

Part Two:

Basic Maintenance and Management of Medical Equipment

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Introduction

Medical equipment management is generally focused on how engineers and technicians deal with repair work and its development. However, many failure cases, called breakdowns, are caused by inadequate maintenance as described in Part 1. This indicates that the capability to manage medical equipment remains rather weak as follows:

- Equipment utilisation and the deterioration of consumable components including accessories are not being monitored through regular inspection;
- The deteriorated consumable components are not being replaced on a regular or appropriate basis;
- Material management that estimates necessary kinds and quantities of consumable components, and carries out procurement, inventory control and supply for these is not being done properly.

From the above discussion, it should be evident that the focus should not only apply to repair systems and abilities, but also to personnel involved in management systems of equipment and materials, and those in technical and general administration. Maintenance and management skills are, therefore, given a priority in training the engineer and technician. In addition, it is necessary to disseminate and enlighten on maintenance, safety and reliability management to doctors, maintenance managers, hospital administrators, MoH administrators, etc ^{Note 2.1}. During the first stage of technical co-operation, the importance of the above-mentioned factors must be made clear to the top management.

The comprehensive MMS is composed of three essential elements as illustrated in Figure 2.1, i.e. Life Cycle Management, Maintenance Cycle Management and Spare Parts Cycle Management. The meanings of these are as follows:

The first is the Life Cycle Management of medical equipment that begins with a process of acquisition planning, and continues into installation, acceptance testing, usage, monitoring/maintenance and decommissioning. The lifespan of medical equipment is generally set between five and seven years. This is based on depreciation, safety, reliability, clinical application, budget, etc. However, in developing countries the purchase load of new equipment is a heavy financial burden. On the other hand, continuous use of old equipment requires maintaining the standard of reliability and safety. The life cycle approach is to monitor the operating

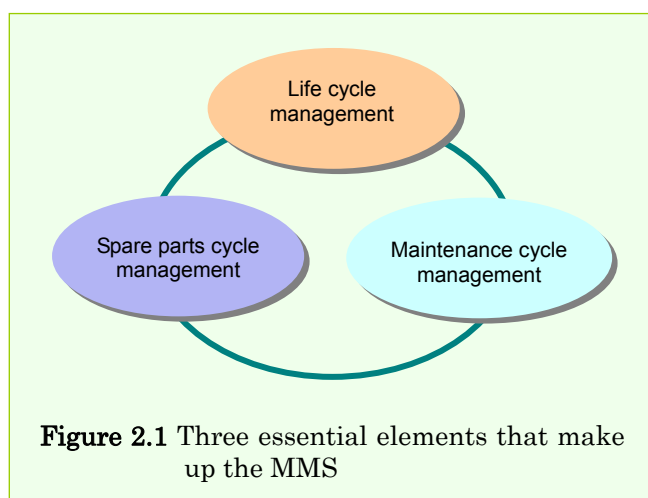


Figure 2.1 Three essential elements that make up the MMS

conditions of equipment related to life, operation, inspection, repair, training, record, etc. in order to achieve successful long-term management of medical equipment.

The second essential element is the Maintenance Cycle Management that manages the reliability and safety of medical equipment through maintenance and inspection. Use of unsafe and unreliable equipment can cause fatal medical accidents. The medical equipment has a vital role to take care of the life of the patient, directly or indirectly. Carrying out regular inspection is, therefore, essential to maintain the following conditions:

- To prevent breakdowns;
- To maintain accurate and hazard-free functioning of equipment;
- To attain the expected lifespan of equipment;
- To maintain and manage equipment rationally and economically.

This scenario is similar to clinical patient management. For example, in the hospital, an individual patient is identified, and then the history of treatment, doses of medicine and examination data are recorded and managed. In the field of medical equipment, individual equipment should be identified, and the history of inspection, repair and measured data should be recorded and managed.

The third element is the management of spare parts, called Spare Parts Cycle Management or Spare Parts Control. As mentioned in Figure 1.10 in Part 1, 60% of all failure cases are caused by deterioration of consumable components including accessories. This deterioration can be predicted, and the designated lifespan of general consumable components is mentioned in manufacturer's instruction manual. If the time and frequency of equipment usage is analysed, then questions such as what, when and how many consumable components are required can be predicted. Estimation on procurement, stock and use of the consumable components should be done every fiscal year so that the expected lifespan of equipment can be accomplished whilst maintaining its safety and reliability.

The above-mentioned three elements are a precondition of sustainable management of medical equipment under MMS. Here, we refer to these three elements as 'Three Cycle Management'. Three Cycle Management should be carried out simultaneously, and should be managed in collaboration with specialist management sections and all stakeholders, because the MMS adopts an integrated and multidisciplinary approach that takes into consideration the clinical, technical, economic, logistical and organisational aspects. In addition, the record of all activities should be made. Based on these statistics, an analysis should be done to evaluate equipment management.

2.1 Life Cycle Management

The life cycle management approach is a key strategy to proper and comprehensive management of medical equipment. This approach to equipment management is a continuous process that begins with:

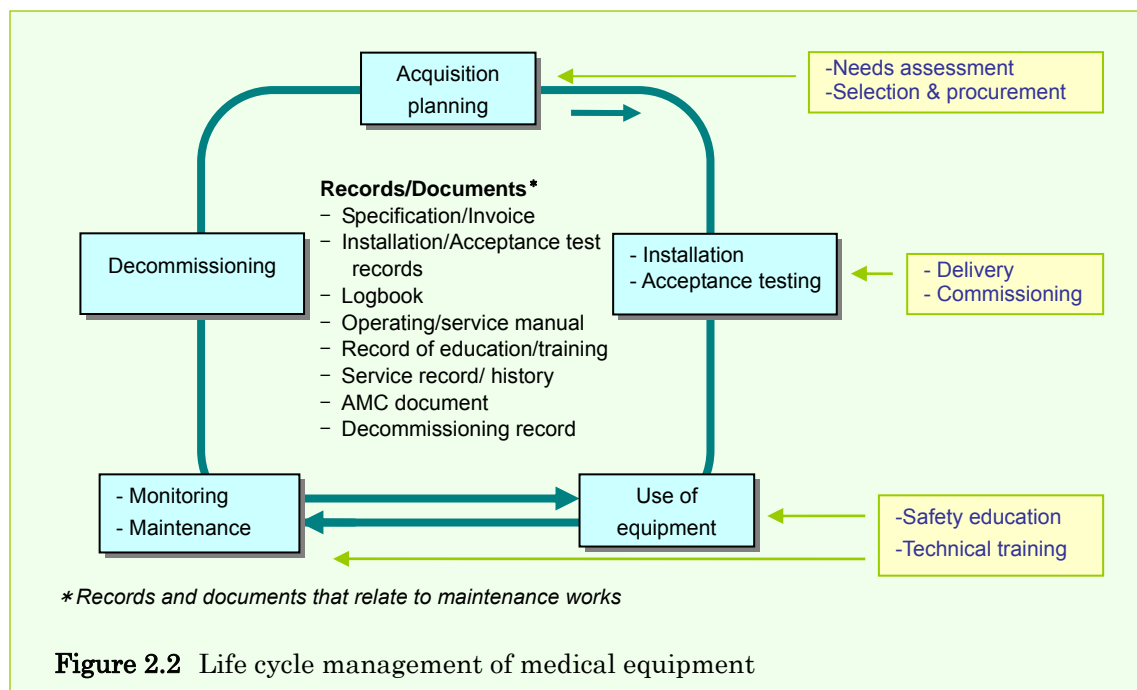
- Acquisition planning;
- Selection and procurement;
- Delivery, installation and commissioning;
- Use of equipment;
- Maintenance and monitoring;
- Decommissioning.

The Life Cycle Management of medical equipment that follows these processes is illustrated in Figure 2.2. Ideally, the ME section should be involved in the entire process, i.e. from acquisition planning through decommissioning. In the absence of the ME section, the responsible section and the person in charge of equipment management must be familiar with all these cycles ^{Note 2.2}. In this case, the personnel who have the knowledge and management ability in medical equipment are appropriate even though the person in charge may not be an ME engineer.

In general, attention is focused only on the equipment operating phase, and consideration to the entire life cycle management is insufficient. This phenomenon is especially seen for donated equipment. Therefore, the ME section should contribute to the safety and reliability of the clinical service by relating to the life cycle management of all the medical equipment even if the provision of equipment is separate.

In the Sanjay Gandih Post-graduate Institute of Medical Sciences (SGPGIMS) for example, life cycle management has been introduced. Appendix-1 shows guidelines for life cycle management in this institute. The management processes from selection/procurement, installation, use and maintenance/monitoring up to decommissioning (except acquisition planning) are covered, and it may become a reference for other health facilities.

In Bach Mai General Hospital, Vietnam for example, the ME section has been attempting the implementation and performing of the life cycle management in co-operation with the



‘Medical Equipment Management Committee (MEMC)’ headed by the hospital director. The ME section of this hospital has also been trying a nation-wide dissemination of the life cycle management jointly with the Ministry of Health. In this case, different stakeholders are involved from the acquisition plan to the decommissioning stage. In such a situation, one of the issues was how to establish better co-operation amongst them (as of 2002).

