintenance staff is developed on an empirical rather than analytical basis. There is no manpower development policy and no system for continuing in-service training for technicians as well as for users of the equipment.

Hospital maintenance service has a three-level structure: a central maintenance department in San Salvador, two regional maintenance workshops and several local maintenance workshops. Maintenance services are divided into those related directly to the patient, e.g. medical equipment, and those related indirectly, e.g. hospital equipment. Usually the hospital maintenance system receives support only for repair work when there is a breakdown.

The project on hospital maintenance in El Salvador was initiated in 1988 with the support from GTZ when situation analysis was made identifying causes of deficiencies and suggesting possible solutions which was developed into the plan of operation up to 1991. The objectives of the plan are training of technical personnel and equipment users according to the master plan based on the identified needs, strengthening of infrastructure by establishing workshops and providing equipment, reorganization of maintenance service administration, development of technical information system, and implementation of adequate acquisition system.

To rationalize activities they are incorporating support from USAID and the Dutch Government coming through PAHO/WHO as well as the decision-makers in the Ministry of Health and all levels of the national maintenance system.

Before the project started training has usually been ad hoc, often carried out abroad with no planning, programming and continuity. Since 1988 when the master plan was developed responding to the real needs for technical personnel, there is a clear structure according to the levels of required staff. This includes specialized engineers (level 4) for the central maintenance department, specialized technicians (level 3) for the regional workshops, hospital technicians (level 2) for the local hospitals, hospital technicians (level 1) for health centres, and polyvalent technicians (level 0) for health posts.

Polyvalent technicians of level 0 are responsible for basic maintenance and simple repairs of equipment at the health posts, they are provided with training in basic electricity and plumbing during the courses of 40 hours duration. One hundred and fifteen polyvalent technicians were trained in 1989. Hospital technicians of levels 1 and 2 need to have secondary education and specialization in mechanics, electricity and/or electronics, they are responsible for preventive maintenance and repair of more complex equipment at the local hospitals and health centres. Specialized technicians of level 3 need to have training and experience in hospital maintenance to staff workshops at the regional hospitals, they are responsible for preventive and corrective maintenance and repair of complex hospital and biomedical equipment, as well as for support, consultation and coordination provided to levels 1 and 2. Specialized engineers of level 4 are responsible for complex and specialized activities including management and administration of the system.

It is envisaged to develop the training programmes foreseen by the master plan in three years. They will include courses for staff in charge of hospital maintenance services varying between 40 and 120 hours duration. They will include practical experience in maintenance workshops, laboratories and with specific equipment. The system for continuing education and for user training is also foreseen.

Fiji

A population of 700,000, spread over many islands, is served by three divisions with divisional hospitals where specialized services are provided, nineteen subdivisions, ten of which have general hospital facilities and 64 medical areas with nursing stations or health centres.
Health care equipment has been supplied through government budget or donor agencies. However, because of lack of funds, experienced manpower and maintenance organization, the equipment has deteriorated. At any one time about 50 percent is not functional and the accuracy of the remainder is unreliable.

Health authorities have recognised and accepted the need for a health care technical service and the Department of Biomedical Engineering was created at the Central Division in 1980. It has as its primary objectives the provision of a cost-effective and efficiently managed biomedical engineering service to the Ministry of Health and private hospitals, maintenance and repair of health care equipment throughout the country to ensure its efficient and safe use including in this respect preventive maintenance procedures and keeping the stock of spare parts, participation in acquisition and replacement processes.

However, little progress has been made and there are still only two senior technicians and unskilled workers in the service with no administrative support, no budget of its own, no transport and under-equipped working facilities. Thus the department can provide only the very minimum basic service.

The immediate goal for the Biomedical Engineering Department is to achieve a staffing of seven experienced technicians and one assistant technician (trainee) including one principal technician/supervisor to head the service, three senior technicians to be in charge of maintenance units in each divisional hospitals and three technicians, one for each divisional hospital.

The minimum requirements to meet the objectives of the Biomedical Engineering Department are the provision of a necessary budget allocation, staff establishment, adequate training for personnel, maintenance workshops in all divisional hospitals and appropriate transport including a mobile equipment repair vehicle for servicing subdivisional general hospitals and health centres.

France

The Higher International Institute for Training of Health Personnel (Institute International Superieur de Formation des Cadres de Sante) in Lyon founded by the Public Hospitals of Lyon in 1960 under the aegis of WHO, added a centre for maintenance training for French-speaking countries which acceded its first students in 1984. It was intended to provide training similar to that provided for English-speaking countries in the Cyprus centre, and has attracted over 40 students from many countries of Africa, the Eastern Mediterranean and Central America. It also trains young French people from the NGO called Mission Bioforce Development who wish to work in the field of maintenance in developing countries - about 70 of these have completed the training.

The polyvalent technician training lasts for 1,000 hours spread over nine months, plus one month of on-the-job training with a hospital maintenance company or with a manufacturer. The successful student is awarded a certificate and reaches the standard defined by the French standardization agency for the third grade.

Contents of the course include fundamental technology, biomedical techniques (the use, role, preventive maintenance and repair of basic hospital equipment), hospital environment techniques, logistics, technical English and documentation studies. The approach is specifically adapted for work in developing countries, e.g., the use of simple test equipment, the emphasis on learning the correct use of equipment and learning to service equipment in the real hospital situation. This requires a pool of specialised trainees and a large amount of medical equipment.

Over five intakes (with an average of 23 trainees in each) the overall success in achieving certificates was 85 percent - if trainees from only developing countries are considered the rate is 93 percent.
More than 80 percent of those from developing countries are working in hospitals and seven percent in health ministries, so that the percentage of loss is small. Fifty-six percent of the Mission Bioforce trainees became employed in foreign countries.

About half of the entrants from developing countries had entry qualifications at the high school level and the majority of the others had experience as technicians or senior technicians. Their supporting grants came from WHO, 33 percent, French cooperation projects, 29 percent, World Bank, 31 percent, and own government or private sources, seven percent.

Following the example of the Nicosia centre, it is proposed to offer specialised courses dealing with specific categories of equipment such as radiology equipment and laboratory equipment. These courses will each last for five months, of which two months will be spent in on-the-job training in companies; these are intended for technicians who have completed polyvalent education or have a professional interest in the specific fields.

**Germany. Federal Republic of**

In most developing countries there are significant deficiencies related to policy and planning of equipment management and its related issues, which is not being carried out at the required standards or is even completely ignored. As a consequence technical conditions are mostly deplorable.

The Department of Health at the German Agency for Technical Cooperation (GTZ) endeavours to tackle this complex problem by an integrated approach, which usually consists of advisory services, provision of maintenance workshops and related equipment and most importantly training programmes.

Maintenance staff may be divided into three levels, senior management (professional engineers), middle level management (hospital maintenance technicians), junior management (hospital artisans/craftsmen). The distribution of such personnel is in the form of a pyramid with the junior level the most numerous.

GTZ training programmes, due to limited resources, is focused at the technician level. This is a compromise between developing practical skills and the ability to stand one's ground in the hospital hierarchy.

The basic concept of the training is the prevention of breakdowns for commonly used equipment and not for the more sophisticated apparatus. It is for this reason that the polyvalent technician training has been adopted and is designed to give a basic but broad level of competence.

The number of trainees is determined by the requirements of the particular national public health sector. For example, in Senegal, 18 students are taken every two years, whereas in Kenya, with a higher demand, the intake is 20 students annually.

A crude rule of thumb which is usually employed is two technicians/100 beds. In the case where a health facility has to cater for secondary facilities in its region up to four technicians may be required.

The duration of polyvalent training should be three years due to the wide range of tasks that need to be catered for. The training content usually has a 50/50 theory to practical ratio, although a more practical bias would have been preferred. Subjects include mechanical, electrical, hospital engineering, technical drawing, workshop skills, electronics, mathematics, physics, languages, computer science, etc. In addition, practical attachments always follow the training.

For national training to be successful it must be officially recognised by the authorities, which usually leads to a recognised salary scale after graduation.
A constraint in the development of national training programmes is the provision of national staff, the creation of new posts and training of trainers. Some advanced training for trainers is sought for in industrialised countries. Attention should therefore be paid to creating an adequate technical service infrastructure, with the maintenance department acting as a coordinating body for training activities.

International Federation of Hospital Engineering (IFHE)

The IFHE was founded in 1970 and is a nongovernmental organisation which joins national professional institutions and associations in a worldwide federation. Its main objectives are to promote, develop and disseminate hospital engineering technology and experiences; to promote the principle of integrated planning and evaluation; to promote more efficient management of operation, maintenance and safety of hospitals, their equipment, buildings and engineering installations and to offer collaboration with other international organisations.

The IFHE endeavours to encourage through its goals and efforts the exchange of information towards improving the design, maintenance and management of health care buildings and their engineering installations. More recently the IFHE’s statute was amended to open membership to public authorities, industrial and consultancy firms as well as individuals with the aim of broadening the contributions made to IFHE’s aims and objectives.

IFHE holds an International Congress of Hospital Engineering every second year and publishes and distributes free to members the international issues of its journal - Health Estate (former Hospital Engineering).

Currently the Federation is promoting close collaboration with international agencies, particularly WHO with which it is in official relations. Main areas of collaboration are mutual exchange of information and experiences, manpower development and training, support to WHO activities with IFHE’s professional expertise and promotion of hospital engineering in developing countries.

International Federation of Medical and Biological Engineering (IFMBE)

The IFMBE is a nongovernmental organization that is an affiliation of 32 national societies with a total membership of 10,000. Its main objectives are to generate and disseminate information, to provide an international forum for the exchange of experience and ideas, to encourage research and educational programmes and stimulate international cooperation in the field of medical and biological engineering.

The IFMBE together with the International Organization for Medical Physics forms the International Union of Physical and Engineering Sciences in Medicine. It has a consultancy status with UNIDO and is in official relations with WHO.

The IFMBE is establishing liaison with developing countries to encourage and promote the development of biomedical and clinical engineering, particularly through information support and training. Emerging fields are given strengthened support by the Federation through its committees, working groups and divisions, such as Developing Countries Committee, International Liaison Committee, Clinical Engineering Division, Working Group on Far Eastern Activities, etc.

The IFMBE holds an International Congress every three years as well as annual Regional Conferences. It publishes the Journal of Medical and Biological Engineering and Computing, the MBEC News, the Clinical Engineering Update and the monograph series for users on various types of equipment.

The IFMBE is promoting close cooperation with WHO. Main areas of collaboration are mutual exchange of information and experiences, manpower development and training, support to WHO activities with IFHE’s professional expertise and promotion of biomedical and clinical engineering in developing countries.
Peru

Under a joint technical cooperation project between the Republic of Peru and the Federal Republic of Germany, the Peruvian Health Ministry in collaboration with GTZ has established a National Centre for Training of Technicians in Hospital Maintenance (Centro Nacional de Formación de Técnicos en Mantenimiento de Establecimientos de Salud) attached to the regional hospital in Chimbote. This is recognised as a Higher Technical Institute.

The Centre provides a two-year course to train high level technicians in corrective and preventive maintenance of all types of hospital and clinical equipment, which leads to the degree of Hospital Maintenance Technician (Técnico en Mantenimiento de Establecimientos de Salud).

Twenty students are admitted each year after the selection process. Candidates must have five years of secondary education or equivalent and practical experience in hospital maintenance. All instruction is given in Spanish.

There are six terms of nine weeks and about 40 hours of teaching per week. Courses include general studies, basic science, applied science and technology which occupies about 75 percent of the time and is subdivided into about 17 specific applications, in these the ratio of hospital or plant engineering to clinical or medical equipment engineering is about 2:1.

The Centre also offers short courses on specific subjects to technicians and medical professionals, conducts technological research in medical and hospital equipment, gives a service of plant and medical equipment maintenance as a part of its practical training, and serves as an information and resource centre on hospital equipment and technology.

Swaziland

Following the concern expressed by Ministers of Health of the East, Central and Southern African subregion over the unsatisfactory state of management and maintenance of health care equipment, a consultant surveyed the region and recommended the Swaziland College of Technology (SCOT) as a suitable place to start a training course. A course director was appointed by the Commonwealth Fund for Technical Cooperation in 1978 and another after his retirement in 1984.

There were many reasons for dissatisfaction and after a further review by consultants in 1985 the programme was suspended pending improvements.

A consultation meeting held in Harare in June 1989 discussed the future of the SCOT programme and other strategies for networking manpower development and training in the region. The recommendations included the continuation of a medical polyvalent technician course at SCOT with the duration cut to one year and a new syllabus drafted with the assistance of a Project Hope adviser; the next intake should be in September 1990. It was also recommended that an advisory committee on manpower development and training for maintenance and repair of health care equipment be set up, that collaborative support from WHO, CPTC and other international and donor organisations be encouraged, that training of craftsmen and artisans should be undertaken at national technical institutions and that short specialised programmes on imaging systems and advanced medical electronics be started in Zimbabwe and Kenya, respectively.

The Swaziland Minister of Health has obtained from Project Hope, on a three-year contract, an experienced American adviser to assist the acting director of the SCOT biomedical engineering programme to develop a syllabus, set up a medical engineering laboratory and provide lecture guides in core subjects. He will also assist the acting director to set up a biomedical engineering repair and maintenance workshop at the government general hospital.

A draft syllabus is now being reviewed and evaluated. A short term consultant is helping to set up the hospital workshop. SCOT has assigned one full time lecturer as counterpart to the Project Hope consultant and two other lecturers will go abroad for
advanced training in electronics and biomedical engineering. The WHO Regional Training Centre in Cyprus has also agreed to support SCOT in running the courses at the initial stage and in training the trainers for the programme. It is envisaged that there will eventually be a faculty of four full-time lecturers, all with B.Sc. engineering degrees and relevant training or experience.

The centre must train students from other countries to remain viable and it is expected that participants from Commonwealth countries will be funded by CPTC and from other sources such as WHO, World Bank and national governments. Project Hope will provide financial support for test equipment and selected books and will also fund their shipment.

A sensitive issue has been the award to be given to successful students. It has been agreed that the syllabus will have to be comparable to that of all other technical institutions in the region, equivalent to part III or HNC, and be approved by SCOT, WHO and the Commonwealth.

In the future, SCOT hopes to set a three-year programme at HND level as a department within the engineering school and also to run short specialised courses within the programme of continuing education.

United Kingdom

a. Medical College of St Bartholomew's Hospital, London

The College, which is part of London University, offers a full-time 12-month course which leads to the postgraduate diploma of Medical Electronics and Medical Equipment Management. It is intended to provide a thorough grounding in practical medical electronics for professional staff employed in the field of management and maintenance of medical electronic equipment. The course was designed with the aim of satisfying the particular needs of personnel involved in developing or managing medical equipment departments.

The course content includes application of electronics techniques to medicine, study of the design of medical electronic equipment, and particularly their safety aspects, use of servicing and management techniques, including personal computers, introduction courses in medical physics and human physiology, use of medical equipment for measurement, diagnosis and therapy. The development of practical skills is a significant part of the course and includes project-based investigation and on-the-job work experience and visits.

The Department of Medical Electronics, which runs the course, is split-up into several specialist areas, which include management and maintenance of equipment, extensive research and development laboratories related amongst others to applications of lasers, ultrasonics and magnetic resonance.

The Department also offers a medical electronics course at Masters level. Graduates from the diploma course may be accepted to the Masters course provided they have a good diploma result and satisfy the entry requirements to the Masters course.

The current fees for the diploma course are £6,900, which excludes books, accommodation and travel. The course commences in October of each year. Entry qualifications are a degree, HND or HNC in an appropriate subject including physics or electronic engineering. Candidates with other qualifications who have acquired appropriate professional experience may also apply.

b. Department of Clinical Physics and Bioengineering (DCPB), Glasgow

The Department belongs to the West of Scotland Health Boards and serves a number of health authorities in Scotland and is the largest department of its kind, giving a full service of advice and assistance in applying the physical and engineering sciences to health care, it contains the Clinical Physics Department of the University of Glasgow.
The largest of its varied activities is the management and maintenance of health care equipment and it has had an internal training scheme for over 30 years. This led to bilateral projects to assist in the development of medical equipment maintenance and training centres for Egypt at Abbassia, Cairo, and for Bahrain. From this experience grew an extensive involvement with WHO, other international organizations, national aid agencies and individual governments involving short and long-term consultancies and support in developing countries and the practical training of staff from these countries in Scotland. A section of the DCPB headed by Dr David Porter is fully and continuously engaged in this activity which is now being expanded within a new organisation called Scottish Overseas Health Support which will be sited within DCPB but will coordinate support to other countries from the whole of the Scottish Health Service including every aspect of health care.

The special feature of the overseas training offered by DCPB is that it is not a single educational course or several courses which every participant must follow, but rather is targeted training which is arranged to meet the needs of each participating individual. It is possible for an inexperienced technician to follow the same systematic training given to the DCPB’s own staff, which includes education in a local technical college and practical training in the department and on-the-job, but the majority of overseas trainees are more senior staff who will become key managers, engineers and trainers in their countries’ HCST.

Ideally, DCPB staff visit the country to assess the needs and help in selection of trainees. They then work with the trainees in Glasgow: typically the trainee spends some weeks revising and practising the basic technological skills then works alongside DCPB staff in general or specialised maintenance and repair work in hospitals large and small. To obtain the best results, the DCPB trainer should return with the trainee to help him or her to apply the skills in the country situation - it is not enough to train a person to work only in a developed country and leave him unprepared for the difficult stage of adapting to the more difficult environment of underdevelopment.

Whether the trainee be an experienced senior engineer or relatively inexperienced technician, whether the time allowed be a few weeks or a few years, the objective is to plan the most effective training for the individual within the time and resources allocated.

USSR

In the Soviet Union it has been recognised as vital to increase the efficiency of the health care system by having effective management and maintenance of health care equipment.

The design of equipment is carried out at research institutes under the auspices, amongst others, of the USSR Ministry of Health, and the Academy of Medical Sciences. Recently new equipment on diagnosis, treatment and rehabilitation have been produced with attention being given to the automation of diagnosis and research equipment.

However, rapid technological developments result in acute problems in planning and utilisation of equipment as well as training of user and service personnel. It is now clear that training of clinical engineers who should have adequate expertise and background in the issues involved is a priority.

Training of bioengineers is currently taking place in various institutions in Moscow, Leningrad, Tomsk, Kharkov, Tbilisi and several other cities.

This training is mainly carried out by three categories of institutions, namely, (i) technical faculties of universities and technical institutes, (ii) joint medical-technical departments of various institutions, (iii) joint medical-biological faculties of medical institutes.

The initial steps to train engineers were made in 1962 in Leningrad, which still has the main training activity in this field in the USSR.
A standard for a biotechnical system (BTS) training programme was defined and includes: principles, systematic analysis and synthesis, methods of optimal and adaptive maintenance, computer uses and applications, BTS in health care, theoretical and experimental research.

The above scheme is used by the various training institutions, which adapt their training content accordingly and which is at present geared to biomedical and biological topics. However, training in medical electronics is now recognised as a necessity and is being provided. Such graduates together with medical physicists are intended to participate and contribute to promoting better health care delivery.

The first steps are now being taken to train engineers in the management aspects of equipment, particularly dealing with inventory, purchasing, specifications, maintenance and repair. The first eighty graduates have already been trained. It is also intended to strengthen cooperation with foreign institutions and international organisations.

There are, however, currently obstacles which need to be overcome if training is to work effectively. These are mainly due to the present multilevel and administrative control systems, the lack of information support, training materials, weak collaboration between training institutions and the lack of recognition of the position of clinical engineer.

**Viet Nam**

The problems of medical equipment in Viet Nam are very similar to those described at the Cyprus Interregional meeting - a wide range of equipment provided by international organizations and donor agencies but with not more than 50 percent working, and often working inefficiently. Engineers and technicians lack basic qualifications and have little chance of complementing their training. There is also lack of documentation and technical literature. Users are not qualified to use equipment efficiently and consequently it has a short life.

Following the recommendations of the Cyprus meeting, the Ministry of Health established the department of technical materials, a training school for technical workers in X-ray and laboratory equipment with an intake of 70 per year, and also two repair factories for medical equipment, one in Hanoi with 200 engineers and technicians and the other in Ho Chi Min City with 80 staff. There is a workshop in the ministry hospital and two provincial workshops in the south and north, the latter has five engineers and 20 technicians. Under these provincial workshops are HCTS groups in provincial hospitals with five engineers and 15 technicians and HCTS groups in district hospitals with one engineer and three technicians. The service is still weak because:

- engineers, who have polytechnic education, are not experienced in health care equipment;
- technicians are trained in the MOH technical school where there is a lack of training materials and appliances, and of expert instructors.
- equipment users lack sufficient knowledge to make full and proper use of equipment.

There is an urgent need to raise the standard of technical knowledge in engineers, technicians and users. Since the Cyprus meeting, 12 two-week training courses in management, maintenance and repair of health care equipment have been organised for managerial staff, engineers and technicians in central hospitals and institutions and for staff in charge at suburban districts and communes. Also, a number of short courses on specific equipment (X-ray, ultrasound, etc.) have been organised with foreign instructors.

If WHO were to choose a country which had already carried out many of its recommendations and were to support their development so that it could serve as a study model for other countries of the region, it is suggested that Viet Nam would be an appropriate country to choose. It is also suggested that the Biomedical Engineering
Division, Health Equipment Maintenance Service, MOH, Manila, Philippines would be a suitable regional training organisation if it received support to bring in experienced trainers and to upgrade its classrooms and equipment.

Yemen Arab Republic

Since 1977 a joint WHO/Yemen maintenance project set up three regional repair workshops with the final aim of having one such workshop in each governorate. Two more workshops are currently being planned with World Bank support. The manpower requirements for a national health care technical service have already been determined.

A national training programme (NTP) in health care equipment maintenance and repair has commenced in Yemen in 1987 in collaboration with WHO.

The NTP has been set up as an extension of the central workshop in Sana'a and is under the supervision of the Health Manpower Institute. Students need to be employees of the Ministry of Health and in order to be employed they must pass an entrance examination. The biomedical technical training (BMT) is two years and the course can take up to 10-15 students. The entry qualification is for graduates of secondary technical schools. After graduation students are assigned for a further year to a regional workshop for training. On completion of this they are then assigned to their first duty station. For graduates who show leadership potential additional training is provided through fellowships overseas. Such personnel would be expected to lead a regional workshop.

Before setting up the national training centre a plan of operation was drawn-up which covered the various commitments, inputs, outputs and means of effecting the training programme. The NTP is split-up into five terms, with the first two having a higher theoretical component and the last two being the opposite. The third term is purely practical.

There are certain constraints facing the NTP, the main one being the availability of suitably qualified students. Special courses are being planned in regions where the educational level is low in order to produce adequately qualified candidates.

The NTP also has a component on planned preventive maintenance. An equipment inventory is also essential and currently a national equipment survey is in progress in order to produce one. A technical library with manuals, technical information and books is also available at the central workshop.

Private companies also carry out mainly repair work. The aim is for maintenance to be carried out by Ministry of Health staff.
Annex 3

Programme of Work

Monday, 20 November 1989

08.00 - 09.00  Registration of participants

09.00 - 10.00  Opening of the meeting
- Welcome address by Dr Fernando Lopez, Director General, University Hospital, State University of Campinas, Campinas, Brazil
- Statement by Dr Andrei Issakov, Medical Officer, Division of Strengthening of Health Services, World Health Organization, Geneva, Switzerland
- Opening address by Dr Binseng Wang, Equipment Adviser to the Secretary of Health, Health Secretariat of the State of San Paulo, San Paulo, Brazil

10.00 - 10.30  Coffee break

10.30 - 12.30  Plenary Session
- Objectives of the meeting, agenda, outline for the discussion and method of work by Dr A. Issakov
- Introduction of participants
- Election of chairman and rapporteurs
- Composition of working groups
- Presentation of working paper No. 1 by Professor J. McKie
- Presentation of working paper No. 2 by Mr T. Judd

12.30 - 14.00  Lunch break

14.00 - 15.45  Plenary session
- Presentation of the reports from countries, participating institutions and organizations

15.45 - 16.00  Coffee break

16.00 - 17.00  Plenary session
- General discussion of working papers and the above presentations
- Introduction to work in groups on the topics of HCTS manpower planning and training including manpower requirements, job responsibilities, training needs, curriculum content and entry requirements for each level of personnel by Dr A. Mallouppas

17.00 - 19.00  Working group discussion

20.30 - 22.00  Welcome cocktail

Tuesday, 21 November 1989

08.30 - 10.45  Working groups discussion (continued)

10.45 - 11.00  Coffee break

11.00 - 12.30  Working group discussion (continued)
12.30 - 14.00  Lunch break
14.00 - 15.45  Working group discussion (continued)
15.45 - 16.00  Coffee break
16.00 - 19.00  Plenary session
   - Working group presentations
   - General discussion and summary of working group conclusions and recommendations on the above topics

Wednesday, 22 November 1989
08.00 - 08.30  Plenary session
   - Introduction to work in groups on the topic of HCTS manpower training including curriculum development, training materials, training of trainers, continuing education, user training, and levels, location and organization of training centres by Dr A. Malloupas
08.30 - 10.45  Working group discussions
10.45 - 11.00  Coffee break
11.00 - 12.30  Working group discussions (continued)
12.30 - 14.00  Lunch break
14.00 - 14.30  - Introduction to work in groups on the topics of HCTS manpower utilization including career structure and development, HCTS physical infrastructure and working environment, motivation, incentives, certification, need for professional societies, organization and management of national HCTS manpower development programmes as well as of the networking of training institutions and the role of international organizations, donor agencies, NGOs in supporting HCTS manpower development process by Dr A. Malloupas
14.30 - 15.45  Working group discussions
15.45 - 16.00  Coffee break
16.00 - 19.00  Working group discussions (continued)

Thursday, 23 November 1989
08.00 - 10.45  Plenary session
   - Working group presentations
   - General discussion and summary of working group conclusions and recommendations on the above topics
10.45 - 11.00  Coffee break
11.00 - 12.30  Meeting of the secretariat
   - Drafting of the report
12.30 - 13.30  Lunch break
13.30 - 16.30  Visit to the Centre for Biomedical Engineering, State University of Campinas
16.30 - 19.00  Plenary session
- Presentation of the draft report by Mr. H. Halbwachs
- Discussion of the draft report and recommendations for follow-up action

20.00 - 22.00 Joint reception with the 6th National Seminar on Maintenance of Hospital Equipment

**Friday, 24 November 1989**

08.00 - 10.45  Plenary session
- Discussion of the draft report and recommendations for follow-up action (continued)
- Adoption of the draft report

10.45 - 11.00  Coffee break

11.00 - 11.30  Closure of the meeting
Annex 4

Outline of the issues for discussion

The following issues were suggested for discussion at the meeting:

- manpower requirements including types, levels and numbers of staff for HCTS;
- internationally accepted definitions and job responsibilities for each level and type of personnel with particular emphasis on developing countries;
- entry requirements, curriculum content, duration and methods of training for each level;
- curriculum development, teaching aids and materials;
- types of qualifications awarded, methods of assessment, certification process;
- organization of training centres, their location and level (national, subregional, regional, interregional, global), linkages and networking between the centres;
- training of trainers;
- retaining of HCTS staff, career structure and development, motivation, incentives, need for professional societies, etc;
- continuing education, in-service training, refresher or in-depth specialized short courses, manufacturer training, etc;
- training of equipment users;
- planning, organization and management of HCTS manpower development programmes;
- role of international organizations, donor agencies, professional NGOs, their collaboration and coordination;
- development of international network of training institutions for management, maintenance and repair of health care equipment.
Annex 3

List of Participants

1. Dr Yadin David, Director, Biomedical Engineering Department, Texas Children’s Hospital, Chairman, American College of Clinical Engineering, PO Box 20269, Houston, TX 77225, USA.

