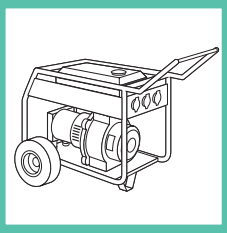
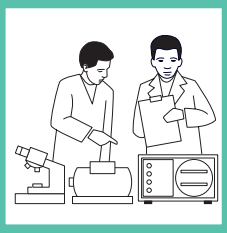


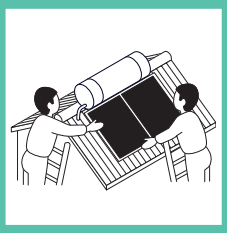
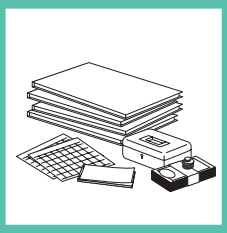
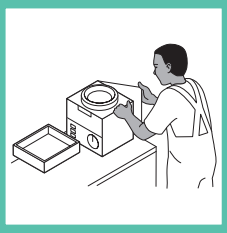

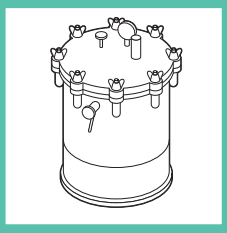

'How to Manage' Series for Healthcare Technology

Guide 4

How to Operate Your Healthcare Technology Effectively and Safely

Management Procedures for Health Facilities and District Authorities

ZIKEN INTERNATIONAL

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Dedicated to baby Nathan and Trevor, for their patience and help.

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Ziken International (Consultants) Ltd,
Causeway House, 46 Malling Street, Lewes, East Sussex, BN7 2RH, UK
Tel: +44 (0)1273 477474, fax: +44 (0)1273 478466, email: info@ziken.co.uk,
website: www.ziken.co.uk

'How to Manage' Series for Healthcare Technology

Guide 1: How to Organize a System of Healthcare Technology Management

Guide 2: How to Plan and Budget for your Healthcare Technology

Guide 3: How to Procure and Commission your Healthcare Technology

Guide 4: How to Operate your Healthcare Technology Effectively and Safely

Guide 5: How to Organize the Maintenance of your Healthcare Technology

Guide 6: How to Manage the Finances of your Healthcare Technology Management Teams

Keywords: *healthcare technology, management procedures, health service administration, district health services, developing countries, operation, use, cleaning, safety, equipment*

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Design and layout by Jules Stock (email: julesstock@macunlimited.net

Illustrations and charts by David Woodroffe (email: davedraw@dircon.co.uk)

Edited by Sarah Townsend Editorial (email: sarah@sarahtownsendeditorial.co.uk,
website: www.sarahtownsendeditorial.co.uk)

‘How to Manage’ Series for Healthcare Technology

Guide 4

How to Operate Your Healthcare Technology Effectively and Safely

by:

Caroline Temple-Bird
Healthcare Technology Management Consultant,
Ziken International Consultants Ltd, Lewes, UK

Manjit Kaur
Development Officer, ECHO International Health Services, Coulsdon, UK

Andreas Lenel
Health Economist Consultant, FAKT, Stuttgart, Germany

Willi Kawohl
Financial Management Consultant, FAKT, Stuttgart, Germany

Series Editor

Caroline Temple-Bird
Healthcare Technology Management Consultant,
Ziken International Consultants Ltd, Lewes, UK

CONTENTS

Foreword

This Series of Guides is the output from a project funded by the UK government's Department for International Development (DFID) for the benefit of developing countries. The output is the result of an international collaboration that brought together:

- researchers from Ziken International and ECHO International Health Services in the UK, and FAKT in Germany
- an advisory group from WHO, PAHO, GTZ, the Swiss Tropical Institute, and the Medical Research Council of South Africa
- reviewers from many countries in the developing world

in order to identify best practice in the field of healthcare technology management.

The views expressed are not necessarily those of DFID or the other organizations involved.

Garth Singleton
Manager, Ziken International Consultants Ltd, Lewes, UK

Preface

The provision of equitable, quality and efficient healthcare requires an extraordinary array of properly balanced and managed resource inputs. Physical resources such as fixed assets and consumables, often described as healthcare technology, are among the principal types of those inputs. Technology is the platform on which the delivery of healthcare rests, and the basis for provision of all health interventions. Technology generation, acquisition and utilization require massive investment, and related decisions must be made carefully to ensure the best match between the supply of technology and health system needs, the appropriate balance between capital and recurrent costs, and the capacity to manage technology throughout its life.

Healthcare technology has become an increasingly visible policy issue, and healthcare technology management (HTM) strategies have repeatedly come under the spotlight in recent years. While the need for improved HTM practice has long been recognized and addressed at numerous international forums, health facilities in many countries are still burdened with many problems, including non-functioning medical equipment as a result of factors such as inadequate planning, inappropriate procurement, poorly organized and managed healthcare technical services, and a shortage of skilled personnel. The situation is similar for other health system physical assets such as buildings, plant and machinery, furniture and fixtures, communication and information systems, catering and laundry equipment, waste disposal, and vehicles.

Preface (continued)

The (mis-)management of physical assets impacts on the quality, efficiency and sustainability of health services at all levels, be it in a tertiary hospital setting with sophisticated life-support equipment, or at the primary healthcare level where simple equipment is needed for effective diagnosis and safe treatment of patients. What is vital – at all levels and at all times – is a critical mass of affordable, appropriate, and properly functioning equipment used and applied correctly by competent personnel, with minimal risk to their patients and to themselves. Clear policy, technical guidance, and practical tools are needed for effective and efficient management of healthcare technology for it to impact on priority health problems and the health system's capacity to adequately respond to health needs and expectations.

This Series of Guides aims to promote better management of healthcare technology and to provide practical advice on all aspects of its acquisition and utilization, as well as on the organization and financing of healthcare technical services that can deliver effective HTM.

The Guides – individually and collectively – have been written in a way that makes them generally applicable, at all levels of health service delivery, for all types of healthcare provider organizations and encompassing the roles of health workers and all relevant support personnel.

It is hoped that these Guides will be widely used in collaboration with all appropriate stakeholders and as part of broader HTM capacity-building initiatives being developed, promoted and implemented by WHO and its partners, and will therefore contribute to the growing body of evidence-based HTM best practice.

The sponsors, authors and reviewers of this Series of Guides are to be congratulated for what is a comprehensive and timely addition to the global HTM toolkit.

Andrei Issakov, Coordinator, Health Technology and Facilities Planning and Management, World Health Organization, Geneva, Switzerland

Mladen Poluta, Director, UCT/WHO HTM Programme, University of Cape Town, South Africa

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This Guide was written:

- **with specialist support from:**

  Juliette Cook, Biomedical Engineer, Advisor to Ministries of Health of Mozambique, and Vanuatu

- **with assistance from an Advisory Group of:**

  Hans Halbwachs, Healthcare Technology Management, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ-GmbH), Eschborn, Germany

  Peter Heimann, Director, WHO Collaborating Centre for Essential Health Technologies, Medical Research Council of South Africa, Tygerberg, South Africa

  Antonio Hernandez, Regional Advisor, Health Services Engineering and Maintenance, PAHO/WHO, Washington DC, USA

  Andrei Issakov, Coordinator, Health Technology and Facilities Planning and Management, Department of Health System Policies and Operations, WHO, Geneva, Switzerland

  Yunkap Kwankam, Scientist, Department of Health Service Provision, WHO, Geneva, Switzerland

  Martin Raab, Biomedical Engineer, Swiss Centre for International Health of the Swiss Tropical Institute, Basle, Switzerland

  Gerald Verollet, Technical Officer, Medical Devices, Blood Safety and Clinical Technology (BCT) Department, WHO, Geneva, Switzerland

  Reinhold Werlein, Biomedical Engineer, Swiss Centre for International Health of the Swiss Tropical Institute, Basle, Switzerland

- **reviewed by:**

  Dr E Aniteye, Consultant/Lecturer in Anaesthesia/ICU, Korle-Bu Central Hospital, Kumasi, Ghana

  Dr P Asman, Head of the Bio-engineering Unit, Ministry of Health, Accra, Ghana

  Tsibu J. Bbuku, Medical Equipment Specialist, Central Board of Health, Lusaka, Zambia

  Peter Cook, Biomedical Engineer, ECHO International Health Services, Coulsdon, UK

  Freedom Dellosa, Chief of Hospital Equipment Maintenance Service Division, Region 9 – Mindanao Peninsula, Department of Health, Zambonga City, Philippines

  Pieter de Ruijter, HTM Consultant, HEART Consultancy, Renkum, The Netherlands

Roland Fritz, HCTS Coordinator, Christian Social Services Commission, Dar es Salaam, Tanzania

Andrew Gammie, Project Director, International Nepal Fellowship, Pokhara, Nepal

Jan Huys, HTM Consultant, HEART Consultancy, Renkum, The Netherlands

Pramod Joshi, Medical Equipment Engineer, Technical Assistance Programme, International Nepal Fellowship, Nepalgunj, Nepal

Godfrey Katabaro, Biomedical Engineering Technologist, Kagera Medical Technical Services, church health sector, Kagera, Tanzania

Derrick Mayungo, Deputy Head of Biomedical Engineering, University Teaching Hospital, Lusaka, Zambia

Jenny Poulter, Nursing Consultant, Green Pastures Hospital, International Nepal Fellowship, Pokhara, Nepal

Dr. S. Samnakey, Clinical Director of Surgery, Aga Khan Foundation Private Hospital, Nairobi, Kenya

Sulaiman Shahabuddin, Director, Patient Services, Aga Khan Foundation Private Hospital, Nairobi, Kenya

Dr Sok Srun, Hospital Services Bureau Chief, Ministry of Health, Phnom Penh, Cambodia

Birgit Thiede, Physical Assets Management (PAM) Advisor, Ministry of Health, Phnom Penh, Cambodia

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Abbreviations

AAP	annual action plan
AHA	American Hospital Association
AMC	average monthly consumption
Amps	Amperes
BP	blood pressure
CD–Rom	compact disc – read only memory
CSSD	central sterile supplies department (central sterile services department, in the USA)
DB	distribution board
DVD	digital versatile disc
ECG	electrocardiograph
EDP	equipment development plan
ELCB	earth-leakage circuit-breaker
FIFO	first in, first out
g	grams
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German government technical aid agency)
HIV	human immuno-deficiency virus
HTM	healthcare technology management
HTMS	healthcare technology management service
HTMWG	healthcare technology management working group
Hz	Hertz
ICU	intensive care unit
IEC	International Electrotechnical Commission
IEE	Institution of Electrical Engineers
ISO	International Organization for Standardization
kPa	kilo-Pascals
LPG	liquefied petroleum gas
LT	lead time
Max.	maximum level
MES	medical electrical safety (tester)
Min.	minimum level
MOH	Ministry of Health
NGO	non-governmental organization
OPD	out-patients department

OQ	order quantity
PAT	portable appliance tester
PME	protective multiple earthing
PPM	planned preventive maintenance
PVC	polyvinyl chloride
RCD	residual current device
RFI	radio frequency interference
RS	reserve stock
SMART	specific, measurable, achievable, relevant, time-bound (targets)
SLFO	shortest life, first out
TB	tuberculosis
TBO	time between orders
TST	time, steam-under-pressure, and temperature
UPS	uninterruptible power supply
V	Volts
VDU	visual display unit
WHO	World Health Organization

List of Boxes and Figures

1. INTRODUCTION

Why is This Important?

This introduction explains the importance of healthcare technology management (HTM) and its place in the health system.

It also describes:

- the purpose of the Series of Guides and this Guide in particular
- the people the Guides are aimed at
- the names and labels commonly used in HTM, in this Series.

The Series of Guides is introduced in *Section 1.1*, and this particular Guide on effective operation and safety is introduced in *Section 1.2*.

1.1 INTRODUCTION TO THE SERIES OF GUIDES

Healthcare Technology Management's Place in the Health System

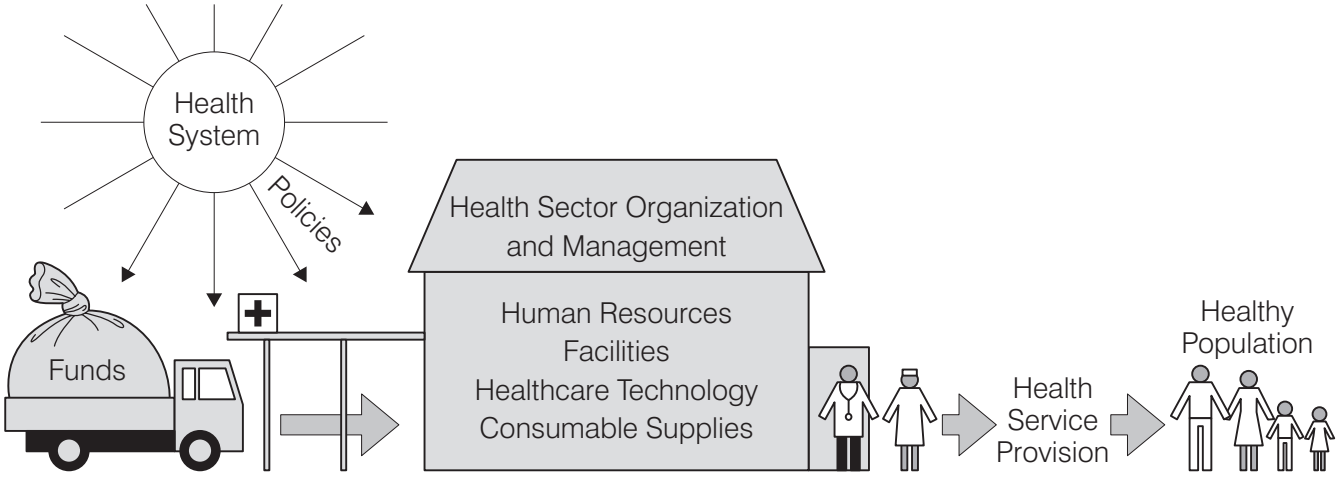
All health service providers want to get the most out of their investments. To enable them to do so, they need to actively manage health service assets, ensuring that they are used efficiently and optimally. All management takes place in the context of your health system's policies and finances. If these are favourable, the management of health service assets can be effective and efficient, and this will lead to improvements in the quality and quantity of healthcare delivered, without an increase in costs.

The health service's most valuable assets which must be managed are its human resources, physical assets, and other resources such as supplies. Physical assets such as facilities and healthcare technology are the greatest capital expenditure in any health sector. Thus it makes financial sense to manage these valuable resources, and to ensure that healthcare technology:

- is selected appropriately
- is used correctly and to maximum capacity
- lasts as long as possible.

Such effective and appropriate management of healthcare technology will contribute to improved efficiency within the health sector. This will result in improved and increased health outcomes, and a more sustainable health service. This is the goal of healthcare technology management – the subject of this Series of Guides.

Figure 1: The Place of Healthcare Technology Management in the Health System



What Do we Mean by Healthcare Technology?

The World Health Organization (WHO) uses the broader term 'health technology', which it defines as including:

'devices, drugs, medical and surgical procedures – and the knowledge associated with these – used in the prevention, diagnosis and treatment of disease as well as in rehabilitation, and the organizational and supportive systems within which care is provided'

(Source: Kwankam, Y, et al, 2001, 'Health care technology policy framework', WHO Regional Publications, Eastern Mediterranean Series 24: Health care technology management, No. 1)

However, the phrase 'healthcare technology' used in this Series of Guides only refers to the physical pieces of hardware in the WHO definition, that need to be maintained. Drugs and pharmaceuticals are usually covered by separate policy initiatives, frameworks, and colleagues in another department.

Therefore, we use the term healthcare technology to refer to the various equipment and technologies found within health facilities, as shown in *Box 1*.

BOX 1: Categories of Equipment and Technologies Described as 'Healthcare Technology'

medical equipment	walking aids	health facility furniture
communications equipment	training equipment	office equipment
office furniture	fixtures built into the building	plant for cooling, heating, etc
service supply installations	equipment-specific supplies	fire-fighting equipment
workshop equipment	fabric of the building	vehicles
laundry and kitchen equipment	waste treatment plant	energy sources

For examples of these different categories, see the Glossary in *Annex 1*.

Often, different types of equipment and technologies are the responsibility of different organizations. For example, in the government sector, different ministries may be involved, such as Health, Works, and Supplies; and in the non-government sector, different agencies may be involved, such as Health, and Logistics.

The range of healthcare technology which falls under the responsibility of the health service provider varies from country to country and organization to organization. Therefore each country's definition of healthcare technology will vary depending on the range of equipment and technology types that they actually manage.

For simplicity, we often use the term 'equipment' in place of the longer phrase 'healthcare technology' throughout this Series of Guides.

What is Healthcare Technology Management?

First of all, healthcare technology management (HTM) involves the organization and coordination of all of the following activities, which ensure the successful management of physical pieces of hardware:

- Gathering reliable information about your equipment.
- Planning your technology needs and allocating sufficient funds for them.
- Purchasing suitable models and installing them effectively.
- Providing sufficient resources for their use.
- Operating them effectively and safely.
- Maintaining and repairing the equipment.
- Decommissioning, disposing, and replacing unsafe and obsolete items.
- Ensuring staff have the right skills to get the best use out of your equipment.

This will require you to have broad skills in the management of a number of areas, including:

- technical problems
- finances
- purchasing procedures
- stores supply and control
- workshops
- staff development.

However, you also need skills to manage the place of healthcare technology in the health system. Therefore, HTM means managing how healthcare technology should interact and balance with your:

- medical and surgical procedures
- support services
- consumable supplies, and
- facilities

so that the complex whole enables you to provide the health services required.

Thus HTM is a field that requires the involvement of staff from many disciplines – technical, clinical, financial, administrative, etc. It is not just the job of managers, it is the responsibility of all members of staff who deal with healthcare technology.

This Series of Guides provides advice on a wide range of management procedures, which you can use as tools to help you in your daily work. For further clarification of the range of activities involved in HTM and common terms used, refer to the WHO's definition of the technology management hierarchy in *Annex 1*.

Box 2 highlights some of the benefits of HTM.

BOX 2: Benefits of Healthcare Technology Management (HTM)

- Health facilities can deliver a full service, unimpeded by non-functioning healthcare technology.
- Equipment is properly utilized, maintained, and safeguarded.
- Staff make maximum use of equipment, by following written procedures and good practice.
- Health service providers are given comprehensive, timely, and reliable information on:
  - the functional status of the equipment
  - the performance of the maintenance services
  - the operational skills and practice of equipment-user departments
  - the skills and practice of staff responsible for various equipment-related activities in a range of departments including finance, purchasing, stores, and human resources.
- Staff control the huge financial investment in equipment, and this can lead to a more effective and efficient healthcare service.

Purpose of the Series of Guides

The titles in this Series are designed to contribute to improved healthcare technology management in the health sectors of developing countries, although they may also be relevant to emerging economies, and other types of country. The Series is designed for any health sector, whether it is run by:

- government (such as the Ministry of Health or Defence)
- a non-governmental organization (NGO) (such as a charitable or not-for-profit agency)
- a faith organization (such as a mission)
- a corporation (for example, an employer such as a mine, who may subsidize the healthcare)
- a private company (such as a health insurance company or for-profit agency).

This Series aims to improve healthcare technology at a daily operational level, as well as to provide practical resource materials for equipment users, maintainers, health service managers, and external support agencies.

To manage your technology effectively, you will need suitable and effective procedures in place for all activities which impact on the technology. Your health service provider organization should already have developed a Policy Document setting out the principles for managing your stock of healthcare technology (*Annex 2* provides a number of resources available to help with this). The next step is to develop written organizational procedures, in line with the strategies laid out in the policy, which staff will follow on a daily basis.

The titles in this Series provide a straightforward and practical approach to healthcare technology management procedures:

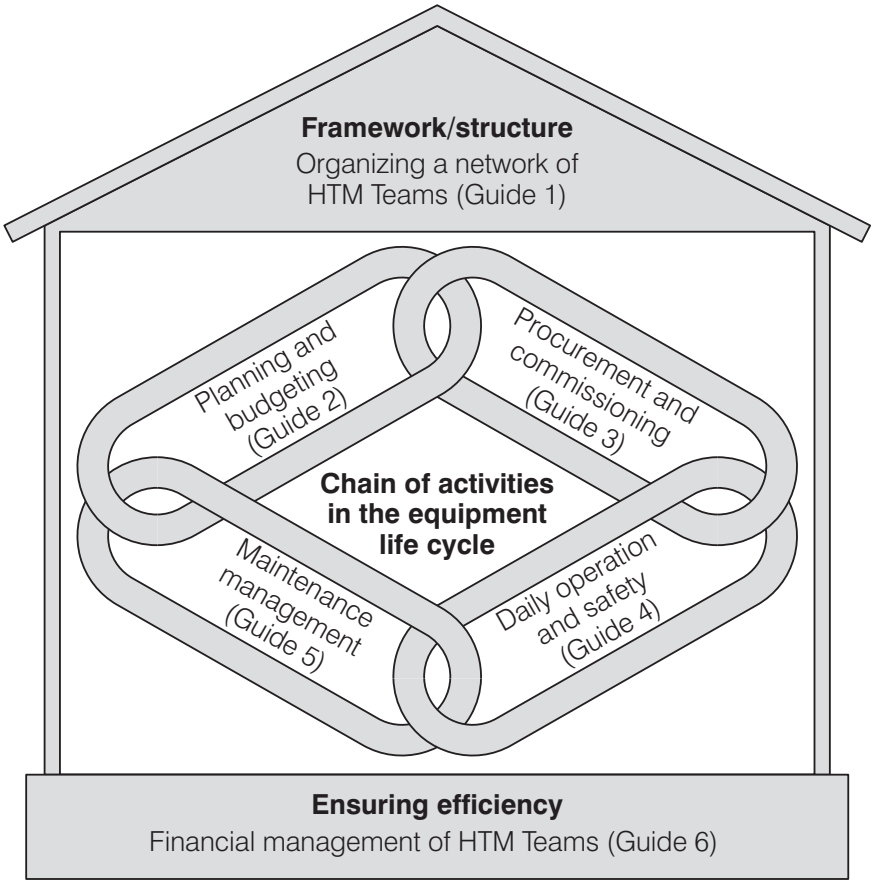
Guide 1 covers the framework in which Healthcare Technology Management (HTM) can take place. It also provides information on how to organize a network of HTM Teams throughout your health service provider organization.

Guides 2 to 5 are resource materials which will help health staff with the daily management of healthcare technology. They cover the chain of activities involved in managing healthcare technology – from planning and budgeting to procurement, daily operation and safety, and maintenance management.

Guide 6 looks at how to ensure your HTM Teams carry out their work in an economical way, by giving advice on financial management.

How the Guides are coordinated is set out in *Figure 2*.

Figure 2: The Relationship Between the Guides in This Series



Who are These Guides Aimed at?

These Guides are aimed at people who work for, or assist, health service provider organizations in developing countries. Though targeted primarily at those working in health facilities or within the decentralized health authorities, many of the principles will also apply to staff in other organizations (for example, those managing health equipment in the Ministry of Works, private maintenance workshops, and head offices).

Depending on the country and organization, some daily tasks will be undertaken by end users while others may be carried out by higher level personnel, such as central level managers. For this reason, the Guides cover a range of tasks for different types of staff, including:

- equipment users (all types)
- maintenance staff
- managers
- administrative and support staff
- policy-makers
- external support agency personnel.

They also describe activities at different operational levels, including:

- the health facility level
- the zonal administration level (such as district, regional, diocesan)
- the central/national level
- by external support agencies.

Many activities require a multi-disciplinary approach, therefore it is important to form mixed teams which include representatives from the planning, financial, clinical, technical, and logistical areas. Allocation of responsibilities will depend upon a number of factors, including:

- your health service provider
- the size of the organization
- the number of decentralized levels of authority
- the size of your health facility
- your level of autonomy.

The names and titles given to the people and teams involved will vary depending on the type of health service provider you work with.

For the sake of simplicity, we have used a variety of labels to describe different types of staff and teams involved in HTM.

This Series describes how to introduce healthcare technology management into your organization. The term **Healthcare Technology Management Service (HTMS)** is used to describe the delivery structure required to manage equipment within the health system. This encompasses all levels of the health service, from the central level, through the regions/districts, to facility level.

There should be a referral network of **workshops** where maintenance staff with technical skills are based. However, equipment management should also take place where there are no workshops, by involving general health facility staff. We call these groups of people the **HTM Team**, and we suggest that you have a team at every level whether a workshop exists or not. Throughout this Series, we have called the person who leads that team the **HTM Manager.**

At every level, there should also be a committee which regularly considers all equipment-related matters, and ensures decisions are made that are appropriate to the health system as a whole. We have used the term **HTM Working Group (HTMWG)** for this committee, which will advise the Health Management Teams on all equipment issues.

Due to its role, the HTMWG must be multi-disciplinary. Depending on the operational level of the HTMWG, its members could include the following:

- Head of medical/clinical services.
- Head of support services.
- Purchasing and supplies officer.
- Finance officer.
- Representatives from both medical equipment and plant maintenance.
- Representatives of equipment users from a variety of areas (medical/clinical, nursing, paramedical, support services, etc).
- Co-opted members (if specific equipment areas are discussed or specific interest or need is shown).

The HTM Working Group prepares the annual plans for equipment purchases, rehabilitation, and funding, and prioritizes expenditure across the facility/district as a whole (see *Guide 2* on planning and budgeting). It may have various sub-groups to help consider specific aspects of equipment management, such as pricing, commissioning, safety, etc.

How to Use These Guides

Each Guide has been designed to stand alone, and has been aimed at different types of readers depending on its content (*Section 1.2*). However, since some elements are shared between them, you may need to refer to the other Guides from time to time. Also, if you own the full Series (a set of six Guides) you will find that some sections of the text are repeated.

We appreciate that different countries use different terms. For example, a purchasing officer in one country may be a supplies manager in another; some countries use working groups, while others call them standing committees; and essential service packages may be called basic healthcare packages elsewhere. For the purpose of these Guides it has been necessary to pick one set of terms and define them. You can then modify them for your own situation.

The terms used throughout the text are outlined, with examples, in the Glossary in *Annex 1*.

We appreciate that you may find it hard to pursue the ideas introduced in these Guides. Depending on your socio-economic circumstances, you may face many frustrations on the road to achieving effective healthcare technology management. We recognize that not all of the suggested procedures can be undertaken in all environments. Therefore we recommend that you take a step-by-step approach, rather than trying to achieve everything at once (*Section 2*).

These Guides have been developed to offer advice and recommendations only, therefore you may wish to adapt them to meet the needs of your particular situation. For example, you can choose to focus on those management procedures which best suit your position, the size of your organization, and your level of autonomy.

For more information about reference materials and contacts for healthcare technology management, see *Annex 2*.

1.2 INTRODUCTION TO THIS SPECIFIC GUIDE

The Importance of Operating Equipment Safely

Healthcare technology is such an important part of healthcare today that it cannot easily be ignored. It has a very wide application; for example equipment is used to:

- help *diagnose* whether a patient has malaria
- *treat* a patient by removing their gall stones
- *monitor* the condition of a patient's heart
- provide *therapy* in order to get a patient moving about again
- *control* the environment by supplying heat and light
- *provide* necessities such as running water
- *transport* patients and staff
- *feed* patients and staff
- provide *clean* surroundings.

Every different type of equipment has its own way of functioning, and its own safety requirements. Thus it is very important to know how to make the best use of all types of equipment, so that they can last as long as possible, provide you with maximum benefits, and not become hazardous to you or your patients.

Did you know?

A number of investigations have shown that, of the equipment problems reported, approximately:

one-third	arise from operator problems
one-third	arise from minor easy-to-solve technical problems (such as a blown bulb or fuse, or a loose power cord)
only one-third	require more serious fault-finding procedures and special knowledge of the equipment.

So at least two-thirds (and maybe as much as 80%) of the problems could be corrected by properly trained equipment users. Leaving, at most, one-third of the problems which require specially trained maintenance personnel.

Staff may feel that the use of equipment is something they already know about intuitively. But as the statistics above show, it is vital to address how operators use their equipment, in order to ensure the correct care and handling of equipment. Thus, it is necessary to:

- formalize and write down procedures
- ensure staff are properly trained about the procedures
- monitor the implementation of the procedures.

Equipment operation and safety is based on a series of commonly accepted ideas and standards, which should be used to develop guidelines for staff.

Who is this Guide Aimed at?

This Guide is particularly suitable for the following:

- Equipment operators, and their department and facility managers within your organization.
- Technical (maintenance) staff in their capacity both as operators and as equipment maintainers.
- Equipment managers in your Healthcare Technology Management Service (HTMS).
- Other types of staff who have various responsibilities relating to operation and safety work, such as administrators, safety inspectors, infection control staff, trainers, and finance, purchasing, human resource, supplies and stores personnel.

All of these staff should have a good understanding of equipment operation and safety, in their common effort to provide an effective and safe health service.

The recommendations and procedures outlined are primarily aimed at facility and district level personnel. However, the Guide also explains what the responsibilities are at all levels of the system, to help you to see the bigger picture.

What Topics are Covered?

The Guide outlines a number of practical steps for:

- equipment operation
- safety
- care of equipment
- disposal of equipment
- supplies management.

These will help you to use and look after your equipment without coming to harm, and to continue to deliver health services to patients.

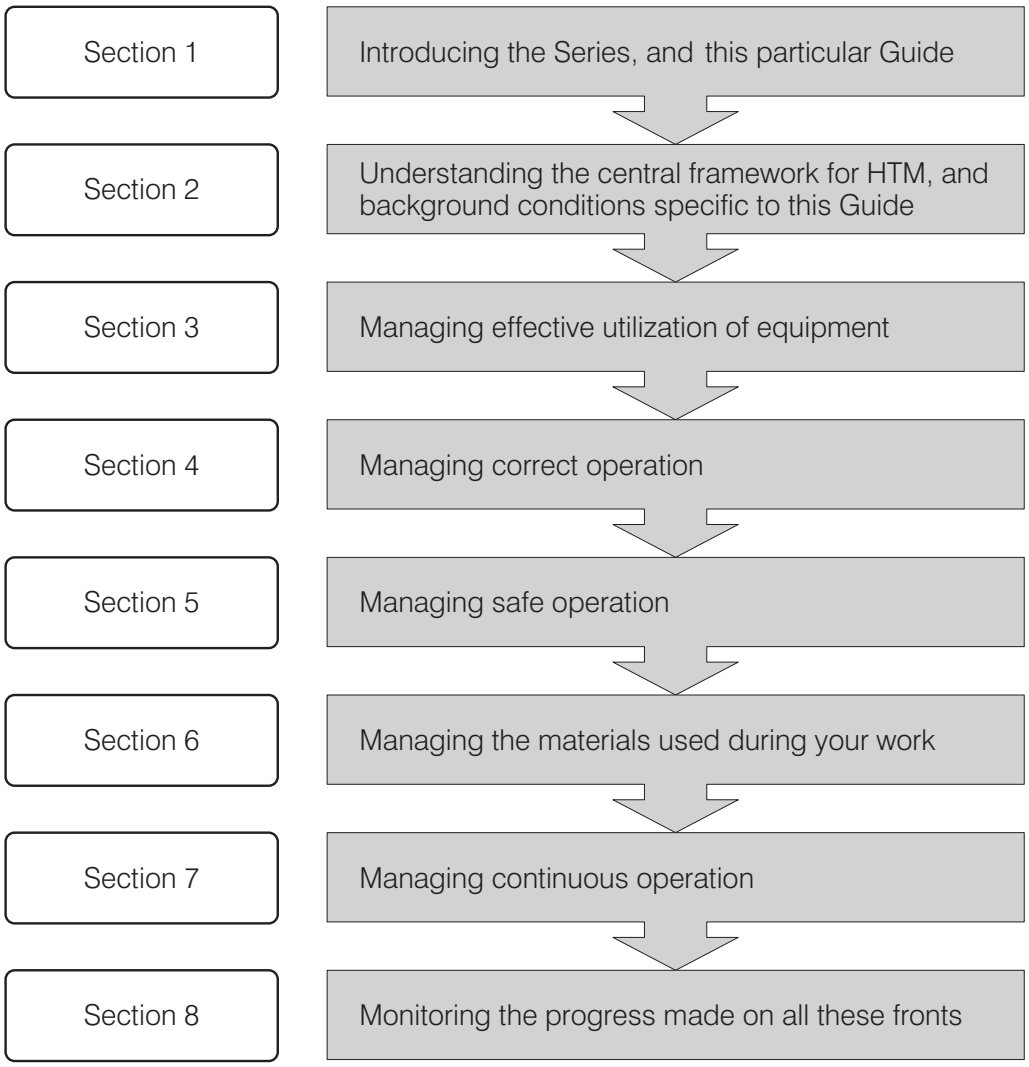
The system introduced in this Guide provides a solid approach to managing equipment operation and safety. However, we recognize that there are other ways of organizing these issues which may be more appropriate for your administrative system. The important thing is to implement a well-functioning system.

As you read through the recommendations in this Guide, you may find it useful to refer to advice in other Guides in the Series, as indicated in the text. Additional useful reference materials and contacts are given in *Annex 2*.

How is This Guide Structured?

The structure of *Guide 4* highlights the different activities which you must manage in order to achieve safe and correct use of equipment, as shown in *Figure 3*.

Figure 3: The Structure of Guide 4



Who Does What in Operation and Safety?

We suggest that the HTM Working Group has a large role to play in advising the Health Management Team on all equipment matters. Depending on the size of your facility or what level of the health service you are operating at, your HTM Working Group may like to set up a number of smaller sub-groups.

In this Guide, we suggest various **safety sub-groups** which should have appropriate members that can develop policies and practices for various safety issues, such as radiation, fire and accidents. Infection Control Committees are also required at district level and at facility level (depending on its size). Ideally these comprise:

- a micro-biologist or a medical doctor, as chair
- an Infection Control Officer
- members from all relevant departments such as laundry, kitchen, pharmacy, cleaning services, equipment maintenance, central sterile supply department (CSSD), theatre, wards, and teaching departments.

A **stock sub-group** which evaluates the recurrent stock requirements for equipment accessories and consumables could have the following types of members:

- Purchasing and Supplies Officer.
- HTM Manager.
- Stores Controller.
- Representatives from equipment user departments (appropriate to the equipment being considered).

A **training sub-group** which considers equipment-related training issues could include the following types of staff:

- Human Resource Manager.
- Head of Medical Services.
- Head of Support Services.
- HTM Manager.
- In-Service Training Coordinator.
- Infection Control Officer, senior users, and technicians (as appropriate to the equipment being considered).

Most organizations have a body which is authorized to oversee the process of condemning old and unsafe equipment. In this Guide, such a body is referred to as a **Board of Survey**. This body has the authority to officially condemn the property and assets of your organization, take it out of service, and dispose of it. It has the authority to auction-off condemned equipment and sell materials for scrap. The monies generated must usually, but not always, be returned to the central financial body of your organization (such as the treasury). These responsibilities are very important: if your Board of Survey does not function promptly and effectively your health facility will contain a large graveyard of old equipment.

Depending on the size of your organization and how many levels of decentralized authority exist, you may have just one Central Board of Survey, or you may have Regional/District Boards of Survey – you may even have Boards of Survey at facility-level. Facility-level Boards of Survey could be comprised of the following types of staff:

- Purchasing and Supplies Officer.
- HTM Manager.
- Maintenance staff.
- Head of Support Services.
- Other relevant co-opted members.

Tip

- There may seem to be a large number of sub-groups but the aim is to spread the work around different members of staff so that the HTM Working Group (*Section 1.1*) doesn't have to do everything.
- If you have a small health facility with few staff, the groups that form to oversee operation and safety can be much smaller. Try to use relevant staff with experience and those who show an interest in the task.

Since equipment that is well looked after lasts a long time, it is important for operation and safety to be seen as a collective responsibility in the health service. Thus many people have a role to play, as shown in *Box 3*.

BOX 3: The Collective Responsibility for Operation and Safety

Working Together

Equipment Users	◆ are **key** to successful operation and safety ◆ are accountable for the equipment they use (*Section 3.1*) ◆ follow good practice and behaviour around equipment (*Section 3.2*) ◆ ensure they have the necessary skills to apply the equipment correctly (*Section 3.5*) ◆ ensure they are familiar with equipment operation (*Section 4.1*) ◆ provide adequate care and cleaning of equipment (*Section 4.3*) ◆ follow correct safety procedures for themselves and patients (*Section 5*) ◆ keep equipment secure (*Section 7.1*) ◆ provide regular checks on the performance of equipment in use and carry out the planned preventive maintenance (PPM) tasks designated for users (*Section 7.2*) ◆ ensure equipment is in a functional state (*Section 7.3*) ◆ carry out basic repairs, when suitably trained
Section Heads	◆ are responsible and accountable for the equipment in their section ◆ ensure that equipment is used well – in other words the equipment is cleaned, cared for, checked, calibrated, used correctly and safely, and is kept securely ◆ report faults to the HTM Team promptly (*Section 7.4*)

Continued overleaf

BOX 3: The Collective Responsibility for Operation and Safety (continued)

Working Together

HTM Managers	◆ ensure technical staff carry out planned preventive maintenance and periodic user training (see *Guide 5* on maintenance management) ◆ ensure that senior technical staff correctly write-off and dispose of equipment at the end of its life (*Section 7.5*)
HTM Teams	◆ test equipment to ensure that it is in an acceptable and trustworthy condition (*Section 7.3*) ◆ know the correct maintenance and repair routines, follow good maintenance practice, and have the necessary skills (see *Guide 5* on maintenance management)
Health Management Teams (at facility, district, regional and central level) and their HTMWG	◆ address the practical issues involved with implementing all the equipment usage and safety policies ◆ ensure sufficient financial and human resources are available to guarantee the continuous effective operation and safety of equipment (see *Guide 2* on planning and budgeting) ◆ train staff to understand their responsibilities towards equipment (*Section 3.5*) ◆ ensure equipment is replaced when it reaches the end of its life (see *Guide 2* on planning and budgeting) ◆ ensure annual goals and plans are set and monitored to improve the operation and safety of equipment (*Section 8*)
Finance Officers	◆ take into account the calculations of accessory, consumable, and spare part usage rates, when calculating recurrent budgets (see *Section 6.3*, *Guide 2* on planning and budgeting, and *Guide 5* on maintenance management) ◆ allocate sufficient funds for all operational and safety costs (see *Guide 2* on planning and budgeting)
Purchasing and Supplies Officers	◆ promptly procure the required accessories, consumables, and spare parts, so that equipment remains functioning (see *Section 6.1*, and *Guide 3* on procurement and commissioning)
Stores Controllers	◆ make equipment accessories and consumables stockable items in the stores system (*Section 6.2*) ◆ use a stock control system to reorder goods before stocks run out (*Section 6.3*)
Human Resource Departments	◆ hire suitably skilled operators and maintenance staff and offer attractive packages in order to retain them in post (*Section 2.2*) ◆ facilitate in-service training to improve the skills required for equipment (*Section 3.5*) ◆ ensure that staff performance, with regards to good and bad practice when using equipment, is reflected in appraisals (*Section 8.2*)
In-Service Training Coordinators	◆ enable staff to express needs for equipment-related skills development ◆ arrange the necessary relevant training in equipment-related subjects for all staff ◆ develop training resources, and train staff according to timetables (*Section 3.5*)
Infection and Hazard Control Officers and Safety Sub-groups	◆ monitor levels and incidence of infection, hazards, and accidents (*Section 8.2*) ◆ develop policies and practices to control infection, hazards, and accidents (*Section 5*) ◆ train staff and assist them to comply with safety procedures
Boards of Survey	◆ are authorized to condemn and board equipment at the end of its life (*Section 7.5*) ◆ are authorized to officially dispose of the property and assets of your organization ◆ are authorized to officially auction-off condemned equipment and provide the monies to the central financial body (such as the treasury).

2. FRAMEWORK REQUIREMENTS

Why is This Important?

In order to deliver quality health services, it is essential to undertake effective healthcare technology management.

There are various framework requirements to help you do this. These include legislation, regulations, standards, and policies.

These framework requirements create the boundary conditions within which you undertake healthcare technology management. They include central or national guiding principles, policy issues, and high-level assumptions that can impede or assist you in your work.

It is very difficult to function effectively if these framework requirements do not exist, and you should lobby your organization to develop them.

Depending on how autonomous your health facilities are, you may be able to develop these framework requirements at facility, region/district, or central level.

In most industrialized countries, laws, regulations, policies and guidelines form an indispensable part of health service management. For many developing countries, however, these regulatory procedures have yet to be developed.

Guide 1 provides a fuller analysis of how to develop these instruments, and shows that effective healthcare technology management (HTM) is essential in order to deliver quality health services. *Section 2.1* summarizes these points and offers advice on:

- the regulatory role of government
- establishing standards for your health system
- policy issues for HTM
- the importance of introducing an HTM Service
- managing change.

Section 2.2 goes on to discuss the background conditions specific to this Guide, and provides advice on:

- authorities responsible for guidance on equipment operation and safety
- the aims, staffing requirements, and funding issues for operation and safety.

2.1 FRAMEWORK REQUIREMENTS FOR QUALITY HEALTH SERVICES

Regulatory Role of Government

The World Health Organization (WHO) identifies four distinct functions for health systems:

- The provision of health services.
- The financing of health services.
- The creation of health resources (investment in facilities, equipment, and training).
- The stewardship of health services (regulation and enforcement).

Health service provision and financing, as well as resource creation may be taken on by both the government and the private sector. Thus, there are various options for organizing health systems:

- Mainly public.
- Mainly private for-profit (for example, run by a commercial organization), and private not-for-profit (for example, run by faith organizations, NGOs).
- A mixture of government and private organizations.

However in all these systems, the government is solely responsible for the regulation of health services. The reason for this is that the government has a duty to ensure the quality of healthcare delivered in order to protect the safety of the population. These regulations may then be enforced directly by government bodies or they may be enforced by publicly funded bodies, such as professional associations, which apply government sanctioned regulations.

Most governments would agree that the protection of health and the guarantee of safety of health services is vital. However, in many countries this regulatory function is underdeveloped, with weak legal and regulatory frameworks.

To regulate health services, the government should:

- adopt suitable quality standards for all aspects of health services, including acceptable international or national standards for healthcare technology, drugs, and supplies in order to ensure their efficacy, quality and safety
- establish systems to ensure standards are met, so that the bodies enforcing regulations have legal sanctions they can use if standards are infringed
- establish wide-ranging policies covering all aspects of the utilization, effectiveness, and safety of healthcare technology, drugs, and supplies
- establish systems to ensure these policies can be implemented.

For health services, the Ministry of Health is the body most likely to develop these government regulations. Other health service providers need to be guided by government laws, and should look to the Ministry of Health for guidance or follow their direction if required to do so by law or regulation.

Establishing Standards for your Health System

The government should agree on which quality standards have to be met by the health services in general. These will cover areas such as:

Standard
a required or agreed level of quality or attainment set by a recognized authority, used as a measure, norm, or model

- procedures and training
- construction of facilities
- healthcare technology, drugs, and supplies
- safety
- the environment
- quality management.

Since drawing up these standards can be both time consuming and expensive, governments may often choose to adopt acceptable international standards (such as ISO), rather than develop their own. However, they must be suitable and applicable to your country situation and fit in with your country's vision for health services.

The adoption of suitable international or national standards for healthcare technology is of particular relevance to this Guide. Such standards would cover areas such as:

- manufacturing practices
- performance and safety
- operation and maintenance procedures
- environmental issues (such as disposal).

These are important since countries can suffer if they acquire sub-standard and unsafe equipment. Again, in the majority of cases ministries of health would save money and time by adopting internationally recognized standards. For more information on introducing internationally recognized standards into your procurement procedures, refer to *Guide 3* on procurement and commissioning.

It is not enough simply to establish these standards; they also need to be adhered to. For this reason, you should establish a national supervisory body that has the power to ensure that health service providers comply with the standards in force. To be effective, such an enforcement agency must be allocated sufficient financial and personnel resources. It should also be linked or networked with corresponding international bodies.

Much healthcare technology in developing countries is received through foreign aid and donations, but such products don't always meet international standards. Therefore, your country will need to negotiate with external support agencies. The best way to do this is to develop regulations for donors that supply equipment (see *Annex 2*, and *Guide 3* on procurement and commissioning).

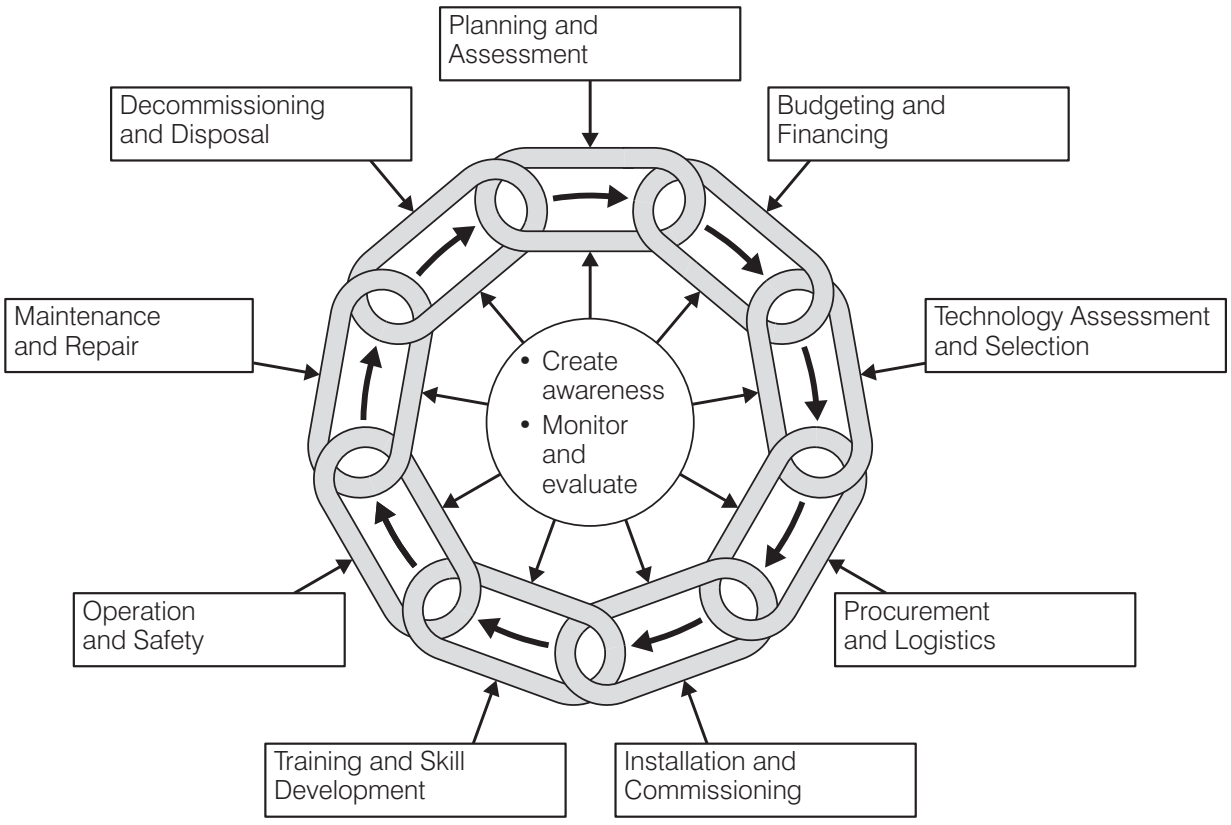
The legal system plays an important role in enforcing such standards, by ensuring that any infringements can be effectively prosecuted. It is therefore essential that the legal system is allocated sufficient financial and human resources to enforce claims against any institution operating equipment that does not meet the prescribed standards.

Developing Policies for Health Services

Every country needs to establish wide-ranging policies covering all aspects of health services. National health policies are usually developed by the Ministry of Health. If these policies are linked to regulations, then other health service providers must also follow them. Each health service provider can expand them internally, and must establish systems to ensure they are implemented.

One key framework requirement for this Series of Guides is that your health service provider should have started work on a Healthcare Technology Policy (for guidance on this process, see *Annex 2*). Such a policy usually addresses all the healthcare technology management (HTM) activities involved in the life-cycle of equipment, as shown in *Figure 4*.

Figure 4: The Healthcare Technology Management Cycle



Here we will consider just four issues that provide key background conditions:

- A vision for health services.
- Standardization.
- The provision of maintenance.
- Finances.

A Vision for Health Services

Every health service provider needs a realistic vision of the service it can offer. This should include a clear understanding of its role in relation to other health service providers in the national health service. Only when this vision is known can the health service provider decide what healthcare technology is needed, and prioritize the actions required to develop its stock of equipment.

It is unhelpful if lots of individual health facilities pull in different directions, with no coordinated plan for the health service as a whole. The central authority of each health service provider should be responsible for considering what sort of healthcare should be offered at each level of their health service. Preferably they will collaborate with the Ministry of Health, or follow their guidance if regulated to do so.

If there is no health service plan, there is no framework on which to base decisions. *Guide 2* provides further information on developing a vision and planning your healthcare technology stock.

Standardization of Healthcare Technology

Standardization
(also known as rationalization, normalization and harmonization) – the process of reducing the range of makes and models of equipment available in your stock, by purchasing particular named makes and models.

Introducing an element of standardization for healthcare technology will help you to limit the wide variety of makes and models of equipment found in your stock. By concentrating on a smaller range for each equipment type, your technical, procedural, and training skills will increase and your costs and logistical requirements will decrease (see *Guide 1*).

It is easier to achieve standardization if equipment is planned and ordered on a country-wide, district-wide or health service provider basis. It is therefore important to combine forces with other facilities or health service providers, and it may be wise to follow standardization strategies of the Ministry of Health. It is important that these standardization efforts do not just apply to products purchased by health facilities, but also to donations.

Standardizing your healthcare technology may be difficult for a number of reasons. Your country and local businesses may have their own trade practices and interests. National donors may have tied-aid practices, while the procurement procedures of international funding agencies, health service institutions, and individuals may act against your standardization strategies (see *Guide 3*).

You may need to hold discussions with organizations such as the Ministry of Industry and/or Trade, the chambers of commerce or specific business associations, as well as external support agencies. However, it is well worth persevering, as standardization offers many benefits, both in terms of cost and efficiency.

Provision of Maintenance

Proper maintenance is essential to ensure that the equipment you have purchased continues to meet the standards required throughout its entire working life.

Undertaking maintenance belongs to the service provision function of health systems, and could therefore, in principle, be carried out by the government, the private sector, or by a mixture of the two.

It is useful to organize the maintenance system along similar lines to the health service provision already existing in your country. For instance, if the health sector is predominantly run by the government, it is probably simplest to let the government run the maintenance organization as well. In contrast, if private organizations run the health services, it makes little sense for the maintenance activities to be carried out by a government body. In the majority of cases, a mixed system is most likely.

However, the government may wish to take a regulatory role and establish regulations that guarantee that healthcare technology performs effectively, accurately, and safely. The rules established are valid for all health service providers, irrespective of their type of organization.

Specific maintenance requirements would not need to be prescribed by the regulatory body. Instead, it is up to individual health service providers to decide how these will be provided. However, the nature and the complexity of some maintenance services often call for partnerships between the public and private health service providers. Partnerships may also exist between health service providers and private sector sources of maintenance support. For more details, refer to *Guide 1*.

To provide maintenance services, you will normally need to establish good links between maintenance workshops. This will create a network that supports the needs of all your health facilities. Maintenance is, of course, only one of many HTM activities that need to be carried out. However, the fact that maintenance workshops usually already exist in most countries serves as a useful starting point for establishing a physical HTM Service across your health service provider organization and across your country. For more details on how to organize an HTMS, refer to *Guide 1*.

Finances

To ensure that healthcare technology is utilized effectively and safely throughout its life, your health service provider will need to plan and allocate adequate capital and recurrent budgets. See *Guide 2* for more advice on this.

In a government-organized system these funds have to be provided by government budgets, while private systems or mixed systems must generate the required funds from their customers, or from benefactors and donors.

Depending on your health service provider and country, your HTM Service may be able to generate income by charging for services provided. Whether this income can be used to further improve the HTM Service depends on the policies of the responsible financing authority (such as the treasury or central finance office). *Guide 6* provides advice on this.

The Importance of Introducing a Healthcare Technology Management Service

We have established the importance of:

- adopting standards for healthcare technology
- developing healthcare technology policies
- establishing systems to ensure the policy is implemented.

All these aims could be achieved if each health service provider practised healthcare technology management (HTM) as part of the everyday life of their health service. The best way to do this is to have an HTM Service incorporated into each health service provider organization.

Box 2 (*Section 1.1*) shows that HTM provides a wide range of benefits. *Guide 1* attempts to express this in terms of the sorts of savings that can be made if HTM is effectively carried out. Taking maintenance as an example, we can see that it has not only a positive impact on the safety and effectiveness of healthcare technology, but that it also has two important economic benefits:

- it increases the life-span of the equipment
- it enhances the demand for health services, since demand for services is crucially dependent upon the availability of functioning healthcare technology.