From the standpoint of the ME section, the significance of the aspects on the life cycle management is described in section 2.2. Full details of the life cycle management are given below:

2.1.1 Acquisition Planning

It is essential to develop an acquisition plan in order to promote rational equipment acquisition and sustainable utilisation of equipment. In most countries, standardised procurement procedures for general materials and equipment are already developed; however, establishment of a reasonable system for procurement of medical equipment is rarely done. For instance, the section head or the hospital director and supplier often go ahead with selection and procurement of medical equipment in the absence of a contribution of the ME section. The fact is that the importance of the ME section - its evaluation and trust - are not recognised ^{Note 2.3)}.

The acquisition planning process should be consultative and participatory, and should involve all stakeholders and the MEMC of the health facility. In addition, the acquisition plan must consider the finances and human resources involved to sustain proper utilisation and maintenance of the medical equipment. In the planning process, necessary medical equipment and hospital laboratory equipment for clinical application are carefully discussed regarding needs, purpose, specification, performance, safety, price, benefit to patient, etc. The plan is supported by feasibility studies, capacity assessment, appraisal of physical/environmental requirements, life cycle cost and cost-benefit analysis.

The decision-making process should be informed by various assessments as follows:

- Needs assessment for clinical application;
- Availability of qualified users;
- Availability of maintenance services and support;
- Availability of consumables and spare parts;
- Environmental conditions for operation;
- Approved reassurance of recurrent operating budget source.

Decision-making for medical equipment acquisition is conducted to promote a transparent and rational decision making process. This is done by the recognised authority at the different levels of the health system.

Procurement of medical equipment should be considered so as to assure the proper purchase of appropriate medical equipment and its sustainable use. The procurement is carried out according to the existing Government Rules and Regulations. Purchase orders for all medical equipment should include the following conditions for equipment distributors/suppliers:

- Adequate training for end-users;
- Adequate training for maintenance engineers/technicians;
- First supply or stock of consumables;
- Supply or stock of spare parts;
- Availability of accessories;
- Instruction/operating manual that contains consumables list with ordering code;
- Service Manual that contains schematic diagram and spare parts list with ordering code;
- Availability of contracted-out maintenance service.

It must be remembered that the fate of equipment over its life cycle will be decided in the acquisition planning phase.

2.1.2 Installation and Acceptance Testing

Newly acquired medical equipment is installed after arrival at the hospital. There is almost no problem with installation carried out by manufacturer's engineers, but the installation carried out by local engineers often leaves problems. Some local engineers unpack the equipment, switch on its power, and confirm its rough function only. At this stage, they assume the installation is completed. They neither adequately explain how to operate and handle equipment nor submit an installation report to the user.

Installation means:

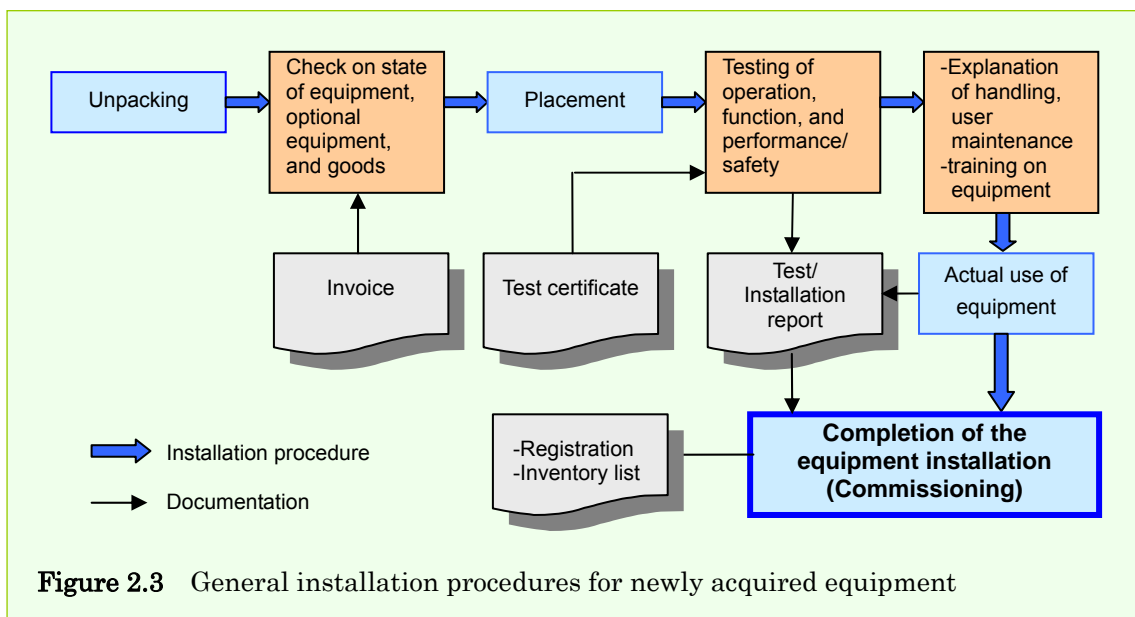
- Carrying out the performance and safety inspection based on the manufacturer's standard for the particular model;
- Recording parameter data of the above;
- Adequately explaining to the user about proper equipment handling;
- Demonstrating application of the equipment according to the user's request;
- Submitting a comprehensive installation report according to the above.

Suppliers should take responsibility until equipment is put to actual use. These procedures are illustrated in Figure 2.3. A representative of the ME section should participate in all installation processes as far as possible.

For general medical equipment (not specific and sophisticated equipment such as CT, MRI, X-ray equipment. etc.), the ME section should carry out the acceptance testing according to the requirement of the particular model (refer to Appendix-2). The acceptance test confirms whether the new equipment fulfils its performance and safety requirements. This test starts from inspection of the mains plug, equipment protection, enclosures, insulation resistance and leakage currents.

Recently, various types of medical equipment made by countries that have newly entered the medical equipment market have been appearing in the market ^{Note 2.4)}. This medical equipment is supposed to satisfy the specifications, performance and safety in accordance with international standards, but some of this equipment fails to fulfil it. In addition, the problem of second-hand medical equipment provided by NGOs was pointed out recently ^{Note 2.5)}.

Acceptance or rejection of medical equipment would depend on the recommendation of the supervising doctor in charge of equipment. When the new equipment is introduced, the decision to accept or reject should be from the viewpoints of both the clinical and technical sides.



2.1.3 Commissioning

After completion of equipment installation, the commissioning of the new medical equipment should be performed in order to hand it over from the supplier to the user. After this, the equipment will be entered into inventory management as well as for registration. In case of donated medical equipment, however, the commissioning or registration is mostly carried out by the donor in the absence of the ME section. In addition, such information on equipment often shows only the name of the equipment, manufacturer and model number. The information on equipment made by the hospital is similar to this. In such a case, when two or more items of equipment of the same model are introduced, individual equipment is difficult to identify. As a result, the equipment management faces the following difficulties:

- It is difficult to identify where each piece of equipment is put in use;
- It is, therefore, difficult to capture utilisation for each equipment item;
- The attention of the user is focused only on the equipment operating phase. As a result, an integrated equipment management system based on life cycle approach is difficult to implement.

The above-mentioned issues are usually not taken into consideration though it is a big problem in medical equipment management. This is the reason why it is necessary to register equipment to solve the problem of this reality after the equipment is put to use. The registration of equipment in detail will be described in paragraph 2.2.1.

2.1.4 Use of Equipment at Clinical Site

Equipment operators have a role of understanding the purpose of their equipment. Keeping equipment in good condition and handling it appropriately will contribute to safety, accurate diagnosis and therapy. However, training for safety and correct use of equipment conducted by clinical sections is not often seen.

In addition, due to an insufficient installation process, operating skills are not transferred from the installation team to the equipment operator as mentioned in paragraph 2.1.2. Since the equipment is operated in such a condition, accuracy of the results is not obtained. In such cases, the blame is placed on lack of performance or malfunction of the equipment. Such a problem should be dealt with by the ME section. This is an important activity in order to disseminate correct knowledge and information on operating principle, application, structure and operating sequence of the equipment. In accordance with circumstances, it is necessary to get consent from the site management in conjunction with a doctor who is familiar with medical equipment.

It is useful for individual equipment to have a logbook where useful information such as number of patients, equipment load, and dates of inspections carried out will be entered. The logbook becomes an important reference when decommissioning the equipment. It is only necessary to keep a record of laboratory equipment and other important equipment in clinical use.

The section head should always understand the overall utilisation and operation of equipment and regularly submit reports to the hospital authority. Copies of the reports should be sent to the ME section who, upon analysing the report technically, will immediately attend to any faults.

2.1.5 Safety Education and Training on Operation and Maintenance

For safe use of medical equipment, it is necessary to pay attention to patients, operators and surroundings. Table 2.1 shows areas of safety to which attention should be paid in the hospital. Safety should be noted in operating and applying the medical equipment at all times.