2. Professor Astrid de Debuchy, Director, Centre for Research and Planning of Physical Resources for Health (CIRFS), University of Buenos Aires, Paseo 121, Buenos Aires 1014, Argentina.


4. Mr Abdul Hanif, Biomedical Engineering Technician, Officer in Charge, Biomedical Engineering Department, C.W.M. Hospital, Suva, Fiji.

5. Mr Arturo Herrera, Sub-Chief, Maintenance Department, Coordinator of SIMSS Programme, Caja Costarricense Seguro Social, PO Box 10105, San José 1000, Costa Rica.

6. Dr Pius O. Igharo, Secretary-General, Commonwealth Association of Polytechnics in Africa (CAPA), CAPA Secretariat, PO Box 52428, Nairobi, Kenya.

7. Dr Andrei Issakov, Medical Officer, Division of Strengthening of Health Services, World Health Organization, 1211 Geneva 27, Switzerland, (Secretary).

8. Mr Thomas Judd, Division Manager, Biomedical Services, Hospital Corporation of America Management Company, Membership Chairman, American College of Clinical Engineering, One Parkway Center, 1850 Parkway Place, Suite 620, Marietta, GA 30067, USA, (Rapporteur).

9. Dr Andreas Malloupas, (also representing International Federation of Hospital Engineering - IFHE), Head, WHO Collaborating Centre for Training and Research on Maintenance and Repair of Health Care Equipment, Eastern Mediterranean Regional Training Centre, Higher Technical Institute, PO Box 2423, Nicosia, Cyprus, (Chairman).

10. Mr Jean-Christian Marcel, Director, WHO Collaborating Centre for Training and Research on Maintenance and Repair of Health Care Equipment, Departement de Genie Hospitalier, Institut International Superieur de Formation des Cadres de Sante, Hospices Civils de Lyon, 162 Avenue Lacassagne, 69003 Lyon, France.

11. Professor Joseph McKie, Director, Department of Clinical Physics and Bioengineering, West of Scotland Health Boards, 11 West Graham Street, Glasgow G4 9LF, Scotland, UK, (Rapporteur).

12. Mr Luis Mosquera, Project Leader, GTZ/El Salvador Project on Hospital Maintenance, PO Box 2941, San Salvador, El Salvador.

13. Mr Binh Nguyen Xuan, Deputy Director, Department of Pharmacy and Medical Equipment, Ministry of Health, 138 A Giang Vo, Hanoi, Viet Nam.

14. Mr Jethro Mkhize Mshangase, Biomedical Engineer, Ministry of Health, Programme Director, Biomedical Engineering, Swaziland College of Technology, Ministry of Health, PO Box 5, Mbabane, Swaziland.
15. Mr Frank Painter, Director, Clinical Engineering, Bridgeport Hospital, Chairman, U.S. Board of Examiners for Clinical Engineering Certification, 267 Grant Street, Bridgeport, CT 06611, USA.

16. Mr Cesar Piscoya, Director, Technical Institute for Hospital Maintenance, Alfonso Ugarte 542, Bellavista, Callao, Peru.

17. Mr Bastiaan L. Remmelzwaal, Technical Officer, World Health Organization, PO Box 543, Sana'a, Yemen Arab Republic.

18. Dr John R. Roberts, Senior Lecturer/Course Director, Department of Medical Electronics, Medical College of St Bartholomew's Hospital, Charterhouse Square, London EC1M 6BQ, UK.

19. Dr Max E. Valentimuzzi, Developing Countries Committee, International Federation for Medical and Biological Engineering (IFMBE), Laboratory of Bioengineering, National University of Tucuman, c.c. 28, Suc. 2, 4000 San Miguel de Tucuman, Argentina.

20. Mr Jorge E. Villamil Gutierrez, Chief Engineer, Division of Engineering and Maintenance of Hospitals, Fondo Nacional Hospitalario, Calle 55, No. 10-32, Bogota, Colombia.

21. Dr Binseng Wang, Equipment Advisor to the Secretary of Health, Health Secretariat of the State of San Paulo, Department of Biomedical Engineering, State University of Campinas, Campinas, SP 13081, Brazil.

22. Professor Vadim G. Zilov, Vice-Rector for Sciences, First Moscow Medical Institute, Bolshaya Pirogovskaja Str. 2/6, Moscow, USSR.
Annex 6

Composition of Working Groups

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<th>Group 3</th>
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<td>Debuchy, Argentina</td>
<td>David, USA</td>
<td>Hanif, Fiji</td>
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<td>Halbwachs, FR Germany</td>
<td>Herrera, Costa Rica</td>
<td>Issakov, WHO</td>
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<td>Judd, USA</td>
<td>Igharo, CAPA</td>
<td>Mallouppas, Cyprus/IFME</td>
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<td>McKie, UK</td>
<td>Nguyen Xuan, Viet Nam</td>
<td>Marcel, France</td>
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<td>Mosquera, El Salvador</td>
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<td>Mtshangase, Swaziland</td>
<td>Villamil, Colombia</td>
<td>Pescoya, Peru</td>
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<td>Rummelzwaal, WHO/Yemen</td>
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<td>Valentinuzzi, IFMBE</td>
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Annex 7

Working Paper No. 1

MANPOWER AND TRAINING NEEDS
OF A DEVELOPING
HEALTH CARE TECHNICAL SERVICE

Professor Joseph McKie
Director
Department of Clinical Physics and Bioengineering
West Of Scotland Health Boards
and
University of Glasgow
Scotland
UK
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Summary

1.1 The problems of management and maintenance of health-care equipment can be overcome only if a range of professional personnel is involved. Many problems are due to the absence of trained staff at the level of Health Ministries where policies must be formulated and strategies planned. From this high level, the range of necessary staff extends to the individual health-care institutions.

1.2 No actions to improve the management of health-technology are likely to be effective unless they are planned with an understanding of the differences between the cultures of the industrialised countries, which have become permeated by technology, and those of the developing countries whose cultures are still essentially non-technical. These differences slow the rate of technology-transfer and necessitate different practices in the provision of a health care technical services (HCTS).

1.3 The immediate need for expertise in the management of technology within the Ministry is likely to be met by sending a senior officer, probably one who is medically qualified, for specialised training which gives an overview of technology and teaches management techniques and skills. This training may soon become available at international training centres.

1.4 The majority of staff in a HCTS should be in an intermediate category (called 'Type B') whose attributes are outlined. In some countries it may be possible to train those leaving technical schools or colleges to the requisite level but in most third-world countries it will be necessary to train university graduates; the two training schemes are outlined.

1.5 Another category of staff ('Type A') can be useful where there are Type B staff to manage and supervise; their training may be partly in the educational sector and partly in the health sector; various schemes are suggested.

1.6 An important aspect of the management of technology is the training of the users of equipment in good practices of using and caring for their equipment.

1.7 All training schemes depend on the availability of knowledgeable and experienced trainers. In the formative years of an HCTS training school there will be a need for expatriate expertise to train the trainers. Ways of arranging this assistance are discussed.
2. **INTRODUCTION**

2.1 If the application of technology to health-care is to be optimised, a wide range of professional and occupational groups must become involved. Often, the only aspect of management of technology which is recognised and addressed is the problem of repairing hospital equipment, when it becomes evident that a large fraction of a country’s equipment is in an unusable condition. The action taken is usually to attempt to impart the technical knowledge necessary for repair to a relatively small number of technicians who are to be employed in hospital workshops or maintenance centres.

2.2 This is a solution which can be successful in dealing with the limited problems which sometimes occur in developed, industrialised countries which have a long-established technological culture. In a poorer, developing country in which technology is not yet indigenous but is being imported and assimilated, the education, training and employment of technicians, important though it is, cannot by itself achieve the desired results.

2.3 When faced with a piece of non-functioning equipment in a hospital, we are likely to ask "What is the fault, and how can it be repaired?". But there are other questions which may be equally important, or more important. "Why is it here? Is the cost of its purchase, use and maintenance a justifiable expenditure, in the context of the health-priorities of the community? Are the necessary resources available for its use and its upkeep?" For if the country or the institution is not able or not willing to make a significant allocation of funds for maintenance, or is unable to provide the currency needed to import spare parts and consumable supplies, no amount of technical 'know-how' will keep the equipment functional.

2.4 We should also ask "Is it appropriate to the physical environment and to the available services such as power supplies?" We may think of a CT scanner in a city where the mains voltage is often 100% lower than nominal, and sometimes as much higher, the bed-pan washer where the water pressure is almost zero, or the mortuary cabinets designed to work in a temperate climate and not in the tropical heat.
2.5 A less obvious but even more vital question is "Is it appropriate to the intellectual climate of use - i.e., do the users have the knowledge and experience necessary to use the equipment effectively and to interpret or control the results?" It is possible that all those who will use the machine lack a technical background; it is often difficult for an observer from a developed country to appreciate the extent of this disadvantage, which can cause even equipment which is technically simple to be seriously abused. When very sophisticated laboratory or imaging equipment is provided, the doctor may have been working for many years with simpler apparatus which has been performing very inefficiently and so may be seriously lacking in the skill and experience which is a prerequisite for use of the advanced technology.

2.6 Another vital issue is "Can it be supported by the manufacturer?" Even if all other circumstances are favourable, for all except the simplest of devices it is likely to become necessary to communicate with the manufacturer to obtain supplies, spare parts or information. If no lines of communication can be established, if there are problems of language, currency, finance, transportation, the potential life of the equipment may never be achieved.

2.7 If all of these questions are to be satisfactorily answered, it will be clear that an extended structure for management of technology is required. It will not be enough to concentrate on only one aspect of the problem, whether at the 'grass-roots' level or in the 'corridors of power'. Some of the issues can be resolved only at Government level, some at the intermediate level of Province or Region, some at the level of Hospital ward or clinic.

2.8 At each of these levels there is a need for staff with technical understanding, skill and experience. Also, at each level there is a requirement for managerial understanding, skill and experience. Varying proportions of technical and managerial skills are needed at different levels. An Assistant Secretary in a Ministry of Health does not need to be efficient at fault-finding on a printed-circuit board, although his contribution will be enhanced by enough knowledge to make him respect those who have acquired this skill. The electronic technician in the workshop does not require a diploma in management, although he will be of limited value if he does not know how to manage his own working processes and his relationships with the variety of colleagues whom he serves.
2.9 It is in the first stages of development of a Technical Service that the need for a mixture of these types of expertise is most important. The first technical staff in an institution need to have considerable managerial skills, for they will be responsible for building the foundations of the infrastructure at the working level. The first administrators who formulate technological policy at Ministry level will be impotent without technical knowledge, as there will be no reliable technical advisers to support them.

2.10 In the public health-sector of a typical developing country there will be some senior personnel with a concern for these problems: they will know the symptoms well, but will not have been able to analyse the root-causes or to formulate solutions. At the opposite end of the spectrum, there will be some 'technicians' who are craftsmen by training and experience and who may have been able to extend their technical abilities by their own enterprise. There will also be younger 'technicians' with technical school training but with no specific knowledge or experience in medical equipment. It is very unlikely that there will be staff whose knowledge and experience or whose status falls between these extremes. There will be no posts established for such persons, and even if there were such posts, persons qualified to fill them will be in short supply and will be able to command salaries which the public health service will not be prepared to pay.
CHARACTERISTICS OF DEVELOPING COUNTRIES

3.1 The reference in the preceding paragraph to a 'typical developing country' invites strong criticism. Developing countries have characteristics as diverse as developed countries; their development has started from different circumstances and has reached different stages. Most third-world countries, which are poor relative to the economic parameters, the life-styles and living standards of the 'first-world' industrialised countries, are developing in the sense of reducing these differences. But some developing countries are relatively rich. Some are becoming industrialised very rapidly. In the process of development, some retain a very distinctive national culture, others avidly adopt imported cultures or have had these cultures superimposed upon the indigenous culture.

3.2 The help which countries need in order to utilise technology effectively in their approach the goal of 'health for all' is correspondingly varied. Some need little more than sound advice based on the practice of the industrialised, first-world countries; their process of development may be speeded up by supplying literature, training syllabi, etc. But in this paper, 'typical' describes the conditions seen in many Country Surveys, or outlined in Country Reports, where progress is slow or un-detectable, where the country does not seem able to help itself, where earlier aid programmes have provided resources and seeded development activities but these have decayed rapidly and have had no multiplying effect.

3.3 Two important factors have been seen to contribute to this discouraging scenario. The first is so obvious that its implications are often given insufficient weight: the country is poor and technology is expensive! Medical technology has become increasingly expensive in the first world whilst countries of the third world have become relatively poorer. The resources required to manage imported, first-world technology effectively simply cannot be made available. No advice, encouragement or transient aid-programme will transform the situation. For example, working practices and sources of motivation which are familiar to ex-patriates, and which they try to encourage, may be impracticable where the wages from one employment cannot provide a family with
the basic necessities of life and where 'moonlighting', bribery, misappropriation of supplies, etc., are the common techniques of survival.

3.4 The second factor is less obvious. The culture of the typical third-world country lacks the technological elements which have gradually permeated the culture of the first-world countries during the centuries since their industrial revolution. Those who live and work in these industrialised countries do not appreciate the extent to which technology has affected personal and community life: they can see the overt effects on their daily activities (cars, television, etc.) but overlook the less obvious influences in their educational system, their political and social attitudes, their philosophy and religion, their personal aspirations and values. More significantly, they do not understand how this unseen technological culture provides a basis for their overt technological activities. Therefore they do not adequately evaluate the difficulties of transferring their technological practice to a country where the support of this technological culture is absent or is still embryonic.

3.5 In a technologically developed country we admire high technological and technical skills; we assume that a skilled technologist will be relatively well paid. We value technological education and have no hesitation in directing a child into this subject, when aptitude is shown. Many people who are not themselves technicians or technologists will acquire technical skills to help them in their work, or as a leisure pursuit; they will learn to repair or improve home, car, etc., sometimes for economic reasons, sometimes for enjoyment and often for both. There is no class or caste barrier to technological activity, understanding or enjoyment. Even where an individual has no technical skill or interest, he or she will almost certainly understand the need for effective management of their personal, domestic or occupational technology; in most cases they will have learned this from the experience of many generations of their families.

3.6 Such characteristics are not commonly found in the typical third-world country. Traditional technical skills are practiced by persons who are not highly ranked in the social order; there is a pronounced tendency to place technologists on the lower side of a caste barrier, amongst the poorly paid. Consequently, technical education is not chosen for the children who are most able or whose
parents are from the influential social groups. Education is a means of escape from menial, manual work and whereas the intellectual component of technology may be admired, its practical activities are avoided as much as possible both during education for a profession and in its practice. Technical skills are not widely acquired, practised or enjoyed amongst general population. The need to manage technology wisely and economically is not commonly understood; traditionally, the rich have had no need to develop this skill, the poor have had no opportunity to do so.

3.7 The symptoms of these cultural differences are seen in many aspects of everyday life, surprising and irritating the visitor from a developed country. They have a profound influence on the transfer of first-world medical technology, limiting the speed at which it can be assimilated. A large proportion of the symptoms which are common to all reports on health-care equipment in these countries can be understood in terms of these generalisations about lack of a technological culture. For example, the generalisations explain the inattention to maintenance by managers and administrators, high levels of equipment abuse by staff, acceptance of poor equipment performance and poor after-sales service, poor educational levels of technical trainees, low status of technical staff (including low self-image) and low wages.

3.8 This emphasis on two factors which profoundly affect the utilisation of technology and which cannot readily be overcome is not intended to make the task of technology-transfer seem impossible, or to suggest that no action to overcome the prevalent symptoms of mis-management of medical equipment is worthwhile. But it is intended to show that the simplistic approach which has characterised many aid-programmes and most of the well-intentioned national, regional and international schemes - an approach which is still evident in current plans and programmes - can result only in disappointment, frustration and waste of the substantial resources which are expended.

3.9 Most projects intended to improve the management and maintenance of equipment set unrealistic objectives which cannot be attained within the planned timescale, or with the resources allocated. The time-scale allowed for projects may be as short as two weeks and seldom exceeds two or three years. Of course, as components in a larger programme, short projects may be valuable. But the
time required to effect a substantial improvement in the management of medical technology in a country where no effective technical infrastructure already exists, and to ensure that the improvement can be continued from indigenous resources, without expatriate support, is unlikely to be less than a decade. Even within this longer period, success is unlikely to be achieved unless there is co-ordinated action to meet the needs at all levels of health-care provision.
4 TRAINING OF STAFF AT HEALTH MINISTRY LEVEL

4.1 In considering the manpower needs and the training and development implications at the various levels, it must be understood that simultaneous action at all levels is necessary. Many past projects have had no substantial success because the objective was to train only low-level technicians, who were subsequently faced with an impossible task due to all the failures of higher-level management and control outlined in section 2, in addition to all the intrinsic difficulties of lack of a technological culture described in section 3. But of course it would be equally ineffectual to provide highly-qualified management within a health ministry, but no technologists or technicians to work within the hospitals and clinics. However, this review must start at some level, and the first level to be considered will be the highest level, for the reason that this has been the most-neglected problem.

4.2 The tasks to be undertaken at Ministry level to avoid or to reduce the problems of transfer of medical technology are many and various: they have been examined at greater length in the working papers for the Cyprus meeting. The following summary is not intended to be comprehensive or to indicate priorities, but rather to indicate the type of individual required and the manpower development which is necessary. These tasks include:

- policy on appropriate types and levels of equipment within the country;
- policy on sources of equipment, including negotiations with donor agencies;
- control of standards of manufacturing and of servicing;
- regulation of safety (electrical, gas, radiological, bacteriological, etc);
- financing policy (e.g. insistence on correct apportionment for maintenance);
- assistance with problems related to import and currency restrictions;
- assistance with regulation of procurement practices;
- organisation of information technology (inventories, etc);
- provision of specialised services for projects involving installation of major equipment (e.g. an X-ray department)
- planning and implementing the structure of the HCTS in the public sector;
- setting realistic levels of wages, conditions of service, incentives;
- controlling the staff-development programme, in liaison with the Educational sector;
determining methods of certification of competence, in association with professional bodies, etc.; collaboration with bodies regulating other professional training (doctors, nurses, etc) to improve user-training for technology; collaboration with Universities, etc, in relevant education, research and development; collaboration with industry towards self-sufficient in appropriate technology.

4.3 Typically, there will be no officer in the Ministry of Health who has a technological qualification or expertise and experience in the management of medical technology. The most senior person with technical knowledge to whom the Minister of his officials can turn for advice is often a senior but poorly-qualified technician or tradesman within the service - perhaps, in a public health laboratory under the direct control of the Ministry. Alternatively, the Minister may seek advice from a senior member of the academic engineering community who has no understanding of the practical problems of health-care and whose advice may be designed to promote academic activity rather than the improvement of health.

4.4 Ideally, one of the senior officers in the Ministry of health should be a well-qualified engineer with specialised experience of the problems of health-care technology and knowledge and experience of the science of management. But this is a goal for the future, not a real possibility for the present. This combination of attributes is rare in a developed country and non-existent in developing countries. Of course it would be possible that, after a health care technical service had been established and able engineers had gained experience, some would rise to the highest level of responsibility. But it has been argued that the HCTS cannot be successfully established until there is effective leadership in the Ministry: so where is this to be found?

4.5 Clearly, there is a need for a type of training which is not yet being provided. It must be given to staff who are to occupy senior positions in their Ministries, for they must be able to influence national policies and national actions which involve large resources. It is not realistic to suppose that the necessary status and authority will be given to someone who does not already
have substantial seniority. When a Minister is persuaded of the vital importance of training for such a post, he will be likely to select an individual—or more than one—who has already shown ability in a responsible post. This seems most likely to be a medically-qualified person, but might sometimes be a non-medical administrator. As the HCTS develops we can expect that there will be qualified technologists added to the Ministry staff and sent for this special training. At that stage the curriculum will be widened to meet the needs of entrants with diverse educational backgrounds and experience, but initially the emphasis will be on a general overview of current health technology, a study of management theory and techniques, the goals of the manager of medical technology and on the acquiring of skills in practical problems of technology management.

4.6 It may be possible for such an innovative programme of education and training to be provided at one international centre, or perhaps at a few centres, in the developed world. The resources required are large, not only for the establishment of a centre but also for the upkeep of its facilities. If the third-world countries are to benefit, aid-programmes will be needed. There have been studies on the requirements and on possible ways of satisfying them, and these are now being considered by the senior staff of WHO. It is too early to predict the outcome.

4.7 In view of the list of tasks outlined in para. 4.2, it will seem foolish to think of only one or two individuals receiving the appropriate education and training. But the concern of this paper is with a practicable and a well-planned start towards a comprehensive service. There is a great danger of presenting comprehensive and detailed plans which would require resources far beyond those which can be provided, and of setting targets which are impossible to reach. Sometimes this is a deliberate strategy to avoid taking action, sometimes it is the result of naivety; in either case the inevitable result is disillusionment and a delay in making progress, possibly with waste of the resources initially committed and a reluctance to take further and wiser action.

4.8 In many countries, the rate of progress would be greatly increased if at least one senior official in the health Ministry had real understanding of the needs of technology and of the techniques needed to manage it. To ensure that this
minimum provision is made in every country where it is needed would be a major achievement which would change the global problem by removing 'understanding' from the top of our list of international shortages. Certainly, when the benefits to medical technology of knowledge and managerial skills have been demonstrated, more staff will be trained and employed, and more of the tasks can be tackled. In the interim, the Ministries are likely to make use of the technologists whose training will be discussed in the following section.
5 TRAINING OF STAFF FOR THE INTERMEDIATE LEVEL (TYPE B)

5.1 This section considers another class or group of staff which has been neglected in many programmes for staff development for technology; this class is identified as 'Type B'. Although in the majority of developing countries there may be some persons who can be placed in this category, there will be very few, and many more will be needed. It is this class which is the most numerous in the HCT5 of the more advanced countries or in the servicing divisions of the industrial and commercial enterprises which produce and supply technical equipment. Examination of the manpower in these developed countries may show many sub-divisions of this class; sometimes there are rigid distinctions between them, such as University graduate/ Technical School graduate, or Engineer/Technician; there may be distinctive schemes for certification or registration and differences in salary levels between the sub-groups. Indeed, there is often a noticeable tendency for advisers and consultants coming from developed countries to be more concerned to ensure that these distinctions are introduced into a developing country than to get the tasks done using the best indigenous structure which will enable staff to be found, trained and employed.

5.2 At the technical level, persons of average ability in this class of staff will have the ability required to -

- find and repair hardware faults (given spare components), using circuit diagrams, on any common type of clinical equipment such as patient physiological monitors, defibrillators, surgical diathermy, laboratory bench equipment, this being equipment which is not microprocessor-controlled;

- correct hardware faults to pcb level on more complex equipment, given service manuals and replacement parts;

- replace components on boards;

- identify software problems, given user and service manuals;

- improvise using substitute components or materials;

- be trained by the Manufacturer to service complex equipment such as X-ray machines.

- carry out performance checks on most types of equipment;

- carry out standard electrical and other safety checks on all types of equipment;
inspect equipment and to recognize symptoms of wear, misuse, etc. which may lead to breakdown, hazard or unacceptable performance. Judge when equipment is obsolete or unfit for further service. Commission most types of new equipment, given user manuals. Read technical literature and to communicate on technical issues with confidence in the international language in use in the country.

5.3 At the managerial and inter-personal level, typical Class 8 staff will be able to:

- set their own immediate goals and to monitor their own performance;
- recognize the limits of their competence and to reject tasks beyond this level;
- improve their capabilities by self-regulated study;
- direct and supervise the work of subordinate staff, setting realistic goals and monitoring performance;
- communicate their knowledge to peer and subordinate staff;
- communicate with, and gain the confidence of, superior staff, explaining their needs and problems, and suggesting solutions;
- take an informed overview of the situation within which they work, its constraints and its opportunities.

5.4 This class will inevitably contain staff with a wide range of ability, some capable of more than the outcomes listed above, some less. But the level of ability will be generally recognizable from this outline. For any country it will be necessary to assess realistically the educational background from which trainees will be selected, and the type of training which they will require, in order that the necessary abilities will be developed and applied. It is vital to understand that judgements on these matters will necessarily differ from country to country: in particular, the practice of a developed country may be totally inappropriate. It is here that an understanding of the effect of cultural differences is important - especially the effects of the differences in the technological content of the culture.

5.5 In some developed countries the majority of persons who perform work at this level do not receive a university education; they are educated in technical schools or colleges (sometimes by part-time or 'sandwich' schemes) and obtain
technological diplomas or certificates which are highly respected by employers in both public and private sector. Their education and their employment earn them both respect and satisfactory monetary rewards, as described in para 3.6. The attitudes and customs of the society imposes no barrier to the personal career opportunities, which is largely dependent on the individual ability and energy.

5.6 In other cultures the ability needed to work at this level is most unlikely to be developed in a person who does not fulfill the requirements for university entrance. Even if the individual has the inherent abilities, the society will not accord to non-graduate the status, the responsibility and the rewards which are appropriate and necessary for this class of work. Also, individuals are generally captives within their cultures and only exceptionally will a person strive to break through the cultural barrier.

5.7 Many well-intentioned projects to train and to employ HCTS staff have been frustrated because these issues have not been faced and judged correctly. There has been great difficulty in imparting the ability to trainee 'technicians' and on the rare occasions when this has been successfully achieved, the subsequent work-performance has been very poor. The sponsors and the project staff have been disappointed and disillusioned. This need not happen if the correct decisions are taken, based on the characteristics of the country. It must not be thought that there is 'loss of face' if a culture is judged to be different from that of the country which sponsors or provides advisers and helpers. It is a sign of maturity to match policies and plans to the national characteristics, rather than to those of another country.

5.8 The training needs are obviously very different for entrants who have already studied engineering or science to first degree level, compared to those who have just left technical school or technical college. But it must not be assumed that the university graduate is fitted for employment in the HCTS without further education and training. Once again it is important to take into consideration the characteristics of a non-technological culture. If it is thought that cultural considerations make it appropriate to train university graduates rather than those qualified in technical school, it will probably also be true that the university course has been directed towards the development of
intellectual abilities and has done little to develop practical technical ability. In many academic institutions of the third world there is a shortage of the apparatus needed for practical work in laboratory and workshop, and the available equipment may be very old and based on obsolescent technology. Also, there is now a tendency to use practical laboratories as an aid to imparting theoretical knowledge rather than to develop technological knowledge and skills; this is less serious in the industrialised world where the student can be expected to have developed technical interests and acquired technical skills outside the formal educational process; it is particularly unfortunate in a third world country because it fails to compensate for the lack of technical skill and reinforces the cultural devaluation of technical ability.