Healthcare technology that is out of order quickly leads to a decline in demand, which will in turn reduce the income and quality of services of the health facilities. You will lose clients if, for example, it becomes known that malfunctioning of sterilization equipment may endanger the health of the patients. Similarly, patients will avoid visiting health facilities that do not possess functioning diagnostic equipment.

Thus the justification for introducing an HTM Service is that it will benefit you economically and clinically, by ensuring that healthcare technology continues to meet the standards required throughout its working lifetime.

The activities of an HTM Service belong to the service provision function of health systems. However, the government may wish to take a regulatory role and establish regulations that guarantee that HTM occurs. To achieve this, it will be necessary to have:

- a government body to provide regulations that will ensure the continued performance and safety of healthcare technology throughout its life
- a control mechanism to check that all health service providers pursue these healthcare technology management activities effectively
- legal or other sanctions that are enforceable if the rules are infringed.

The government body responsible for providing regulations could be the central level of the national HTM Service. Each health service provider could then develop its own HTM Service. It should involve a network of teams and committees that enable HTM to be practised in all facilities. In order to establish an effective HTM Service, you will need to provide sufficient inputs, such as finance, staff, workshops, equipment, and materials. Only in this way will you get the outputs and benefits that you require. For details of how to develop such an HTM Service, see *Guide 1*.

The organizational chart for the HTM Service will vary depending on the size of your country and your health service provider organization, and whether you are just starting out. However, *Figure 5* provides an example of the relationship between HTM Teams and HTM Working Groups (*Section 1.1*) that we envisage.

How to Manage Change

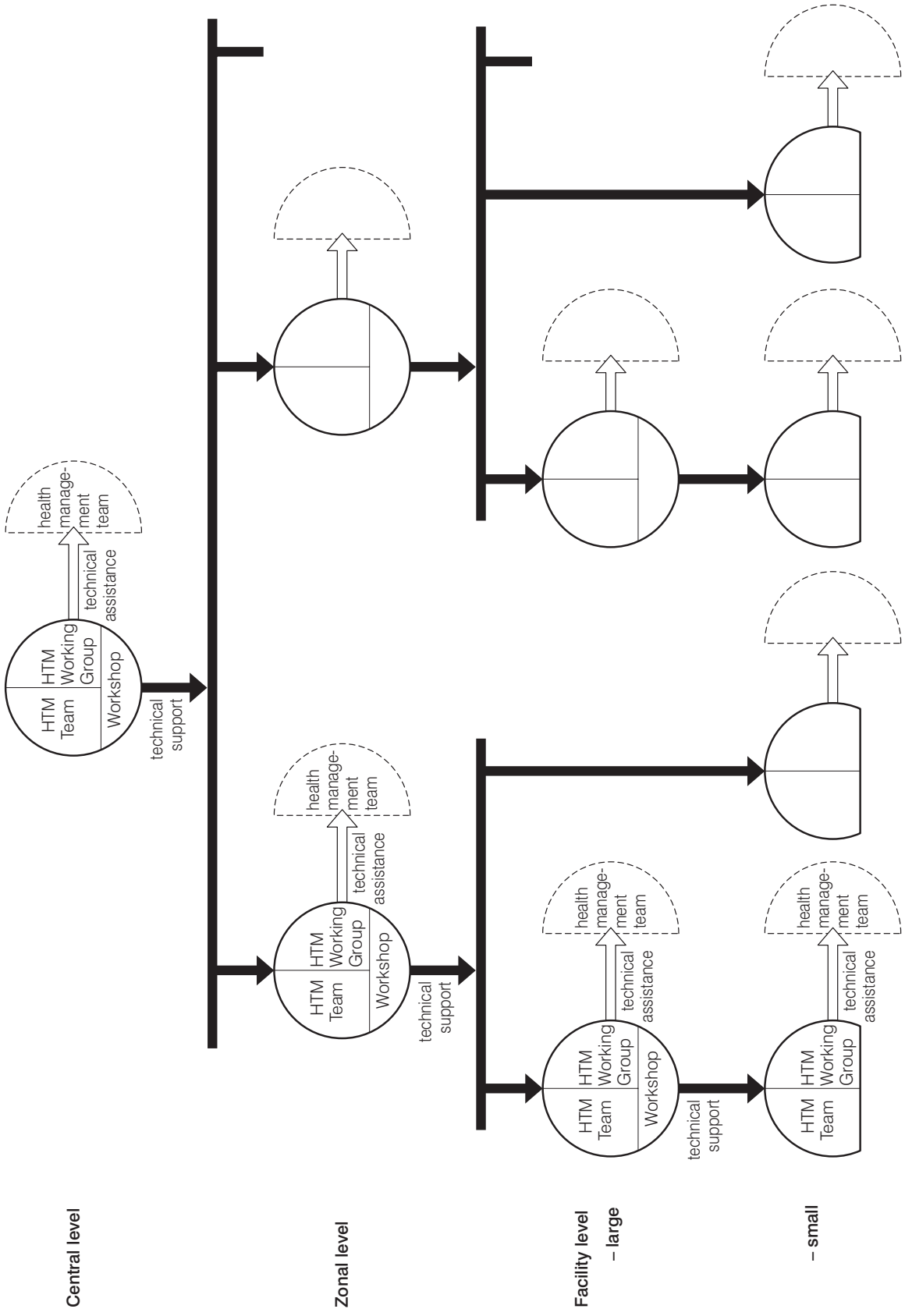
The regulatory requirements presented in this Section may appear somewhat idealistic, compared to the reality in many health systems. However, the aim is not to highlight the deficiencies of existing systems, but to provide a blueprint for a functioning healthcare technology management system. Hopefully, this will enable you to get the right framework conditions in place, and thus improve the effectiveness and the safety of your health services.

We are **not** recommending that your health service provider:

- throws out all its current HTM strategies and starts again
- makes sudden and sweeping changes that are likely to fail if they are over ambitious.

Rather it is better to take a step-by-step approach, introducing changes gradually, with a careful review process. To implement an HTM system with all the complexities described in this Series of Guides will take several years, and to try to achieve everything at once could be disastrous. However, for healthcare technology management to improve, it is important to act.

Figure 5: Sample Organizational Chart for the HTM Service



It is possible to write down all the correct procedures and yet still fail to improve the performance of staff. To ensure that your HTM procedures are effective, it is important for there to be good managers who can find ways to motivate staff (*Sections 2.2 and 8*). Simply ordering staff to implement new procedures doesn't usually work. It is much better to discuss and develop the procedures with the staff who will implement them. This could take the form of discussion, working groups or training workshops. People who are involved in developing ideas about their own work methods are more likely to:

- understand the objectives
- understand the reasons why processes are necessary
- be encouraged to change their way of working
- be more interested in making changes which result in improvement
- see that the aim of the HTM procedures is to improve their delivery of healthcare.

We recognize that many readers will face difficulties such as staff shortages, poor finances, lack of materials, a lack of influence and time, and possibly even corruption. Introducing new rules and procedures into a system or institution that has no real work ethic, or which possibly employs dishonest workers, will not have any significant effect.

Therefore, strategies may be required to bring about cultural and behavioural change. For example:

- When materials are short, instead of focussing upon breakages and loss, place more emphasis upon the importance of staff working hard and putting in the hours.
- Favour good managers who are seen to be present and doing what they preach.
- Encourage an atmosphere where staff are praised for good work, rather than a culture of judgement and criticism.

Introducing rules and administrative procedures alone will not be sufficient to bring about cultural change. You will also need to find ways of increasing performance and productivity, and acknowledging/rewarding good behaviour is essential. For example:

- it is better to break a tool while actively undertaking maintenance, rather than breaking nothing but never doing any work
- it is better to break a rule in an emergency (such as withdrawing stocks from stores), rather than stick to the rules and risk the possible death of a patient.

Annex 2 has some examples of useful reference materials. To bring about such changes, you will require skills in:

- managing change
- staff motivation
- effective communication
- encouragement
- supportive training with demonstrations.

All parties involved in the network of HTM Teams and HTM Working Groups need to participate in developing the HTM Service. This will encourage a sense of ownership of the Service and its responsibilities, and will lead to greater acceptance and motivation among staff. If you are short of skilled staff (such as technicians, managers, planners or policy-makers), you may need to obtain specialist support to assist with some of these tasks.

2.2 BACKGROUND CONDITIONS SPECIFIC TO THIS GUIDE

Your country and health service provider may have existing regulating principles and conditions which will affect, or can inform, aspects of your operation and safe use of equipment.

You will need to see if the regulations and policies discussed in this Section exist in your country/organization. If they do, then follow them. If not, you will need to flag these issues at the central level of your organization, and continue to follow the advice provided in this Guide at your level.

Responsible Management Authorities

If you work for a health service provider organization, you will need to conform to:

- any regulations and guidelines concerning equipment operation and safety produced by the central management body.

In addition, there may be professional bodies which provide guidance for their area of expertise (*Section 4*). For example:

- Bodies such as the Medical Council and General Nursing Council which have guidelines on clinical practices.
- The National Laboratory which provides guidance on laboratory practices.
- The National Board of Survey which has regulations and procedures on the condemning, boarding, and auctioning of equipment at the end of its life.

Country Experience

Many developing countries are short of staff who can monitor and regulate safety issues, and suffer because of this. For example:

- *Some have few safety inspectors nationally who can monitor the performance of boilers, lifts, electricity installations, etc.*
- *Some may only have one infection control officer for the whole country.*

Authorities Responsible for Safety

A great many bodies may exist in your country which produce guidance on the wide range of safety issues covered in *Section 5*. For example, you will need to conform to:

- national 'Health and Safety at Work' legislation
- the national body responsible for the regulations on radiation control, and guidelines regarding dosimeters
- the National Laboratory which sets quality standards for laboratory tests
- bodies such as the Medical Council and General Nursing Council which have guidelines on infection control
- the national body, such as the Ministry of Labour, which sends out inspectors who issue certificates of safety and workmanship on pressure vessels (such as boilers and autoclaves), and inspect lifts
- local government bodies or council authorities which produce building safety regulations and waste disposal systems
- any environmental and/or public health authority which produces environmental policies and procedures and waste disposal regulations
- local fire service authorities which develop fire regulations and guidelines
- the national body responsible for the regulations and standards for electricity supply and electrical installations.

Infection and hazard control committees are required in the health service at district level and at facility level (depending on the size of the facility). They need access to international data on hazards. Feedback is available on hazards from international sources, in the form of international 'Alert' reports (see *Annex 2*). The central level of your health service provider organization will need to subscribe to the sources of this literature, and make it accessible to health facilities.

With guidance from government, your health service provider needs to take overall responsibility for safety issues within its facilities, from a management and legal viewpoint (*Section 2.1*), since the health service provider is the body that people will make claims against if there are any adverse incidents.

Effectiveness of Equipment

This Guide defines 'effectiveness' as the appropriate use of equipment and its availability for use (*Section 3.3*). It does not attempt to cover cost-effective delivery of healthcare. Measuring the cost-benefits of effective healthcare delivery requires special monitoring techniques. It is an enormous subject, and is not the main scope or aim of this Guide. *Guide 2*, however, covers how to effectively plan and budget for healthcare technology, and will help you to deliver the healthcare that you wish to provide.

Healthcare technology represents a substantial asset for your health service provider that needs to be managed efficiently. Health facilities need sufficient functioning items of equipment which support the efficient and effective delivery of patient care. Under-provision threatens the effective treatment of patients. Equipment can involve risks to patients and staff, particularly if it is not used properly. Thus, the quality of care delivered to patients is dependent upon how effectively you purchase, manage, and use your equipment.

Staffing and Skills Levels

If your health service provider is to guarantee the correct and safe use of its equipment, it needs to recruit enough staff with the necessary skills (*Section 3.5*). Adequate training for equipment operators and managers is necessary if you are to fill the wide variety of health service posts, and ensure specialists for many disciplines are available. It will be very difficult to ensure effective and safe equipment operation without sufficiently skilled staff. Thus your organization will need to offer adequate recruitment packages so that staff can be retained in employment.

Ideally your health service provider will be able to pursue strategies (*Section 8.2*) to:

- motivate staff
- evaluate staff performance
- use staff appraisal as a positive tool to develop staff skills and enable career progression
- discipline staff when necessary.

However, their ability to achieve these goals will depend on the type of human resource policies and procedures they have in place.

In addition, the central level of your organization usually plays a significant role in, among other things:

- developing training plans
- organizing and providing training scholarships
- approaching external support agencies to finance training programmes.

Staff training needs should be addressed at every level by an overall Equipment Training Plan. This is an ongoing programme of in-service training. The development of such a plan is described in *Guide 2* on planning and budgeting , and should be financed by your health service provider. It will also need to develop a clear policy on what form of 'bonding' you will use to ensure that a member of staff sent for training remains within the health service on their return.

To be able to hire staff, your health service provider needs an adequate structure of suitable posts. Job descriptions are valuable tools for managers as they enable you to:

- identify suitable candidates for each post
- make the best use of the staff available
- plan for further training
- recruit suitable people.

Job descriptions are equally important for each worker: they are a guideline for the work expected of them, the skills required, and possible ways to achieve promotion. However, it is important not to limit any individual to working at a specific level as this could seriously hamper the service. A doctor must sometimes be prepared to help out with tasks such as nursing and cleaning activities.

To be able to recruit clinical and support staff with these skills, there need to be sources of basic training in your country or geographical region. *Section 3.5* discusses the sorts of basic training required: its availability and your ability to access such courses will depend on the country you live in. It is important for there to be modules on the basic training courses which teach equipment-specific skills; however this will depend on the strategies that have been adopted by your training authorities.

Recurrent Funding

Equipment only remains operational and safe if adequate recurrent budgets are planned and allocated by your health service provider. These budgets need to cover all equipment-related expenditure requirements, including the supply of:

- accessories
- consumables
- spare parts
- protective clothing
- test equipment
- reference materials.

Guide 2 of this Series provides advice on how your health service provider can plan and budget for recurrent costs. You will need to work within the financial resources allocated to you. In addition, you will have to follow the financial policies and procedures of your organization, in order to ensure that stock management and expenditure accounting are carried out according to the regulations.

Box 4 contains a summary of the issues covered in this Section.

BOX 4: Summary of Issues in Section 2 on Framework Requirements

Quality Health Services

Government	◆ actively regulates health services whether they are delivered by public providers, private providers, or a mixture of the two ◆ develops checking systems and legal sanctions for infringement of health regulations ◆ adopts suitable standards for quality health services, in general ◆ specifically for healthcare technology, adopts standards for: - design, development and manufacturing - performance and safety - use and training - waste disposal ◆ develops donor regulations to ensure all equipment received through foreign aid and donations also complies with the standards ◆ establishes public or quasi-public supervisory bodies to enforce regulations and standards.
Ministry of Health	◆ develops national policies for health services ◆ specifically develops a Healthcare Technology Policy to cover all healthcare technology management activities including: - a vision - an element of standardization - the provision of maintenance - provision of finances for all HTM activities - the organizational structure for an HTM Service ◆ regulates on these issues (if required) ◆ develops an HTM Service made up of a network of teams and working groups ◆ uses the central level of the HTMS as the national regulatory body, if necessary, and to ensure that HTM policies are implemented ◆ provides sufficient inputs to ensure the HTMS is effective ◆ uses strategies to manage the changes involved carefully, so that they can be successful.
All Health Service Providers in general	◆ conform to regulations and guidelines provided by government ◆ conform to the standards set by government ◆ follow the policies of the Ministry of Health (MOH) if regulated to do so ◆ develop their own internal Healthcare Technology Policy and expand strategies ◆ develop their own HTM Service made up of a network of teams and working groups, with sufficient inputs to ensure it is effective, in order to ensure that HTM policies are implemented ◆ follow MOH regulations on the HTMS if regulated to do so ◆ implement strategies to develop skills in managing change, staff motivation, effective communication, encouragement, and supportive training with demonstrations ◆ introduce rules and procedures using discussion, working groups, training workshops, etc with the staff that will implement them ◆ include all parties involved in the network of HTM teams and working groups in the development of the HTMS ◆ introduce changes to HTM step-by-step, with a careful review process.

Continued overleaf

BOX 4: Summary of Issues in Section 2 on Framework Requirements (continued)

Operation and Safety	**All Health Staff and Managers**	◆ conform to regulations and guidelines provided by relevant bodies on: - equipment operation and safety - clinical practice - laboratory practice - condemning, boarding, and auctioning of equipment at the end of its life - health and safety at work - radiation control and dosimeters - quality standards for laboratory tests - infection control - safety inspections - building safety - waste disposal - the environment - fire - electricity supply and electrical installations.
	Health Service Providers	◆ set up infection and hazard control committees and a variety of safety groups to cover all safety areas ◆ subscribe to relevant sources of operation and safety literature, such as international data on hazards ◆ develop human resource policies and procedures to ensure staff career development and help to motivate staff ◆ establish an Equipment Training Plan (see *Guide 2*) and job descriptions ◆ liaise with training authorities to provide suitable equipment-specific modules on basic training courses ◆ develop financial policies and procedures which will ensure adequate funds for equipment operation and safety, and effective stock management.

3. HOW TO ENSURE EQUIPMENT IS UTILIZED EFFECTIVELY

Why is This Important?

Equipment plays an essential role in the provision of healthcare services. Staff must therefore be responsible for the equipment they use, be accountable for their actions, and practise good behaviour when handling equipment.

To obtain maximum benefit from the equipment you own, it must be used efficiently.

In order to respond to the rapid changes in equipment design and utilize equipment effectively, you need to introduce an ongoing skill-development programme for equipment operators.

It is necessary to monitor how effectively equipment is utilized. Proper equipment usage leads to the following advantages:

- Equipment is operated safely both for patients and users.
- Equipment lasts longer.
- You will achieve maximum benefit for any financial investments.
- Equipment which is kept in good working order helps health staff to do their work and deliver better services to patients.

In this Section the effective utilization of equipment is discussed through the following issues:

- Making staff accountable for their actions with equipment (*Section 3.1*).
- Encouraging staff to practise good behaviour when handling equipment (*Section 3.2*).
- Using equipment efficiently (*Section 3.3*).
- Providing access to information and reference materials (*Section 3.4*).
- Developing staff skills (*Section 3.5*).

It is useful for your health service provider to develop an Equipment Usage Policy. This could be based on the procedures and good practice provided in *Sections 3 to 8* of this Guide. Once a policy has been developed, staff should be trained to understand the issues involved.

3.1 ACCOUNTABILITY

Users are the custodians of the equipment they operate. It is their responsibility to ensure that equipment is in a good functional state at all times. In other words, that it is:

- working
- giving reliable results
- being operated correctly and safely.

It is common for health service staff to feel that they do not own the equipment, therefore it is not their responsibility, and it must be somebody else's problem. It will be necessary to introduce the following new ideas to all staff, and incorporate such responsibilities into their job descriptions:

- Collective responsibility for health service property.
- Their new role of being accountable for equipment.
- Their performance with regard to equipment being registered as part of their appraisals (*Section 8.2*).

Not only must users be responsible for the equipment in their care, they must also be responsible for using consumables correctly. For example, placing the wrong type of overhead transparencies into photocopiers or printers will result in the plastic melting and the equipment being damaged.

It is inevitable that equipment will be lost or damaged from time to time. Equipment security should be addressed seriously (see *Section 7.1* for guidelines). Damaged equipment that has not been subjected to abuse should not be charged to the operator. But your organization has to consider what action will be taken if equipment is missing or abused, and if particular individuals are the persistent cause of problems. Good or bad performance when using equipment can then be used in the staff appraisal process (*Section 8.2*).

Your response to good and bad performance will depend on local human resource policies and procedures, your strategies for motivating staff (*Section 2.1*), and whether you take a positive approach, a disciplinary approach, or a combination of the two.

One option is to take a positive approach which encourages good behaviour. Staff who consistently treat their equipment well and take care of it are given a reward as an incentive. This could be the chance to attend a skills-development course, or perhaps nomination as a trainer of others: the strategies chosen would depend on the type of equipment involved. For example, individual staff members may be issued with diagnostic sets which are checked once a week (or once a month). Anyone who has a complete set every three (or six) months is given a bonus: some batteries, for example. After five years, the diagnostic set could perhaps become the property of the staff member.

BOX 5: Strategies for Making Staff More Accountable

Type of Staff	Strategies
Heads of Section	◆ given overall responsibility for the equipment in their section, according to their inventory (see *Guide 2* on planning and budgeting for a description of the inventory), and undertake regular inventory checks to look for missing equipment and accessories ◆ made responsible for conforming to the local security regulations for the facility and its site (*Section 7.1*) ◆ ensure their staff have sufficient skills to operate and care for equipment correctly and safely, and help them to access appropriate training or reference materials (*Sections 3.4 and 3.5*).
Operators-in-Charge	◆ during every shift, made responsible for undertaking functional checks on the equipment as part of user Planned Preventive Maintenance (PPM) schedules (*Section 7.2*).
Equipment Users	◆ made responsible for the state of the equipment, accessories and consumables they handle and use ◆ take personal responsibility for ensuring they operate equipment correctly, and that they know the correct operating techniques and applications (*Sections 4.1 and 4.2*) ◆ take personal responsibility for using the correct consumables in a non-wasteful way (*Section 6*) ◆ take personal responsibility for ensuring they operate equipment safely, and knowing the proper safety procedures (*Section 5*) ◆ made responsible for the daily care and cleaning of the equipment they use with the correct cleaning chemicals (*Section 4.3*) ◆ made responsible for monitoring that equipment is functioning properly and is providing the type of results expected, and reporting any faults immediately to the HTM Team through their Head of Section (*Section 7.4*) ◆ ensure they have been specifically trained to undertake these tasks, and if they require further skill-development put in a request to their Head of Section (*Section 3.5*) ◆ take responsibility for conforming to the local security regulations for the facility and its site (*Section 7.1*).
Purchasing and Supplies Officers	◆ made responsible for purchasing the correct consumables and cleaning chemicals.
Stores Controllers	◆ made responsible for keeping track of stocks of consumables and materials in the various stores (*Section 6*).

Continued overleaf

BOX 5: Strategies for Making Staff More Accountable (continued)

Type of Staff	Strategies
Health Management Teams	◆ try to develop a suitable working environment where managers are seen to be present, and performing well themselves ◆ consider positive strategies with bonuses and rewards for good behaviour with equipment, as incentives for making staff more responsible and accountable. ◆ consider disciplinary mechanisms so that staff are charged for intentional loss of, or damage to equipment and accessories, to make them more accountable for their actions. Typical issues to consider to make the system fair are: - Should someone who breaks equipment while working correctly be charged? - How do you ensure that charging doesn't result in people breaking nothing by doing nothing? - Should missing or wilfully damaged equipment be charged to the operator or the Section Head, in order to deter theft and abuse? - Should fines be deducted from the salary of staff by instalments? - In the case of more expensive items, should penalties be incurred in the individual's terminal benefits? - Should persistent loss or abuse result in suspension or termination of employment? - Should equipment and accessory damage caused by the incorrect use of chemicals for disinfection be chargeable to the individuals responsible? - Should chemical damage caused by the purchase of incorrect products be charged to the Purchasing and Supplies Officer responsible?

Another option is to take a disciplinary approach, and establish mechanisms so that damage and breakages can be charged to staff. This method aims to make staff more accountable for their actions, in the same way that maintainers are often charged for damage to tools (see *Guide 5* on maintenance management). Serious negligence may lead to suspension – for example, for crashing an ambulance due to reckless driving – and persistent offending may result in termination of employment. If you choose to take such a route the system should be fair, and only target those who abuse equipment intentionally (*Section 2.1*). Each case should be assessed individually, using formal disciplinary hearing procedures. Finance and salary departments should base fines on realistic quotes for replacing equipment.

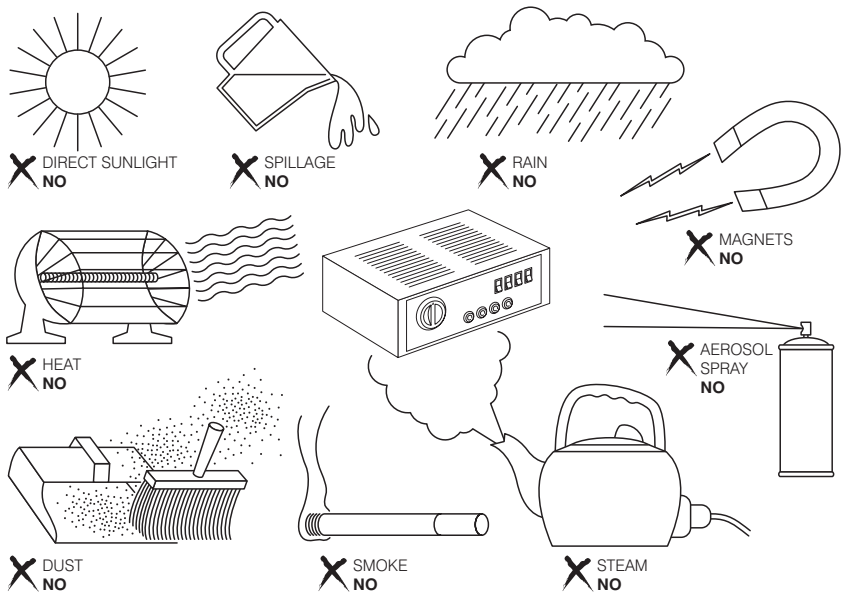
However, any approach taken to enforce rules for general staff is only workable if it takes place in the right working environment, otherwise petty tyranny may prevail. The most important thing is for staff to be in an environment where their managers are present, involved, expect the correct results, and are seen to perform well themselves.

Box 5 provides some strategies for making staff more accountable, by clearly setting out their responsibilities towards equipment.

3.2 GENERAL GOOD BEHAVIOUR TOWARDS EQUIPMENT

It is very important to instil in health staff good practice concerning their interaction with equipment. Some staff will intuitively know how to treat equipment, others will need to be guided and taught. Some staff may not have regularly come into contact with equipment before starting their job in the health service. This Section looks at the general behaviour of staff in relation to any type of equipment. The approach should be to teach staff, using demonstrations, to remember the basic motto and strategy of 'Safety – Care – Maintenance': they need to understand the basic dos and don'ts when dealing with equipment.

A list of dos and don'ts is often given in the equipment manufacturer's literature. Staff should also have written resources from their training sessions and, in some cases, posters which display the guidance and experience of their colleagues on good behaviour towards equipment (*Section 3.5*). Copies of this advice should be made available in the library for reference (*Section 3.4*).



Source: Lee, P, 1995, 'Get it Right!: A Guide to Maintenance, Safety Precautions & Hygiene of Medical Equipment', ECHO International Health Services Ltd, UK, unpublished

Box 6 provides some examples of dos and don'ts that apply to equipment in general.

BOX 6: General Good Behaviour Strategies When Dealing With Equipment

DO

- only use equipment for the purpose it was designed for
- only use portable equipment while it is safely positioned on a suitable flat surface, such as a worktop, trolley, or the floor
- ensure moveable parts such as lids, wheels, and extensions are securely locked in place before the equipment is used
- only use equipment if you know the correct operating technique and are competent and trained to use it (*Section 4.1*)
- keep loose clothes away from moving parts (*Section 5.5*)
- only use equipment when you have the proper safety gear, for example, lead aprons, gloves, goggles (*Section 5.1*)
- only use equipment with patients when you are sure it is functioning correctly and safely (*Section 5*)
- always make sure the correct service supplies are available (such as electricity, water, gas) before switching the machine on
- only use the correct accessories specific to a particular machine (*Section 6*)
- only use the correct consumables specific to a particular machine (*Section 6*)
- place and store accessories carefully in the appropriate holder, pouch, or drawer to prevent them dropping on the floor or getting lost
- only use the correct chemicals and cleaning methods specific to a particular machine (*Section 4.3*).

DON'T

- pull equipment around by its lead
- use equipment to prop open doors
- balance equipment on the edge of beds
- drop equipment
- tangle and create knots in the leads
- spill liquids over equipment
- use equipment surfaces as tables
- scratch equipment
- use equipment for private purposes without permission
- use hot equipment surfaces for heating food (other than legitimate kitchen appliances)
- store food in refrigerators designed for other purposes, such as for storing vaccines, or a blood bank
- leave cables or equipment in positions where people may trip or injure themselves
- leave windows open but unlatched, as a strong wind could swing them against the wall and shatter the glass
- put rubbish down toilets – this will block the drains.

There are also specific dos and don'ts for each type of equipment. *Box 7* provides an example of the type of instructions for an hydraulic operating table.

BOX 7: Examples of Dos and Don'ts for an Hydraulic Operating Table

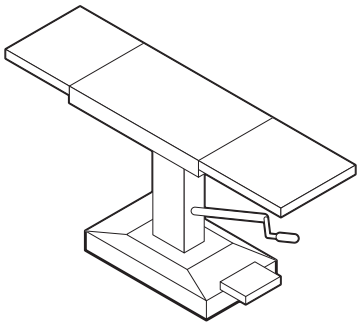
(these may vary or require additions depending on the make and model)

DO

- check leg section is secure and apply brake on table base before using
- only use correct mattress and accessories for table
- avoid placing sharp objects against mattresses/pads or radiographic table top
- always lower table top completely before cleaning
- always leave head and leg sections fully lowered when table is not in use

DON'T

- pull a table – always push it
- lift a table by its top
- push a table over rough surfaces – use a trolley or lift
- drop a table (or individual sections) when transporting it
- drop heavy objects onto the table (especially the radiographic top)
- spill oil, ether, or other chemical fluids on mattresses/pads.



Any member of staff who sees a problem arising with the treatment of equipment, should fill in an Incident Report Form for the HTM Working Group, so that the problem can be addressed (*Section 8.2*).

3.3 EFFICIENT USE OF EQUIPMENT

To obtain the maximum benefit from your equipment, it is best to use it efficiently. There are a number of issues to address if you want to be efficient:

How Much is Your Equipment Utilized?

Some ways of utilizing equipment are more economical than others. Your main aim is to make the most of your investment in the equipment.

For example, it is more efficient use of an X-ray machine to do at least 50 exposures a week than to do just two. Thus, how much use you will make of a machine may determine whether you want to purchase one in the first place. It may be better to share an X-ray machine with several neighbouring facilities. These are issues which should normally be discussed before you buy the equipment, in the planning phase (see *Guide 2* on planning and budgeting).

However, if you already have a machine that is not used a great deal you can either:

- choose to operate the machine on just one day a week, and call patients in on that day. This way, the machine has a chance to warm up and can be used effectively for the day, rather than being switched on and off throughout the week.
- or plan when the equipment will be used during the day. For example, arrange for the majority of blood tests to be sent to the laboratory immediately after doctors' rounds in the morning. This would give you a large number of samples available before using your centrifuge and batch chemistry analyzer.

Do You Use Your Equipment and Materials Effectively?

How often you plan to use your equipment will have an impact on how effectively you utilize the consumables and materials required.

For example, if you are running an antenatal clinic, it is a good idea to ensure that the laboratory technician is available at the same time. Then he or she can do the haemoglobin screening test while the clinical appointment takes place, and it will not be necessary to ask the patient to return to the clinic another day for the laboratory test. By concentrating equipment use to specific times, you can open a multi-pack of consumables (such as stick-on electrodes or reagent strips) without fearing that the items you do not use will go off. Thus, with better coordination you can make more efficient use of your consumables.

Another strategy for ensuring the most effective use of equipment and materials is to train special equipment operators, who will be responsible for running particular equipment during clinics or work sessions (*Section 3.5*).

The layout of buildings and departments can also contribute significantly to the effective use of equipment and staff. Architects can advise on placing furniture and equipment in the available space in an orderly and effective way, which ensures appropriate flow patterns suited to the function of the room (see *Guide 2*).

Is Your Equipment Economical to Run?

It is best to choose makes and models of equipment which are input-efficient. Just as some vehicles are more fuel efficient than others, some makes of equipment are more economic in their use of consumables. This should be considered during equipment planning and procurement (see *Guide 2* on planning and budgeting and *Guide 3* on procurement and commissioning).

All equipment has a life-cycle cost – the recurrent cost required to keep it going throughout its life, such as fuel, consumables, maintenance, and training. The cost of these factors can vary considerably between different manufacturers, especially consumables. For example, the initial purchase price of infusion pump type A may be cheaper than type B. However, the annual running costs for infusion sets for type A may be much more expensive than those for type B. Thus, it would be worth the higher initial cost to purchase pump B, so that you can benefit from the lower running costs.

When choosing equipment which uses consumables, you should try to use 'open' rather than 'closed' procurement systems. Open systems mean that anyone can supply the consumables for your equipment, and different manufacturers' consumables can fit your machine; this competition leads to lower-cost consumables. Closed systems mean that the equipment and its consumables are only made by one manufacturer, and you are limited to one supplier only; this monopoly leads to more expensive consumables (see *Guide 3* on procurement and commissioning).

Other issues which will affect the functioning and cost of running your equipment are:

- the availability of spare parts
- a functioning in-house maintenance service (see *Guide 5* on maintenance management)
- the presence of a local representative of the manufacturer who can offer you support.

If there is no local support or source of supplies, it will be much more expensive to continually get help and materials from abroad. These issues should be considered when products are compared during the procurement process (see *Guide 3* on procurement and commissioning).

3.4 ACCESS TO INFORMATION AND REFERENCE MATERIALS

It is important for staff to have access to written references to help them with their work. It is common for such data to be missing from health facilities, and for manuals arriving with new equipment to go missing. We suggest you develop a library of professional literature, reference materials, and equipment manuals. *Box 8* provides some strategies for developing such a library; although we recognize that following these recommendations will require time, staff input, and money.

BOX 8: Strategies for Expanding Your Library (see *Annex 2*)

Strategy	Type of Material/Information	Action
Obtain literature which is usually available free of charge.	◆ manufacturers' care and cleaning guidelines (from manufacturers and their representatives) ◆ safety guidance for specific machines (from manufacturers and their representatives) ◆ operation and safety guidance from national bodies (Medical/Nursing Council, National Laboratory, Fire Service, etc – see *Section 2.2*).	For existing equipment, find as many of these as possible.
Obtain literature from neighbours which, with negotiation, may be available for the cost of photocopying and postage.	◆ operation and safety guidelines ◆ copies of manufacturers' operator and service manuals for older machines.	Contact as many other health facilities and health service provider organizations in your country and neighbouring countries as possible, to obtain existing resources.
Obtain information available internationally which can be paid for as one-off items, or by annual subscription (depending on the material type and source). This material may come as a hard copy or as part of a software package.	◆ text books relevant to different professional disciplines (laboratories, theatres, laundries, physiotherapy, child health, etc) ◆ manufacturers' operator and service manuals ◆ equipment hazard reports and safety literature ◆ journals, data, reference books, and reference materials ◆ internationally available advice on operation and safety of equipment, etc.	Try to get hold of these resources – consider subscribing to them – and look for help to pay for them.
Make sure you order relevant literature when purchasing all your new equipment (see *Guide 3* on procurement and commissioning).	◆ operator manual ◆ service manual which should include care and cleaning instructions and safety guidance.	◆ when the manuals arrive, store the original copies in a safe place (such as the HTMS library, the facility library, or the workshop library) ◆ make photocopies of the operator manuals, and give one copy to the relevant user department, and one copy to the HTM Team or relevant workshop ◆ make photocopies of the service manuals, and give one copy to the HTM Team or relevant workshop.

Continued opposite

BOX 8: Strategies for Expanding Your Library (see *Annex 2*) (continued)

Strategy	Type of Material/Information	Action
Investigate other sources for getting literature and information which you do not have.	◆ suppliers ◆ manufacturers' local representatives ◆ international agencies ◆ links with health facilities abroad.	Make use of internet (world wide web) contacts where possible, as this method will become more and more important in future.
If material is no longer available on paper, find a more accessible format.	◆ CD-Rom ◆ video ◆ DVD.	Investigate these alternative sources of information. Make copies and print-outs of the material and make it available to other facilities.
Scan single copies of printed documents into a computer and keep them as electronic copies.	◆ user manuals ◆ service manuals.	Scan these documents into your computer system and make them more easily available to maintenance technicians at many locations.

3.5 DEVELOPING STAFF SKILLS

Since so many new makes and models of equipment are coming out almost every year, staff (both users and maintainers) need to continually update their skills. Training for equipment operators will need to cover:

- good practice when handling equipment – basic dos and don'ts (*Section 3.2*)
- how to operate equipment (*Section 4.1*)
- the correct application of equipment (*Section 4.2*)
- care and cleaning (*Section 4.3*)
- safety procedures (*Section 5*)
- management of stocks and stores (*Section 6*)
- planned preventive maintenance (PPM) for users (*Section 7.2*).

Maintenance staff will also need to obtain many of these skills. In addition, there will need to be training for maintainers in PPM and repair; these requirements are discussed in *Guide 5* on maintenance management.

Remember that training should not be an activity that only happens once. Training is required at various times throughout a member of staff's career:

- Induction training – when staff are new in post, move to a new department or facility, or to a new location with different responsibilities.
- Training at the commissioning of equipment – when new equipment first arrives.
- Refresher training – to update and renew skills throughout the working life of staff.

The provision of such training must be addressed seriously by the health service provider. There are a number of options available for developing skills in-service, and each health service provider has to pursue a combination of strategies for sourcing the training required. Whatever options prove to be the most feasible, a skills development programme is vital. As explained in *Section 2.2*, the training needs of staff at every level should be addressed by the overall Equipment Training Plan, which is an ongoing rolling programme of in-service training.

We suggest that the HTM Working Group, or possibly a smaller training sub-group (*Section 1.2*), is responsible for establishing all training requirements. This Section looks at some strategies which can be taken at the facility or district level to implement the Equipment Training Plan (developed in *Guide 2* on planning and budgeting).

You will need to consider the sources of training and professional support available, and *Box 9* provides a variety of strategies to help you with this.

When you begin to monitor how equipment is used, you will notice a number of prompts that training is required. These training requirements should be passed on to your Health Management Team (*Section 8.2*). *Figure 6* shows the likely prompts.

Figure 6: Example of Prompts Showing That Training is Required

Prompt	Response
Staff newly arrived at a facility, or transferred between departments	In-Service Training Co-ordinator organizes induction training on equipment-related skills
Staff admit that they need any type of equipment-related training	They request it from their Head of Section
Heads of Section see that staff are short of particular equipment-related skills	They request the necessary training from the HTM Working Group (or its training sub-group)
Maintenance staff identify user-related problems with equipment	They report this to the HTM Manager
New equipment arrives at the health facility (according to the Equipment Development Plan – *Guide 2*)	The training sub-group/Commissioning Team organizes this
An incident report is submitted *(Section 8.2)*	The HTM Working Group, or its safety sub-groups, decides if extra training is the appropriate solution
Skill shortages are discovered during the staff appraisal process *(Section 8.2)*	Managers agree with the individual which training would be the best development strategy, and request it from the Human Resource Department/training sub-group

BOX 9: Strategies for Developing Equipment Skills

Strategy	Advantage/Disadvantage
Send staff to factories that manufacture equipment	This can be good training but may be expensive as it often entails going abroad and paying in foreign currency. However, the equipment manufacturer may have a local representative that has the skills to provide the necessary training. Although this is a more affordable option, the danger is that the company will offer a course which is either too simple (not much more than a factory tour), or alternatively is very theoretical. Good communication is required to ensure that this equipment-specific training is effective and appropriate.
Invite engineers from manufacturers to visit your facility to conduct training on their equipment	This option may not be the most affordable, and therefore may not be ideal if you are facing financial constraints. If the company's local representative has sufficient skills to undertake the training, this may be more affordable.
Send staff to other locations which have already developed the skills required	Other facilities, workshops, or teams may already have developed skills that you need. Here your staff can either attend specific training courses, or have a period of secondment in order to obtain skills through on-the-job training, work experience, or work exchange visits.
Link the provision of training to the procurement process	When equipment is purchased from a company, you can ask them to provide training at the time of commissioning (see *Guide 3* on procurement and commissioning). Who covers the cost of the training and where it will take place are negotiated as part of the procurement contract, and may be dependent on the type and total cost of the equipment.
Run in-house (on-the-job) training sessions	You can make use of local, national, or regional experts who are maintenance and/or clinical staff. It may be necessary to send some staff for training abroad so that they can become the local trainers/experts.
Make use of regular clinical/professional meetings	These can be used as a forum to introduce staff to particular equipment concerns. They can be run at facility, district, central, or international levels.
Make use of academic courses at various levels	These are useful for gaining additional specialist skills. They will be available nationally, regionally, and overseas.
Approach local colleges to develop, run, and accredit new modules	Health colleges (who provide basic training for nurses, doctors, physiotherapists, etc) can introduce new modules aimed at developing equipment-related skills for equipment users.
Provide opportunities for practical on-the-job experience	Practical experience, with or without supervision, provides excellent training as long as it is targeted at the right skill level. When a piece of equipment is not in use, staff should be encouraged to familiarize themselves with the equipment, and learn its principles and its different applications.

Continued overleaf

BOX 9: Strategies for Developing Equipment Skills (continued)

Strategy	Advantage/Disadvantage
Provide opportunities for studying and teaching	Books, manuals, and articles from journals will answer many questions on principles of operation and care for different types of equipment (see *Annex 2*). If staff are given opportunities to study, with a little pressure and an expectation that they will lecture to colleagues afterwards, the benefits for individuals can be great.
Let different types of staff (nurse, radiographer, laboratory technician, etc) attend their peer group meetings	This allows staff to share experiences regarding equipment, to learn from their colleagues, and to develop a professional approach to work. The meetings will be available nationally and internationally.
Provide various training materials for staff to refer to (see *Box 8* and *Figure 7*).	The materials, together with demonstrations, help staff to learn as well as providing them with something that they can regularly refer to when they are unsure.

A variety of resources can help you when you decide to undertake training yourself. These will vary depending on the training source, and on which of the available skill-development options (described in *Box 9*) you use. *Box 10* details some of the resources you may require.

BOX 10: Resources Required When Running Training Courses Yourselves

Information	about the training required (background and needs assessment) and the training sources available.
Training materials	appropriate to the piece of equipment to be studied.
Space	suitable for carrying out the training in.
Equipment	to be practised on during the training courses.
Test and calibration instruments	in order to verify technical conditions and safety during training.
Spare parts	appropriate for user PPM training.
Supplies	for user training, such as consumables, medical supplies, and cleaning materials.
Manuals	to refer to, such as the manufacturer's operator and service manuals.
Test method and certificate	a formal way of testing trainees and issuing them with a certificate at the end of the training course, as a quality control and motivating factor (depending on the extent of the training).
Recognition	a formal way of ensuring that the additional skills attained by staff are reflected in their promotion chances and job grades by the Human Resource Department.
Additional expenses	possible room hire, overnight accommodation, travel and subsistence, trainers' fees, visual aids, teaching equipment, etc.
Records	a system for keeping a record of the specific training that a staff member has received.

Developing Training Materials

We suggest you develop simple guidelines for each type of training required for every type of equipment, based on good principles and procedures. This Series includes the following examples:

- *Guide 2* covers equipment planning and budgeting.
- *Guide 3* covers procurement, adjudication of tenders and quotes, installation and commissioning.
- *Guide 5* covers PPM and repair for maintainers, and spare parts' management.
- *Guide 6* covers financial management for HTM Teams.
- Finally, this Guide, *Guide 4*, covers good practice when handling equipment (basic dos and don'ts), how to operate equipment, the correct application of equipment, care and cleaning, safety procedures, planned preventive maintenance for users, and stores management.

The specific guidelines for different equipment types should be modelled on the advice in:

- the equipment manufacturers' operator and service manuals
- the manufacturers' PPM schedules
- written resources produced by other organizations (see *Annex 2*).

Training can also incorporate the experience of existing staff. *Figure 7* (overleaf) shows a number of strategies to follow when developing training materials.

Training Trainers

The trainers who run the equipment training sessions are usually one or more of the following:

- Staff from the equipment manufacturer.
- Staff from the manufacturer's representative.
- Clinical or maintenance staff from other teams, workshops, health facilities, and health service providers who are knowledgeable about the equipment.
- Senior clinical or maintenance staff within your team, workshop, or health facility who were previously trained on the equipment or who have the necessary skills.
- Partners in technical cooperation projects, or staff from non-governmental organizations and charities.

If you don't currently have enough trainers, you can nominate staff who can be trained to become trainers. When users and maintainers are being trained at the time of commissioning new equipment, it may be useful to select staff from among the trainees who you would like to become trainers. These individuals can then go on to train staff who could not attend the initial training sessions: for example, a matron could be trained to teach other nurses.

The trainers will need to be taught sufficient skills to train their colleagues. They should be capable of running both formal and informal training sessions in order to pass on their skills in the operation, care, and maintenance of equipment. They will require training on the specific equipment concerned and can receive this either from the manufacturer, from other facilities where the equipment is in use, or from colleagues with the necessary experience.

Figure 7: Strategies for Developing Training Materials

Process	Activity
The HTM Working Group or its training sub-group:	
Meet regularly	To develop training resources for existing equipment as an ongoing exercise to develop a library of written resources.
Hold special meetings when new equipment arrives	Study the operator and service manuals and develop suitable training resources from them.
Notify manufacturers or their representatives of your training needs	If manufacturers are going to carry out training on equipment, notify them in advance of the range of training and resources you require from them.
Observe staff training carried out by equipment manufacturers or their representatives	Attend the training sessions, record the training given, obtain copies of any handouts or overheads used, and compile written resources in the usual format to add to the stock of training guidelines.
Convert the written guidelines into a range of resources/visual aids	• Handouts for the trainees. • Posters which can be placed on the wall beside the equipment. • Laminated cards or paper in plastic pockets attached to/hung from the equipment itself. • Laminated cards showing User PPM schedules for the staff to carry around and refer to when carrying out User PPM (*Section 7.2*). • Acetates (for use with overhead projectors – OHP) so that the training courses can be run and rerun for refresher training purposes. • PowerPoint presentations (a developing computer tool) and video/computer projectors for larger institutions who often make presentations (the modern OHP).
Video the training activities	Videos can form a useful resource for re-training, as back-up, and for reference, etc. If the video is to be of use, it is important that suitably experienced professionals undertake the filming. Investigate the possibility of hiring a video camera and cameraman from persons who currently undertake the videoing of such technical activities.
Buy ready-made training videos	Obtain these from manufacturers and other sources, for example, electrical safety (RS Components), safe handling of medical gases (BOC), care and use of the microscope (Olympus) – refer to *Annex 2*.
Keep copies of the training resources produced together in one place	Choose a suitable location for storing the various resources (handouts, posters, laminated cards, overhead acetates, videos, computer files). Possibilities are: the office of the In-Service Training Coordinator, HTM Manager, or Human Resource Manager, or in your library if you have one (*Section 3.4*).

Experience in Africa

In a number of government central referral hospitals in Zambia, senior doctors nominate members of staff to be special equipment operatives. For example, ECG recorder attendants are given responsibility for always setting up and running ECG recording sessions. In addition, the Biomedical Engineering Unit of the Central University Teaching Hospital has a training centre where senior maintainers teach medical staff how to use specialized equipment, such as those from intensive care units, operating theatres and special care baby units.

The MOH in Ghana trains equipment users as application specialists for various service areas, such as clinical laboratory, life support systems, and imaging devices. These people are selected from their specific clinical area, seconded to the HTM Service part-time, given formal technical training, and sent on training-of-trainers programmes. Whenever new technologies are introduced by the MOH into these clinical areas, the specialists are always available to give application training to new users.

Another strategy pursued by the Ghanaian MOH, is to set up a skills laboratory where examples of new devices are installed and linked to simulators, for the purpose of training new users and technical personnel. These laboratories are manned by the application specialists.

Training Special Equipment Operatives

Another strategy is to nominate and train certain members of staff to be some form of special equipment operative. These individuals can be trained to set up, operate, apply, and take care of specific items of equipment in order to ensure that it is used consistently and that it provides a reliable service. Examples are given in the country experience box above. Such a strategy has additional benefits. For example, nomination as a special equipment operative can be an incentive to motivate staff, and lead on to them becoming trainers.

Box 11 contains a summary of the issues covered in this Section.

BOX 11: Summary of Procedures in Section 3 on Utilizing Equipment Effectively

Good Behaviour		
	Equipment Users	◆ follow good practice when handling equipment and make themselves aware of general dos and don'ts (see *Box 6*)
	HTM Teams	◆ report any poor behaviour by equipment users that they observe, through the HTM Manager to the Health Management Team
	Section Heads	◆ ensure their staff follow good practice with equipment, and report any problems to the Health Management Team so that any training needs can be addressed

Continued overleaf

BOX 11: Summary of Procedures in Section 3 on Utilizing Equipment Effectively (continued)

Accountability	**Health Service Provider**	◆ ensures that sufficient numbers of suitably skilled staff are recruited to operate its equipment, and implements strategies to encourage retention of staff in service ◆ develops the mechanisms for making staff accountable for the equipment they work with (see *Box 5*) ◆ agrees the action to be taken by the Human Resource Department if persistent loss or abuse of equipment is discovered ◆ agrees incentives for good performance with the Human Resource Department
	Equipment Users and Section Heads	◆ ensure they understand their responsibility for equipment and act in such a way as to protect it ◆ ensure they understand how accountability for equipment will affect them
Efficient Use	**Health Service Providers and Health Management Teams**	◆ plan the location of equipment so that it can be used efficiently ◆ consider sharing resources between facilities (see *Guide 2* on planning and budgeting) ◆ plan when to use equipment, and how to link appointments and services for patients in order to use equipment efficiently ◆ when purchasing equipment, choose products which make efficient use of resources such as consumables, fuel, finances and maintenance support (see *Guide 2* on planning and budgeting and *Guide 3* on procurement and commissioning)
	Equipment Users and Section Heads	◆ use consumables efficiently without wastage ◆ plan when to use consumables, so that once a pack is opened its contents do not go off
Resources	**Health Management Teams**	◆ develop a reference library (see *Box 8*) to contain all resource materials that staff may need
Skills Development	**Health Service Provider**	◆ develops and funds an Equipment Training Plan (see *Section 2.2* and *Guide 2*) ◆ provides inputs for the in-service training programme ◆ coordinates training scholarships ◆ considers 'bonding' issues for staff sent for training
	HTM Working Groups (or Training Sub-Groups)	◆ investigate and use the broad range of training sources available (see *Box 9*) ◆ develop training materials (see *Figure 7*) ◆ identify and train suitable staff to be trainers ◆ identify and train suitable staff to be special equipment operatives ◆ receive and act on any prompts which indicate that staff need training (see *Figure 6*) ◆ provide the necessary resources when running training courses themselves (see *Box 10*)

4. HOW TO ENSURE CORRECT OPERATION

Why is This Important?

If staff operate equipment correctly, the equipment is less likely to become damaged, and staff will therefore get the best performance out of it.

Staff can gain maximum benefit from equipment by knowing how to:
- **use it**
- **apply it in different situations**
- **take care of it.**

This Section covers how to ensure correct operation by discussing:
- how to operate equipment (*Section 4.1*)
- the correct application (*Section 4.2*)
- care and cleaning (*Section 4.3*).

For all these issues there are likely to be national and international bodies which can offer guidance and regulations (see *Section 2.2* and *Annex 2*).

4.1 HOW TO OPERATE EQUIPMENT

'Operation' of equipment means using the correct physical methods to get the equipment to work. In order to do this successfully, the user needs to know:
- the specific operating characteristics of a machine
- the operational procedures that make the machine work
- how to use its various functions
- how to make it perform its customary cycles and routines
- how to change the bulb, paper roll, batteries, etc.

The equipment manufacturer's user manual is often the best source of this information. Other sources include:
- a wide range of reference material (see *Annex 2*)
- written resources from staff training sessions
- experienced colleagues.

Guidance from colleagues can be summarized as a one-page poster, laminated card, or sheet of paper in a plastic pocket (*Section 3.5*) which can then be mounted near – or on – the equipment itself. Copies of reference materials should be kept in the library (*Section 3.4*).

Box 12 provides some examples of general strategies when operating equipment.