In general, attention is paid to immediate threats such as electrical shock, power failure, biohazard, radiation hazard, etc. which are well recognised, but in some cases little or no attention is paid to indirect threats such as excessive energy, mis-information, accurate temperature, lighting density, etc. For instance, radiation therapy equipment was going to be introduced in cases where doses

Table 2.1 Safety to which attention should be paid in the hospital

Category	Main factors threatening safety
Electrical Safety	Electrical shock, Excessive energy, Interference between equipment and the other equipment, Power failure, Misinformation, etc.
Mechanical Safety	Dropping, Pressure, Sharp edge, Loose piping joint, Broken tube, Excessive concentration of ultrasonic wave, Blood leakage, etc.
Chemical Safety	Misuse of medical gases and drugs, Too small quantity or too much quantity, Corrosion of instruments, Characteristics change of materials, Abnormal temperature, Concentration of heat, explosion, etc.
Thermal Safety	Unstable temperature, Abnormal low temperature/high temperature, Concentration of heat, Explosion, etc.
Radioactive Safety	Radiation leakage, Excessive energy irradiation, Excessive concentration, Long period half-life effect, Surface strength, Radioactive waste, Irradiation to radiation workers and surroundings, etc.
Optical Safety	Insufficient optical energy, Out of object and leakage by inflection or reflection, Ultraviolet, etc.
Biological Safety	Bio-infection by insufficient isolation system, Contamination of thrombosis, Physical reaction, etc.

of radiation could not be calculated in a certain hospital. In another example, a repairperson tried to look into the UV-lamp directly with the naked eye while working on a spectrophotometer.

These instances illustrate that overall safety consideration is generally not so high. Therefore, the safety education and training of the equipment operator and the staff of the ME section for each item as shown in Table 2.1 is very important (see also Photo 2.1).



Photo 2.1 Protection from safety hazard: A medical technician wearing a mask and gloves repairs a mercury BP machine (Biomedical Engineering Department, University Teaching Hospital, Zambia).

On the other hand, a comparatively large number of breakdowns of medical equipment are due to inappropriate handling as mentioned in Figure 1.10 (Part 1). This not only gives rise to a substantial financial loss but also contributes to other risks. Mishandling of equipment threatens the safety of operators, patients and surroundings; moreover, it may also cause misdiagnosis due to inaccurate results. Training in the proper operation and user maintenance for the equipment operators should be conducted so that medical equipment may function safely.

In Zambia for example, training in operation and maintenance of medical equipment for midwives is implemented as a part of the postgraduate training course (Photo 2.2). This is a four-day training undertaken by the Biomedical Engineering Department (BMED) of the University Teaching Hospital (UTH). During training, BMED provides the basic knowledge on operation and maintenance of medical equipment.



Photo 2.2 A four-day training course on the operation and maintenance of medical equipment for midwives undertaken by BMED, University Teaching Hospital, Zambia (March, 2005)

In Cambodia, NMCHC (as the highest referral hospital) runs midwifery training. During this training, there is a training component on the operation and maintenance of medical equipment, which incorporates the ME section. The ME section of NMCHC is the only centre that functions systematically in Cambodia in the field of MMS (as of 2003). Based on the technical know-how of the ME section, the National Medical Engineering Workshop (NMEW) was set up under MoH. Supervision in provincial hospitals is carried out by NMEW as part of its activities (Photo 2.3).



Photo 2.3 An activity of NMEW at Kompong Thom Referral Hospital, Cambodia: Two members of NMEW instruct the equipment operators how to operate and maintain an oxygen concentrator (December, 2002).

Training on specific maintenance and inspection as well as safety education to the staff of the ME section is essential. Appendix-3 presents a sample curriculum course for the general technician involved in the maintenance of health facilities and equipment at the district hospital level in developing countries, as recommended by WHO.

In Lao P.D.R. for example, the Medical Equipment Service Centre (MES) under the Ministry of Public Health (MoPH) exists. MES is a central point of the medical equipment maintenance in Laos and cooperates with ME sections existing in some major hospitals. MES has been carrying out the technical service for medical equipment in hospitals located in the capital, Vientiane, as well as rural hospitals. MES also conducts training for engineers and technicians who work in these hospitals as part of their responsibilities (Photo 2.4). This activity is supported and funded by ADB as of 2004.

A programme centering on repair of equipment was conducted at one time in Japan. The content of this training tended to focus on troubleshooting electric and electronic circuits. This is necessary for repair skills for maintaining the medical equipment. However, the engineers and technicians who received such training often created difficult problems when repairing clinical laboratory equipment.



Photo 2.4 Opening ceremony for a two-month training course on medical equipment maintenance held in September 2004 at MES training room, Laos: This was the third training, and it targeted 12 engineers and technicians from 8 northern provinces.

The reason being that consideration was made only to defective electric and electronic circuits of the equipment without considering biochemical and analytical methods. Most defects of clinical laboratory equipment (analytical instruments) are caused by preparation of reagent and samples, improper handling processes, and dirt in the detection area. In such a situation, trying to attempt a repair of electric/electronic circuits may lead to another defect, resulting in a failure which cannot be rectified.

Medical equipment technology is a combination of medical science and engineering science. Troubleshooting of the electric and electronic circuits is not given priority in the training of MMS. Even if training in medical equipment technology is conducted for ten years, the effect is not achieved if that person does not combine the two science disciplines. The consequences of training in medical equipment technology, as mentioned here, are to understand from the operating principles, application and structure of the equipment in order to practice the ‘three cycle management’ that this book describes.

2.1.6 Maintenance and Monitoring

Maintenance and inspections are essential for continuous and safe use of medical equipment ^{Note 2.6}. The basis of maintenance and inspection is the user’s maintenance, and this is carried out by equipment operators. The maintenance and inspection that should be carried out by the operators is always described in the operating manual. In accordance with this, the basic performance and safety can be maintained. In general, the maintenance and inspection carried out by the operators do not require special tools, measuring instruments or specific techniques.

Specific maintenance and inspection carried out by the ME section or contracted-out service are required in order to ensure further safety and reliability of medical equipment. Most technicians of the ME section, however, generally have problems carrying out this task due to lack of knowledge of the medical science, and are inclined toward electric and electronic equipment while they belong to the ME section. On the other hand, the problem is that the hospital establishes the ME section with staff whose level of ability is in the repair of home appliances. As a result, the working condition of medical equipment is determined by either ‘functioning’ or ‘not functioning’ in the range of the repair technique they are familiar with. The concept of maintaining safety and reliability through regular inspection is overlooked. Even if a repair technician completed the repair of an anaesthesia apparatus for example, he is not able to evaluate its reliability and safety.

NMCHC established a maintenance group comprising two anaesthetic nurses and an anaesthetic doctor to address the above-mentioned problem. They continued making efforts to monitor the safety and reliability of medical equipment and surgical facilities in the operating theatre. As a result of these daily inspections, problems were solved by working together with the ME section and Facility Maintenance Section ^{Note 2.7}. The person in charge of the medical equipment service of the ME section,

who was inclined to the exclusive use of electronic equipment, was replaced by a former anaesthetic nurse who was interested in medical equipment technology, and has a clinical background. This resulted in the service of both maintenance and management technology improving, and the hospital has recognised the services of the ME section by upgrading its status to become one of the hospital management sections ^{Note 2.8)}.

Equipment breakdown hardly occurs if maintenance and monitoring are performed. Simple repairs such as power plug replacement can prevent 'breakdowns'. Accidental breakdown of a complex electronic circuit may still occur. However, when the fault is beyond the repair capability of the engineer or technician, a decision should be made for the repair to be contracted-out. Attempts to repair beyond the engineer's or technician's ability may result in further damage to a point where even the engineer from the manufacturer cannot restore the faulty equipment. At this point, it is important to make a detailed report of the attempted repair. This report can be used for discussion with maintenance and repair specialists of the equipment manufacturer or agency. A logical conclusion of the repair technique can be learnt and can be used as a guide for further improvement of the repair technique.

Maintenance/monitoring from a technical viewpoint will be described in paragraph 2.2.5.

2.1.7 Annual Maintenance Contract

For large-scale precision equipment (e.g. CT, MRI, and X-ray equipment) and clinical laboratory equipment (e.g. CD4 counter and haematology analyser), the control of their accuracy, performance and safety cannot be done through maintenance by operators and the ME section alone.

To resolve this issue, the annual maintenance contracts (AMCs) or spot maintenance contracts that the equipment manufacturer or agency offers are required. In some cases, AMCs or spot contracts are needed even for general medical equipment to ensure performance, safety and reliability.

AMCs have the following examples of contracts:

- Complete maintenance including repair in accordance with manufacturer's technical standard: includes small amount of consumables free of charge, but the customer must bear the cost of expensive consumables;
- Performing functional inspection, and maintaining performance and safety by regular visits: includes small amount of consumables free of charge, but the customer must bear the cost of expensive consumables; on call repair service is charged;
- Maintenance execution of content based on mutual agreement with customer by regular visits: customer bears the cost of all consumables; on-call repair service is charged.