5.9 The graduate may also have had an education which is narrowly specialised and may know little about other branches of engineering or science. So there will be a need for courses which cover the engineering and scientific fields which are relevant to medical equipment; this means that each student will find some parts familiar and elementary and others unfamiliar and more interesting. But it should always be remembered that no course covers everything, no examination tests every part of the curriculum, no student studies every particular of the taught course and none understands all that is studied. The average student leaves a university course with substantial gaps in knowledge, some of them on subjects which are considered to be basic, core material of the subject. Also, students may be able to satisfy examiners by returning the ideas in the way in which they were formulated by the teachers, without possessing the depth of understanding which is needed to apply the ideas to the problems of the real world. So it is very desirable that all trainees are made to study all those subjects which are highly relevant to the work to be done.

5.10 An obvious gap in the pre-entry education of most engineers will be human biology and medical practice. An overview of these subjects will be needed. The teachers should be chosen with care, for there is a tendency for lecturers to include the detail which they cover when teaching doctors, nurses and other professionals. The object should be to enable the technologist to understand the purpose and use and important parameters of equipment and clinical techniques, and to communicate intelligently with the clinical users; it is not the aim to replicate the expertise of other professions.
5.11 The largest component and the most vital part of a course for university graduates must be the practical training. This can be divided into two parts. The first will develop general practical skills and should cover the important basic practices in mechanical workshop technology, electrical technology and electronics. All trainees should receive training in each of these branches. The purpose is threefold. Firstly, to be useful the trainee must be self-sufficient when working with equipment; in many situations there will be no reliable staff of lower grade to do the 'dirty work'. Secondly, the trainee will eventually be expected to direct and supervise the work of less-skilled technicians and craftsmen; he will not be effective unless he has an understanding of the task and, ideally, can show the subordinate how it should be done. Thirdly, the aversion to practical work and the devaluation of practical skills must be quickly overcome and there is no better way than by personal discovery of the challenge and the rewards of practical work.

5.12 The second part of the part of the practical training will be the application of the technologies to the testing, maintenance, fault-finding and repair of the common types of medical equipment. At first this will probably be done in the workshops of the training school, using equipment kept for this purpose. When the students are able to dismantle, reassemble, test and use the equipment, deliberate faults can be introduced to teach fault-finding skills. However, it is then necessary to move closer to the working situation by dealing with the real problems which are presented to the HCTS workshop, in which the solution is not known and which may or may not be within the capability of student (or tutor). Until the trainee learns to cope with this situation, the training is unrealistic. A training centre should be associated with a service workshop which deals with a substantial load of routine work, to provide this experience. Even this should not be the final stage of the training: the student should be attached to a service team in a hospital or district workshop to learn to deal with the routine work in the actual working environment with all the pressures of variable workload, absence of information, shortage of spares, unreasonable expectations of users, etc. This will reduce the problem which many trainees face when they have to make the transition from the carefully simulated problems of the classroom to the untidy, open-ended difficulties of the working environment. If the gap is wide and the newly-trained employee is inadequately
supervised (as can easily occur in a developing service) the individual may lose confidence and may never develop into a useful employee.

5.13 The type of training described in the preceding paragraph will most effectively be given within a school which is established for this purpose. It is possible that this could be contained within a larger technological institution or within an institution which meets broader needs for the Health Services, but there will be little in common with the other courses in either type of institution, and the school requires staff who specialise in the field of medical equipment and have relevant experience. There are obvious advantages in such a linkage from the viewpoint of resource-sharing, but it is more important to have close links with health-care institutions to provide easy and continuous access to practical experience.

5.14 The importance of managerial skills has been stressed, and this will require a specialised course which may be divided into several parts. Some parts will be aimed at developing general managerial skills, applicable to many types of activity. Subjects will include:

- managing people at work,
- managing personal performance through goal-setting and achievement-appraisal,
- managing inter-personal relationships.

There may be local expertise which can be used—perhaps there will be a department of management studies in the educational institution with which the course is associated. These parts of the course should be planned at an elementary level; they can be expanded and deepened at a later stage in the development of the HCTS.

5.15 Other parts of the course will be specific to the management of health care technology and will include:

- an overview of the health environment and policy in the country,
- aspects of financial management,
- operational management related to service facilities,
- inventories,
- costing and invoicing of work,
- quality control,
logistics, information technology systems.

For some of these subjects there may be no obvious sources of expertise in the country, so that expatriate help will be needed in the early stage of development. Again, it is important to plan at a realistic and simple level at first, and to expect further development as the HCTS and the training school develops.

5.16 If the situation in a country is such that staff who are educated in technical schools/colleges can be satisfactorily trained and employed as Type B technologists, then a more prolonged course of basic technical training will be needed. This may be done in a separate training school or within an institution which has broader responsibilities for technological training. Much of the core material will be common to other courses in such an institution and the teachers will generally have more experience in educational techniques that those in a health-service school whose experience is in service rather than in teaching. However, a characteristic of educational establishments which should be avoided is excessive detail in the syllabus; sometimes a syllabus reads like an encyclopedia of all technical knowledge; this suggests that the teachers have no experience of practical application. Only knowledge which is used in practical work, or which is essential to understanding of practical technology, should be included – this will be sufficiently comprehensive and challenging to students. A more general way of expressing this principle is that the tuition should be planned to meet the needs of the health service and not those of the educational institution. This will often require tact and firmness at the planning stage.

5.17 The later parts of the training will be similar to that described in para 5.12; irrespective of the education level at entry, every person trained for this class of service must have practical training in the management and maintenance of the equipment used in health-care. For this second part the school within an educational institution can have serious limitations, unless it is close to a major health institution and can have intimate links with it. It is not satisfactory to teach the practical applications only within a classroom or teaching-laboratory situation where the equipment faults presented to the students inevitably become artificial and where the working environment, the
working conditions and the motivation remains that of a school rather than a health-care institution.

5.18 Another difficulty experienced in providing the practical training within an educational establishment is the difficulty of finding tutors who are sufficiently experienced in the techniques which they teach - and, if they are found, of keeping this experience updated. The persons whom have the most knowledge to impart to the students are those who are actively engaged in providing a good service. However, it does not follow that they are best able to transfer the knowledge to the trainees. The best compromise is to use staff who have a dual role, partly as service-providers, partly as teachers, and to ensure that they are adequately trained for both roles. If this is done, the training can be located either in an educational establishment which is closely associated with an active service workshop, or in a service workshop/training school which is associated with an educational establishment.

5.19 A benefit of a link with an educational establishment is the ability to give a recognised award to a student who successfully completes the training. In most countries this is a necessity, if the staff are to be motivated and respected. When there is urgency to get some training scheme started, it is easy to overlook the need to reward the trainee with a qualification which society will recognise and will value; as a result of this oversight, the quantity and quality of entrants can be permanently depressed.

5.20 When the HCTS is sufficiently developed to ensure that those emerging from the formal course of training can be placed in working-situations where they can be adequately supervised and evaluated, there is much to commend the requirement of completion of a probationary period of practical service before the qualification is awarded. This is, of course, a common practice in other professions both inside and outside the health-care sector. The transition from trainee to serving officer can be eased by this process, and the loss of staff at the end of training can be reduced.

5.21 This review will not attempt to describe the division of 'Class B' staff into a hierarchy of sub-groups, or the training implications of such a 'finestructure'. When an HCTS is well-established and the service can be improved to
the best international standards, this will be a necessary development. In the situation where there is great difficulty in finding and in funding a small group of suitable entrants for the service, where qualified trainers are even more rare and where even the first training establishment has primitive facilities, it is unwise to set goals which are unattainable within a reasonable timescale. Nothing which has been recommended will be incompatible with a more highly structured and refined system of training, once more basic and modest targets have been achieved.

5.22 For the same reason, the review does not attempt to calculate the number of staff who will be needed and the training resources required to produce them. The writer has no experience of any third-world country where such a calculations could be meaningful or helpful at this time, or for many years to come. The urgent need is to start on the small scale which can be practicable today.
6 TRAINING OF STAFF FOR THE LOWEST TECHNICAL LEVEL (TYPE A)

6.1 The third class of staff to be considered, described as 'Type A', may have a variety of different descriptors or titles in different countries. A common description is 'Polyvalent Technicians' which implies that they can do anything, this is far from the truth. The majority of training schemes for technicians in the third world have attempted to train this type of technician, and the word 'polyvalent' seems to justify this activity. In the writer's opinion, the reason for concentrating on training at this level is not that the trainees are especially useful, but rather that the entry level is relatively low and the training is relatively easy and cheap to provide. Such training schemes give the impression that something is being done to alleviate the problem of health-care equipment, but in reality the outcomes are very small.

6.2 This is not to say that Type A staff are not useful, nor that they should not be trained and employed. The mistake is to train and employ only Type A staff, or to produce Type A first, before there are any Type B. For Type A staff are useful when they supplement more highly qualified staff and are managed and supervised by them. Where effective management is provided, this class of staff is useful; where it is not, the provision of these persons is a waste of resources.

6.3 Staff of this type will generally possess a short range of skills which form a subset of a very wide spectrum of craft skills. There can be no clear distinction between the work of craftsmen and technicians - the use of such terms varies from country to country. Even within one group in one country there can be large variations in the range of work, the level of skill and the proportions of manual and intellectual ability which the work requires. Therefore, following characteristics are not comprehensive but give some indication of the class in general.

6.4 Type A staff will have the ability to -

- fabricate parts in a mechanical workshop using hand and power tools, according to instructions/drawings;
- repair mechanical parts by soldering, welding, etc.;
- inspect, lubricate, clean, change filters, hoses and generally service and
perform preventive maintenance on mechanical equipment;
or
solder, desolder, fit parts to electrical equipment, make measurements of
basic electrical parameters;
make safe and satisfactory connections to electrical mains supplies, test
and fit batteries, etc.;
carry out prescribed safety checks and performance checks on electrical
equipment;
and
recognise common types of medical equipment and have a general
understanding of their purpose and function;
recognise common faults on widely used equipment;
keep adequate records of work done;
write meaningful reports in the native language;

and will achieve self-fulfilment by acquiring and exercising these abilities.

6.5 The basic skills needed in this class of staff can be imparted in craft school
or technical college; there will almost certainly be suitable institutions which
give similar training for industry, etc; it should not be necessary to create a
special course, although an institution which trains for health care should
include practical examples from this field.

6.6 In addition to the basic skills, the students will need a medical orientation
course, to enable them to work safely in the hospitals and clinics. They will
require a course dealing with the commoner types of medical equipment, at a
simple, practical level.

6.7 After college-based courses (or perhaps concurrently, in a 'sandwich' pattern)
there should be an apprenticeship period when the trainee works under close
supervision of an experienced type A staff member. After this a certificate can
be awarded.

6.8 Local circumstances will determine the duration of the training periods, but a
typical course would cover two years, one college-based and one work-based.
6.9 When the training scheme is well-established, it will be useful to give further 'in-service' training in more specialised work, by means of short modules; this will provide opportunities for career-advancement for the ablest workers.

6.10 Because staff in this class are of little use without good management and supervision, the numbers to be trained should be governed by the rate of production of Type B staff. Where there is a team with one or more senior staff, one or more staff of Type A will be useful. In a well-established workshop with a mechanical workshop and specialised facilities (e.g., for electronics, medical gas equipment, refrigeration, etc.) the proportion of Type A staff will be higher.
TRAINING OF USERS OF EQUIPMENT

7.1 In any country, developed or undeveloped, the majority of faults affecting equipment which is in use can be avoided if the user understands how to operate and to care for the equipment. The general lack of understanding of technology in a third-world country intensifies the degree of mis-use; simple care such as cleaning of equipment or its protection when not in use is almost totally neglected.

7.2 One of the most useful tasks which the staff of a HCTS can perform is to educate the users with whom they work. This requires staff who have the necessary status and can command respect, and who can communicate effectively; this is one of the reasons for valuing Type B staff above Type A, for duties in health-care establishments. One of the goals of HCTS staff training is an understanding of the contribution which users should make to the care of equipment, and the development of techniques of teaching, encouraging and monitoring user-care.

7.3 Of course, if the users do not see that the HCTS staff are caring for equipment, they will not be impressed by their teaching. It is when HCTS staff are regularly inspecting and performing preventive maintenance that they will be credible advocates for equipment-care. HCTS should also prepare instructions which should be attached to equipment or given to users, detailing the important user-actions; these may be clearly stated in the user-manuals but experience shows that manuals seldom reach the user when equipment is new and are almost never available to subsequent users after the equipment has been in regular service.

7.4 Ideally, all staff should be taught about the need for elementary care of the equipment which they will use, during their basic training. In trying to introduce this teaching to the curriculum for doctors and nurses, we face the problems of the many demands for additional teaching time, of the lack of understanding of the importance of the subject amongst teaching staff and of the absence of resource material for the teaching. The development of teaching programs for nurses and doctors, which use audio-visual aids to show care of common equipment in a third-world setting, would be a valuable contribution to equipment management.
7.5 The systematic teaching of users is one of the issues which should be handled at national level by staff whose seniority enables them to exert an influence over the difficult area of professional education.
8 THE TRAINING OF TRAINERS

8.1 The training of trainers is a crucial issue when plans are being formulated to meet the training needs of a HCTS. There will usually be few, if any, technologists in the country who have the necessary experience in the application of technology and in its management which can be passed on to the trainees, and who are also skilled in the techniques of training.

8.2 Sometimes the only option available may be to train the Type B staff (and, in an extreme case, the Type A staff also) outside the country in a Regional Centre or in a country where the HCTS is more highly developed. This is an expensive, short-term measure which makes only a limited contribution to the national situation, as it has little impact on the underlying problem of creating a technological culture.

8.3 A better use of expatriate resources is made by sending to the other country those who will become the teachers and trainers within the national training schools. It is sometimes assumed that all staff who are sent for training to another country will share their knowledge on their return, but this is not always the outcome. In fact, many staff are sent to other countries without clear specifications of the expected outcomes. When prospective trainers are sent for training, there should be clear specification that a required outcome is ability to train and to communicate knowledge; the attachment should be planned so that it will deliver this outcome.

8.4 A training attachment for a prospective trainer will usually have several outcomes. One will be a deepening of the individual's technical knowledge and skill. Another will be experience in the application of this knowledge and skill to the work of a HCTS. A third will be experience in the management of a HCTS. The fourth will be that outlined in the previous paragraph, namely the ability to impart the knowledge and experience to other staff.

8.5 Most institutions in a developed country to which the prospective trainer may be attached can offer experience in producing one or more of these outcomes, but few can provide all to the same standard of excellence. It may be advisable to
arrange several attachments, specifying different outcomes for each - although a contract may be made with one centre which will sub-contract as appropriate.

8.6 A difficulty is to get good advice. Any centre will tend to overstate its strengths and to understate its weaknesses. WHO Regional Offices should be able to advise, but few, if any, possess the expertise to judge. Here there is a clear future role for WHO Headquarters.

8.7 However, an attachment to another country is not the only way in which expertise may be imparted to trainers. It is possible to bring expatriate staff to assist in the setting up of training schools and workshops, including the training of the school staff. There are advantages and disadvantages of each method. Training in a developed country will give the trainee access to experience of a developed HCT, to a wide range of teachers and to good facilities; but the trainer who learns to work in a rich, technological culture may be unable to work in the different conditions of a poor country with a non-technological culture. Expatriate teachers visiting the third-world country will have to train the student for the real working situation, but with limited exposure to established practical work and using only the knowledge and ability of one (or, ideally, a few) person(s).

8.8 However, if the aid-project is wisely planned, it may be possible to combine the two methods, both taking the prospective trainer to learn in an expatriate centre and also taking staff from that centre to work as counterparts in the developing country. Probably the best sequence is a visit from the developed centre to appreciate the conditions which the new school will encounter and to select the appropriate individuals to receive the training, then the attachment to the developed country and finally the joint work in the new centre. This is a scheme which has been found to be effective, provided that the collaboration extends over a sufficiently long period.
Annex B

Working Paper No. 2

A MODEL FOR MANPOWER DEVELOPMENT AND TRAINING
FOR HEALTH CARE EQUIPMENT PROFESSIONALS

Dr Yadin David
Director
Biomedical Engineering
Texas Children’s Hospital
Houston, Texas

Mr Thomas Judd
Division Manager
Biomedical Services
Hospital Corporation of America Management Company
Marietta, Georgia

Mr Robert Morris
Director
Clinical Engineering
Oregon Health Sciences Centre
Portland, Oregon

Mr Frank Painter
Director
Clinical Engineering
Bridgeport Hospital
Bridgeport, Connecticut

USA
Primary authors of the paper gratefully acknowledge the advice and contribution provided by:

Dr. A. Iisakov, World Health Organization, Geneva, Switzerland

Professor J. McKie, West of Scotland Health Boards and University of Glasgow, Glasgow, Scotland, UK

Dr. B. Wang, Health Secretariat of San Paulo State and State University of Campinas, Campinas, San Paulo, Brazil

Professor H. Weed, Project Hope, Millwood, Virginia, USA

Mr. H. Metz, National Institutes of Health, Bethesda, Maryland, USA

Mr. M. Brinkman, Hospital Maintenance Consultants, Lebanon, Wisconsin, USA
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Introduction

We share the World Health Organization's concern for problems faced by countries, particularly developing ones, in the field of management, maintenance and repair of health care equipment. We recognize the worldwide unsatisfactory situation for medical devices which deteriorates the quality of health care delivery and results in inadmissibly high wastage of both national and international resources.

In this working paper for the WHO International Meeting in November, 1989, Campinas, Brazil, we will suggest a model for manpower training and development of health care equipment professionals, potentially applicable for any country's medical device needs and circumstances. This model draws from the collective experience of four primary authors and a number of secondary consultants. The primary authors have close ties with the International Certification Commission (ICC), but the views expressed are our own. The ICC -- whose membership constitutes a broad representation of members of the health care community, including representatives from engineering, medical, industrial, and governmental groups and agencies -- supervises the certification of clinical engineers, biomedical equipment technicians, and other related specialists through an organization of examining boards in different countries.

The model is intended for use such that a country's Minister of Health (MOH) and key equipment advisor could identify the country's medical equipment, the manpower necessary to manage and repair this equipment, and the training likely required by this manpower. We believe it is very important to identify the different levels of health care professionals who will manage these medical devices. (Managing medical equipment technology is intended here to mean overseeing a device through its entire life cycle -- involvement in the selection/procurement process, involvement in the optimization of equipment usage, and involvement in equipment initial inspection and ongoing preventive and repair maintenance, until the equipment is removed from use.) Each level for health care technology professionals must have distinct beginning and ending boundaries. Progress into another level must be able to be verified in a straightforward manner. If these identified levels were to be internationally adopted, the intent would be to give the MOH a framework on which to build a national Healthcare Technical Service (HCTS) infrastructure and to confer status to the healthcare professionals at each of the identified levels.

The four elements of the model we will present are the following:

(1) identify the different levels of healthcare professionals and the knowledge, skills, and abilities required at each level;

(2) identify the different classes of medical devices, a means of determining reasonable annual expected service hours for each class, and a method of correlating how equipment and annual service hours can be utilized in determining manpower requirements for most situations;
(3) identify methods of verifying progress of professionals at each different level – includes using the existing international certification programs as well as other means; and

(4) identify the training sources – with a sampling of current ones – necessary to bring an existing pool of personnel in a country to the required levels to meet existing needs.

An idealized, phased process for fleshing out a country's HCTS infrastructure would thus be the following:

**Phase I** - MOH, with assistance of key equipment advisor, determines to survey what medical devices and resources the country has. They will also determine what additional resources are needed and what requirements must be taken into account to best manage this equipment.

**Phase II** - An analysis should be made of what manpower will be required to meet these needs. Utilize a matrix which matches people and their expected productive output at a given level, i.e. a person who can repair 90% of all defibrillators that fail, at 2 hours each repair, with 2 expected repairs for this device per year. Also, utilize a matrix which identifies all the different classes of medical devices and their average annual preventive maintenance and repair maintenance times.

**Phase III** - Establish occupational classifications (levels) for all health care equipment professionals. Recruit as able the ideal profile of persons to meet these identified needs. Take the pool of people that the country has; help them get into the level that is possible in the short term. To do this, identify the available training sources/sites for each level. It may be necessary to recruit some persons from outside the country to fill certain strategic positions; but this should be only a short term strategy on the way to a high degree of self-sufficiency.

Begin the technology management process in some key hospitals. Demonstrate success in this process such that there is increased quality of patient care, increased access to patient care by patients, and cost-effective services are delivered. Progressively expand the program to build on this success to other appropriate areas and facilities, recognizing and dealing with possible limitations with manpower and training.

Recognize that it will be required to have international networks for replacement or spare parts and technical and management expertise to aid the country's HCTS and to help them reach their potential for healthcare technology management.

**Phase IV** - Evaluate people and program. Establish a program to monitor and evaluate progress in medical device readiness level, individual practitioner development, adequacy of training programs, and appropriateness of the personnel classification system. The purpose of this monitoring is to ensure continuous improvement.
HEALTH CARE EQUIPMENT PROFESSION: 
LEVELS OF INVOLVED PRACTITIONERS

Prepared for the World Health Organization 
by 
Robert Morris, PE, CCE
Oregon Health Sciences Center 
Portland, Oregon

POSITION CLASSIFICATION DESCRIPTIONS 
(for different LEVELS of practitioners)

Appropriate job classifications and their descriptions are necessary for proper operation of a biomedical maintenance facility and mandatory for long term success. They provide a career development path for employees and assist in selecting people with appropriate knowledge, skills and abilities to perform required job functions.

When considering the operation of a biomedical maintenance or clinical engineering facility, certain classifications are necessary. The exact number of different classifications and their descriptions must be tailored for each location. Since much of the equipment located in hospitals is mechanical rather than electronic, mechanical technicians are also necessary.

The complete system of classifications includes 8 technician levels (4 for electronic or electrical and 4 mechanical), a technician supervisor, and 3 clinical engineer levels.

The appendices include typical and more complete descriptions for each of the classes mentioned.

The classifications/levels are:

1. Semi-Skilled (electronic and mechanical)
2. Technician I (electronic and mechanical)
3. Technician II (electronic and mechanical)
4. Technician III (electronic and mechanical)
5. Technician supervisor (electronic and mechanical)
6. Clinical Engineer I
7. Clinical Engineer II
8. Clinical Engineer III

It is very important to remember that what is proposed here are "personnel classifications". They are not intended to be used to create civil service or other
categories of personnel descriptions. The classifications would typically have established salary ranges. They are NOT intended to be position descriptions. A position description is created under classification for a particular position in a particular organization.

For example, a particular organization may wish to employ an individual to maintain sophisticated imaging equipment. First a position description must be written. The position description would describe particular duties required, the per cent of effort for each, chain of command, and any specific knowledge or skills required (previous training and experience). Then a search of the available classifications would indicate that this particular position would probably fall under the classification of Technician III (electronic). The classification of Technician III would determine minimum qualifications and the salary range for the person employed.

A second example would be a position of which the major duties would be the repair of centrifuges, vacuum pumps, mechanical repairs for other devices. Depending on the skill level required to perform the work, possible classifications would be Semi-Skilled, Technician I (electronic or mechanical).

As a third example, consider a job which has as a major function the training of medical, nursing, and technical personnel. The proper classification could be Technician II or III or Clinical Engineer I or II depending on the specifics of the duties of the position to be filled.

People wishing to enter the field would have the classifications to use as a guide for educational and experience requirements. They could then plan their education and other activities appropriately.

Semi-Skilled Technician

The semi-skilled technician typically reports to senior technicians or the technician supervisor.

The semi-skilled technician is typically a high school graduate (preferably from a technical high school) who has completed some basic technical classes and is familiar with the use of basic hand tools and equipment but who has little or no experience.

The semi-skilled technician would be assigned work, taught the proper method of performing the work, and closely supervised and monitored to ensure that the work was done properly and to enable the worker to learn the necessary skills.

Technician I

The Technician I typically reports to senior technicians or the technician supervisor.

Technician I is an entry level technical position and requires education and training beyond high school. A Technician I must have knowledge and skills usually associated with a graduate of a technical school beyond high school, an associate
degree in electronic or mechanical technology, or the equivalent. They must be familiar with a wider variety and more sophisticated test equipment, machines and tools than a semi-skilled technician. Prior experience is not required.

The Technician I would be assigned tasks, shown the proper method of performing the tasks, and supervised and monitored to ensure that the tasks were done properly and to enable the technician to add to their knowledge and improve their skills.

A Technician I should develop to the point where they can do the preventive maintenance and repair 80% of Class I equipment and 20% of Class II equipment within the average time allotted.

The mechanical Technician I would be familiar with the use of machine tools such as lathe, milling machine and drill press and have an elementary knowledge of gas and arc welding. They must also possess knowledge of basic materials and how to work them.

A Technician I may oversee and assign work to a semi-skilled technician.

**Technician II**

The Technician II typically reports to a senior technician or the technician supervisor.

A Technician II is typically a Technician I who has sufficient experience and knowledge to pass the BMET Certification examination or its mechanical equivalent. They would typically have attended specialized training schools covering particular equipment or techniques.

A Technician II would be assigned tasks, often determining the proper method of performing the tasks, function without continuous supervision, with periodic monitoring to ensure that tasks were done properly and to enable the technician to add to their knowledge and improve their skills.

A Technician II should, with experience and training, develop to the level where they can perform preventive maintenance and repair on 80% of Class II equipment and 20% of Class III equipment within the average time allotted.

The mechanical Technician II would typically be at the journeyman level in capability and knowledge.

A Technician II may assign tasks, monitor performance and quality and act as supervisor for those in the Technician I or Semi-Skilled classifications.

**Technician III**

The Technician III typically reports to the technician supervisor or a clinical engineer.
A Technician III is typically a Technician II who has passed the BMET Certification examination or its mechanical equivalent. They would typically be eligible or have passed specialized training schools covering advanced equipment or techniques.

A Technician III would be assigned tasks, determine the proper method of performing the tasks, function with minimal supervision, with only periodic monitoring to ensure that tasks were done properly and to enable the technician to add to their knowledge and improve their skills.

A Technician III should, with experience and training, develop to the level where they can perform preventive maintenance and repair on 80% of Class III equipment within the average time allotted after specialized training.

The mechanical Technician III would typically be at the journeyman level in capability and knowledge. He/she would have a thorough knowledge of the properties of materials, their biocompatibility and proper adhesives.

A Technician III assigns tasks, monitors performance and quality and acts as supervisor for those in the Technician I, Technician II, or Semi-Skilled classifications.

**Technician Supervisor**

The technician supervisor typically reports to a senior engineer, department director, or other administrator or manager.

A technician supervisor is typically a Technician III who is certified and has passed a specialty certification. They would typically have a minimum of 6 years of experience. The experience should indicate progressive responsibility and capability. He/she should have some management and supervisory training.

A technician supervisor would assign tasks, determine the proper methods and procedures for performing the task, and allocate resources appropriately. He/she would typically assist in budgeting and be responsible for operating within budgetary constraints.

A technician supervisor should, with experience and training, develop to the level where they can manage a small department (2 to 6 technicians), making most operational decisions.

A technician supervisor assigns tasks, monitors performance and quality and supervises those in the Technician I, Technician II, Technician III, or Semi-Skilled classifications.