BOX 12: General Strategies When Operating Equipment

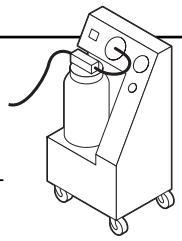
- make sure you have the authority and knowledge to operate equipment before you start
- refer to the manufacturer's operating manual for correct advice
- **always** follow the safety procedures specific to the machine (*Section 5*)
- only connect a machine to an electrical socket outlet which has been checked by the electrician for proper grounding, and only use the correct plug for the socket (for example, **never** put a two-pin plug into a three-pin socket – *Section 5.5.2*)
- do **not** start equipment that requires water for its operation without checking that the water supply is available
- use the machine only with the correct type and quantities of water, oil, fuel, etc
- always handle accessories carefully as these are the most easily damaged component of equipment
- always use the correct consumables without wasting them
- always respond to alarms, and check what is causing them
- ensure that the relevant waste pipeline is not blocked, before allowing equipment to discharge its contents into the waste water/sewage system or special container for hazardous material (*Section 5.4*)
- if the electricity power supply is cut off, switch off all electrical equipment to protect it from electrical surges which may occur when the power is restored. Once power is returned, ensure that vital equipment (such as refrigerators) is switched back on
- ensure that any mains-powered equipment which will be required to work off batteries during a power failure (defibrillator, vital signs monitor, ICU ventilator, etc) is always plugged into a live socket and **left switched on** so that its batteries are continuously charged
- when oxygen and other gases are no longer required, **turn off** the supply so that gas is not discharged into the atmosphere and wasted.

Each type of equipment has specific operating instructions. *Box 13* provides an example of the type of instructions required when using an electrical suction pump.

When operating equipment, it is also essential to follow good strategies for using consumable materials (*Section 6*).

BOX 13: Example of Operating Instructions for an Electrical Single-Jar Suction Pump

(these may vary and require additions depending on the make and model)



How the equipment works:

- The suction pump is used to remove a body fluid such as blood, mucus or vomit from a body cavity, wound, or respiratory tract. There are several types of suction machine. According to the design, different flow rates and different pressures – high, low, or dual – can be attained. Some machines can only be used intermittently and should not be used for several hours at a time.
- The pump draws fluid from the patient through a flexible tube into a reservoir jar (bottle).
- When the jar has filled to a certain level, the float valve prevents fluid entering the pump, by cutting off the suction. The machine must then be switched off and the jar emptied.
- A bacterial filter between the jar and the pump reduces the risk of cross infection and potential damage to the pump.

To prepare for use, check the following:	**Think about:**
◆ You have the correct machine for the task	Is the pressure [kPa] sufficient? Is the pressure and flow rate too high for infants?
◆ The state of the machine	Is it clean and in good condition?
◆ The machine is in the correct position	Is it upright on a level surface? Are the ventilation grills free of obstructions?
◆ The jar has been sterilized and is undamaged	If it is dirty, cracked, or chipped, change it.
◆ The float valve can move freely	If it can't, try cleaning it, or get technical help from the HTM Team.
◆ The filter is not wet or discoloured	If so, change the filter.
◆ The patient's (anti-static) suction tube has been sterilized	If not, get a new sterile one.
◆ The jar lid, or its rubber gasket, is not broken or perished	If it is, change it.
◆ The patient's suction tube is connected	Attach it to the inlet nozzle on the jar lid.
◆ The tubing is straight	Ensure there are no kinks or knots in it.
◆ There is no visible damage to the electrical lead and plug	If there is, call the HTM Team.
◆ Connect the machine correctly to the electrical supply	Plug it into the socket and switch on.
◆ All connections are tight	Ensure there are no obvious leakage points.
◆ An appropriate vacuum suction rate is selected	Turn the vacuum control knob and check the pressure gauge.
◆ The vacuum gauge reading is not permanently low	Discontinue use and obtain a replacement machine.

To use the suction pump, do the following:

1. Take the sterilized part which will enter the patient (metal hand-piece or suction catheter) and attach it onto the free end of the patient's tube.
2. Remove excess fluids from the patient as required.
3. Stop sucking when the level of fluid in the jar reaches the $^3/_4$ full mark (if you let the jar overfill, the float valve will close and the vacuum will stop).
4. When your first jar is $^3/_4$ full, switch the machine off and:
   either empty the jar, reconnect the lid firmly and continue sucking.
   or reposition both the 'patient' and 'inlet' tubing from your first jar lid to the lid of a replacement empty jar, so that sucking can continue. Then empty the full jar.
5. If the jar overfills and the filter gets wet the machine will be damaged (fluid in the pump, and risk of cross-infection) and a replacement machine must be used. Disinfect the full machine and send it to the HTM Team to be repaired.
6. When finished with the machine, unplug it from the electrical socket.

4.2 THE CORRECT APPLICATION

Staff may feel confident about how to operate equipment, but it is imperative that they also know the correct 'application' for the equipment. Staff need to be able to apply their taught (clinical) procedures correctly, and to employ the correct methods of application so that equipment is used to its fullest capacity.

Staff will need to be trained in order to fully appreciate when and how to use equipment. They will need to know:

- when different features will be employed for different patients or uses
- the range of assistance a machine can offer them
- how to alter the relationship between the machine and the patient, or sample, for different purposes
- the different procedures to pursue for different disorders or treatments.

They will also need to understand the safety precautions they must take (*Section 5*).

Traditionally, colleges offering basic training for health are responsible for teaching clinical procedures. Thus, they must have access to the necessary equipment for this purpose, both in their teaching rooms and at suitable clinical locations such as hospitals.

There will be many areas where staff need to brush up their application skills, and it will be an ongoing requirement to identify these training needs. *Box 14* provides some common examples.

Equipment users will need to admit their need for application training and ask for help. The HTM Working Group must consider application training when purchasing new equipment, and the possibility of incorporating such information and training into the 'package of inputs' purchased with the equipment (see *Guide 3* on procurement and commissioning).

Equipment users should only operate equipment for which they are suitably qualified. Clinical meetings, committee meetings, departmental meetings, or specifically organized training sessions can all be used to provide application training (as appropriate).

Country Experience

Often in developing countries, clinical procedures are taught in health training schools using obsolete equipment, or with insufficient units to give students adequate exposure. When the staff graduate they then find that they lack the necessary knowledge or techniques for the clinical procedures required. They are therefore incapable of applying particular machines and cannot deliver the necessary healthcare.

BOX 14: Common Examples of Application Training Requirements

Ophthalmoscopes in diagnostic sets	Eye doctors can train operators on the correct clinical application, diagnosis, and use of the different features offered.
Electrosurgical/ diathermy units	Surgeons need to practise with the many different features offered by newer models (making use of pieces of meat from the kitchen, or bars of soap, and definitely not patients!)
Defibrillators	Management committees and surgeons need to clarify when these can be used; users need to refresh their memories on the correct application for different sizes of patient, as well as familiarizing themselves with the defibrillator's controls and how to operate it.
Resuscitators/ ambu bags	Operators need training from doctors concerning the correct clinical application and use of the different features offered, as well as a policy on who is authorized to use the oxygen facility.
Doppler foetal heart-rate detectors	Users need to familiarize themselves with these units, and get some practice in their use with assistance from an ultrasound radiographer.
Infant warmers	Paediatricians need to control the programming of the settings on these units, and must closely monitor their appropriate use to ensure that no harm comes to any infants.
Radiographic equipment	Radiographers need to know the settings for various diagnostic examinations by X-ray and fluoroscopy, of the: skeleton (fractures), head (trauma, infection), chest (TB, infections, tumours, trauma), abdomen (trauma, intestinal obstructions), soft tissue (foreign bodies, calcification).
Ultrasound machines	Users should not perform pathological diagnosis of liver, kidney and other internal organs unless they have received the required specialist training.

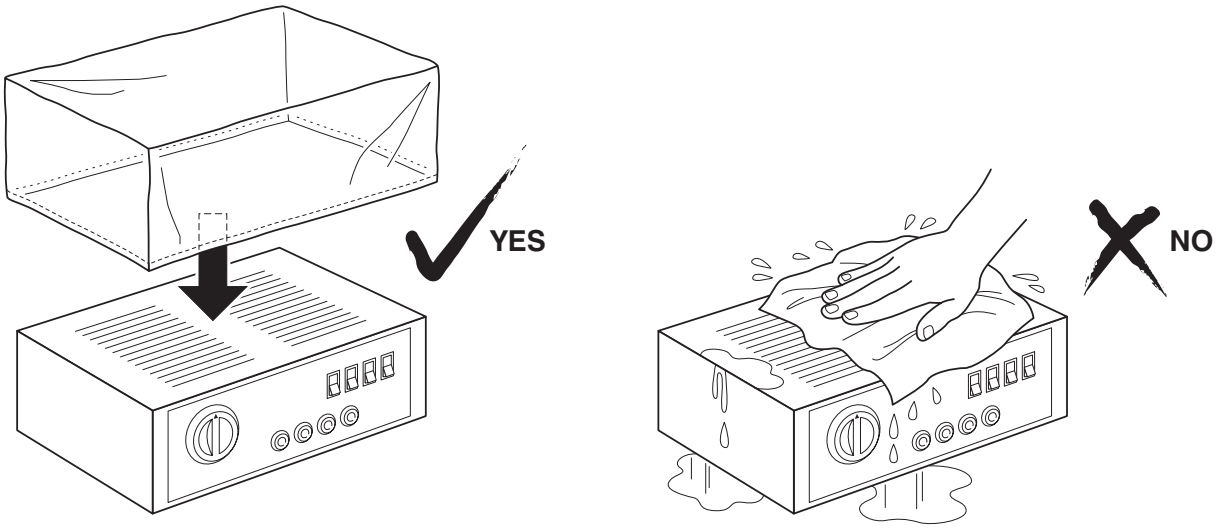
4.3 CARE AND CLEANING

To maximize the life of equipment, it is necessary that equipment users and maintainers know how to look after the equipment and clean it. Users must care for and clean equipment regularly, to a given timetable. It is beneficial to do this because:

- it is easier to see faults (such as damaged suction pump tubing) when the equipment is clean
- it prolongs the life of equipment (for example, protecting electronic parts from damage by dust, protecting metal from corrosion by liquids or chemicals, protecting rubber seals from degradation by greases)
- it protects the operator and patient from infections (from microscope eyepieces, for example)
- it improves the performance of equipment (clean probes for ultrasound, clean seals on fridge doors, etc).

The best information regarding the care and cleaning of equipment is usually contained in the manufacturer's user manual and/or service manual. A wide range of reference material is also available (see *Annex 2*). In addition, staff should have written resources from their training sessions and, in some cases, posters which provide the guidance and experience of their colleagues (*Section 3.5*). If staff do not have personal copies of these resources, they should be available in the library for reference (*Section 3.4*).

Box 15 provides some examples of general strategies when caring for and cleaning equipment. In addition, *Section 5.3* discusses the safety implications of the various cleaning methods and materials available.



Source: Lee, P, 1995, 'Get it Right!: A Guide to Maintenance, Safety Precautions & Hygiene of Medical Equipment', ECHO International Health Services Ltd, UK, unpublished

Experience in Vanuatu

When a maintainer was visiting a remote health facility, the nurse practitioner said that she had a small gas stove in the maternity ward that had not worked for 12 months and that she needed a new one. The stove was filthy, so the maintainer dismantled the burners and started to clean it. The burners were full of debris, including gecko eggs. When she removed the eggs and finished cleaning the stove, it looked new and worked perfectly. If the nurses at the health centre had kept their stove clean, they could easily have prevented the problem and would have been able to prepare hot food for the mothers and staff.

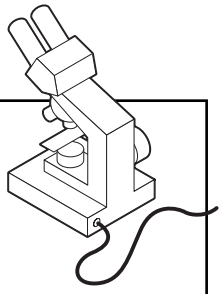
BOX 15: Common Care and Cleaning Strategies

- Keep all items clean and dry.
- Dust equipment (such as large free-standing items) regularly.
- Where applicable, replace the dust cover at the end of the shift; if there is no dust cover, make one.
- Keep equipment, such as laundry and kitchen equipment, clear of debris such as fluff, food, threads, grease, paper waste, etc.
- Switch-off and unplug items when they are not in use, **except** for items which have a battery back-up that must keep charging (such as defibrillators), or items which need a continuous supply (refrigerators, etc).
- When cleaning, never flood the machine with fluid or a dripping wet cloth, use a damp cloth instead.
- Clean with the appropriate chemicals, solutions and materials at the end of the shift (equipment which comes into contact with patients, uses gels, etc). The operator manual will contain guidance on the correct chemicals to use (*Section 5.3*).
- Disinfect equipment such as theatre equipment after each patient. Check the operator manual for guidance on the correct disinfection method (*Section 5.3*).
- Unknot tangled leads on ECG recorders, interferential units and the like.
- When moving equipment, unplug the power cord and wind it up starting from the machine end and working to the plug, in order to avoid twists.
- Wipe accessories such as ultrasound probes and reusable electrodes clean of lubricants and fluids.
- Store accessories carefully in appropriate places (pouches, holders, etc).
- Store small items properly when they are not in use (keep diagnostic sets in their cases, for example).
- Remove batteries when battery-operated items are not in use in order to avoid corrosion (for example, ophthalmoscopes, doppler heart rate detectors).
- Take apart items that disassemble easily and clean internal parts (for example, unscrew stethoscope earpieces and remove aural wax, detach and clean the valves on ambu bag resuscitators).
- Store lenses, such as microscope objectives and eye pieces, with a desiccator such as silica gel sachets to prevent fungal growths.
- In the case of items that need water to operate, such as water stills and autoclaves, always check that water is present before switching the item on.
- Check that oxygen bottles are free from oil and grease (which can cause explosions).

Each type of equipment will have specific care and cleaning instructions. *Box 16* provides an example of the type of instructions required when cleaning and caring for a microscope.

BOX 16: Example of Care and Cleaning Instructions for a Microscope

(these may vary and require additions depending on the make and model)



Daily	
DO	**DON'T**
◆ Dust optical surfaces (condenser, objectives, eyepieces) using a blower or soft camel hair brush.	◆ Use your fingers (as they are greasy).
◆ Remove immersion oil from the objective at the end of each day using a small amount of mild soap solution.	◆ Use other materials (tissue paper, rags, etc) on lenses as they may scratch the surface.
◆ Clean grease from lenses only using lens paper or medical cotton wool. For stubborn dirt, absolute alcohol (ethyl alcohol or methyl alcohol) can be used – but handle carefully as it is flammable.	◆ Use ethanol, acetone, or xylene to clean lenses as they can dissolve the cement holding the lenses in place.
◆ Dust the body of the microscope and then clean with a small amount of mild soapy water and dry thoroughly.	◆ Use alcohol as it will damage painted or plastic surfaces.
◆ Store the microscope under a dust cover at night and when not in use. In humid environments, store the microscope in an air-tight plastic cover with blue silica to absorb moisture. This prevents the growth of fungus. If the silica turns pink, the item is moist and should be dried out in a hot air oven.	◆ Store the microscope in a wooden box in humid environments, unless the box is heated by a 15W bulb.

General care

- Never remove the eyepieces from the microscope and leave the openings unplugged.
- Never dismantle the optical components as they can become misaligned.
- Never clean with a dripping wet cloth, always use a damp cloth instead.
- Always switch off the light and unplug the microscope when not in use.

Monthly

- The microscope's mechanical parts (mechanical stage, coarse and fine adjustments, and the condenser focusing) will need to be cleaned and lubricated with a drop of oil. This can be done as part of user PPM (*Section 7.2*) when other parts and alignments will be checked.

Staff will need to ensure they know the correct care and cleaning techniques for all the equipment they use or maintain, and that they ask for help and training when necessary. The HTM Working Group must consider care and cleaning training when purchasing new equipment, and the possibility of incorporating such information and training into the package of inputs purchased with the equipment (see *Guide 3* on procurement and commissioning).

Box 17 contains a summary of the issues covered in this Section.

BOX 17: Summary of Procedures in Section 4 on Correct Operation

How to Operate	**Health Service Provider**	◆ allocates the user departments with sufficient consumable resources for the operation of equipment (*Section 6*)
	HTM Service	◆ ensures that all necessary service supplies (electricity, gas, water, etc) are available, are appropriate, and are in a good condition, before equipment is used
	Equipment Users, Section Heads, and HTM Teams	◆ ensure they know the correct operating techniques for the equipment they use, and ask for help and training if unsure ◆ refer to operator manuals for guidance, as well as any training materials (*Sections 3.4 and 3.5*) ◆ follow good strategies when operating equipment, as detailed in *Box 12* ◆ report any problems to the Health Management Team in order to trigger training interventions
Correct Application	**Health Service Provider**	◆ ensures application training is planned for and given
	Equipment Users, Section Heads, and HTM Teams	◆ ensure they know how the equipment they use should be applied, and ask for help and training if unsure ◆ refer to operator manuals and reference books for guidance, as well as any training materials (*Sections 3.4 and 3.5*) ◆ report any problems to the Health Management Team so that any training needs can be addressed
Care and Cleaning	**Health Management Teams**	◆ allocate the user departments with sufficient appropriate cleaning materials and resources for the care and cleaning of equipment (*Section 5.3*)
	HTM Service and HTMWGs	◆ prepare care and cleaning instructions and timetables
	Equipment Users, Section Heads, and HTM Teams	◆ ensure they know the care and cleaning techniques for the equipment they use, and ask for help and training if unsure ◆ ensure care and cleaning of equipment takes place according to the given timetable, and following good strategies as described in *Box 15* ◆ for guidance on the correct method for care and cleaning, refer to the manufacturer's manual as well as training resources and posters (*Section 3.5*) ◆ report any problems to the Health Management Team so that any training needs can be addressed

5. HOW TO ENSURE SAFE OPERATION

Why is This Important?

Every different type of equipment has its own safety requirements, and it is necessary to make sure equipment does not become hazardous to you or your patients. Equipment also has a role to play in various safety strategies around the health facility.

Thus Health Management Teams need to guarantee the safety of patients, staff, and visitors by introducing safety procedures for equipment relating to:

- **the use of equipment**
- **how to behave around equipment**
- **national health and safety at work legislation.**

5.1 GENERAL DISCUSSION ON SAFETY

There are many different types of equipment safety issues that need to be addressed by your health service provider. Although many of these safety areas are inter-related, for the purpose of this Section we have grouped them under the following headings:

- Specific hazards when operating different equipment (*Section 5.2*).
- Infection control issues which relate to equipment, such as decontamination, linen handling, and ensuring the workplace is clean (*Section 5.3*).
- Waste management issues relating to equipment, such as separation of general and hazardous waste, and the handling, treatment, and disposal of waste (*Section 5.4*).
- Other equipment-related hazards, such as gases, electricity, radiation, laboratories, fire, and accidents (*Section 5.5*).

The security of equipment, and testing for its electrical and mechanical trustworthiness is discussed in *Section 7*.

This Section describes some commonly accepted ideas and standards for the safety issues listed above, and the procedures staff should follow. Your health service provider needs to develop policies for these areas of safety. Once that has been done, they will need to expand this field further to cover any other hazards and safety issues discovered. National and international bodies can offer guidance and regulations on these safety issues (see *Section 2.2* and *Annex 2*).

We suggest that the central HTM Working Group, or its smaller safety sub-groups (*Section 1.2*), should be responsible for considering the issues, policies, and procedures required for the different safety areas. The district and facility HTM Working Groups (or safety sub-groups) must follow this guidance in order to implement good safety practices.

Staff will need written guidelines and training to assist them in the safe use and maintenance of equipment. The development of such guidelines and their use for staff training is described in *Section 3.5* of this Guide.

Tip

- We suggest that each health facility has some formal method of reporting problems, accidents, and adverse incidents in all these safety areas. Some type of Accident Record Book or Incident Report Form can be used so that staff can report whenever any type of incident occurs. All adverse incidents should be submitted to the HTM Working Group (or its safety sub-groups), who can monitor and act on the incidents (*Section 8.2*), and report to the Health Management Team.
- It will be necessary for Health Management Teams to ensure that their staff have the necessary safety gear required to do their jobs, such as gloves, goggles, masks, overalls and boots.

5.2 SAFETY DURING EQUIPMENT OPERATION

Staff need to understand the hazards that equipment can pose to the patient, operator, maintainer and visitor while it is in use. *Box 18* contains some examples of common safety issues that arise when operating healthcare technology.

Therefore, safety procedures for each type of equipment should be included in equipment operation training. It should be requested as part of the 'package of inputs' purchased with the equipment (see *Guide 3* on procurement and commissioning).

The best information regarding equipment safety during operation is usually contained in the manufacturer's user manual and/or service manual. A wide range of reference material is also available (see *Annex 2*). The HTM Working Group should provide written guidance, and, in some cases, posters can be displayed for staff which summarize the guidance and experience of their colleagues (*Section 3.5*). If staff do not have personal copies of these resources, they should be available in the library for reference (*Section 3.4*).

BOX 18: Some Examples of Common Safety Hazards During Equipment Operation

Air-conditioning / ventilation systems	◆ not cleaning and drying the filters, and checking the air-flow regularly, can lead to the growth of bacteria and the spread of airborne infections
Autoclaves	◆ inadequate venting of the chamber (so that air pockets remain inside) leads to a failure to sterilize, the infected material will not have been made safe, and staff handling it are at risk ◆ lack of care when opening the door before the contents have cooled down leads to steam scalds, and when sterilizing fluids can cause the bottles to explode ◆ absence of gloves or unloading tongs for hot contents can lead to burns ◆ use with water with a high mineral or salt content that has not been treated (softened) leads to a build up of scale which blocks the safety valves
Centrifuges	◆ use of unstoppered tubes (instead of screwcapped ones) means infectious fluids can fly out when the machine is started or stopped ◆ use of unsealed buckets (instead of sealed ones) means that when tubes break infectious aerosols and slivers of broken glass are released over a large area ◆ failure to balance the load or locate the trunnions and buckets properly means these heavy objects can be 'spun-off' and ejected
Electrosurgical/ diathermy units	◆ poor positioning of electrodes, or the patient, against metal parts of the operating table, can cause burns to the patient
Engines	◆ not replacing the safety guards after maintenance leaves the operators at risk from fast moving parts
Infant incubators	◆ poor cleaning of the cabinet promotes the growth of bacteria in the humid atmosphere, which the infant will breathe in
Phototherapy units	◆ not using blindfolds on babies can lead to retinal damage
Pressure-cooker type sterilizers	◆ allowing them to boil dry so that there is dry heating without water will damage the contents and the sterilizer, and the operator can be burnt ◆ operating them when the steam-release valve or safety valve is faulty means that the pressure vessel cannot release trapped steam and will explode
Stoves	◆ insufficient care of the hot surfaces or naked flames will cause burns
Suction pumps	◆ not sterilizing the machine before maintenance work is started, means maintainers can possibly be infected by the body fluids ◆ not covering cuts or abrasions, not wearing gloves, and sucking or blowing into any part of the machine can lead to maintenance staff being infected
Water pumps	◆ allowing mineral lubricant to come into contact with the water being pumped will contaminate the water
Welding equipment	◆ not wearing proper welder's goggles/mask will cause retinal damage

5.3 EQUIPMENT-RELATED INFECTION CONTROL

Internationally, the term 'infection control' has come to mean control of a wide range of practices, processes and procedures in the clinical work of the health facility as a whole. In this Guide, we only cover the equipment issues that contribute to infection control.

Proper infection control (relating to equipment) can be achieved by making decisions about a number of different issues:

- Decontamination, through appropriate use of cleaning, disinfection, and sterilization methods, as well as monitoring sterility (*Section 5.3.1*).
- Linen handling (*Section 5.3.2*).
- Ensuring the workplace is clean (*Section 5.3.3*).

Many strategies in these topic areas are covered in this Section, but additional ones may need to be developed. Associated infection control issues relating to waste management are discussed in *Section 5.4*. Information and advice must be sought from the relevant national body that is responsible for infection control (*Section 2.2*), since national policies should have been established to ensure that risks are reduced.

We suggest that the central HTM Working Group, or its smaller sub-group, the infection control committee (*Section 1.2*), should be responsible for establishing policies and guidelines to prevent contamination through exposure to blood, body fluids, body parts, and infectious agents.

5.3.1 Decontamination

It is important to correctly treat equipment that is contaminated with body fluids and toxic substances, so that infectious diseases are not transmitted to users, maintainers, and patients who come into contact with equipment. In order to decontaminate equipment effectively, it will be necessary to make decisions about and address the following issues:

- The appropriate decontamination methods to follow.
- Who will be responsible for decontamination of which type of item.
- Daily procedures.

Decontamination is a broad term covering processes which remove, inactivate, or destroy contaminating infectious agents from items or surfaces, and make items safe for handling, disposal, or reuse (if this is possible and advisable, see *Sections 5.4 and 6.1*).

Decontamination processes are used to prevent contamination and the spread of infection by medical instruments and equipment. The three decontamination processes commonly used are: cleaning, disinfection, and sterilization.

It is important to understand how successful these processes are, and to understand what the commonly used terms actually mean. Brief definitions are provided here to show the difference between terms, and help to show the least successful method (cleaning) through to the most successful (sterilization):

Cleaning removes visible material (dirt, grease, blood, body fluids, etc) and reduces the number of some infectious micro-organisms.

Disinfection reduces the population of harmful micro-organisms on any surface, but does not eliminate all viruses and bacterial spores. Therefore, it is important to realize that boiling and using chemical disinfectants do not produce sterility.

Sterilization removes or destroys **all** living organisms making any surface free of micro-organisms, viruses, and bacterial spores. Sterilization is absolute, therefore an item cannot be 'nearly' sterile.

In addition, you should be aware that there are two other terms you may hear which are used in particular fields:

Sanitize a term used in connection with catering and food equipment that means to reduce the number of micro-organisms to an acceptable level on these items.

Antisepsis a term used in connection with living tissues and wounds that means the destruction of micro-organisms on these areas in order to prevent sepsis (rot) or decay.

We are going to concentrate on cleaning, disinfection and sterilization in this Section. Three different processes, or a combination of them, are required because equipment is made up of a variety of components (plastics, rubber, metal, electronics, etc) which react differently to each procedure. The procedures available have different drawbacks, for example:

- Some cleaning chemicals leave a sticky residue or are corrosive (ruining valves, for example).
- High temperatures can distort the shape of some items (ruining face masks, for example).
- Some chemicals give off fumes that must be ventilated (and therefore must not be used for breathing circuits).
- Exposure to liquids over a long time can cause rusting (of surgical instruments and the like).
- Chemicals require the right concentration to be effective.
- Most methods are dependent on a certain exposure time to be effective.
- Bad practice will make the methods ineffective, such as adding an additional contaminated object to a solution that is already treating items.
- Use of chemicals can pose a significant danger to operators and the environment.

Thus, it is advisable to make use of expert advice to discover the best methods that you can afford to implement for different purposes (see *Annex 2*). The common use of various decontamination methods for different purposes and for different types of equipment, are shown in *Box 19*.

BOX 19: Use of Different Decontamination Procedures

Recommended process	Suitable for supplies and items	Examples
Cleaning Using water, soap or detergent	◆ in contact with intact skin ◆ not in contact with the patient ◆ of low infection risk ◆ to be disinfected or sterilized	Bed frames, mattresses with impermeable covers, trolley tops before use, work surfaces
Disinfection By boiling or chemical disinfection Note: there are a wide variety of chemical disinfection methods (see *Box 22*)	◆ in contact with intact skin or intact mucous membrane ◆ contaminated with readily transmittable organisms ◆ of medium infection risk	Metal tongue depressors, work surfaces, washing bowls, soiled items, contaminated items, thermometers, infectious spills such as blood or urine on mattresses
Sterilization Using autoclaves to provide steam under pressure – this is the preferred and most common method	◆ in contact with broken skin or broken mucous membrane ◆ that penetrate the skin or enter sterile body areas ◆ contaminated with readily transmittable organisms ◆ of medium to high infection risk	Surgical instruments, dressings, reusable items such as sterilizable syringes and needles, reusable patient hoses, bellows and other plastic, metal, and rubber components which do not distort at high temperatures

Note:

- Hot air sterilizers can be used but are only effective if the instructions are followed **exactly**, and they reach the sterilizing temperature (160°C) and **remain** there for a minimum of one hour. Their disadvantages are: long cycle time (up to two hours), high running costs, high operating temperatures can damage sensitive items, possibility of low temperature pockets which affect sterilization, operator interference may interrupt the cycle meaning sterilization is not guaranteed.
- For materials that cannot bear the high temperature of steam, there are other methods using ethylene oxide, gas plasma, low temperature steam, formaldehyde, or radiation. These require specialized equipment, and many of them are very expensive and require daily microbiological checks.

To prevent contamination through exposure to blood, body fluids, and other infectious agents, the HTM Working Groups (or infection control committees) need to develop and implement good infection control practices. *Box 20* provides some important strategies.

BOX 20: Decontamination Strategies

- Establish a definite policy for hand disinfection, covering:
  - all staff being made aware of the method of washing hands between attending to patients using soap, alcohol impregnated tissues, or 70% alcohol spray;
  - all staff (including maintenance staff) being made aware of when and how to use surgical gloves and/or rubber household gloves.
- Equipment must be decontaminated by an appropriate method both after use and between uses (for example between one patient and the next), and before maintainers are expected to handle or repair it.
- Decontamination of medical equipment, such as suction pumps, must be addressed by the user department (as equipment operators know what the equipment has been used for), in order to prevent cross-contamination due to improper cleaning and improper disinfection.
- General handling of infectious agents (blood, body fluids, infectious organisms, etc) to be addressed by a Waste Management and Hygiene Plan (*Section 5.4*).
- Decontamination of equipment should be controlled by a central department or group of people in the health facility to ensure that correct methods are followed, and that sterility is achieved when required. Such a department should be the Central Sterile Supplies Department (CSSD), with advice from the infection control committee.
- All staff involved in decontamination should be provided with appropriate safety clothing, especially for the cleaning of equipment before sterilization. The risk of infection is high at this stage when dirt, blood, and tissue are being removed prior to sterilization. Aprons, strong rubber gloves, facemasks, etc are recommended.
- Develop preventive medicine policies to provide staff with post-exposure prophylaxis when contaminated with infectious agents.
- Contaminated equipment and instruments must be transported in labelled, sealed plastic bags or boxes to the point where they will be decontaminated.
- Develop staff training and a refresher training plan on infection control strategies.

Decontamination Methods

You should **always** use the appropriate method of decontamination according to the guidance provided in the equipment manufacturers' manuals, the national policies, and the resources available to you.

As explained, the most common methods available to you are cleaning, disinfection and sterilization. But it is important to realize when combating infection, that **only** proper sterilizing equipment (the most common being steam-pressure autoclaves) can sterilize products. Thus, each health facility needs to implement appropriate decontamination methods, suited to its size and needs. The CSSD (or relevant group of staff) must ensure that the correct equipment is used and the correct method for each job is implemented, as follows:

Method 1: Cleaning

It is essential to clean all contaminated items since the cleaning process makes the subsequent disinfection and sterilization more effective. Cleaning:

- gets rid of all visible dust and dirt
- removes organic matter which can reduce the action of disinfectants or sterilizing agents
- removes the breeding ground for surviving micro-organisms
- protects against corrosion and rusting (if the item is dried adequately)
- ensures free movement of equipment parts.

Therefore, it is important to observe the following strategies:

- after use and before cleaning, all items which can be immersed in water should be soaked to prevent deposits drying up and becoming more difficult to remove
- as different materials should be cleaned with either water only, water and soap, or water and detergent, refer to the manufacturer's manual, national guidelines, and expert advice (see *Annex 2*)
- after cleaning and before sterilizing or disinfection, all items should be rinsed thoroughly with clean water and dried.

Method 2: Disinfection

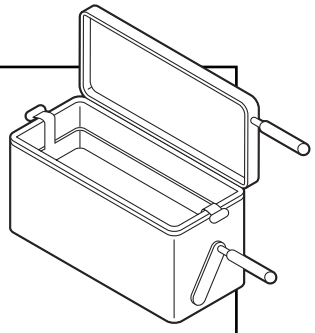
The two main disinfection methods are boiling and chemical disinfection. The boiling method is chosen for items which:

- can be immersed in water
- can withstand high temperatures
- can fit into a container (for boiling).

If your items cannot meet these criteria the chemical method is used.

a. Boiling: This usually takes place in a special boiling pan (boiler) or a saucepan with a close-fitting lid. *Box 21* describes the safety issues that must be addressed when using boilers, if disinfection is to be successful.

BOX 21: Safety Issues When Using Instrument Boilers



DO

- fill the boiler with clean water
- separate the items so that they are not touching each other or the sides of the boiler, and open hinged instruments
- cover the items completely with sufficient water that cannot boil dry
- boil the items for the required time (which will vary from 10–60 minutes depending on your height above sea level)
- time the boiling period from when the water boils
- if boiling stops for any reason (such as a power cut), you must restart the process again from the beginning
- allow the boiler to cool down before draining the hot water, to avoid scalds
- clean the boiler after each day's use

DON'T

- load the boiler with many items touching each other as disinfection will not be guaranteed
- boil without enough water to cover the items as this will damage the boiler and the items
- add any items during the boiling cycle as this will contaminate the existing items, and you will need to start timing from the beginning again
- time the boiling period from the time the water starts to be heated, otherwise the items will not be disinfected
- leave disinfected items in the water because it can easily become re-contaminated
- disinfect by boiling more than 24 hours before you use the items, as the items may become contaminated even if stored in a closed container

b. Chemical disinfection: This can be achieved by making use of the wide range of chemical disinfectants that are available. Each is best suited for a specific purpose and must be used in a particular way to be effective. Because not all disinfectants will kill all organisms, a single disinfectant will not fulfil all your requirements: stocking two different disinfectants may be sufficient. Choose disinfectants which:

- offer a wide range of activity
- are not readily inactivated
- are non-corrosive when diluted
- are non-irritant to skin
- are low cost.

Proper chemical disinfection depends on using the appropriate disinfectant at the right concentration and for adequate contact time. It is important to follow the manufacturer's instructions for disinfectant handling, preparation, use and storage. Incorrect dilution, poor storage, and repeated use of the same working solution reduce the effectiveness of chemical disinfection.

Box 22 summarizes some common chemical disinfectants and their potential applications; the columns show the various benefits and hazards of using each type. The Health Management Team should refer to the manufacturer's manual, national guidelines, and expert advice in order to ensure that they purchase sufficient stocks of the correct chemicals (see *Annex 2*).

Box 22: Some Common Chemical Disinfectants and Their Potential Applications

Chemical disinfectant	Dilution–(g/litre)[a]	Contact time (min)		Inactivates				Important characteristics								Potential application			
		Lipid viruses	Broad spectrum	Vegetative bacteria	Lipid viruses	Non-lipid viruses	Bacterial spores	Shelflife[a] > = 1 week	Corrosive	Residue	Inactivated by organic matter	Skin irritant	Eye irritant	Respitory irritant	Toxic	Work surface	Dirty glassware	Equipment & surface decontamination	Liquids to be discarded
Quaternary ammonium compounds	1 – 20	10	NE	+	+			+			+	+	+		+	+	+	+	
Phenolic compounds	10 – 50	10	NE	+	+	#		+	+	+		+	+		+	+	+	+	
Hypochlorites[b]	5 – 10	10	30	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+
Iodoform[b]	0.075 – 16	10	30	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Ethanol	700 – 850	10	NE	+	+	#		+					+		+	+	+	+	
Isopropanol	700 – 850	10	NE	+	+	#		+							+	+	+	+	
Formaldehyde solution	2 – 80 (of gas)	10	30	+	+	+	+	+		+		+	+	+	+	+	+	+	
Glutaral	20	10	30	+	+	+	+	+		+		+	+		+	+	+	+	

a = Of the pure disinfectant, stored under appropriate conditions
b = Available halogen
\# = Variable results with different viruses
NE = Not effective

Source: WHO, 1994, 'Maintenance and Repair of Laboratory, Diagnostic Imaging, and Hospital Equipment', WHO, Geneva

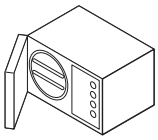
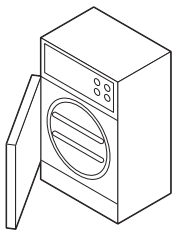
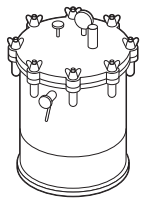
Method 3: Sterilization

To ensure that sterilization is achieved, each health facility should consider which strategies are appropriate for its size and needs. The CSSD (or relevant group) needs to ensure that:

- the correct equipment is used (there are three main types of sterilizers: those for naked instruments and utensils, those for wrapped or porous/fabric loads, and those for fluids)
- the correct method for each job is followed
- the 'sterile chain' is maintained. There must be quality control at each stage of the process: cleaning, set-assembly, wrapping, loading, sterilizing and sterile storage
- a system of monitoring for sterility is implemented. It is advisable to have a centralized sterilizing system: this ensures that sterile supplies are available for all sections in the health facility, that bad practices are eliminated, and that the most effective use is made of available and appropriate equipment.

Box 23 provides some strategies that may require you to make changes to your existing system in order to achieve these ends. The main advantage of these proposals is to ensure the sterility of items. It is also likely that these proposals will save money. Some additional linen, bowls, trays and instruments may need to be purchased to help the introduction of this alternative system, but the theatre and CSSD functions will improve, resulting in a quicker, more efficient service for the theatre and wards. If necessary, a specialist could be contracted to set up the new system, to ensure it is functioning correctly, and to train staff.

BOX 23: Strategies for Ensuring Sterility

Choose methods that ensure sterility	◆ End the use of instrument boilers (disinfectors) as they do not sterilize. ◆ Do **not** try leaving instruments in the sun, as this practice does not work. ◆ End the practice of soaking dropped instruments for a period of time in chemical disinfectants (liquids or creams). This does **not** sterilize the instruments: in fact, if the chemicals are not renewed regularly, they have proven to be a good culture medium.
Choose the right equipment in the right place, in order to establish a 'sterile-pack' supply service  	In small health facilities (such as clinics):  ◆ Use the simple pressure-cooker type autoclave or bench-top autoclave for small volume and low quantity of unwrapped, non-porous, non-fabric items. ◆ For porous or fabric items use the hot-air sterilizer, larger autoclave, supply of sealed sterile products from a district source, or learn a steam-pulsing method for the pressure-cooker type autoclave (see *Annex 2*). In larger health facilities: ◆ Only use bench-top autoclaves where specialist, small volume and low quantity unwrapped, non-porous, non-fabric items are involved, such as in the dentist clinic or eye theatre. ◆ Ensure all the remaining instruments and supplies are sterilized centrally in the large autoclaves in the Central Sterile Supplies Department (CSSD), to cover normal working needs and dropped items. ◆ Ensure the CSSD supplies sterile packs to all relevant sections in the health facility as a whole – the sooner this can be introduced, the easier it will be to stop the ineffectual practice of soaking and boiling at other locations around the health facility. ◆ Reorganize the packing system (see below) in order to facilitate the 'sterile-pack' service and to be more effective in achieving sterility.
Reorganize the packing system to provide smaller sets and packets of items	◆ Prepare smaller, individual packets of each item (cotton dressings, mayo cloths, etc), and only sterilize them on demand based on order lists from the user departments. This will eliminate the practice of sterilizing large drums containing a volume of items which will not be used in one day, which, in turn, leads to the drum standing around for a day or two and becoming contaminated as the lid is continually opened for items to be removed. This will also eliminate the need for continual resterilization of the items, which is more costly and leads to the contents deteriorating.

Continued overleaf

BOX 23: Strategies for Ensuring Sterility (continued)

Reorganize the packing system to provide smaller sets and packets of items (continued)	◆ Reorganize instrument sets into 'basic' sets, and 'specialized additional instruments' sets for specific types of operation (for example, caesarian extras, laparotomy extras, orthopaedic extras). Then pack these sets separately. This avoids the practice of packing all instruments, bowls and towels for a certain type of operation on one tray, creating a set that is cumbersome, heavy, and difficult to sterilize. ◆ Make up bowl packs into major and minor categories, and linen packs into major and minor categories. ◆ Secure and seal the drum closure flaps with heat-sensitive tape after packing, so that: - the lids do not fly open upon removal from the autoclave thereby risking the loss of sterility - the tape can be checked for the correct colour-change to show sterilization was achieved (see *Box 24*). ◆ Label the packs with details of the owner, content, sterilization date, and person responsible.
Ensure there is a 'sterile chain'	◆ Set up a quality control system for each of the following steps: cleaning, set-assembly, wrapping, loading, sterilizing, and sterile storage (correct conditions and duration). ◆ Organize the routing of goods through the department to ensure: - separate areas for cleaning, wrapping, and sterile storage - there is no crossing of flows of the sterile and non-sterile goods.

It is necessary to ensure that autoclaves are working properly, otherwise sterilization will not have occurred. Monitoring for sterility is therefore essential.

Monitoring Sterility

In order to obtain sterility, autoclave cycles need to incorporate three factors – time, steam under pressure, and temperature (known as TST). For steam to penetrate into large or porous loads and achieve sterility throughout the load, the autoclave must be designed to provide pulses of steam. In addition, it is important to allow the load to dry after sterilization before it is stored, otherwise the moisture will provide a breeding ground for micro-organisms.

You must regularly monitor the performance of autoclaves in order to ensure that the items are sterile by the end of the autoclave's cycle (in other words to ensure that sufficient time, steam under pressure, and temperature were received). The common cycles (depending on the material to be sterilized) are steam at 134°C for three minutes or 121°C for 15 minutes, and 115°C for 30 minutes (for fluids).

Sterilization performance can only be guaranteed if you:

Registration
means that the process parameters are recorded during each sterilization process.

- register the physical conditions (pressure, temperature, time, and steam penetration) during each sterilization cycle
- validate (verify) these results against a known similar correct test process profile, and
- ensure such results are consistent and reproducible.

The process parameters fall into two categories. The first – pressure, temperature and time – can be easily recorded, but the second – steam penetration – is more difficult to monitor.

For the first category, advanced automatic sterilizers usually have a recorder that prints the basic parameters (pressure, temperature, time) on special sheets of paper and/or stores them in a computer database. For manually operated sterilizers, the operator needs to read and write down the pressure and temperature at specified intervals (for example, every minute).

To monitor steam penetration in autoclaves you will also need some form of 'passage indicator' – a consumable that changes colour to indicate that steam penetrated your load/pack and that it successfully passed a sterilization process. The method to use is the 'Bowie & Dick test' – the internationally accepted standard. *Box 24* shows different ways of carrying out the test depending on the resources you have available for buying the consumables required (see *Annex 2*).

Experience in Nigeria

A mission hospital in Nigeria uses a small, vertical, electric autoclave run by two nurse aides under the supervision of a nursing sister. With this arrangement they cover all the sterilizing needs of the theatre, maternity department, and wards. Sterile instrument packs are prepared for all major operations and stored on shelves in a room adjacent to the operating theatre.

BOX 24: Different Types of Bowie & Dick Tests Available

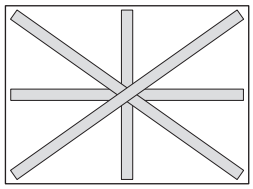
- **Ready-made Bowie & Dick test packs:**
  These are square blocks that are placed inside the autoclave for a cycle. Inside the block is a sheet containing lines of special chemical finish that change during the autoclave's cycle, and display different colours to illustrate if there are any TST problems. They are sensitive and diagnostic, since the different colour changes can indicate seven different types of problem.
- **Ready-made Bowie & Dick test sheets (arrow-check indicators):**
  These are individual A4-size sheets of special paper that you place inside your own Bowie & Dick test pack made of cloths (see *Figure 8*) instead of strips of autoclave tape. They contain lines of chemical finish that change from light to dark evenly across the whole sheet if the autoclave cycle has been successful. Although they are sensitive, they only tell you that the cycle failed, they don't tell you what type of problem you may have.
- **Ready-made small Bowie & Dick test TST strip/indicators:**
  These are individual strips of special paper with a large circle/dot of chemical finish which changes colour if the autoclave cycle has been successful. They should be placed in the most difficult location in the load (such as inside packs or drums). Although they are sensitive, they only tell you that the cycle failed, they don't tell you what type of problem you may have.
- **Using standard heat-sensitive autoclave tape in order to make up your own Bowie & Dick test pack (see *Figure 8* and *Annex 2*):**
  This requires knowledge of the correct method of making a pack. The tape will change from light to dark during the autoclave cycle and will show if there are parts of the tape which did not change colour and therefore did not receive sufficient TST. Although cheaper, it is a more complicated method and does not give you diagnostic information about the type of problem within the autoclave.
- **An alternative method when sterilizing fluids, instruments, or glassware is to use sterilizer control tubes containing fluid:**
  The fluid in the tube changes colour depending on whether the correct temperature was obtained for the correct time. However, these tubes cannot verify that steam was present. Another drawback is that the sterilizer control tubes must be kept in a cool place, preferably a refrigerator.

Validation
means that the users compare their recorded results with a 'correct process profile' – the results for a similar test load made in the same autoclave where sterilization was successfully achieved.

There are a number of ways of obtaining the correct process profile:

- In the case of new automatic machines, the process profile should be provided by the manufacturer.
- You can find and download common process profiles from the internet (world wide web). However as the profile needs to be specific to your machine the maintenance staff may need to check and alter it for your autoclave. *Annex 3* shows a process profile that is suitable for many types of common autoclave.

Figure 8: How to Make Up Your Own Bowie & Dick Test Pack

Steps	Issues
Obtain 36 freshly laundered cotton cloths (for example, theatre or Mayo cloths). Fold them to A4 size.	Do not use cloths that have been autoclaved and not laundered once again, as they will lack natural moisture. The cloths must be freshly laundered, but without the use of fabric conditioner. The cloths must be dried and aired for at least one hour.
Stack 18 of the folded cloths one on top of the other. On the top of the 18th cloth place autoclave tape in a special cross pattern (see diagram). Place the remaining 18 folded cloths on top. Compress, and wrap all 36 cloths into a pack and seal it with tape. The pack should be about 25 cm high and weigh about 7 kg.	Criss-cross four pieces of autoclave tape (standard heat sensitive autoclave tape) from corner to corner and from side to side, as shown: 
Autoclave the pack in the centre of an empty autoclave.	Always use the required temperature for the required length of time (as per the instructions for the autoclave's normal cycle).
Allow the pack to cool on an acceptable surface.	Do not place it on stainless steel as this will cause condensation to gather at the base of the pack, unless the stainless steel surface is covered first.
Open the cooled pack and assess the findings on the criss-cross tape.	If the autoclave tape has evenly changed there is no problem with the autoclave. However if there are differences in intensity in the tape changes, this indicates that there are air pockets in the autoclave preventing total steam penetration. This means that there is a problem and the vacuum is defective and not removing the air from the chamber. Therefore, the autoclave requires adjustment.

- Maintenance staff can create the process profile for each machine. They must:
  - make up a typical, most difficult test load for use in your autoclave
  - have thermocouples, an electronic thermometer, and a pressure gauge
  - place the thermocouples at various points in the sterilizer and the load, and connect them to the thermometer – these will show that correct temperatures were reached at correct points in the cycle
  - use the pressure gauge to verify that correct readings were obtained on the pressure gauges of your autoclave
  - put your autoclave through its various different cycles
  - record all the parameters during each cycle to create a process profile – as long as the readings are what they would expect, sterilization will have been achieved and the profile will be a correct one.

The official standard validation test uses eight thermocouples to measure temperatures, but a basic validation kit is available which uses just two: one in the chamber, the other in the load (see *Annex 2*).

The idea is that CSSD staff only release the load from the sterilizer to the users if all the process parameters were met. For every cycle, ideally, registration would take place and a Bowie & Dick test would be performed, then only if the results are validated is the sterility of the load or pack confirmed. However, this method requires CSSD staff to have time and a continuous supply of these consumables. The alternative is to undertake registration and Bowie & Dick tests as frequently as possible over specified periods of time (daily, weekly or monthly), on the understanding that if the machine fails to pass the tests it means that you could not be satisfied with the sterility of any loads since the last test (in other words, for the last day, week or month). Therefore, the longer the gap between tests, the greater your uncertainty about sterility will be. *Box 25* provides some strategies for monitoring sterility.

BOX 25: Strategies for Monitoring Sterility

Use of registration, and Bowie & Dick tests	◆ Ideally your health facility will use: - a recorder to register pressure, temperature and time on a special recording pad - ready-made Bowie & Dick test packs for large autoclaves - small TST strips for bench-top autoclaves - heat sensitive tape for sealing drums. ◆ If the recorder and ready-made tests are not available, CSSD staff will: - manually record pressure, temperature and time - make up home-made Bowie & Dick tests. ◆ The Health Management Team must ensure adequate supplies of the necessary materials are available, and that staff are trained to understand their roles.
Frequency for large autoclaves	◆ Ideally, CSSD staff will: - register pressure, temperature and time for every cycle of each autoclave, and validate it against the correct process profile - undertake a Bowie & Dick test (with a readymade test pack) on each large autoclave once a day - use heat sensitive tape to seal the drums for every load during the day - keep a record of the results for referral at any time if a query is made about the sterility of a particular load. ◆ If the tests cannot be performed this often, start with once a week and increase the frequency when a more regular supply of ready-made Bowie & Dick tests can be guaranteed, and staff are familiar with the regular recording process.

Continued opposite

BOX 25: Strategies for Monitoring Sterility (continued)

Frequency for small autoclaves	◆ Ideally, users of small autoclaves (such as dental clinics, eye clinics, and small health facilities) will: - register pressure, temperature and time for every cycle of each autoclave, and validate it against the correct process profile - put a TST strip in every load placed into each bench-top autoclave. ◆ If tests cannot be performed this often, start with once a day (on those days when you use the autoclave) and increase the frequency when a more regular supply of TST strips can be guaranteed, and staff are familiar with the regular recording process.
Validation and frequency by maintainers	◆ Maintenance staff will: - be responsible for obtaining correct process profiles, either from the manufacturer, or by checking and modifying downloaded ones, or by creating their own using a kit containing thermocouples, etc - validate each autoclave using the kit: when a machine first arrives, after each maintenance/repair job, during the annual service (or a more regular service), and if a new type of load or pack is to be used - undertake a Bowie & Dick test every time PPM or repairs are carried out on any autoclave, before the autoclave is handed back to the users.
Bad results	◆ If any registration fails to match the correct process profile, or any Bowie & Dick test produces a non-uniform colour change, the autoclave requires adjustment and the users will: - know that the load or pack is not sterile - know the sterility of all loads or packs since the last test cannot be guaranteed and warn the relevant users - contact the HTM Team for assistance. ◆ If a ready-made Bowie & Dick test pack was used, the maintenance staff (or supplier's technical representative) will be able to use it to diagnose the problem (in other words, to establish whether the problem was with steam penetration, steam temperature, time of steam penetration, air leaks, air evacuation, non-condensible gases, superheat, or over-saturation of steam). ◆ Once the autoclave has been repaired by the technical staff, the validation process and the Bowie & Dick test will be repeated.

5.3.2 Linen Handling

All washable fabrics can easily be disinfected:

- either by hot water, if the correct temperature is used for the correct time
- or by cold water, if the correct disinfectant is used at the correct concentration, for the correct time.

The word 'linen' is used to cover all items to be laundered. It is recommended that, in health facilities, linen is divided into two categories:

- *Soiled linen* which has been used and is no longer fresh, but is *uncontaminated* by infectious agents.
- *Fouled and infected linen* which is obviously fouled (with urine, faeces, blood, vomit, pus, etc) or is known to have been in contact with an infection: this is *contaminated* linen.

It is necessary to have appropriate linen handling procedures in place in order to avoid cross-contamination, and to avoid the transmission of infectious diseases to the linen handlers. Many linen handling strategies are dependent on the use of the correct equipment.

To prevent contamination through exposure to contaminated linen, HTM Working Groups (or infection control committees) need to develop and implement good infection control practices. *Box 26* provides some important strategies.

Other equipment-related safety issues in the laundry are as follows:

- Do **not** overload the washing, spinning, or drying machines as this strains the bearings.
- Do **not** under-load washing machines as this wastes cleaning chemicals, and increases the friction in the linen, making it wear out more quickly.
- Avoid accidents (*Section 5.5*) – laundry floors must be well drained to avoid slippage, and pipes must be lagged to prevent burns.
- Do **not** spread linen on the ground or over bushes to dry but hang it from washing lines if spin- and tumble-driers are not available.
- Always iron items that have hung in the open air if your country has insects (such as the mango fly) that lay eggs on linen drying outdoors. The ironing process, whether by hand or by machine, kills the eggs and prevents the larvae from hatching and burrowing into skin.