Selection of conditions to achieve maximum effectiveness by the least cost is, however, very difficult. In addition, cases where maintenance and inspection are properly carried out by agency are rarely fulfilled in accordance with contract terms. The hospital authorities often assume and hope for the following: 'the contracted-out equipment does not break down, and accomplishes its lifespan without any defects since AMC or contracted-out service is in place.' It is unfortunately rare that this expectation is realised. It is for this reason that the hospital should at least monitor the state of the equipment.

The following points are important for monitoring AMCs:

- Compare and confirm between contents of contractual coverage and actual work done;
- The technical person from the hospital should witness the contractual work by the agency;
- Request a report of the functional state of the equipment and insist on submission of its test certificate.

2.1.8 Decommissioning

There are few developing countries where a standard decommissioning system and its operational

procedures have been established. Moreover, in these few countries, even with the establishment of a 'Decommissioning Committee (or Condemnation Board)', execution by reasonable means is rarely done. This is because when medical equipment is delivered free of charge such as through grant aid and technical cooperation, the concept of depreciation is not so high. In addition, the procedures for decommissioning are difficult due to technical problems with evaluation of safety and performance parameters. It is necessary that all stakeholders should agree during decommissioning of medical equipment, and the responsible ministry should be informed accordingly.

In general, the following elements are considered as criteria for decommissioning:

- The procurement budget;
- The depreciation in income from present equipment;
- The clinical loss of need for the equipment;
- Procurement and stocking possibility of spare parts: After discontinuing manufacturing of equipment, the equipment manufacturer has a responsibility to stock spare parts for eight years. However, the procurement of spare parts for old equipment is usually difficult;
- Reliability and safety of the equipment: The equipment is clinically unsafe.

From the above-mentioned criteria, the decommissioning committee in the hospital is generally composed of an ME section representative, a clinical section representative, an accounting section representative and an administrative section representative, including the presence of the hospital director as the head of committee.

Appendix-1 shows the format of an equipment decommissioning report being used in SGPGIMS that is filled in by the ward or station concerned, the administrative section and the ME section. This report is submitted to the decommissioning committee for discussion and approval.

2.1.9 Record, Inventory and Documentation

In life cycle management, all the processes of the procurement plan, installation, registration, acceptance test, technical service, decommissioning, etc. should be recorded and preserved to monitor and manage the utilisation of medical equipment. The technical service report is one of the daily activities among these records. This is used for recording the contents of service when installation, repair, maintenance and inspection, etc. are carried out. Appendix-4 is an example of the service report being used in NMCHC. Implementation guidelines for maintenance of this report have been approved by the hospital steering committee (see Appendix-5).

The records of registration and technical service will be used for the medical equipment inventory management system. This system assures consolidated, timely, consistent and accurate information on medical equipment. Inventory entries should include optional equipment, accessories, spare parts, operating manuals and manufacturers/local agencies. Based on these records and documents, a medical equipment inventory and documentation system is developed.

Such systems provide information to support different aspects of medical equipment management. The management system for medical equipment adopts an integrated and multidisciplinary approach that considers the clinical, economic, technical, logistical and organisational aspects. The approach entails the active participation of all stakeholders in all aspects of the management process to ensure a holistic and coordinated approach. Therefore, it is necessary to set the inventory with documentation so that each department and all relevant personnel are able to understand the status of the equipment.

The usefulness of some aspects will be further expanded under sections 2.2 and 2.3.

2.1.10 Disseminating the Concept of Life Cycle Management

To maintain and manage medical equipment, the life cycle approach is a key strategy. This is applicable

at both national and hospital levels. As described at the beginning of this part, sensitisation of top hospital management and MoH officials regarding the MMS, including life cycle management, is essential. This is because the smooth operation of MMS depends on MMS involvement in activities which concern introduction of equipment and its utilisation across the healthcare system.

One of the best methods to effectively establish and disseminate the MMS is to conduct a seminar and workshop on medical equipment management. Besides top hospital management and MoH management, it is necessary to devise a method where management knowledge spreads to all levels. Conducting the seminar and workshop is, therefore, strategically considered in three separate management levels as follows:

- 1) **Hospital top management and MoH management level** (Photo 2.5): This is targeted at hospital directors, hospital/MoH administrators and financial administrators, engineers, directors of the medical equipment section of MoH, directors of provincial health offices, etc ^{Note 2.9}.
- 2) **Hospital intermediate level** (Photo 2.6): This is targeted at maintenance managers (or health technology managers), engineers and doctors in charge of medical equipment management in hospitals and health facilities ^{Note 2.10}.
- 3) **Site level:** This is targeted at engineers and technicians who carry out maintenance, inspections, preventive repairs, and inventory/monitoring of medical equipment at the site.

Because the management system for medical equipment adopts an integrated and multidisciplinary approach, stakeholders from the finance, logistics, procurement, clinical, pharmaceutical and human resource sections are all involved in the above-mentioned seminars and workshops. In addition, the above-mentioned three levels are integrally coordinated in the MMS.



Photo 2.5 Workshop on Medical Equipment Management at top management level (Cambodia, March, 2003): Most participants were directors of National / Referral Hospitals, Provincial Health Departments, Central Supply of MoH and of other medical institutions.

Photo 2.6 Workshop on Medical Equipment Management at hospital intermediate level (Afghanistan, December, 2004): The Deputy Minister of Public Health gives a certificate to the workshop participants.



2.2 Maintenance Cycle Management

Monitoring the operation of all the equipment in the hospital is carried out using this type of cycle management. This is an annual activity. For this type of work the existence of the ME section is required because it is difficult to accomplish with a contracted-out service.

The Maintenance Cycle Management of medical equipment is illustrated in Figure 2.4. First, the registration of individual equipment is carried out through survey, and based on this, a list of equipment is made. From this inventory, an inspection schedule is made and implemented accordingly. When some faults are found during an inspection, preventive repair is carried out.

During inspection and preventive repair, equipment utilisation, safety, performance and spare parts consumption are monitored. At the same time, it is important that one protects oneself from infection by following the infection prevention rules of the hospital.

At the end of the fiscal year, it is necessary to carry out an estimation of necessary consumables, calculation of EURs, summation of operational costs, revising the list as well as planning for the coming year. An updated report is submitted to the hospital authority.

When the inspection part of the maintenance cycle management begins, it is important to do away with all the breakdown and malfunction cases. During the process of survey and registration, all inoperative medical equipment must be found. Clearly indicate reasons as to why the equipment is inoperative and attempt to find solutions as shown in Table 2.2.

In NMCHC for example, 170 pieces of medical equipment were in use as of 1998. However, a lot of equipment had faced various problems because maintenance had not been carried out since 1993. Random failure occupied only a few cases among these failure cases, while others had been caused by malfunctioning, mis-handling, initial failure with ‘pulse noise’ on power supply, lack of consumables, inadequate user inspection and unclear causes. It took one year to correct all these problems.

It is evident that many problems exist in health facilities without a maintenance system. In this case, repairs which take one or two years may be necessary to commence maintenance and