**Clinical Engineer I**

The Clinical Engineer I typically reports to the senior engineer or department director.
A Clinical Engineer I is an entry level technical and engineering position and requires an engineering degree or its equivalent. A Clinical Engineer I need have no prior experience. He/she should be able to function with partial supervision.

The Clinical Engineer I would be assigned tasks by the department director or engineering manager. He/she would act as a technical consultant, assist the maintenance technicians, design equipment modifications to enhance equipment performance and assist in developing financial and operational goals for the department. This individual would work with medical and nursing staff to analyze new equipment and needs.

The Clinical Engineer I would develop programs for training nurses and medical staff in the use of medical devices and to improve the capability of technicians and others within the clinical engineering department.

After 3 years of appropriate experience, a Clinical Engineer I should be eligible to become a certified clinical engineer.

A Clinical Engineer I may oversee and assign work to technicians.

Clinical Engineer II

The Clinical Engineer II typically reports to the department director or higher administrator.

A Clinical Engineer II is typically a certified clinical engineer with at least three years experience. A Clinical Engineer II should be able to function effectively without supervision.

The Clinical Engineer II would typically be a department director or manager. He/she should be able to prepare and manage departmental budgets, set departmental goals, develop systems for equipment management and produce necessary reports to document department performance.

He/she would act as a technical consultant, assist the maintenance technicians, design equipment modifications to enhance equipment performance and assist in developing financial and operational goals for the department. This individual would work with medical and nursing staff to analyze new equipment and needs.

The Clinical Engineer II would develop programs for training nurses and medical staff in the use of medical devices and to improve the capability of technicians and others within the clinical engineering department.

The Clinical Engineer II would typically supervise and manage an entire department.
Clinical Engineer III

The Clinical Engineer III would serve in the manner the Clinical Engineer II does, but for a multi-hospital system. He/she would oversee multiple clinical engineering departments on behalf of the central management for two or more hospitals and the hospital administrators involved.

Career Path

The above classifications provide a career path for both technicians and clinical engineers. These paths may be modified where necessary to suit local conditions. The time progress is as follows:

<table>
<thead>
<tr>
<th>Time in Practice</th>
<th>Position Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3 Years</td>
<td>Semi-Skilled Technician I</td>
</tr>
<tr>
<td>3-5 Years</td>
<td>Technician II</td>
</tr>
<tr>
<td>5+ Years</td>
<td>Technician III</td>
</tr>
<tr>
<td>6+ Years</td>
<td>Technician Supervisor</td>
</tr>
</tbody>
</table>

FOR ENGINEERS

<table>
<thead>
<tr>
<th>Time in Practice</th>
<th>Position Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3 Years</td>
<td>Clinical Engineer I</td>
</tr>
<tr>
<td>3+ Years</td>
<td>Clinical Engineer II</td>
</tr>
<tr>
<td>6+ Years</td>
<td>Clinical Engineer III</td>
</tr>
</tbody>
</table>

After reaching the rank of Clinical Engineer II, a clinical engineer may improve his/her managerial and administrative skills and move into a higher administrative positions.
JOB TITLE BIOMEDICAL EQUIPMENT TECHNICIAN I
(Electronic Option)

I. GENERAL STATEMENT

The biomedical equipment technician I is an entry level position. The incumbent has minimal related education, or equivalent experience. Performs skilled work of routine difficulty under close supervision.

II. DUTIES AND RESPONSIBILITIES

Performs and documents scheduled preventive maintenance, performance assurance, and corrective maintenance on new and existing patient care and laboratory equipment according to protocols previously generated by department clinical engineers.

Determines the need for, and assists in the purchasing of parts and materials necessary to accomplish preventive maintenance and repair.

Must be aware of relevant codes and standards related to the hospital environment and the performance assurance activities (examples in U.S. are NFPA 99, UL 544, JCAHO and internationally, IEC-TC 62).

Is responsible for calibration and performance of medical instruments, the failure of which could directly affect the medical mission.

Utilizes various measurement techniques to obtain optimum operation efficiency.

In the performance of equipment maintenance duties, works closely with engineering and medical personnel. Communicates orally with medical, administrative and engineering professionals.

Applies conventional technical principles to modify, install and correct malfunctions on medical instruments.

III. DIRECTION RECEIVED AND/OR SUPERVISORY RESPONSIBILITY

The incumbent works under close supervision, usually receiving specific and detailed instructions. The work is checked during progress and is reviewed for accuracy upon completion. There are usually no supervisory responsibilities.

IV. WORKING CONDITIONS

The working conditions require occasional lifting and exertion for short periods. The work site is within University Hospital and includes patient areas where the employee may be exposed to sick patients and to research projects.
V. MINIMUM QUALIFICATIONS

1. Two-year associate degree in accredited electronic technology program or educational equivalent.

2. Must be able to use conventional electronic troubleshooting instruments such as multimeters, functional generators, oscillators, oscilloscopes and typically hospital electrical safety testing equipment such as current leakage meters (safety analyzers), defibrillator analyzers and electrosurgical analyzers. Should also be able to use conventional machine shop equipment such as drill press, grinder, belt sander, shear, brake and standard handtools.

3. Must possess or be able to acquire a knowledge of the techniques, theories and characteristics of electronics and electricity in conjunction with physics, chemistry, anatomy, physiology, optics, pneumatics, mechanics and hospital procedures.

4. Must be willing to work toward becoming a certified biomedical equipment technician.
JOE TITLE  BIOMEDICAL EQUIPMENT TECHNICIAN I  
(Mechanical Option)

I. GENERAL STATEMENT

The biomedical equipment technician I is an entry level position. The incumbent has minimal related education, or equivalent experience. Performs skilled work of routine difficulty under close supervision.

II. DUTIES AND RESPONSIBILITIES

Performs and documents scheduled preventive maintenance, performance assurance and corrective maintenance on new and existing patient care and laboratory equipment according to protocols previously generated by department clinical engineers.

Determines the need for, and assists in the purchasing of parts and materials necessary to accomplish preventive maintenance and repair.

Must be aware of relevant codes and standards related to the hospital environment and the performance assurance activities (examples in U.S. are NFPA 99, UL 544, JCAHO and internationally IEC-TC 62).

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IV. WORKING CONDITIONS

The working conditions require occasional lifting and exertion for short periods. The work site is within University Hospital and includes patient areas where the employee may be exposed to sick patients and to research projects.
V. MINIMUM QUALIFICATIONS

1. Two-year associate degree in accredited mechanical technology program or educational equivalent.

2. Must be able to use conventional mechanical maintenance and fabrication equipment such as lathes, milling machines, surface grinders, buffers, grinders, drill press, brake, shear and welding equipment and electrical safety testing equipment such as current leakage meters (safety analyzers).

3. Must possess or be able to acquire a knowledge of the techniques, theories and characteristics of materials, adhesives, drafting and fabrication techniques in conjunction with physics, chemistry, anatomy, physiology, optics, pneumatics, mechanics and hospital procedures.
JOB TITLE BIOMEDICAL EQUIPMENT TECHNICIAN II
(Electronic Option)

I. GENERAL STATEMENT

The biomedical equipment technician II reflects additional experience and/or training beyond that of the biomedical equipment technician I. The incumbent has education and experience which enable him/her to perform sophisticated technical work on medical and laboratory equipment with a minimum of supervision and which qualifies him/her for the BMET certification examination.

II. DUTIES AND RESPONSIBILITIES

Performs and documents scheduled preventive maintenance, performance assurance and corrective maintenance on new and existing patient care and laboratory equipment according to protocols previously generated by department clinical engineers.

Determines the need for, and assists in the purchasing of parts and materials necessary to accomplish preventive maintenance and repair.

Must be aware of relevant codes and standards related to the hospital environment and the performance assurance activities (examples in U.S. are NFPA 99, UL 544, JCAHO and internationally IEC-TC 62).

Is responsible for calibration and performance of medical instruments, the failure of which could directly affect the medical mission.

Utilizes various measurement techniques to obtain optimum operation efficiency.

In the performance of equipment maintenance duties, works closely with engineering and medical personnel. Communicates orally with medical, administrative and engineering professionals.

 Applies conventional technical principles to modify, install and correct malfunctions on medical instruments.

III. DIRECTION RECEIVED AND/OR SUPERVISORY RESPONSIBILITY

The incumbent works under close supervision, usually receiving specific and detailed instructions. The work is checked during progress and is reviewed for accuracy upon completion. There may be some supervisory responsibilities.

IV. WORKING CONDITIONS

The working conditions require occasional lifting and exertion for short periods. The work site is within University Hospital and includes patient areas where the employee may be exposed to sick patients and to research projects.
V. MINIMUM QUALIFICATIONS

1. Two-year associate degree in accredited electronic technology program or educational equivalent plus a minimum of two years experience as a biomedical equipment maintenance technician or four years of experience in other equipment maintenance.

2. Must be able to use conventional electronic troubleshooting instruments such as multimeters, function generators, oscillators, oscilloscopes and typical hospital electrical safety testing equipment such as current leakage meters (safety analyzers), defibrillator analyzers and electrosurgical analyzers. Should also be able to use conventional machine shop equipment such as drill press, grinder, belt sander, shear, brake and standard handtools.

3. Must possess or be able to acquire a knowledge of the techniques, theories and characteristics of electronics and electricity in conjunction with physics, chemistry, anatomy, physiology, optics, pneumatics, mechanics and hospital procedures.

4. Biomedical equipment technician certification is highly desirable. If not certified, must be willing to become certified as soon as possible.
JOB TITLE BIOMEDICAL EQUIPMENT TECHNICIAN II
(Mechanical Option)

I. GENERAL STATEMENT

The biomedical equipment technician II reflects additional experience and/or training beyond that of the biomedical equipment technician I. The incumbent has education and experience which enable him/her to perform sophisticated technical work on medical and laboratory equipment with a minimum of supervision.

II. DUTIES AND RESPONSIBILITIES

Performs and documents scheduled preventive maintenance, performance assurance and corrective maintenance on new and existing patient care and laboratory equipment according to protocols previously generated by department clinical engineers. Fabricates required components on devices when appropriate.

Determines the need for, and assists in the purchasing of parts and materials necessary to accomplish preventive maintenance and repair.

Must be aware of relevant codes and standards related to the hospital environment and the performance assurance activities (examples in U.S. are NFPA 99, UL 544, JCAHO and internationally IEC-TC 62).

Is responsible for calibration and performance of medical instruments, the failure of which could directly affect the medical mission.

Utilizes various measurement techniques to obtain optimum operation efficiency.

In the performance of equipment maintenance duties, works closely with engineering and medical personnel. Communicates orally with medical, administrative and engineering professionals.

Applies conventional technical principles to modify, install and correct malfunctions on medical instruments.

III. DIRECTION RECEIVED AND/OR SUPERVISORY RESPONSIBILITY

The incumbent works under close supervision, usually receiving specific and detailed instructions. The work is checked during progress and is reviewed for accuracy upon completion. There may be some supervisory responsibilities.

IV. WORKING CONDITIONS

The working conditions require occasional lifting and exertion for short periods. The work site is within University Hospital and includes patient areas where the employee may be exposed to sick patients and to research projects.
V. MINIMUM QUALIFICATIONS

1. Two-year associate degree in accredited mechanical technology program or educational equivalent plus a minimum of two years experience as a biomedical equipment maintenance technician or four years of experience in other equipment maintenance.

2. Must be able to use conventional mechanical maintenance and fabrication equipment such as lathes, milling machines, surface grinders, buffers, grinders, drill press, brake, shear and welding equipment and electrical safety testing equipment such as current leakage meters (safety analyzers).

3. Must possess or be able to acquire a knowledge of the techniques, theories and characteristics of materials, adhesives, drafting and fabrication techniques in conjunction with physics, chemistry, anatomy, physiology, optics, pneumatics, mechanics and hospital procedures.
JOB TITLE BIOMEDICAL EQUIPMENT TECHNICIAN III
(Electronic Option)

I. GENERAL STATEMENT

The biomedical equipment technician III reflects considerable education and experience beyond that of the biomedical equipment technician II. The incumbent’s education and experience enable him/her to analyze complex medical or laboratory equipment for purposes of affecting corrective maintenance, developing appropriate preventive maintenance or performance assurance protocols or designing and implementing modifications which permit enhanced operational capability.

II. DUTIES AND RESPONSIBILITIES

Analyzes complex medical or laboratory equipment for purposes of affecting corrective maintenance, developing appropriate preventive maintenance or performance assurance protocols or designing and implementing modifications which permit enhanced operational capability. Often supervises maintenance and modification performed by others.

Must know the relevant codes and standards related to the hospital environment and the performance assurance activities (examples in U.S. are NPPA 99, UL 544, JCAHO and internationally IEC-TC 62).

Is responsible for calibration and performance of medical instruments, the failure of which could directly affect the medical mission.

Performs and documents scheduled preventive maintenance, performance assurance and corrective maintenance or modification on new and existing patient care and laboratory equipment.

Determines the need for, and assists in the purchasing of parts and materials necessary to accomplish preventive maintenance and repair.

Utilizes various measurement techniques to obtain optimum operation efficiency.

In the performance of equipment maintenance duties, works closely with engineering and medical personnel. Communicates orally and in writing with medical, administrative and engineering professionals. Develops written procedures and recommendations for administrative and technical personnel.

III. DIRECTION RECEIVED AND/OR SUPERVISORY RESPONSIBILITY

The incumbent functions in a "lead" technician capacity often supervising or directing the work of other technicians.
IV. WORKING CONDITIONS

The working conditions require occasional lifting and exertion for short periods. The work site is within University Hospital and includes patient areas where the employee may be exposed to sick patients and to research projects.

V. MINIMUM QUALIFICATIONS

1. Two-year associate degree in accredited electronic technology program or educational equivalent. Four year engineering degree desirable. Minimum of four years experience as a biomedical equipment maintenance technician at least two of which are in a progressively responsible supervisory capacity or eight years of experience in other equipment maintenance at least two of which are in a progressively responsible supervisory capacity.

2. Must be able to use conventional electronic troubleshooting instruments such as multimeters, function generators, oscillators and oscilloscopes. Should also be able to use conventional machine shop equipment such as drill press, grinder, belt sander, shears, brake and standard handtools.

3. Must possess or be able to acquire a knowledge of the techniques, theories and characteristics of electronics and electricity in conjunction with physics, chemistry, anatomy, physiology, optics, pneumatics, mechanics and hospital procedures.

4. Biomedical equipment technician certification is required. Individual should be eligible for specialty certification.
JOB TITLE BIOMEDICAL EQUIPMENT TECHNICIAN III
(Mechanical Option)

I. GENERAL STATEMENT

The biomedical equipment technician III reflects considerable education and experience beyond that of the biomedical equipment technician II. The incumbent's education and experience enable him/her to analyze complex medical or laboratory equipment for purposes of affecting corrective maintenance, developing appropriate preventive maintenance or performance assurance protocols or designing and implementing modifications which permit enhanced operational capability.

II. DUTIES AND RESPONSIBILITIES

Analyzes complex medical or laboratory equipment for purposes of affecting corrective maintenance, developing appropriate preventive maintenance or performance assurance protocols or designing and implementing modifications which permit enhanced operational capability. Often supervises maintenance and modifications performed by others.

Must know the relevant codes and standards related to the hospital environment and the performance assurance activities (examples in U.S. are NFPA 99, UL 544, JCAHO and internationally IEC-TC 62).

Is responsible for calibration and performance of medical instruments, the failure of which could directly affect the medical mission.

Performs and documents scheduled preventive maintenance, performance assurance and corrective maintenance or modification on new and existing patient care and laboratory equipment.

Determines the need for, and assists in the purchasing of parts and materials necessary to accomplish preventive maintenance and repair.

Utilizes various measurement techniques to obtain optimum operation efficiency.

In the performance of equipment maintenance duties, works closely with engineering and medical personnel. Communicates orally and in writing with medical, administrative and engineering professionals. Develops written procedures and recommendations for administrative and technical personnel.

III. DIRECTION RECEIVED AND/OR SUPERVISORY RESPONSIBILITY

The incumbent functions in a "lead" technician capacity often supervising or directing the work of other technicians.
IV. WORKING CONDITIONS

The working conditions require occasional lifting and exertion for short periods. The work site is within University Hospital and includes patient areas where the employee may be exposed to sick patients and to research projects.

V. MINIMUM QUALIFICATIONS

1. Two-year associate degree in accredited mechanical technology program or educational equivalent. Four year engineering degree desirable. Minimum of four years experience as a biomedical equipment maintenance technician at least two of which are in a progressively responsible supervisory capacity or eight years of experience in other equipment maintenance at least two of which are in a progressively responsible supervisory capacity.

2. Must be able to use conventional mechanical maintenance and fabrication equipment such as lathes, milling machines, surface grinders, buffers, grinders, drill press, brake, shear and welding equipment and electrical safety testing equipment such as current leakage meters (safety analyzers).

3. Must possess or be able to acquire a knowledge of the techniques, theories and characteristics of materials, adhesives, drafting and fabrication techniques in conjunction with physics, chemistry, anatomy, physiology, optics, pneumatics, mechanics and hospital procedures.
JOB TITLE TECHNICIAN SUPERVISOR

I. GENERAL STATEMENT

The technician supervisor supervises the operation of the biomedical equipment maintenance program. It is his/her role to assure that the goals of the biomedical equipment maintenance/management program are attained in the most cost-effective manner. To accomplish this the technician supervisor must daily analyze the resource requirements of the workload and prioritize the utilization of his/her resources to best assure a balance between short term corrective maintenance needs and long term preventive maintenance-performance assurance needs. Decisions must often be made to obtain the most cost-effective maintenance. Should the resources (equipment, supplies, personnel or space) fall below that required to maintain the program, the technician supervisor must develop and implement short term solutions while working with superiors or the department director to develop long term solutions to the resource needs.

II. DUTIES AND RESPONSIBILITIES

Plans, supervises, and directs the biomedical equipment maintenance program. Analyzes medical or laboratory equipment maintenance/management workload for purposes of assigning and scheduling corrective maintenance. Develops or obtains appropriate preventive maintenance or performance assurance protocols and plans, schedules and implements the required PM/PA workload. Designs, or obtains designs of modifications which permit enhanced equipment operational capability and sees to their implementation. Provides supervision of the maintenance or modification as it is performed by others. Ensures proper parts and materials are available to accomplish preventive maintenance and repairs.

Must know the relevant codes and standards related to the hospital environment and the performance assurance activities (examples in U.S. are NFPA 99, UL 544, JCAHO and internationally IEC-TC 62).

Incumbent is responsible for calibration and performance of medical instruments, the failure of which could directly affect the medical mission and subject the hospital to litigation.

In the performance of equipment maintenance duties, works closely with engineering and medical personnel. Communicates orally and in writing with medical, administrative and engineering professionals. Develops written procedures and recommendations for administrative and technical personnel.

III. DIRECTION RECEIVED AND/OR SUPERVISORY RESPONSIBILITY

The incumbent is the "operations" supervisor of the maintenance facility.
IV. WORKING CONDITIONS

The working conditions require occasional lifting and exertion for short periods. The work site is within University Hospital and includes patient areas where the employee may be exposed to sick patients and to research projects.

V. MINIMUM QUALIFICATIONS

1. Two-year associate degree in accredited electronic technology program or educational equivalent. Four year engineering degree desirable. Technical education should be supplemented by a minimum of one year (27 term hours of business management coursework) or equivalent. Minimum of six years experience as a biomedical equipment maintenance technician at least three of which are in a progressively responsible supervisory capacity; or eight years of experience in other equipment maintenance at least two of which are in a progressively responsible supervisory capacity.

2. Must have business knowledge and management skills which enable him/her to do budgeting, cost accounting, personnel management, including behavioral counseling, job description development and interviewing for hiring or firing purposes. Knowledge and experience in the use of microcomputers for inventory and workload management is desirable. Must also be able to use conventional electronic troubleshooting instruments such as multimeters, function generators, oscillators and oscilloscopes. Should be able to use conventional machine shop equipment such as drill press, grinder, belt sander, shear, brake, and standard hand tools.

3. Must possess or be able to acquire a knowledge of the techniques, theories and characteristics of electronics and electricity in conjunction with physics, chemistry, anatomy, physiology, optics, pneumatics, mechanics and hospital procedures.

4. Biomedical equipment technician certification or specialty certification required.
JOB TITLE CLINICAL ENGINEER I

I. GENERAL STATEMENT

The clinical engineer I by his/her education and experience, acts as a maintenance consultant to the Clinical Engineering Department's biomedical equipment maintenance technicians and, when appropriate, designs equipment modifications which may correct factory design deficiencies or enhance the clinical performance of medical equipment. He/she may also supervise the implementation of those design modifications. The incumbent's education and experience enable him/her to analyze complex medical or laboratory equipment for purposes of defining corrective maintenance and developing appropriate preventive maintenance or performance assurance protocols. The clinical engineer I works with nursing and medical staff to analyze new medical equipment needs, and participates in both the preacquisition purchase planning process and the incoming acceptable testing process. He/she also participates in the equipment management process by participating in the system development, implementation, maintenance and modification.

II. DUTIES AND RESPONSIBILITIES

Does complete performance analysis on complex medical or laboratory equipment and summarizes results in brief, concise and communicable terms for purposes of recommending corrective action or developing appropriate preventive maintenance or performance assurance protocols.

Designs and implements modifications which permit enhanced operational capability. May supervise the maintenance or modification as it is performed by others.

Must know the relevant codes and standards related to the hospital environment and the performance assurance activities (examples in U.S. are NFPA 99, UL 544, JCAHO and internationally IEC-TC 62).

Responsible for obtaining the engineering specifications (system definition) for systems considered unusual or one-of-a-kind that are not commercially available.

In-service maintenance technicians on codes and standards and on preventive maintenance, performance assurance and corrective maintenance or modification requirements on new and existing patient care and laboratory equipment.

Teaches measurement, calibration and standardization techniques which promote optimum performance.

In the performance of equipment engineering duties works closely with maintenance and medical personnel. Communicates orally and in writing with medical as well as administrative and maintenance professionals. Develops written procedures and recommendations for administrative and technical personnel.
III. DIRECTION RECEIVED AND/OR SUPERVISORY RESPONSIBILITY

The incumbent functions with minimum supervision often supervising or directing the work of biomedical equipment maintenance technicians.

IV. WORKING CONDITIONS

The working conditions require occasional lifting and exertion for short periods. The work site is within University Hospital and includes patient areas where the employee may be exposed to sick patients and to research projects.

V. MINIMUM QUALIFICATIONS

1. Four year bachelor degree in electrical/electronic engineering or related sciences required (preferably with clinical, biomedical adjunct). Hospital internships desirable.

2. Must have some business knowledge and management skills which enable him/her to participate in budgeting, cost accounting, personnel management, including behavioral counseling, job description development and interviewing for hiring or firing purposes. Knowledge and experience in the use of microcomputers desirable. Must also be able to use conventional electronic troubleshooting instruments such as multimeters, function generators, oscillators and oscilloscopes. Should be able to use conventional machine shop equipment such as drill press, grinder, belt sander, shear, brake, and standard handtools.

3. Must possess or be able to acquire a knowledge of the techniques, theories and characteristics of materials, adhesives, drafting and fabrication techniques in conjunction with physics, chemistry, anatomy, physiology, optics, pneumatics, mechanics and hospital procedures.

4. Must be willing to work towards becoming a Certified Clinical Engineer.
JOB TITLE  CLINICAL ENGINEER II

I. GENERAL STATEMENT

The clinical engineer II by his/her education and experience, acts as a manager and technical director of the Clinical Engineering Department. He/she designs or directs the design of equipment modifications which may correct design deficiencies or enhance the clinical performance of medical equipment. He/she may also supervise the implementation of those design modifications. The incumbent's education and experience enable him/her to analyze complex medical or laboratory equipment for purposes of defining corrective maintenance and developing appropriate preventive maintenance or performance assurance protocols. The clinical engineer II works with nursing and medical staff to analyze new medical equipment needs, and participates in both the preacquisition purchase planning process and the incoming acceptable testing process. He/she also participates in the equipment management process by participating in the system development, implementation, maintenance and modification.

II. DUTIES AND RESPONSIBILITIES

Works with medical and nursing staff in the development of technical and performance specifications for equipment required in the medical mission. Once equipment is specified and purchase order developed, generates appropriate testing of the new equipment.

Does complete performance analysis on complex medical or laboratory equipment and summarizes results in brief, concise and communicable terms for purposes of recommending corrective action or developing appropriate preventive maintenance or performance assurance protocols.

Designs and implements modifications which permit enhanced operational capability. May supervise the maintenance or modification as it is performed by others.

Must know the relevant codes and standards related to the hospital environment and the performance assurance activities (examples in U.S. are NFPA 99, UL 544, JCAHO and internationally IEC-TC 62).

Responsible for obtaining the engineering specifications (system definition) for systems considered unusual or one-of-a-kind that are not commercially available.

In-service maintenance technicians on codes and standards and on preventive maintenance, performance assurance and corrective maintenance or modification requirements on new and existing patient care and laboratory equipment.

Supervises parts and supply purchase activities and develops program policies and procedures for same.

Sets department goals and develops budgets and policy, prepares and analyzes
management reports to monitor department activity, and manages and organizes the department to implement them.

Teaches measurement, calibration and standardization techniques which promote optimum performance.

In the performance of equipment engineering duties works closely with maintenance and medical personnel. Communicates orally and in writing with medical as well as administrative and maintenance professionals. Develops written procedures and recommendations for administrative and technical personnel.

III. DIRECTION RECEIVED AND/OR SUPERVISORY RESPONSIBILITY

The incumbent functions with minimum supervision often supervising or directing the work of biomedical equipment maintenance technicians and less senior clinical engineers.

IV. WORKING CONDITIONS

The working conditions require occasional lifting and exertion for short periods. The work site is within University Hospital and includes patient areas where the employee may be exposed to sick patients and to research projects.

V. MINIMUM QUALIFICATIONS

1. Four year engineering bachelor degree in electrical/electronic program or equivalent required (preferably with clinical, biomedical adjunct). Masters degree desirable. Minimum of three years experience as a clinical engineer with two years in a progressively responsible supervisory capacity.

2. Must have some business knowledge and management skills which enable him/her to participate in budgeting, cost accounting, personnel management, including behavioral counseling, job description development and interviewing for hiring or firing purposes. Knowledge and experience in the use of microcomputers desirable. Must also be able to use conventional electronic troubleshooting instruments such as multimeters, function generators, oscillators and oscilloscopes. Should be able to use conventional machine shop equipment such as drill press, grinder, belt sander, shear, brake, and standard handtools.

3. Must possess or be able to acquire a knowledge of the techniques, theories and characteristics of materials, adhesives, drafting and fabrication techniques in conjunction with physics, chemistry, anatomy, physiology, optics, pneumatics, mechanics and hospital procedures.

4. Clinical engineering certification and/or professional engineering registration are required.
TRANSLATING THE MEDICAL DEVICE SURVEY INTO MANPOWER REQUIREMENTS

Prepared for the World Health Organization by
Thomas M. Judd, MS, PE, CCE
Hospital Corporation of America
Marietta, Georgia, USA

Determining precise manpower requirements for health care equipment professionals for medical facilities has historically been a difficult issue. The primary thrust in this country has been to place an appropriately qualified person into a role where he or she can provide equipment services which are both of high quality and minimize equipment downtime thereby maximizing patient access to the best possible care. Additionally, in most circumstances, these positions must be demonstrably cost-effective. Typically, this would be shown by position costs being offset by a reduction in outside service costs or by reducing equipment liability.

