

2.5 PLANNED PREVENTIVE MAINTENANCE

2.5.1 Scope

Planned preventive maintenance is regular, repetitive work done to keep equipment in good working order and to optimize its efficiency and accuracy. This activity involves regular, routine cleaning, lubricating, testing, calibrating and adjusting, checking for wear and tear and eventually replacing components to avoid breakdown.

Productive preventive maintenance refers to the proper selection of equipment to be included in planned preventive maintenance. Decisions must be made on what to include, to reduce costs; inexpensive units that are not necessarily included in the planned preventive maintenance programme can be replaced or repaired when they break down. The overriding consideration is cost-effectiveness.

An important aspect of planned preventive maintenance is the participation and commitment of the user. Preventive maintenance should start with users, and the bulk of the work should be their responsibility. The task must be performed daily, with joint activities involving the user and a technician engineer at the end of the week. Highly technical repairs, which are the engineer's responsibility, may be scheduled every six months.

2.5.2 Setting up a planned preventive maintenance system

In order to establish an effective, efficient planned preventive maintenance system, a registry filing system is needed. The manufacturer's manual for preventive maintenance of the equipment can be supplemented by computer packages in setting up such a system; if a computer is not available, a manual file can be set up. The planned preventive maintenance administrative system requires the following:

2.5.2.1 Equipment inventory

All equipment in the hospital that is in the care of the service workshop should be recorded on cards, as shown in the sample equipment record in Annex 4. All relevant information about the equipment must be entered, including its location, records of repair and maintenance and the manufacturer.

A reference number is given and written on a printed paper label, which is attached to each item. This number is recorded in a ledger of equipment with full identifying details.

2.5.2.2 Definition of maintenance task

The work that must be done to maintain each item of equipment in safe and reliable operating condition must be defined; this is known as the maintenance task. These tasks can be established by consulting the manufacturer's literature and product information.

2.5.2.3 Establishing intervals of maintenance

After determining what is to be done, the frequency of the task must be decided. A heavily used item must be cleaned and checked more frequently than one which is used less often; however, minimum standards must be set. The frequency suggested in the manufacturer's manual can be used as a guide, but the actual usage should determine the maintenance procedure required. Annex 5 provides a sample schedule for planned preventive maintenance, which can be used as a guide.

2.5.2.4 Personnel

Individuals who are qualified and available to do preventive maintenance must be identified. A list should be drawn up of personnel who are readily available. Once the personnel have been listed, specific responsibilities should be assigned, perhaps in the form of a work order, giving clear instructions for the task. Each person should have a clear knowledge of his or her responsibilities. Job assignments must correspond to the training, experience and aptitude of the individual.

Training is discussed in the previous chapter. If the hospital staff includes a large number of well trained, experienced individuals who are familiar with medical equipment, in-service training can easily be undertaken.

2.5.2.5 Reminder system

Maintenance of instruments and equipment is a continuous process: once the equipment has been inventoried, the programme must continue. It may be necessary to develop a reminder system, so that appropriate personnel are notified when certain tasks are to be performed. Whether a card index system or a computer programme is used, the date that each item of equipment is scheduled for its next preventive maintenance should be recorded. The administrator should look up in advance the jobs that need to be done and draw up a monthly or weekly schedule.

2.5.2.6 Special test equipment

People responsible for equipment management and maintenance should have at their disposal a range of test equipment to check the correct functioning of medical equipment as well as its compliance with the basic electrical safety standards. The brand and specifications of such test equipment will vary from country to country; however, a range of general-purpose electrical and safety test equipment for medical use is available in the United Kingdom from Rigel (Graseby Medical Ltd, Colonia Way, Watford, Herts WD2 4LG; Telex 929263 GRAMED G; Fax 92331595) and Ultramedic Ltd (4C Newton Court, Wavetree Technology Park, Liverpool L13 1EJ; Fax 51228 0354). Similar test equipment can be obtained in the USA from Bio-Tek Instruments Inc. (Highland Park, Box 998, Winooksi, VT 05404-0998; Telex 940136 BIO TEK SHVT; Fax 802655 7941) and internationally through a variety of distributors. Such equipment allows the technician to perform basic electrical medical safety tests under controlled conditions. Furthermore, these safety tests indicate whether the equipment complies with the standards laid down by the International Electrotechnical Commission. Since this equipment can be contained in a briefcase, it can be carried by the technician. A wide range of tests can be undertaken, to measure different values for insulation resistance, each continuity and leakage current in different situations, under both normal and single-fault conditions.