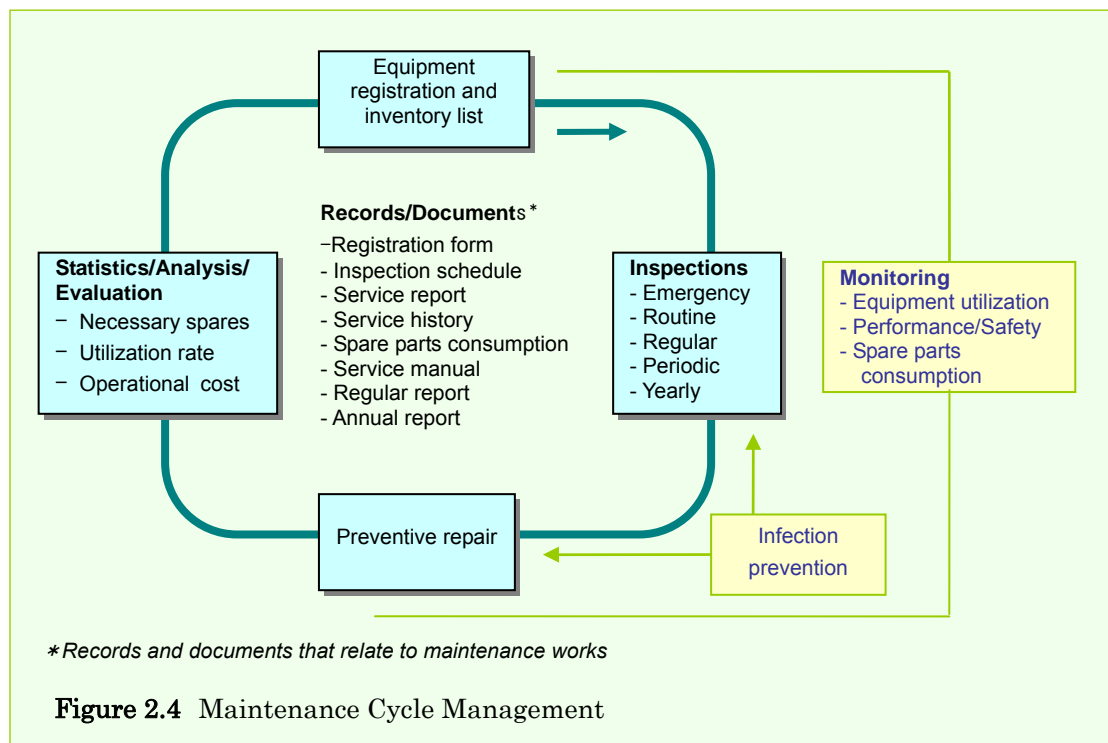


Figure 2.4 Maintenance Cycle Management

Table 2.2 Measures taken for equipment conditions

Reasons	Measures Taken
Breakdown and irreparable (unavailability of spare parts, old age, technical problem for repair, etc.)	Decommissioning, requesting local agency to evaluate for repair
Breakdown and repairable (possible to repair in-house)	Procuring spare parts, contracting- out repair
Malfunctioning (reason unknown)	Carry out investigation, spare parts procurement
Lack of consumables	Procure the consumable
Uncertain operation	Conduct an in-service training on how to use it properly
Unnecessary	Move to another ward that requires it
Reason unknown	Carry out the appropriate solution after investigating the cause
Old age	Decommissioning, newly purchase

inspection system. However, because the cause of failure ratio shown in Figure 1.10 (Part 1) applies to equipment from installation to about ten years, 60% of all the failure cases could be easily solved by replacing old accessories and consumable parts with new ones. To do this, procurement of consumables and spare parts is required.

Full details of the maintenance cycle management are shown below:

2.2.1 Survey, Registration and Inventory List

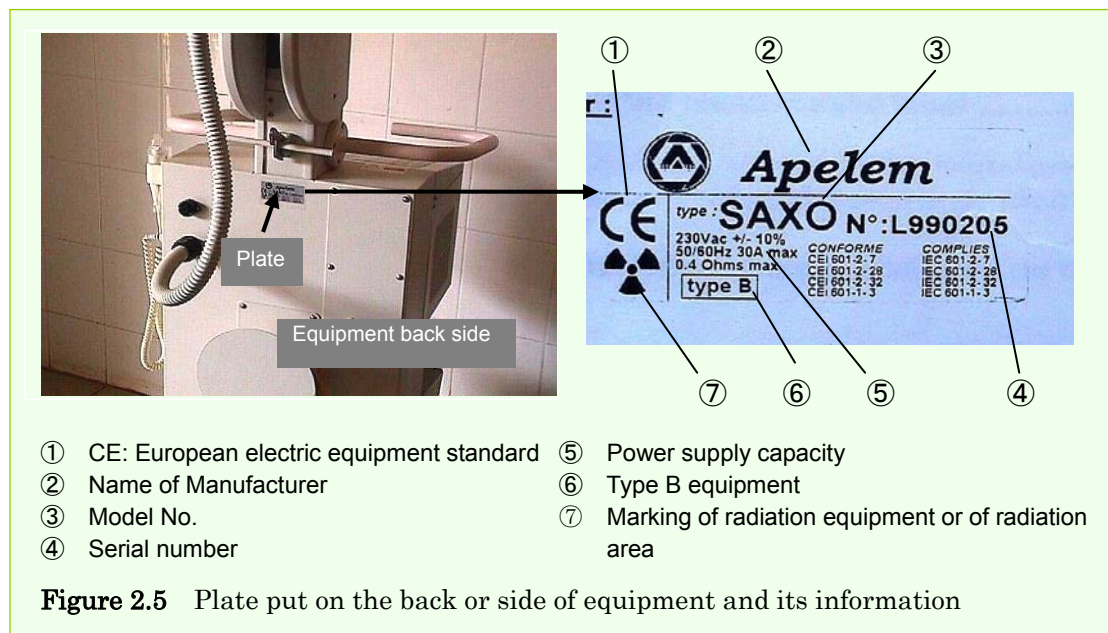
Existing medical equipment is registered in the hospital inventory ledger. The purpose is to handle medical equipment in the same way as other equipment, and to manage it in a businesslike manner. Medical equipment should be managed differently from other types of equipment such as computers, copy machines, etc. In the case of registration of medical equipment, all information related to an individual equipment item that will be maintained and managed should be recorded. When the database is set up, it becomes a basis of information. In addition, this should be referred to when the decommissioning procedure is carried out in the future.

In order to register individual medical equipment, a survey should be carried out (Photo 2.7). In the survey, information on all equipment in use and in storage is collected. The survey not only collects data/information and functional state of equipment but also carries out and records opinions of interviewed equipment operators.



Photo 2.7 Example of carrying out survey of medical equipment by engineers from Central Medical Equipment Workshop of the Ministry of Public Health, Afghanistan (Ali Abad Hospital, October, 2003): It is performed by two persons; one who reads out information and data on the equipment, and the other, who records it.

The data recorded on the equipment registration form includes all the details from the plate located at the back of the equipment (see Figure 2.5), as well as any information relating to the invoice, specifications, catalogues, etc.



Necessary data for the equipment registration is as follows:

- **Ward/Department:** Name of ward or department in which the equipment belongs;
- **Location:** Location or room where the equipment is actually placed;
- **Doctor in charge:** Doctor who takes charge of management of the equipment;
- **Name of Equipment:**
- **ID No.:** Number that identifies an individual equipment item;
- **Name of Manufacturer:**
- **Model No.:**
- **Serial No.:** It is important for identification of individual equipment, and for spare parts procurement for the concerned model;
- **Unit Price:**
- **Manufacturing Country:** Name of the country in which equipment is manufactured;
- **Equipment Class and Type:** Class I, Class II and Internally powered equipment in accordance with the type of protection against electrical shock (e.g. reinforced insulation); B, BF, and CF in accordance with the degree of protection against electrical shock (e.g. reducing patient leakage currents);
- **Equipment Group:** Grouping of equipment according to the penetration degree to the patient stipulated by EU for example— Group-1: Electro-surgical units, Defibrillators, MRI, Ventilators, X-ray equipment, etc., Group-2: Internal planted pace makers, Group-3: ECG equipment, Patient monitors, Ultrasonic diagnostic equipment, etc., Group-4: Electro-motor beds, Rehabilitation equipment etc., other than groups 1-3;
- **Power consumption:** This information is usually indicated on a plate put on the back or side of equipment (see Figure 2.5);
- **Availability of instruction and service manuals:**
- **Optional Equipment:** Equipment that is used in connection with actual equipment (main body).

Record the related information similar to the actual equipment;

- **Form of Provision:** e.g. Foreign government assistance, JICA technical cooperation, MoH, NGO, UNFPA, UNICEF, WB, WHO, hospital self-procurement and private donation;
- **Date Provided:** Day of arrival at site;
- **Date Installed:** Date when equipment installation was completed;
- **Supplier:** Local agency, trading company, and so on;
- **Warranty Period:** In general, 12 calendar months (one year) from the date of completion of installation;
- **Type of Warranty:** e.g. one year guarantee according to agreement of the grant aid programme and one year after purchasing according to written guarantee;
- **Utilisation:** Example: A = Fully utilised, B = Partly utilised, C = Not utilised (equipment rarely used but which is absolutely necessary for diagnostic and therapeutic purposes. In this case, it is assumed fully utilised.);
- **Equipment Condition:** e.g. GC=Good condition (equipment state excellent), WC=Working condition (partly functioning), and NW=Not working (functioning is unsatisfactory or does not operate at all);
- **Equipment Manufacturer:** Address, contact person, telephone number, e-mail address, etc.;
- **Local Agency:** Address, contact person, telephone number, e-mail address, etc.;
- **Remarks:** Fill in the content of the equipment condition that should be noted, e.g. recent maintenance and repair service, detailed status and any other condition noticed.

The above-mentioned information is entered on the medical equipment registration form. Appendix-6 shows an example of the medical equipment registration form being used in NMCHC. Ideally, the registration of equipment should be completed at the time of installation (see Figure 2.3 and Photo 2.8). If registration is done during the survey, which is carried out after installation of equipment, the information on the registration form will be different. Due to the absence of a registration system in many developing countries, it is unavoidable to register the equipment during time of its use ^{Note 2.11}. Therefore, Appendix-6 contains registration information from either installation or survey.