A framework for correlating medical devices - and their typically required annual service hours - to the resulting manpower requirements is provided below. The framework has five elements: (1) an equipment classification system, which references element (2) a listing of most medical devices - in use anywhere - by type and including the average annual preventive maintenance and corrective maintenance (repair) hours; (3) a discussion of how the service hours listed may be affected by different geographical and cultural factors; (4) a correlation of equipment classes with levels of health care equipment professionals; and (5) a discussion of how annual service hours relates to productivity.

The end result of this framework is to allow the Minister of Health and key equipment advisor to determine manpower requirements based on existing inventories and circumstances. In addition, a listing of typical test equipment utilized by these practitioners is provided.
EQUIPMENT CLASSIFICATION SYSTEM

Reference:  *Equipment Type Code System, HCA Biomedical Services, 1989

Average annual service hours for each type of medical device system.

Attached.

- **CLASS I**  5 hours per year service* or less
  [Except Imaging (500 series Type Codes) ≤ 60 hours if specific training is received.]

- **CLASS II**  >5 hours ≥15 hours/year of service
  [Except Imaging (500 series Type Codes) ≤ 120 hours if specific system training is received]

- **CLASS III**  >15 hours/year of service
  [Imaging >120 hours, if specific training received]

BIOMED SPECIALTIES: Dialysis, Lasers, Cath Lab Computers/Monitors, Large Sterilizers, Blood Gas Systems, Respiratory Therapy

CLINICAL LAB: Medium, High Tech Systems

IMAGING SPECIALTIES: Radiology, CT Scanners, Nuclear Medicine, MRI Scanners, Ultrasound, Lithotripsy, Radiation Therapy

*See Service Hours Geographical Variation Discussion
**CAUTION:** Annual service hours may vary widely in different countries due to circumstances beyond the control of the service provider. A suggested rule of thumb is to double the annual hours given for planning purposes.

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CAUTION: Annual service hours may vary widely in different countries due to circumstances beyond the control of the service provider. A suggested rule of thumb is to double the annual hours given for planning purposes.

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Annual service hours may vary widely in different countries due to circumstances beyond the control of the service provider. A suggested rule of thumb is to double the annual hours given for planning purposes.

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### CAUTION:
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NCA Biomedical Services

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**CAUTION:** Annual service hours may vary widely in different countries due to circumstances beyond the control of the service provider. A suggested rule of thumb is to double the annual hours given for planning purposes.

**TYPE CODE SYSTEM**

**HCA Biomedical Services**

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**HCA Biomedical Services**

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**CAUTION:** Annual service hours may vary widely in different countries due to circumstances beyond the control of the service provider. A suggested rule of thumb is to double the annual hours given for planning purposes.
**CAUTION:** Annual service hours may vary widely in different countries due to circumstances beyond the control of the service provider. A suggested rule of thumb is to double the annual hours given for planning purposes.

### TYPE CODE SYSTEM

**HCA Biomedical Services**

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CAUTION: Annual service hours may vary widely in different countries due to circumstances beyond the control of the service provider. A suggested rule of thumb is to double the annual hours given for planning purposes.

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CAUTION: Annual service hours may vary widely in different countries due to circumstances beyond the control of the service provider. A suggested rule of thumb is to double the annual hours given for planning purposes.

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**CAUTION:** Annual service hours may vary widely in different countries due to circumstances beyond the control of the service provider. A suggested rule of thumb is to double the annual hours given for planning purposes.

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**CAUTION:** Annual service hours may vary widely in different countries due to circumstances beyond the control of the service provider. A suggested rule of thumb is to **double** the annual hours given for planning purposes.

**TYPE CODE SYSTEM**
MCA Biomedical Services

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* denotes additional required hours.
**CAUTION:** Annual service hours may vary widely in different countries due to circumstances beyond the control of the service provider. A suggested rule of thumb is to double the annual hours given for planning purposes.

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<td>2.00</td>
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</table>
SERVICE HOURS GEOGRAPHICAL VARIATION

A given country's annual service hours per medical device are a function of a number of important variables. These factors are superimposed on the normal issue of degree of sophistication in equipment design which results in varying annual preventive maintenance and repair hours. These factors include the following:

1. CULTURE - some factors include daily hours available for work and the general attitude toward work;

2. RESOURCES - key factors include availability of replacement/spare parts, technical information, and appropriate test equipment;

3. MANAGEMENT/ADMINISTRATIVE SUPPORT - "Is there sufficient budget for service resources?"; "How many signatures are necessary to buy needed service resources in a timely manner?"; Is there sufficient space to conduct required service activities?" are key factors;

4. INDUSTRY - what constraints does the medical device industry face in the given country that affect medical equipment service, i.e., requirement for joint ownership of companies which may limit in-country presence, and restrictions on companies dealer/distribution networks such that minimal spare parts are stocked and available; and

5. FINANCING - a financial philosophy and system in which it is easier to buy new systems rather than repair existing ones is the primary factor here.

*NOTE: Annual service hours may vary widely in different countries due to circumstances beyond the control of the service provider. A suggested rule of thumb is to double the annual hours given for planning purposes, and then to seek to optimize that number to the lowest average reasonable, in light of the geographical variation factors noted above.*
*CORRELATION OF EQUIPMENT CLASSES TO LEVELS*

**Time in Practice**

0 Years

SEMI-SKILLED - familiarity with basic electronic test equipment.

0-2.5 Years

TECH I - develops** at this level to point where 80% of equipment in CLASS I and 20% in CLASS II can be PM and repaired (to component level) in average times allotted.

2.5 - 5 Years

TECH II - develops** at this level to point where 100% of equipment in CLASS I, 80% of equipment in CLASS II, and 20% in CLASS III can be PM and repaired (to component level, as necessary) in average time allotted.

>5 Years

TECH III - develops** at this level such that 100% of equipment in CLASS I & II and 80% of CLASS III equipment for which aptitude is indicated and specialty training is received and applied -- may be PM and repaired (to component level, as necessary) in average times allotted.

> 5 Years

TYPICALLY

- TECH SUPERVISOR

- Staff position typically utilized in situations where there are two or more technicians required.

- Minimum level of Tech II in this role, but typically at Tech III level.

- Would normally spend 25% of time supervising others (see job responsibilities, Reference 1, Table 8.4, p. 13, Attached).

- A role which may be required when 2,500 or more productive equipment annual service hours are required in a given setting and typically required when 4,000 or greater annual service hours.

**Development occurs through a mixture of formal training - typically as received from manufacturers and upwards of 2 weeks per year, informal training from more senior technicians, some occurring each week, and daily on-the-job training through experience.**

*See Typical Test Equipment Used Discussion.*
CORRELATION OF EQUIPMENT CLASSES TO LEVELS - CONTINUED

Time In Practice

0-3 Years  CLINICAL ENGINEER I

- Staff position, 0-3 years post-undergraduate engineering degree.
- 16% equipment design and modification, 34% equipment service, 50% other equipment management activities (Ref. 1, Table 8.5, p. 13).
- Typically in teaching hospitals where significant engineering-level activities are required.

3-6 Years  CLINICAL ENGINEER II

- Department head, 3-6 years post engineering degree.
- 30% supervisor, 10% service, 60% other equipment management opportunities (Ref. 1, Table 8.6, p. 13).
- A role typically not required when less than 5,000 annual service hours in a given setting and typically required when 8,000 or greater annual service hours.
- Other outside factors which may lead to hiring of CE II: hospital administration's desire for (a) visible, credentialed individual to manage medical devices with hospital department heads; (b) visible, credentialed individual to assist and relate well with medical staff; and (c) significant technology management activities other than equipment maintenance, i.e., device selection or optimization of existing medical equipment already in clinical use.

> 6 Years  CLINICAL ENGINEER III

- Same requirements as Clinical Engineer II plus the following:
  - Multi-hospital department director, typically 6+ years post-engineering degree.
  - Track record of having built successful single hospital program.
  - Demonstrated aptitude for creative management of people and business and technical resources that meets current management's patient-care and cost-effectiveness goals.

### TABLE 8.1
**BMET I**  
**Job Responsibilities (%)**

<table>
<thead>
<tr>
<th>Job Category</th>
<th>Percentage</th>
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</thead>
<tbody>
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<tr>
<td>Repairs</td>
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</tr>
<tr>
<td>Safety Testing</td>
<td>24.3</td>
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<tr>
<td>Design &amp; Modifications</td>
<td>1.6</td>
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<tr>
<td>Supervision of Others</td>
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</tr>
<tr>
<td>Incoming Testing</td>
<td>5.7</td>
</tr>
<tr>
<td>Coordinate Outside Services</td>
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</tr>
<tr>
<td>Give Training &amp; Inservice</td>
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<tr>
<td>Receive Training &amp; Inservice</td>
<td>3.8</td>
</tr>
<tr>
<td>Purchasing &amp; Requisitions</td>
<td>2.5</td>
</tr>
<tr>
<td>Prepurchase Evaluation</td>
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</tr>
<tr>
<td>Department Development</td>
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<tr>
<td>Other</td>
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### TABLE 8.2
**BMET II**  
**Job Responsibilities (%)**

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<td>Repairs</td>
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<tr>
<td>Safety Testing</td>
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<tr>
<td>Give Training &amp; Inservice</td>
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</tr>
<tr>
<td>Receive Training &amp; Inservice</td>
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<tr>
<td>Purchasing &amp; Requisitions</td>
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<tr>
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<tr>
<td>Department Development</td>
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<tr>
<td>Other</td>
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### TABLE 8.3
**BMET III**  
**Job Responsibilities (%)**

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<td>Supervision of Others</td>
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<td>Incoming Testing</td>
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<tr>
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<tr>
<td>Give Training &amp; Inservice</td>
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<tr>
<td>Purchasing &amp; Requisitions</td>
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<td>Department Development</td>
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### TABLE 8.4
**BMET Supervisor**  
**Job Responsibilities (%)**

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</tr>
<tr>
<td>Coordinate Outside Services</td>
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<tr>
<td>Give Training &amp; Inservice</td>
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<tr>
<td>Receive Training &amp; Inservice</td>
<td>1.8</td>
</tr>
<tr>
<td>Purchasing &amp; Requisitions</td>
<td>6.1</td>
</tr>
<tr>
<td>Prepurchase Evaluation</td>
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### TABLE 8.5
**Clinical Engineer**  
**Job Responsibilities (%)**

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<tr>
<td>Coordinate Outside Services</td>
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<tr>
<td>Give Training &amp; Inservice</td>
<td>5.5</td>
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<tr>
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<tr>
<td>Purchasing &amp; Requisitions</td>
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<tr>
<td>Prepurchase Evaluation</td>
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<td>Department Development</td>
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</tr>
<tr>
<td>Other</td>
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### TABLE 8.6
**CE Supervisor**  
**Job Responsibilities (%)**

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<tr>
<td>Other</td>
<td>6.1</td>
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</tbody>
</table>
TYPICAL TEST EQUIPMENT USED*
(Electronic)

Level

Semi-Skilled

Analog meters
Common hand tools

Tech I

Bench Power Supplies
Soldering equipment
Oscilloscopes
Tube and Transistor Testers
Bridges
Digital meters
Biomedical Systems Analyzers - Defibrillators, Electrosurgery, Safety,
IV Pump, Pressure
Patient Simulators

Tech II

Function generators
Multi-channel storage oscilloscopes
Imaging Systems, basic - high voltage bleeder, cable, mAS meter, KVP meter
Phototachometer
Specialized soldering equipment
Pacemaker Analyzer

Tech III (Test equipment particular to technical specialty)

Ventilator Tester, Test Lung
Ultrasound Wattmeter, Phantoms
Imaging Tube replacement accessories
Imaging test phantoms, calibration accessories
Laser power meters
Personal computer diagnostic test systems
Spectrum Analyzer
Dialysis test systems
Anesthesia system analyzers
Optics system analyzers - microscopes, lasers, etc.

*Typical test equipment expected to be commonly used prior to progress to next level.
PRODUCTIVITY IN MANPOWER PLANNING

To utilize the data provided of annual service hours per equipment type, recognizing that we have suggested doubling these hours for planning purposes, the following discussion of productivity is relevant.

Productivity defined [1] is "the actual rate of output per unit of time worked." Recent studies [2], [3], [4] have shown that in the United States, there are 1800 - 1900 annual available hours given a 2,080 hour work-year (52 weeks at 40 hours per week). Of these available hours, 1400 - 1500 annual hours will be productive. We, therefore, suggest 1400 annual service hours as the basis for determining one FTE (full-time equivalent worker).

References


CLINICAL ENGINEERING AND BIOMEDICAL EQUIPMENT TECHNOLOGY CERTIFICATION

Prepared for the World Health Organization
Interregional Meeting on the Manpower Development
and Training for Health Care Equipment
Management, Maintenance and Repair.
Campinas, Brasil 20-24 November, 1989

by

Frank R. Painter, MS, CCE
Chairman, Board of Examiners for Clinical Engineering
Bridgeport Hospital
Bridgeport, Connecticut, USA

Definition

Certification is a means where an individual can indicate to
the general public, co-workers and employers that a non-
governmental, impartial, nationally-recognized organization
has determined that they have met certain minimum standards of
education, experience and technical knowledge.

Benefits

Individual recognition is obtained through the process by in-
dicating a high level of professional achievement. It allows
the certified individual to establish that they have met a
benchmark of proficiency in the skills required in their
profession.

Recognition of the profession is gained and credibility estab-
lished when a peer review process is created to compare its
individuals to a high professional standard. The existence of
a certification process enables employers to quantify achieve-
ment levels in the field and select individuals that meet an
established standard.
Requirements

A Biomedical Equipment Technician (BMET) must meet at least one of the following in order to be eligible to take the certification exam:

1) Two years experience as a BMET and an associates degree (two year degree) in biomedical equipment technology.
2) Three years experience as a BMET and an associates degree in electronics technology.
3) Four years experience as a BMET.

A biomedical equipment technician is a person knowledgeable in the theory of operation, the underlying physiological principals and safe clinical application of biomedical equipment. His or her responsibilities may include installation, calibration, inspection, preventive maintenance and repair of general biomedical equipment and systems. He or she might also be involved in the operation of equipment, equipment control and supervision of biomedical equipment maintenance activities.

The BMET certification examination consists of 150 multiple choice questions and must be passed with an overall score of 70%. The exam typically takes five hours to complete although six hours are allowed. Additional specific information about the BMET certification exam can be found in Appendix A.

There are also specialties for BMET's in radiology equipment (Certified Radiological Equipment Specialist) and in laboratory equipment (Certified Laboratory Equipment Specialist). In these specialties the experience requirement and examination focus are directed toward these fields.

Clinical Engineers must meet at least one of the following requirements in order to be eligible as a candidate for certification:

1) Have a bachelors (four years) degree or higher in engineering or electronics technology from an accredited program and have at least three years clinical engineering experience.
2) Be a registered professional engineer and have at least three years of clinical engineering experience.
3) Have a bachelors degree in basic science from an accredited program or a bachelors degree in electronics technology from a non-accredited program; have passed the "Engineering in Training for the professional license" exam; and have at least four years of clinical engineering experience.

4) Have established standing in the clinical engineering profession and have been engaged in practice at least 15 years of which 6 have been in responsible charge. Experience must have been as a clinical engineer. (Further clarification of this can be found in Appendix A.)

The clinical engineer competently applies engineering principals in a clinical setting, participates professionally with hospital staff in the technological aspects of health care delivery, has intensive knowledge in at least one branch of engineering, has significant knowledge of physiology, medicine and clinical care of patients, plays a supportive role in patient care including investigation and resolution of patient incidents, possesses knowledge of related regulations and codes, has the ability to teach inservice education to equipment users and has the professional maturity to understand ethical conduct and to work in the best interest of the patient and general public.

The examination process consists of filing an application with the secretariat, providing the names of five professional references and a certified copy of the college transcript. The next step is taking a written exam consisting of 150 multiple choice questions (50 questions each in medical science, clinical engineering and engineering) and four essay questions, two of which are mandatory. The written exam must be passed with a minimum score of 60 percent. The final part of the exam is an oral interview with two members of the board of examiners.

Additional specific information about the clinical engineering certification process or exam can be found in Appendix B.

History

Certification of clinical engineers and biomedical equipment technicians began in the early 1970's. Two separate organizations were certifying CE's and one was certifying BMET's.
When these boards were first formed certification was offered to those who met the education and experience criteria without having to take the examination (referred to as "grandfathering"). In May 1983 both organizations merged to form one body to certify all CE's and BMET's in the US and Canada. The new organization, the International Certification Commission for Clinical Engineering and Biomedical Equipment Technology (ICC), provides management of the certification program in several countries including the US and Canada. A board of examiners exists for each specialty in each country. The ICC has certified clinical engineers from nine countries including Singapore, Jordan, USSR, Canada, Saudi Arabia, South Africa, Poland and Brazil.

Organization

The ICC consists of representatives of 15 health care organizations and the chairman of each board of examiners. The organizations which all have an interest in the advancement of health care and the certification of CE's and BMET's include the Association for the Advancement of Medical Instrumentation, Canadian Medical and Biological Engineering Society, IEEE-Engineering in Medicine and Biology Society, Joint Commission for the Accreditation of Healthcare Organizations, National Society of Professional Engineers and Veterans Administration.

Each board of examiners is chosen by election for a three year term and consists only of individuals who have previously been certified by the board. The responsibility of each board of examiners is to:

1) Evaluate applications
2) Administer the written and oral exams
3) Manage requests for appeals
4) Prepare and make changes to the application, written exam, operating procedures and bylaws of the board.
5) Recommend to the ICC activities and programs that will enhance the certification process, the professional specialty and the profession

The Bylaws of the Clinical Engineering Board of Examiners, the Constitution of the Certification Commission and the Bylaws of the Certification Commission are included in Appendix C.
Future Issues

The practice of clinical engineering is rapidly changing as technology becomes integrated in the health care delivery system. Over the last 10 years clinical engineers and biomedical equipment technicians have been increasingly asked to fill the role of technology manager, to become involved in risk management and to manage larger and larger staffs providing technical support to biomedical equipment. This new role in technology management does not fit into the traditional definitions of CE's or BMET's established more than 10 years ago, yet a larger percentage of our profession is filling this function. The ICC is therefore studying the appropriateness of either adding a third certification category called Certified Healthcare Technology Manager or changing the definition of clinical engineering to encompass a less technical but more management oriented profession.

The process of certification has not been a financially self supporting activity. That is to say the the expenses of administering the test (e.g. postage, copying, supplies, phone, secretarial expenses, etc.) have exceeded the income from registration fees and other related activities. The ICC has had to rely on the AAMI Foundation for contributions to remain solvent. In an effort to become financially self sufficient the ICC has considered a small renewal/recertification biannual fee and demonstration of evidence of having participated in some form of professional continuing education. This will both provide the supplementary income needed and will insure that those certified are continuing to be professionally active.

Certification as a International Benchmark

An analysis of the levels of development for clinical equipment and health care technology support using the model of three BMET levels, BMET supervisor, Healthcare Technology Manager and three levels of clinical engineering development shows that the certification process can be used to verify attainment of certain professional levels. The verification points and criteria that could be used are as follows:
1) Entry level BMET I - Verify entry into this level by attainment of AAS degree.
2) Transition from BMET I to BMET II - Verify advancement by passing general BMET certification exam.
3) Transition from BMET II to BMET III - pass BMET speciality exam (radiology, laboratory, etc.).
4) Transition from BMET supervisor to Healthcare Technology Manager - pass Healthcare Technology Manager certification exam.
5) Entry level of Clinical Engineer I - attainment of BS degree.
6) Transition from CE I to CE II - pass clinical engineering certification exam.
7) Transition from CE II to CE III - attainment of masters degree (MS, MHA, MBA).

As an additional means of verifying progress at each level in the model or properly classifying individuals already in the system, a detailed questionnaire could be sent to each practicing health care professional and his/her hospital administrator. The results of the questionnaire could then be used to begin to determine in which level each practitioner currently resides. This information can then be used to determine the next step in helping plan further appropriate training for the practitioner or to appropriately place the individual within the country's healthcare technology management system.

This model could be modified to meet the cultural or technical needs of the country or healthcare system implementing it. By using a pre-established certification process however, including the exam and its associated minimum educational and experience requirements to verify an individual's technical and professional level, the healthcare equipment management system will have reference points on an international level.

*Editor's Note:

These questionnaires, which can be used by the Minister of Health and the key equipment advisor, are to be developed at the WHO Campinas meeting.
APPENDIX A

APPLICATION FOR CERTIFICATION OF
GENERAL BIOMEDICAL EQUIPMENT TECHNICIANS
CERTIFICATION OF GENERAL BIOMEDICAL EQUIPMENT TECHNICIANS

GENERAL INFORMATION

The Board of Examiners for Biomedical Equipment Technicians, operating under the International Certification Commission for Clinical Engineering and Biomedical Technology (ICC), maintains a certification program for candidates (those entering the field); biomedical equipment technicians (BMETs); and technicians who specialize in the limited areas of radiological and clinical laboratory equipment technology. The objective of the certification program is to identify competent persons in the field of biomedical equipment technology.

The membership of the ICC provides a broad representation of members of the health care community, engineering, medical, industrial, and government groups and agencies. It supervises the certification of biomedical equipment technicians as well as that of clinical engineers.

*The biomedical equipment technician is a person knowledgeable in the theory of operation, the underlying physiological principles, and the safe clinical application of biomedical equipment. His or her responsibilities may include installation, calibration, inspection, preventive maintenance, and repair of general biomedical and related technical equipment. He or she might be involved in the operation of equipment and in equipment control, safety, and maintenance.
Full Certification - Eligibility for taking the certification examination requires the satisfaction of at least one of the following: (a) two years of BMET experience and an associates degree in biomedical equipment technology, (b) three years of BMET experience and an associates degree in electronics technology, (c) or four years of BMET experience.

Candidate - Eligibility for taking the candidacy certification examination requires satisfaction of at least one of the following: (a) an associates degree in biomedical technology, (b) an associates degree in electronic technology plus one year of BMET experience, or (c) two years of BMET experience.

Candidacy is a step toward full certification. An individual who applies as a candidate and passes the examination does not have to retake the examination. Full certification is granted upon verification of the completion of the necessary additional employment and/or education requirements as outlined under Full Certification. It is the responsibility of the candidate applicant to notify the International Certification Commission when they believe they have adequate job experience to qualify for full certification. (An “update” application will be forwarded for completion by the candidate. Upon verification of the updated information the candidate is certified and can use the CBET designation.)

FEES

Applicants for Full Certification

The fee for full certification as a biomedical equipment technician is $175, due in full at the time of application. Applications submitted without the full fee will not be processed. This covers the cost of processing the application, determination of eligibility, one examination, initial listing and certificate fee. An applicant found ineligible to take the examination will be refunded $105. An applicant who does not pass the examination will be refunded $25.

Candidate Status Applicants

The fee for BMET student applicants is $100, due in full at time of application. Applications submitted without the full fee will not be processed. This covers the cost of processing the application, determination of eligibility, and one examination. An application found ineligible to take the examination will be refunded $80.

Student who have passed the examination, may apply for full certification after additional work experience or educational requirements for full certification are met. The additional fee for full certification is $75. This covers the cost of processing and reviewing the updated application. An applicant who is not recommended for certification at this stage will be refunded $25.

Failure to Appear for BMET Examination

After a mutually agreed upon date and location for the examination has been established, there will be a $25 rescheduling fee charged to any applicant who fails to inform the ICC Secretariat that they will not appear for the examination within 14 days prior to the agreed upon test date.
Provision for BMET Retesting

An applicant wishing to retake the certification examination may do so after a one year waiting period. The fee for retesting as biomedical equipment technician is $135, due in full at time application. Applications submitted without the full fee will not be processed. This covers the cost of processing the application, determination of eligibility, one examination, initial listing and certification fee. An applicant who does not pass the examination will be refunded $25. Full application fees ($175) will apply to those retesting after two years have elapsed.

NOTE: "WHILE CONTRIBUTIONS OR GIFTS TO AAMI ARE NOT TAX DEDUCTIBLE AS CHARITABLE CONTRIBUTIONS FOR FEDERAL INCOME TAX PURPOSES, THEY MAY BE TAX DEDUCTIBLE UNDER OTHER PROVISIONS OF THE INTERNAL REVENUE CODE."

EXAMINATION SITES

Examinations are given throughout the year in cities determined by the geographic distribution of applicants eligible for examination. Applicants will be notified of examination dates and sites. After a mutually agreed upon date and site for examination has been determined a $25.00 rescheduling fee will apply to an applicant who fails to appear for the examination and has not contacted the Secretariat within 14 days prior to the agreed upon test date.

NICET test sites are available to candidates for certification in various locations in the U.S. in addition to the ones provided by the ICC. There is an additional charge of $10 per examinee for use of NICET test sites. Individuals who intend to use NICET test sites must have their applications completed and with eligibility to test approved at least eight (8) weeks in advance.

*****Information*****

Entrance to the examination room requires a picture identification.

EXAMINATION FORMAT

The Certified Biomedical Equipment Technician Examination consists of 150 multiple choice questions. This examination is used for both candidates and full certification applicants. The percentage of multiple choice questions in each area is as follows:
- Anatomy and physiology - 15%
- Electric and electronics fundamentals - 25%
- Medical equipment function and operation, which includes radiology and laboratory equipment - 20%
- Safety in health care facilities - 15%
- Medical equipment problem solving - 25%

EXAMINATION SCORING

The test is graded on a pass-fail basis, with 70% the minimum passing overall score; and 50% the minimum score in each subject area.

EXAMINATION TIME AND AIDS

Although six (6) hours are allotted, the typical examinee takes approximately five (5) hours to complete the examination. The examinee can bring a nonprogrammable memory electronic calculator or a slide rule. A list of mathematical formulas is included with the examination package for the examinee’s use during the examination.
SUGGESTED READINGS - Certified Biomedical Equipment Technician Examination

The following texts contain representative material for the areas indicated. Other equivalent texts may be substituted.

Anatomy and Physiology and Medical Terminology


Electronics and Instrumentation

- Floyd, Thomas L.: DIGITAL FUNDAMENTALS, Charles E. Merrill, Columbus, OH 1986.

Safety

- Pertinent manuals, standards, and guidelines published by organizations such as the National Fire Protection Association (NFPA), Association for the Advancement of Medical Instrumentation (AAMI), Underwriters Laboratories (UL), and the Joint Commission on the Accreditation of Hospitals (JCAH).
- GUIDELINES FOR PREVENTION AND CONTROL OF NOSOCOMIAL INFECTIONS, U.S. Dept. of Health and Human Services Centers for Disease Control, Atlanta, GA, February 1983.

Biomedical Apparatus

SAMPLE EXAMINATION QUESTIONS

GENERAL BIOMEDICAL EQUIPMENT

Anatomy and Physiology

(The biomedical equipment technician must be able to communicate intelligently with the physician and other hospital staff members. Also, in order to fulfill his responsibilities in the area of safety, calibration and related areas, he must have a reasonable knowledge of anatomy and physiology. The knowledge should include familiarity with terminology and body functions.) Sample:

In fresh, normal human blood, the volume of cells is:

a. 25% of total volume.
b. 45% of total volume.
c. 80% of total volume.
d. 90% of total volume.