BOX 26: Strategies for Linen Handling

Staff protection	All staff involved in handling contaminated linen should be provided with appropriate safety clothing. The risk of infection is high when dirt, blood, and infectious agents are present. Aprons, strong rubber gloves, facemasks, working boots, etc are recommended.
In each section	Sections using linen (such as wards, OPD clinics, treatment rooms and theatres) must use two separate types of receptacle (soiled linen containers) of different colours with labels; one for contaminated linen and the other for uncontaminated linen. Uncontaminated linen may be collected in some form of cotton bag: contaminated linen should always be placed in strong waterproof plastic bags. Used linen should be handled as little as possible to avoid cross-infection. Nursing staff should place used linen into the correct collection bag (either for contaminated or uncontaminated items) at the bedside to avoid carrying dirty linen through the department. Staff should avoid sorting contaminated linen before washing as much as possible. No sluicing (rinsing under a stream of water) of contaminated linen should take place within the section (for example, at ward level). Instead, this will be done in the laundry with cold water. Depending on the frequency of collection by laundry staff, and the availability of pre-wash facilities in the laundry, it may be necessary to soak contaminated linen in the sections using linen. Soaking is required to prevent stains from becoming engrained and spoiling the linen, as follows: ◆ Sections which use linen should be provided with rubber garbage bins, in which staff can soak contaminated linen in a freshly-prepared sodium hypochlorite solution (such as a 0.5% concentration of bleach in water) for at least one hour ◆ Section staff send the soaked material to the laundry on a regular basis, to be processed quickly so that the damp linen does not go mouldy.
In the laundry	Refer to the manufacturer's manual, national guidelines, and expert advice in order to ensure that sufficient stocks of the correct industrial cleaning agents and chemicals are purchased for the laundry (see *Annex 2*). Laundry staff must understand the proper use of appropriate chemicals to kill bacteria, and the correct amount of cleaning agent which is effective, not wasteful, and does not cause foaming. Refer to the manufacturer's manual, national guidelines, and expert advice to ensure that the correct temperatures for washing are used (see *Annex 2*). To save energy, some hospitals wash different types of linen at different temperatures, but if you cannot be certain of the type of contamination involved it is safer just to use the higher temperature level, as follows: ◆ 65ºC for 10 minutes for soiled linen. ◆ 93ºC for 10 minutes for fouled and infected linen. These figures only work if detergent is used, and additional time is allowed for the warming up and mixing of contents by the washing machine. If you have no detergent, you will have to boil the linen (at 100ºC) for five minutes. If you have no hot water, use proper laundry detergents and chemicals suitable for cold washing, as well as chlorine bleach.

Continued overleaf

BOX 26: Strategies for Linen Handling (continued)

In the laundry (continued)	If you do not have washing machines, wash linen by hand, and hang it on lines to dry in fresh air and sunlight to assist with disinfection. To save resources, water from the laundry may be recycled, for example, for watering garden crops. However, water from the washing machines used for 'infected' linen (in other words blood-stained, or containing solids) is unhygienic and should not be recycled.
Transporting linen	Staff should ensure hygienic storage and rotation of linen, always keeping dirty and clean linen apart. Ideally laundries should be designed and built in such a way that there is a physical barrier between the dirty and clean linen areas. If not, there must be sufficient physical separation between: ◆ the routes used by dirty laundry and clean linen trolleys ◆ the trolleys designated and labelled for use with dirty or clean linen ◆ the storage locations for clean linen and piles of dirty or condemned linen. If your linen is transported for many miles to reach the nearest laundry, or it is laundered by a private contractor, great care must be taken to address all hygiene and infection control risks so that you protect members of the public from your infectious agents.

5.3.3 Ensuring the Workplace is Clean

It is necessary to have procedures that ensure you keep the workplace clean, in order to maintain general levels of hygiene. Many of the issues involved are dependent on the correct use and care of equipment, such as:

- cleaning the health facility in general
- hygiene practices in the kitchen
- controlling infestations by vermin
- guaranteeing a safe water supply
- general waste and sewage management (this will be discussed in *Section 5.4*).

To guarantee the general cleanliness of the health facility, the HTM Working Groups (or infection control committees) need to develop and implement good infection control practices for these areas.

Cleaning the Health Facility in General

The regular cleaning of rooms, service installations, fixed equipment, furniture, etc is necessary to create an hygienic workplace. Most of this work can be done with readily available cleaning agents (see *Box 27* for examples). Fresh water must be used for cleaning – no surface can be cleaned with dirty water.

It is a waste of money to use chemical disinfectants for all cleaning. Disinfectants are not cleaning agents: they do not remove dirt, nor do they increase the cleaning power of cleaning agents. Where a chemical disinfectant is to be used, it is more effective applied to a clean surface. Some 'germicidal' or 'bactericidal' cleaning agents have a disinfectant already added to them. *Box 27* shows examples where disinfectants are recommended.

The importance of simply using water must not be underestimated. For example, flushing lavatories with water is more effective for decreasing microbes and reducing smells than the use of chemical disinfectants. This is true for facilities with piped water (such as water closets) and also for facilities attached to pits or septic tanks (such as pit latrines and aqua privies) where you can usefully dispose of waste water to flush the toilet pan/squat hole. The greatest infection hazard in lavatories is transmission by hand. Thus, the most important strategy is to provide some form of toilet paper as well as hand-washing facilities with clean water and soap.

In order to clean the health facility effectively, it will be necessary to address, and make decisions about, the following issues (see *Box 27* overleaf for examples):

- Which method to use.
- What cleaning equipment to use.
- The correct daily maintenance and sterilization of the cleaning equipment.
- The frequency that different areas must be cleaned.
- The appropriate cleaning agents and disinfectants to use, and the correct concentrations.
- The protective clothing required.
- Possible rationalization and standardization of cleaning materials in order to enable groups of health facilities to have common purchasing power.

Hygiene Practices in the Kitchen

The regular cleaning of all the equipment in the kitchen has been discussed in other parts of this Guide. Other equipment-related issues to address, and staff practices to introduce, are:

- Separate equipment (such as knives, chopping boards and slicing machines) that are used for handling raw food from those used for cooked food so that microbes are not transferred to the cooked food, causing food poisoning.
- Hand-washing facilities with soap for kitchen staff so that they can wash their hands between handling different types of food, between different activities, and after going to the toilet.
- Adequate refrigeration through properly working refrigerators and cold store rooms.
- Extraction hoods over cookers which are clean and working effectively.

BOX 27: Strategies for General Cleaning of Health Facilities

Where to use cleaning agents	◆ always use clean, freshly drawn water ◆ damp dust in any area ◆ clean walls, floors, ceilings, or furniture in most areas with a general-purpose detergent (an anionic liquid) ◆ use scouring powders (that are not so abrasive that they scratch the surface) on sinks, wash-basins, sluices, slop-hoppers, baths, showers, and lavatories ◆ use washing soda for cleaning waste-pipes and overflows in sinks, baths, showers, wash-basins, drain grids, and drain pipes ◆ use a grease-solvent paste for cleaning cookers ◆ use a non-foaming detergent in dishwashers.
Where to use disinfectants	Disinfect: ◆ baths during or after cleaning ◆ kitchen work surfaces **after** cleaning ◆ floors and work surfaces in operating theatres, renal dialysis units, special care units, and other high-risk areas, during or after cleaning on some occasions (when areas are known to have been soiled with infected organic material) ◆ patches of floor soiled by incontinence or bedpan spillings during or after cleaning.
How frequently to clean	The frequency of cleaning varies for different areas of the health facility. For example: ◆ operating theatre floors: several times a day ◆ baths, showers, basins, and lavatories: at least once a day ◆ walls: once a month, but immediately after being splashed with organic material.
What cleaning equipment to use	◆ **All** cleaning should be done using one of the following, which must be wet, but not dripping wet: cloths, sponges, scrubbing brushes, buckets and mops, wet-vacuum pick-ups, scrubbing machines, polishers, etc. ◆ Do not use brooms, dusters, dry mops, etc as these dry cleaning methods whisk dust and microbes into the air and increase the risk of infection.
Care and cleaning of the equipment	**All** cleaning equipment must be sterilized regularly and maintained because: ◆ the equipment itself is a breeding ground for microbes ◆ the equipment can spread the microbes further around the facility ◆ the cleaning water must be regularly changed for fresh water otherwise you are simply moving dirt from one place to another, and stagnant water breeds microbes ◆ redistribution of dirt is time-consuming but it is not cleaning, and therefore it might as well be left undone.

Controlling Infestations by Vermin

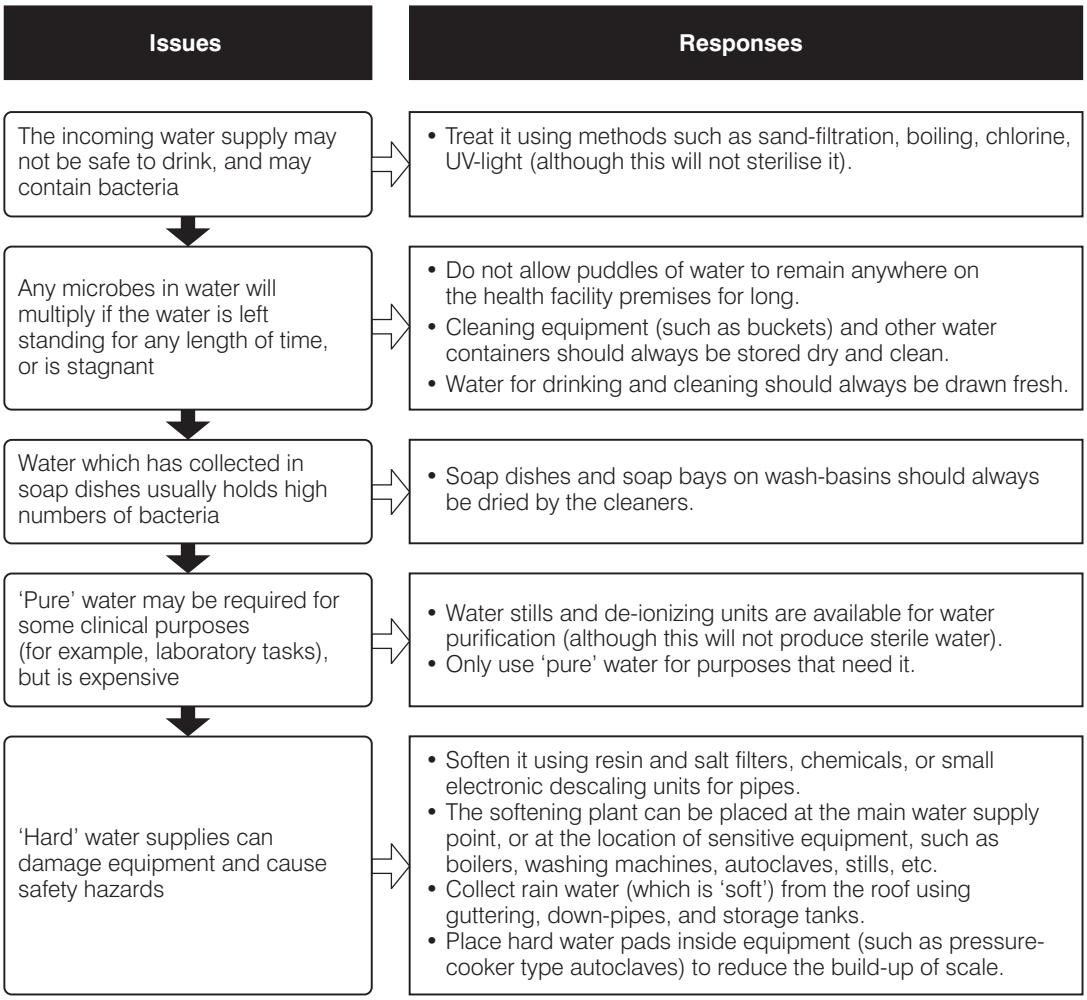
There are a number of pests that are commonly found in health facilities. All of them carry microbes on their bodies, and their droppings are microbe-laden. In addition, many of them get into and damage equipment. *Box 28* provides some examples, and strategies for controlling them.

Cleaners must report signs of pests immediately. If steps are not taken to remove the pests, efforts to clean areas frequented by them are a waste of time. The regular removal of litter is essential for reducing vermin (*Section 5.4*).

BOX 28: Strategies for Controlling Vermin

Vermin	Habits	Strategies
Rats and mice	◆ are attracted to the sewage pipelines and the kitchen grease-trap/drains ◆ move from there through holes in floors and walls which admit service pipes ◆ like to eat materials available in the kitchen (food), mortuary (corpses), and the pharmacy (glycerine tablets), thus are very effective at spreading microbes from one place to another ◆ climb inside equipment and chew through wires – rats have been found in X-ray machines and electricity distribution boards, mice in infant incubators and operating theatre lights.	◆ block any likely entrance holes ◆ use poison or traps ◆ either purchase equipment with vermin grills and guards, or make your own from metal, mesh, or plastic ◆ keep rooms in regular use ◆ consider keeping cats for vermin control.
Ants and cockroaches	◆ like warmth and food so are common in kitchens and autoclaving units ◆ have trails that run for long distances: they visit drains and sluices for moisture, feverish patients for sweat, open wounds for the discharge, and commonly spread infections ◆ have even been found in 'sterile' packs, resuscitation equipment, and drip tubes.	◆ cover served food and stored food ◆ store food in air-tight containers ◆ keep gifts of food for patients covered inside lockers ◆ tightly close bags containing soiled and fouled linen ◆ fill crevices in walls ◆ use poison and control chalk.
Birds (such as pigeons)	◆ bird droppings foul areas of the health facility they have access to, such as verandas, laundry ◆ bird droppings – and occasionally dead birds – can foul the water supply, if the roof to the water tank is broken.	◆ use wire netting across openings to keep birds out of the health facility ◆ regularly maintain water tank covers and roofs.
Flies and mosquitoes	◆ flies breed in dustbins and garbage bags, and contaminate food ◆ mosquitoes breed in any stagnant water, and spread malaria.	◆ seal rubbish in plastic or paper bags and put in bins with lids ◆ wash and dry rubbish bins ◆ do not let puddles and water that has collected in open containers stay standing for long.
Bees, wasps and hornets	◆ make their nests in partially enclosed areas and the nest wraps around parts of equipment ◆ have made nests under the roof eaves around telephone and electricity cables, in the wiring of distribution boards, etc.	◆ keep a watch out for insect nest building ◆ destroy the nests when they are in their early stages and are therefore still small.
Bats	◆ make their nests in roofs, especially in buildings of simple design where access is easy ◆ are carriers of disease and can foul areas of your health facility with their droppings.	◆ cover openings with mosquito netting if an uninterrupted form of fixing can be found ◆ investigate chemical and ultrasound deterrents ◆ in the long-term, alter building designs to avoid admittance.

Figure 9: Ways of Improving the Quality of Water



Guaranteeing a Safe Water Supply

The main water supply for many health facilities (whether piped or from pumps) is safe to drink, in others it must be treated first to get rid of bacteria. However this supply of water will not be sterile. The water supply always contains some microbes and if it is allowed to stand for several days their numbers will increase. Thus water for drinking and cleaning should always be drawn fresh, and cleaning equipment should be stored clean and dry. Even water that has collected in soap dishes usually holds high levels of bacteria.

Some clinical processes require 'pure' water in the form of distilled or de-ionized water. As water purification is expensive, it is necessary to know the level of purity required and to use precious pure water only for purposes that need it.

Depending on your geographical area, your main water supply may be 'hard' water (water that has a high mineral or salts content). These substances build up inside pipes and any equipment using water, causing scaling, furring, and equipment corrosion. Such effects can be a safety hazard, (such as blocking valves) and can damage the equipment. In order to prevent this build up, hard water may need to be softened or a source of 'soft' water (such as rain) can be harvested.

Figure 9 provides some strategies for guaranteeing a safe water supply. All these strategies can be undertaken on a small scale for particular needs, or on a large, facility-wide scale.

5.4 WASTE MANAGEMENT

Not only does equipment use and maintenance produce waste products (for example, disposable electrodes, X-ray fixer, laboratory reagents, machine oil), but also many waste management strategies involve equipment (such as incinerators, biogas plants). Proper waste management is therefore required in order to reduce:

- risks to health staff who, for example, may be injured by sharps
- risks to support staff who, for example, handle infectious linen and materials
- risks to maintenance staff, for example plumbers unblocking sewers who may have little understanding of the infectious nature of the material they are handling
- exposure of any staff to toxic or hazardous chemicals
- exposure of patients and visitors to any of these risks
- risks to the environment and neighbouring population, through contamination of the soil, and pollution of groundwater or air
- risks for landfill workers and waste pickers.

5.4.1 Waste Management Philosophy

In order to dispose of waste effectively, you will need to address and make decisions about issues such as:

- the *identification and handling* of different categories of waste from the health facility
- the methods for *treating* different types of waste and the documentation required to monitor its treatment (such as monitoring the use of the incinerator)
- the methods for *disposing* of different types of waste, and the documentation required to monitor its regular occurrence.

To help you to achieve all of this, we suggest that the central HTM Working Group develops the policies on waste management and a Waste Management Hygiene Plan (see reference material in *Annex 2*) with advice from national and municipal experts. The facility level HTM Working Group, or its smaller sub-group, the infection control committee (*Section 1.2*) needs to develop and implement good waste management practices.

Box 29 discusses the idea that waste management strategies should follow the waste management hierarchy of – avoidance, utilization, and disposal.

BOX 29: Strategies for Waste Management

Hierarchy	Strategies	Examples
Avoidance: Avoidance and reduction of waste generation minimizes the necessary effort for waste treatment and disposal at health facilities.	◆ Waste reduction at source, through product selection. In practice, it will not always be easy to decide what material is environmentally friendly or which chemical is less harmful. The relevant expertise must be developed or advice sought.	◆ use reusable articles whenever possible (as long as they have not been contaminated by hazardous chemicals, radioactive substances, or infectious organisms) ◆ use products with minimal packaging ◆ give preference to products which are made of environmentally-friendly materials ◆ use less-harmful chemicals, if these are available
	◆ Segregation of waste. If waste is properly segregated at source before it gets mixed up, special precautions in waste handling are only necessary for the hazardous portion of the waste (see *Box 30*)	Segregating waste at source offers the opportunity: ◆ to separate hazardous waste from non-hazardous waste ◆ to recover material for reuse or recycling ◆ to ensure the correct handling for each type of waste (see *Box 30*).
Utilization: Waste can be a source of 'secondary' raw materials, in other words items that can be reused or recycled. If items are cleaned and uniformly separated, they are easier to use again. Waste should be sorted at source by those who know the dangers, such as doctors and nurses.	◆ Reuse. Some medical items can be reused only if the necessary precautions regarding disinfection, cleanliness, sterilization, and safety are taken. If these hygiene requirements are followed, items such as infusion bottles and some sharps can be reused. Bandages can be reused only if they have been washed at over 90°C. Infusion sets, catheters, etc should not be reused.	Typical articles for general reuse within or outside the health facility are: ◆ glass or plastic bottles and containers ◆ cardboard or timber boxes ◆ sheets and bags made of paper or plastics ◆ plastic or rubber tubes ◆ lead batteries.
	◆ Recycling. If articles are broken, dirty or contaminated so that reuse is no longer feasible, it is still possible to use some waste as raw material for processing and manufacturing. Although recycling is not the task of a health facility, collecting and selling recyclable material might generate some additional funds.	Typical examples of recycling that can occur: ◆ Recovery of silver from the fixing baths of X-ray film processing. ◆ Metals and plastics separated by type. ◆ Glass sorted according to colour. ◆ Paper. All material leaving the facility must be properly disinfected.

Continued opposite

BOX 29: Strategies for Waste Management (continued)

Hierarchy	Strategies	Examples
Disposal: Waste is treated before final disposal to lower its hazardous potential.	◆ Treatment of healthcare waste. It is important to segregate different types of waste (see *Box 30*), then the majority is no more harmful than solid waste and does not need to be treated. Only the fraction which is hazardous will need to be treated.	◆ General waste and non-infectious healthcare waste can be disposed of untreated. ◆ For infectious and pathological waste, incineration is the most appropriate method (or possibly burning). ◆ Chemical waste may need chemical treatment, such as neutralization or denaturing. ◆ Radioactive substances have to be packed and sealed for final disposal.
	◆ Final disposal of healthcare waste. The final disposal method depends on the type of waste, thus segregation is again important.	◆ General waste, non-infectious healthcare waste, incinerator ash, and neutralized/denatured chemical waste can be landfilled with ordinary municipal solid waste. ◆ Hazardous waste (radioactive, carcinogenic, mutagenic, or infectious waste) must be disposed of separately in specially designed landfill sites, waste pits, or guarded underground places.

There are four types of healthcare waste:

Type A General waste and non-infectious healthcare waste, which requires handling similar to that of municipal solid waste. For example, newspapers, magazines, books, packaging material, food residue.

Type B Infectious waste, which require special precautions during handling and disposal. For example, sharps (syringes, needles, scalpels), blood-soaked bandages, cultures, and stocks of infectious agents.

Type C Pathological waste, which requires special treatment for reasons of hygiene and particularly for cultural and ethical reasons. For example, body tissue, body parts, human foetuses, organs.

Type D Toxic waste, which needs individual disposal methods. For example, drugs, chemicals (diesel, oil, formaldehyde, acids, solvents, mercury, developer, reagents, etc), radioactive substances, batteries, X-ray film.

Most waste – about 90% – is non-hazardous general waste (type A) and doesn't need special treatment. However, if it is mixed with hazardous waste, then it **all** needs special treatment. Thus it is very important to segregate different types of waste, in order to reduce the cost of its treatment and disposal.

5.4.2 Managing Different Types of Waste

Box 30 discusses the appropriate handling technologies required for:

- collection and separation of waste
- transportation within the health facility
- intermediate storage
- on-site treatment
- on-site disposal
- transport to centralized waste handling and disposal facilities.

One particular category of infectious waste type B is 'sharps'. These are items such as scalpel blades, needles, syringes, razor blades, or even broken glass. Not only are these items hazardous in themselves (they can cut the handler or be the cause of 'stick' injuries), but they also may be contaminated with body fluids that can be transferred to the handler. Thus, both the safe handling and the safe disposal of sharps is very important. *Box 31* overleaf provides some strategies for their disposal, and *Annex 2* lists additional reference material.

BOX 30: Strategies for Handling Waste

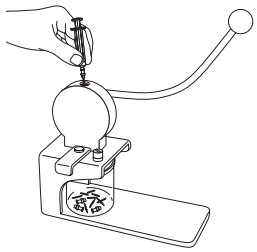
Issues	Strategies
Collection and separation Waste has to be collected wherever it is generated. According to the principle of segregation at source, different collection vessels or bins must be available for the various types of waste. They must be marked so that they are not mixed up.	Various types of waste should be segregated and held in colour-coded containers. To prevent waste being mixed up, the colour coding should be agreed at national level: General waste type A - use plastic bags, containers, or bins (50 to 150 litre), which are black (for example) Infectious waste type B - use puncture-proof containers (5 to 20 litre), which are red (for example) Pathological waste type C - use strong plastic bags or containers (10 to 30 litre), which are green (for example) Toxic waste type D - use puncture-proof containers, such as sealed drums or lead boxes, labelled with the respective symbol (5 to 10 litre), which are yellow (for example).
Transport The transport of waste inside the health facility	Waste type A - human handcart Waste type A & B - transport trolley with a lid or hood, or 180 litre 'tote' bin with wheels Waste type C - either of the above, as long as in sealed plastic bags or containers Waste type D - either of the above, as long as in its sealed container

Continued opposite

BOX 30: Strategies for Handling Waste (continued)

Issues	Strategies
Intermediate storage General waste type A is normally dumped immediately, while waste from the other categories sometimes needs to be stored before it is treated on-site or transported to centralized waste handling sites outside your facility. Thus you will need a suitable storage place for the waste.	◆ Waste type A should be kept in its usual type of container, but protected from weather and scavengers. The collection points should be fenced, roofed, and protected from the wind. ◆ Waste types B, C, and D require special storage facilities: - lockable to prevent unauthorized access - large enough to store the volume of waste gathered between collection dates, with enough space for movement of the carts used to move the waste - well lit, well ventilated, and as cool as possible – protected from the sun or even air-conditioned - walls and floor to be waterproof, smooth, rustproof, well-drained, easy to clean and disinfect - located well away from fresh food stores and food preparation areas - chemicals and radioactive agents should be kept separate from other (infectious) waste in a separate room or locked cupboard.
On-site treatment Not necessary for waste type A.	◆ The main treatment methods for waste of category B, C, or D are disinfection and incineration. ◆ Radioactive waste should **never** be treated on-site, but should be collected and taken to an appropriate treatment site. ◆ Some liquid chemicals may be neutralized or diluted. ◆ Sewage and wastewater treatment systems include pit latrines, septic tanks, aeration ponds, biogas plant, seedbed purification, etc.
On-site disposal Health facilities at remote places out of reach of any municipal waste management structure have to dispose of their own waste.	◆ Normal dumps are sufficient for general waste of type A, and the ash from incinerators. To avoid any danger of infecting the neighbouring population these landfill sites should be fenced and locked. ◆ Organic solid waste (such as vegetable matter) can be composted on-site. ◆ Untreated infectious waste type B and pathological waste type C require specially designed waste pits which guarantee that nobody is able to come into contact with the waste. ◆ Toxic waste type D should **never** be disposed of on-site, but transported to authorized collectors. ◆ Soakpits and drainfields are used for wastewater after treatment.
Transport to centralized waste handling facilities	◆ Various open vehicles can be used for general waste, as long as they are covered with a net, plastic foil, tarpaulin, etc to prevent the loss of waste during transportation. Examples include animal carts, tractor and trailer, conventional truck. ◆ Infectious, chemical, or radioactive waste should only be transported in locked vans or lorries.

BOX 31: Strategies for Disposing of 'Sharps'

Strategy	Examples
Countries should: ◆ Reduce overuse of injections and assure safe injection practices, by implementing *multidisciplinary strategies* comprising three elements.	i. Change behaviour, by encouraging patients and healthcare workers to adopt safe practices and avoid unnecessary injections. ii. Ensure sufficient quantities of clean injection equipment are available in each healthcare facility. iii. Establish procedures so that sharps are disposed of in such a way that dirty injection equipment is not reused, and the risk of accidental needle-stick injuries is minimized.
◆ Choose between the three different types of injection equipment available.	i. Reusable syringes and needles. These can be effectively sterilized with steam, **however** evidence indicates that the result is difficult to ensure and that breakdown in such systems leads to lack of sterilization. ii. Disposable injection equipment. High rates of consumption mean high costs. Potentially the safest method, but the quality of such equipment must be regulated by national authorities, so that unsafe reuse of disposables is actively prevented. iii. 'Auto-disable syringes'. These are inactivated automatically after one use and prevent dangerous reuse of injection equipment.This product is new, so may not be available in your country in all sizes.
◆ Implement a system of collecting used sharps in a secure way.	**Either** use 'sharps containers' which are puncture-resistant, leak-proof, shatter-proof containers into which sharps and syringes are placed. In-house solutions include using a plastic bottle with a small opening and a screw top, or some form of rigid, closable cardboard box; otherwise commercial products are available.  **Or** use an encapsulated mechanical destruction device that destroys the needle only. This should be designed to have a sealed collection compartment which ensures any aerosol of contaminated fluids created is not exposed to the air. The syringes should be collected like all other infectious waste. 
◆ Implement an effective and safe system of disposing of sharps containers.	Use incineration (or burning) for all sharps containers and for the sealed collection compartments of the mechanical destruction devices.

Source: WHO, 2003, Safe Injection Global Network (SIGN) website

One method of waste treatment is burning/incineration. Open burning by adding petrol, diesel, or oil to a heap of waste (in a pit or in the open) should be avoided. By this method combustion is often incomplete leading to scavenging, the residue may still be infectious, and the air pollution due to emission of particles and bad smells are unacceptable. A better method is to use an incinerator. There are specific safety issues relating to these pieces of equipment.

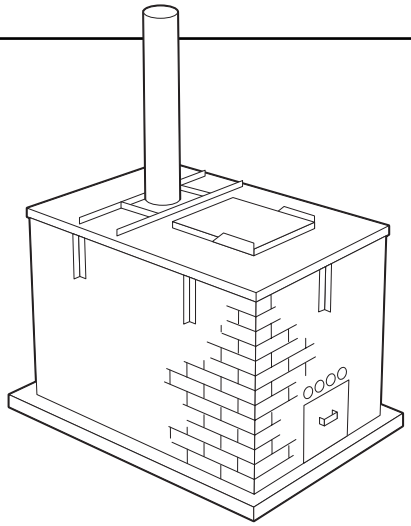
Many health facilities in developing countries cannot afford the expensive investment and subsequent running costs of the sophisticated incinerators used in modern hospitals in industrialized countries, which meet all hygiene and environmental protection requirements. However, there are simpler incinerators that are designed for smaller facilities, such as a ready-made two-chamber pyrolytic incinerator, the more traditional brick incinerator (preferably with two chambers), or a specially-designed drum incinerator (although this will be less efficient). These types can be effective if certain technical principles are followed (see *Annex 2*).

The aim of incinerators is to provide high temperature combustion (around 800°C) with good ventilation, over a long enough period to destroy infectious organisms. This also reduces the volume and weight of waste down to ash, ensuring that aesthetically offensive waste components (such as blood, materials soaked with body fluids, or body parts) are destroyed beyond recognition. However, poorly functioning incinerators do not achieve the desired results. *Box 32* overleaf discusses some issues to address in order to ensure 'safe' incineration (also see *Annex 2*).

Country Experiences

- *In Indonesia, implementing strategies which have changed people's behaviour has resulted in a substantial and sustained decrease in the overuse of injections.*
- *In Burkina Faso, increasing the availability of clean, disposable injection equipment through community pharmacies has almost eliminated unsafe injection practices.*
- *In a pilot project in Côte d'Ivoire, the introduction of small-scale, locally-built incinerators and, at the same time, training of healthcare workers have successfully eliminated dangerous needles and other sharps waste from the environment.*

BOX 32: Safety Issues Relating to Incinerators



DO	DON'T
Design issues ◆ Have an upper pre-heating chamber where wet waste can dry out prior to combustion. ◆ Ensure good ventilation using enough air inlets and a sufficiently high chimney (greater than 4m) made of stainless steel. ◆ Generally require fuel (wood, charcoal, coal, paraffin, oil, gas, coconut husks, etc) to be added only during the start-up period. ◆ Include a method for cleaning flue gases, in other words, a cross-draught combustion system that requires all gases to pass through the hottest part of the chamber.	
Ensuring proper combustion ◆ Use fuel to preheat the waste in the start-up period. ◆ Add waste in small amounts: for example, load with only a few plastic sacks, and wait for these to burn away before adding more. ◆ Load with a good mix of combustible and non-combustible material. ◆ Add additional fuel (firewood, oil, or gas) if the waste does not burn properly – you can collect waste motor oil for this purpose and soak cloths, paper, sawdust, etc to place in the incinerator. ◆ Leave the cover closed until most of the waste has burned away. ◆ Ensure regular maintenance.	◆ load with too much waste at one time ◆ load with waste that is too wet ◆ burn polyvinyl chloride (PVC) as it produces toxic gases including dioxins ◆ add liquid fuel directly to the fire when using the incinerator ◆ add whole bottles filled with liquid fuel as they can explode
Safety for the operators ◆ Use protective clothing, boots, and gloves. ◆ Avoid direct skin contact with wastes at all times. ◆ Avoid skin contact with, or inhalation of, the ash – collect it in a covered metal container. ◆ Handle unburnt residues from the incinerator with care as they may still be infectious.	◆ open waste bags or handle the waste, as it is hazardous ◆ open observation or loading doors to look inside during operation, as you can sustain eye injuries
Safeguarding the environment ◆ Consider the prevailing wind direction when siting the incinerator. ◆ Attempt to separate PVC from waste where possible to avoid production of toxic gases. ◆ Check whether you can meet local environmental regulations on pollution control. ◆ Dispose of ash and unburnt residues in landfill sites.	◆ let smoke pollute the health facility or neighbouring areas ◆ assume the emissions are not hazardous – depending on the waste burnt they may contain dioxins, metals, furans.

5.5 CONTROL OF OTHER HAZARDS

Besides each type of equipment having its own operational safety issues and procedures (*Section 5.2*), equipment can present hazards in general. This Section discusses the hazards of:

- gases (*Section 5.5.1*)
- electricity (*Section 5.5.2*)
- laboratories (*Section 5.5.3*)
- radiation (*Section 5.5.4*)
- fire (*Section 5.5.5*)
- accidents (*Section 5.5.6*).

There may well be other hazards that you will have to develop strategies for.

We suggest that the central HTM Working Group, or its smaller safety sub-groups (*Section 1.2*), should be responsible for establishing policies and guidelines in all safety areas. It will have to consult with the relevant national authorities that provide guidance in these areas (*Section 2.2*). The facility level HTM Working Group, or its smaller safety sub-groups, needs to develop and implement good safety practices.

5.5.1 Gases

Health facilities often contain a variety of cylinders which may contain various fuels and gases under pressure (such as oxygen, medical air, carbon dioxide, propane, LPG, acetylene). Various strategies are shown in *Box 33* overleaf for the safety of gas cylinders, because they can be hazardous for a number of reasons:

- They contain a flammable substance.
- Their contents are contained under pressure.
- They are heavy.
- Their invisible contents may leak.

Some health facilities may have oxygen concentrators and/or piped gas as well as cylinders. They will require similar safety strategies to keep flammable sources away, to prevent liquid getting into the equipment, and to test for wasteful leaks.

In addition, hazardous materials can give off fumes, such as chemicals and solvents. A number of strategies should be pursued, such as:

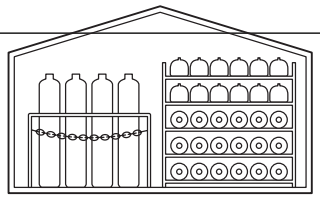
- following the instructions for use carefully
- wearing face masks
- providing appropriate ventilation (open windows, switch on fans, etc)
- using fume cupboards in laboratories.

BOX 33: Strategies for the Safety of Gas Cylinders

DO	DON'T
Personnel ◆ Take great care when handling the cylinders, making sure that there are at least two people to lift and carry large cylinders. ◆ Wear good foot protection when moving a cylinder in case it is inadvertently dropped. ◆ Use a wheeled cylinder trolley to move cylinders (regular dragging of cylinders will cause severe damage to the fabric of the health facility, such as stairs).	◆ carry a cylinder by its valve ◆ allow pressurized gas to come into contact with the skin ◆ allow flames or smoking anywhere near the cylinders as the contents promote combustion ◆ use grease or oil anywhere on the equipment as this can create an explosion risk
Storage ◆ Keep cylinders dry, clean, and in a well-ventilated area. ◆ Keep cylinders away from flames, lighted cigarettes, flammable liquids, and combustible material. ◆ Use clear signs to warn of potential dangers. ◆ Sort and store different gases separately. ◆ Store E-sized and smaller cylinders of medical gas (only) on their sides, and larger cylinders in an upright position. ◆ Store cylinders of liquefied petroleum gas (LPG) in an upright position. ◆ Use chains and other methods to prevent cylinders from falling over. ◆ Ensure that cylinders are used in strict rotation by date. ◆ Keep empty cylinders separate from full ones. ◆ Replace the protective covers or caps onto the valves of empty cylinders. ◆ Ensure that empty cylinders are returned to the suppliers.	◆ store cylinders in direct sunlight as this can cause the gas to expand and the cylinder pressure to increase excessively ◆ use excessive force to shut cylinder valves; tighten by hand tool only
In the event of fire ◆ Raise the alarm and, unless life is endangered, attempt to move the cylinders away from the area. ◆ If personnel are not trained to use fire-fighting equipment, leave cylinders in the fire zone and carry out statutory fire drill procedures. ◆ Only allow trained personnel to handle cylinders that have been affected by fire or excessive heat.	◆ let people gather near any areas where cylinders are stored when there is a fire.

Continued opposite

BOX 33: Strategies for the Safety of Gas Cylinders (continued)

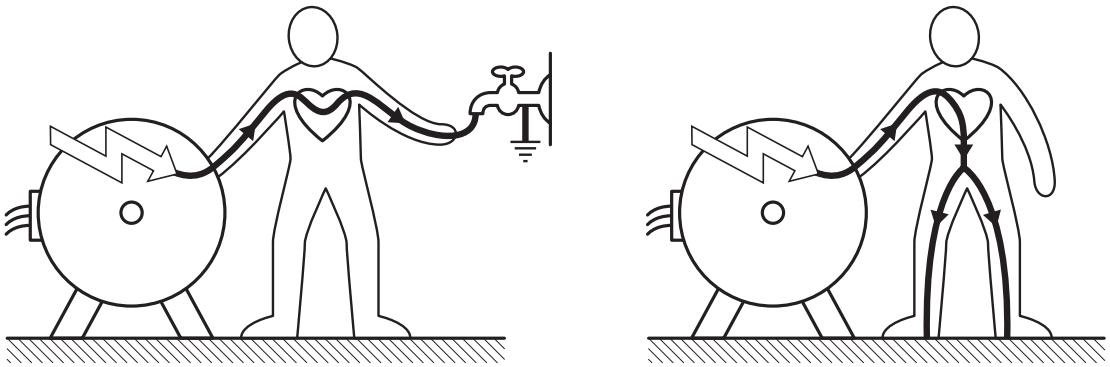
DO	DON'T
Use ◆ Ensure cylinders are not damaged or rusted. ◆ Ensure cylinder valves have their protective caps or seals in place and that their threads and pin-indexes are in good order. ◆ Ensure the correct cylinder valves are fitted. ◆ Ensure the cylinders are colour-coded and stamped correctly according to the standard laid down by the national governing authority. ◆ Ensure the valves are free from oil, grease, moisture, and dust. ◆ Ensure the correct key, or spanner of similar length (not more than 150mm), is available for opening valves; severe damage can be caused if the wrong tool is used. ◆ Close the cylinder valve when the equipment is not in use, otherwise the life of the regulator will be shortened. ◆ Check regularly for leaks – listen for a hissing noise and, with a toothbrush, apply detergent solution (e.g. 0.5%) on the suspect area and look for small bubbles which appear at the leakage point.	 ◆ point pressurized gas towards anyone ◆ use more than one Bodok washer on a pin index valve connection ◆ attempt to remove the regulator with the cylinder valve open as the excessive pressure will severely damage the thread ◆ dismantle a cylinder valve or re-adjust a pre-set pressure regulator – if either of these develop a leak, they must be replaced ◆ check for leaks using oily soap as this can create an explosive mixture ◆ use jointing compounds or tape to mend a leak.

5.5.2 Electricity

Electrical Installations and Earthing

Human and animal bodies are electrical conductors. The passage of electrical current through the body can cause burns, or such severe muscle cramp that the victims are unable to free themselves from the point of contact. If electricity flows through the human heart (see *Figure 10* overleaf) it causes irregular heartbeats. If it is not possible for someone to switch off the electrical source immediately, the individual will be unable to breathe and the heart will soon stop beating. The seriousness of the electrical accident will depend on the intensity of the current flowing through the body.

Figure 10: Routes for Electricity to Flow Through the Heart to Earth



Source: Neureiter, J, & Tschank, A, 1989, 'Technician's Handbook for Hospital Engineering', Kenyan-Austrian Development Cooperation, Ministry of Foreign Affairs, Austria

Did you know?

- Currents as small as 0.5 milliamperes (0.0005 Amps) passing through humans can be felt as a tingling in the tongue or fingers.
- If humans come into contact by hand with a 'live' object, currents of 10 milliamperes (0.01 Amps) can make their muscles contract and their hand grasp the live object and not let go.
- Currents upwards of 50 milliamperes (0.05 Amps) can be fatal if they pass through the heart.
- For comparison, consider that such a current is 100 times less than that used by a single bar of a normal electric fire, which takes 5 Amps.

Currents will always flow from a high source of volts (the electricity supply) to earth (0 volts) through the easiest path (the path of least resistance, known as impedance and measured in Ohms). Thus electrical installations and electrical equipment must be designed to ensure that humans and animals:

- are protected from access to high voltages (above 50V)
- cannot touch bare metal which is 'live' (connected to a voltage supply)
- do not offer the best path (of least resistance) for currents to earth (therefore a better earthing route with an impedance of 0.3 Ohms or less must be provided).

Earth leakage protection is therefore required to minimize the risk of electric shock to humans and livestock. Earth leakage currents exceeding 25 milliamperes can prove to be dangerous and soon become fatal. Therefore to prevent dangerous earth leakage currents, attention is required to ensure that:

- the electrical installation is carried out carefully
- the installation is examined and overhauled regularly
- one of the methods available for earth leakage protection is used.

There are three methods of protection which can be used to prevent the occurrence of earth leakage currents:

i. Using extra low voltages as your power supply

Extra low voltage (below 50 volts) prevents the occurrence of dangerous earth leakage currents and can be provided by using batteries, or transformers (the secondary winding isolated from earth) as your power source.

ii. Using 'all insulated' or 'double insulated' systems

The first requires the complete insulation of all parts of an electrical installation. The second requires the use of double insulated equipment. Such equipment (a hand-held electric drill for example) has insulation around different internal components, as well as an external housing which is insulated (because it is made of plastic). Such equipment can be recognized by the 'box within a box' symbol on it ⧈, and no earth connection is required.

iii. Earthing

This means that all metal parts of your electrical installation are linked within a system that has an earth lead. This earth lead must be connected to the general mass of earth via an earth electrode (a metal rod or mat). The system is designed to ensure the immediate electrical discharge of stray currents to earth without danger.

Box 34 describes some common problems with the electrical installations at health facilities, all of which can present safety hazards to any humans and animals wandering around the site.

Experience in West Africa

- *At one hospital, the electrical installation for a ward block had much too small an earth cable (similar to lamp flex). This was mounted on the external wall of the building and had (erroneously) been intended to provide an earth by being buried in the ground. However, goats had nibbled through this wire leaving no earth protection for the building.*
- *At another hospital, the main incoming electricity supply cable for the facility came in at floor level into the waiting room of the out-patients department. There it had been stripped of all insulation to connect into the main distribution board. This left bare metal at 380 Volts within easy reach of the children playing while they waited.*

BOX 34: Common Problems With Electrical Installations

Poor or no earthing arrangement. Earthing is by far the most important factor determining safety of equipment and installations.	◆ No earth is provided at all. ◆ Ineffectual attempts are made to provide an earth (and the impedance is much too high, >0.3 Ohms), because: - tiny earth wires are used - the earth wire is broken - the earth rod is too short - the earth rod is only buried shallowly.
Poor circuit design with little or no attention paid to circuit loading and cable sizing.	◆ Many installations are fed from already overloaded supplies, and are subject to large voltage drops (indicated by dimming of the lights). ◆ Undersized cables are used and, if the supply voltage is low, equipment stops functioning. ◆ The circuit loading between the three phases is not balanced and this causes voltage and frequency fluctuations.
Unsatisfactory cable joints.	◆ Proper connectors that give a mechanically and electrically sound connection are not used. ◆ Bare metal is left exposed. ◆ People erroneously simply twist cables together to join them (even main overhead incoming supply line conductors up to 25mm sq).
Poor workmanship.	◆ Colour coding of cables for different parts of the circuit is ignored. ◆ Sharp metal edges are left on the cut-outs in distribution boards which cables can catch on. ◆ Single insulated cables are run exposed on walls rather than inside conduit. ◆ Connections and cable joints are left with the metal exposed without any insulation (even those carrying a 380V three-phase supply).

Strategies are required to obtain good quality electrical installations, which provide a decent earth and prevent against electric shock hazards. Advice should be sought from the electricity supply company and **reputable** electrical contractors who should work according to wiring regulations (for example, for anglophone countries the latest Institution of Electrical Engineers (IEE) Wiring Regulations – see *Annex 2*). *Box 35* provides examples of some of the strategies required, and who is responsible for them.

BOX 35: Strategies for Providing Good Quality Electrical Installations and a Decent Earth

Providing the earth at the origin of the installation	It is usually the responsibility of the electricity supply body to provide an adequate earth at each site, by one of the following methods: ◆ Protective Multiple Earthing (PME) incorporated into the design of the electricity distribution system around your country. ◆ The cable sheath (armouring) of the electricity supply company's main incoming cable to your site is connected back to the earth at the supply company's sub-station. ◆ A driven earth system at each site (either a metal rod or a mat buried several metres underground) that provides an earth, the quality of which is dependent on the local soil conditions and the depth of the water table.
Installation protection	If the chosen method is a driven earth system, the quality of earth is inconsistent because it is dependent upon soil conditions. Thus the electrical installation needs further protection from some form of residual current device (RCD) that disconnects the supply when it detects small leakage currents to earth (of between 10 and 300 milliamperes). The RCD can be fitted at one of the following points: ◆ At the main electrical incoming point for the whole installation. Simple and cost-effective protection, **but** in the event of a fault the entire installation is disconnected. ◆ On each distribution board (DB). More expensive, but provides more localized protection and makes faults easier to find. ◆ On each circuit. The most expensive option, but the most localized protection, making faults easiest to find. Advisable for: sensitive areas with several pieces of medical equipment, or the risk of using equipment near water. Note: earth-leakage circuit-breakers (ELCBs) sense current flowing from equipment to earth, and automatically disconnect the supply when it exceeds a pre-set value. But if the equipment's earth connection has failed (perhaps because it broke), the ELCB does not work. Thus RCDs are gradually replacing ELCBs. RCDs work independently of the earth connection, measure small imbalances in current flow to and from circuits, and disconnect the supply when these leakage currents are too high.
Reticulation of the earth around the site	It is the responsibility of the health service provider to run cables from the main earth (at the incoming supply point) to the distribution board for each building, and to run cables within each building to every socket outlet and light point. The size (cross-sectional area, in mm sq) of the earth conductor in any circuit should relate to the size of the main phase (line) conductor/s. For example: ◆ Phase conductors greater than 35mm sq require earth conductors at least half the size (and rounded up to the next nearest size of cable), for example, an incoming supply cable of 95mm sq requires a main earth conductor of 50mm sq. ◆ Phase conductors of between 16 and 35mm sq require earth conductors of 16mm sq. ◆ Phase conductors of less than 16mm sq require earth conductors of the same size, so a 2.5mm sq ring main circuit requires an earth conductor also of 2.5mm sq.

Continued overleaf

BOX 35: Strategies for Providing Good Quality Electrical Installations (continued)

Distribution boards	Any electrician or electrical contractor that you employ or hire must connect up the electrical installation to the distribution boards. It is essential that they: ◆ file off the sharp metal edges of the cut-outs made in the distribution board ◆ calculate the loading of the various circuits, and design the circuits, cable sizes, and circuit-breakers correctly so as not to overload or unbalance the system ◆ provide separate circuits for lights, normal socket outlets, and special loads such as stoves, water heaters, air-conditioners, etc ◆ use the correct colour codes for the cables used for earth, live, and neutral parts of the circuits, so that they can be easily identified ◆ label all the circuits in the distribution board, for easy fault-finding later on ◆ use proper cable terminations at all times for safety.
Correct socket outlets	There are many different styles of electrical socket outlets and plugs in use throughout the world. They all use different pin configurations and different colour coding of wires and cables for the earth, the live, and the neutral conductor. It is essential that the electrician or electrical contractor ensures that: ◆ enough socket outlets are available and located conveniently – the use of long leads, overloaded adaptors, or makeshift extension blocks is dangerous (the earth may become disconnected and the risk of electrocution increases) ◆ sockets are at least 2 metres from any source of water (a basin, for example), and sockets should never be placed in a bathroom or shower-room ◆ an earth wire is provided in the socket outlet and the plug, if you have a three-wire and three-plug system (some equipment has only two wires in the power cable, such as the 'double-insulated' items, and do not need an earth connection) ◆ the correct plug is fitted to your equipment which matches your socket outlets (for example, a three-pin plug for a three-pin socket) – makeshift modifications are dangerous ◆ the correct cable colours are identified and correctly connected inside the plug.
Exposed metal	Metalwork, which is not part of an installation, could become 'live' and would be dangerous under faulty conditions (gas and water pipes, radiators, water taps, sinks, bathtubs, etc). The electrician/electrical contractor should either 'bond' all such pieces of metalwork (that is connect them to the earth), or completely insulate them.
Lightning protection	Overhead distribution lines can attract lightning, and therefore may provide a natural route for earthing. Thus, the electricity supply body or an electrical contractor should be asked to fit lightning arresters to the overhead poles at the ends of the main distribution lines, or at a point where the distribution lines change direction.

Once a good electrical installation has been provided, it should be regularly inspected and tested by reputable electricians, using the correct test instruments (*Section 7.3*). To guarantee the safety of the installation, they need to:

- test for earth leakage
- test for circuit continuity
- test for loose connections
- perform insulation tests
- test switch leakages
- test for power
- check for the correct rating
- check whether wiring regulations were followed during installation.

Medical Electrical Safety

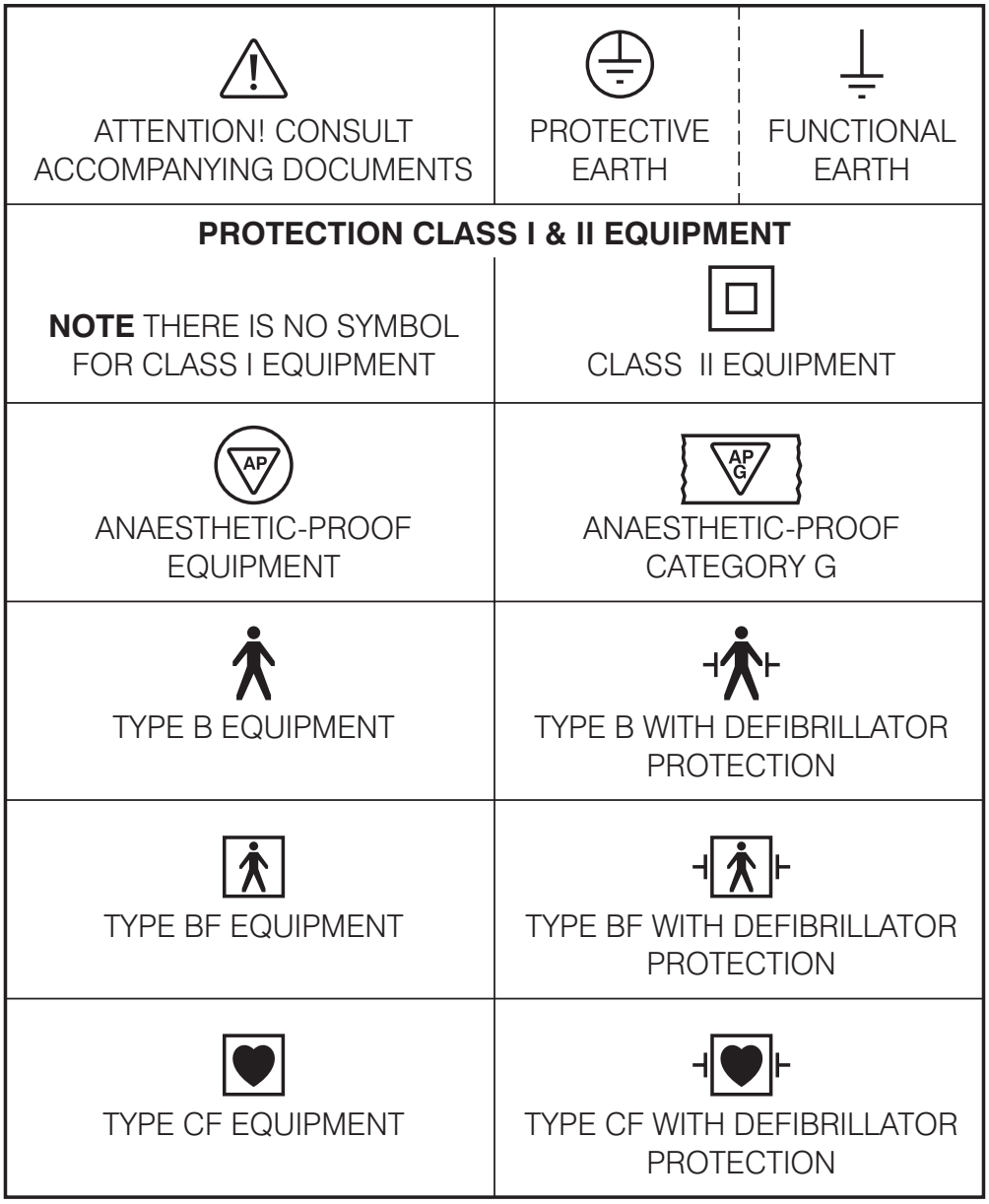
Another important area of safety is medical electrical safety. Medical electrical equipment has stricter electrical safety requirements and considerations than non-medical equipment, because it comes into direct contact with patients (for example, ECG recorders, monitors, diathermy units, and physiotherapy ultrasound).

All such equipment should conform to (and be manufactured to) the international safety standard IEC 60101 (see *Guide 3* on procurement and commissioning). It describes electro-medical equipment according to the **type** of protection provided against electric shock (defined as Class I, II, or III), and the **degree** of protection provided against electric shock (defined as Type B, BF, or CF). You can tell which sort of equipment you have, by studying the symbols on the manufacturer's label attached to your equipment, as shown in *Figure 11*.

Such equipment will require dedicated safety testing procedures and test instruments, which go further than the standard electrical safety tests described above. All electro-medical equipment should be regularly inspected and tested by bio-medical technicians, using the correct test instruments (*Section 7.3*). To guarantee safety, they should perform a variety of tests on each piece of equipment depending on its Class and Type, such as:

- self checks
- supply voltage check
- insulation resistance test
- earth bonding test
- earth leakage current test
- enclosure leakage current test
- patient leakage current test
- patient auxiliary current test
- mains voltage on the applied part test.