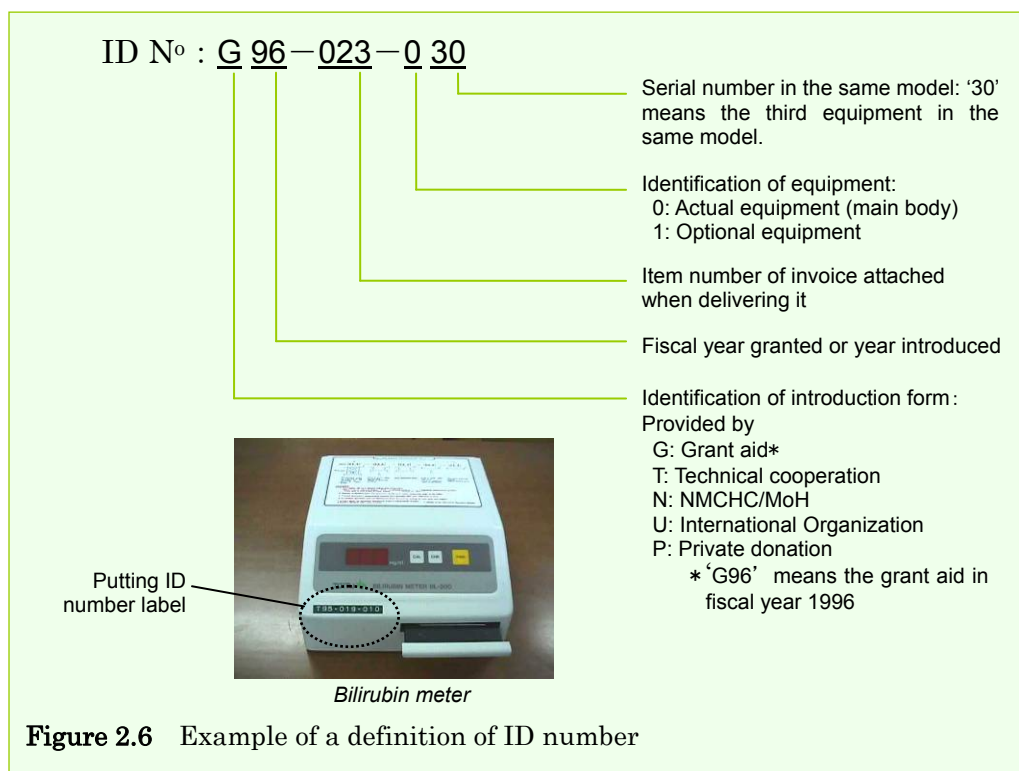


Photo 2.8 Resistration of equipment (rotators for use in molecular biology) at the installation stage, University Teaching Hospital, Zambia: Guidelines for maintenance and management should be applied even to such small and simple equipment.

All relevant information collected will be included on the registration form. Completed registration forms are then filed according to the group of equipment or the equipment location. Detailed information on how to manage the registration form will be described in section 2.7.

One of the most important items of information is the ID number (Identification number) of an individual equipment item. In fact, putting ID numbers on individual equipment items is essential work for carrying out MMS. Although the equipment serial number can be used to recognise the ID of individual equipment items, the universal ID number of the hospital is necessary to manage the medical

equipment collectively. For instance, NMCHC-defined identification number as shown in Figure 2.6; the identification label is put on an individual item. However, there is need to develop necessary definitions to create improved ID numbers, e.g. adding identification numbers of ward, equipment category and group.



Based on the registration form, a list of equipment can be made. This is called an equipment inventory list. The equipment inventory list is the most important document that assures consolidated, timely, consistent and accurate information about medical equipment. This list should be developed at both hospital and national levels. In NMCHC for example, the inventory list that has already been developed as shown in Appendix-7 includes an updated inventory list in its annual report and is submitted to the hospital management and MoH.

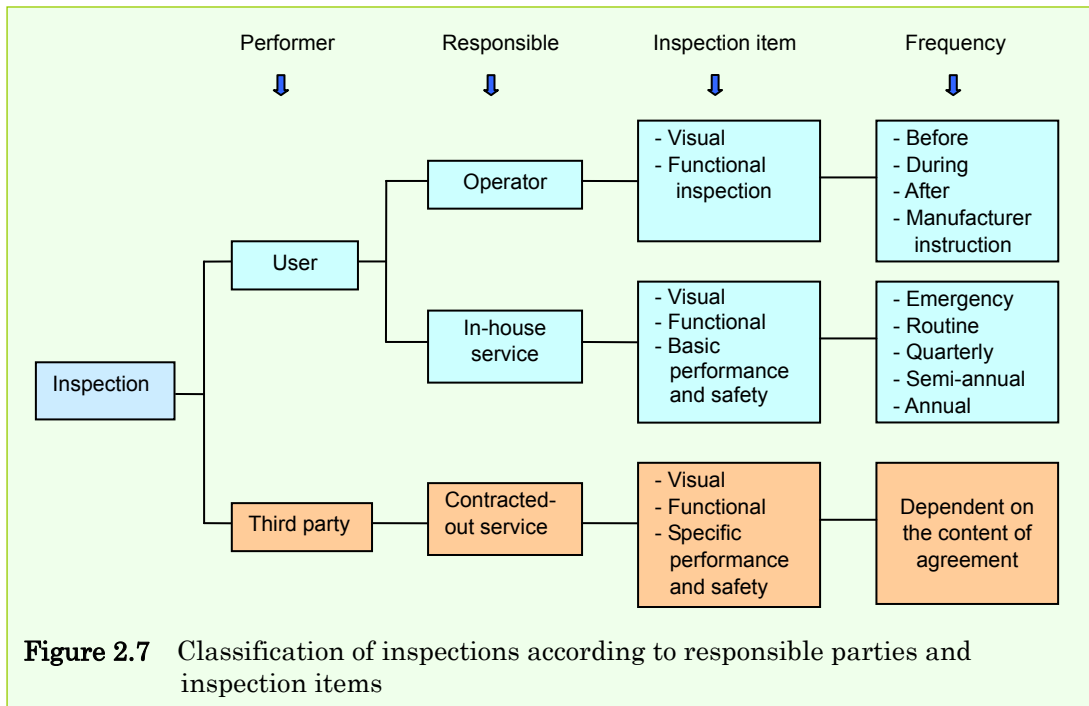
At the national level, it is necessary to develop a National Inventory Control System including a list that keeps track of information related to the highly sophisticated or expensive medical equipment available in the health facilities of the country. In Cambodia for example, an inventory control system at both national and hospital levels was first introduced by GTZ in conjunction with seminars and workshops on Physical Assets Management (PAM) in 2001. The inventory control system is now operating, with the cooperation of JICA in conjunction with seminars and workshops on medical equipment management (as of March, 2003).

2.2.2 Inspection

Inspection can be classified according to the person who carries it out (see Figure 2.7): user's inspection or contracted-out inspection. The user's inspection can be classified according to the responsible inspector: equipment operator or technical staff of the ME section.

The basic inspection that is carried out by equipment operators is as follows:

- **Visual inspection:** The inspection is carried out by naked eyes and/or hands to confirm the physical injury and condition of the equipment without running it, e.g. accessories, rusty/damaged main body, caster, switch and LCD/CRT display;



- **Functional inspection:** This inspection deals with the handling and functioning of equipment. The functional inspection is performed in three steps as follows:
 - 1) Before operation: Confirm initial stage of equipment, e.g. earthing, alarm and output level adjustment,
 - 2) During operation: Check whether functioning according to the specification of equipment is accomplished, e.g. pilot lamp, switch functioning, setting knob, alignment curve and blood leakage, and
 - 3) After operation: This inspection indicates the fault of problems, reducing inefficiency and any breakage that may occur during operation. It is also necessary to check the patient's condition such as blisters caused by transducer.
- **Periodic inspection:** Check the points as instructed in the operating manual.

Inspection carried out by the ME section is as follows (see also Photo 2.9):

 - **Urgent inspection:** Inspection in response to calls from the ward;
 - **Routine inspection:** This inspection is decided at certain intervals and is based on experience;



Photo 2.9 A staff from the ME section carries out the routine inspection of an infant incubator (NMCHC)

- **Visual/Functional inspection:** The contents are basically the same as the inspection that the operator carries out;
- **Performance inspection:** Inspection corresponding to the type of equipment is carried out as per international/national standards in conjunction with manufacturer's standard, e.g. overall characteristics, detection, amplification, signal input/output, transmission/receiving, display and recording system;
- **Safety inspection:** e.g. electrical safety ^{Note 2.12)}, output safety and alarm as per IEC and national standard.

Performance and safety inspections are carried out every three months, six months or every year according to the type of equipment, and these are carried out by qualified Biomedical Engineers (BMEs)/Biomedical Technicians (BMTs) or Clinical Engineers (CEs).

Inspection by a contracted-out service depends on the contents of the agreement with the service provider, though it is basically the same as what the ME section performs. As for sophisticated medical equipment (e.g. ultrasonic diagnostic equipment and X-ray equipment) and some laboratory equipment (e.g. flow cytometer, HPLC and haematology analyser-Photo 2.10), the inspection of a specific performance is performed corresponding to its specifications.



Photo 2.10 A haematology analyser: An analytical instrument that analyses RBC, WBC, HGB, HCT, MCV, etc. in blood sample; such equipment cannot be maintained only by operator and in-house service.