Basic Electricity and Electronics

(Fundamental to many areas of the BMET's function is an indepth knowledge of basic electricity - not to the engineering depth but certainly including an understanding of current and voltage relationships in both DC and AC circuits and the ability to apply fundamental mathematical formulas to circuitry problems.) Sample:

At 600 Hz, the reactance of a 0.1mF capacitor is

a. 2.650 ohms.
b. 2.65 kilohms.
c. 15.9 kilohms.
d. 26.5 kilohms.

(Knowledge of solid-state devices is certainly important. The BMET must know semiconductor theory and principles as well as solid-state circuitry. He should know concepts such as biasing, input impedance, and feedback.) Sample:

The formula for AC current gain of a transducer in common-emitter configuration is:

a. $\frac{I_C}{I_B}$ with $V_{CE}$ constant.
b. $\frac{I_C}{I_E}$ with $V_{CE}$ constant.
c. $\frac{I_C}{I_B}$ with $I_E$ constant.
d. $\frac{I_E}{I_B}$ with $V_{BE}$ constant.

An amplifier with a triode in common-emitter configuration featuring a purely resistive load, the emitter voltage and the collector voltage are:

a. in phase.
b. not related.
c. $90^\circ$ out of phase
d. $180^\circ$ out of phase.
Safety in Health Care Facilities

(This area includes all aspects of safety relating to: (1) conductivity of floors in operating rooms; (2) flammability of gases used in the medical environment; (3) radiation safety; (4) leakage currents; and (5) pressure safety devices such as those on sterilizers.) Sample:

Select the anesthetic agent that is considered the most flammable:

a. Halothane
b. Cyclopropane
c. Nitrous oxide
d. Trichloroethylene

Medical Instrumentation: Principles and Application

(The BMET should possess broad knowledge of equipment and instrumentation used in the medical environment. His knowledge should include the theory of operation, clinical application, and unique safety requirements relating to items such as: (1) coronary care systems, (2) spectrophotometers, colorimeters, and other lab instruments; (3) suction and pressure units; (4) anesthesia machines, respirators, and other gas equipment; (5) diathermy, ultraviolet units; (6) X-ray equipment; and (7) sterilizers.) Sample:

A sphygmomanometer is used for

a. urinalysis.
b. measuring blood pressure.
c. measuring respiration rate.
d. high-speed counting of erythrocytes.

The paper-speed (chart-speed) usually selected for clinical electrocardiography is

a. 15 millimeters per second.
b. 25 millimeters per second.
c. 50 millimeters per second.
d. 10 centimeters per second.

Medical Equipment Troubleshooting

(The BMET must be able to perform theoretical troubleshooting using schematics ranging from the simple, serologic water bath to one for an electrocardiograph. Foldout schematics are provided.) Sample:

The operator complains of AC interference in all lead positions. See foldout schematic No. 6 (not provided for this guide). This trouble could be caused by

a. Zener diode CR1 shorted.
b. K-1 relay not energizing.
c. An "A" deck of S-1 common open.
d. The "D" deck of S-1 shorted on the chassis.
I. Anatomy & Physiology
   A. Anatomy
   B. Physiology

II. Fundamentals of Electricity, Electronics & Solid State Devices
   A. Passive Devices & Circuits
      1. Devices & Circuits
         a. symbols
         b. resistive
         c. capacitive
         d. inductive
         e. transformers
         f. misc./combin.
   B. Active Devices & Circuits
      1. Devices
         a. diodes
         b. transistors
         c. FETs
         d. op amps
         e. batteries
      2. Circuits
         a. oscillators
         b. amplifiers
         c. comparators
         d. feedback
         e. other
   C. Digital
      1. Devices
         a. symbols
         b. gates
         c. truth tables
         d. counters
         e. flipflops
         f. other
      2. Circuits
         a. latches
         b. triggers
         c. timing
         d. other
   D. Microprocessors & Computers
      1. Devices
         a. CPUs
         b. memory
         c. I/O devices
         d. A/D convertors
         e. communication
         f. other
      2. Circuits
         a. buses
         b. controllers
         c. sensors
E. Transducers & Sensors
   1. Pressure
   2. Temperature
   3. Motion
   4. Position

III. Medical Equipment Function & Operation
A. General Equipment
B. Fundamentals of Radiology Equipment
   1. Diagnostic X-ray
   2. Nuclear Medicine
   3. Radiation Therapy
   4. CT
   5. MRI
   6. Ultrasound
C. Laboratory Equipment
   1. Chromatography
   2. Photometry
   3. Blood Gas

IV. Safety in Health Care Facilities
A. General Equipment
B. Radiology Equipment
   1. Diagnostic X-ray
   2. Nuclear Medicine
   3. Radiation Therapy
   4. CT
   5. MRI
   6. Ultrasound
C. Laboratory Equipment
   1. Chromatography
   2. Photometry
   3. Blood Gas
D. Electrical
E. Mechanical
F. Toxic Materials
G. Fire/Explosion
H. Radiological
I. Standards
J. First Aid
K. Miscellaneous

V. Medical Equipment Problem Solving
A. Specific Devices (with schematics)
B. Radiology Equipment
   1. Diagnostic X-ray
   2. Nuclear Medicine
   3. Radiation Therapy
   4. CT
   5. MRI
   6. Ultrasound
C. Laboratory Equipment
   1. Chromatography
   2. Photometry
   3. Blood Gas
WHEN FILLING OUT YOUR APPLICATION

PLEASE BE SURE TO NOTE:

1. Section d) Duties - % of time in each activity is filled out correctly. The four categories (Installation, Repair, and Calibration, Educational Activities/In-Service and Management) when added together should total 100%. (Refer to sample below.)

2. Section e) Equipment services, calibrated, etc.: complete this section by listing specific types of equipment. (Refer to sample below.)

3. Please include complete addresses for persons who you submit as a reference. The initial review of your application can be delayed by references not being promptly returned.

4. Remember it takes 6 weeks to process your application - so please submit early.

**SAMPLE**

<table>
<thead>
<tr>
<th>Dates</th>
<th>d) Duties</th>
<th>% of time in each activity</th>
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<td>From</td>
<td>To</td>
<td>Total Time</td>
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<tr>
<td>Mo. Yr.</td>
<td>Mo. Yr.</td>
<td>Yrs. Mos.</td>
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</table>

a) Employer:

- xray
- nuclear med.
- cardiovac.
- pulmonary
- anesthesia

b) Your Position

- clinical lab.
- phys. therapy
- other (specify)

c) Immediate Supervisor:


Is this part-time work? e) Equipment serviced, calibrated, etc.:

If yes, how many hours per week?

Total
APPLICATION FOR CERTIFICATION
FOR
GENERAL BIOMEDICAL EQUIPMENT TECHNICIANS

Board of Examiners for Biomedical Equipment Technology
3330 Washington Blvd, Suite 400 Arlington, VA 22201
(703) 525-4890

INSTRUCTIONS:

Your eligibility for certification will be judged on the information you give in this application, the opinions of your references, and the results of your written test. You should fill out the application accurately and completely. To eliminate delays in processing your application, supply all necessary details. Instruct your colleges and technical institutions to forward applicable transcripts of your studies promptly to the Board of Examiners.

The description below outlines the role and responsibilities of the BMET. Review this job-description to insure that your position and functions are those of a BMET as defined by the International Certification Commission.

A biomedical equipment technician (BMET) is an individual who is knowledgeable about the theory of operation, the underlying principles, and the practical, safe application of biomedical equipment. His or her capabilities may include installation, calibration, inspection, preventive maintenance, and repair of biomedical and related equipment. He or she might be involved in operation or supervision of equipment and in equipment control, safety and maintenance.

This application should be used for persons interested in certification as a GENERAL BIOMEDICAL EQUIPMENT TECHNICIAN.

Check only one of the two categories:

___ FULL CERTIFICATION

___ CANDIDACY

Applicant's Name ________________________________ (Type or print your name as it should appear on your certificate.)

Office use only:
Application received ____________________________
Fee received ____________________________
Application number ____________________________
(Please type or print all information material)

**PERSONAL**

Name ___________________________ Date of Birth ______________________

Home Address ___________________________

Present Employer ___________________________

Telephone Number (Office) ___________________________

Employer's Address ___________________________

Address Mail to (check one)  Home Address  Business Address

Present Position ______________________ Department ______________________

Immediate Supervisor's Name Title ___________________________

Other Certifications: ___________________________

Social Security #: ___________________________

**EDUCATION**

<table>
<thead>
<tr>
<th>Name of School</th>
<th>City</th>
<th>State</th>
<th>Course or Program</th>
<th>Dates of Attendance From</th>
<th>To</th>
<th>Diploma or Degree</th>
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<tr>
<td>High School</td>
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<tr>
<td>Technical Institute*</td>
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<td>College*</td>
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</table>

Other ___________________________

*Please have the school(s) send official transcript(s) promptly to the Board of Examiners for any program which supports your eligibility for certification.

**REFERENCES**

List five health care professionals* who have knowledge of your work experience, especially within the past five years. In applying for full certification list one physician who in charge of medical services.

<table>
<thead>
<tr>
<th>Name</th>
<th>Telephone Number</th>
<th>Complete Address</th>
<th>Position</th>
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*Physicians, BMET's, instructors of BMET courses, clinical engineers, hospital administrators, or other persons in responsible positions in the health care community. -2-
Note: Start with your most recent employment and account for each year since high school. (For non-RNET experience, you should only complete sections a, b, and c.)

Instructions: Give in sequence and detail for each position (a) name, address, and telephone number of employer, (b) title of your position, (c) name and title of your immediate supervisor, (d) percentage of time spent in each of the activities listed below, and (e) list some of the equipment you have serviced.

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<th>Repair &amp; Calibration</th>
<th>Educational Activities</th>
<th>Managing</th>
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<td></td>
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</tbody>
</table>

a) Employer:
- x-ray
- nuclear med.
- cardiovascular
- pulmonary
- anesthesia

b) Your Position:
- clinical lab.
- phys. therapy
- other (specify)

c) Immediate Supervisor:

Is this part-time work? [ ]
If yes, how many hours per week?

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a) Employer:
- x-ray
- nuclear med.
- cardiovascular
- pulmonary
- anesthesia

b) Your Position:
- clinical lab.
- phys. therapy
- other (specify)

c) Immediate Supervisor:

Is this part-time work? [ ]
If yes, how many hours per week?

e) Equipment serviced, calibrated, etc.: [ ]

Total

(This form may be duplicated if additional sheets are needed.)
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### a) Employer:
- x-ray
- nuclear med.
- cardiovass.
- pulmonar
- anesthesia
- other (specify)

### b) Your Position
- clinical lab.
- phys. therapy

### c) Immediate Supervisor:

### d) Duties

#### Total
- e) Equipment serviced, calibrated, etc.

### d) Duties

#### Total
- e) Equipment serviced, calibrated, etc.

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My check is enclosed. (U.S. money only.)
I certify that all information I have entered on this form is correct. I understand that any misrepresentation may result in rejection of this application or the revocation of any certificate issued as a result of this application. I am also aware that any certification I may receive from the International Certification Commission will not constitute and shall not be construed as a license. I authorize and release from all liability the Board of Examiners for Biomedical Technology to any inquiries that are necessary in ascertaining my eligibility for certification.

**Signature**

**Date**
REQUEST FOR TESTING FORM

My application for testing has been approved, please register me for the certification examination on _______ (date) in _______ (city and state).

My application is pending final approval, I would like to be considered for the certification examination on _______ (date) in _______ (city and state).

My application is enclosed, I would like to be considered for the certification examination on _______ (date) in _______ (city and state).

I would like to register for retesting* on _______ (date) in _______ (city and state).

*Note: When requesting retesting, please include an update on your BMET experience, current mailing address and work telephone number. A retesting fee of $60.00 must accompany this form. If it has been two years from your original test date a new application must be filed and the full fee of $175.00 must be submitted with this new application form.

Name: __________________________________________

APPLICATION NUMBER (IF RETEST):

Return this form to:
ICC c/o AAMI
3330 Washington Blvd
Suite 400
Arlington, VA 22201
APPENDIX B

APPLICATION FOR
CERTIFICATION IN CLINICAL ENGINEERING
GENERAL INFORMATION

The International Certification Commission, whose membership constitutes a broad representation of members from the health care community, including representatives from engineering, medical, industrial, and governmental groups and agencies, supervises the certification of clinical engineers, biomedical equipment technicians, and other related specialists through the organization of examining boards.

Guided by the Commission, the Board of Examiners for Clinical Engineering Certification considers a clinical engineer to be an engineer whose professional focus is on patient-medical device interfacing; one who applies engineering principles in managing medical systems and devices in the patient setting.

The Board consists of 13 certified clinical engineers, each of whom holds office for three years. Any certified clinical engineer may petition the Board in his or her name or may suggest another certified clinical engineer as a candidate for membership. Each candidate must submit to the Secretariat at the above address, a resume and the names of three other CCEs who would act as references in support of their nomination. The Secretariat will make a copy of these materials available to each Board member prior to a Board membership election. New members are selected by a majority vote of the Board, and final approval of the membership is made by the Commission.

The clinical engineer's level of education and experience coupled with the ability to competently apply engineering principles in a clinical setting enables him or her to participate professionally with physicians, hospital administrators and other personnel in the technological aspects of health care delivery. The clinical engineer has intensive knowledge in at least one branch of engineering analogous to a professional engineer. In addition, significant knowledge of physiology, medicine, and clinical care of patients enables the clinical engineer to play a supportive role in patient care, including the investigation and resolution of patient incidents. Knowledge of regulations, codes and administrative procedures is necessary to provide a supportive role in hospital administration. The clinical engineer's teaching ability is suitable for involvement in inservice education of equipment users. Finally, the clinical engineer has the professional maturity required to understand ethical conduct and to work in the best interest of the patient and general public.

To differentiate among clinical engineers, biomedical equipment technicians, and biomedical engineers, the Boards consider a biomedical equipment technician to be a technician whose professional focus is on the repair and maintenance of medical devices or research devices as used in applied or basic care research.
The biomedical equipment technician installs, inspects, repairs, calibrates and modifies medical devices, health care research devices, and medical support systems; advises on theory of operation, underlying physiological principles, and safe clinical application of medical devices; and supervises biomedical equipment maintenance activities.

The Board considers a biomedical engineer to be an engineer whose professional focus is on the design and development of medical devices; one who utilizes engineering principles and methods in the solution of problems in biology and medicine. The biomedical engineer usually works in a corporate or university research setting applying the principles and methods of engineering to the design and development of devices used in conjunction with living organisms.

In biological research, the biomedical engineer applies an engineering approach which is relevant and productive to both biological and engineering science. Utilizing knowledge of both sciences, the biomedical engineer works on the development of basic theory.

NOTE: CERTIFICATION BY THE INTERNATIONAL CERTIFICATION COMMISSION DOES NOT CONSTITUTE A LICENSE TO PRACTICE ENGINEERING; PUBLIC USE OF THE SAME MAY CONSTITUTE A MISREPRESENTATION UNDER THE PROVISIONS OF MANY STATE BOARD RULES CONCERNING THE PRACTICE OF ENGINEERING. THOSE IN VIOLATION OF THESE RULES MAY BE SUBJECT TO ENFORCEMENT ACTION BY THE STATE BOARD. PLEASE CHECK WITH YOUR STATE BOARD FOR FURTHER INFORMATION.

FEES

Applicants for Full Certification

The fee for full certification in clinical engineering is $200, due in full at time of application. Applications submitted without the full fee will not be processed. This covers the cost of processing the application, determination of eligibility, one examination, initial listing and certificate fee. An applicant found ineligible to take the examination will be refunded $160. An applicant who does not pass the examination will be refunded $25.

Student Status Applicants

The fee for student status applicants in clinical engineering is $100, due in full at time of application. Applications submitted without the full fee will not be processed. This covers the cost of processing the application, determination of eligibility, and one multiple choice portion of the examination. An applicant found ineligible to take the examination will be refunded $60.

Students who have passed the multiple choice portion of the examination, may apply for full certification after additional work experience or education requirements for full certification are met. The additional fee for full certification is $100. This covers the cost of processing and reviewing the updated application, and the oral and essay portions of the examination. An applicant who does not pass this portion of the examination will be refunded $25.

NOTE: "WHILE CONTRIBUTIONS OR GIFTS TO AAMI ARE NOT TAX DEDUCTIBLE AS CHARITABLE CONTRIBUTIONS FOR FEDERAL INCOME TAX PURPOSES, THEY MAY BE TAX DEDUCTIBLE UNDER OTHER PROVISIONS OF THE INTERNAL REVENUE CODE."
ELIGIBILITY REQUIREMENTS FOR CERTIFICATION

To be eligible for certification in clinical engineering a candidate must:

(1) Have a bachelor's or higher degree in engineering or electronics technology from a program accredited by the Accreditation Board for Engineering and Technology (ABET) and have at least 3 years of clinical engineering experience.

or

(2) Be a registered professional engineer and have at least three years of clinical engineering experience.

or

(3) Have a bachelor's degree in basic science from an ABET accredited program or a bachelor's degree in electronics technology from a program not accredited by the ABET; have passed the EIT; and have at least 4 years of clinical engineering experience.

or

(4) Have established or have recognized standing in the clinical engineering profession and have been engaged in practice at least 15 years of which 6 years have been in responsible charge. Experience must be as a clinical engineer.* Patient contact and interface with physicians and nurses, and hospital administrators on a continued basis in a clinical environment during the years of experience are required. Residencies will not be recognized as part of the experience criteria. Experience criteria must be achieved prior to application for certification.

* Applicants attempting to qualify under category (4) must demonstrate in their application that they have met at least four of the following six characteristics of a clinical engineer during the first 9 years of their experience and all six characteristics in the final 6 years.

1. Application of engineering principles in a clinical setting
2. Intensive knowledge of at least one branch of engineering
3. Supportive role in patient care including investigation and resolution of incidents
4. Knowledge of health care regulations and administrative problems
5. Teaching of clinical equipment users
6. Professional maturity and career growth
CERTIFICATION PROCESS

Clinical Engineering certification is a three-step process: Application review by examiners, written examination, and oral interview.

I. APPLICATION

An application for clinical engineering certification should be directed to the Secretariat. Additionally, the candidate should request that his or her college/university forward verification of graduation to the Secretariat. The Secretariat will obtain the candidate's references and forward the application, references, and academic verification to three members of the board for review.

II. WRITTEN EXAMINATION

The written examination tests the candidate's basic clinical engineering knowledge in a wide range of relevant areas. The written portion of the clinical engineering certification examination contains a total of 150 multiple-choice questions (50 questions in each of three sections: Medical Science, Clinical Engineering, and Engineering) and five essay questions.

Subject areas covered by the multiple-choice section are:

- Anatomy and Physiology
- Engineering Principles
- Physical Plant
- Codes, Standards, Regulations
- Management
- Medical Instrumentation
- Nuclear Medicine
- Inservice Training, Ethics, Legal Affairs
- Pulmonary Service
- Surgery
- Radiology
- Ultrasound
- Wards and Clinics
- Special Units
- Laboratory

There are two mandatory essay questions and a choice of two additional essays from a given list of questions.

III. ORAL INTERVIEW

The oral interview is used in conjunction with the written examination to determine the candidate's depth and breadth of clinical engineering experience. During the oral interview, the candidate's professional ability to make engineering judgements is assessed. Particular attention is paid during the oral interview to those areas of the written examination in which the candidate may not have demonstrated sufficient knowledge. The oral interview is conducted informally by at least two interviewers. Each turns in to the Board of Examiners written comments on the interview that state the reasons why the candidate should or should not be recommended for certification. If both interviewers agree that the candidate meets all the eligibility requirements for certification, the chairperson shall recommend to the International Certification Commission that the candidate be certified. The candidate will not be recommended for certification if one or both of the interviewers document the reasons why the candidate should not be recommended. The Board shall then make the recommendation not to certify to the International Certification Commission. If the candidate is not recommended for certification, the candidate may follow the procedures for appeal.
RECOMMENDATION SUSPENDED

If after testing, the candidate is determined to be lacking sufficient experience or specific academic preparation, a maximum period of one year will be given to present proof that the deficiency no longer exists. The Board of Examiners will then recommend to the International Certification Commission that the candidate be certified. Certification will not be recommended if the deficiency has not been amended within the one year period.

APPEALS PROCEDURE

Candidates should direct appeals through the Secretariat. Appeals are to contain information not previously presented or information that clarifies a point.

The Secretariat shall direct each appeal to the Board for review. The Board shall decide, by majority vote, whether the candidate may be retested, or whether the appeal should be evaluated further at the next meeting of the full Board. The decision of the Board shall be reported to the candidate through the Secretariat.

Candidates who are not satisfied with the decision of the Board may appeal through the Secretariat to the International Certification Commission.

EXAMINATION SCORING

Correct answers only are used to establish a pass/fail grade. The essay questions are worth a maximum of 10 points each, the multiple-choice questions are worth one point each. The oral interview is also part of the overall grading process.

EXAMINATION INSTRUCTIONS

Five and one-half (5 1/2) hours are allowed for the written exam. The examination will be given in two sections: Part 1, multiple choice questions, will last 3 1/2 hours; Part 2 the essay questions, will last 2 hours. There will be a 15 minute break between these two sections. Examinees are permitted to use a calculator and/or slide rule. No reference material is allowed in the examination.
SUGGESTED REFERENCES


16. References on equipment management, codes, standards, and regulations published by organizations such as the Association for the Advancement of Medical Instrumentation (AAMI), the American Hospital Association (AHA), the Joint Commission on the Accreditation of Health Care Organizations (JCAHO), the National Fire Protection Association (NFPA), and the Underwriters Laboratories (UL).
SAMPLE QUESTIONS

1. The S.A. node is normally the pacemaker because of its:
   a. rate of impulses.
   b. location in the atrium.
   c. proximity to the A.V. node.
   d. magnitude of electrical impulse

2. Ground-fault circuit-interrupters:
   a. measure the resistance of the ground.
   b. protect the electrical ground against corrosion.
   c. monitor the difference between currents in two conductors.
   d. establish an auxiliary ground if the main ground is interrupted.

3. In accordance with JCAH standards, hospital electrical power supplied by an emergency system must transfer from normal to emergency power in a minimum time of:
   a. 1 millisecond.
   b. 1 second.
   c. 10 seconds.
   d. 1 minute.

4. The sum of the residual volume and the expiratory reserve volume is equal to:
   a. vital capacity.
   b. total lung capacity.
   c. resting tidal volume.
   d. functional residual capacity.

5. The most frequent site for nosocomial infection is:
   a. skin.
   b. blood.
   c. urinary tract.
   d. respiratory tract.

6. The Swan-Ganz catheter is used in the:
   a. monitoring of renal efficiency.
   b. monitoring of arterial pressure.
   c. measurement of cerebrospinal fluid viscosity.
   d. measurements of volume changes in body segments.

7. The temperature of pure saturated steam 15 psig is:
   a. 105°C
   b. 110°C
   c. 121°C
   d. 125°C

8. According to Beer's Law, optical density is:
   a. directly proportional to concentration.
   b. inversely proportional to concentration.
   c. proportional to the square of the concentration.
   d. inversely proportional to the square of the concentration.

9. In diagnostic ultrasound, higher frequencies have:
   a. better penetration and better resolution.
   b. poorer penetration and better resolution.
   c. poorer penetration and poorer resolution.
   d. better penetration and poorer resolution.

10. An X-ray grid is used to:
    a. intensify the image.
    b. position the patient.
    c. control the tube current.
    d. reduce secondary radiation.

11. Pair production, the photoelectric effect, and the Compton effect all predominate different energies. Which of the following is the ascending energy order:
    a. pair production, Compton Effect, photoelectric effect.
    b. Compton Effect, photoelectric effect, pair production.
    c. pair production, photoelectric effect, Compton Effect.
    d. photoelectric effect, Compton Effect, pair production.
12. For compliance with NFPA Standard No. 56A, no conductive floor location shall have a resistance less than:

a. 10,000 ohms.
b. 25,000 ohms.
c. 1,000,000 ohms.
d. 5,000,000 ohms.

13. In diagnostic ECG amplifiers the minimum bandwidth, between 3dB points is:

a. 0.05 to 10 Hz.
b. 1 to 100 Hz.
c. 0.05 to 100 Hz.
d. 10 to 100 Hz.

14. The third derivative of y with respect to x in the equation \( y = 8x^3 \) is:

a. 0.
b. 48.
c. 48x^2
d. 24x^2.
APPLICATION FOR CERTIFICATION IN CLINICAL ENGINEERING
BY
THE INTERNATIONAL CERTIFICATION COMMISSION
FOR CLINICAL ENGINEERING AND BIOMEDICAL TECHNOLOGY
3330 Washington Blvd, Suite 400
Arlington, Virginia 22209-1899

Please include the $200.00 application fee with your application.
Your completed application form must be returned to the address above via Certified Mail.

PERSONAL

Application must be typed to be considered by Board of Examiners

Name __________________________ Date of Birth __________________________
Month Day Year

Home Address
Street __________________________ City __________________________ State ______ Zip Code ______

Present Employer

Telephone No. (area code) ______

Employer’s address
Street __________________________ City __________________________ State ______ Zip Code ______

Address Mail to (check one) Home Address Employer’s Address

Present Position __________________________ Title __________________________

Immediate Supervisor’s name and title __________________________

REFERENCES 3

List five (5) references who can respond on the following areas: (1) engineering ability, (2) clinical experience interfacing with physicians, (3) clinical experience interfacing with nursing staff, (4) administrative experience. References from nurses, physicians, administrators, and engineers are preferred. Note: In listing references, please provide complete name, address, and telephone number.

1. Incomplete information on this application will require correspondence and unduly delay consideration of this application.

2. Processing of application requires four to six months to allow for response from references and review by the Board of Examiners.

3. Please obtain permission to list these references, and inform them that a recommendation form will be sent to them.
Application for Certification

REFERENCE LIST

<table>
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<tr>
<th>Name and Title</th>
<th>Complete Address &amp; Telephone Number (area code)</th>
<th>Position</th>
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EDUCATION

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<tr>
<th>Name of School</th>
<th>Location</th>
<th>Major</th>
<th>Dates of Attendance From</th>
<th>To</th>
<th>Diploma or Degree</th>
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<td>High School</td>
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Applicants should arrange for transcripts to be sent directly to the ICC by the registrar of all colleges attended.

List professional registrations and certifications you now hold, stating issuer, date and length of registration or certification.

List professional or technical societies of which you are a member.

Have you ever taken the American Board of Clinical Engineering or International Certification Commission written examination? (Check one.)

Yes_______ No_______ If yes, when? Date__________________

Were you ever designated as a Clinical Engineering Candidate by the American Board of Clinical Engineering or Certification Commission? (Check one.)

Yes_______ No_______ If yes, when? Date__________________
EMployment

NOTE: Start with your most recent employment and account for each year since high school.