Figure 11: IEC Symbols on Equipment Labels Showing the Level of Safety Protection



Note:
- Class III equipment relies on protection from a supply at Medical Safety Extra-Low Voltage (MSELV) and is rarely encountered now.
- Equipment that is battery powered is not described as Class I, II or III.

Source: Deller, A, 1994, 'Notes on Electrical Safety', Centre for Medical Electronics, St Bartholomew's Hospital, London, unpublished

Variations in Supply

When you have a mains electricity supply, it is preferable to have an emergency back-up generator. When there are interruptions in the main supply (power cuts), the generator cuts in to ensure that electricity continues to be supplied to key areas. If you are used to having electricity 24 hours a day, it becomes crucial for the working of some equipment and the provision of some services.

Thus, for safety reasons, the emergency generator should be connected to items such as:

- the refrigeration unit controlling the mortuary body store
- the blood bank fridge
- the water pump
- any sewage pump
- an autoclave
- an operating theatre
- any intensive care facilities.

Some health facilities will not have a main electricity supply from a supply company, but will have to rely on an electrical generator alone, which will be used for only a few hours a day. This will affect the type of equipment you can own. Other facilities will use alternative sources of electricity, such as solar panels.

Whatever your power source, you need to protect against sudden changes in supply (such as electrical surges, spikes, cut-outs, lightning strikes, etc) which can ruin your equipment and mean you lose your data. The most sensitive equipment in health facilities is the advanced electronic equipment, such as:

- telecommunications equipment (telephones, fax machines, radio transmitters and receivers)
- data processing equipment (computers, printers, plotters, monitors)
- electronic diagnostic equipment (radiography, ECG, ultrasound, monitoring machines)
- electronic laboratory equipment
- any other equipment with electronic control circuits.

Box 36 describes several measures you can take to adapt the power supply to the requirements of your equipment, and protect it.

Tip

- These measures assume that your generators and the mains supply grid are in a good condition or cannot be influenced (in the case of the public mains supply). If they **can** be improved, solve these problems first if possible.

Box 36: Power Conditioning Strategies

Problem	Solution
Your power supply voltage may become too high or too low	An over- or under-voltage cut-out device. This automatically switches off the power supply when it is too high or too low, but your equipment may be cut off frequently.
Your supply voltage is stable but always too high or too low by a constant amount	A step-up or step-down transformer. This provides a fixed increase or decrease of voltage, but it cannot cope with voltage fluctuations.
Your power supply suffers from voltage fluctuations	Voltage stabilizers. These stabilize (smooth) the variations in the voltage without cutting off the power supply to your equipment. There are various manual and automatic types of stabilizer.
Your power supply suffers from frequency fluctuations (measured in Hertz)	Frequency stabilization. If the problem lies with your own generator, you can improve the situation through maintenance strategies (see *Annex 2*). If the problem lies with the electricity authority's supply, there is little you can do. In the case of expensive equipment, using an electronic inverter type of voltage stabilizer (see above) and a true online type of uninterruptible power supply (UPS) (see below) may help.
Your equipment is affected by power surges, peaks, and ripples caused by electro-magnetic interference from lightning, switching operations of heavy machinery, permanent electro-magnetic fields from transmitters, etc and electrostatic discharges	Suppression of electro-magnetic interferences. There are various strategies (see *Annex 2*), such as: ◆ ensuring all equipment is connected to a good earth (grounded) ◆ ensuring all ground connections are at the same voltage ◆ providing metallic shielding of power lines and data lines ◆ twisting of cable pairs which are connected to equipment input terminals ◆ separating power circuits for sensitive electronic equipment from those for heavy loads ◆ using radio frequency interference (RFI) filters ◆ unplugging equipment during thunderstorms ◆ installing an effective external lightning arresting system (using lightning conductors) ◆ installing a transient absorption system for high-energy peaks and spikes (using various separate types of surge arresters at different points in the electrical installation).
You suffer from power failures or power flaws, and want to ensure that the supply of power is transferred to a back-up system	Power back-up systems using generators or banks of batteries, either for the total installation, parts of it, or individual pieces of equipment. These can involve: ◆ manual change-over, introducing a significant delay in restoring power (from tens of minutes to several hours) ◆ automatic change-over with interruption of power, introducing a delay of about 10 minutes ◆ automatic change-over without an interruption in power, using a UPS. There are various types that can switch over immediately or within fractions of a second (see *Annex 2*).

Many countries have a voltage supply system based on 230V at a frequency of 50Hz. However countries in the Americas use a different standard of 110V at 60Hz. You may live in the first type of country and buy or receive equipment designed for the American standard. Then between the mains supply and each piece of equipment like this:

- you will have to install a step-down transformer (to reduce your 230V to 110V)
- you may have to install an electronic inverter stabilizer or online UPS (to increase your 50Hz to 60Hz) depending on the advice in the equipment documentation.

5.5.3 Laboratory Hazards

Safety in the laboratory is essential because staff are exposed to biological, chemical, and physical agents with the risk of infection, poisoning, and injury. Many of these issues relate to the equipment used, both because it is in contact with infectious organisms and also because it can be a danger in itself.

Infection Risks

Infections can be spread more easily in laboratories because of the large amount of organisms present, and because infectious materials are being handled. Whether or not an infection occurs depends on a number of factors, including the means of entry into the body, the number of organisms entering the body, and the immune status of the worker.

Figure 12 overleaf provides some strategies for establishing barriers that will block the routes of infection. The extent of these barriers depends on the nature, and to some degree the amount, of the micro-organisms that are handled in the laboratory. Those that are unlikely to cause human disease require little more than good laboratory practice – more to protect the work than the worker. Those that cause serious disease require very strict containment using highly effective barriers.

Infections can spread through a number of routes. *Box 37* describes these routes, and some strategies to avoid them.

BOX 37: Laboratory Infection Risks and Strategies to Avoid Them

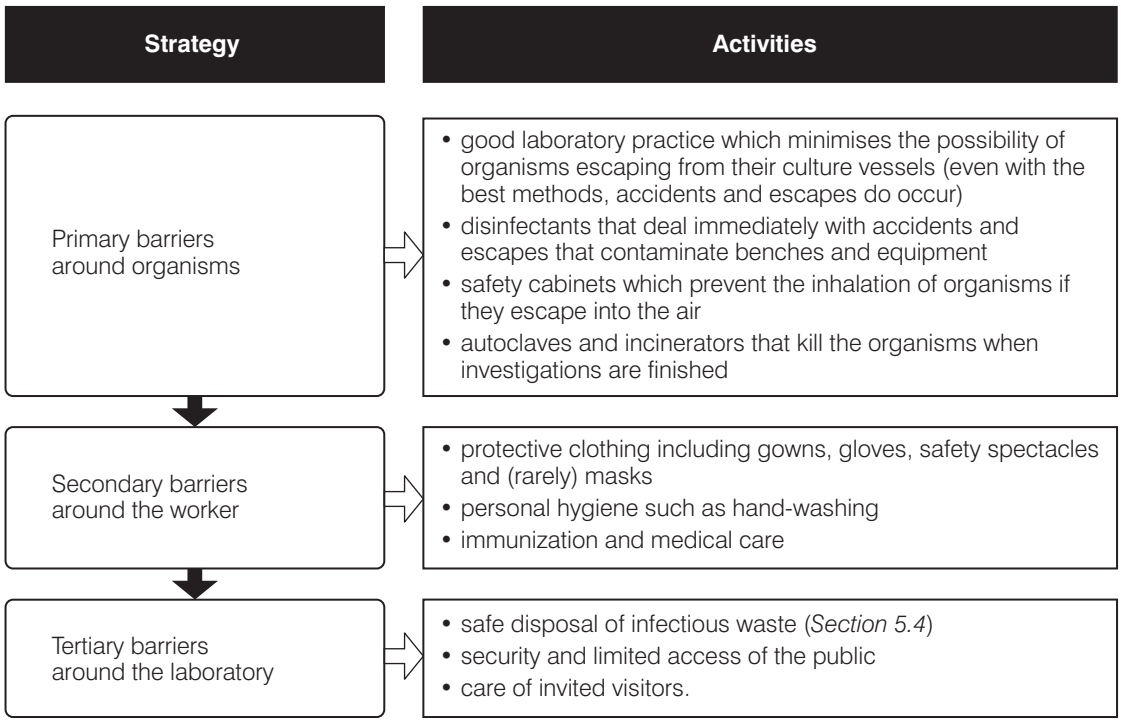
Entry through the skin	Do the following: ◆ Cover all obvious cuts and abrasions with waterproof dressings. ◆ Wash hands frequently but do not scrub them. ◆ Use barrier creams. ◆ Use disposable gloves. ◆ Wear overalls.
Entry through the eye	To avoid entry via the conjunctivae, do the following: ◆ Try to avoid splashes into the eye. ◆ Avoid rubbing the eyes with infected fingers. ◆ Consider wearing safety glasses.

Continued overleaf

BOX 37: Laboratory Infection Risks and Strategies to Avoid Them (continued)

Inhalation (breathing in)	Avoid the following actions which create aerosols and infectious airborne particles: ◆ Using inoculating loops larger than 3mm in diameter or incompletely closed, as they will shed their contents. ◆ Vigorous spreading of culture plates and slides with loops – gentle movement is safer. ◆ Flaming charged loops in ordinary bunsens – use hooded bunsens or disposable plastic loops instead. ◆ Blowing out pipettes causing bubbles to form and burst – drain the pipettes instead. ◆ Vigorous mixing of cultures (such as sucking and blowing with pipettes) – use vortex and other mixers instead together with culture tubes or bottles that are stoppered. ◆ Allowing drops to fall from the tips of pipettes onto hard surfaces – use an absorbent bench covering preferably soaked in disinfectant. ◆ Using unstoppered centrifuge tubes and misbalanced loads – use screw-capped tubes and sealed buckets instead (see *Box 18*). ◆ Homogenization that creates aerosols that are released when the container is opened – use stomachers instead. ◆ Mixing in unstoppered containers – use bottles and tubes with stoppers instead or vortex mixers. ◆ Dropping cultures where possible – plastic petri dishes release less aerosols than glass ones when dropped. ◆ Allowing probes of automated equipment to move too abruptly – fit guards and slow the movement down instead. ◆ Pouring infected fluids straight into another fluid – use a funnel with its tip beneath the surface of the fluid.
Ingestion (swallowing)	Do the following: ◆ Ban mouth pipetting – use pipetting devices instead. ◆ Provide hand basins and encourage hand-washing to break the hand-to-mouth route of infection. ◆ Ban eating, drinking, and storing food in the laboratory, as contamination is too easy. ◆ Ban smoking and the application of cosmetics in the laboratory, since they provide opportunities for organisms to transfer from contaminated fingers to the mouth.
Injection	Do not use: ◆ hypodermic needles and syringes in place of pipettes. If necessary, obtain instruments which remove septum caps so that pipettes can be used. ◆ automated equipment which uses needle probes (to take samples from septum-capped bottles) without fitting a shield. ◆ glass pasteur pipettes as hands are easily stabbed – use soft plastic ones instead. ◆ poor quality culture tubes which may break when stoppered and inoculate staff – buy better quality items instead. ◆ chipped culture tubes, the rims of which may be contaminated and inoculate the operator – have a glassware inspection routine and regularly discard condemned glassware.

Figure 12: Basic Microbiological Safety Strategies



Chemical and Physical Risks

There are other hazards in laboratories due to:

- faulty use of certain equipment such as centrifuges (risk of flying objects), autoclaves (risk of bursting bottles), etc (see *Box 18*)
- explosion risks from gases, faulty use of gas burners, and sparking centrifuges because of worn brushes (from lack of maintenance)
- incorrect storage and handling of flammable chemicals such as ether, nitric acid, and hydrogen peroxide
- incorrect handling, storage, and spillage of chemicals and reagents (acids, alkalis, ammonia, etc).

Advice on all these issues should be available from your country's National Laboratory Service, and reference materials (see *Annex 2*).

Quality Control

In addition, the National Laboratory should provide a system of quality control procedures to monitor the performance of the work undertaken in all laboratories. There are a variety of methods that they can employ for double-checking that test results and readings are consistent and accurate.

5.5.4 Radiation Hazards

X-ray Equipment

X-ray machines are obvious sources of radiation, and safety policies and procedures must be produced regarding:

- lead lining of rooms, leaded control booths, or screens with leaded glass
- the use of mobile machines outside of lead-lined rooms
- the direction and timing of firing/exposure
- the use, monitoring and follow-up of exposure badges for operators
- the use of lead aprons by operators
- the use of gonad protectors for patients.

Methods are required for monitoring and recording exposures and any adverse incidents. Procedures are required for getting exposure badges (dosimeters) checked, and implementing any follow-up actions needed.

Advice on all these issues should be available from the national body responsible for radiation control (*Section 2.2*), and reference materials (see *Annex 2*). *Box 38* provides some strategies for the use of X-ray machines.

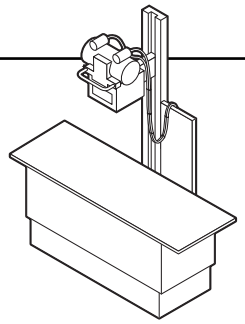
Other Radioactive Sources

In addition, in larger facilities there may be radiation hazards from other radioactive substances such as radio-opaque materials and radioisotopes used for imaging, and radioisotopes and radionuclides used in laboratories for tagging and radio-immunoassay. Follow these guidelines for these substances:

- Use them in a separate room to normal work.
- Store them in locked cupboards.
- Ensure monitoring equipment is available.
- Ensure emergency kits are available, containing protective clothing, equipment, neutralizing agents, and information.
- Ensure that the room and staff are part of the routine radiation monitoring system used in the X-ray department.
- Dispose of them according to your Waste Management and Hygiene Plan (*Section 5.4*).

Such substances are not usually handled in large quantities. Good practice is required to deal with the three main hazards, as shown in *Box 39* overleaf.

BOX 38: Safety Strategies When Using X-Ray Machines



Installation

- Earthing is essential :
  - connect the generator to the main earth, if agreed by the electricity authorities, and follow the local regulations exactly
  - if not specified by local regulations, connect to an independent earth electrode close to the X-ray department
  - **never** connect the X-ray generator to the water-piping system.
- All X-ray equipment must be installed by the manufacturer or their local representative for warranty and safety reasons, and it must be checked before acceptance.
- When equipment is being relocated, it is essential that any workers you hire have experience of X-ray installation.
- Incorrect installation may be both dangerous and expensive.

Operation

- Users and maintainers must be aware of the risks associated with the use of X-rays, and operate the X-ray equipment accordingly.
- The operator must use the correct X-ray exposure techniques (kV and mAs).
- The operator must adjust the collimator to the size of the film.
- The operator must use protective devices for the patient when appropriate.
- The operator must protect him- or herself behind the protective screen.
- The operator must allow no one other than the patient in the X-ray room during the exposure (if the patient must be held or supported, a lead apron and gloves must be worn by all who do this).
- The operator must process the film according to good practice techniques, following especially the time and temperature guidelines.
- In the case of battery-powered machines, the operator must know how to regularly care for the batteries.

Maintenance

- Except for minor maintenance, only specially trained and experienced service technicians or engineers should carry out maintenance and repair.
- Do not service the equipment unless the main electricity supply is turned off.
- Do not open the generator control console to attempt to make repairs.
- Never use a fuse of a different rating, or type, from that recommended by the manufacturer.
- If a fuse blows regularly, inform the HTM Team or the manufacturer's representative.
- Check protective lead aprons and gloves every six months for tears and cracks; if necessary doubtful areas can be examined by X-ray or fluoroscopy.
- Do not purchase a spare X-ray tube to keep in store, not only are they expensive, but they will deteriorate if not put to use.
- As the battery pack for battery-powered machines may store enough power to give a life-threatening electric shock, keep all metal tools away, and do not wear metal watches, watchstraps, bracelets, or necklaces, whilst working around it.

BOX 39: Strategies for Dealing with the Hazard of Radioactive Sources

Skin contact	◆ Wear overalls and gloves. ◆ If skin contact occurs, wash with soap and tepid water taking care not to spread the contamination (to the eyes, for example) until monitoring shows that the radiation levels are acceptable.
Ingestion	◆ Ban mouth pipetting. ◆ Ban eating, drinking, smoking, and applying cosmetics in the work area where these substances are used.
Spillage	◆ Put on the protective clothing from the emergency kit. ◆ Place contaminated articles and waste in plastic bags ◆ Decontaminate and dispose of this radioactive waste in the correct way (*Section 5.4*) ◆ Wash contaminated areas with water, taking care not to spread the agent any further, until monitoring shows that the radiation levels are acceptable.

Other Radiation Risks

There could also be potential radiation risks from other emission sources, such as microwaves, ultrasound, infrared, ultraviolet, etc. Little is known about the actual hazards from some of these sources, and it is necessary to monitor, and keep up-to-date with, international information and opinion on the possible hazards of these other emission sources (see *Annex 2*). Some reported problems are shown in *Box 40*.

BOX 40: Reported Radiation Risks From Other Emission Sources

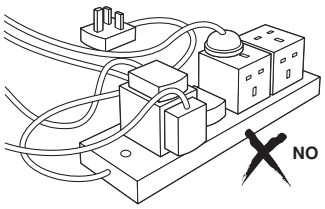
Ultra-violet sources	◆ 'sand in the eyes' symptom of conjunctivitis
Lasers	◆ eye lesions
Ultrasonic cleaning baths and cell disruptors	◆ threat to hearing ◆ skin lesions if hands are immersed in the bath ◆ respiratory infections from aerosols generated
Visual display units (VDUs)	◆ physical strain from poor positioning ◆ risks to pregnant women may be possible, but as yet are unconfirmed ◆ eye strain from poor lighting
Microwave ovens	◆ burns to hands if the source does not automatically switch off when the door opens.

5.5.5 Fire

Box 41 describes the various issues that have to be considered when managing fire risks.

BOX 41: Issues to Address When Managing Fire Risks

Fire hazards	◆ boilers ◆ incinerators ◆ cooking equipment ◆ poor electrical wiring ◆ bypassing of fuses, safety trips, or circuit-breakers ◆ overloading of equipment, systems, socket outlets, and extension blocks ◆ electrical machinery ◆ burning waste ◆ gas cylinders ◆ chemicals and flammable materials such as laboratory and cleaning agents, X-ray films and developing chemicals, workshop lubricants and fuels.
Fire fighting	◆ the presence of adequate fire-fighting equipment (such as sand, blankets, water, extinguishers, hoses, sprinklers) ◆ its regular maintenance ◆ training in its use.
Procedures in case of fire	◆ the suitability of the buildings in terms of fire exits ◆ the use of alarms ◆ the use of fire drills ◆ training of staff in the evacuation of patients and visitors.
Safe storage of flammable materials	◆ store away from heat sources and not in direct sunlight ◆ store in well-ventilated areas ◆ ensure materials are clearly labelled ◆ display signs prohibiting smoking and the use of naked flames.
Electrical installation	◆ regularly check the electrical installation for frayed or damaged (rat eaten) cables, water, debris, dirt, etc ◆ prohibit the use of coiled cables, extension leads, adaptor blocks and adaptor plugs.



Experience in Southern Africa

The boiler that supplied the steam for all heating, hot water, laundry, kitchen and autoclaving needs for a hospital broke down. The hospital accepted the cheapest quote from a local man who said he was an electrical contractor. He got the boiler working again, but only by bypassing all the safety features. This caused a tremendous fire, and both the boiler and the boiler house burnt down.

Advice on all these issues should be available from experts such as building inspectors, government occupational safety officers, municipal regulatory bodies, fire-fighting bodies, etc (*Section 2.2*), and reference materials (see *Annex 2*). *Box 42* highlights the most common causes of fires.

BOX 42: The Most Common Causes of Fires

Common electrical faults responsible for fires

- Overloading of circuits – too may appliances plugged into one socket outlet.
- Long and badly positioned electrical cables – too near hotplates or similar equipment, or where they are in contact with water.
- Equipment left switched on unnecessarily, overnight, or left unattended.
- Equipment that uses flammable liquids or gas placed too near to naked flames.

Common naked flame faults associated with fires

- Gas-heated appliances (cookers, bunsen burners etc) whose flame (full-flame or pilot) is left unattended.
- Containers of flammable liquids (oil, petrol, ether, etc) or flammable materials (cotton wool, paper, etc) left too close to the flames of gas-heated appliances, or other naked flames (such as cigarettes).
- Gas-heated appliances (including those using propane and acetylene) connected with perished, incorrect, or poor quality tubing.
- Use of matches instead of mechanical lighters – matches are not always extinguished when discarded.

5.5.6 Accidents

Equipment should be in an acceptable condition at all times, so that it cannot cause harm to patients, staff, or visitors. To avoid accidents:

- buildings need to be structurally sound
- service supplies should be dependable and trustworthy
- equipment should perform competently and safely.

There are a number of issues to consider regarding the prevention of accidents related to equipment, which can befall staff, patients, and visitors. These are shown in *Box 43*.

Local 'health and safety at work' legislation and inspectors may cover these issues, and provide guidance.

BOX 43: Typical Causes of Accidents

Hazardous operation of equipment, such as:

- clothing caught in moving parts of machinery
- equipment which, by its nature, is dangerous, such as lathes, drills, circular saws, welding machines
- operation which requires protective clothing such as eye goggles, safety guards, etc
- lack of attention by operators, such as poor driving of health vehicles.

Hazardous condition of facilities and equipment, such as:

- brickwork falling down on someone
- broken windows
- holes in the ground which can trip people up
- flooding from blocked drains
- loose wires providing electric shocks from sockets and switches, etc.

Hazardous practices, such as:

- leaving equipment in corridors for people to fall over
- undertaking maintenance in a place where people will slip on oil spills
- wet or highly polished floors, etc.

Box 44 contains a summary of the issues covered in this Section.

BOX 44: Summary of Procedures in Section 5 on Ensuring Safe Operation

Discussion

Health Service Provider	◆ develops safety policies for all risk areas ◆ provides sufficient and appropriate resources (both financial and material) to tackle all safety issues
HTM Working Group (and its Safety Sub-groups	◆ consults with appropriate national bodies for guidance on the various safety issues ◆ consults Section Heads to identify safety issues relevant to their sections ◆ develops appropriate safety procedures to address: - hazards when operating equipment - equipment-related infection control - waste management - control of all other hazards ◆ acts on incident reports

Continued overleaf

BOX 44: Summary of Procedures in Section 5 on Ensuring Safe Operation (continued)

Operating Equipment	**Section Heads, Safety Sub-groups, In-Service Training Coordinator**	◆ ensure that staff are trained in the correct procedures to reduce risks when operating equipment ◆ monitor implementation of the correct procedures
	Equipment Users and HTM Teams	◆ carry out the correct safety procedures when operating equipment ◆ report any incidents (*Section 8.2*)
Infection Control	**Section Heads, Safety Sub-groups, In-Service Training Coordinator**	◆ ensure that staff are trained in the correct procedures for infection control ◆ monitor implementation of the correct procedures
	Equipment Users and HTM Teams	◆ carry out correct methods for: - decontamination and monitoring of sterility - linen handling - keeping the workplace clean ◆ report any incidents (*Section 8.2*)
Waste Management	**Section Heads, Safety Sub-groups, In-Service Training Coordinator**	◆ ensure that staff are trained in the correct procedures to reduce risks when handling, treating, and disposing of waste ◆ monitor implementation of the correct procedures
	Equipment Users and HTM Teams	◆ carry out the correct waste: - reduction - segregation - storage - transport - treatment - disposal ◆ report any incidents (*Section 8.2*)
Hazard Control	**Section Heads, Safety Sub-groups, In-Service Training Coordinator**	◆ ensure that staff are trained in the correct procedures to reduce risks from other hazards ◆ monitor implementation of the correct procedures
	Equipment Users and HTM Teams	◆ carry out the correct procedures to reduce risks from: - gas - electricity - laboratories - radiation - fire - accidents ◆ report any incidents (*Section 8.2*)

6. HOW TO ENSURE THE AVAILABILITY OF ACCESSORIES AND CONSUMABLES

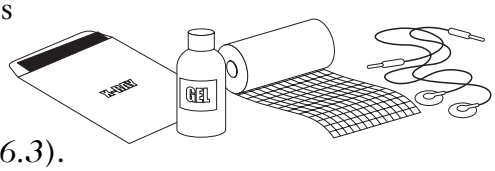
Why is This Important?

Equipment accessories and consumables are essential because without them equipment simply will not function.

Ensuring that suitable equipment accessories and consumables are always available is a vital management issue.

This Section looks at assessing the need for equipment accessories and consumables, through the following issues:

- A general discussion on accessories and consumables (*Section 6.1*).
- The storage system and procedures (*Section 6.2*).
- Calculating usage rates and reorder levels (*Section 6.3*).



The procedures required for purchasing accessories and consumables are discussed in *Guide 3* on procurement and commissioning .

This Section is aimed at anyone responsible for ensuring that adequate supplies of accessories and consumables are available. Equipment users are most commonly responsible for this, though, in health systems where these needs have been neglected, the HTM Service may have taken over this responsibility.

6.1 GENERAL DISCUSSION ON ACCESSORIES AND CONSUMABLES

Besides accessories and consumables, staff will also need access to equipment spare parts and maintenance materials. Equipment operators need to use these items when undertaking user PPM (planned preventive maintenance), and the health facility may be responsible for their storage. The specific discussion on equipment spare parts and maintenance materials is provided in *Guide 5* on maintenance management. However, the discussion here on accessories and consumables covers similar issues of availability and storage procedures.

Health service providers must also ensure they supply staff with adequate safety gear needed to do their jobs, such as gloves, goggles, masks, overalls and boots. In some health systems, these items are purchased as general supplies and paid for out of administrative costs (see *Guide 2* on planning and budgeting) and therefore are not strictly considered accessories and consumables.

It doesn't matter which way you purchase this safety gear, as long as it is not forgotten. The advice offered in this Section is just as relevant for safety gear, and can assist you with its purchase, storage, and replenishment.

Availability

Accessories are those items which:

- connect the machine to the patient (breathing circuits, ECG leads, probes/transducers, etc)
- assist with the use of the machine (internal trays, foot-switches, computer mouse, etc)
- adapt its performance (different sized adaptors, objectives, lenses, etc).

Thus accessories are often:

- the main link to the patient
- the part most handled by staff
- flexed, bent, twisted and even mis-used
- subject to a great deal of wear and tear
- the most vulnerable part of a piece of equipment.

Even if a piece of equipment lasts for years, accessories may need to be replaced regularly, therefore accessories must be available for the lifetime of the equipment.

Consumables are those items which:

- are used up daily during the operation of the equipment (such as X-ray film, disposable electrodes, laboratory reagents, ultrasound gel, washing powder, toner and solder.
- will be needed throughout the lifetime of the equipment.

The availability of accessories and consumables will dictate how long staff can keep using a piece of equipment. Once accessories and consumables are no longer available, a piece of equipment cannot be used even if it is in perfect working condition.

Disposable or Reusable?

Some accessories and consumables (such as diathermy plates, probes, breathing circuits, electrodes, and filters) are available as disposable and as reusable products, and you may need to decide which type to buy.

Both types have advantages and disadvantages in terms of convenience and cost, as shown in *Box 45*.

BOX 45: Advantages and Disadvantages of Disposables and Reusables

Disposables	◆ are items designed for single use ◆ reduce the risk of cross-infection ◆ are more convenient to use than reusables ◆ should only be used once and should not be reused ◆ cost more than reusables since they need to be replaced more often and must be bought in bulk regularly ◆ require you to have a regular and reliable recurrent budget ◆ require a regular and reliable supply of replacements from a reputable source ◆ are not designed to be sterilized.
Reusables	◆ are designed to be used more than once ◆ should only be reused after proper cleaning and sterilization and/or disinfection ◆ are cheaper to buy, but you will have the additional cost of sterilizing them ◆ require you to have the necessary equipment required for sterilization ◆ put staff and patients at risk of diseases such as hepatitis B and HIV, if the items are not properly sterilized between uses ◆ may be more reliable, if supply problems are likely for disposables ◆ can be kept as a reserve stock for times when disposables are not available.

To help you to decide what type is most suitable for your health facility, you should consider the following issues:

- The national policy.
- The resources available to you for sterilization.
- Whether a regular supply of stocks of these items is available.

It is usually easier and more practical to follow any existing national or local policy regarding the use of disposables or reusables. The policy-makers should have taken into account the cost implication of their recommendation, and should make satisfactory recurrent budget provision for the regular supply of these essential inputs.

However, health facilities in remote areas are advised to have a stock of reusable supplies that will help them when disposable supplies are received late or are not available.

Finance

Your aim is for equipment to remain operational, and to be available to support your clinical workload. Thus, it is necessary for sufficient budgets to be calculated and allocated for the purchase of the required accessories and consumables. This cost will be relevant over the whole lifetime of the equipment. Thus, continually finding the money for these items will be a challenge over the life of the equipment. *Guide 2* on planning and budgeting provides guidance and procedures on budgeting for the recurrent costs of equipment.

Many accessories and consumables come from abroad, therefore you will need access to foreign currency. Some organizations set up a 'revolving fund' to help with the continual purchase of equipment-related supplies (spare parts, accessories, etc), sometimes with assistance from external support agencies (donors) – see *Box 46*.

BOX 46: How a Revolving Fund Works

The aim of a revolving fund is to keep a pot of money full so that you can buy equipment-related supplies regularly:

- The health service provider places initial capital in the fund so they can buy the supplies.
- Local health facilities buy the supplies from the health service provider as they require them.
- Their payments are put back into the fund in order to refill it.
- Thus the fund is always available for further purchases of equipment-related supplies.

A revolving fund can be set up to operate using local currency, foreign currency, or a mix of the two. Seek assistance from external support agencies if necessary:

- The fund can be 'primed'/pre-financed with foreign currency in order to purchase equipment-related supplies from abroad.
- The initial 'priming' of the fund with foreign currency can be done by your health service provider or with help from donors.
- Either the health facilities which purchase the supplies pay for them in foreign currency, if this is possible, or the health facilities pay a local currency equivalent amount which is converted back into the foreign currency.
- Sometimes donors have an ongoing relationship with the fund, and provide the equivalent in foreign currency for the local currency paid into it.

Country Experience

Planners often fail to realise that equipment operating costs have a much greater financial impact than the initial procurement cost, and can account for anything from 5% to 100% of the procurement cost per year. For example, health staff in Germany discovered that an infusion pump which cost US $24,000 to run over its 10-year lifetime, mainly due to the cost of the continuous supply of infusion sets required. However, many health service providers have not calculated and budgeted for the real operating requirements of their equipment.

Procurement Issues

Different brands of accessories and consumables are not necessarily interchangeable and cannot always be used with all makes and models of equipment. For example, different makes and models of equipment will use:

- different X-ray film cassettes
- different pipe connectors
- different lead connectors (they can be the identical shape but have different wiring configurations)
- different threads on gas connectors
- different widths of chart recorder paper
- different test strips for blood glucose monitors
- different printer cartridges
- different photocopier toner packs.

Therefore when ordering equipment (see *Guide 3* on procurement and commissioning), it is vital to specify particular and exact requirements for your accessories and consumables. For each item, you will need to provide as much of the following information as possible:

- The name of the manufacturer of the equipment.
- Make, model, and year of manufacture of the equipment.
- Serial number of the equipment.
- A full description of the item required (try to use the description and names used in the manufacturer's manual or order catalogue).
- Size, type (for infant, child, adult, etc), and material.
- Quantity and pack size required.
- Manufacturer's order number for that part and quantity.

When buying new equipment, you can try to rationalize your accessory and consumable stock. You achieve this by buying equipment which makes use of the types of accessories and consumables which you already keep in stock. This would be the most efficient use of your stock of supplies, and is an important reason for standardizing the equipment you buy to a small number of makes and models (*Section 2.1*). Also, consumables and accessories bought in bulk are often much cheaper.

However, for maximum safety there are situations where you actually want non-interchangeable accessories and consumables. For example, you will want:

- gas connectors with different threads so that you cannot connect carbon dioxide to the oxygen inlet
- transducers for measuring different parameters which are colour coded to prevent confusion when you connect them to the equipment.

For most countries, the procurement of accessories and consumables from abroad is a lengthy and tedious process. It takes time to obtain quotations, secure foreign currency, and ship goods. If you want to retain stock levels and receive items on time, you must plan ahead for items procured from abroad.

Items procured locally should not pose such problems, as long as funds are available. They can be obtained from local suppliers or from a body such as a Central Medical Stores. The HTM Working Group may want to develop a policy to purchase equipment, accessories, and consumables locally where possible, in preference to overseas, to encourage the development of sustainable local markets.

The HTM Working Group, or its smaller stock sub-group (*Section 1.2*), should develop procedures for comparing products, and reviewing their cost and performance before reordering them, to avoid the purchase of items known to be poor. Purchasing should be a process without political or social influence to avoid possible allegations of bribery. You should also have a policy of only accepting free gifts if they come with a stock of accessories and consumables, to ensure the equipment can be used (see *Guide 3* on procurement and commissioning).

The quality and effectiveness of a machine is often jeopardized by the use of low quality accessories and consumables. Poor accessories and consumables may break if they are not strong enough, they may not perform as expected, or they may rub, corrode, or in some way damage other parts of the machine. Even if you have a first class piece of equipment:

- poor paper gives you a poor recording for diagnostic purposes
- poor film or poor quality developer give you poor radiographs for diagnostic purposes
- poor breathing circuits which collapse easily compromise the functioning of a ventilator or anaesthetic machine
- poor quality drill bits break quickly
- poor quality engine oil reduces the life of the engine
- poor quality batteries affect the performance of the equipment, have a short life, and leak
- poor tyres compromise the safety of a vehicle.

Cost and quality often go together. Equipment manufacturers' own brand of accessories and consumables often produce better results than 'lookalikes'. Many companies are set up solely for the purpose of manufacturing lookalikes – these products are often (but not always) cheaper, but may be of inferior quality. We recommend that, as the items get more technically complex or critical, you should try and buy better quality accessories and consumables. A discussion on sourcing and obtaining good quality products can be found in *Guide 3* on procurement and commissioning.

High technology equipment may introduce hidden consumable problems, such as special miniature internal batteries that store the set-up parameters of the equipment.

In your country, there may be other supply routes which could help your health service provider to obtain high quality supplies. For example:

- Your country may have a booming photographic industry which could help with the sourcing, import, distribution, and storage of good quality X-ray film.
- Sometimes, church or mining health sectors can be more flexible than government ones in their procurement practices. Thus, it will be useful for different health service providers to collaborate and do business with each other.

Quantities to Buy

Many accessories and consumables have a shelf-life:

- Items with an expiry date.
- Items affected by heat.
- Items which rust or collect condensation.
- Items which deteriorate, such as batteries.

Shelf-lives will:

- affect your ability to buy in bulk
- affect your ability to buy well in advance
- require you to provide good quality storage facilities (*Section 6.2*)
- require you to have an effective stock control system, to ensure that you conform to the rules for stocks with shelf-lives – SLFO (shortest life, first out) and FIFO (first in, first out) principles (*Section 6.2*).

Thus, where possible use centralized storage and bulk purchasing arrangements as these are more economical and ensure a good turnover of stock. The quantities that you decide to buy (*Section 6.3*) also depend on the 'lead-time' for each item (the time taken for goods to arrive once ordered).

When purchasing new equipment and funds are available, it is a good idea to purchase a supply of consumables, accessories, and spare parts at the same time. Consider purchasing enough for a set period, such as a two-year supply (see *Guide 3* on procurement and commissioning).

Manufacturers' manuals, their local representatives, and suppliers can often provide information and advice about the likely consumption rates of the items you require, and this may help you decide on the quantity to order.

Responsibilities

Equipment-related supplies are often forgotten among all other general and medical supplies (such as food, stationery, linen, bandages, syringes, and catheters). If you are told that there is not enough money in the recurrent budget to cover equipment-related needs, many clinical activities will stop because there are no rolls of recorder paper, tubes of ultrasound gel, replacement bulbs, and the like. Therefore, staff need to see the management of these materials as a collective responsibility. *Box 47* shows the many people who have a role to play.

BOX 47: Responsibilities for Recurrent Materials

Health Management Team	◆ ensures that adequate quantities of equipment consumables and accessories are available at all times, through the work undertaken by the Purchasing Department and the Finance Section.
Purchasing and Supplies Officer	◆ purchases the correct items of good quality from reliable suppliers.
Stores Controller	◆ correctly and efficiently stores, issues, and controls equipment consumables, accessories and spare parts, as well as cleaning materials ◆ monitors the stock levels of equipment materials in the main stores, and ensures that they reorder the materials in time.
Equipment Users	◆ correctly handle and store equipment accessories before, after and during use ◆ ensure that consumable items are not used in a wasteful manner.
HTM Teams	◆ correctly handle and store equipment spare parts and tools ◆ ensure that maintenance materials are not used in a wasteful manner.
Section Heads	◆ monitor the use of equipment materials in their section ◆ monitor the stock levels of equipment materials in their sub-stores and sections, and ensure that they reorder from the main stores in time.

Experience in Botswana

Health staff were having problems describing which equipment accessories and consumables they wanted to order, and stores staff had difficulty identifying the items requested. Thus the government's Central Medical Stores decided to develop an order catalogue that described each item, together with an illustration.

6.2 STORAGE SYSTEM AND PROCEDURES

Elements of the Storage System

Your health service provider will need to decide where equipment accessories and consumables are stored. There are a number of options depending on:

- the size of your organization
- the different levels of healthcare delivery
- the supply and distribution system
- the storage system used by the health service for other types of supplies
- the structure of your Healthcare Technology Management Service (HTMS)
- the skills and trustworthiness of your staff.

It is important that someone takes responsibility for these equipment-related items so that they do not get forgotten. Options are:

- First decide whether to include them with all other general and medical supplies in the health service storage system, or separate them out and place them in the HTMS storage system.
- Then use your normal distribution system and store different quantities at:
  - the central level
  - the district/regional level
  - the health facility store or maintenance workshop store.
- Finally, decide whether the people looking after the stocks are going to be either trained stores personnel or departmental staff (equipment users or maintainers). Whatever you decide, the individuals responsible should be given training on how to run the stock control system.

Different countries and health service providers find different solutions to this dilemma. The most important issue is that you choose a flexible system which ensures that:

- the person in charge of the stores (at every level) is trustworthy
- there is a proper stock control system
- equipment users and maintainers have easy access to the items they need whenever they need them (without abuse of the system)
- the people running the stores are familiar with the items they order and issue.

Do not forget that you also have a responsibility for other equipment-related items, such as the spare parts and maintenance materials. A similar discussion for these items is provided in *Guide 5* on maintenance management. The HTMS storage system may end up being responsible for **all** equipment-related items.

Whether you decide to turn departmental staff into stores persons, or use the professional skills of existing stores personnel depends on:

- the knowledge of the staff
- their recognition of the range of equipment-related supplies
- whether the stores are holding bulk quantities or only those for daily/weekly use
- whether you need access to the supplies for out-of-hours emergencies.

It is common for general stores staff to have a problem with recognizing the wide range of equipment-related supplies in stores, and this can lead to a number of problems such as non-issue, loss, and incorrect ordering.

It is vital to train stores staff and procurement officers to recognize equipment-related items.

There needs to be some mechanism to control when accessories are replaced and consumables used, to avoid abuse of the system. For example, this needs to avoid batteries being replaced early and the old ones being used at home, printer ink being ordered unnecessarily and sold off privately, and light bulbs being used in people's homes.

Box 48 provides some strategies for all these issues.

The storage system (at any level, such as a hospital) may have a main store which stocks the major bulk of all items, but issues weekly/regular requirements to smaller sub-stores in user-departments or the maintenance workshop. The items issued to the sub-stores depend on the value and frequency of use of each item.

A user-department or workshop is allowed a sub-store when:

- they have a secure, lockable storage room
- it is agreed which are the regular items required on a daily/weekly basis for storage in the department
- the Stores Controller provides the department with the necessary stores forms to complete
- the Stores Controller trains a suitable staff member from the department to correctly fill in the necessary stores forms for the stocks held in their department
- the department has special storage requirements (goods requiring refrigeration, for example), so the Stores Controller allows bulk stores to be held outside the main stores under agreed special conditions, as long as they are secure.

Box 49 overleaf provides some strategies for creating a suitable secure and clean store which is organized in a simple and logical way.

BOX 48: Strategies for Storing Equipment-Related Items

Strategy	Suggestions
If you decide to use a general health service store for the majority of the stock, designate a separate section where all equipment-related items can be stored together	This separate section would contain equipment, spare equipment accessories, equipment consumables, equipment spare parts, and maintenance materials. In this way, it is possible to ensure that the small quantities of many varied technical items do not go missing and unrecognized amongst the bulk of general items kept in the stores.
Ensure that the correct technical item is used for the correct application	There are various possibilities: ◆ All equipment spare parts required for user PPM could be issued only with the signature of an HTM Manager or his deputy. ◆ If there is any uncertainty concerning which is the correct part, accessory or consumable to be issued/used for a certain application, seek the advice of the HTM Manager or Head of Department or consult the equipment manual. ◆ The old part should be returned to the HTM Manager for inspection and disposal.
Any store should have an identification code system for the items in stock	If such a system already exists for general and medical items, it can be extended to cover equipment-related supplies. Some equipment items will be covered by relevant codes for existing categories, and some will require new ones to be set up. For example, there will usually be: ◆ existing codes — for surgical items, etc ◆ an existing code — for hardware, which could cover spare parts and maintenance materials ◆ an existing code — for fuel and lubricants, which will cover some maintenance materials ◆ a new code required — for equipment accessories ◆ a new code required — for equipment consumables ◆ any new code — as required.
Develop an illustrated catalogue	This should show equipment-related items with descriptions and photographs or drawings, together with their stores code.
Use a proper stock control system	This ensures that you use some form of Stock Card in order to keep track of the stocks ordered and issued (see below).
Ensure work orders clearly show the supplies required	In this way, you can check the amount and rate of use of supplies against the stock left at the time of the annual audit.

BOX 49: Strategies for Creating Suitable Store Rooms

Space	◆ Provide a space which is secure, clean, dry, free from pests, not too hot or cold, well-ventilated, and not exposed to direct sunlight. ◆ Provide enough space to store all the equipment-related supplies and materials on shelves, in cupboards, or in containers such as bins. ◆ If no shelving is available, make your own shelves using planks of wood supported on bricks or crates. ◆ Make use of the space in the middle of the room for shelves – putting shelves only around the walls takes up a lot of space and wastes the space in the middle of the room.
Organization	◆ Organize the store in a simple and logical way so that items can be found quickly and easily. ◆ Organize the stock into different sections for different categories of supplies: in other words, cluster items by their application. ◆ Code each row, block, shelf and bin, in order to identify the location of each part. ◆ Clearly label each section of the store, allocate each item to a specific place and label the position of the item on the shelf so that it is easy to read. ◆ Provide every bin and shelf partition with a stock card.
Monitoring	◆ Monitor stock movements, either through a paper record system or using a computer program. ◆ Rotate stocks according to their expiry date: - Use the SLFO (shortest life, first out) and FIFO (first in, first out) rules, and store items that have the latest expiry date at the back and items with the earliest expiry date at the front. - Use the FIFO rules for items without an expiry date and mark these with the date of receipt. ◆ Put a red star or a similar mark on the labels of all items that have an expiry date within the current year. ◆ Remove expired, damaged, or obsolete items from the shelves and dispose of them according to approved waste management procedures (*Section 5.3*).

Experience in El Salvador

The Maintenance Department of the Public Health Service in El Salvador established their central store, and regional and local sub-stores, with support from German Technical Aid. All their equipment-related supplies are given codes which are linked to their equipment inventory coding system. Their storage space is divided according to the inventory codes, and the shelves are divided and labelled accordingly. In this way, supplies common to individual pieces of equipment are kept next to each other. In addition, their inventory coding system included codes for families of equipment/areas of use (such as radiographic equipment, suction equipment, heating and ventilation equipment); in this way, supplies for individual machines are stored in the same area as supplies for other machines in the same equipment family. In order to make the stock control system faster and more efficient, they developed a computerized system (with support from Dutch Aid).

What to Keep in Stock

Most stores systems have what are known as 'stockable' items: these are items which are automatically replenished when stocks run low, and are therefore always in stock. This is a common system for medical and general items, but is rarely in place for equipment-related supplies and this makes it very difficult to keep equipment functioning. You should therefore aim to make equipment-related items stockable too, including:

- equipment consumables
- commonly-used accessories
- the spare parts and maintenance materials required for PPM
- those parts and materials which experience tells you will be required for common repairs.

Less commonly used equipment-related items may remain as non-stockable items.

How the System Works

Usually, the Stores Controller monitors the stock levels of stockable items and, when stocks are running low, submits order forms to the Purchasing and Supplies Officer to automatically buy in another batch.

However, if a stockable system has not yet been established for equipment-related items (perhaps because funding for the health service is unstable), recurrent items are considered for purchase each month or quarter, when cash is available. In this case, the user department submits its order for further supplies to the Purchasing and Supplies Officer (as described in *Guide 2* on planning and budgeting) – see *Annex 4*.

In addition, user departments submit their orders for non-stockable items to the Purchasing and Supplies Officer, as and when they are required.

Keeping Track of Stocks

Whenever new equipment-related supplies arrive, they should be entered into the stores system. Also when new equipment arrives, the stocks of accessories and consumables that were purchased with it should be entered by the Commissioning Team into the Stock Control system (as described in *Guide 3* on procurement and commissioning) – see *Annex 5*.

Stores staff should:

- allocate code numbers to the different equipment accessories and consumables
- enter onto the stock cards (bin cards) the sorts of information that is shown in *Figure 13*. Guidance on the stock levels required can be sought from the Head of Department or HTM Manager, and information generated from a one-off exercise (as described in *Section 6.3*)
- store the new supplies on labelled shelves with their stock cards (bin cards)
- issue a list of the codes for specific items to the user departments and HTM Teams, so that they can easily identify and order items (for example, a spare bottle for suction pump Type A may have code number EA 07 050).

Figure 13: Sample Stock Card (Bin Card)

Stock Card (Bin Card)

Card no:

Item description:
Unit/pack size: Cost: Item code no:
Maximum level: Minimum/Reorder level: Location:
Reserve stock level: Order quantity: Lead time:

Date	Received from/ issued to	No. received	No. issued	New balance	Remarks	Signature

If user departments have sub-stores, the staff in the main store can consult with the Head of Department, and issue the short-term requirements to the sub-stores every week (or month). The Stores Controller then monitors the usage rate of stocks in the sub-stores to ensure that the user department doesn't request too much for its regular issues, and ensures that the department is only issued with what it really needs.

As goods are issued, and marked off on the stock card, the record system tells the Stores Controller when the stocks are low and the reorder level has been reached. Then:

- in the case of non-stockable equipment-related items, the Stores Controller prompts the user department to complete an order form requesting further supplies
- in the case of stockable equipment-related items, the Stores Controller writes a purchase order for approval by the Health Management Team and submits it to the Finance Officer for payment.

The stores stock control system can be either a manual paper system or a computerized system. It doesn't matter which you use, because the sort of data that you must record is the same whether you are designing the layout of a card or the fields on your computer screen. Also, any computer system involves an element of paperwork, as standard forms can be printed out for stores staff and departments to fill in.

The rest of this Section covers paper forms, and various manual ways to summarize the data. If your health service provider has a computerized stores stock control system, this can automatically generate purchase orders when reorder levels are reached. Stock management is an area in which simple computer systems have proved to be quite valuable (see *Annex 2*).

6.3 CALCULATING USAGE RATES AND REORDER LEVELS

When stocks of equipment accessories and consumables decrease, levels must be replenished. Thus it is necessary to monitor and control the stock of accessories and consumables, in order to ensure that you always have the required items in stock on the shelves when they are needed. To achieve this, the Stores Controller needs to know when to reorder goods and how many should be reordered. A number of factors will affect these calculations for different types of items:

- The rate of use of each item (for example, 20 per day, six per week).This will be affected by patient attendance figures, the frequency of particular clinics or equipment sessions, timetabled care and cleaning schedules, and the likely breakdown rate (life of an accessory) estimated from past experience and records.
- The lead-time for each item (that is the time taken for goods to arrive from the supplier or central stores once ordered).
- How often you can place orders (the frequency of ordering).
- The cost of each item.
- The shelf-life of the item.

First, you will need to identify what is worth holding in stock and how much is required, based on the type of work you perform. Secondly, it is necessary to continually restock so that you always have sufficient items to carry out the necessary work. This calculation is based on rates of consumption. The following sub-sections discuss how to do this.

Annual Requirements: What to Have in Stock

First, the user departments need to get an idea of how much of each type of accessory/consumable they are using (a discussion on spare parts for user PPM can be found in *Guide 5* on maintenance management). If such goods have not been stockable items up to now, there will be little information currently on stores stock cards from which the Stores Controller can make these calculations. Thus, for existing equipment, you may need to carry out a one-off exercise to identify the type of accessories and consumables required, the quantities used, their sources, and possible prices (see *Guide 2* on planning and budgeting). The HTM Working Group can nominate a stock sub-group (*Section 1.2*) to undertake this one-off exercise, the findings of which will be based on the experience and identified needs of the user departments.

Guide 2 describes how the information collected can be used to calculate more realistic recurrent budgets. The information should also be given to the Stores Controller for entry onto the stock cards, so that there is sufficient data on usage rates, reorder levels, and reorder times for equipment accessories and consumables.

In the case of new equipment purchases, a well documented list of the accessories and consumables supplied should be entered into the stores system automatically during the equipment acceptance process (as described in *Guide 3* on procurement and commissioning) – see *Annex 5*.

You will need to decide:

- What type of supplies do you need? (What do you commonly use? What is worth holding in stock?)
- What quantities of each item should you order? (How much do you need to have available for use?).
- Which items are the most important to keep in stock? (Is the accessory/consumable/cleaning material essential? Can you work with the majority of your patients, samples, etc without this item? Is there somebody available who is skilled enough to use the accessory/consumable/cleaning material?)

You will need to order large quantities of items that are frequently used, and fewer of items that are only used occasionally. It is preferable not to stock items that are rarely used, since it is not good to tie up your money in stocks that sit on shelves for years doing nothing.

Ordering too little (understocking) results in shortages: your health facility will be unable to provide effective treatment and care as a result, and staff and patient confidence in the service will be undermined. Ordering too much (overstocking) results in a build-up of stock and wastage (of items that are not used before their expiry date, for example, or that become spoiled if left unused for too long) as well as tying up valuable funds unnecessarily.

The quantity of replacement accessories and consumables that you order depends on factors that you can anticipate, such as:

- how much stock is normally used
- how much work is planned or can be expected
- seasonal demands
- how often you place an order
- the storage capacity of your store.

You may also need to order a limited quantity of extra stocks of some items so that you can deal with unexpected events.

The number and type of accessories and consumables that you decide to own and stock depends on the type of work you perform, and the way in which you work. There are several things to consider, and *Box 50* provides the basic calculations required to work out how much you should own.

Remember, these calculations will have to be done for each type of accessory and consumable, and for each type of equipment that you operate. You will also then need to multiply these quantities by the unit price for each accessory or consumable, in order to find out the overall cost of your needs and whether you can afford them in your budget (also see *Guide 5* on maintenance management for similar calculations for PPM spare parts requirements).

BOX 50: Steps for Calculating Annual Requirements of Accessories and Consumables

Step 1. **Consider the Type of Accessory**	
Consider	***Example***
The different uses you will make of the equipment, and therefore the different types of accessories you may need.	Do you need high speed as well as low speed dental drill handpieces? Do you need bipolar coagulation forceps as well as monopolar hook electrodes for your diathermy machine? Do you need 40x microscope objectives as well as 100x oil immersion objectives?
The different applications for your equipment, and therefore the different varieties of each types of accessory you may need.	Do you need pulse oximeter probes for use on the ear, the finger, or the toe? Do you need temperature probes for use on the skin, or rectally?
The different types of patient or sample, and therefore the size of accessories you may need.	Do you need BP cuffs for adults, children, infants, and neonates? Do you need centrifuge rotors that can take 50ml test tubes or 15ml test tubes?
If the accessory should be a reusable or a disposable type.	Do you want reusable ECG plate electrodes and fixing straps, or disposable stick-on ECG electrodes?
The associated and connecting parts for the accessories you need.	Don't forget that the patient leg supports/poles for your operating table will also need sleeves, straps, and clamps.