For the practical assessment of whether different types of medical equipment are working effectively, a number of specific analysers, calibrators and simulators are available from, for example, Bio-Tek in the USA and Ultramedic in the United Kingdom. These allow technicians to check the function of ventilators and to calibrate blood pressure monitors, pressure transducers, electrocardiographs and the full range of monitoring equipment used in the intensive care unit. Analysers are available for checking the effectiveness of defibrillators, electro-surgical instruments and ultrasonic phototherapy equipment. A special-purpose analyser has been developed to assess infusion devices; this had hitherto been difficult because of their very low flow rates. It may not be appropriate for every maintenance department to be fully equipped with a complete range of such instruments, and some may be located in the major maintenance workshops, provincially or nationally.

Most common items of test equipment are listed below. Others may be specified by manufacturers:

- multimeters: simple, robust, digital multimeter with clamp-on attachment to measure high current in X-ray equipment;
- milliamperemeter: to measure milliamperes in X-ray equipment;
- line resistance meter: low-value meter for the power requirements of X-ray equipment (mainly for generator and control units);
- electrocardiograph simulator: lead II output simulator to check the performance of the electrocardiograph;
- spectrophotometer standards: to check wavelength calibrations; preferably filter standard instead of solutions, for ease of use and transportation;
- pH meter standards: buffer solutions to check the accuracy of readings;
- oscilloscope: standard 50-MHz model, dual trace, for testing, fault finding and calibration;
- DC power supplies: electronic power supplies, approximately 25 V DC variable and 5-V and 10-V outputs for testing equipment;
- signal generators: 0-10 MHz, sine, square and sawtooth waveform generators for calibration and testing;
- X-ray phantoms: various phantoms, such as hand, step wedge and grating, to test for picture quality; and
- defibrillator tester: to measure output (in joules).

2.5.2.7 Technical library

A full technical library should be available. Installation and recommended spare parts manuals, annotated with the number of the corresponding equipment, should be kept together with electronic and component data books and appropriate technical books.

2.5.2.8 Surveillance

After the programme has been set up, periodic surveillance must be carried out to ensure that records are legible and that all entries are being made.

2.5.3 Patient and worker safety

It is the responsibility of those involved in equipment management to see that both staff and patients are protected from the potential hazards that exist in the hospital environment. These hazards arise from the use and presence of:

- radiation,
- electricity, and
- biological materials.

Each of these is covered by a set of national standards and working practices; these may be encompassed by legislation, such as the "Health and Safety at Work Act (1974)" used in the United Kingdom.

The use of increasingly complex electrically powered medical equipment in hospitals has brought about the need for a clearly defined policy to avoid the occurrence of accidental injuries to both staff and patients. In the past, only a massive fault in an electronic device could result in the

electrocution of a patient, as the high resistance of the body often protected the heart. With the advent of sophisticated electromedical instrumentation, this high natural resistance was deliberately minimized to allow more efficient monitoring of the patient, and the danger of electrocution is thus greater. The problem is magnified by the common practice of connecting to the patient several pieces of electrical equipment, each of which is powered independently from the main supply.

Since even a very low current, measured in milli- or even microamperes, could be hazardous, precautions must be taken to ensure proper grounding of equipment and of conductive objects that are within the reach of the patient and attending medical staff. The electrical grounding should be maintained, and periodic checks must be made to ensure that power cords are not frayed, plugs are not damaged and there is no leakage of current within the ratings specified by the manufacturers or the national standards. Medical staff should be trained to understand the need for electrical safety and some of the problems that can arise, so that they can take an active role in minimizing the potential hazards and report those that occur.

As standards of electrical safety are constantly being revised, it is beyond the scope of these guidelines to furnish current details on this subject. Hospital authorities should obtain standards from reliable references developed by such entities as the US Department of Health, Education, and Welfare and the International Electrotechnical Commission.

The sophisticated testing equipment listed in Paragraph 2.5.6, while an essential part of the planned preventive maintenance programme, should not, however, substitute for basic common sense in the use and installation of electromedical equipment that is to be connected to patients. Mains-powered units must have a good earth. A three-pin plug must be used on the appliance lead, which must be directly compatible with the socket outlets in the hospital. Adaptors, extension blocks and extension leads should not be used, since these provide an opportunity for the earth wire to be disconnected, thus seriously compromising basic electrical safety.