SAMPLE FORMAT

<table>
<thead>
<tr>
<th>Dates</th>
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<th>Total Time</th>
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<td>Mo.Yr.</td>
<td>Mo.Yr.</td>
<td>Yrs. Mos.</td>
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On separate sheets, in the following format give in sequence and detail: (a) Name and address of employer, (b) Title of your position, (c) Name and title of your immediate supervisor, (d) Description of duties and responsibilities (be factual and specific). Identify the positions which you feel are part of your clinical engineering experience.

(Attach additional sheets)

EDUCATION, EXPERIENCE AND ACCOMPLISHMENTS IN CLINICAL ENGINEERING

The questions below will help the Board determine whether your education, experience and accomplishments meet the general criteria outlined in this description. Consequently, each question should be answered carefully (use additional paper).

1. Describe briefly how your relevant educational background helps to qualify you as a clinical engineer.

2. Describe your experience in the clinical environment:
   (a) Engineering activities in the clinical environment
   (b) Engineering, management and supervisory responsibilities in the clinical environment
   (c) Describe briefly the health care facilities in which you acquired your relevant clinical engineering experience

3. Briefly describe your major accomplishments as a biomedical or clinical engineer in the following areas:
   (a) Research
   (b) Instrument or systems research and development
   (c) System design
   (d) Clinical engineering support organization planning
   (e) Clinical engineering
   (f) Clinical engineering consultation
   (g) Clinical engineering public service
Application for Certification

4. List relevant patents, papers, etc., that have been published or presented.

5. Indicate how becoming certified in clinical engineering helps you or your institution.

6. Describe briefly other skills, experience, training or hobbies which might be relevant.

My check for $200.00 is enclosed (U.S. dollars).

I certify that all information submitted is correct. I understand that any misrepresentation may result in rejection of this application and/or revocation of a certificate issued as a result of this application. I am also aware that an certification I may receive from the International Certification Commission will not constitute or be construed as a licensing procedure. I authorize the International Certification Commission to make any inquiries that are necessary in ascertaining my credentials for certification and release them from all liability. I agree to abide by the decision of the International Certification Commission.

I understand that the certification in clinical engineering is not legal registration. Each state has its own regulations regarding use of the term "engineer." The Board of Examiners recommends that all applicants check with their state(s) for further information regarding pertinent regulations.

Signature ___________________________ Date ____________
APPENDIX C

BYLAWS OF THE BOARD OF EXAMINERS
FOR CLINICAL ENGINEERING CERTIFICATION

CONSTITUTION OF THE INTERNATIONAL CERTIFICATION COMMISSION

BYLAWS OF THE INTERNATIONAL CERTIFICATION COMMISSION
OPERATING PROCEDURES

U.S. Board of Examiners for
Clinical Engineering Certification

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OPERATING PROCEDURES - U.S. Board of Examiners for Clinical Engineering

I. Applications

1. Requests for information and application shall be filled by the Secretariat of the U.S. Board of Examiners.

2. Completed applications shall be submitted to the Secretariat who is responsible for coordinating the application process. Processing an application will proceed through the following steps:

2.1 Establish a file for each applicant and send acknowledgement of receipt of application and receipt for payment if received.

2.2 If the payment is not submitted with the application, then the applicant shall be billed and no further action taken on the application by the Board until the fee is received.

2.3 The Secretariat will screen and return any applications that clearly do not meet the minimum relevant educational and/or relevant experience requirements. These applications and fees should be returned to the applicant, along with a letter describing the deficiency. If the application does meet minimum requirements then the fee is considered non-refundable.

2.4 Preprinted reference forms and envelopes will be sent to each of the five references listed on the application.

2.5 Upon receipt of the completed reference forms, application and college transcripts, a copy of the applicant's entire file shall be sent to at least three members of the Board of Examiners, picked on a rotational basis, for review to determine the eligibility for testing. Any Board member may refuse to review an application of a candidate that is known to them. The Secretariat will supply a list to the Board of the applications in process at least twice a year.

2.6 An evaluation sheet will be attached to the candidate's packet for review. This sheet will be completed by the reviewing Board member. A majority decision of the reviewers is required to determine if the candidate is eligible to take the written and oral examinations.

3. A letter advising the applicant of their eligibility to be examined together with a copy of the examination schedule and guidelines for the exam, will be sent to the candidate by the Secretariat.

4. The Board of Examiners shall be responsible for conducting a written and an oral examination. Printing, security and distribution of the examination shall be the responsibility of the Secretariat.

5. Written and oral exams will be held throughout the year in various locations as determined by the Board.

6. The written and oral examinations are normally, yet not necessarily, held within a day or two of each other. The oral exam
will be conducted by at least two members of the Board following the established Oral Examination Guidelines.

7. The results of the written and oral examinations will be presented to the full Board for review. A majority vote is required to either pass, fail or suspend a decision on certification for each applicant.

8. The recommendation of the Board will be submitted to the International Certification Commission (the Commission) for review and approval.

9. The Commission's Secretariat shall notify the candidate of the decision of the Commission. If certification is not granted, the candidate is to be informed of the appeals process.

10. Certificates shall be mailed to the candidate by the Secretariat as soon as possible after notification of certification.

II. Suspension

If examination reveals that a candidate is lacking in sufficient experience or specific academic preparation, a maximum period of one year can be allowed to present proof that the deficiency no longer exists.

1. The candidate will be notified of suspension of the certification process for one year by letter from the Chairman of the Board which will specify the deficiencies that need to be corrected before the candidate can be recommended for certification. A copy of the letter will be sent to the Commission.

2. Before the year ends, the Secretariat must contact the candidate concerning completion of the requirements. If another oral examination was deemed necessary at the time of suspension, the Secretariat will make arrangements for this to take place.

3. Information supplied by the candidate regarding correction of deficiencies (together with the results of the oral examination if one was required), will be provided by the Secretariat to the members of the Board for a vote on the final recommendation for this candidate.

4. If certification is recommended by the Board and approved by the Commission, the candidate will be notified of his/her certification.

5. If certification is not recommended by the Board, the candidate will be notified and the necessary documentation sent to the Commission. The candidate will also be informed of the appeals procedure.

6. If the candidate does not respond to the inquiry by the Secretariat or has not corrected the deficiencies within the one year, the applicant will be required to reapply should he/she choose to seek certification in the future.

7. An extension of the suspension may be granted by the Chairperson of
the Board of Examiners only if the candidate submits this request in writing prior to the end of the suspension period.

III. Appeals

A candidate wishing to appeal the decision of the Board of Examiners, must provide this request in writing to the Board. The reason for the appeal must be described in detail and any supporting material enclosed. To facilitate the rapid handling of the appeal, this request shall be made within six months from the date of mailing of the Board’s decision.

1. The Secretariat will copy this material to the Board for review. A majority vote of the Board shall be requested by ballot (mail or regular meeting) to decide 1) if the candidate should be given a retest be a written and/or oral examination, or 2) to decide on another course of action by the Board or candidate. The Board will provide its recommendation to the Commission. The recommendation will be conveyed to the applicant by the Secretariat within two months of the Board’s receipt of the request for appeal.

2. Upon receiving the Board’s recommendation, the candidate has the following options: 1) accept the Board’s decision and abandon the appeal; 2) retake the written and/or oral exam as recommended by the Board at the earliest opportunity; or 3) continue the appeal to the Commission. The candidate has one month to decide on one of the three options and communicate a decision in writing to the Secretariat. No action on the part of the candidate will be assumed to mean that the Board’s decision has been accepted.

3. Further appeal may be made by an unsatisfied candidate to the Commission, which is the certifying body, and final step in the appeals process. However, the candidate must have first appealed to the Board, before the Commission will directly consider the appeal. If the appeal reaches this final step in the process, the Secretariat will send the candidate’s file to the Commission. The Commission will consider the appeal and by a majority vote decide on the resolution of the appeal. This ballot can be taken by mail or at the regular meeting. The candidate should be informed of the Commission’s decision within two months.

4. The time between each of the steps in the appeal process are not to be construed as inflexible. They are specifically designed to facilitate rapid handling of the appeal by the Board and Commission. The process is to be completed within one calendar year to give the candidate the opportunity to retest, if necessary, as soon as possible.

IV. Examination Subcommittee

There shall be a standing subcommittee of the Board to continually review and update the examination process.

1. The subcommittee shall consist of at least three Board members. The Board’s Vice-Chairperson shall be the Chairperson of the subcommittee.
2. The subcommittee will update all or a portion of the written examination yearly.

3. The subcommittee will make recommendations to the Board for changes in the examination process as necessary.

V. Oral Examination Guidelines

The purpose of the oral examination is to determine if the candidate is able to deal with practical clinical engineering problems and situations. The written examination should be used as the determination of the candidate's theoretical ability. This approach provides more uniformity between examiners. The interview should be straightforward and low key.

1. The oral questions should be directed as the examiners deem appropriate to adequately explore the candidate's abilities as reflected on the written examination.

2. The length of the oral exam should be from 45 to 60 minutes.

3. The examiners should ask the candidate for their opinion of the examination and certification process.

4. Candidates should be told that the International Certification Commission will inform them of the results in approximately 4 to 6 weeks.

5. Upon completion of the oral exam the examiners must complete the examination evaluation form. The examiners should recommend: 1) certification if both examiners agree; 2) deny certification if both examiners agree; or 3) if there is a split decision, then the Chairperson and Secretariat should be notified as soon as possible to arrange for another oral exam by other Board members. If the examiners do not recommend certification they must describe in detail their reason on the evaluation form.

6. At the annual Board meeting or through mail vote, the oral examiners will review their recommendation with the full Board. A majority vote of the Board for each candidate will determine the certification recommendation from the Board to the International Certification Commission.

VI. Former A.B.C.E. Students/Candidates

The former American Board of Clinical Engineering (ABCE) offered written examinations to graduating clinical engineering students as well as experienced clinical engineers. Under the merger agreement all ABCE certified clinical engineers were recognized as fully certified. ABCE also had categories for "students" who passed the written examination and "candidates" who were individuals who had passed the exam and applied for clinical engineering certification. At the April, 1984 meeting of the Board, the following policies were enacted.

1. Individuals who submit evidence of having successfully completed the written examination under the ABCE program and who had not
applied for ABCE certification will be considered to be in the student category. The following guidelines have been established by the Board.

1.1 The student must complete the application for certification and meet all of the educational and experience requirements in effect at the time of application.

1.2 The prevailing fee for the certification application minus $20 already paid to ABCE is required.

1.3 Successful written examination results on the ABCE exam will be accepted as fulfillment of that portion of the exam requirements. An oral exam will still be required.

1.4 All of the usual steps for certification will be followed with the exception of not requiring an additional written examination.

2. Individuals who submit evidence of having been accepted by the ABCE as a clinical engineering candidate are required to meet the following requirements before full certification can be granted.

2.1 A new application or additional fees will not be required.

2.2 The written examination results will be accepted as fulfillment of that portion of the exam requirements. An oral exam will still be required.

2.3 At least three years of relevant experience as defined by the Board at the time the candidate applies for certification is required. The candidate must submit a detailed description of this experience.

2.4 A list of five references familiar with the candidate's work experience should also be submitted. The Board has the option of contacting these individuals if it chooses.

VII. Current Student Applicants

Students who are about to complete a BS or MS degree in an accredited engineering program can take the multiple choice portion of the examination.

1. Requests to test must go through the Chairperson and be processed by the Secretariat.

2. The student must submit to the Secretariat their name, address, education, transcripts, experience (if any), and any other pertinent information deemed necessary.

3. The fee for the examination will be $20.

4. The Board will ask educators at the universities where the exams are given for new questions at the time the test is given as a condition of testing.
5. If the proctors of the exam wish to test, they must wait 4 years from their most recent administration of an exam before doing so.

6. The student will be notified by the Secretariat if they pass the exam and informed that they have a maximum of 7 years to complete the full certification process.

7. The student will be notified by the Secretariat if they fail the exam and informed of their areas of weakness. A student who fails the exam must wait 3 to 5 years before they apply for full certification.

VIII. Operating Procedures and Bylaws Revision

Annually the Chairperson shall review the Operating procedures and Bylaws for possible revision. All revisions shall be voted on by the Board and submitted to the Commission for approval.
CONSTITUTION AND BYLAWS FOR THE INTERNATIONAL CERTIFICATION

COMMISSION FOR CLINICAL ENGINEERING AND BIOMEDICAL TECHNOLOGY

Constitution: Revised May 1985

Bylaws: Revised August 1985
CONSTITUTION FOR THE INTERNATIONAL CERTIFICATION COMMISSION
FOR CLINICAL ENGINEERING AND BIOMEDICAL TECHNOLOGY

ARTICLE I - NAME, PURPOSE, AND FUNCTION

1. The name of this organization is hereinafter referred to as the Commission.

2. The purpose of the Commission shall be to serve the health care community relative to the certification of clinical engineers, biomedical equipment technicians, and other related professions. Accordingly, the Commission shall:

   2.1 Formulate general policies on certification;

   2.2 Advise the respective examining boards in matters of certification;

   2.3 Grant certification upon review of the Board of Examiners' recommendation in each discipline;

   2.4 Assist the education community in developing relevant continuing educational and fundamental training programs;

   2.5 Foster and advocate advancement of professional standards.

3. In order to achieve these purposes, the Commission shall:

   3.1 Provide overall policy direction of certification programs;

   3.2 Establish Boards of Examiners in professions the Commission deems appropriate;

   3.3 Approve members nominated to examining boards;

   3.4 Establish advisory councils or committees as necessary;

   3.5 Ensure that each examining board operating under the Commission carefully evaluates applications and prepares, administers, and evaluates written examinations to determine the qualifications of individuals seeking certification.

ARTICLE II - BYLAWS

1. Bylaws shall be established for the purpose of governing the operations and the administration of the Commission.

2. The term Bylaws as used in the Constitution refers only to the Bylaws of the Commission.
3. Bylaws may be amended as hereinafter set forth.

ARTICLE III - MEMBERSHIP

1. The Commission shall consist of as many organizational and individual members in the health-care community as the Commission deems appropriate. The Commission shall have a minimum of nine members.

2. Tenure of membership shall be as specified in the Bylaws.

3. The initial membership of the Commission shall be comprised of all previous members of the original Commission and members of the American Board of Clinical Engineering Commission of Trustees.

ARTICLE IV - OFFICERS

1. Officers of the Commission shall be elected from members of the Commission. They shall consist of a Chairperson, Vice-Chairperson, Immediate Past Chairperson, and Secretary/Treasurer (all of whom shall be members of the Commission as noted in the Bylaws).

2. Criteria for office, terms of office, and election shall be as specified in the Bylaws.

3. The officers shall perform those duties specified in the Bylaws and those duties otherwise specified by the Commission.

ARTICLE V - COMMITTEES

1. The Executive Committee of the Commission shall consist of the officers of the Commission as described in Article IV.1.

2. Standing and other committees shall be as specified in the Bylaws.

ARTICLE VI - GOVERNANCE

1. The Commission shall maintain a headquarters within the United States of America.

2. The Commission shall hold at least one official administrative meeting each year as specified in the Bylaws.

3. The Chairperson shall, upon election, become a member-at-large. That is, he or she shall not be simultaneously Chairperson and representative of a member organization of the Commission.
4. A quorum for conducting business at a meeting of the Commission shall be a simple majority of its members. Business may also be conducted by mail, as specified in the Bylaws.

5. Meetings of the Boards of Examiners shall be as specified in their bylaws.

6. The fiscal year of the Commission shall be as defined in the Bylaws.

7. The Commission may receive, hold, and dispense funds as specified in the Bylaws.

8. The latest revision of Robert's Rules of Order shall apply to the conduct of all Commission business.

9. The Secretary/Treasurer shall provide an itemized financial statement to the Commission each year, at least thirty days before the Commission's annual meeting.

10. Submittals for Commission action or review shall be received by the Secretariat and transmitted to all Commission members no less than forty-five (45) days prior to the next scheduled meeting of the Commission.

ARTICLE VII - GENERAL

1. The Commission shall not attempt to influence local, state/provincial or national legislation. The Commission shall not participate in, or intervene in (including the publishing or distribution of statements) any campaign on behalf of any candidate for public office.

2. All official records, archives and historical material shall be in the custody of the Secretary/Treasurer.

3. No provision of this Constitution is intended to be in violation of a federal or state law. If any provision is found to be in violation of a state or federal law, the provision will immediately become ineffective.

ARTICLE VIII - AMENDMENTS

1. Amendments to this Constitution shall be proposed in writing to the Executive Committee by at least two Commission members.

2. Proposed amendments shall be so identified and shall be transmitted in writing to all members of the Commission by the Secretary/Treasurer at least sixty days prior to an official administrative meeting of the Commission at which a vote thereon will be called.

3. A proposed amendment to the Constitution is adopted upon an affirmative vote of at least two-thirds (2/3) of the Commission. Absentee votes from Commission members must be received in writing thirty days following the meeting.
4. A proposed amendment to the Bylaws shall be presented in writing to the Commission members attending an administrative meeting.

5. A proposed amendment to the Bylaws shall be adopted upon an affirmative vote of two-thirds (2/3) of the members. If a two-thirds majority is not possible, the amendment may be approved pending final two-thirds mail ballot to be concluded within thirty (30) days following the administrative meeting of the Commission. The Secretary/Treasurer shall mail copies of the amendment to all Commission members within fifteen (15) days following approval of the amendment.

6. An adopted amendment to the Constitution shall become effective sixty days following the meeting at which it is presented for vote. The Secretary/Treasurer shall issue minutes of the meeting within sixty days of the meeting.

Date of Adoption ___________________________ May 7, 1985

Date of Amendments ________________________
BYLAWS OF THE INTERNATIONAL CERTIFICATION COMMISSION
FOR CLINICAL ENGINEERING AND BIOMEDICAL TECHNOLOGY

I GENERAL

These Bylaws provide detailed guidance for the supervision and management of Commission affairs in accordance with the Constitution. Amendments may be made by means of the procedures described in Article VIII of the Constitution, and shall take effect as therein provided.

II MEMBERSHIP

1. Commission: In addition to the members of the Commission as described in Article III of the Constitution, there shall be ex-officio members without voting rights consisting of the Chairpersons of the Boards of Examiners for Clinical Engineering, Chairpersons of the Boards of Examiners for Biomedical Equipment Technicians, the Chairperson of other approved specified Boards, and the Chairperson of each Advisory Council.

1.1 Terms of Service: Each member organization will nominate to the Commission a representative for a term lasting three years.

1.1.1 Maximum length of service shall be two 3-year terms.

1.1.1.1. The Chairperson of the Commission, upon taking office is excluded from the maximum length of service requirement.

1.1.2 Tenure and replacement due to expiration of normal three year terms may be subject to modification by the Executive Committee to insure that no more than one third (1/3) of the Commission Membership is changes during any calendar year.

2. Boards of Examiners:

2.1 Members of the Clinical Engineering Board of Examiners must be certified in clinical engineering and must be approved by the Commission.

2.2 Members of the BMET Boards of Examiners will represent a broad range of relevant medical instrumentation professionals -- namely, technicians, engineers, physicians, nurses, educators and manufacturers and must be approved by the Commission.

2.2.1 At least half of the BMET Board of Examiners membership must be certified by the Board as a CBET or specialty BMET certification.

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3. Advisory Councils: Advisory Councils may be created to serve the Commission. Each Advisory Council shall be created for a specific function and operate for a period of time specified in advance by the Commission.

4. Admission and Acceptance: All elections to the Commission and the Advisory Councils shall be by a simple majority vote of the Commission and shall be formally accepted in writing. This acceptance shall be received by the Secretariat within thirty days of notification. If acceptance is not received by the Secretariat within that time, the Commission shall take appropriate action to fill the vacancy. Privileges of membership shall not occur until the acceptance is received.

5. Privileges: Voting rights on the Commission are transferable but only to alternates bearing notes of delegation. Proxy votes are not acceptable. Voting rights on the Boards are as stated in their approved operating guidelines.

6. Resignation: A member of the Commission may resign by stating his or her intention, in writing, to the Chairperson of the Commission.

7. Termination and replacement:

7.1 A written request for termination and replacement of a Commission or Board of Examiners member, received by the Secretariat, shall be transmitted to the Commission Chairperson for appropriate action.

7.2 Any member of the Commission or Secretariat may be removed by a two thirds (2/3) vote of the entire voting members of the Commission. Voting may be at a regular or special meeting or by mail.

7.3 Any member of a Board of Examiners may be removed by a two thirds (2/3) vote of the Board of Examiners, subject to approval by the Commission.

8. Conditions of termination:

8.1 Any member of the Commission who does not attend two consecutive annual meeting of the Commission may be considered for termination and replacement.

8.2 Failure of any Commission member to regularly complete standing or advisory committee assignments may be cause for termination and replacement.

8.3 Any member organization may remove and replace their representative to the Commission as they may determine necessary subject to approval of the replacement in accordance with Article II, section 11 of the Bylaws.

9. Termination of organizational affiliation:

9.1 The Commission may terminate the affiliation of any current or future organization in accordance with Article III of the
Constitution, at any time, if the Commission determines that further affiliation is not consistent with the mission of the Commission or its Boards of Examiners.

10. Appeals of terminations:

10.1 Termination of a member of the Commission or a Board of Examiners may be subject to appeal to the Executive Committee of the Commission upon written request for appeal submitted to the Chairperson of the Commission.

10.1.1 Decisions of the Executive Committee may be appealed to the entire Commission upon submission of a written request to the Secretariat.

10.1.2 Decisions of the entire Commission are not subject to further appeal.

11. Notification of termination proceedings:

11.1 Upon receipt of a recommendation of termination of any member(s) of the Commission or Boards of Examiners by the Secretariat, the Secretariat shall notify the Chairperson of the Commission who shall notify the member(s) at least thirty (30) days prior to a scheduled vote. That notice shall be sent by certified mail to the last address recorded by the Secretariat.

III RESPONSIBILITIES

1. Commission: The responsibilities of the Commission shall include the certification in Clinical Engineering, Biomedical Equipment Technology and in other areas of specialized engineering or technology as recommended by their respective boards of examiners and recognized by the Commission. Other responsibilities of the Commission shall be to:

1.1 Provide guiding principles for the Boards, towards attaining the purposes cited in the Constitution.

1.2 Maintain appropriate staff assistance to insure the continuation of activities. This staff assistance shall be provided by the Secretariat to the Commission.

1.3 Ensure that the preparation and administration of examinations for certification by the Board of Examiners are in the best interest of the public.

1.4 Seek to establish the certification process as a financially self-sustaining effort. A fee shall be imposed upon applicants to defray the cost of certification.
2. Boards of Examiners: The responsibilities of the Boards shall be specified in their Bylaws. The Boards shall also:

2.1 Insure adequate communication with the Commission, members of the Board, applicants, appropriate agencies and individuals seeking information about certification.

2.2 Insure that each phase of the certification process is carried out as outlined and approved by the Commission.

2.3 Insure that all candidates are treated equally and impartially throughout all phases of certification.

2.4 Insure that the contents of the examination reflect the current state of the art, responsibilities, and capabilities pertinent to the field in which the applicant seeks certification.

2.5 Provide the Commission with written, operational guidelines that promote prudence in the Boards' actions, competency of the examiners, and maintenance relevancy of the examinations with respect to current technological trends. These guidelines are to be approved by the Commission.

IV FEES

1. The application fee shall be paid at the time the application is made.

2. The application fee shall be made payable to and determined by the Commission, from time to time, to defray costs as incurred by the certification process.

3. The application fee shall cover only the period specified for the certification examination. Additional fees shall be required as determined by the Commission for re-examination.

4. Refund policy for application fees shall be determined by the Commission to cover situations which may occur during the certification process.

V MANAGEMENT

1. Commission

1.1 The Commission shall consist of members as described in Article III, Section 1 of the Constitution.

1.2 Meetings shall be open to members of the Boards and Advisory Councils. Other interested persons or representatives of associations may also be permitted to attend. An executive (closed) session will be held upon request of a simple majority of voting members present.
1.3 Meetings shall be held at least once a year, in conjunction with national meetings in the field of biomedical engineering.

1.4 Executive Committee meetings shall be held at the call of the Chairperson by written notice to all members of the Executive Committee at least thirty days prior to the meeting date.

1.5 Business may be conducted by mail. Action must be affirmed by a majority of the voting members of the Commission with at least thirty days allowed for the return ballots.

1.6 A quorum for conducting business shall be at least one-half of the number of voting members. In absence of a quorum, business may be conducted by mail as specified in Section 1.5.

1.7 The fiscal year shall be January 1 through December 31.

1.8 The Executive Committee, as specified in the Bylaws, shall be charged with carrying out the policies and day-by-day activities of the Commission between meetings of the Commission.

2. Boards of Examiners: The supervision of conformance of the Board of Examiners to their own bylaws shall be performed by the Commission. Officers elected by any of the Boards must have the approval of the Commission before they take office. Terms of office shall be according to the bylaws of the Board as approved by the Commission.

3. Advisory Councils: All Advisory Councils established by the Commission shall report to the Commission only.

4. Secretariat: The Secretariat shall assist the Commission by performing administrative duties as assigned by the Commission or any of the Boards.

VI OFFICERS OF THE COMMISSION

1. The Chairperson, the Vice Chairperson, and the Secretary/Treasurer shall be elected at the annual administrative meeting from among the members of the Commission. The Chairpersons of the Boards serve as Officers of the Executive Committee, but ex-officio, without vote. The Secretariat, by appointment of the Commission may serve as the Secretary/Treasurer for a length of time to be specified by the Commission. The Secretariat shall not have voting privileges as Secretary/Treasurer and voting privileges shall be reinstated upon election of a new Secretary/Treasurer from the members of the Commission.

2. Terms of office shall be for three calendar years, except in the case where interim vacancies are filled. For filled interim vacancies, the term of office shall be only for the remainder of the term being filled. Periods spent in interim status shall not be considered as terms of office.
2.1 The Chairperson and Vice-Chairperson shall hold no more than two successive terms.

2.2 The Secretary/Treasurer shall hold no more than two successive terms, except in the case where the Secretariat performs the duties of the Secretary/Treasurer. The terms for this alternative situation are to be determined by the Commission as outlined above and are not necessarily limited to 2 terms.

2.3 The terms of Chairperson and other officers of the Boards shall be as stated in the operating guidelines of the Boards, as approved by the Commission.

3. The Chairperson shall be the principal officer of the Commission.

3.1 He or she shall preside at the annual administrative meeting and all other meetings as specified in the Bylaws.

3.2 He or she shall be an ex-officio member of all committees, without vote.

4. The Vice Chairperson shall preside at all meetings from which the Chairperson is absent. In cases where the absence is to be permanent, the Vice Chairperson shall accede to the Chairpersonship, and an interim Vice Chairperson shall be elected for the remaining period of the term.

5. In the event of the absence or incapacity of both the Chairperson and the Vice Chairperson, the Immediate Past Chairperson shall serve during such absence or incapacity or until the positions can be filled. (The intent is that the Immediate Past Chairperson serves only as an emergency measure.)

6. The Secretary/Treasurer, under the direction of the Commission, shall have general supervision of the Secretariat in the keeping of records of meetings, activities, membership, and any other records required by law.

6.1 He or she shall be responsible for arrangements for all meetings, and shall be bonded, with costs borne by the Commission.

6.2 He or she shall transmit to members such notices as the business of the Commission may require, and carry out assignments as directed by the Commission.