2.2.3 Infection Prevention

In the hospital, infection is usually spread by patients, visitors or staff and occasionally through contact with equipment. In such a situation, we must be aware of the risk of infection during maintenance work. The regulations of infection prevention are maintained by the Infection Prevention Committee in the hospital. However, it is unusual for ME staff to be aware of the infection risks of examining equipment. In order to carry out safe maintenance works, regulations that stipulate 'infection prevention when servicing medical equipment' must be implemented for the ME section.

Care must be taken for the following items:

1) Disinfecting Hands

Always wash hands, especially after finishing work on equipment. It is strongly recommended to use gloves while handling equipment. Prior to leaving the working area, remove overalls or laboratory coat.

2) Disinfecting Tools

Used and contaminated tools should be cleaned after use, e.g. by wiping out with a moist tissue containing or soaked in disinfectant such as Cidex.

3) Equipment Indirectly Connected to the Patient

Examples of this type of equipment include patient monitors, defibrillators, infusion pumps and non-invasive blood pressure measuring equipment. For patient monitoring systems, disposable

leads (which have been used) should not be taken to the maintenance workshop with the equipment but should instead be disposed of in the normal way.

4) Equipment Making Contact with Body Fluids

Examples of this type of equipment include ventilators, suction units, endoscopes, laryngoscopes and some invasive blood pressure monitoring equipment. For site checks or repairs of such equipment, maintenance staff should take similar precautions as those taken by staff operating the equipment.

5) Equipment Collecting Body Fluids

Suction Pumps and other apparatus used for collecting body fluids must be cleaned out before carrying out the maintenance work.

6) Decontamination of Equipment

Equipment removed from the area of use and taken either to maintenance workshop or elsewhere must undergo an appropriate decontamination process. The person removing the equipment must ensure that this has been done.

7) Maintenance Works at Laboratory

Within a Laboratory Environment, maintenance staff should work under the same regulations as the laboratory staff.

2.2.4 Preventive Repair

There is a general notion that repair is to be carried out after equipment becomes defective. However, equipment is continuously exposed to stresses during operation due to electric current flowing, operators touching it, being in contact with patients, etc. This results in particular parts deteriorating, leading to deterioration in the performance of the entire apparatus. In general, such equipment found during inspection has not yet begun malfunctioning. However, if use of the equipment is continued, such a situation can develop into serious failure, which may occasionally lead to a medical accident. Repair service that prevents failure in advance by faultfinding is called preventive repair.

In preventive repair, replacement of deteriorated parts, and adjustments to electronic circuits are carried out. In addition to this, the designated performance and safety of the equipment, in accordance with technical standards, is maintained. In cases where performance and safety tests do not match with the technical standard, the equipment is recommended for technical service at the agency or manufacturer level. Attempts to repair, adjust and calibrate which exceed the level of the ME section might prove difficult to restore and may cause another failure.

In cases where urgent inspection is requested by the ward, generally simple faults (e.g. poor contact of mains plug and socket outlet, inappropriate application of electrodes, discharged battery and improper setting of parameters) are found. Reliability and safety may be reduced remarkably because of loose connections. In case of inappropriate electrode application, discharged battery, inappropriate setting, etc., restoration of function should be performed and proper handling of equipment should be politely explained to the operator.

2.2.5 Monitoring Aspects of Maintenance Cycle

Monitoring is carried out during the processes of inspection, preventive repair and infection prevention in Figure 2.4. During the process of inspection, specification parameters and operating condition of the equipment are monitored. During preventive repair, remedy and adjustment results including consumption of spare parts are monitored.

Medical equipment is exposed to various stresses from the time of putting it into clinical application. The ME section has a role to monitor and ensure that the equipment is operated in good condition. In addition, it is also necessary to consider the safety of patients, operators and surroundings. When problems are found in equipment usage during monitoring, the ME section should take appropriate measures as mentioned in Table 2.3.

Table 2.3 Measures taken for monitoring aspects

Problems	Measures Taken
Inappropriate handling	Planning and conducting an in-service training on handling of equipment
Inadequacy of user's maintenance	Planning and conducting an in-service training for user's maintenance
Inappropriate installation environment	Improvements and recommendations about electricity, water quality, atmosphere, etc. on installation features and locations
Influence of external noise to equipment: For instance, interference with the cellular phone to CPU-controlled medical equipment used to be an issue many years ago.	In case of interference from a cellular phone, inform the person to stop using it near equipment. Research causes of influences from other external sources.
Interference between items of equipment: It is well known that interference takes place between equipment, e.g. interference from equipment installed close to ECG and EMG equipment that processes minute signals.	Check equipment installation environments, e.g. earthing system, with other equipment nearby and structure of electric facility. Research causes of interference from other types of equipment.
Safety hazard to patient: e.g. patient's burn caused by electro-surgical unit due to improper earthing circuit.	Check that the earthing circuit is properly equipped. Research causes of other safety hazards.
Others	Respond to requests from equipment operators.

Besides problems mentioned in Table 2.3, an unexplained phenomenon may take place ^{Note 2.13}. In this case, the basis of the problem solving is pursued according to the following procedures.

- whether it is out of standard value;
- why the measured value has changed with reference to standard value;
- what is the cause;
- how to make adjustment.

A progress report on the measures against the problems should be recorded, and submitted to the top hospital management. In addition, a progress report on having performed necessary safety and performance tests during inspection is evaluated and preserved. These works relate to 'Risk Management'.

At a clinical site, cases in which human error or improperly adjusted medical equipment contributes to a medical accident are often reported. For this reason, a Risk Management Committee is set up in the hospital to prevent medical accidents. In many cases, medical equipment contributes to the possibility of a medical accident. The ME section should contribute to risk analysis and measures against equipment usage which interrupts safe use of medical equipment.

During inspection and preventive repair, spare parts are monitored as to what kinds of spare (or consumable) parts are needed, over what period they deteriorate, and when they should be replaced. As a result, with experience, the necessary type and quantity of the spare parts can be determined. However, this method cannot be applied for all types of spare parts, but only for the moving parts that have turnover lifespan of less than three years. In this case, it is essential to apply a system where procurement is done in advance of the deterioration of consumable parts.

2.2.6 Service History

Data from technical services are recorded in the service report (Appendix-4). By compiling all the service reports, the service history of a particular item can be appreciated. From an analysis of this history, operating conditions, service qualities, necessary spare parts, maintenance policies, technical training, etc. can be planned.

Refer to Appendix-8. This is an example of the service history of the high-pressure steam steriliser ^{Note 2.14)} allocated to the CSSD of NMCHC. This equipment history shows all the services that have been performed during five years (1998-2002) of operation.

From the equipment history in Appendix-8, the following points are identified:

- The frequency of maintenance services including repair services is four-seven times a year. From this information, it can be concluded that the standard inspection frequency is four times a year;
- Replacement of water filters, door gaskets, strainers and valves is understood to be routine work. Therefore, the frequency of replacement of these spare parts can easily be estimated;
- The cost for servicing this equipment during 1998-2002 was US\$ 4,239.00. This becomes the criteria for the cost to manage maintenance for this type of equipment;
- On the negative side, inappropriate handling of the filter housings has resulted in replacement of filter-housing several times.

It is worthwhile to note that most of the services were completed within the same day. The reason for this is that the equipment utilisation is always monitored, because the MMS is in place. Therefore, the service is done promptly since the replacement time of consumable parts is predicted, and spare parts are procured in advance. In addition, it is possible to deal with an urgent request at once. Offering such a service is not possible in a haphazard repair system where breakdown is passively awaited.

Two similar pieces of equipment are introduced, and are utilised alternatively or simultaneously. During regular inspection one item is serviced while the other one in use. This arrangement ensures uninterrupted (24 hours) sterilisation service. The same arrangement can be applied for other types of important equipment.

2.2.7 Statistics, Analysis and Evaluation

It is necessary to carry out statistics on activities of the maintenance cycle management once or twice a year. Based on the statistics, the status of equipment utilisation, operational cost, necessary spare parts and so on are analysed. Through this analysis, problems are found and resolved. In addition, a plan for the coming year is settled on.

Statistics carried out during the first half of the year are referenced to monitoring medical equipment, and statistics of the second half also include reference to the annual report. Important statistics are classified mainly into three: EURs, spare parts consumption, and operational cost. The flowchart obtained from these statistics is illustrated in Figure 2.8. The basic documents which provide necessary information for statistics are mainly composed of the equipment inventory list, spare parts inventory list, spare parts consumption report, logbook and registration form.