Continued overleaf

BOX 50: Steps for Calculating Annual Requirements of Accessories and Consumables (continued)

Step 2. **Calculate the 'Basic Set'**	
Calculation	***Examples***
Once you know the type of accessories you require, you need to decide on the quantities of each accessory required for the way you work: this will make up your 'basic set'. Once this has been established, you can order multiples of the basic set of accessories.	Although you only use one monopolar diathermy electrode at a time, you may need to own a basic set of three monopolar electrodes: ◆ one in use ◆ one being cleaned ◆ one as a spare. Although your small bench-top autoclave may only have two shelves, you may need to own a basic set of six trays (three for each shelf): ◆ two that have just come out of the autoclave full of newly sterilized instruments ◆ two in use in the autoclave full of items being sterilized ◆ two being filled with dirty instruments waiting to be sterilized.

Step 3. **Consider the Lifetime of the Accessory or Consumable**	
Consider	***Examples***
The next issue to consider is how long the accessory will last before it fails. Some accessories have a long life, some have a short life, and some are disposable (thrown away after one use). Consumables are considered in the same way as disposables, as follows:	
a. Accessories with a long life. These are not likely to wear out, therefore you do not need any extra ones in stock. When they break, you can buy them as required as a spare part.	Baskets in pressure-cooker-type sterilizers
b. Accessories with a short life that are reusable. The manufacturer's literature and your experience will tell you the likely life of the part, so you can calculate how many you will need in a year.	Jars of suction pumps, diathermy probes, patient lead sets
c. Disposable accessories, and consumables. These are used up as you operate the equipment, so you need to calculate the consumption rate (this is dependent on how busy you are and your rate of use). How much you buy will also depend on the pack size for these products.	Stick-on ECG electrodes are *disposable* accessories; they can be supplied in various quantities, such as bags of 50, or boxes of 1,000. Rolls of recorder paper and tubes of ultrasound gel are *consumables*. You can order various quantities, such as: ◆ boxes of 10 rolls of paper, or cartons of 100 rolls ◆ 100g tubes of ultrasound gel, 1 litre bottles, or 50 litre containers.

Continued opposite

BOX 50: Steps for Calculating Annual Requirements of Accessories and Consumables (continued)

Step 4. Calculate Quantities	
Consider	***Examples***
a. Accessories with a long life. Simply buy the 'basic set' required for each machine. **b and c. Accessories with a short life, as well as disposable accessories, and consumables.** Buy multiples of the items in your 'basic set' by taking into account the life of the items or their consumption rate. Use the following calculations:	For example: i) A suction pump jar (accessory A) may have a life of six months; $L_A = 6$ (months) ii) A reusable pulse oximeter finger probe (accessory B) may last four months; $L_B = 4$ (months) iii) A box of 50 diathermy disposable patient plates (disposable accessory C) may last one week; $L_C = 0.25$ (month) iv) A 100g tube of electrode contact gel (consumable D) may last two weeks; $L_D = 0.5$ (month)
i) Quantities according to lifetime Find out the life of the part (in months), or how quickly it is used up [life of item A = L_A]. This type of information can be obtained from the manufacturer, their literature, or your experience. Then calculate the quantity used as follows: Number of accessory Z used per year, [$Number_Z$] $= \frac{12 \text{ months}}{\text{Life of item Z (or rate of use)}} = \frac{12}{L_Z}$	In the examples above: i) Number of jars used each year [$Number_A$] = 12/6 = 2 ii) Number of finger probes used each year [$Number_B$] = 12/4 = 3 iii) Number of boxes of 50 patient plates used each year [$Number_C$] = 12/0.25 = 48 iv) Number of 100g tubes of gel used each year [$Number_D$] = 12/0.5 = 24
ii) Multiples according to the 'basic set' Take into account the multiples in your basic set, if applicable, to allow for the way you work. Then calculate the quantity required as follows: Quantity of accessory Z required per year, [$Quantity_Z$] = $Number_Z$ x $Multiple_Z$	From example (ii) above: If your basic set of pulse oximeter finger probes is two (one in use, one being cleaned); $Multiple_B = 2$. Thus, quantity of finger probes required each year [$Quantity_B$] = 3 x 2 = 6
iii) Totals according to the number of machines you own Consider the total number of similar machines you are buying accessories and consumables for [N]. Then calculate the quantity required as follows: Total quantity of accessory Z needed per year, [$Total_Z$] = $Quantity_Z$ x N	In example (ii) above: Perhaps you have four pulse oximeters in use; N = 4. Thus, total quantity of finger probes needed per year, [$Total_B$] = 6 x 4 = 24.

Regular Monitoring: When to Restock

Once the accessories and consumables are in store with stock cards, the stores staff can record the weekly issue quantities, and monitor the departmental usage rate.

Other types of information need to be filled in on the stock cards (see *Figure 13*); this data covers issues such as:

- when to reorder
- how much to reorder
- how long the delivery time is
- how low stocks can fall.

Box 51 shows you how to calculate the data that should be put on each stock card. From experience over time, the Stores Controller should be able to help you to calculate this data.

The purpose of recording this information on the stock cards, is so that the stock control system will prompt you when it is necessary to buy more stocks. Then the Stores Controller can automatically order the items to ensure that you don't run out of the materials you require for the work in your department.

Once a month the information on the stock cards is transferred to a 'stock control ledger' (stores record book). It is simpler to make an order using the summary in the stock control ledger than using all the individual stock cards. The stock control ledger is also a useful tool for analyzing stock management and reviewing the accuracy of stock levels.

A stock control ledger (stores record book) should be kept by every departmental store in order to keep track of the quantities of accessories and consumables used and kept in stock. The department's storesperson should be responsible for keeping these records. You can either obtain a stock control ledger from your Health Management Team or make one yourself, using a separate page to keep records for each type of item. *Figure 14* shows two different sample layouts for the ledger.

BOX 51: How to Calculate Reordering Times and Quantities

Supply Term Definition	Principle	Calculation	Examples
Time Between Orders [TBO] – supply period, which reflects your frequency of ordering.	In some organizations, you must place orders according to a regular schedule. In others, you can order supplies at any time, as and when you need them.	Look at your records/regulations and work out how often you can place an order, for example, once a year, once a quarter, or once a month. Express this in months.	For example, assume: a. recorder paper is ordered once a quarter, thus TBO = 3 b. suction bottles are ordered once a year, thus TBO = 12
Lead Time [LT] – delivery time.	This will depend on the distance, transport, and supplier/sources involved, and will vary from item to item.	Look at your records and work out the time between placing an order and receiving it. Express this in months.	In examples above, assume: a. the LT for paper is 1 month b. the LT for bottles is 6 months
Average Monthly Consumption [AMC] – average quantity of an item issued/used each month.	This is calculated over a period of months to take account of seasonal variations in demand.	Look at your records and work out: $AMC = \frac{\text{total quantities issued/used in a time period}}{\text{number of months in that time period}}$	In examples above, assume: a. 48 paper rolls are used in 6 months, thus AMC = 48/6 = 8 b. 24 bottles are used in a year, thus AMC = 24/12 = 2
Reserve Stock [RS] – safety or buffer stock, in other words, the lowest level of stock for each item.	Quantities should not be allowed to fall below this level. It is the extra supplies required to ensure there are no 'stockouts' when there is an unexpected increase in demand, or a delay in receiving supplies	RS = quantity used in half the lead time $= \frac{AMC \times LT}{2}$	In examples above: a. $RS = \frac{8 \times 1}{2} = 4$ paper rolls b. $RS = \frac{2 \times 6}{2} = 6$ bottles
Minimum Level [Min.] – reorder level, in other words, the stock level that indicates you need to place an order.	You must reorder when you reach this level to avoid running short of supplies. It will change as your usage rate and supplier/source changes, so it needs to be checked regularly.	Min. = reserve stock + stock used during lead time = RS + (AMC x LT)	In examples above: a. Min. = 4 + (8 x 1) = 12 paper rolls b. Min. = 6 + (2 x 6) = 18 bottles

Continued overleaf

BOX 51: How to Calculate Reordering Times and Quantities (continued)

Supply Term Definition	Principle	Calculation	Examples
Order Quantity [OQ] – quantity of items that is ordered to be used in one supply period.	As the quantity ordered will be used up in the time between orders, it must be calculated to maintain stocks above the reserve stock level [RS] until the next delivery of supplies is received.	OQ = average monthly consumption x time between orders = AMC x TBO	In examples above: a. OQ = 8 x 3 = 24 paper rolls b. OQ = 2 x 12 = 24 bottles
Maximum Level [Max.] – maximum amount you will have at any time.	Usually you only have the maximum level just after receiving a delivery. It prevents you over-ordering. It will change as your usage rate changes, so it needs to be checked regularly.	Max. = reserve stock + order quantity = RS + OQ	In examples above: a. Max. = 4 + 24 = 28 paper rolls b. Max. = 6 + 24 = 30 bottles
Example Summary:	a. You use 48 recorder paper rolls in six months, order them once a quarter, and they take one month to arrive. Thus, when 12 rolls are left in stock, you place an order for 24 rolls. Your safety reserve stock is four rolls, and the maximum amount you ever have in stock is 28 rolls. b. You use 24 suction bottles in a year, order them once a year, and they take six months to arrive. Thus, when 18 bottles are left in stock, you place an order for 24 bottles. Your safety reserve stock is six bottles, and the maximum amount you ever have in stock is 30 bottles.		

Figure 14: Sample Layouts for the Stock Control Ledger

Example 1:

Stock Control Ledger

Item description: Item code no:
Unit/pack size: Order quantity:

Date	Quantity received	Quantity used	Balance	Quantity to order	Signature

Example 2:

Stock Control Ledger

Item description: Item code no:
Unit/pack size: Order quantity:

Date	Previous count (physical)	Amount received	Amount used	Present count (physical)	Quantity to order	Signature

The Head of Department and storesperson will routinely review the stock control ledger, and will submit the information on accessory and consumable requirements and rates of use to:

- the Finance Officer in order to improve budget allocations
- the Purchasing and Supplies Officer, Specification Writing Group, and Tender Committee (see *Guide 3* on procurement and commissioning) in order to incorporate experience of the quality, performance, and cost of items into the next round of purchasing
- the Stores Controller in order to prompt the reordering process and timing of procurement.

Box 52 contains a summary of the issues covered in this Section.

BOX 52: Summary of Procedures in Section 6 on Accessories and Consumables

Needs	**Health Service Provider**	◆ ensures sufficient accessories and consumables are available for health facilities ◆ considers the use of a 'revolving fund' to help finance the needs for accessories and consumables
	Section Heads	◆ decide on the accessories and consumables required for different types of equipment
	Health Management Teams	◆ buy good quality accessories and consumables
Storage System	**Health Service Provider**	◆ decides whether equipment accessories and consumables will be stored in a separate section of the health service storage system, or a separate network of HTMS stores ◆ provides the resources necessary for a full stock control system ◆ decides whether to employ stores personnel throughout the system, or to train other staff to be storespersons ◆ provides training to ensure stores staff recognize equipment-related supplies ◆ develops an illustrated stores catalogue of equipment-related supplies
	Section Heads or HTM Managers	◆ create suitable stores and sub-stores for equipment-related items ◆ follow rules for keeping a store ◆ provide advice/authority for the issuing of stocks, to ensure the correct parts are used for the correct application
	Stores Staff	◆ implement a stores code numbering system for equipment-related items ◆ enter new equipment-related stocks onto stock/bin cards ◆ make equipment-related items 'stockable' items, whenever possible ◆ issue regular requirements to smaller sub-stores
Usage Rates and Reordering	**Health Management Teams (or HTMWG)**	◆ undertake a one-off exercise to discover the usage rates and requirements of equipment-related supplies for which there is no current information available (see *Guide 2* on planning and budgeting)
	Section Heads	◆ calculate annual requirements (see *Box 50*) ◆ provide the stores staff with the results for the stock control system
	Stores Staff	◆ calculate the reorder levels and order quantities (see *Box 51*) ◆ enter the data on the stock cards ◆ keep a stock control ledger ◆ use the prompts from the stock control system to reorder more stocks when they are required, so that stocks are always on the shelves

7. HOW TO ENSURE CONTINUOUS OPERATION

Why is This Important?

You wish to get the most out of your equipment, and for it to be available for use most of the time. Thus it is necessary to make it secure. Also, if you take good care of your equipment, it will last longer.

To ensure the continuation of the health service that your equipment supports, it is necessary to replace the equipment at the end of its life. (For example, if you want to continue offering dental services to patients, you must replace your dental drill at the end of its life).

In this Section, we offer advice on how to ensure the continuous operation of your equipment, by covering the following issues:

- Security (*Section 7.1*).
- User planned preventive maintenance (PPM) (*Section 7.2*).
- Testing for electrical and mechanical trustworthiness (*Section 7.3*).
- Fault reporting (*Section 7.4*).
- Decommissioning, disposal, and replacement of equipment (*Section 7.5*).

7.1 SECURITY

Health Management Teams need to provide adequate security measures in order to ensure their equipment is always available for use. A number of strategies should be pursued in order to try and prevent the loss and theft of equipment. *Box 53* lists some possible strategies, depending on conditions in your country.

BOX 53: Possible Security Strategies to Consider

The compound	Health facility compounds should have only one entrance; if this cannot be achieved, additional security guards will be required to cover all entrances. Health facilities should have security guard cover 24 hours a day; the Health Management Team will need to review the availability, capacity, and coverage of these guards. Security guards should check vehicles leaving the compound.
The buildings	All windows on the ground floor should have security grills/bars fitted. Upper storey rooms which contain expensive equipment and are vulnerable should have grill doors fitted. As part of planned preventive maintenance (PPM), the HTM Team should ensure that doors and locks are trustworthy and in good condition at all times.
Room occupancy	In the case of all departments or rooms used only during the day (dental, laundry, kitchen, main laboratory, main pharmacy, outpatient day-clinics, offices, maintenance workshop etc): ◆ the Head of Section, or person responsible, should lock them at the end of the day ◆ the Head of Section, or person responsible, should hand the keys into the In-Charge's room, where they will be kept in a locked cupboard ◆ one person from the night-shift team should be allocated responsibility for accessing keys if they are required in an emergency during the night. In the case of all departments or rooms used 24 hours a day (dispensary, in-patients, 24-hour OPD, casualty, maternity/labour, small laboratory, staff room, etc), night team members should lock individual rooms when not in use. While any department or room is in use at any time of day, equipment not in continuous use (for example, sphygmomanometers, diagnostic sets, foetal dopplers) should be locked in the Head of Section's office. All staff should be responsible for showing continued vigilance for items in continuous use.
Monitoring	Heads of Section should regularly check their inventory of equipment, to see if all items are present.
Response to problems	In accordance with the accountability strategies (*Section 3.1*), the Health Management Team should consider: ◆ how good behaviour is to be rewarded ◆ what penalties to introduce for non-compliance and negligence if theft is to be a punishable offence. Similar strategies should be pursued for all maintenance tools (see *Guide 5* on maintenance management).

7.2 USER PLANNED PREVENTIVE MAINTENANCE (PPM)

Equipment which is well looked after will last a long time. The best way to look after equipment is to maintain it. Maintenance is a collective responsibility with lots of people involved, such as maintenance staff in workshops, equipment manufacturers, and your HTM Team (see *Guide 5* on maintenance management). However, general health staff and equipment users, as part of the HTM Service (*Section 1.1*), have a vital role to play (see *Box 3*). They should report any faults promptly to the maintenance department, but they should also undertake some daily, basic-level maintenance tasks themselves. These activities are mainly aimed at ensuring that the performance and functioning of equipment is checked and corrected.

Planned preventive maintenance (PPM) is a series of activities carried out on equipment with the aim of preventing breakdowns and ensuring that equipment is operational and safe. By following a specified schedule of activities according to a given timetable, user PPM should reduce the amount of time the equipment is out of service.

PPM is important because it enables your department to:

- catch any problems before they become crises
- prevent breakdowns
- save money, as PPM is cheaper than repairs following breakdowns
- make sure that equipment is fully operational
- guarantee accuracy and reliability (the autoclave sterilizes, the laboratory results are correct, etc)
- increase the availability of equipment and reduce down-time
- extend the life-span of equipment
- reduce equipment running costs
- ensure equipment is safe, for patients, users, and maintenance staff.

Experience in West Africa

A doctor handed over a stethoscope to a maintainer complaining about a muffled sound. The diaphragm was in order. What was the problem? The doctor was not aware that even stethoscopes must be stored and taken care of properly, and after removing the nest of a solitary bee from the flexi-tube, the device was working again.

PPM consists of a number of tasks of varying technical complexity. Regardless of the complexity of the equipment, there may be three levels of tasks that can be undertaken by different types of staff:

- The simpler duties – performed by the users of the equipment, if they are adequately trained.
- The bulk of the work – performed by (in-house) technicians with a basic training (see *Guide 5* on maintenance management).
- More complex work – has to be done by specialized maintenance personnel. This can be in-house maintainers or, for some sophisticated equipment, may involve staff from the manufacturer or service agent. For details on managing such maintenance contracts, see *Guide 5*.

Tip

- Users should only undertake the sorts of PPM tasks that do not require the intervention of technical staff from the HTM Service, and for which they have been trained. For examples see *Box 54*.

The approach should be to teach staff, using demonstrations, to remember the basic motto and strategy of 'Check – Replace – Inform'; they need to know the correct methods for undertaking maintenance and repair of equipment.

Information is available from a variety of sources:

- The best information on equipment PPM is usually contained in the manufacturer's user manual and/or service manual.
- A wide range of independent reference material is also available (see *Annex 2*).
- Managers should write PPM schedules and timetables (see below).
- Resources from training sessions and (in some cases) posters provide the guidance and experience of colleagues (*Section 3.5*).
- Staff without personal copies of these resources should find them in the library (*Section 3.4*).

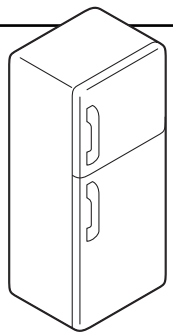
BOX 54: Typical Examples of the User's Role in the PPM of Equipment

- Calibrate equipment to ensure it is operating within its required parameters (scales, photometer, etc).
- Check and tighten loose screws (bed frames, etc).
- Change filters after their recommended duration of use (suction pumps, infant incubators, etc).
- Check for correct oil levels (air compressor engine oil, washing machine gear oil, etc), or water levels (bench-top autoclave reservoirs, infant incubator humidifiers, etc), and refill as necessary.
- Oil or grease moveable parts (trolley wheels, microtome slides, etc).
- Replace lost, worn out, cracked, or broken parts (stethoscope earpieces and diaphragms, rubber seals in pressure-cooker-type steam sterilizers, etc).
- Sharpen blades (scissors, microtome knives, etc).
- Check and replace chart recorder paper (blood bank refrigerators, ECG recorders, etc).
- Ensure that programmable or manual settings are returned to normal after the work of the previous day or shift (diathermy machines, monitors, etc).
- Inspect for wear and damage, and either inform technical staff (in the case of cracks in bedframes, poor condition of mains cable and connectors, etc) or replace the faulty article if it is a standard stock item (chipped suction bottles, torn screen material, etc).
- Replace batteries and bulbs when they reach the end of their lives.
- Check battery charging level lights, and warning lights and respond as necessary (defibrillator, patient monitor, etc).
- Check that dials, gauges, indicator lights, etc are working properly.
- Go through the machine's automatic functional check programme (infant warmers etc)
- Descale elements (water distillers, boilers, etc).
- Perform Bowie & Dick tests (for autoclaves) according to the recommended scheme.

For each equipment type there will be specific user PPM instructions. *Box 55* provides an example of the type of instructions required for refrigerators.

BOX 55: Example of User PPM Instructions for (Any Type of) Refrigerators

(these may vary or require additions depending on the make and model)



Note: the daily duties of checking the temperature, the burner flame, and the gas/fuel level, fall under 'care of equipment' activities (*Section 4.3*).

Weekly

- Check the ice formation on the evaporator. If the ice on the freezing compartment walls is more than 5mm ($^1/_4$ inch) thick, defrost the refrigerator. Otherwise your refrigerator will not work properly.

  Note:

  - Some modern gas and electric refrigerators defrost themselves so you do not have to do it.
  - If you are finding it necessary to defrost every week, the door is probably not sealing properly. You should refer to your training notes and take corrective action to check the door seal and adjust the hinges.
- Check that the refrigerator is level, and adjust as necessary.
- If you have a kerosene refrigerator clean the flue, the baffle, and the burner, and trim the wick. Also check whether the kerosene tank needs cleaning.
  Note: if the tank needs cleaning every week, you are not filling it correctly.

Monthly

- Clean the condenser coils at the back of the refrigerator with a brush. If the coils are dirty, the refrigerator will not work properly. Be careful as the coils are hot.
- Check the outside of the refrigerator for damaged paint work. If you find some, clean the damaged surface, remove all the rust, and repaint the damaged area.
- When necessary:
  - clean the refrigerator inside and out with a damp cloth. Use a mild detergent only
  - clean the door gasket and powder it with some talcum.
- If you have a kerosene refrigerator, turn off the burner and allow it to cool, then clean the burner chamber with a soft brush, and relight the burner.
- If you have a gas and electric-operated absorption refrigerator:
  - clean the flue if the flame has been smoking
  - follow the correct procedure for checking the gas line connections for leaks.
- If you have an electric compressor refrigerator:
  - turn off and unplug it, clean the compressor with a soft brush, check the mains lead and plug for damage and loose connections, then plug back in and switch on
  - check that the warning notice saying "Do not switch off" is in place next to the socket outlet, and that tape is placed over the plug and switch to ensure it is left permanently on.

Annually

- If you have a gas and electric-operated absorption refrigerator:
  - clean the gas burner and gas jet
  - clean the flue and baffle.

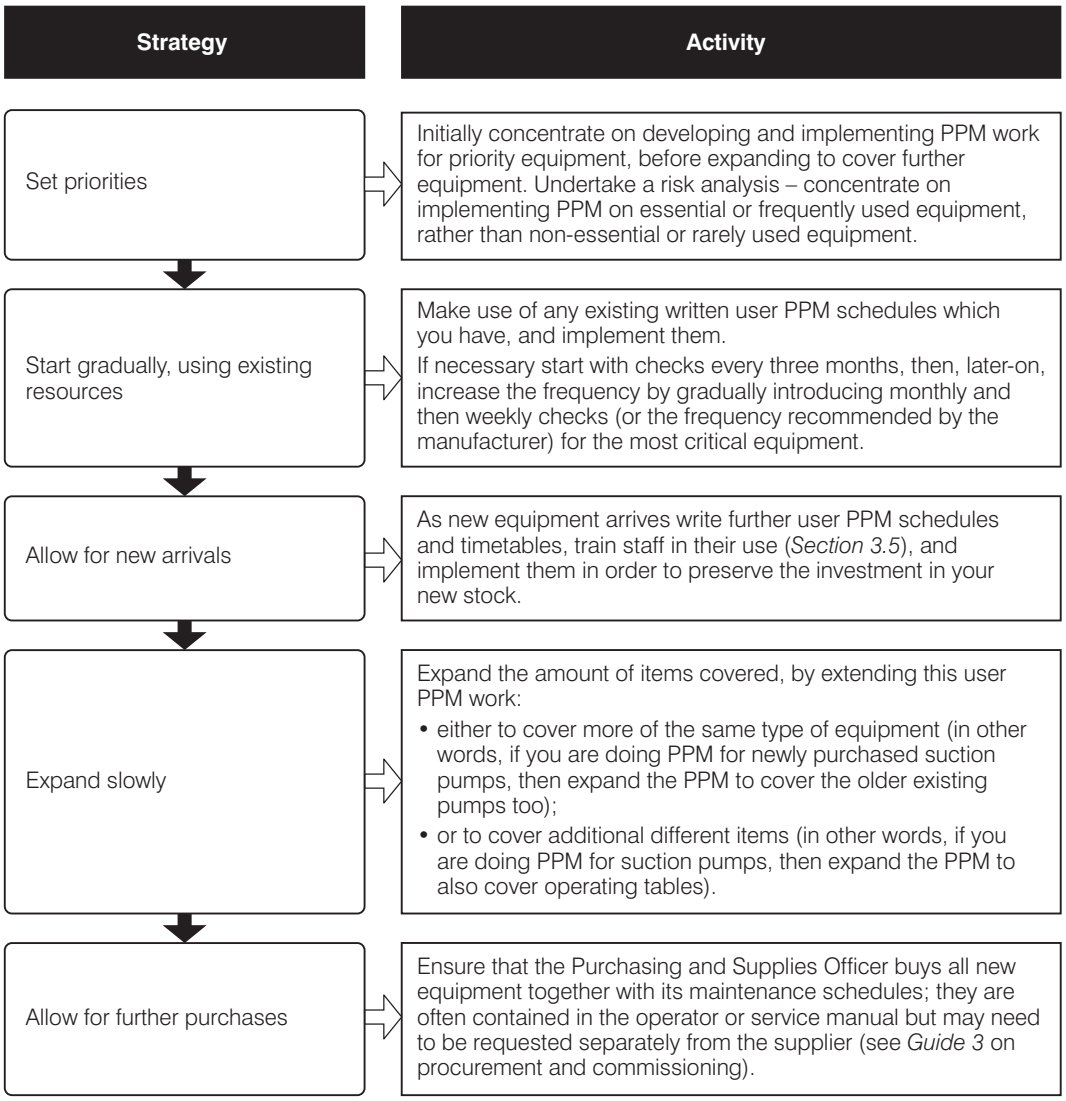
There may currently be very little user PPM undertaken in your health facility. Thus, it will be necessary to find ways of encouraging staff to carry out PPM and to improve any existing attempts. You can significantly reduce equipment-related problems by implementing a user PPM system. *Figure 15* provides some strategies for doing this.

Figure 15: Strategies for Making User Staff Undertake Maintenance and Repair

Strategies	People Responsible
Promote a sense of ownership among users	Managers, maintainers, and users meet together to agree on responsibilities for measures and actions that are acceptable to all (according to staff accountability strategies – *see Box 5*).
Provide resources	The Health Management Team ensures that adequate maintenance and repair resources (personnel, materials, money) are available for the continuous functioning of the equipment stock during its life, through the work of the HTM Service and external contractors.
Plan the work	Heads of Section should be responsible for planning user PPM tasks and timetables as advised by the HTM Service, giving the tasks to appropriate operators, and monitoring that the work is done.
Implement the plans	Operators should take personal responsibility for ensuring that they undertake the user PPM tasks that they have been trained for, and allocated by their Head of Section.
Guarantee safety	To preserve the safety of the patient, operators should assume that all medical equipment present in clinical areas is operational at all times; therefore any faulty equipment will have been removed.
Respond to faults	As soon as a fault appears on equipment which is used by the patients' bed-side, the operator should remove it from the clinical area. When equipment breaks down, or is not functioning correctly, the user should report this to their Head of Section, who completes a 'Work Request/Job Form' and sends it immediately to the HTM Team (*Section 7.4*). Users should remove the equipment or disable it, and clearly label it as faulty. Maintainers should ensure that they respond as quickly as possible to any maintenance and repair requests.
Ensure continuous services	The Health Management Team ensures the continuation of clinical services by promptly disposing of and replacing equipment when it is condemned by the HTMS at the end of its natural life (*Section 7.5*).
Provide career development	HTM Teams should ensure that the staff in their facility have sufficient skills to enable them to maintain, repair, and operate equipment effectively and safely, by implementing a rolling programme of refresher training. If operators and maintainers require further skill-development, they should put in a request to their Head of Section. The Human Resource Department includes the duties of cleaning, basic care, and maintenance of equipment in the job descriptions and contracts for health service staff.

You will need a strategy to slowly expand how much of your equipment stock receives user PPM. User departments should consult with the HTM Service and follow strategies to build up PPM gradually over time, as shown in *Figure 16*

Figure 16: Strategies for Expanding User PPM



PPM Schedules

PPM schedules (protocols, or lists of activities) need to be developed separately for both users and maintainers. They should provide simple guidelines for all types of equipment, covering the tasks to be undertaken in the following areas:

- Care and cleaning (*Section 4.3*).
- Safety procedures (*Section 5*).
- Functional and performance checks.
- Maintenance tasks.

These guidelines should include timetables showing the frequency with which the activities must take place.

Box 56 provides some strategies for expanding your library of PPM schedules, and hence your PPM work.

Another important task for Heads of Department or the training sub-group, is to convert the user PPM schedules into some or all of the following:

- Posters which can be placed on the wall beside the equipment.
- Paper copies in plastic pockets attached to/hung from the equipment itself. This is known as an equipment card and should be kept permanently with the equipment. It will also show the date of the next service due from the HTM Team (see *Guide 5*).
- Laminated cards, for the staff to carry around and refer to when carrying out PPM (see *Section 3.5* and *Figure 7*).

BOX 56: Strategies for Developing PPM Schedules

Type of Material/Information	Action
PPM schedules and timetables are usually written by the equipment manufacturers, and can be found in their operator or service manuals.	Try to get hold of as many of these as possible (using the strategies presented in *Box 8*).
Some PPM schedules and timetables have already been developed by international agencies and other sources (see *Annex 2*).	Try to get hold of these resources (see *Box 8* for strategies).
All these documents and systems can be modified by technical and clinical staff to suit local conditions.	Meet with your colleagues and draw on your own experiences to adapt the resources to local needs and realities.
Expand the written resources and establish a library of user PPM schedules.	The HTMWG's training sub-group (*Section 1.2*) could be made responsible for this.
Some organizations have developed computer software programs which help with planning PPM. They generate requests for PPM according to timetables, and keep records of the work and results. Some systems also provide generic PPM schedules for different equipment types (see *Annex 2*).	Investigate this software if your organization wishes to use computerized maintenance systems (see *Guide 5* on maintenance management).

PPM Timetables and Wall Calendars

PPM work must be carried out at specified intervals, as detailed in your schedules. The HTM Managers and Heads of User Departments should liaise to draw up timetables to ensure that the PPM work is undertaken at the required frequency. Some tasks need to be carried out after every use, every shift, daily, or weekly, and so on. If your Healthcare Technology Management Service has a computerized maintenance management system (see *Guide 5* on maintenance management), this can automatically generate work orders when PPM is required.

The simplest form of timetable is to have a monthly duty list. Alternatively, it is useful to display the planned work on wall calendars indicating when PPM should be carried out. The calendar should incorporate space where staff can sign off and date when they finish the task, to show that each timetabled PPM activity has taken place. This method provides you with a visual record for managers to monitor. An example is shown in *Figure 17*.

It is also important to keep a record of any pieces of equipment that are substituted. If your equipment has been labelled with some form of inventory code number (see *Guide 2* on planning and budgeting), it will be easier to tell which particular piece of equipment you have been maintaining.

User PPM charts, calendars, and instructions should be displayed on the equipment, or as near to it as possible, to remind staff of their duties, and for ease of completion. Wall calendars can also be used to display daily care and cleaning schedules.

Figure 17: Example Timetable of PPM for Users in Wall Calendar Format

PPM Wall Calendar Timetable																
Months	**Jan**				**Feb**				**Mar**				**Apr**			
Week	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Water Still	PH q												q			
Microscope		CdS m				PH m				m				m		
Refrigerator	PH w	CdS w	CdS w	PH m	CdS w	PH w	w	m	w	w	w	m	w	w	w	m
Key: q = 3 monthly (quarterly) m = monthly w = weekly																

7.3 TESTING FOR ELECTRICAL AND MECHANICAL TRUSTWORTHINESS

Equipment should be kept in an acceptable physical and working condition at all times, so that it can perform competently and safely. Equipment should not be allowed to deteriorate to such an extent that it becomes untrustworthy or hazardous (*Section 5*). For example:

- frayed mains leads
- disconnected earth
- metal with stress fractures
- leaking gas valves
- cracked glass
- failing brakes
- perished rubber materials.

One strategy is for staff to regularly check equipment visually for such disintegration. However, to reduce the risk of such problems, regular testing for electrical and mechanical trustworthiness, using test instruments, is required.

Such testing ensures the safety of equipment and calibrates its performance, and so requires safety testing and calibration instruments. Safety and calibration testing usually takes place regularly throughout the life of the equipment:

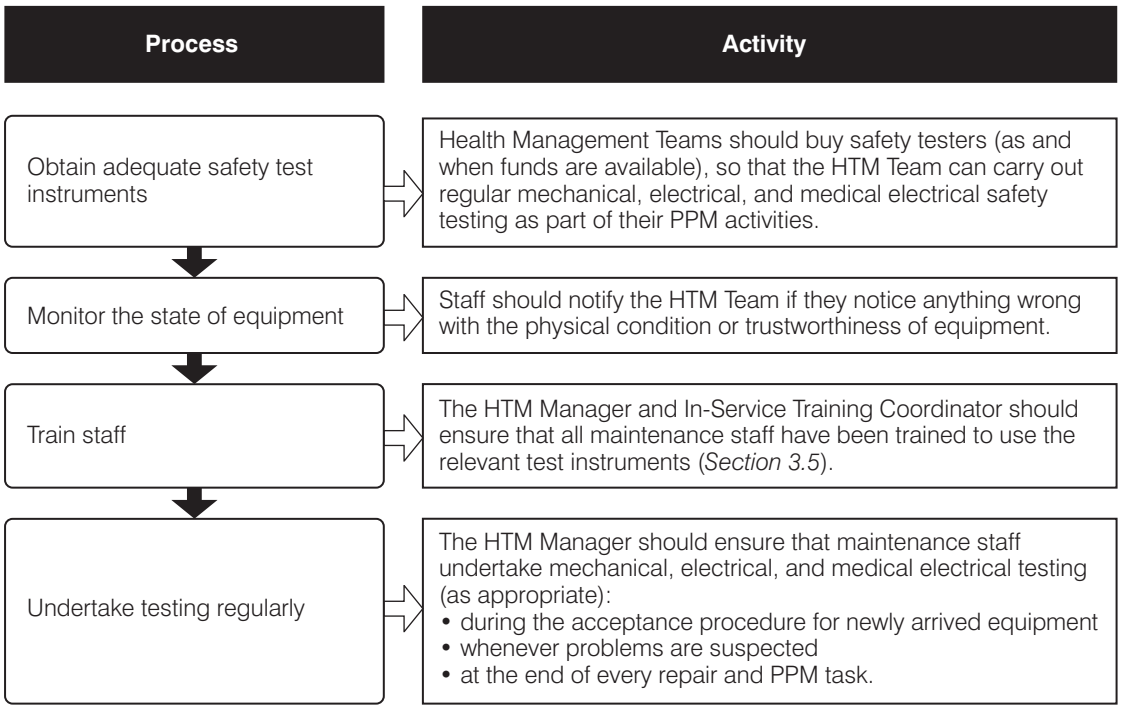
- During the acceptance process when equipment first arrives (see *Guide 3* on procurement and commissioning).
- Whenever staff suspect that there may be a problem, or the equipment may not be performing properly.
- Regularly as part of the usual planned preventive maintenance tasks (*Section 7.2*).
- At the end of every repair process, whenever equipment breaks down (see *Guide 5* on maintenance management).

Safety and calibration testing should be encouraged, even though some of the instruments required are expensive. *Section 5.5.2* discussed some tests required for electrical installations and for medical equipment. Most test instruments are used for electrical, electronic, or medical equipment purposes. Medical equipment has stricter electrical safety requirements and considerations than non-medical equipment, because it comes into direct contact with patients. Such equipment will require dedicated safety test instruments which go further than simple electrical safety testers.

Thus, the HTM Team will require adequate test instruments. *Annex 6* provides a list of the types of basic and more complex testers that an HTM Service will need. Not all workshops/health facilities at every level will need all of the instruments listed. The type of test instruments you own will depend on the skills of your HTM Team; it may be more economical and effective if the complex items are placed at regional or central levels, where specialist staff are based and provide maintenance support by outreach.

Figure 18 offers some suggestions for increasing safety testing. We recognize that following these suggestions will require a lot of resources (money, people, time).

Figure 18: Strategies for Safety Testing



7.4 FAULT REPORTING

Besides PPM, there will be faults and breakdowns needing repair, and maintenance work requiring more skills than the users have. Equipment users and their Section Heads are responsible for reporting all equipment faults **promptly** to the HTM Team.

We suggest that fault reports are made by completing some style of Work Request/Job Form. Relying solely on telephone calls or radio communication can mean that there is no physical record of the request made. In many instances, reporting a fault to the HTM Team by telephone or radio is justifiable and the only quick method available; however, this process must be followed up by the prompt submission of a Work Request/Job Form in order to provide a written record of the reported fault.

You need a way of recording how many requests for maintenance support are made, and how each request is progressing. You could keep some form of Maintenance Book, but the HTM Service may be using a Work Request/Job Form system (such a system is described in *Guide 5* on maintenance management).

Annex 7 gives an example of a triplicate Work Request/Job Form which has multiple uses in the maintenance record system. The user department fills in the top half of the form, and keeps the top copy to create their own set of records.

We also suggest that each user department establishes a User Department Maintenance File to keep track of whether jobs were attended to. Such a file could be divided in half, so that it becomes a record of all the maintenance work that the department has asked for, as well as a record of those jobs that have been completed. The Work Request/Job Form can be moved from the front of the file to the back when the job has been completed, so that the two halves work as follows:

- The front of the file is the *pending* section and is a record of all the jobs reported to the HTM Team, organized according to the date the report was made.
- The back of the file is the *completed* section and is an ongoing record of all the jobs that have been completed, organized according to the date they were finished.

When a job is completed (and the equipment is returned), the Section Head:

- goes to the User Department Maintenance File
- retrieves the Work Request/Job Form (from the pending section) relevant to that job
- signs it to acknowledge completion
- moves it to the completed section.

To see how the overall maintenance record system works, and the responsibility of the user department in it, refer to *Guide 5* on maintenance management.

Whatever method is used, the department or facility initiating the job needs to keep a record of the number of requests made and monitor their progress. By reviewing the User Department Maintenance File regularly (at least once a month), the Section Head can monitor the progress of maintenance requests (*Section 8.2*).

Experience in Pakistan

The Director of Maintenance at the Aga Khan University Hospital in Karachi successfully introduced a telephone-based fault reporting system, where a written record of each telephone request was also made as a back-up. After evaluation, he found that a greater number of faults were reported as a result of the new system, and in a shorter time.

7.5 DECOMMISSIONING, DISPOSAL, AND REPLACEMENT OF EQUIPMENT

Discussion

When a piece of equipment comes to the end of its life, a decommissioning, disposal, and replacement process must take place. Decommissioning is the process of condemning equipment when it is no longer safe, or of use, and taking it out of service. This process is sometimes known as 'boarding' because, originally, government bodies called 'Boards of Survey' were responsible for carrying out this task for government property.

All equipment has a life expectancy which will be dependent on the type of equipment and the type of technology it contains. For example, five years might be the typical life for an ECG monitor, 10 years for a suction pump, 15 years for an operating table, and 20 years for an electricity generator. Reconditioned equipment has a shorter lifetime than equipment bought from new. Once equipment reaches the end of its life, no amount of intervention will help, it just needs to be replaced if the service it provides is to continue. In fact, to keep on trying to maintain equipment which has reached the end of its life will be costly.

To understand how equipment depreciates, it is necessary to know the likely 'life' of your equipment. Typical lifetimes for common equipment are given in *Annex 8*, though these may need to be modified depending on:

- the rate of use of the equipment (how many tests per day? How many patients per month? etc)
- how many back-up units you have, (is the equipment used to its limit, overworked or overloaded?)
- how the equipment is handled (is it abused?)
- how well the equipment is cared for and cleaned
- how well the equipment is serviced and how often
- the initial quality of the equipment (was it new or reconditioned?)
- the physical environment and climate that the equipment is used in.

Any replacement must be undertaken in accordance with the replacement policy (see *Guide 2* on planning and budgeting). *Box 57* provides an example.

BOX 57: Example of a Replacement Policy

Equipment will **only** be replaced when one of the following valid reasons have been fulfilled:

a. It is worn out beyond repair (has reached the end of its natural life).

b. It is damaged beyond repair.

c. It is unreliable – faulty, old, or unsafe.

d. It is clinically or technically obsolete.

e. Spare parts are no longer available.

f. It is no longer economical to repair.

And one of the following valid reasons have also been fulfilled:

g. Utilization statistics are available to show that it is still required.

h. A demonstrated clinical or operational need still exists.

Equipment will **not** be replaced simply because:

- it is old
- staff do not like it
- a newer model has arrived on the market.

Maintenance technicians and engineers are required to judge these issues, and procedures are required for the following steps:

i. assessing whether equipment has reached the end of its life, and condemning it
ii. physically disposing of the equipment safely and promptly
iii. taking it off the health service records
iv. triggering its replacement, so that the service it provided can continue.

Currently, equipment in the health service is seen as the property of the controlling body of the health service provider organization. In other words, Ministry of Health equipment is the property of the national government, and equipment in a private hospital is the property of the business firm that runs the health service. These controlling bodies require the equipment to be officially written off by a relevant authority (for example, in the government sector the Ministry of Finance will have some form of Board of Survey). These decommissioning authorities may be based nationally, at the district/region, or even at the health facility level.

These authorities must be told when equipment reaches the end of its life. They will then officially condemn it, and arrange for its disposal and any auctioning of viable items or scrap to recover money for the controlling body (the treasury in the government sector, for example). This process can take a long time, but should occur regularly in order to avoid large and dangerous graveyards of old equipment dotted around the facility site. Health facilities must be able to cope with the stocks of condemned equipment in the meantime, and must create special storage sites within their grounds.

The Condemning, Disposing, and Replacement Process

Figure 19 shows the likely steps in a typical decommissioning process.

The Health Management Team might have to chase the Board of Survey to visit the health facility promptly in order to officially condemn the equipment, and arrange for it to be auctioned off.

Ideally, condemned equipment is only disposed of once the official condemning process has occurred. However, if this does not happen regularly, the health facility cannot afford to become choked with old and scrap items, and should start a process of cannibalizing the equipment in order to reduce the impact of the stockpile and to gain as much use as possible from the old items. Hazardous components should be properly disposed of, as described in *Section 5.4*.

The Health Management Team should pursue with the health service provider the possibility of:

- establishing their own facility-level Board of Survey as soon as possible (if one does not already exist)
- being able to sell off metal items for scrap
- returning any money raised from the sale of condemned items to the budget of the health facility.

Figure 19: Steps in a Typical Decommissioning Process

Steps	Activities
Timing	Senior maintenance staff technically evaluate equipment to assess its fitness to continue in service. This can happen at any time: • when there is a fault (see *Guide 5*) • during the annual Equipment Inventory updating process (see *Guide 2*) • during the Equipment Development Planning (EDP) process (see *Guide 2*).
Judgement	Senior maintenance staff from your local workshop consider four issues and judge: • whether the equipment fulfils any of the valid replacement criteria defined in the Replacement Policy (as described in *Box 55*) • what the internationally advised typical life-time is for the equipment (see *Annex 8*) • the equipment's track record and state of health as documented in its service history records (see *Guide 5*) • whether it will be necessary to override the average expected lifespan and condemn early, or even to extend the lifespan. For expensive equipment, it may be helpful to obtain an evaluation from the supplier.
Technical action	If the equipment is condemned because it is unreliable, damaged, or in any way unsafe, the maintenance staff: • take it out of service immediately for safety reasons and to prevent its return to use • inform the Head of the User Department • take unsafe moveable items to the maintenance workshop, or arrange for unsafe fixed equipment to be disassembled • if there is to be a delay with either of these actions, leave notices on the equipment and make them inoperable (for example, by removing the accessories, or the mains connection).
Reporting	The HTM Manager of your local workshop: • writes a technical report explaining why the equipment should be officially condemned • submits this report to: – the Health Management Team and relevant User Department, for information and discussion at management meetings – the Purchasing and Supplies Manager, who starts the official process – the HTMWG, in order that the condemnation triggers a replacement in the annual Equipment Development Planning process (see *Guide 2*).
Administration	The Purchasing and Supplies Manager completes a form, such as a List of Expendables to be Written Off form (see *Annex 9*), and submits it to the relevant: • financial head office of your organization (for example, the Ministry of Finance) • local Board of Survey, whether it is a facility or district branch (*Section 1.2*)
Official response	The Board of Survey scrutinizes the report, visits the facility, and condemns the equipment, thereby providing the HTM Service with authority to remove the equipment from service.
Technical action	The HTM Team from your local workshop cannibalizes the equipment by: • removing any useful components and parts from the condemned equipment, for use on other equipment • storing these components and parts in the facility stores and maintenance sub-stores (depending on their size and number) • ensuring that any hazardous components or parts (such as radioactive sources, asbestos, mercury, etc) are disposed of in a safe manner according to the Waste Management & Hygiene Plan (*Section 5.4*), taking advice from the Infection Control Committee and any other relevant safety sub-group of the HTMWG • placing the remaining (unusable) parts of the equipment outside at a specially designated site within the grounds of the health facility or workshop, which is a secure site that is fenced-off and locked.
Record-keeping	The HTM Manager ensures that the record of the written-off items: • is removed from the Equipment Inventory (see *Guide 2*) • is removed from the maintenance files (see *Guide 5*) • is used to update the Equipment Development Plan (see *Guide 2*).
Official action	The local Board of Survey auctions off: • only the remaining equipment items which are safe to reuse • any remaining materials for which scrap value can be obtained (for example, scrap metal).

Box 58 contains a summary of the issues covered in this Section.

BOX 58: Summary of Procedures in Section 7 on Ensuring Continuous Operation

Security	**Health Service Provider and Health Management Teams**	◆ address the practical issues involved in implementing the equipment security strategies (see *Box 53*) ◆ introduce the security strategies to Section Heads and explain their implications
	Section Heads	◆ introduce the security strategies to their staff and train them in their application ◆ monitor that their staff are adhering to the equipment security procedures
	All Staff	◆ make it their responsibility to guarantee the security of equipment
User PPM	**Health Management Teams**	◆ allocate the user departments sufficient resources to undertake user PPM (materials, funds, training, etc)
	Heads of Department	◆ liaise with the HTM Service to develop the user PPM system ◆ plan these activities and implement them according to the written guidelines and timetables ◆ monitor to ensure that their staff are adhering to correct PPM techniques and timetables for equipment ◆ report any problems to the Health Management Team so that training needs can be addressed
	User Staff	◆ only undertake the sorts of procedures that do not require the intervention of the maintenance department ◆ undertake the user PPM activities regularly according to a timetable, and the training received ◆ refer to the training resources and posters provided (*Section 3.5*) and manufacturers' manuals (*Section 3.4*) for guidance
	HTM Team	◆ report any problems identified with user PPM to the Head of Section and Health Management Team, so that training needs can be addressed, or disciplinary action can take place ◆ plan and implement the more technical PPM tasks (see *Guide 5* on maintenance management)
Testing	**Health Service Providers**	◆ ensure the HTM Service has sufficient safety testers (see *Annex 6*)
	All Staff	◆ undertake visual checks to monitor whether equipment is electrically and mechanically trustworthy
	HTM Teams	◆ undertake regular safety tests with the necessary test instruments
Fault Reporting	**Equipment Users**	◆ report any faults to their Section Head **immediately** they occur
	Section Heads	◆ report any faults to their HTM Team **immediately** using the correct Work Request/Job Form (see *Guide 5* on maintenance management) ◆ use the User Department Maintenance File to review progress on maintenance work (see *Guide 5*)

Continued overleaf

BOX 58: Summary of Procedures in Section 7 on Ensuring Continuous Operation (continued)

Decommissioning	**HTM Service**	◆ undertakes the technical judging activities to identify when equipment should be decommissioned ◆ undertakes the necessary reporting, dismantling, cannibalizing, and storage activities to ensure equipment is taken out of service and does not return to use
	Purchase and Supplies Officers	◆ administer the official communication with the Board of Survey and the finance head office of the health service provider
	Health Management Teams	◆ chase the Board of Survey to act so that large graveyards of scrapped equipment do not gather on health facility grounds ◆ ensure that disposal of equipment and parts is undertaken according to the Waste Management and Hygiene Plan (*Section 5.4*) ◆ ensure that decommissioning of equipment triggers the purchase of a replacement item (when applicable)
	Boards of Survey	◆ officially write-off equipment **promptly** ◆ organize the auction of only those pieces of equipment which are safe for reuse, and any materials for which a scrap value can be obtained.

8. HOW TO UNDERTAKE ACTION PLANNING AND MONITORING OF PROGRESS

Why is This Important?

Managing the activities described in this Guide will involve a cycle of actions.

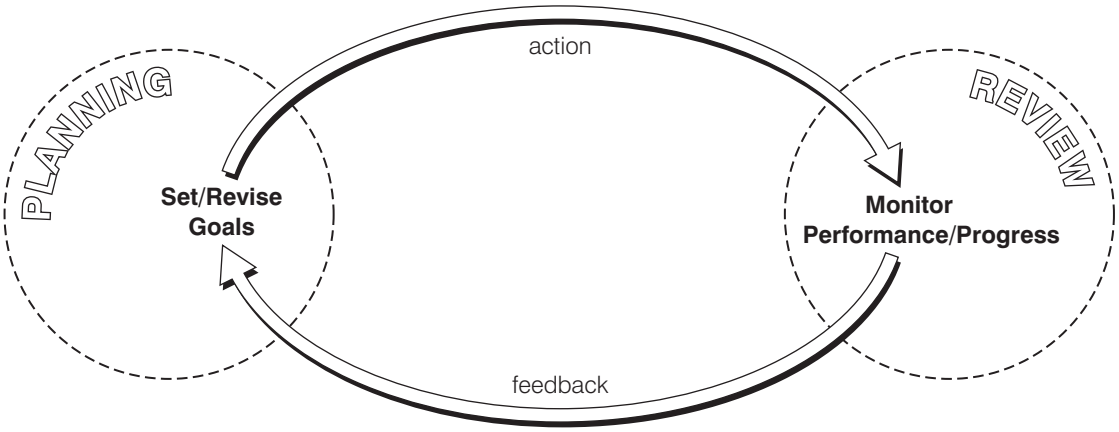
You need to monitor your performance, and set yourself goals so that you can improve. Then you monitor your progress, revise your goals, and review your progress again – thus undertaking a continuous cycle of planning and review.

Such evaluation helps you to ensure the quality of your work. This is one element of quality management – an important goal for managers.

The planning and review activities are interlinked in a cycle as shown in *Figure 20*, but it is necessary to start the discussion at some point in the cycle. This Section discusses:

- the planning process (setting goals) in *Section 8.1*
- the review process (monitoring progress) in *Section 8.2*.

Figure 20: The Planning and Review Cycle



All staff involved in equipment operation and safety should be involved in planning and reviewing their progress with this work. Thus, this Section is relevant for all different types of staff in:

- the user departments and committees
- HTM Teams
- HTM Working Groups
- their various safety sub-groups.

The main outcome of the planning and review process is that you are able to evaluate your performance. This is important for ensuring the quality of your work (quality assurance), which is an essential component of quality management.

Aims of Quality Management

- client satisfaction
- cost efficiency
- compliance with laws

We recommend that quality management is introduced into the health management systems of all the decentralized levels of the health service. It can help to improve staff attitudes, and this, in turn, can help staff handle the challenges connected with the many reforms and new management tasks they face (such as those described in this Guide). Important elements of quality management are:

- a management team approach
- supervision and evaluation
- participative leadership
- methods for encouraging staff
- individual responsibility and initiative
- control measures such as performance measurements and impact analysis
- community participation.

8.1 SETTING GOALS (ANNUALLY) FOR EQUIPMENT OPERATION AND SAFETY

Purpose

It is necessary for each user department/safety sub-group to have goals and plans which set out their priority activities. The goals and plans must be clearly defined so that they guide the work of:

- the department/sub-group
- its staff
- the health facility
- the health service as a whole.

The goals and plans will also enable staff and managers to monitor their own performance and progress with regard to the operation and safety of equipment (as well as their wider range of clinical activities).

Every department or team can benefit from an Annual Action Plan which contains clear, specific goals relating to its key activities. An action planning process should take place once a year, as standard practice. This is an opportunity for the members of the team to agree the range of activities (initiatives and changes) they want to implement, because they believe the activities will improve:

- their working environment
- their performance
- the service they provide.

There are boundaries and limitations to this planning process. The need for major investments in equipment should be discussed outside the annual action planning process, through activities such as the Equipment Development Planning exercise (see *Guide 2* on planning and budgeting). Similarly, ongoing shortages of staff or money are usually excluded from the annual action planning process, and should be addressed instead by higher authorities who can influence such issues.

Instead, we suggest that annual action planning should focus on improvements and changes that staff can undertake themselves, and that can be achieved with existing staff, equipment, facilities and other resources. Staff involved in the use and safety of equipment should devise a wide range of initiatives and goals for all aspects of their work, such as:

- obtaining information about new products
- improving operator skills in using equipment
- establishing safety guidelines
- improving stock control of accessories and consumables
- improving user PPM.

The planning process, and the plans themselves, should be clear and straightforward. This assists participation and produces goals that can be understood and used by all staff. Staff who are involved in setting goals and preparing plans are more likely to be committed to carrying them out. Thus, the planning process should incorporate representatives of all different types of staff, from all relevant disciplines.