6.3 He or she shall be an ex-officio member (without vote) of all standing committees.

7. The Secretary/Treasurer, under the direction of the Commission, shall have general supervision of the fiscal affairs and shall be responsible for supervising the maintenance of records established by the Commission or required by law. He or she shall have charge of the funds and maintain the financial record of the Commission. He or she shall collect fees, make all disbursements, and prepare and submit all financial
reports that are subject to the procedures defined in the Constitution and Bylaws.

8. Officers shall be elected at the annual administrative meeting from a written ballot prepared and presented by the Nominations Committee.

8.1 The Nominations Committee shall include in its ballot at least one candidate for each office derived from the Committee's deliberations, and any other candidates proposed by at least two members of the Commission. Ballots shall be mailed no less than thirty days in advance of the annual administration meeting. All candidates must have consented to serve if elected. A roster of the candidates shall have been sent to each member of the Commission prior to the annual meeting.

8.2 Secret votes shall be taken to elect a single individual for each office by affirmation of at least a majority of the voting members comprising a quorum. Results shall be tabulated by the Secretariat and the results shall be announced by the same.

VII COMMITTEES OF THE COMMISSION

1. Permanent standing committees shall include: Executive Committee, Finance Committee, Nominations Committee, and others the Commission may establish.

1.1 The Chairperson of each standing committee, except as otherwise provided, shall, with the approval of the Commission, be appointed by the Chairperson of the Commission and shall serve for one fiscal year. A chairperson whose term of office has expired may continue to serve until his successor is appointed and is ready to serve. A standing committee chairperson is limited to serving no more than four successive terms.

1.2 Members of committees, except as otherwise provided, shall be nominated by the committee chairperson within sixty days following appointments of the chairperson. Nominations become appointments upon approval of the Chairperson of the Commission. Unless otherwise specified at the time of formation of the committee, the term of office of a committee member shall be for one fiscal year. A member whose term of office has expired may continue to serve until his successor has been appointed.

1.3 Subcommittees of a standing committee may be organized and directed by the committee Chairperson.

1.4 The Chairperson of the standing committee may establish such other subcommittees as he or she deems necessary or as he or she is directed by the Commission.

1.5 A committee Chairperson shall submit to the Commission any budget requests and forecasts, as directed by the Finance Committee.
1.6 The annual administrative meeting shall be so arranged that the Chairperson of the Commission can make committee appointments prior to adjournment.

1.7 All standing committees shall report at the annual administrative meeting.

2. The Nominations Committee and the Finance Committee shall consist of a Chairperson and two additional members.

3. If the term of office of committee members is specified at the formation of that committee is to be more than one year, and a fraction of the membership is to be rotated each year, appropriate initial terms of office shall be made by the committee chairperson.

4. Ad Hoc Committees:

4.1 Ad Hoc Committees may be established by the Chairperson of the Commission, from time to time, as needed.

VIII FINANCIAL MANAGEMENT

1. The Commission shall be neither organized nor operated for profit.

2. Income shall be derived normally from fees and grants.

3. As recommended by the Finance Committee and approved by the Commission, the Commission may accrue and maintain an operating revolving fund.

4. Within the approved annual budget, the Chairperson or his or her delegate may employ professional staff to provide services and procure supplies necessary for the operation of the Commission.

XI CONTINUING CERTIFICATION

Procedures that may be developed by the Boards of Examiners, that may require demonstrated continued competence in clinical engineering or biomedical equipment technology are subject to Commission approval.

X CORRESPONDENCE

The Commission will use stationery that will prominently display the name of all current member organizations and special individual representatives, as well as the names of each examining board and their respective Chairpersons. The addresses of the Commission's Secretariat and the Secretariats for all Boards of Examiners shall also be displayed for return correspondence addressing and should be displayed accordingly. These addresses shall be listed in the capacity that they are charged, namely their positions as Secretariats.
XI DISSOLUTION

Upon the dissolution of the Commission or the winding up of its affairs, any accrued assets of the Commission shall be distributed exclusively to those organizations organized and operated exclusively for charitable, scientific, literary, or education purposes which qualify under the provisions of Section 501(c)(3) of the Internal Revenue Code and its Regulations, as they now exist or as they may hereafter be amended.

Date of Adoption ______________________________

Date of Amendments ______________________________
APPENDIX D

PROPOSED CERTIFICATION IN
HEALTH TECHNOLOGY MANAGEMENT
SUMMARY OF ACTIVITIES RE CERTIFICATION PROCESS DEVELOPMENT
FOR CERTIFIED HEALTHCARE TECHNOLOGY MANAGER (CHTM)
FEBRUARY 8, 1989

Task Force Committee:
Steven Friedman, MSEE, CCE
Chuck Jones, PE, CCE
Darrell Steltenpohl, CBET
Paul Svatak, CBET

After numerous meetings, telephone calls, discussions with other clinical engineering practitioners the consensus is that there is a defined need for a new certification process which addresses the issue of formal recognition of this type of manager. Approximately 80% of those polled were in favor of this process. What I am hearing and what, I believe, is going to be a major hurdle is the perception of many current CBET's and CCE's that after a person moves into a management position, their occupation is still an engineer or technician. In point of fact, the focus must change to the following:

"An engineer or technician is something that I did in my former occupation. I am now a manager with technical skills and my primary focus has changed to one of effectively controlling, delegating, managing, directing the activities of my department."

To make this certification process successful, the aspiring manager of a technical department must change and broaden their thinking both vertically (I am now a manager) and horizontally (I manage healthcare technology not just clinical medical devices). Its the old question about what business we are really in. To survive and make a significant impact on healthcare this must happen, especially in light of current healthcare trends.

To this end the following certification process was devised. Rather than permit grandfathering of selected persons into the program, we decided to create a 3 year "window of opportunity" which allows some relaxation of the final requirements for examination. For anyone to become certified they must conform to the prerequisites and sit for the examination.

TITLE: Certified Healthcare Technology Manager

PREREQUISITES: During 3 year window:

1. Certification (CBET or CCE)
   If not certified, must take Part I of examination.
2. Three years experience managing a clinical engineering service or department.
A quorum would be 50% of the total membership or 9 members. The Chair must not be a currently sitting member of either the CCE or CBET Boards.

RECERTIFICATION: The task force felt that, at the very outset, a recertification process should be part of the program. The consensus was that this should take the form of Continuing Education Units where 1 CEU = 10 contact hours via workshops, seminars, etc. This must be documented and a record of the activities sent to the CHTM Board for verification. The minimum requirement for recertification would be the acquisition of 5 CEU's every 24 calendar months beginning on the initial certification anniversary date and continuing for every subsequent 24 month period.
CLINICAL/HOSPITAL ENGINEERING TRAINING IN DEVELOPING COUNTRIES: PROBLEMS AND ISSUES

Prepared for the World Health Organization (WHO)
by
Yadin David, Ph.D., P.E.
Texas Children's Hospital
Houston, Texas

The efficacy of the health care delivery system is dependent to a large extent on the effective adoption and utilization of the various care-related technologies. However, the readiness level of medical equipment, for the delivering or supporting of health care procedures, is less than desirable in most of the developing countries. This should cause concern among policy decision makers and health care professionals as scarce resources may be wasted.

A statement was made in a report generated by the WHO Inter-regional Meeting on the Maintenance and Repair of Health Care Equipment [1] that, "In one South American country, it is estimated that the replacement value of medical equipment is $5 billion. Forty percent of this is not functioning, representing a loss of assets of $2 billion." Furthermore, it is stated that "About 20-40% of all existing equipment is not working because of the lack of installation, service, parts, and/or supplies." At the IEEE/EMBS (Engineering in Medicine and Biology Society) Annual International Conference R.S. Khandpur of India [2] suggests that, "various studies have indicated that about 40-60% of biomedical equipment in developing countries is non-operational due to inadequate maintenance services." R.P. Patterson reported [3] on their team's experience at a university hospital in Nicaragua. "Some of the obvious deficiencies were no working ventilators, no working ECG or blood pressure monitors, and no blood gas measurement capabilities. The repair technicians faced a lack of parts and of Spanish manuals for U.S. made equipment, and the lack of a medical understanding of the function and use of the equipment...".

While the problem is not new, recognition of its impact and furthermore a commitment to its solution will require a global cooperation. Each of the policy making and operation levels need to commit to develop and participate in a system where global, national, regional, and local resources are pooled together [4]. A commitment to develop a training program for the preparation of a skilled work force who will support most or all of the medical technologies is critical. The training programs will feed into technical service centers that will focus on the facilitation of continuous improvement in the efficacy level of the medical
technologies utilization. A number of the centers selected, will
concentrate on providing the training that will prepare and improve
the skilled work force.

Medical technologies may consist of a variety of diagnostic,
therapeutic, rehabilitative, and operation supporting types of
equipment. These include medical instrumentation, clinical
laboratory equipment, various imaging systems, computers, hospital
utilities and appliances [5]; and equipment that is integrated into
the daily delivery of health care and on which medicine comes to
depend upon. According to A. Issakov, of WHO, [6] the reason for
the ineffective management and maintenance of the health care
technologies is the lack of awareness, policy commitment, effective
infra-structure of health care technical service, manpower
development programs, and a comprehensive approach at a country
level.

There is, therefore, an obvious need to begin solving the
problem through training programs that will:

(1) increase the awareness of health care officials and
administrators to this waste;

(2) increase in the number of available, qualified managerial
as well as technical personnel [7];

(3) increase access to technical documentation and
replacement parts;

(4) develop the required guidelines and tools for the
initialization of comprehensive medical technology
management programs and promotion of their goals [8];

(5) demonstrate that the increased availability of capable
technical, and managerial personnel is reducing waste and
improving health care;

(6) promote recognition for technical expertise and
professionalism;

(7) provide for skill maintenance and continuing education
at all levels; and

(8) improve the country's productivity in the long term [9].

The first step toward solving the problem, and perhaps the
most significant change towards consistent and continuous
improvement in the medical equipment performance will be the
development of national policy on medical equipment management.
Such a policy should lead to the generation of information
regarding technology-specific manpower needs and thus define
training program goals as they relate to the needs of the medical
equipment management program [10]. The training program should be able to address the needs of each locality as hospitals vary in their technology volume and complexity. The director of Biomedical Engineering at Project HOPE recently stated [11] that "the problem is not only equipment, its use and maintenance, but also involves the recognition of the need to provide a work place, financial support, and an administrative structure for biomedical engineering from the hospital administration to the Ministry of Health." It is imperative that part of the national policy shall be devoted to and address the resources needed for development and implementation of comprehensive biomedical engineering training programs [12].

The establishment of training and continuing education programs will have a stronger impact if there are job opportunities recognizing the biomedical engineering personnel expertise, unique skills, and money to fund these jobs [13]. The specific training program's goals depend on the equipment inventory (number and type) planned to be served, needed workforce skills (number, levels, and type), available trainers and staff, facilities and budget, and the extent of the supporting structure committed to the program [14].

There are several good training centers already in existence. Their developed guidelines is described in a WHO report [15]. Global cooperation and pooling of resources can promote effective development and delivery of needed training programs, while maintaining the quality of the programs output. A useful example of a general program is provided by the West German high school system. Almost three-fourths of young Germans get classroom instruction in one of more than 400 trades, plus on-the-job experience. State government pays for classroom instruction, which comes to about a day per week, while employers pay wages. Such a job training partnership provides two to three years of training and employment at a craft with practical skill. This technical high school approach should provide the skill level of the manpower which will be placed at the entry technical level [16]. In the United States, several training programs begin at the high school level with a sequential choice of either a two or four year technical college curriculum intended to prepare technicians and technical supervisors [17]. Following a six month period of supervised internship at a hospital, the entry level person is ready to be tested and upon successful demonstration of improved skills, would be promoted into a Technician I job grade. Another route for entering the technical manpower pool is through training at a two to three year technical school. This post high school program can produce technologists with more advanced skills and capabilities. One such program's details appear in the Appendix and it is offered by the Texas State Technical Institute at Waco, Texas, USA [18].

The next technical training level is the four year undergraduate program at an engineering college or university where an academic degree with emphasis on Biomedical Engineering is
awarded [18]. Some continue further training obtaining a graduate
degree in the field. At the next education level that is offered
by the undergraduate program and the universities, in most of the
countries they are experiencing more of a conversion program than
a direct hospital or clinical engineering oriented curriculum [19].
In the conversion program, the electrical or mechanical engineering
programs produce graduates who take additional special training to
become hospital/clinical engineers [20]. Degrees conferred by the
university provide for more recognition and have an international
status. A lack of such is a problem that most technicians are
faced with. A demonstration of and a criteria for verification of
skills can be helpful. If this verification is furthermore
provided by an international body, it should help in reducing this
problem. All these programs are complemented by highly focused
short courses offered by the industry and university faculty.
While these programs are usually product or single technology
oriented, they are offered as a rapid, focused skill improvement.
There are several private training seminars that are industry
sponsored and are oriented towards equipment/model specific. These
are offered for period of between several days and several months.
They are usually used by industry to train their own field service
technicians, with hospital-based personnel, taking part in the
training as well.

Experiences with a wide spectrum of educational programs
outside and inside the Biomedical Engineering field is existing
globally [21]. In one approach to training of technically
competent biomedical engineering staff is to add interdisciplinary
training with an exposure to the clinical environment to existing
general curriculums. This can be achieved through hospital
internship and supervised on-the-job training [22].

Additional informal training programs are presently being
experimented with in the USA. They are of short duration (4-6
weeks), intended for foreign trainees and have focused objectives
(i.e., repair of imaging systems) and enjoy the ability to somewhat
screen the level of the students intake. Yet the author found that
the training is less than optimal due to the language barrier.
When training programs are transposed from one locality to another,
and the training program attempts to service more than one region,
then the training efficacy is deteriorating as linguistic
differences increases. This maybe one of the major obstacles to
the further development of quality training programs. The main
obstacle to wider diffusion of the training programs in general,
is the linguistic problem. There are nevertheless, success stories
of transferring a curriculum. One such example which was well
supervised under Project HOPE guidance, is the Texas State
Technical Institute in Texas, the curriculum of which was
transformed from the USA to Central America. Table I summarizes
possible resources available and product output expected of various
levels of training programs.
<table>
<thead>
<tr>
<th>Center Orientation</th>
<th>Academia</th>
<th>Industry</th>
<th>Hospital</th>
<th>Training Level</th>
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<tr>
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<tr>
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<td>Semi-Skilled/Tech I</td>
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Table I: Training Center Orientation

From discussions with several training directors who recently practiced in Central and South America, it was concluded that most of the local technical schools would rather add [23] some biomedical courses to their already established electronic instrumentation curriculum, than to develop an independent biomedical program curriculum [24]. The successful programs were those that involved academic institutions (i.e., technical schools, universities, or medical schools) with hospital-based programs for providing the practical internship. In the G.D.R. and in China, the medical school collaborated together with the hospital to conduct biomedical technician and biomedical engineering training programs. According to the Biomedical Engineering Director at Project HOPE, a training program improved medical equipment up-time on the average from 30-40% prior to the initiation of the training program, to an average of 95% over a 5-6 year period of training program existence.

From the entry level of semi-skilled individuals, to the mature biomedical engineer, (designer, researcher) and the professional manager, all of the training programs should include a component about professionalism, communication skills and the commitment to serve the society [25]. Every program should be reviewed monitored, its output measured, and adjusted as needed for strengthening its impact on the medical equipment readiness level [26].

The development of training staff in the areas of technical managers, engineers, technicians, operators, and users is to be included. Priority should be placed on strengthening national training capabilities, including the establishment of various levels of training centers to help in the development of a cadre of trainers/educators. These centers in turn will be training individuals in the basic and progressive skill and know-how levels. Few clinical engineering programs are presently providing "train
the trainer" internship programs at various U.S. hospitals. While it is too early to determine its usefulness [27], it already helped initiate international technical cooperation.

During the implementation of this program, analysis of the training needs is one of the most important phases. At any given country, or a given region, the difference between the desired work force skill level and the existing skill level is the target at which the training program is aiming. Once training needs are identified, a decision regarding which training methodology to utilize is made. Perhaps a combination of methods is to be used.

When the system is implemented or outcome evaluated, the importance of matching the student population traits to the training programs style cannot be over-emphasized. A good match will enhance the recruitment of and retention of quality future candidates as the graduates will serve as good will ambassadors for the program.

The best combination of training techniques is the one that teaches all the skills necessary at the lowest cost. The major requirement of the semi-skilled training program is to produce qualified task performers and the purpose for a technician program is to improve their performance level in repairing a device. Once acceptable task performance limits are established, we can tell when training has done its job; the technicians must perform these tasks within the prescribed standards.

A training manager must be able to differentiate between and respond to the individual needs. Once the proper need has been determined the decision of selecting between group or individualized training programs becomes apparent. Existing programs are the first place to check. In the technical world, if the training need is product specific or specialized in nature and a very small population is involved, formal training sessions are normally developed.

The flow chart (Figure 1) describing the step-by-step procedure to follow in developing a performance improvement cycle.

(Task Approach to Technical Training, September, 1982, Training Development Journal.)
Figure 1: The Performance Improvement Cycle

1. Need Detection → Task Identification → Collect Task Performance Data → Commission Developer → Pilot Test

   → Content Requirements
   → Task Performance Certification Requirements

2. Performance Improvement Materials

   → Certification Test
   → Retest

   - Passed Certification Test
   - Failed
   - Performance Improvement Program

3. Criterion Referenced Performance Certification Test

   → Commission Developer

   → Pilot Test

   → A
REFERENCES:


ADDITIONAL REFERENCES:


AINING ADDITIONAL REFERENCES:


Technical Education Research Centers, "Digest of Educational Programs: Biomedical Equipment Technology", Cambridge, Massachusetts, 74.

CONCLUSIONS

A POTPOURRI OF INSIGHTS FROM AUTHORS & SECONDARY CONSULTANTS

INCENTIVES

Question: Once you have identified and trained manpower, how do you keep qualified practitioners? Answer: Reasonable pay, reasonable work conditions, reasonable job growth opportunities. Different strategies make this answer work in situations where salaries are low - bonus system; revenue-sharing; structure work hours so that staff can work on their own time using program shop area and test equipment to do entrepreneurial work, i.e., repair of consumer electronics.

VERIFYING PROGRESS BETWEEN LEVELS

The authors recognize, along with the ICC, that existing certification examinations must be made culturally relevant to each country desiring participation in the ICC. Interested parties should contact William Betts, ICC Chairman. His address is the following: Biomedical Engineering, University Medical Center, 1501 N. Campbell Avenue, Tucson, Arizona, USA, 85724, Telephone - (602) 694-6124.

TRAINING

- It is typically better to train existing personnel in a given situation. Before training new personnel, one should seek to ensure that their positions are economically viable.

- The ideal way to choose "trainers" - who will later train others in their own country - to be trained by outside experts is to provide a six-week on-site (host country) course to trainer candidates. Then the host country MOH and the outside consultants can best choose good "trainers".

- An important way to judge progress of Technicians I, II, and III within their levels is by answering these key questions:

  (1) How long does it take to troubleshoot and fix their assigned equipment?
  (2) How many recalls (same equipment returned quickly for repair) are there as a percentage of work done?

- Seek collaborative relationships between many trainers and training centers to give best coverage to WHO regions, i.e., between WHO, PAHO, ICC, PADF, Project HOPE, U.S. NIH, etc.
MANPOWER REQUIREMENTS

- What are possible reference points for determining required manpower levels?
  1. average annual service hours - allows determination of needed FTE's;
  2. current annual service costs - too many variables make this an unreliable indicator;
  3. hospital bed size - too many other variables make this an unreliable indicator; and
  4. equipment initial value or replacement value - an aggregate for all kinds of medical devices of 5% of initial or replacement value may be used as an indicator of annual service costs; of this 5%, typically 60% will be for labor costs and 40% for parts costs.

TREND TOWARD NATIONAL LEGAL REQUIREMENTS FOR CLINICAL ENGINEERING DEPARTMENTS

East Germany and Japan have enacted laws which call for qualified health care equipment professionals to be on staff of hospitals before certain clinical services can be offered. Japan made this change this year after an older law, which required extended warranties by manufacturers of medical devices (six years), led to unacceptable response times and equipment down times. The new in-house responsibilities called for will significantly decrease response time to equipment problems in technology-intensive hospitals.

VARIABILITY OF ELEMENTS IN THIS MODEL

The spirit with which this model was written was that each country or region should review the model and adapt it appropriately to their culture. Each culture will have their own "substantial equivalencies" for educational requirements, job descriptions, training equivalencies, etc.

DEVELOPMENT OF INTERNATIONAL NETWORKS VIA TECHNICAL REFERENCE/COLLABORATION CENTERS

We believe, along with Dr. Wang of Brazil, that the development of these centers is crucial. WHO should joint venture with entities in each WHO region to provide centers which will collect technical information and documentation on medical devices as well as providing fast access to spare parts. This will take a collaboration between international medical device manufacturers, governments, and non-profit centers that WHO and its affiliated global contacts must encourage. The focus of the centers should be on developing countries only.
MARKETING TO HEALTH CARE LEADERS

It will take significant effort to market the benefits of medical device technology management to health care leaders, including the spectrum from hospital administrators up through and including a country's Minister of Health. Existing problems now include:

- lack of awareness by leaders
- lack of equipment management skills by leaders
- leaders very individualistic with respect to medical device selection.

PHILOSOPHICAL OBSTACLES (to Manpower Development and Training)

- Rapid changes in government structure, policies, etc., leads to a requirement for an "anchoring point" within a country or region which will not change as political structures change. The "anchor" will allow an HCTS infrastructure once put in place, to remain viable. Three models which currently exist as anchors include:

  (1) University-based system
  (2) Hospital system - based
  (3) National Professional Society - based

- A related issue is the finding of a "champion" in each country, perhaps better known as the key equipment advisor to the MOH. These people are needed "to make the whole program work."

- The financing utilized to purchase equipment in developing countries often leads to an ill-conceived technology management environment. For example, loans which bring in poor or overpriced equipment, without suitable consumables/accessories and without spare parts.

- Differing expectations in countries concerning the technology of equipment versus the "psychology" of equipment repair. For example, countries are faced with donors (i.e., foundations, foreign aid) who give out of a "public relations" philosophy and not a "needs-based" philosophy. This leads to donations for new equipment, but not for repair resources for existing equipment.

OUR COMMITMENT TO CHANGE

The primary authors wish to demonstrate our commitment to further development of the World Health Organization's Global Action Plan and to good-will through the submission of this voluntary and unpaid effort.
Annex 9

Bibliography of Background Papers


2. Malloupas A., Background document - WHO Programme for Support to Countries in the Field of Maintenance and Repair of Hospital and Medical Equipment, SHS/86.5, WHO, Geneva


14. Initial Concept on Train the Trainers Programme, (Draft), 1988, AAMI-ACCE-ICC, Marietta, USA

15. Hospital Engineering in Developing Countries, GTZ Symposium, Glessen, FR Germany, 6-16 November 1983, GTZ, Eschborn, FR Germany

16. Regional Training Centre Prospectus on the Repair and Maintenance of Hospital and Medical Equipment, Higher Technical Institute, Nicosia, Cyprus
17. Les Formation Internationales à la Maintenance Technique Hospitalière, Département de Genie Hospitalier, Institut International Supérieur de Formation des Cadres de Santé, Hospices Civils de Lyon, Lyon, France

18. Cycle de Specialisation des Ingenieurs Biomedicaux et Hospitaliers, Université de Technologie de Compiègne, Compiègne, France

19. Diploma Course in Medical Electronics and Medical Equipment Management, the Medical College of St. Bartholomew's Hospital, London, UK


21. Information on Training Course in Maintenance Engineering for Medical Equipment, 1989-90, Japan International Cooperation Agency, Japan

22. Biomedical Equipment Technology/Biomedical Equipment Technology Curriculum 1989-90/Industrial Cooperative Education, Texas State Technical Institute, Waco, USA

23. Technical Education, Houston Community College System, Houston, USA

24. Biomedical Instrumentation Technology, College of Health Related Professions, University of Arkansas for Medical Sciences, Little Rock, USA

25. Engineering Training Centre, Veterans Administration Medical College, North Little Rock, USA

26. Graduate Programmes in Biomedical Engineering at Harvard University and the Massachusetts Institute of Technology, Cambridge, USA

27. Technical Service Training/ Technical Training for Customer Personnel, Training Centre, Medical Division, Siemens, Erlangen, FR Germany

28. Information on Training Service Experts for Medical Technology, Medicor Training Centre, Medicor, Budapest, Hungary

29. The Importance of Biomedical Engineering Education/Project Hope Biomedical Engineering Programme/Project Hope Biomedical Engineering Maintenance and Repair Centre in Shanghai, Project Hope, Millwood, USA

30. Curriculum of Biomedical Technicians Training Programme, Health Manpower Institute, Ministry of Health, Sana'a, Yemen Arab Republic

31. Medical Training College Syllabus for Medical Engineering Technician Course, Hospital Maintenance Training School, Ministry of Health, Nairobi, Kenya


33. G. Slack, J. McKinney III, Training Manual for Biomedical Equipment Technicians, Clinical Engineering Section, American Society for Hospital Engineering of the American Hospital Association

34. Announcing the Clinical Engineering Monograph Series, Clinical Engineering Division, International Federation of Medical and Biological Engineering, 1986

36. R. Scott, Education and Certification of Biomedical Engineers in Canada, Journal of Medical Engineering and Technology, vol. 3, No. 4, July 1979

37. B. Brown, Training for Biomedical Engineering in India, Journal of Medical Engineering and Technology, vol. 3, No. 4, July 1979


39. S. Hughes, Biomedical Engineering Training in Dundee, Engineering in Medicine, vol. 12, No. 3 1983

40. V. Wright, D. Dowson, Education in Bioengineering: Experience at the University of Leeds, Engineering in Medicine, vol. 12, No. 3, 1983

41. A. Unsworth, Bioengineering at Durham University, Engineering in Medicine, vol. 12, No. 3, 1983

42. J. Paul, The Masters Degree in Bioengineering at the University of Strathclyde, Engineering in Medicine, vol. 12, No. 3, 1983

43. B. Pullan, J. Chapman, A. Williams, C. Taylor, D. Hukins, H. Sharma, Medical Biophysics in Manchester, Engineering in Medicine, vol. 12, No. 3, 1983

44. C. Gentle, Biomedical Engineering at Trent Polytechnic, Engineering in Medicine, vol. 12, No. 3, 1983

45. R. Bosma, Biomedical Engineering at the University of Technology Twente, Enschede, The Netherlands, Engineering in Medicine, vol. 12, No. 4, 1983

46. P. Farrell, W. Flicker, N. Svensson, Biomedical Engineering Training and Research at the Centre for Biomedical Engineering, University of New South Wales, Kensington, Australia, Engineering in Medicine, vol. 12, No. 4, 1983

47. T. Sasada, Education in the Field of Biomedical Engineering for Japanese Engineering Students, Engineering in Medicine, vol. 12, No. 4, 1983

48. M. Shaffer, J. Kuhn, C. Coakley, Clinical Engineering Education in the High Technology Hospital, Medical Instrumentation, vol. 18, No. 5, September-October 1984


50. H. Ranu, Biomedical Engineering at the Louisiana Technical University, Engineering in Medicine, vol. 14, No. 3, 1985


57. New Concept in Medical Equipment User Training, Health Technology Trends, August 1989