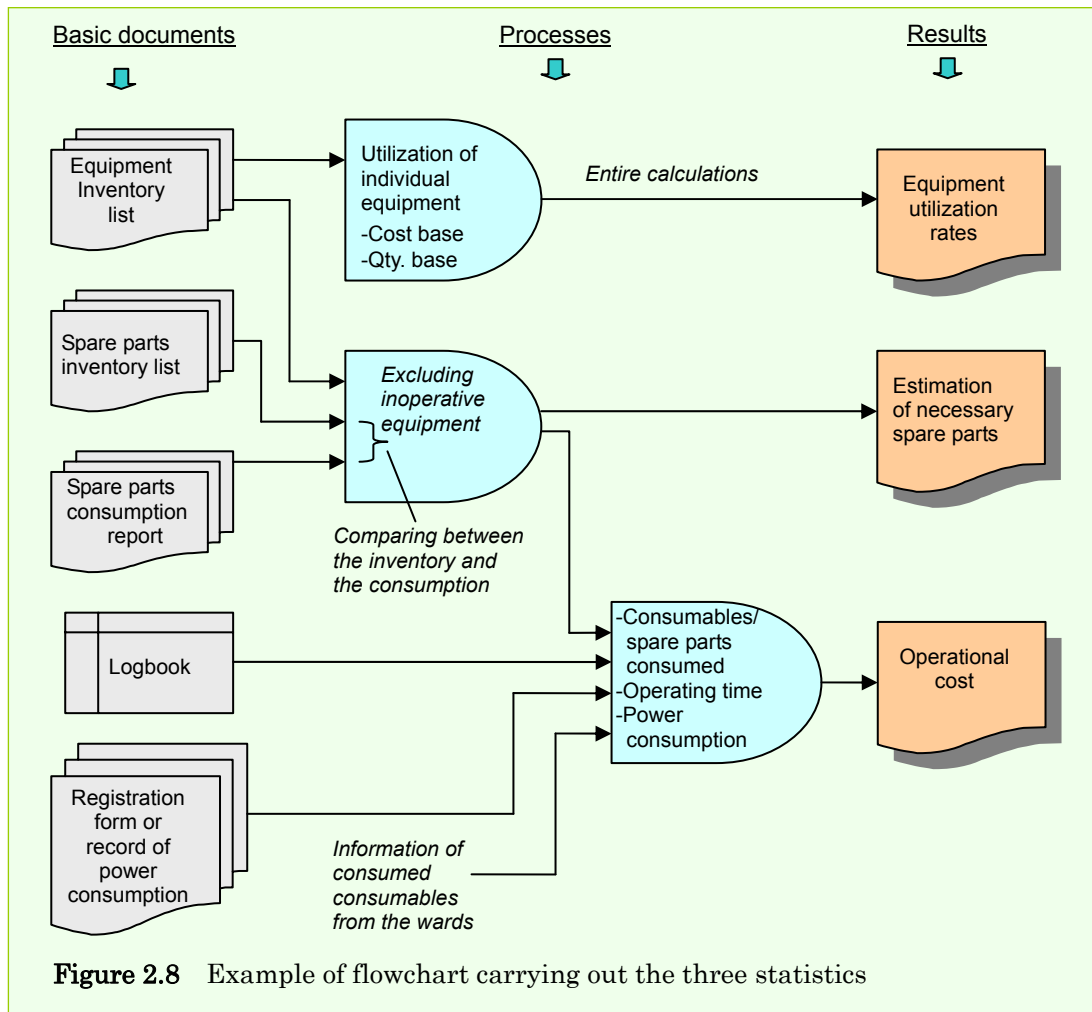
These three statistics are carried out through such various documents and their related processes. The methods of obtaining these three statistics and their meaning are as follows:

1) EURs

A numeric evaluation of the activity of the ME section is reflected in EURs. Statistics for EURs are carried out based on the equipment inventory list. The inventory list provides for information on utilisation of individual equipment. The EURs are based on the price and quantity of the equipment; the first is called the cost basis, and the second is called the quantity basis.

Refer to the utilisation of individual equipment on the equipment inventory list at first. Calculate prices of both inoperative equipment and of operative equipment. Calculate the percentages of the total number of either operative or inoperative total of the entire equipment so that equipment utilisation on cost basis can be obtained. Next, count operative and inoperative equipment respectively so that equipment utilisation on quantity basis can be obtained.

The EUR on cost basis is calculated in the percentages of the total cost of either operative or inoperative cost of entire equipment.



For example,

- Operative equipment	:	US\$ 992,124.00
- Inoperative equipment	:	US\$ 114,205.00
- Total price of equipment	:	US\$ 1,106,329.00

Hence,

$$(992,124/1,106,329) \times 100 \doteq 89.7 (\%)$$

The EUR on quantity basis is calculated in the percentages of the total number of either operative or inoperative total of the entire equipment as cost basis is calculated in the same way.

The report on the EURs on cost basis and quantity basis should be sent to the hospital management so that an appropriate analysis can be done. The result of this analysis will be used as a basis for making appropriate adjustment to the utilisation rates.

Appendix-9 shows an example of the report on EURs at NMCHC. In this report, the EURs are classified into individual wards and departments in the upper portion, and each EUR is obtained. EURs according to the form of provision (grant aid, JICA TC, NMCHC/MoH and others) are also made in the lower portion. This is because the report was made from the standpoint where technical co-operation was carried out. These EURs may not be necessary from the viewpoint of the hospital authority; only the EURs according to the individual wards and departments are necessary – that is, the form of provision need not be recorded. In any case, reporting EURs is one of the most important activities in evaluating the economic and effective use of equipment in the hospital.

The EURs dynamically change. To reach and maintain EUR at 100% is almost impossible due to technical reasons. EURs at 80-90% on both cost basis and quantity basis can be realised and maintained, though there are many factors which affect it ^{Note 2.15)}.

2) Spare parts consumption (necessary spare parts for the next fiscal year)

This is the calculation of the spare parts consumed by an individual item of equipment every half year or fiscal year. The statistics on spare parts consumption become a basis of the estimation of necessary spare parts in the next fiscal year. Details are described in paragraph 2.3.3.

Spare parts of less than one year lifespan and those of two to three years lifespan are identified separately. However, this is often misunderstood. For instance, C/P made estimation of necessary spare parts of three years lifespan, which already had been exhausted in one fiscal year. However, he records the same spare parts as they were also necessary in the coming year, though actually this is not necessary until three years later.

Refer to the equipment inventory list to identify inoperative equipment. The spare parts for the inoperative equipment should be excluded from this estimation. Next, compare the spare parts inventory list and the spare parts consumption report to confirm accurate consumption and stock.

3) Operational cost

Costs of power consumption, consumables, accessories, spare parts and repairs, etc. are calculated based on the time used on individual equipment within a half year or a fiscal year. In fact, equipment that consumes a lot of power and consumable components are included, while others may be omitted.

Operational cost can also be roughly estimated through consumption prediction instead of statistics obtained from data collection shown in Figure 2.8. A patient monitor for example is as follows:

No.	Consumable Item	Lifespan etc.	Price (US\$)	Cost per Year (US\$)	
1	ECG relay cord	2 years	50	25	} Maintenance cost
2	SaO ₂ sensor	3 years	222	74	
3	Relay tubing	2 years	62	31	
4	Cuff	1 year	62	62	
5	Patient lead	2 years	80	40	
6	Back-up battery	2 years	148	74	
7	Disposable electrode	Consumable	5	500	
8	Recording paper	Consumable	15	900	
9	ECG gel	Consumable	15	180	
10	Power consumption	(100W)	0.2\$/kW*	150	
			<i>Grand total</i>	<i>US\$ 2,036</i>	

Note: • *Dependent on the country
• Personnel cost is not included.

Statistics on the operational cost are sent to the hospital Finance Department, and applied to financial management and future planning ^{Note 2.16)}.

Collect information from necessary spare parts, the logbook and the registration form or record of power consumption. In addition, information on consumption of consumables is collected from the wards. Next, total calculation is done for individual equipment items and the total cost for all equipment is combined so that the operational cost can be obtained.

2.2.8 Annual Report

As a summary of one year's activity in maintenance cycle management, writing and submitting an annual report every fiscal year is very important. Such a systematic report brings further improvement of management technology of medical equipment. In addition to this, it can raise the evaluation and position of the ME section.

For instance, the annual report of fiscal year 2002 that was issued by the ME section of NMCHC included the following contents:

- 1) **Overview:** This column described activity in the prior fiscal year, problem solution, progress on the prior year's plan, summaries of overall evaluation, etc.
- 2) **Status of equipment:**
 - Equipment inventory list and its analysis
 - Utilisation rate and its analysis
- 3) **Activities:**
 - Routine services: service list, maintenance/repair costs
 - Installation and acceptance tests
 - Spare parts management: spare parts delivery/stock, results of inventory check
 - Operator training: participation in training, handling of equipment
- 4) **Statistics:**
 - Failure analysis
 - Maintenance/repair cost analysis
 - Spare parts necessary for next fiscal year
- 5) **Plan for next fiscal year:**
 - Strengthening spare parts control
 - Strengthening operator training
 - X-ray equipment management
- 6) **Suggestions:**

Although this section was not included at this time the annual report usually suggests improvements in utilisation and good management of medical equipment.
- 7) **Appendices:**
 - Equipment inventory list
 - Equipment utilisation rates for each ward/department
 - Spare parts inventory list