We suggest that you hold an action planning seminar once a year. Such seminars can be held in various ways:

- Either across a 'horizontal' level of the health service, in other words, planning for the health service as a whole with participation from all disciplines, undertaken by your health facility or by your district health authority.
- Or across a 'vertical' professional programme within the health service (such as the laboratory service, or maintenance service). In this case, representatives would meet from all the laboratory departments, for example, in your district, or region, or throughout the health service as a whole.

The main purpose is to establish an annual planning cycle which:

- reviews past performance, problems, and needs
- identifies solutions and sets specific goals for the year
- prepares an annual action plan for delivering improvements in the coming year
- monitors implementation
- starts back at the beginning again with another review the following year.

Setting Goals

Three types of goals are required: targets, recommendations, and longer-term objectives.

i. Targets

Targets guide the work of the user department, HTM Working Group (or its sub-groups), and HTM Team during the following year. They help to improve services and make sure that the most important work gets done. Targets are one of the best tools for judging progress and work performance. We suggest that each department/group should have between five and 10 targets, following the 'SMART' target-setting process:

Specific	state **what** should be done and **who** will do it
Measurable	easy to measure, or easy to decide that the target has been achieved or if progress is being made
Achievable	possible to carry out with **existing** staff, equipment and money
Relevant	cover a priority problem or improvement
Time-bound	state when the activity should be completed by.

It will be clearer if targets are written down using the following headings, which can be used when the final plans are produced:

Target	By whom	How to measure	How to achieve	Timetable
Actions agreed, listed in order of priority	Names of persons who will be responsible	How progress will be determined (see indicators below)	Resources required	Time-frame for start and completion

ii. Recommendations

You will discover that some important problems cannot be overcome or improvements achieved unless extra supplies, staff, or funds are provided, or unless assistance is obtained from outside. In such cases, recommendations are required. These should be:

Specifically addressed	to the person, official, department, organization, etc that is able to carry out the recommendation.
Reasonable	there is no point in asking for the impossible, such as 10 times more staff.
Essential	there should be no easy way for the user department to achieve the same results on their own.

iii. Longer-term objectives

You will also discover some problems which cannot be solved in one year. Maybe they need large amounts of money, longer preparation, or plenty of time to achieve. Or maybe it is simply not possible to do everything at once. In such cases, longer-term objectives are required which will be carried forward to the next year, or for implementation later on.

How to Measure the Goals

Each goal must be easily measured, so that you can see if it has been achieved or if progress is being made:

- You need a way of determining if you are moving towards your goal – this is called an *indicator*. There will always be several possible indicators for each goal, and more than one way of measuring them.
- You need to know where you are starting from, in other words, what the situation is now – this is called the *baseline data*. The data chosen must be relevant to the indicator.

Box 59 provides an example of different ways of measuring a goal using indicators and baseline data.

BOX 59: Example of How to Measure a Goal

Goal: Let's make the health facility a cleaner place

An indicator: Increase the number of equipment cleaning schedules implemented

One way of measuring this:

Calculation required: Percentage of available cleaning schedules implemented per month

$$= \frac{\text{Number of equipment cleaning schedules carried out}}{\text{Number of equipment cleaning schedules should have been done}} \times 100\ \%$$

Baseline data: All 10 departments have been given equipment cleaning schedules, but in July only two were found to be following them.

Therefore your baseline data is 20%.

Your aim is to improve this situation and increase this percentage.

Alternative way of measuring this:

Baseline data: In a study of the current situation you find that equipment cleaning schedules have only been written for four departments, and you plan to help them to start implementing these over the next three months. Additional equipment cleaning schedules need to be written for the remaining six departments, and you plan to write them all in the next three months.

Calculation required: Percentage of available cleaning schedules implemented

$$= \frac{\text{Number of equipment cleaning schedules carried out in a time period}}{\text{Number of equipment cleaning schedules should have been done in that time period}} \times 100\ \%$$

and percentage of equipment cleaning schedules developed

$$= \frac{\text{Number of equipment cleaning schedules written in a time period}}{\text{Number of equipment cleaning schedules planned to write in that time period}} \times 100\ \%$$

After three months you find that, in fact, you only managed:

- to get three out of the four departments to implement their equipment cleaning schedules, that is, 75% of your first target
- to write equipment cleaning schedules for three of the remaining departments, that is, 50% of your second target.

It is necessary to choose suitable indicators that are specific to all your annual goals. There are many possible indicators for user departments, safety sub-groups, and the health service as a whole, so staff and managers should decide upon the most important activities (or statistics and results) to measure. Examples of the types of indicators which can be used for equipment operation and safety are those describing:

- the existing situation
  - numbers of user-created faults and breakdowns
  - key accessories and consumables available and used
  - number of X-rays taken
  - numbers of equipment accidents/hazardous incidents
- improved performance
  - number of accident-free driver days
  - waiting time to receive results of laboratory tests
  - numbers of equipment operators attending training courses
  - increase in the number of user PPM interventions
- cost-benefits
  - number of patients seen per piece of equipment owned (for certain departments)
- efficiency and effectiveness
  - equipment availability per year (for different types of equipment).

The user departments, safety sub-groups, HTM Working Group, etc should meet to agree on a few suitable indicators that can be measured easily and quickly (if possible). Positive indicators are preferable as they motivate staff. Sometimes it is useful to use common indicators for different teams, groups, and staff, so that their progress can be compared.

Once the indicators have been agreed, they need regular measuring and charting. The relevant Health Management Team will need to decide:

- how records of these indicators will be kept, for example, in a register, with a form, or on a chart (*Section 8.2*)
- who will be responsible for keeping them
- how regularly the results will be summarized (each month, for example)
- what form of charts and displays you will use to display the monthly summarized results (so that it is easy for people to see how they are progressing).

The Annual Planning Process

In preparation for the annual action planning process, every user department, HTM Team, and safety sub-group should be involved in carrying out a review of:

- their performance and progress in the previous year
- their targets, plans, and needs for the coming year.

Department Heads or Chairs of Sub-Groups should involve their staff through regular meetings. Alternatively, if the team is large, they can nominate a small review group to prepare material for the action planning process. It is useful for each group to undertake an exercise which involves asking a selection of their 'clients' about the department's work. Thus a user department or sub-group will ask their clients what they think are the five most important problems regarding equipment operation and safety.

These clients should be a mixture of:

- staff in the health facility served by the user department or sub-group
- members of the Health Management Team at their facility or district
- the HTM Team
- patients.

If targets were prepared the previous year, they should be assessed to see how well they were implemented. This helps the user department or sub-group to identify and study the successes and problem areas for the team, and agree on which problems are priorities for tackling in the coming year.

The user department or sub-group should now have prepared sufficient information to take to the annual action planning seminar. If the seminar is a large one (in other words, it covers many health facilities, or many departments in a professional service), the Department Head or Chair of Sub-Group may have to nominate a couple of senior, knowledgeable and responsible members of staff to be their representatives at the meeting.

Depending on the number of people attending, the seminar may be a one- or two-day event, as described in *Box 60*. For each priority problem area identified, delegates at the seminar will consider and discuss the issues raised and come up with suggestions for solutions. For each solution or improvement, representatives write new targets, recommendations, and longer-term objectives, as well as indicators for the coming year (as described above).

The Annual Action Plan developed should state the agreed goals, who is responsible for achieving these goals, how they will be measured, the resources required, and the timescale by which they should be achieved. Once the plan is ready, it needs to be communicated to all staff.

BOX 60: Strategies for Running an Annual Action Planning Seminar in the Health Service

All managers (including Heads of Department and Chairs of Sub-Groups) ensure that their nominated representatives attend the annual action planning seminar.

Process	*Actions*
The first half day to one full day Participants are divided into working groups.	No more than 10 people in each group (with a mix of nurses, doctors, and other staff), in order to improve participation.
Each working group is given different departments or areas of the health service to consider.	They are given the material prepared by those departments (as described earlier in this Section).
Each working group analyzes their department/area under study.	They: ◆ review performance over the past year ◆ assess how well targets were implemented ◆ consider the lists of problems and solutions provided ◆ identify successes ◆ carefully examine problem areas.
Each working group prepares a list of: ◆ between five and 10 most important difficulties or problems for the department/area; ◆ their five to 10 targets, recommendations, and longer-term objectives.	They take large sheets of paper, with the name of the working group on top, and from their analysis they clearly list: ◆ the priority problems ◆ the targets, recommendations, and longer-term objectives.
The second half day to one full day The participants are brought together in a plenary session.	The purpose is to reach agreement on all proposed targets, recommendations, and longer-term objectives by the end of the seminar.
Each working group presents its findings in turn.	They display and briefly explain their list of problems, targets, recommendations, and longer-term objectives.
Participants from other groups provide input.	They put forward questions, advice, and suggestions for amendments.
The Chair oversees an end-result of the plenary session.	He or she ensures that agreement is reached for all goals.
After the seminar The Health Management Team reviews and finalizes the material from the seminar.	It ◆ reviews the materials generated at the seminar ◆ arranges them appropriately in order to produce the Annual Action Plan ◆ combines duplicated suggestions from different working groups ◆ writes any additional goals required ◆ makes revisions as necessary ◆ groups together all targets, recommendations, and longer-term objectives by team/department and subject.
The Health Management Team distributes the Annual Action Plan.	It ensures that the Annual Action Plan is reproduced quickly and distributed widely around the service, so that all staff have access to it.
Heads of Department/Chairs of Sub-Groups display their goals.	They ensure the goals are displayed in suitable locations, to ensure that staff are aware of them.

8.2 MONITORING PROGRESS WITH EQUIPMENT OPERATION AND SAFETY

Part of the management of equipment-related activities is the identification of problems and needs. All equipment-related activities should be monitored and evaluated, and the performance of equipment, staff, and departments should be supervised (this applies to all clinical, technical, and support departments). The results of such monitoring are useful for providing feedback to staff, Health Management Teams, and the Healthcare Technology Management Service.

Monitoring progress involves a number of different activities. The following monitoring activities are described in this Section:

- Monitoring progress against the annual goals (as set in *Section 8.1*).
- Monitoring progress in general, using statistics, incident reports and staff appraisal.

Monitoring Progress Against Annual Goals

Monitoring progress against goals is one of the best ways that staff, managers, and the health service provider can judge their work performance. Thus, it is necessary to follow up the plans and goals set, in order to ensure that they are put into practice. If this is not done and goals sit on a shelf gathering dust, then all the time spent planning will have been wasted.

Regular monitoring of progress against goals is essential throughout the year. This should be done using the measuring and charting methods introduced in *Section 8.1*. Displaying annual goals and progress towards them can be helpful to staff.

At the end of each year, it is essential to review and carefully analyze the results achieved on all the department goals, before starting to develop the Annual Action Plan for the following year. This step is the most important – to review results on a regular basis **with the people who are doing the work**.

This is the time to give praise for good progress, or to find out what might be causing shortcomings or problems, and then seek a solution. If solutions are quite impossible it may be necessary to change the plans. If common indicators were used for different departments, groups, and staff, it will be possible to compare their progress.

Once planning and financial systems are established, it is also possible to link annual planning with the process of setting the health facility's budget. For example, the fact that a department achieves its goals could play an important part in justifying the budget allocations they request from the Health Management Team (see *Guide 2* on planning and budgeting).

Monitoring Progress in General

Monitoring equipment-related activities can help to identify problems and needs. Thus the results of monitoring are useful for providing feedback to staff and senior management. By receiving feedback on their activities and answers to their queries, staff benefit from experience, and feel a part of the system as a whole. In this way staff:

- will be informed
- can obtain support
- will feel involved and empowered
- can be encouraged to take responsibility.

Regular monitoring of activities and services is also essential for improving the quality of healthcare. Management need facts so that they can plan effectively, and need to know how equipment-related activities are performed. Thus, it is important to have some method of collecting information, such as:

- the numbers of equipment not functioning
- consumable usage rates
- equipment shortages
- training deficiencies.

It may be possible to incorporate this data gathering into any existing Health Management Information System (see *Guide 1* on organizing HTM). This will enable 'evidence-based' planning to take place.

i. Statistics

Heads of Department/Chairs of Sub-Groups need to gather and compile statistics regularly. These will provide information on the progress of their team and its work performance in relation to equipment. They need to gather this data in order to:

- be better managers
- improve the running of their departments
- provide information to other people and bodies who need to know how their department is functioning.

Thus the Head of Department/Chair of Sub-Group needs to:

- analyze any incident report forms (see below), in order to extract information about problems with equipment, procedures, or staff
- use data from attendance records and departmental work records to compile statistics about equipment use and availability
- review the User Department Maintenance File to obtain feedback on progress with maintenance requests (*Section 7.4*)
- produce brief, informed and accurate written reports for the Health Management Team on pertinent equipment operation issues.

Statistics should be gathered regularly, for example on a monthly or quarterly basis. *Box 61* shows the sort of statistics that can be gathered. You will need to decide which are the most useful ones for your health service.

BOX 61: Examples of Statistics Which Can be Gathered Regularly

Type of statistics	Examples
Statistics obtained by counting numbers	The workload and performance of different types of equipment, such as: ◆ how many times the equipment is used ◆ how many times patients (or samples, etc) are sent away because the equipment was unavailable. The number of times work with equipment is cancelled due to different causes, such as: ◆ consumables not being available ◆ no money to buy cleaning materials ◆ low staffing levels ◆ equipment broken ◆ specific accessories unavailable. The number of adverse incidents due to different causes, such as: ◆ poor safety procedures ◆ no cleaning taking place ◆ no user PPM ◆ untrained staff.
Statistics obtained by doing calculations	Use of internal resources, for example the cost of running equipment.
Statistics obtained by doing analysis	This method is used for things that are more difficult to measure or assess and refers to the quality of performance and user satisfaction rather than quantities.

The compilation of these statistics is made easier if you design relevant and useful Statistics Forms to enter the data into. We suggest that you file these Statistics Forms in Statistics Folders, and that you use them for creating reports for management.

Staff such as the In-Service Training Coordinator and the Infection Control Officer, can also play a role in monitoring equipment skills and issues across the health facility as a whole. This helps them to identify where problems are occurring which they could follow up with in-service training or other measures (*Section 3.5*). In addition, Department Heads should regularly report to the Purchasing and Supplies Officer regarding the quality of materials purchased (*Section 6.3*).

ii. Incident reports

Each health facility should have some formal method of reporting problems, accidents, and adverse incidents in all equipment-related safety areas (*Section 5*). Some type of Accident Record Book or Incident Form can be used so that staff can report whenever any type of incident occurs. These should be submitted to the HTM Working Group (or its safety sub-groups).

The HTMWG should monitor the incidents, and discuss the most appropriate solution in each case. It will need to report to the Health Management Team, and address the problems using a combination of strategies such as:

- changing operating procedures
- introducing further safety measures
- training staff
- penalizing or rewarding the behaviour of staff
- redistributing equipment until such time as the necessary human skills are in place.

iii. Staff appraisal

Another form of reporting and feedback is staff appraisal by managers. Informal methods include activities such as sharing information, support, and supervision. A formal method is a staff appraisal process which monitors the work performance of individuals, and identifies areas for goal-setting for both the individual and their manager. The purpose of the interaction is to:

- guide the individual in their job
- evaluate their performance
- take corrective action to improve job performance
- agree required training, development, and other strategies by the employer, which would assist the employee to become more effective in their job.

Regular monitoring of equipment-related activities will also mean that instances of good or bad work performance, in relation to equipment, can be incorporated into the staff appraisal system.

For a fuller description of staff appraisal strategies, see *Guide 5* on maintenance management.

Box 62 contains a summary of the issues covered in this Section.

BOX 62: Summary of Procedures in Section 8 on Action Planning and Reviewing Progress

Setting Goals	**Health Service Provider**	◆ ensures there is an annual action planning process whether across 'horizontal' levels (within a health facility or district), or within a 'vertical' programme (for example, for the laboratory service as a whole)
	Heads of Department, HTM Teams and HTM Working Groups	◆ set their targets, recommendations, and longer-term objectives each year, in order to improve their performance (after reviewing the previous year's performance) ◆ develop suitable measurement indicators for these goals and gather baseline data ◆ participate in the annual action planning seminar
Monitoring Progress	**Health Service Provider**	◆ ensures the Health Management Information System is developed to include factors which measure progress with equipment
	Heads of Department and Safety Sub-Groups	◆ ensure progress against annual goals is monitored, displayed, and used to provide feedback to department/group staff, as well as to develop improved goals for the following year ◆ decide on suitable equipment-related statistics which are informative and easy to gather ◆ use incident reports, attendance figures, and departmental records to gather and compile statistics, enter them on Statistics Forms, and file them in Statistics Folders ◆ use the statistics when reporting to management ◆ monitor staff's good and bad performance in relation to equipment, and feed it into the staff appraisal system
	Health Management Teams	◆ ensure that progress against any goals (annual or regular) is used to prompt the correct response, such as training, better budgets, different suppliers, career progression, etc ◆ analyze the information in the Accident Record Book or Incident Forms to develop a combination of strategies which will address any equipment-related problems

ANNEX 1: GLOSSARY

Acceptance process:	Activities undertaken when equipment arrives at an health facility, at the end of which the equipment will be operational and officially belong to the facility, such as receipt, unpacking, installing, commissioning, initial training, entering into stores and onto records, payment.
Administrative level:	See decentralized authorities.
Central level:	Highest authority of your health service provider, such as Ministry of Health or Board.
Cleaning:	Removal of visible dirt and reduction of the number of some infectious micro-organisms.
Commissioning:	A series of tests and adjustments performed to check whether, and ensure that, new equipment is functioning correctly and safely before being used.
Communication equipment:	Any equipment that is used for sending or receiving information, such as telephones, two-way radios, nurse-call systems, paging systems.
Decentralized authorities:	Local units of an organization which have had authority transferred to them from the central level of the organization. For example, district, regional, provincial, or diocesan health authority.
Decommission:	Take out of service; dismantle and make safe; board. The process of condemning or writing off equipment and disposing of it.
Depreciation:	The amount by which the monetary value of an asset is reduced over a period of time due to its everyday use ('wear and tear') or due to the fact that it could not be sold second hand for as much as it originally cost; the asset is said to depreciate in value.
Decontamination:	The process of making items safe for handling and reuse.
Dioxins:	A pollutant that is emitted from burning/incineration of healthcare waste which is hazardous to people and the environment.
Disinfection:	The reduction of a population of harmful micro-organisms on any surface without achieving sterility (in other words, not all bacterial spores present are destroyed).
Donor:	See external support agency.
Earth:	Provide an electrical connection from electrical devices to the ground, which is regarded as having zero electrical potential.
Electrical safety:	The guidelines, practices and procedures to ensure that people are protected from the fatal electrical risks posed by electrical supplies, installations, and equipment.
Energy sources:	A source of energy or power, such as generating sets, solar panels or transformers.
Equipment-related supplies:	Items which are essential for equipment use, such as consumables, accessories, spare parts, and maintenance materials used with equipment.
Equipment users:	All staff involved in use of equipment, such as clinical staff (eg. doctors and nurses), paramedical staff (such as radiographers and physiotherapists) and support services' staff (such as laundry and kitchen workers).

External support agency:	A body responsible for providing money, equipment, or technical support to developing countries on various terms, such as international donors, technical agencies of foreign governments, non-governmental agencies, private institutions, financial institutions, faith organizations.
External support agency staff:	People working for external support agencies that health workers come into contact with, such as a country representative, desk officer, consultant, coordinating agency, director.
Fabric of the building:	Items which are part of the integral structure or framework of a building, such as doors, windows or roofs.
Facility:	See health facility.
Fire fighting equipment:	Equipment used to put out fires, such as fire blankets, buckets, extinguishers, hose and sprinkler systems.
Fixtures built into the building:	Items which are not part of the integral structure of a building but are installed into the fabric of the building, such as ceiling-mounted operating theatre lights, scrub-up sinks and fume cupboards.
Furans:	A pollutant that is emitted from burning/incineration of healthcare waste which is hazardous to people and the environment.
Head of section:	Departmental manager, such as head of department, group leader, officer in-charge, senior operator.
Health facility:	Buildings where healthcare is delivered, ranging from small units (clinics, health centres), and small hospitals (rural, district, diocesan), to large hospitals (regional, referral).
Health facility furniture:	Furniture with a specific clinical use in health facilities, such as beds, cots, trolleys, infusion stands.
Health management team:	Health management body, such as facility management committee, district/regional/diocesan/central health management team, Board.
Health service provider:	A provider of health services, such as Ministry of Health or Defence, non-governmental organization, private institution, employer organization or corporation (for example, mine), faith organization.
Health system:	Comprises all organizations, institutions, and resources devoted to health actions (defined as any effort, in personal or public health services or through intersectoral action), whose primary purpose is to improve people's health. (Source: WHO).
HTM Manager:	Head of the HTM Team; ranging from a general member of health staff with some management skills in the smallest HTM Teams, to an engineering manager in the highest level of HTM Team.
HTMS:	Healthcare technology management service made up of a network of HTM Teams and HTM Working Groups.
HTM Team:	A body responsible for the management of equipment, such as, equipment management team, maintenance management team, physical assets management team; Part of the HTM Service.
HTM Working Group:	A working group, or standing committee responsible for making decisions on healthcare technology management issues; part of the HTM Service.

Infection control:	Internationally this term means control of a wide range of practices, processes and procedures in the clinical work of the health facility as a whole; in this Guide the discussion only covers the equipment issues which contribute to infection control.
Installation:	The process of fixing equipment into place; can range from building equipment into the fabric of a room to simply plugging it into an electrical socket.
Inventory:	A systematic listing of stock (or assets) held. An *annual inventory* is prepared at the end of each year following a physical inspection and count of all items owned by an organization. The list gives details, such as location, reference number, description, condition, cost, and the date the inventory was taken.
Laundry and kitchen equipment:	Equipment required for kitchen or laundry activities, such as cookers, cold rooms, washing machines, hydro-extractors, roller-ironers.
Life-cycle cost:	The recurrent cost required to keep equipment going throughout its life (for example, fuel, consumables, maintenance, training, disposal).
Lifetime:	Lifespan, life expectancy. For equipment, the likely length of time that an item will work effectively, dependent on the type of technology and parts used in its manufacture.
Maintainers:	See maintenance staff.
Maintenance staff:	Staff responsible for maintenance of equipment, such as craftspeople, artisans, technicians, technologists, engineers.
Manager:	Any staff involved in the management of equipment-related activities. This could include administrator, nurse-in-charge, medical superintendent, chief executive, director, health secretary, medical practitioner, maintenance manager, policy-maker.
Medical electrical safety:	The guidelines, practices and procedures to ensure that people are protected from the fatal electrical risks posed by medical equipment; stricter requirements than for electrical safety, as medical equipment comes into direct contact with patients' bodies.
Medical equipment:	Equipment used for medical purposes, including X-ray units, diathermy units, suction pumps, foetal doppler, scales, autoclaves, infant incubators, centrifuges.
Office equipment:	Equipment used in an office, such as computers, photocopiers, calculators, record systems.
Office furniture:	Furniture used in an office, such as desks, chairs or filing cabinets.
Operative:	A skilled worker; a skilled equipment user.
Pending:	Awaiting an outcome; waiting for something to take place.
Plant, general:	Machinery such as boilers, lifts, air-conditioners, water pumps or compressors.
PPM schedule:	Planned preventive maintenance protocol, or list of activities, describing the work to be carried out on equipment at specified regular intervals, in order to prevent breakdowns and ensure the equipment is operational and safe.

PPM timetable:	A calendar showing the days when PPM tasks should be performed according to the PPM schedules, in order to ensure that they occur at the required frequency.
Quality control:	A system of maintaining standards; testing a sample against specifications.
Service supply installations:	Supply installations such as electrical installations, water and sewage pipelines, gas supplies.
Standard:	A required or agreed level of quality or attainment set by a recognized authority, used as a measure, norm, or model for all aspects of health services and healthcare technology.
Standardization:	Rationalization, normalization, and harmonization. In other words, reducing the range of makes and models of equipment available in stock, by purchasing particular or named makes and models.
Sterilization:	The destruction or removal of all living organisms on any surface to produce an absolute – a sterile object (an item cannot be 'nearly' sterile).
Stock:	In stores, this is the goods held by an organization for its own use. The 'equipment stock' is all the equipment assets owned by an organization.
Supplier:	Someone who provides equipment, such as manufacturer, manufacturer's representative, wholesaler, salesman.
Support staff:	Additional types of staff in the health service besides medical personnel such as planner, finance officer, procurement officer, stores controller, human resource officer.
Training equipment:	Equipment required when running training courses, such as overhead and slide projectors, video and tape recorders.
Users:	See equipment users.
Vehicles:	Any conveyance used for transporting people, goods, or supplies in the health service, such as ambulances, cold-chain motorbikes, mobile workshops, lorries, buses.
Walking aids:	Items used to aid mobility, such as wheelchairs, zimmer frames, crutches.
Waste treatment plant:	Any plant used to treat waste, including incinerators, septic tanks or biogas units.
Working group:	A group of people set up to be responsible for a particular subject area, such as a standing committee, select committee, or sub-committee.
Workshop equipment:	Equipment used in a workshop, such as hand tools, bench tools, test instruments.
Your organization:	See health service provider.

BOX 63: WHO's Definition of the Technology Management Hierarchy

Equipment support:	undertaking maintenance and repair.
Equipment management:	using the equipment database (inventory and maintenance history) to help you make decisions for improving equipment support.
Asset management:	including cost and utilization information (life-cycle cost analysis) in the equipment database to help you make decisions on replacement and acquisition.
Technology assessment:	reviewing past, current, and future technologies to determine their efficacy and effectiveness, and to help you make decisions for capital planning and acquisition.
Technology management:	using: equipment equipment support equipment management asset management technology assessment to manage technology in health care from conception to retirement.

Source: Department of Health Service Provision, World Health Organization, 2000

ANNEX 2: REFERENCE MATERIALS AND CONTACTS

This Annex is in two parts, and provides information about:

Part i. Books, guidelines, databases, and websites

Part ii. Organizations, sources of publications in part i, resource and information centres.

i. Books, Guidelines, Databases, and Websites

The following books, guidelines, videos, databases, and websites are listed in subject categories according to the topics found in Sections of this Guide. For each publication, a brief description of the content and the main source(s) are included. Contact details for the source organizations are included in *Part ii*. Readers should note that many of the publications are available at low cost. In some countries it may also be possible to obtain these publications from local bookstores, as publishers and distributors increase efforts to ensure wider availability. Published prices may be flexible depending on the order size, discounts available and distribution method.

Tip

- Many books and documents cover a variety of topics that appear in several Sections of this Guide. The first time they appear in this list they are described in full. For each subsequent entry only the basic details are provided.

Healthcare Technology Management Framework Issues

This material covers issues in *Sections 1 and 2*, such as healthcare technology management definitions, policy, regulations, guidance, and services. It is listed alphabetically by title. Further detailed information on this topic is provided in *Guide 1*.

Developing healthcare technology policy

Health care technology management No.1: Health care technology policy framework
Kwankam Y, Heimann P, El-Nageh M, and M Belhocine (2001). WHO Regional Publications, Eastern Mediterranean Series 24. ISBN: 92 9021 280 2
This booklet is the first in a series of four titles. It introduces the ideas of and behind health care technology management, defines terms relating to and sets objectives for health care technology management policy. It examines what should go in to such a policy, and the national policy framework and organization. Capacity-building and human resources issues are considered, as well as economic and financial implications. Attention is also given to legislation, safety issues, cooperation nationally and between countries, implementation, monitoring, and evaluation. See *Guide 1* for information on the three further titles in this Series covering regional strategies, policy formulation and implementation, and country situation analysis.
Available from: WHO

Interregional meeting on the maintenance and repair of health care equipment: Nicosia, Cyprus, 24-28 November 1986
WHO (1987). WHO document WHO/SHS/NHP/87.5
This document provides a comprehensive discussion of the problem of non-functioning equipment and of proposed solutions. The major policies, recommendations, and strategies proposed by the conference on the issue of maintenance and repair of health care equipment are presented. It includes four Working Papers which cover in detail: maintenance and management of equipment, the proposed health care technical service, manpower development, and training.
Available from: WHO

Management of equipment
DHSS, UK (1982). Health Equipment Information No. 98
The aim of this booklet is to recommend a system of equipment management that, if fully implemented, would ensure that all equipment used in the British National Health Service was suitable for its purpose, was maintained in a safe and reliable condition, and was understood by its users. Its recommendations and procedures are structured into sections on equipment selection, acceptance procedures, training, servicing (maintenance, repair, and modification), and replacement policy. It also covers the management of inventories, equipment on loan, servicing, long-term commercial contracts, and infection hazards.
Available from: Her Majesty's Stationery Office (HMSO).

Medical equipment in sub-saharan Africa: A framework for policy formulation
Bloom, G and C Temple-Bird. (1988). IDS Research Report Rr19, and WHO publication WHO/SHS/NHP/90.7. ISBN: 0 903354 79 9
This book provides a good overview of the situation of medical equipment in Africa. Its approach to the analysis is to unpackage medical equipment technology into its component activities, such as planning, allocating resources, procurement, commissioning, operation, maintenance, training, etc. It provides good general policy formulation strategies to address the problems discussed.
Available from: WHO

Practical steps for developing health care technology policy: A manual for policy-makers and health service managers in developing countries
Temple-Bird, C (2000). Institute of Development Studies, University of Sussex, UK.
ISBN: 1 85864 291 4
This book is a practical step-by-step guide for developing health care technology policy. It can be used by health service providers, regional and district health authorities, health facility managers, and external support agencies. It describes a process for developing health care technology policy which is collaborative, participatory, iterative, and involves community stakeholders. Guidance is provided on underlying management concepts, undertaking a situation analysis, running a ideas workshop, formulating policy, developing an implementation plan and procedures manual, as well as the resources required to complete these tasks.
Available from: Ziken International Consultants Ltd

See *Guide 1* for further resources on, and examples of, developing healthcare technology policy.

Regulating relationships with external support agencies that provide equipment

Guidelines for health care equipment donations
WHO (1997). WHO document WHO/ARA/97.3
This document presents guidelines that aim to improve the quality of equipment donations, not to hinder them. They are not an international regulation, but intended to serve as a basis for national or institutional guidelines, to be reviewed, adapted and implemented by governments and organizations dealing with health care equipment donations. They provide detailed guidance and checklists for both the potential donor and recipient. The guidelines are based on extensive field experience and consultations with many experts internationally. They also merge together several earlier documents, including the one listed below.
Available from: WHO

Guidelines on medical equipment donations
Churches' Action for Health (1994). World Council of Churches' publication
This paper is a guide for those accepting and making donations, and is also useful for those planning to buy equipment. It clearly lays out in point form the responsibilities of the recipient and the responsibilities of the donor.
Available from: WCC

Understanding healthcare technology management

Health and disease in developing countries
Lankinen, K et al (eds) (1994). MacMillan Press. ISBN: 0 333 58900 9
This comprehensive book covers health and disease from the wider perspective of development in general. It is of particular interest to medical and other professionals working in developing countries or for international cooperation agencies. It is a valuable resource for district medical officers, and students taking courses in public health and tropical medicine. Besides sections on: society, economy and health; infectious diseases; and challenges for health care, there is a section on health services to meet the challenges. This section contains chapters of particular relevance to equipment, such as:

- **Medical equipment management.** Temple-Bird, C, Chapter 52
- **Essential laboratory services.** Willcox, W, Chapter 51

Available from: major internet bookshops

Health in the commonwealth: Challenges and solutions 1998/1999
Commonwealth Secretariat (1999). Kensington Publications Ltd, London
This digest of articles covers a wide range of health issues, such as: resources and planning; equity of access; medical technology and equipment; health promotion; mother and child health; community health; communicable and non-communicable diseases, etc. The content is aimed at policy-makers and planners. There is a range of technology articles on equipment, telemedicine, hospital design, sanitation, vector control, water and air supplies, including:

- **Managing healthcare technology.** Temple-Bird C, pp 57-60

Available from: Commonwealth Secretariat

International seminar for hospital technicians/engineers: February 1998, Moshi, Tanzania
Clauss J (ed) (1998). FAKT
This document reports the results of intensive work by 38 national and international experts brought together from faith, public, and private agencies to strengthen equipment management measures in the health sector. It includes papers, with country examples, on healthcare technology management, financing maintenance, workshops and tool requirements, cash control, equipment standardization, networking, structures of health care technical services, training, communication technologies, modification of medical and hospital equipment, and energy supply and photovoltaics.
Available from: FAKT

International workshop on healthcare technology management: 2-6 October 2000, Catholic Pastoral Centre, Bamenda, Cameroon
Clauss, J (compiler) (2000). FAKT
This document reports the results of intensive work by 35 national and international experts involved in setting up and operating systems for the sustainable management of healthcare technology. It includes papers, with country examples, on healthcare technology management, the role of stakeholders, public/private partnerships for providing HTM, cost-effective maintenance and repair services, and acquisition and utilisation of healthcare technology.
Available from: FAKT

Medical equipment in Botswana: A framework for management development
Temple-Bird C L, Mhiti R, and G H Bloom (1995), WHO publication WHO/SHS/NHP/95.1
This book reports on the results of a study of the healthcare technology sector in Botswana, and the lessons learnt are of relevance to many other countries. The study was undertaken by unpackaging the sector into its component activities, such as planning, allocating resources, procurement, commissioning, operation, maintenance, training, etc. In this way the book provides good general healthcare technology management strategies to address the problems discussed. This book discusses many of the common operation and safety problems found in health facilities.

Available from: WHO

Physical assets management and maintenance in district health management
Halbwachs H (2000). GTZ document
This paper provides practical guidance to health workers involved in district health systems concerning health technology – one of the critical areas in managing health service delivery at district level. It presents the physical assets management approach, and elaborates on key strategies for maintenance, financing, quality control, monitoring indicators, and a basic paper-based maintenance information system. It also has an example of a maintenance job card.
Available from: GTZ

The effective management of medical equipment in developing countries: A series of five papers
Bastiaan Remmelzwaal (1997). FAKT, Project Number 390
This document is aimed at the health workers, administrators, maintainers, and overseas aid workers who are involved in medical equipment management in developing countries. It examines the variation in performance with management of medical equipment in different countries, with the objective of identifying successful approaches. It addresses some of the managerial issues related to the conservation of equipment; allocation of human, financial and material resources; and acquisition and use. It looks at the structure for the HTM Service, and the HTM cycle.
Available from: FAKT

See *Guide 1* for more information on further relevant issues, such as health service definitions, the place of HTM in health systems, regulations, and standards.

Developing Skills, Managing Change, and Monitoring Progress

This material covers issues in *Section 2.1* on managing change, *Section 3.1* on accountability, *Section 3.5* on training, and *Section 8* on target-setting and monitoring progress. It is listed alphabetically by title.

A book for midwives
Klein, S (1996). Hesperian Foundation. ISBN: 0 942364 23 6
This book provides practical information on antenatal care, labour, birth and post-partum care. It also includes a section on making teaching materials and low-cost equipment.
Available from: TALC

Diagnosis and treatment: A training manual for primary health care workers
Birrell, K and G Birrell (2000). VSO. ISBN: 0 333 72211 6
This is a practical training manual for all first line PHC workers. It gives guidance on how to diagnose and treat the most common illnesses, how to prescribe rationally and deliver good patient care with scarce resources. It is based on a series of training courses developed by VSO, national doctors and health workers. It can be used as a self-study guide and as a reference manual.
Available from: TALC

District health care: Challenges for planning, organization and evaluation in developing countries (2^{nd} edition)
Amonoo-Larston R, Ebrahim G, Lovel H, and J Rankeen (1996). MacMillan. ISBN: 0 333 57349 8
This book contains practical support and advice intended for those in the planning, management and evaluation of health services at district level. It covers a wide range of topics based on country experience, including: staff motivation, teamwork, developing management skills, managing change, managing conflicts, and staff development; managing finances; monitoring and evaluation; as well as district health needs, plans, organization and management.
Available from: TALC

Healthcare technology: Training skills for hospital technicians and engineers
FAKT (1999). FAKT Technical Library Data Sheet
This paper discusses the major objectives of training both on- and off-the-job. It then provides practical guidance on how to undertake on-the-job training effectively by using the PESOS procedures (prepare, explain, show, observe, supervise). It explains each step in detail. Although written for maintenance staff, its advice is just as useful for any other types of staff.
Available from: FAKT

Hospital technology: Communication – a vital skill for successful healthcare technical service management
FAKT (1999). FAKT Technical Library Data Sheet
This paper discusses the importance of communication for both working in a team and working in an organization/network. It provides advice on how to communicate effectively, its importance, the barriers that exist, how to promote effective communication, the role of the head of department, methods to use, and related reading. Although written for maintenance staff, its advice is just as useful for any other types of staff.
Available from: FAKT

How to make and use visual aids
Harford, N and N Baird (1997). VSO. ISBN: 043592317X
This booklet describes a number of useful and practical methods for making visual aids quickly and easily, using low cost materials.
Available from: TALC, VSO

Management support for primary health care: A practical guide to management for health centres and local projects
Johnstone P, and J Ranken, (1994). FSG Communications Ltd, Cambridge, UK. ISBN: 1 87118 02 4
This practical user-friendly book gives support and guidance to leaders in health centres and other local projects to help stimulate and maintain primary health care (PHC) in their surrounding communities. Aid workers, and others unfamiliar with PHC and basic management techniques may also benefit. Includes sections which will assist with staff motivation, such as teamwork and team effectiveness; managing oneself, others and tasks; and managing change, as well as sections on planning and monitoring progress.
Available from: TALC

Medical administration for frontline doctors: A practical guide to the management of district-level hospitals in the public service or in the private sector (2nd edition)
Pearson C (1990). FSG Communications Ltd, Cambridge, UK. ISBN: 1 871188 03 2
This book provides information for doctors who combine wide clinical responsibilities with administration and support for primary health care services. It covers a wide range of topics, with country examples, including: management structures; infrastructure and maintenance; buildings, support services, and equipment; hospital supplies; training; outreach programmes; and wider responsibilities in the district and above. It includes advice on many safety topics such as cleaning procedures, linen handling, earthing, lightning protection, and fire prevention.
Available from: TALC

On being in charge: A guide to management in primary health care (2nd edition)
McMahon R, Barton E, and M Piot (1992). ISBN: 9241544260
This practical guide aims to improve the managerial skills of middle level health workers. The text is reinforced with practical examples, questionnaires and illustrations that help relate the information to health workers' own experiences. Topics include identifying health problems, assigning priorities to their solution, planning and implementing programmes, and evaluating results. Also serves both as a training and reference guide, covering all aspects of primary health care management including equipment and drugs.
Available from: WHO

Physical assets management and maintenance in district health management
Halbwachs H (2000). GTZ document

Setting up community health programmes: A practical manual for use in developing countries (2nd edition)
Lankester, T. (2000). ISBN: 0333679334
A practical 'how-to' manual designed for a wide range of health workers working with community health programmes. With revised and updated material on planning, management and evaluation of health programmes ranging from choosing and training a team through the setting up of clinics and advising village health workers. Includes new information on community-based approaches to safe motherhood, immunisation, malaria and TB, based on WHO guidelines.
Available from: TALC

Training health personnel to operate health-care equipment: How to plan, prepare and conduct user training – A guide for planners and implementors
Halbwachs H, and R Werlein, (1993). GTZ, Eschborn
The aim of this book is to ensure that users are in a position to operate equipment and plant without causing failure or malfunction. Part one addresses the planner/administrator developing user courses and gives information about methods, course organization, finances, etc. Part two discusses interesting issues for the implementers i.e. how to design a course, teaching methods and teaching aids, conducting a course, etc. This practical guide provides sample checklists, questionnaires, worksheets, tests, certificates, etc.
Available from: GTZ

Transfer of learning: A guide for strengthening the performance of health care workers
Intrah/PRIME II/JHPIEGO (March 2002)
This book is for health care workers involved in training and learning interventions and enables them to transfer their newly acquired knowledge and skills to their jobs, resulting in a higher level of performance and sustained improvement in the quality of services at their facilities.
Available from: free online at http://www.prime2.org/prime2/section/70.html

Efficient Use of Equipment

This material covers issues in *Section 3.3* such as equipment utilization, building design, and cost-effectiveness. It is listed alphabetically by title.

Approaches to planning and design of health care facilities in developing areas: Vol 3
Kleczkowski B, and R Pibouleau (eds) (1979). WHO Offset Publication No 45. ISBN: 92 4 170045 9
This volume addresses the issue of hospital design in terms of the building structure itself. It discusses inpatient areas, outpatient department, surgery, radiology department, equipping and mobile facilities. Equipment issues are covered in the section on equipping by Cooper-Poole, and radiology by Palmer.
Available from: WHO

Approaches to planning and design of health care facilities in developing areas: Vol 4
Kleczkowski B, and R Pibouleau (eds) (1983). WHO Offset Publication No 72. ISBN: 924 170072 6
This volume addresses the issue of hospital design in terms of the building structure itself. The design of a hospital is discussed in the context of geographic and demographic data, utilisation, costs and available resources. It is a useful resource for planners, architects and administrators. This volume covers small health care facilities, laboratory facilities, transport systems, local construction materials, health service management, training, commissioning, and engineering and maintenance services. Medical equipment is covered in the sections on commissioning by Steele, and on engineering and maintenance services by Mehta.
Available from: WHO

Design for medical buildings (4th edition)
Mein P, and T Jorgnesen (1988). University of Nairobi, Housing Research and Development Unit; African Medical and Research Foundation
Construction guidelines for medical buildings with special reference to appropriate designs for developing and tropical countries. Relationship diagrams, flow of patients, linkages between different units and services.
Available from: WHO, AMREF

District health facilities: Guidelines for development and operation
WHO Regional Publications: Western Pacific Series No 22 (1998). ISBN: 92 9061 121 9
This revised and expanded book presents detailed, richly illustrated guidelines for the planning and design of district hospitals including the efficient utilization of space and easy movement of people, equipment, and supplies. It also provides extensive information on the selection and maintenance of medical and laboratory equipment. Additional material covers sanitation and waste management, emergencies and disasters, the procurement of essential drugs, and safety testing and calibration instruments.
Available from: WHO

Medical equipment in developing countries: Two neglected issues – planning and financing
Berg H (1992). WHO Document WHO/SHS/CC/92.2
This document is aimed primarily at health planners. It describes planning problems, and outlines the procedures that should occur before equipment is purchased in order to ensure that the implications of ownership are known. It looks at the recurrent cost implications of equipment, and presents a method for unit costing and shows the consequences through examples.
Available from: WHO

See *Guide 2* on planning and budgeting, for more material on planning and designing health facilities and their equipment, as well as the life-cycle costs of equipment.

Operation, Care, and User Maintenance

This material covers issues in *Section 3.2* on equipment handling, *Section 4* on operation, care and cleaning of equipment, and *Section 7.2* on user maintenance. It is listed alphabetically by title.

Anaesthesia at the district hospital (2nd edition)
Dobson MB (1988). Nuffield Department of Anaesthetics, John Radcliffe Hospital, Oxford, UK. ISBN: 92 4 154527 5
A practical manual designed to help medical officers in small hospitals acquire competence in the use of essential techniques for inducing anaesthesia for both elective surgery and emergency care of the critically ill. Addressed to doctors having at least one year of postgraduate clinical experience, the book concentrates on a selection of basic techniques, procedures, and equipment capable of producing good anaesthesia despite the limited resources usually found in small hospitals. The manual was prepared in collaboration with the World Federation of Societies of Anaesthesiologists.
Available from: WHO

Anaesthetic equipment: Physical principles and maintenance (2nd Edition)
Ward C (1985). Baillière Tindall. ISBN: 0 7020 1008 1
This book provides a comprehensive and practical coverage of the wide range of equipment used in anaesthetic practice. It allows the reader to understand the mode of operation and maintenance of equipment, and how to cope with common causes of mechanical failure. Suitable for trainee and established anaesthetists, intensive care specialists, anaesthetic nurses, and theatre and maintenance technicians.
Available from: book suppliers

A pocket book for safer IV therapy (drugs, giving sets and infusion pumps)
M Pickstone (ed.) (1999). ISBN: 094 867232 3
This pocket book has been written to help clinical staff deliver safe IV therapy. It covers the calculation of drug dose, the make-up of drug solutions and the selection of infusion devices and associated equipment.
Available from: major internet bookshops

Basics of light microscopy (training video)
Olympus Microscopes. Code 30892
This video is both suitable for beginners or for those wishing to refresh existing knowledge. It provides information about various objectives, proper illumination, magnification scales, and imaging quality. Based on combined technical know-how and experience, this video is an easily understandable and interesting teaching tool for microscopists and anyone who would like to become one.
Available from: Olympus Microscopes

Blood pressure measuring equipment: Principles, use, maintenance, repair
Huys J (1992). TOOL, Amsterdam. ISBN: 90 70857 26 X
This book is for medical technicians in rural hospital and clinics. It covers the principles of common BP equipment, how to use BP measuring equipment, advice about its use, and instructions for maintenance and repair.
Available from: Medical and Health Library, free at http://media.payson.tulane.edu:8086/cgi-bin/gw?e=t1c11copyrigh-mhl-1-T.1.B.21.1-500-50-00f&q=&l=e&g=00

Care and safe use of hospital equipment
Skeet M and Fear M. (1995). VSO. ISBN: 0 9509050 5 4
This book provides practical advice for health service staff about proper management of the type of equipment found in district hospitals or health centres. It includes guidelines on preventive maintenance and servicing, simple user instructions, checklists for correct and safe use of equipment, and basic technical information for training of first-line maintenance staff. The information is easily accessible to those without a technical background. It includes advice on many topics relating to safety and testing such as checking power supplies, gas cylinders, disinfection and sterilization, as well as a basic tool list.
Available from: TALC, VSO

District laboratory practice in tropical countries (part 1)
Cheesbrough M (1998). Tropical Health Technology. ISBN:0 9507434 4 5
A valuable resource aimed at those responsible for the organization and management of district laboratory services but can also be adapted for use by health centres. Covers selection and procurement of laboratory equipment and supplies, as well as their use, care, and maintenance. It covers parasitological tests, clinical tests and training of personnel, as well as all types of safety issues for laboratories.
Available from: TALC, THT

District laboratory practice in tropical countries (part 2)
Cheesbrough M (2000) Tropical Health Technology. ISBN:0 9507434 5 3
Covers microbiological, haematological and blood transfusion techniques required at district level.
Available from: TALC, THT

Emergency Care Research Institute (ECRI, USA) products
This organization produces a variety of products on healthcare technology. They are available as hard copy and as software regularly renewed by subscription, with special rates for developing countries. They cover various issues, such as:

- **Inspection and preventive maintenance system**
- **Health devices alerts database** (international database of medical hazards, problems and recalls of equipment)
- **Health technology monitor newsletter**
- **Healthcare product comparison system**
- **Health devices source book**
- **Health devices system**

Available from: ECRI

General surgery at the district hospital
Cook J, Sabkaran B, and A Wasunna (eds) (1998). Dept. of Surgery, Eastern General Hospital, Edinburgh, Scotland. ISBN: 92 4 154235 7
A richly illustrated guide to general surgical procedures suitable for use in small hospitals that are subject to constraints on personnel, equipment, and drugs. The book presents an overview of basic principles, and detailed information on simple but standard surgical techniques for the face and neck, chest, abdomen, gastrointestinal tract, urogenital system, and paediatric surgery. Lists of essential surgical instruments, equipment and supplies are included.
Available from: WHO

How to look after a refrigerator
Elford J, (1992). Healthlink (formerly AHRTAG). ISBN: 0 907320 07 4
Provides practical guidelines for care and maintenance of a range of kerosene, gas, electric and solar refrigerators.
Available from: Healthlink Worldwide

Instrumentation for the operating room: A photographic manual (5th edition)
Brooks Tighe S (1999). ISBN 0323003508
Colour photographic reference manual illustrating in detail a range of instruments for major surgical procedures: endoscopic, neurosurgery, ophthalmic, orthopaedic, and oral, maxilla and facial surgery. Also includes a section describing the care and handling of instruments from cleaning to sterilization, inspection and testing.
Available from: major internet bookshops

La maintenance dans les systemes de santé/ Maintenance for health systems: 4th GTZ Workshop, Dakar, Senegal, September 1993
Halbwachs H, and R Schmitt (eds) (1994). GTZ
This document reports the results of intensive work by 67 national and international experts brought together from health services and support agencies to strengthen equipment maintenance measures in the health sector. It includes papers, with country examples, on the benefits of maintenance, the place of maintenance in the district health system, maintenance management and organization, energy management, photovoltaic systems, networking and computers, and training. This document has sections written in both French and English.
Available from: GTZ

Maintenance and repair of laboratory, diagnostic imaging, and hospital equipment
WHO (1994). ISBN: 92 4 154463 5
A practical manual for maintenance and repair of basic laboratory and diagnostic equipment, as well as anaesthetic machines, operation room equipment, and ultrasound and X-ray generators. Intended for use in settings that do not have technicians or engineers with specialist expertise. The manual uses line drawings and numerous checklists for inspection and cleaning, good working practices, routine operation and maintenance. It is also useful as a training aid. It includes advice on many topics relating to safety and testing such as disinfection, gas cylinders, laboratory hazards, radiation hazards, and hazards from other types of equipment.
Available from: WHO

Manual of darkroom technique
Palmer P (1985). WHO Basic Radiological System: ISBN: 92 4 154178 4
This manual is intended for use by operators working with the WHO Basic Radiological System (WHO-BRS), but the principles and methods described can be used in the processing of X-ray films taken with any type of X-ray equipment. The manual provides a step-by-step illustrated guide to darkroom technique, and outlines all the basic requirements for the storage and handling of X-ray films and processing equipment. It contains sections covering the maintenance of the processing tank (non-electric) and the cassettes and screens. This is in the form of schedules of cleaning to be undertaken daily, weekly and monthly.
Available from: WHO

Medical supplies and equipment for primary health care: A practical resource for procurement and management.
Kaur M, and S Hall (2001). ECHO International Health Services Ltd. ISBN: 0 9541799 0 0
This book is intended for health workers and those responsible for the procurement and management of medical supplies and equipment at primary healthcare level. It covers guiding principles for selecting supplies and equipment, provides guidelines for ordering and procurement, storage and stock control, care and maintenance, and considers decontamination and safe disposal of medical waste. The manual also discusses the use of standard lists as a tool for encouraging good procurement practice and includes model lists of medical supplies and equipment required for primary health care activities in both health facilities in the community, and basic laboratory facilities.
Available from: TALC

Physical asset planning and management software (PLAMAHS)
HEART Consultancy
This software package holds information, and supports analysis, on: the equipment inventory, equipment models and standards, existing and planned facilities, procurement support, and maintenance support. The software holds various digital images, standard lists and templates for forms, etc, and has a security system. It has been designed especially with developing countries in mind, is available at special rates for developing countries, and HEART can assist with training requirements.
Available from: HEART Consultancy

Refrigerators use, maintenance and repair series
Expanded Programme on Immunisation (EPI) (1984-1987). WHO
EPI/LOG/84/14 - 19, 21, 22, 25, 26 and EPI/TECH.HB/A - H
This series is grouped into two sub-series: i) User and 'how to look after' handbooks, and ii) Repair technicians handbooks. The user's handbooks are comprehensive illustrated guides that contain information on installation, the components, operation, schedules for daily/weekly/monthly care, fault-finding, basic maintenance procedures, and conversion to electric operation. The 'how to look after' handbooks contain task sheets for different maintenance tasks, with information on the tools and materials required, and step-by-step action required for the tasks (written as training modules). The technician's handbooks have the same format as the user material but cover much more complicated maintenance procedures. They are meant to be used in conjunction with the manufacturers' own maintenance and repair manuals.
Available from: WHO

Selection of basic laboratory equipment for laboratories with limited resources
Johns ML and ME El-Nageh (2000). ISBN: 9290212454
This book provides a framework to help laboratory workers, supply officers and decision makers to choose and buy laboratory equipment and consumables. Includes information on maintenance and energy requirements for laboratory equipment, quick reference buyer's guides and equipment data specification sheets provide easy reference for equipment buyers. The framework can be adapted to guide general equipment purchasing.
Available from: WHO

Surgery at the district hospital: Obstetrics, gynaecology, orthopaedics and traumatology
Cook J, Sabkaran B, and A Wasunna (eds) (1991). Dept. of Surgery, Eastern General Hospital, Edinburgh, Scotland. ISBN: 92 4 154413 9
An illustrated guide to essential surgical procedures in small hospitals for treating the major complications of pregnancy and childbirth, common gynaecological procedures, and managing traumatic injuries, including fractures and burns. Emphasis is placed on standard surgical protocols that represent the safest line of action in hospital settings where equipment may be primitive, drugs limited, and specialist services sparse – these requirements are discussed.
Available from: WHO

Surgical instruments: A pocket guide (2nd edition)
Papanier Wells M, and M Bradley (1998). ISBN: 00721678017
A pocket guide listing and describing surgical instruments: sharps/dissectors, forceps, clamps, retractors, suction tips, dilators, endoscopic instruments, internal stapling devices, and most commonly used instrument sets for a variety of surgical procedures. Includes a picture of the instrument with a brief description explaining the uses, varieties, and alternative names.
Available from: major internet bookshops

Training manual for central service technicians (4th edition)
American Society for Healthcare Central Service Professionals (2001). ASHCSP, USA.
ISBN: 0 7879 5947 2
This manual is an introductory text developed to acquaint entry-level aides and technicians with the scope of the central service (central sterile supply department) profession and with the scientific principles that underlie their daily work. Updated materials include easy-to-read graphs, new photographs, and updated information on regulation, governing agencies, and web links. Other publications are available linked to this manual, such as a workbook, an instructor's guide, a manager's manual, and so on – see ASHCSP website.
Available from: ASHCSP

Where there is no technician: A practical guide for users of medical equipment
Remmelzwaal B, and E de Villiers (eds) (2002). MOHSS, Namibia
This manual aims to cover situations where the nearest knowledgeable maintenance technician or private company is hundreds of kilometres away, and health workers must develop basic skills related to maintenance, calibration, and safe operation of equipment. In a modular style, it covers 10 pieces of medical equipment commonly found in district health facilities. The manual intends to serve both as a training manual and as a practical reference guide for individual health workers.
Available from: Ministry of Health and Social Services, Namibia

Safety Issues

This material covers issues in *Section 5*, such as operator safety, decontamination issues, waste management, electrical safety, medical equipment safety, and accidents. The material is listed alphabetically by title in each sub-section.

Tip

- Some sources cover many topics and are listed in the first sub-section. Sources that cover a single topic are listed in the sub-sections dedicated to that topic. When looking for a specific topic, always check the first sub-section to see if any sources also cover the subject matter you are interested in.

Sources covering many safety topics

Care and safe use of hospital equipment
Skeet M and Fear M. (1995). VSO. ISBN: 0 9509050 5 4

Emergency Care Research Institute (ECRI, USA) products
ECRI

Enhancing patient safety: The role of clinical engineering
American College of Clinical Engineering (2001). ACCE White Paper, ACCE, Plymouth Meeting, USA
This paper discusses the problem (in the USA) of the level of adverse incidents occurring in healthcare due to user error, and the important role clinical engineers need to play in patient safety. It contains information on other papers, websites, and organizations that deal with patient safety issues.
Available from: ACCE website: www.accenet.org

Essentials of health and safety at work
Health and Safety Executive (HSE) (1989). ISBN 0 11 885494 1
This practical, easy to use guide helps you to prevent workplace accidents and comply with UK HSE law without major disruption or expense. It is full of good advice to help you start planning for safety, and contains checklists, diagrams, and case studies covering a wide range of workplace hazards.
Available from: HMSO Books, UK

Gas safe with medical gases (training video)
BOC Medical. Code 888859
This video includes information on the storage and handling of cylinders, identification, and procedures in the event of fire, etc.
Available from: BOC Medical

Infusion systems
Medicines and Healthcare Regulatory Authority (1995). MDA Device Bulletin, No. DB 9503 (May 1995)
This publication addresses many aspects of the use and selection of infusion systems. Its purpose is to raise awareness of the nature of infusion systems, their advantages and their potential risks, with a view to reducing the number of adverse incidents that arise from their use. It describes the different types of infusion devices, risks and applications, training programmes, safety recommendations, purchasing, and management responsibilities.
Available from: MHRA

Maintenance and repair of laboratory, diagnostic imaging, and hospital equipment
WHO (1994). ISBN: 92 4 154463 5

Medical administration for frontline doctors: A practical guide to the management of district-level hospitals in the public service or in the private sector (2nd edition)
Pearson C (1990). FSG Communications Ltd, Cambridge, UK. ISBN: 1 871188 03 2

Medical equipment in Botswana: A framework for management development
Temple-Bird C L, Mhiti R, and G H Bloom (1995), WHO publication WHO/SHS/NHP/95.1

Medical supplies and equipment for primary health care: A practical resource for procurement and management.
Kaur M, and S Hall (2001). ECHO International Health Services Ltd. ISBN: 0 9541799 0 0

Medicines and Healthcare Regulatory Agency (MHRA, UK) products
This agency of the UK government (formerly the Medical Device Agency) ensures medical devices and equipment meet appropriate standards of safety, quality, performance, and effectiveness, are used safely, and that they comply with relevant Directives of the European Union. The MHRA provides a variety of publications, such as:

- **Medical device alerts** (replacing former hazard notices, safety notices, device alerts, advice notices, etc)
- **Device bulletins** (replacing former evaluation reports)
- **Device evaluations**
- **Advice on a wide variety of safety topics** (visit the website, click on contacts, then medical devices, then search under a subject area such as decontamination, or laundry for example).

Available from: MHRA

Safety at work (training video and interactive CD)
RS Components Ltd.(1994). Codes 446-2446 and 446-2452 (catalogue page 1-196 Sept 2003)
This video/CD covers the important safety issues that every electrical apprentice needs to know. It includes sections on the range of hazards and risks of working in the electrical industry, health and safety law, portable appliance testing, keeping an eye out for hazards, using equipment properly, accessing and handling equipment, what to do in an emergency, and recognizing the signs.
Available from: RS Components Ltd

Safety in clinical and biomedical laboratories
Collins C (ed) (1988). Chapman and Hall Medical. ISBN: 0 412 28370 0
This book is a concise guide to proper practice in a clinical environment, to achieve safety at work. It covers chemical, electrical, mechanical, microbiological, and radiation hazards, laboratory first aid, and safety checklists.
Available from: major internet bookshops

Equipment-related infection control

A handbook for managers: Insecticide treated net projects
Chavasse D, Reed C, and K Attawell (1999). Malaria Consortium.
Designed to be a practical decision-making tool for project managers, the handbook covers planning, implementing and monitoring treated net projects, illustrated with examples from more than 30 projects in 16 countries.
Available from: http://www.liv.ac.uk/lstm/malaria/mcpubns.htm

Chemical disinfection in hospitals (2nd edition)
G Ayliffe, D Coates and PN Hoffmann (1993). ISBN: 0901144347
This book is a guide to disinfection in hospitals and laboratories. It covers the principles, properties and safety of chemical disinfection and disinfectants. There are chapters on disinfection policy and cleaning and disinfection of the environment, skin, and medical equipment including endoscope disinfection.
Available from: major internet bookshops

Hygiene promotion: A practical manual for relief and development
Ferron S, Morgan J and M O'Reilly (2000). ISBN: 1853395056
This manual has been written for fieldworkers aiming to reduce the incidence of water and sanitation related diseases in relief and rehabilitation programmes. Also useful for other development workers, particularly those working in the fields of community development, health and engineering.
Available from: TALC

Hospital hygiene (3rd Edition)
Maurer I (1990). Edward Arnold, London. ISBN: 0 7131 4443 2
This book makes an important contribution to the understanding of infection and methods of infection control worldwide. It deals with the subject in an entertaining and stimulating manner and provides direct advice and guidance in a difficult area of hospital administration. It provides any health service worker who deals with hospital hygiene with information and illustrations so that informed decisions can be made, priorities assessed, and training programmes organized. It covers hospital infection, sterilization, disinfection, dust control, cleaning with water, chemical disinfection, and hygiene policies.
Available from: major internet bookshops

Immunisation in practice: A guide for health workers who give vaccines
WHO (1996). MacMillan. ISBN: 0 333 63095 5
A guide for health workers giving immunisations. Explains about vaccinations and provides practical information on how to carry out immunisation, look after vaccines and on methods of sterilisation and boiling.
Available from: TALC, WHO.

Optimalization of the process for manually operated jacket steam sterilizers
Muis B, Bruijn ACP de, Drongelen AW van, and J Huys (2001). RIVM report 318902011
This report describes research to find the optimal process for manually operated jacketed steam sterilizers that are mainly used in developing countries. It looks at various test packs, the use of thermocouples, and test cycles to find the optimal process profile.
Available from: RIVM/Dutch Institute for Public Health and the Environment

Sterilization of medical supplies by steam, volume 1: General theory (2nd edition)
Huys J (2003). HEART Consultancy. ISBN: 90 75829 04 3
This book focuses on the most common and most safe method used for sterilization in the Central Sterile Supplies Department in healthcare institutions – sterilization by pressurised high temperature steam. Originally intended to educate technical service personnel in remote health institutions, it has grown into a textbook that can be used by anyone interested in sterilization. Contains information on steam pulsing, monitoring sterility, self-made test packs, use of thermocouple testing kits, and process profiles. Available in several languages.
Available from: HEART Consultancy

Vector control: Methods for use by individuals and community
Rozendaal J (1997). WHO. ISBN: 92 4 154494 5
Provides practical information on all major disease vectors and pests, and on effective control methods suitable for rural and urban environments. Intended for health workers and auxiliary staff as well as health planners and aid organizations.
Available from: WHO

Waste management

De Montfort medical waste incinerators
Information on the De Montfort University incinerators designed by Prof. DJ Picken can be obtained from a website. It contains copies of drawings and instructions for the building, operation and maintenance of various incinerator models. The range of DMU incinerators has been developed for use by rural PHC facilities, and designed to be constructed on site using local materials. There may be a small charge to cover the cost of printing and postage of the plans.
Available from: website: www.mw-incinerator.info/en/101_welcome.html

How are we managing our health care wastes?
Coad A, and J Christen (1999). SKAT
This document looks at management of health care waste in low-income and middle-income countries using case studies from 6 cities in Africa, Asia and the Middle East. Consists of a series of questions with comments to guide health care waste management.
Available from: ITDG Publishing

Management of solid and liquid waste at small healthcare facilities in developing countries.
Jantsch F, and H Vest, (1999). GATE-Information Service, Division 44: Environmental Management, Water, Energy, Transport, GTZ, Eschborn, Germany
This book aims to raise awareness and provide advice for healthcare waste management in order to improve the overall environmental conditions at health facilities. Part one of this practical guide provides advice on healthcare waste generation and related hygiene risks, waste management and factors influencing its effectiveness at health facilities in developing countries. Part two presents a series of detailed worksheets with illustrations to provide the reader with practical solutions suitable for immediate implementation.
Available from: GTZ, GATE

Safe management of wastes from health-care activities
Pruss A, Giroult E, and P Rushbrook (1999). ISBN: 9241545259
A comprehensive and practical guide covering all aspects of the management of health care waste. The book defines waste categories and characteristics, describes the planning needed, collection, segregation, storage, transport, and disposal of waste. There is also chapter on training and a section on simple and safe waste management techniques for emergencies and small rural facilities. It is relevant to hospitals in developing countries and health centres.
Available from: WHO

Electricity supplies and safety

A guide to power conditioning and power back-up
Huys J (1996). FAKT, Basler Mission, and HEART Consultancy
This document is an introduction to guide you through the terminology and information regarding power conditioning and power back-up. It is aimed at health workers facing problems with ensuring power quality for any electrical equipment, and ensuring power is available when you need it. It deals with the problems which can occur in the mains supply, and an explanation about the main measures which can be taken for power conditioning and power back-up (including advice on suppressing electro-magnetic interferences and radio frequency interference, and advice on different types of uninterruptible power supplies). It is meant for anyone involved in the decision-making process for the procurement and installation of such equipment.
Available from: FAKT

Electricity at work (training video)
RS Components Ltd.(1990). Code 446-2238 (catalogue page 1-201 Sept 2003)
This video examines electricity at work regulations. It includes sections on the need for regulations, the dangers of electricity, safe construction and maintenance of electrical systems, strength and capability of electrical equipment, equipment exposed to adverse conditions, prevention of danger, earthing and protective devices, electrical continuity, joints and sockets, excess current protection, isolation of equipment, live working, access for work, and suitable personnel and training.
Available from: RS Components Ltd

IEE wiring regulations (16th edition)
William Ernest (amended 2004). RS Components Ltd
This is the latest edition of the IEE wiring regulations which describes how to plan and implement electrical installations safely in accordance with international wiring rules. (Guidebooks for implementing the IEE wiring regulations are also available).
Available from: RS Components Ltd

If not in use – switch off!: Guidelines and key recommendations for a sustainable and cost-effective energy supply for health facilities in remote locations
Röttjes M (1995) FAKT, Stuttgart, Germany
This practical document aims to provide a variety of courses of action that medical and administrative staff can pursue when health facilities are hit by energy problems. It covers sustainable and cost-effective energy supplies, the different energy requirements, possible energy sources, and suggestions for a hospital energy supply. It includes PPM schedules for air-cooled diesel power plants.
Available from: FAKT

International seminar for hospital technicians/engineers: February 1998, Moshi, Tanzania
Clauss J (ed) (1998). FAKT

La maintenance dans les systemes de santé/ Maintenance for health systems: 4th GTZ Workshop, Dakar, Senegal, September 1993
Halbwachs H, and R Schmitt (eds) (1994). GTZ

Testing to the 16th edition (training video)
RS Components Ltd.
This video describes how to test electrical installations according to the latest IEE wiring regulations (16th edition).
Available from: RS Components Ltd

Laboratory safety

District laboratory practice in tropical countries (part 1)
Cheesbrough M (1998). Tropical Health Technology. ISBN:0 9507434 4 5

District laboratory practice in tropical countries (part 2)
Cheesbrough M (2000) Tropical Health Technology. ISBN:0 9507434 5 3

Practical laboratory manual for health centres in East Africa,
Carter J and Olema O (1998). AMREF.
Practical laboratory manual providing information necessary to establish, select and use laboratory tests for patient management. Also includes material on implementation of safe working practices, reporting and recording test results, keeping an inventory of supplies and equipment, ordering supplies and maintaining equipment.
Available from: AMREF

Supplies and Stores Management

This material covers issues in *Section 6*, such as supplies management and stock control. It is listed alphabetically by title.

How to manage a health centre store
Battersby A (1994). Healthlink Worldwide (formerly AHRTAG).
Describes in detail the structure and organization of a store or dispensary, methods of arranging stocks, stock control, and basic dispensing.
Available from: Healthlink Worldwide

Medical supplies and equipment for primary health care: A practical resource for procurement and management.
Kaur M, and S Hall (2001). ECHO International Health Services Ltd. ISBN: 0 9541799 0 0

Spare parts and working materials for the maintenance and repair of health care equipment: Report of workshop held in Lübeck, August 1991
Halbwachs H, and C Temple-Bird (eds) (1991). GTZ, Eschborn, Germany
This book, mainly aimed at maintenance technicians, covers the maintenance requirements for common items used at district level (anaesthesia equipment, infant incubators, X-ray equipment, suction pumps, autoclaves and laundry equipment) including some advice on safety testing and test instruments. It also includes information on workshops and stock control of parts.
Available from: GTZ

Stock control software
Stock control of items in stores is an area where simple computer software programs can be of assistance once you have mastered a manual paper system, have a large enough store (for example, at central level), and can obtain sufficient training of staff. The following products can be viewed on the internet and should provide either a full demonstration CD of the software to study, or use of a shareware program free of charge for a set period of time:

- Website: www.easy4you.net/EN/stock.htm
  Low cost stock control and invoicing package for small to medium size businesses, provided as shareware software.
- Website: www.microsoft.com/BusinessSolutions/Navision/supplychain.aspx
  Navision sales and stock management software is suitable for medium to large scale businesses, and is available in various building blocks. Navision is used by several central/national medical stores in Africa, but requires a lot of training
- Website: www.requisoft.com/stock/stock.html
  Requisoft Stock software controls and manages an organization's stock, and allows you to browse through your stock records. It can be used on its own or as a module of the Requisoft Procurement system.
- Website: www.artisan.co.uk/products/index.php?p=Stock
  Artisan stock management and control software is comprehensive, and includes complex assembly component and works order systems.

Technician's handbook for compression refrigerators – Part D: How to keep stocks of spare parts
WHO Expanded Programme on Immunization (1984). EPI/TECH.HB/D, Document EPI/LOG/84/20 in *Refrigerators use, maintenance and repair series*, WHO, Geneva.
This booklet contains a series of case studies to help the reader learn about spare parts management. Although designed for vaccine refrigerators, it can be applied to any spare parts. It has sections covering how to choose and order spare parts, how to keep track of stocks of spare parts, how to decide who should keep the stocks, and how many parts should be kept at each level of the health service. It contains exercises and case studies for each topic.
Available from: WHO

Testing and Decommissioning

This material covers issues in *Section 7.3* on safety testing and test instruments, and *Section 7.5* on decommissioning. It is listed alphabetically by title.

Care and safe use of hospital equipment
Skeet M and Fear M. (1995). VSO. ISBN: 0 9509050 5 4

District health facilities: Guidelines for development and operation
WHO Regional Publications: Western Pacific Series No 22 (1998). ISBN: 92 9061 121 9

Estimated useful lives of depreciable hospital assets (revised 2004 edition)
American Society for Hospital Engineering (2004). American Hospital Association.
ISBN: 1 55648 319 8
One of the organizations which have tried to estimate typical equipment lifetimes for healthcare technology. The AHA's extensive list reflects how equipment lasts within the United States' health care system whether it was manufactured in the US or abroad. It covers buildings, estate, fixed equipment, and individual items of movable equipment. The list was compiled after discussions with manufacturers of healthcare equipment, discussions with various hospital department managers, and analysis of actual retirement practices for actual hospital assets.
Available from: AHA

Maintenance and repair of laboratory, diagnostic imaging, and hospital equipment
WHO (1994). ISBN: 92 4 154463 5

Maintenance and the life expectancy of healthcare equipment in developing economies
Hans Halbwachs, GTZ. In *Health Estate Journal* (March 2000) pp 26-31
This article comes from one of the organizations that have tried to estimate typical equipment lifetimes for healthcare technology. The GTZ estimates are for 16 types of medical equipment and plant, and tries to more closely reflect the realities in developing countries. The article describes the Delphi survey used to obtain feedback from 23 experts from 16 different country backgrounds. Rather than providing exact lifetimes, this approach provides a range for the lifetime which depends on the quality of the initial equipment and how well it has been maintained.
Available from: GTZ

Spare parts and working materials for the maintenance and repair of health care equipment: Report of workshop held in Lübeck, August 1991
Halbwachs H, and C Temple-Bird (eds) (1991). GTZ, Eschborn, Germany

See *Guide 5* on maintenance management for more information on maintenance schedules that include safety tests.

Accessing Information

These websites are sources of information concerning many aspects of health service delivery. They are locations where there is, or may be, information about healthcare technology management and equipment operation and safety.

Africa online: Health website: http://bamako.africaonline.com/afol/index.php
Provides links to health information sites related to Africa. The links are organized into the following categories: health information, health news, events, African organizations, international organizations, schools and hospitals in Africa, projects, publications and health services

AFRO-NETS (African networks for health research and development) website: www.afronets.org
Forum for exchanging health research information in and between East and Southern Africa.

AJOL (African journals online) website: www.inasp.org.uk/ajol
Offers free online access to tables of contents and abstracts of over 70 journals published in Africa.

Blood transfusion safety (BTS) website: www.who.int/bct/Main_areas_of_work/BTS/BTS.htm
WHO site covering blood safety issues from access to safe blood and blood products to evaluations of HIV testing kits.

British medical journal website: http://bmj.bmjjournals.com/
Free worldwide access to BMJ and the student BMJ and wide range of specialist journals to users in low-income countries.

CEN website: www.cenorm.be
The European Committee for Standardisation website lists the essential European Standards they publish regarding sterile supplies. They include standards for different sorts of sterilizers and Bowie & Dick tests (e.g EN285, EN13060), validating sterilization techniques (e.g. EN554), chemical disinfection (e.g. EN1499), testing systems (e.g. EN866, EN877), packaging and labelling (e.g. EN868, EN556).

Centers for Disease Control and Prevention (CDC) website: www.cdc.gov
This agency of the US government is a leading centre for providing up-to-date information on disease prevention and control, health promotion, and education activities. The website has a wide range of information. For example, discussions on:

- the correct laundering of linen at www.cdc.gov/ncidod/hip/STERILE/laundry.htm
- how laundries should wash infected material at www.cdc.gov/ncidod/hip/Blood/worker.htm
- laundering for patients with AIDS at www.cdc.gov/hiv/pubs/brochure/care6.htm#Laundry.

Deliver website: www.deliver.jsi.com
USAID funded project focusing on supply chain logistics for health products in developing countries from estimating demand for supplies, and maintaining optimal supply levels, to proper storage guidelines.

Eurasia health knowledge network (EHKN) website: www.eurasiahealth.org
Specialises in the health information needs of the Former Soviet Union (FSU) and Central and Eastern Europe (CEE). Site links to clinical practical guidelines, medical textbooks, and other educational materials, many in Russian and other regional languages

European forum for hospital sterile supply website: www.efhss.com
The forum runs a website hosting most European associations related to sterile supply. It is a useful resource with a question and answer page, discussion forum, training and other useful information on sterilization.

FIN: Free international newsletters: www.healthlink.org.uk
Healthlink produces this publication that lists over 130 print and electronic health-related newsletters and magazines which are available free to readers in developing countries.

Free medical journals website: www.freemedicaljournals.com
This site is a comprehensive, up to date list of medical journals available free on the internet.

GATE (German Appropriate Technology Exchange): www5.gtz.de/gate/
The GATE Information Service seeks to improve the technological knowledge of organizations and individuals involved in poverty alleviation projects and to develop information and knowledge management systems of organizations.

Global alliance for vaccines and immunization (GAVI) website: www.vaccinealliance.org
This global alliance produces a wide range of information including factsheets and the **Immunization FORUM** newsletter providing updates and topical debate about key immunisation issues.

Healthcare waste website: www.healthcarewaste.org
WHO site for health care waste management

Health exchange website: www.healthcomms.org
Explores issues, ideas and practical approaches to health improvement in developing countries and provides a forum for health workers and others to share viewpoints and experiences in this area.

HealthNet news website: www.healthnet.org/medpub
Weekly newsletter distributed to health professionals in Africa, Asia and Latin America. Features current, practical, clinical and public health information.

HIF-net at WHO discussion group
Discussion list dedicated to issues of improving access to reliable health information in resource-poor settings. To join, email your name, affiliation and professional interests to: health@inasp.info

HINARI (Health inter-network access to research initiative) website: www.healthinternetwork.net
WHO initiative offering free/discounted access to journals from six leading publishers.

HNP flash website: www.worldbank.org/hnpflash
A free monthly electronic newsletter dedicated to sharing knowledge regarding the latest technical developments in the fields of health, nutrition, population, and reproductive health.

ID21 health website: www.id21.org/health
An internet based development research reporting service for health policy makers and development practitioners on global health issues. Latest research summaries are provided on a searchable website, by email and in a quarterly publication.

IEC website: www.iec.ch
International Electrotechnical Committee, which sets standards for the safe manufacture of electrical healthcare technology. There is a wide range of specific standards for medical electrical equipment falling under the standard numbers IEC 60101–1,2, and 3.

IEE healthcare technologies professional network website: www.iee.org/pn/healthtech
The Institution of Electrical Engineers of the UK provides internet sites for a wide variety of engineering professions, with the aim of enabling people to communicate with their peers around the world and access the latest global industry news and key information sources. One of their professional networks focuses on healthcare technologies. It has also hosted a series of seminars on **Appropriate medical technology for developing countries**, and their reports can be obtained from the IEE.

INFRATECH discussion group
WHO forum for global exchange of information on infrastructure and healthcare technology issues. To subscribe, send an email to listserv@listserv.paho.org. Enter in text: subscribe infratech 'your full name'.

International health exchange website: www.ihe.org.uk
Provides training, information and advice to health workers in emergency aid and development situations. This site also provides information about jobs and health development issues.

Joint Commission on Accreditation of Healthcare Organizations (JCAHO) website: www.jcaho.org
This American body has published new patient safety standards that cut across disciplinary boundaries in an attempt to make safety a fundamental principle of patient care. These standards cover infection control, the environment of care, and other disciplines.

KAR (Knowledge and research programme on disability and healthcare technology) website: www.kar-dht.org, and for the latest projects being funded use website: www.disabilitykar.net/
This is the Knowledge and Research Programme on disability and healthcare technology of the UK government's Department for International Development (DFID). It supports a range of projects on development and use of appropriate disability and healthcare technologies in developing countries. The website also provides links to:

i. **Disability and healthcare technology newsletter** produced every six months describing the progress and findings of the projects funded;
ii. **KaR global database** on healthcare technology publications, organizations, manufacturers, training institutions, etc.

NICE (National Institute of Clinical Excellence) website: www.nice.org.uk
Provides guidance to the UK National Health Service (NHS) on current best practice covering both health technologies (from medicines to diagnostic techniques) and the clinical management of specific conditions.

Programme for appropriate technology in health (PATH) website: www.path.org
PATH identifies, develops and applies appropriate technologies to public health problems in developing countries.

Public health care laboratory website: www.phclab.com
Global forum of information exchange and resource centre for laboratory personnel and those concerned with PHC laboratory services in developing countries.

Safe injection global network (SIGN) alliance website: www.who.int/injection_safety/sign/en
This is a network/discussion group for safe injection issues from technical, managerial, and operational issues to policy development, consensus formation and advocacy. It covers a wide range of topics, such as whether to use reusable or disposable items. The alliance produces the electronic newsletter **SIGNpost**. The site is hosted by WHO.

TechNet (Technical network for strengthening immunisation services) website: www.technet21.org
Forum focusing on improving management and operational logistics for health service delivery in developing countries, in particular, immunisation services.

The manager's electronic resource center website: http://erc.msh.org
The ERC website is an electronic information resource and communication service for health managers, containing more than 150 ready-to-use management tools in various languages. A key feature is:

- **The health manager's toolkit**, includes spreadsheet templates, forms for gathering and analyzing data, checklists, guidelines for improving organizational performance, and self-assessment tools that allow managers to evaluate their organizations. Tools cover areas such as strategic planning, developing information systems, cost and revenue analysis, and sustainability.

WHO: Health technology and pharmaceuticals website: www. who.int/technology
This WHO site provides information on pharmaceutical and health technology developments with a particular focus on developing countries. It includes links to blood transfusion safety and clinical technology, essential drugs, medicines, vaccines and biologicals.

WHO: Injection safety website: www.injectionsafety.org
This WHO site focuses on safe injections and the elimination of injection-associated transmission of blood-borne pathogens.

WHO: Management of health services (MAKER) website: www. who.int/management
This WHO site provides information, publications, and country experiences on all types of management issues for health services, such as facility management, resource management, and district management.

ii. Organizations, Sources of Publications in Part i, Resource and Information Centres

For the following institutions we have included the name, address, contact details, a brief description of the various services they offer, and additional contact details for further relevant activities.

AfriAfya
AMREF Building, PO Box 30125, Nairobi, Kenya
Tel: 254 2 609520, fax: 254 2 609518, email: info@afriafya.org, website: www.afriafya.org
Established by Kenya-based health agencies, AfriAfya provides community access to relevant and appropriate health knowledge and information in an interactive manner. As well as a section on HIV/AIDS there is a news centre, message board and discussion forum on their website.

AFTH (African Federation of Technology in Healthcare)
PO Box 19070, Tyberg 7505, South Africa
Email contacts: ykwankam@cht.uninet.cm and pheimann@mweb.co.za
For information use website: http://ifmbe-news.iee.org/ifmbe-news/may1998/mrc.html, and look up the South African Medical Research Council (SA MRC).

Albert Browne (International) Ltd
Chancery House, 190 Waterside Road, Hamilton Industrial Park, Leicester, LE5 1QZ, UK
Tel: 44 116 276 8636, fax: 44 116 276 8639, website: www.thebrownegroup.co.uk
This company manufactures sterilization monitoring systems, and is a source for a wide range of ready-made Bowie & Dick tests in different forms using TST technology.

Amazon Bookshop
PO Box 81226, Seattle, Washington 98108-1226, USA
Website: www.amazon.com or www.amazon.co.uk
Internet bookshop

American Hospital Association
Clinical Engineering Section, 840 North Lake Shore Drive, Chicago, Illinois 60611,USA
Website: http://aharc.library.net/
Their documents are published by HealthForum, use website:www.ahaonlinestore.com

American Society for Healthcare Central Service Professionals (ASHCSP)
One N Franklin Avenue, Chicago, Illinois 60606-3421, USA.
Tel: 1 312 422 3700, fax: 1 312 422 4577, website;
www.ashcsp.org/ashcsp/education/publications.html
This society is for healthcare workers working in the central service and sterile processing field (central sterile supply departments). They produce a wide range of publications covering the training of technicians, advice for managers, continuing education for central service staff, different sterilization techniques, reusables, decontamination, assembly and packaging, administration and organization, cost analysis, and total quality management.

AMREF International (African Medical and Research Foundation)
Resource Centre, AMREF Headquarters, Langata Road, PO Box 00506 – 27691, Nairobi, Kenya
Tel: 254 2 501301/2/3, fax: 254 2 609518, e-mail: amref.info@amref.org, website: www.amref.org
Publishes practical books, journals and other literature for health workers, and provides advice on primary health care. Runs training courses and seminars.

BMA (British Medical Association) and BMJ Bookshop (British Medical Journal)
BMA House, London, WC1H 9JR, UK
Tel: +44 (0)20 7383 6244, fax: +44 (0)20 7383 6455, e-mail: orders@bmjbookshop.com,
website: www.bmjbookshop.com

BOC Medical
Customer Service Centre, Priestley Road, Worsley, Manchester, M28 2UT, UK
Tel: 44 800 111 333, fax: 44 800 111 555, email: bocmedical@uk.gases.boc.com,
website: www.boc.com or bocmedical.co.uk

BOND (British Overseas NGO's for Development)
Website: www.bond.org.uk
A network of more than 260 UK based voluntary organisations working in international development and development education. BOND works to promote the exchange of experience, ideas and information by acting as a broker for a variety of relationships and by collating and distributing information.

Commonwealth Secretariat
Marlborough House, Pall Mall, London, SW1Y 5HX, UK
Tel: 44 207 747 6500, fax: 44 207 930 0827, website:
www.thecommonwealth.org/publications/html/contactus.asp
This website provides access to the publications produced by the Commonwealth Secretariat.

DFID (Department for international development)
Website: www.dfid.gov.uk
UK government's department for international development assistance.

Eastwood Park Training and Conference Centre
Falfield, Wotton-under-Edge, Glos, GL12 8DA, UK
Tel: 44 1454 262777, fax: 44 1454 260622, email: training@eastwoodpark.co.uk, website:
www.eastwoodpark.co.uk
This centre offers:

- a wide range of scheduled and tailor-made short courses in healthcare engineering, estates and facilities, at certificate level accredited with known bodies (such as BTEC, City and Guilds)
- specific equipment courses, such as sterilization technology courses.

ECHO International Health Services Ltd
ECHO International Health Services is no longer trading as it used to. Its services can be accessed as follows:

i. the charitable foundation can be contacted at:
   ECHO, Ullswater Crescent, Coulsdon, Surrey, CR5 2HR, UK
   Tel: 44 208 6602220, fax: 44 208 6680751, website: www.echohealth.org.uk/intro2.html
ii. the trading branch of the business (wholesale providers of medical supplies and equipment) is now:
   Durbin PLC, 180 Northholt Road, South Harrow, Middlesex, HA2 0LT, UK
   Tel: 44 208 8696500, fax: 44 208 8696565, email: cataloguesales@durbin.co.uk, website:
   www.durbin.co.uk
iii. ECHO publications are still available from TALC (see below).

ECRI (Emergency Care Research Institute)
5200 Butler Pike, Plymouth Meeting, Pennsylvania 19462-1298, USA
Tel: 1 610 825 6000 ext 5368, fax: 1 610 834 1275, website: www.ecri.org
Offers guidance and advice on healthcare technology, planning, procurement and management; and health technology assessment and assistance.

Elsevier Health Science
Elsevier Books Customer Services, Linacre House, Jordan Hill, Oxford, OX2 8DP, UK
Tel: 44 1865 474110, fax: 44 1865 474111, email: eurobkinfo@elsevier.com, website:
www.us.elsevierhealth.com
Books published by WB Saunders, Mosby, Churchill Livingstone, and Butterworth-Heinemann are now all members of the Elsevier Science, Health Sciences Division.

European Union (EU)
http://europa.eu.int/comm/development/index_en.htm
EU site for international development and aid.

FAKT (Consultancy for Management, Training, and Technologies)
Gansheidestrasse 43, D-70184 Stuttgart, Germany
Tel: 49 711 21095/0, fax: 49 711 21095/55, email: fakt@fakt-consult.de, website: www.fakt-consult.de
Non-profit consultancy firm, that provides information on appropriate hospital and medical equipment and training in healthcare technologies. FAKT is not a supply organisation.

Global Directory of Health Information Resource Centres.
Health Information for Development (HID) Project, PO Box 40, Petersfield, Hants, GU32 2YH, UK
Tel: 44 1730 301297, fax: 44 1730 265398, email: iwsp@payson.tulane.edu,
website: www.iwsp.org/directory.htm
This is a directory of health information resource centres that is arranged alphabetically by country. Between January 2000 and May 2001, Health Information for Development (HID) compiled a Global Directory of Health Information Resource Centres (HIRCs). This is available from their website. The Directory is updated on an ongoing basis.

GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit – German government technical aid agency)
Division of Health and Education, PO Box 5180, D-6236, Eschborn, Germany
Tel: 49 6196 791265, fax: 49 6196 797104, email: Friedeger.Stierle@gtz.de
Website: http://www.gtz.de/de/4030.htm
Friedeger Stierle is the contact for the GTZ's healthcare technology management programme, and any articles or documents on HTM.

Healthlink Worldwide
Cityside, 40 Adler Street, London, E1 1EE, UK
Tel: 44 20 7539 1570, fax: 44 20 7539 1580, email: info@healthlink.org.uk, website: www.healthlink.org.uk
Publishes a range of free and low-cost newsletters, resource lists, briefing papers and manuals about health and disability. Publications include **HIV testing: a practical approach** which is a briefing paper on HIV counselling and laboratory testing.

HEART Consultancy
Quadenoord 2, 6871 NG Renkum, The Netherlands
Tel: 31 317 450468, fax: 31 317 450469, email: jh@heartware.nl, website: http://www.heartware.nl
Consultancy firm working in all aspects of healthcare technology management in developing countries. It also produces and supplies the PLAMAHS software package for managing the inventory, model lists, maintenance, and procurement needs for your healthcare technology stock. HEART also undertakes research and training, and produces publications on many aspects of sterilization for developing countries. It has developed a basic testkit for performance testing of sterilizers, and can identify suppliers that still manufacture basic sterilizers (manually operated/fuel heated).

HMSO (Her Majesty's Stationery Office)
Website: www.hmso.gov.uk
Publishers of material produced by departments of the UK government.

Humanitarian Information for All
c/o Human Info NGO vzw and Humanity CD Ltd, Oosterveldlaan 196, B-2610 Antwerp, Belgium
Fax: 32 3 449 75 74, email: humanity@humaninfo.org, website: www.humaninfo.org
The goal of this organization is to disseminate health care information free-of-charge in developing countries. Thus, their Medical and Health Library makes publications available on the internet. Refer to their homepage to find the large list of publications available.

Institute of Decontamination Services, UK
Website: www.idsc-uk.org
Formerly the Institute of Sterile Services Management. Publishes the ISSM Journal.

Intermediate Technology Development Group (ITDG) and **ITDG Publishing**
The Schumacher Centre for Technology and Development, Bourton Hall, Bourton-on-Dunsmore, Rugby, CV23 9QZ, UK
Tel: 44 1926 634400, fax: 44 1926 634401, email: enquiries@itdg.org.uk, website: www.itdg.org
The Development Group is a charity concerned with the research and development of 'appropriate' technologies for application in developing countries. It has worked on topics such as, alternative electrical supplies, access to water, disability aids, medical supplies. It also undertake consultancies. The Publication Division produces and disseminates books and journals covering aspects of health, development, and appropriate technology. It can be contacted at: Tel: 44 1926 634501, fax: 44 1926 634502, email: itpubs@itpubs.org.uk, website: www.itdgpublishing.org.uk.

International Atomic Energy Agency (IAEA)
Wagramerstrasse 5, PO Box 100, A-1400, Vienna, Austria
Tel: 43 222 2360, fax: 43 222 230 184, website: www.iaea.org
Offers regionally-based training courses in the field of nuclear medicine.

International Centre for Eye Health (ICEH)
International Resource Centre, Institute of Opthalmology, University College London, 11–43 Bath Street, London EC1V 9EL, UK, website: www.iaea.org/
Tel: 44 20 7608 69 23/10/06, fax: 44 20 7250 3207, email: eyeresource@ucl.ac.uk, website: www.ucl.ac.uk/ioo
Advises and publishes information on all aspects of eye care including prevention of blindness. Produces the **Community eye health journal** distributed free to developing countries, an annual standard list of medicines, equipment, instruments and optical supplies for eye care for developing countries, and teaching slides/text sets and videos.

International Federation of Hospital Engineering (IFHE)
Website: http://home.enter.vg/ifhe/main.html
This body enables national engineering professional organizations to join in a world-wide federation. It encourages and facilitates exchange of information and experience in the broad field of hospital and healthcare facility design, construction, engineering, commissioning, maintenance, and estate management. It arranges an International Congress every two years at different locations, in conjunction with a healthcare trade exhibition. The reports of the papers presented at these congresses are sources of information on many topics, such as sterilization, air flow control, waste management, equipment safety, etc. The IFHE also publishes a newsletter.

International Federation of Infection Control (IFIC)
North Manchester General Hospital, Delaunays Road, Crumpsall, Manchester, M8 6RB, UK
Website: www.ific.narod.ru/

International Federation of Sterile Supply (IFSS)
7 Kendal Drive, Beeston Fields, NG9 3AW, UK
Tel: 44 115 9256364, fax: 44 115 9256364, email: GillianSills@aol.com, website: www.ifssonline.com

Isopharm Sentry Ltd
The Validation Centre, Millindale, Rotherham, South Yorkshire, S66 7LE, UK
Tel: 44 1709 811460, fax: 44 1709 813535, email: sales@isopharm-sentry.com, website: www.sentry-products.co.uk
Supplier of a wide range of validation, testing, and commissioning equipment used with items such as sterilizers, washer/disinfectors, and medical gas pipelines.

Malaria Consortium
The original Malaria Consortium (the joint partnership between the Liverpool School of Tropical Medicine and the London School of Hygiene and Tropical Medicine) is no longer operating under that name. However, the report of its programme, its publications, and continuing projects can be accessed on website: www.liv.ac.uk/lstm/malaria/. There is a new NGO called the Malaria Consortium, which is pursuing similar issues, such as insecticide treated net projects. It can be accessed on website: www.malariaconsortium.org.

Medical Research Council South Africa (MRC-SA)
PO Box 19070, 7505 Tygerberg, South Africa
Tel: 27 21 9380911, fax: 27 21 9380200, email:info@mrc.ac.za, website: www.mrc.ac.za
The MRC-SA's mission is to improve the nation's health status and quality of life through relevant and excellent health research aimed at promoting equity and development. They have a WHO Collaborating Centre for Essential Technologies in Health, at website: www.mrc.ac.za/innovation/whocollaborating.htm

Medicine-hygiene-prevention publishing house (mhp Verlag GmbH)
Wiesbaden, Germany
Website: www.mhp-verlag.de
Produces a number of publications including the **Central service/Zentral sterilization** bilingual journal.

Medicines and Healthcare Regulatory Agency (MHRA)
Hannibal House, Elephant and Castle, London, SE1 6TQ, UK
Tel: 44 0207 972 8000, email: devices@mhra.gsi.gov.uk, website: www.mhra.gov.uk
Offers guidance, advice, and regulations on medical device quality, safety, performance, use, and standards.

Ministry of Health and Social Services, Namibia
Dr N Forster, Under Secretary: Health and Social Welfare Policy, Private Bag 13198, Windhoek, Namibia
Email: nforrster@mhss.gov.na

MSc Envirohealth Products
25 Reedbuck Crescent, Corporate Park, PO Box 506, 15 Randjesfontein, Midrand 683, South Africa
Tel: 27 11 314 7540, fax: 27 11 314 7535, email: scaine@mweb.co.za
Contact for further information about the Medcin 400 Gas Incinerator, a pre-assembled incinerator designed for rural and small-scale healthcare waste management.

Olympus Microscopes, UK
Scientific Divisions, Great Western Industrial Park, Dean Way, Southall, Middlesex, UB2 4SB, UK
Tel: 44 207 253 2772, fax 44 207 251 6330, email: info@olympus.uk.com, website: www.olympus.co.uk
Manufacturer of microscopes and other optical equipment with bases around the world. Source of microscope training video.

PAHO (Pan American Health Organization)
Pan American Sanitary Bureau, Regional Office of the World Health Organization, 525 Twenty-third Street, N.W. Washington, D.C. 20037, USA
Tel: 1 202 974-3000, fax: 1 202 974-3663, website: www.paho.org/
The Pan American Health Organization (PAHO) is an international public health agency working to improve health and living standards of the countries of the Americas. It also serves as the Regional Office for the Americas of the World Health Organization.Antonio Hernandez is the contact for healthcare technology issues, email: 1hernana@paho.org

RIVM (Dutch Institute of Public Health and the Environment)
Laboratory for Medicines and Medical Devices, Dept. LGM, Postbak 50, Postbus 1, 3720 BA, Bilthoven, The Netherlands
Tel: 31 30 2749111, fax: 31 30 2742971, email: info@rivm.nl,
website: www.rivm.nl/sector4/lgm/index.html
Amongst other topics, this organization has undertaken research on the performance of manually operated sterilizers.

RS Components Ltd.
Birchington Road, Corby, Northants, NN17 9RS, UK
Tel: 44 1536 201234, fax: 44 1536 405678, email: general@rs-components.com, website: rswww.com
Supplier of equipment, supplies, parts, and components for a wide range of engineering professions such as electrical, electronic, mechanical, heating, ventilation, air-conditioning, plumbing, welding, pneumatics, computing, automotive. Also a source of textbooks, technical data books, technical literature, and training videos for all these engineering fields.

Source (International Information Support Centre)
The Wellcome Trust Building, Institute of Child Health, 30 Guildford Street, London, WC1N 1EH, UK
Tel: 44 20 7242 9789 ext 8698, fax: 44 20 7404 2062, email: source@ich.ucl.ac.uk, website: www.asksource.info
The Source Centre has a unique collection of over 20,000 health and disability related information resources. These include books, manuals, reports, posters, videos, and CD-Roms. Many materials are from developing countries and include both published and unpublished literature.

Swiss Centre for Development Cooperation in Technology and Management (SKAT).
Website: www.skat.ch/dc/publ/publ.htm
SKAT works internationally in the areas of water and sanitation, architecture and building, transport infrastructure, and urban development. They also publish the **SKAT newsletter**.

Swiss Centre for International Health (SCIH)
Swiss Tropical Institute, Socinstrasse 57, PO Box, CH-4002 Basle, Switzerland
Tel: 41 61 284 82 79, fax: 41 61 271 86 54, email: martin.raab@unibas.ch,
website: www.sti.ch/francais/scih/scih.htm
Undertakes consultancies in healthcare technology management in developing countries and countries in transition.

TALC (Teaching Aids at Low Cost)
PO Box 49, St. Albans, Herts, AL1 5TX, UK
Tel: 44 1727 853869, fax: 44 1727 846852, email: talc@talcuk.org, website: www.talcuk.org/
UK registered non-profit charity specialising in supplying affordable books, slides and teaching aids on health and community issues in developing countries, with a particular focus on materials for PHC and district levels.

Third World Network
Email: twnet@po.jaring.my, website: www.twnside.org.sg
The Third World Network is an independent non-profit international network of organizations and individuals involved in development issues. Its website offers articles and position papers on a variety of subjects related to developing countries, including trade, health, biotechnology and bio-safety.

Transaid (Transport for Life)
137 Euston Road, London, NW1 2AA, UK
Tel: 44 20 7387 8136, fax: 44 20 7287 2669, email: info@transaid.org, website: www.transaid.org
A charity working in the field of international transport management. Thus unique organization works with many sectors, including health, to ensure that transport resources are efficiently and effectively used. Their aim is to develop local capacity in transport and logistics management. They produce a newsletter **Hub and spoke**, and have developed the **Transaid transport management handbook**.

Tropical Health Technology (THT)
14 Bevills Close, Doddington, March, Cambridgeshire PE15 OTT, UK
Tel: 44 1354 740825, fax: 44 1354 740013, email: thtbooks@tht.ndirect.co.uk,
website: www.tht.ndirect.co.uk
Charity concerned with supporting and improving laboratory services in the developing world. Primary focus is laboratory services, information and technology. Specializes in supply of laboratory equipment, books, bench aids, slide sets and microscopes.

UNAIDS
20 Avenue Appia, CH-1211 Geneva 27, Switzerland
Tel: 41 22 791 3666, fax: 41 22 791 4187, email: unaids@unaids.org, website: www.unaids.org
The joint UN programme on HIV/AIDS, publishes an extensive range of materials, including practical and technical guidelines. For information about programmes and activities and materials, contact country-based staff.

UNICEF (United Nations Children's Fund)
UNICEF House, 3 UN Plaza, New York 10017, USA
Tel: 1 212 326 7000, fax: 1 212 887 7454, email: jando@unicef.org, website: www.unicef.org
It provides a wide range of resource materials, journals, books, videos, games and posters for children's programmes. Your regional or field office will offer advice on all aspects of child health care and UNICEF materials – contact details are on the website. UNICEF's **Supply Catalogue** (formerly the UNIPAC catalogue) lists products with their specifications under categories such as: immunization and cold chain; medical devices and kits; water, environment, sanitation and engineering; education, communication; etc. View it online at www.supply.unicef.dk/Catalogue. The goods are supplied by the UNICEF Supply Division, UNICEF Plads, Freeport, 2100 Copenhagen OE, Denmark. Tel: 45 3527 3527, fax: 45 3526 9421, email: supply@unicef.org.

Voluntary Service Overseas (VSO), and VSO Books
317 Putney Bridge Road, London, SW15 2PN, UK
Tel: 44 20 8780 2266, email: webteam@vso.org.uk, website: www.vso.org.uk
A UK-based charity with worldwide experience of providing skilled volunteers for work overseas, including workers in the fields of medicine, hospital engineering, and associated technical services. VSO Books publishes practical books about specific areas of development, using the professional experience of volunteers.

World Bank (WB)
www.worldbank.org
One of the world's largest sources of development assistance including health, nutrition and population projects

World Council of Churches (WCC)
PO Box 2100, 1211 Geneva, Switzerland
Tel: 41 22 791 6111, fax: 41 22 791 0361, email: info@wcc-coe.org, website: www.wcc-coe.org
International fellowship of churches that produces publications and newsletters.
Recent publications include **Guidelines on medical equipment donations**.

World Health Organization (WHO)
20 Avenue Appia, CH-1211 Geneva 27, Switzerland
Tel: 41 22 791 2476 or 2477, fax: 41 22 791 4857, website: www.who.int/en/
WHO offers advice, and undertakes programmes, on all aspects of health care. Contact your regional or field office for advice on all aspects of health care and WHO materials – the addresses of the regional offices worldwide are available on the website.

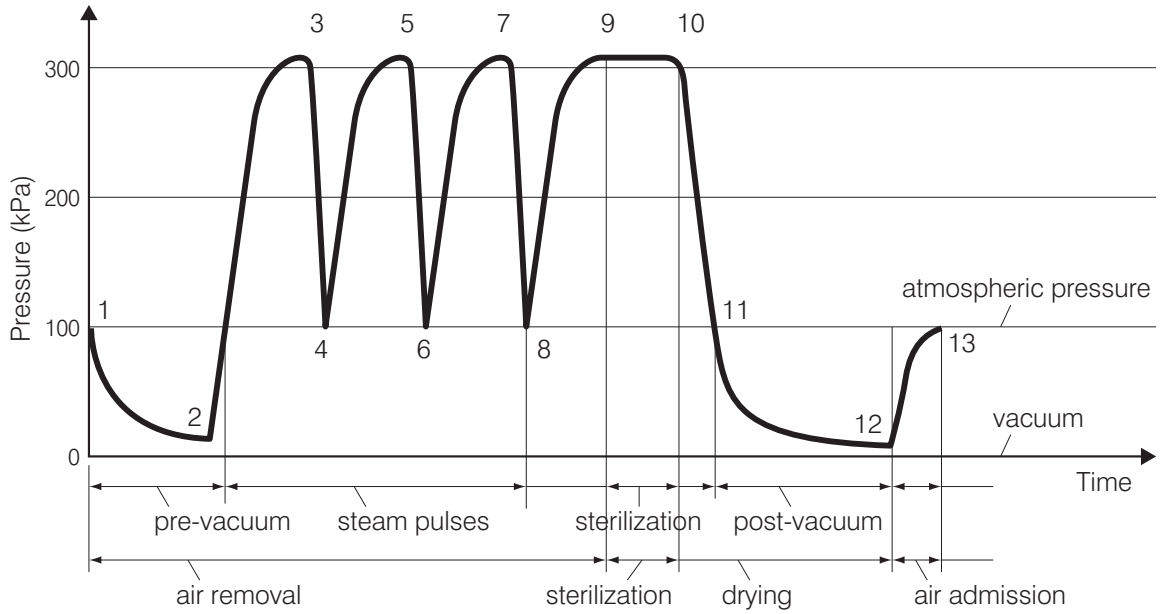
i. WHO has programmes and literature on many aspects of healthcare technology management. Andrei Issakov, Coordinator of Health Technology and Facilities Planning and Management, is the contact, and source of WHO literature on healthcare technology management that is not available as published documents, email: issakova@who.int.
ii. WHO produces and distributes books, manuals, journals, practical guidelines and technical documents, several include aspects of healthcare technology management. The Distribution and Sales Office is the contact point for information on WHO publications, email: publications@who.ch, website www.who.int/publications/en. To order WHO publications use email: bookorders@who.int.
iii. WHO has a comprehensive library and information service on international public health literature. Contact email: library@who.int. The WHO library catalogue has electronic access to more than 4000 technical documents, use website: www.who.int/library.
iv. WHO produces many newsletters, for a list contact website: www.who.int/library/reference/information/newsletters/index.en.shtml

Ziken International Consultants Ltd
Causeway House, 46 Malling Street, Lewes, East Sussex BN7 2RH, UK
Tel: 44 1273 477474, fax: 44 1273 478466, email: info@ziken.co.uk, website: www.ziken.co.uk
A consultancy organization working worldwide in many aspects of health care development, including healthcare technology management.

For information on the wide range of international professional bodies representing different aspects of clinical and hospital engineering, see *Guide 1 or 5*.

ANNEX 3: PROCESS PROFILE FOR COMMON STERILIZERS

Figure 21: Example of a Process Profile Common to Many Sterilizers



Notes:

1. Typical profile for a sterilization process by steam for porous loads.
2. The sterilizer should be equipped with a vacuum system for creating the pre- and post-vacuum.
3. Timing: air-removal by pre-vacuum (5 minutes), then three pulses, followed by 10 minutes sterilization, and post-vacuum for drying (15 minutes).
4. It will be necessary to validate the process in your own sterilizer, with the most difficult load and packaging material.

Source: Huys J, 2003, 'Sterilization of medical supplies by steam, volume 1: General theory', 2nd edition, HEART Consultancy, Renkum, The Netherlands, ISBN: 90 75829 04

ANNEX 4: EXAMPLE OF A SUPPLIES ORDER FORM

Figure 22 shows a form that can be used when ordering supplies. It acts as both a requisition voucher for goods from stores and a record of the items issued. If the voucher is produced as a standard duplicate order book, then the information can be used both by the user department as a record of the goods ordered and by stores staff for stock management purposes.

Figure 22: Sample Store Requisition and Issue Voucher

Store Requisition and Issue Voucher

Health facility **Serial number**

Requesting department ..... Date.....

Requested by ..... (Officer) Authorized by ..... (Department Head)

	Stores code No.	Description	Unit of issue	Quantity		Cost	
				Ordered	Supplied	Unit	Total
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
						Total cost	

Approved by ..... (Budget holder) Issued by ..... (Stores) Date .....

Copies: 1. Requesting department Collected by ..... (Requesting officer) Date.....
2. Stores file
3. Fast copy (remains in book)

ANNEX 5: ENTERING ITEMS INTO THE STOCK CONTROL SYSTEM

Guide 3 on procurement and commissioning describes the procedures involved when you receive equipment supplies on site and undertake the Equipment Acceptance Process. The information here summarizes the steps involved:

- During the acceptance process, the Commissioning Team compiles the following information from the available contracts, packing lists, or invoices, in order to complete a 'Register of New Stocks' form for **each** new piece of equipment received, according to a standard format (see example in *Figure 23*):
  - Type of equipment.
  - Equipment name/model.
  - Name and address of manufacturer.
  - Name and address of supplier/agent if relevant.
  - Price of equipment.
  - Manufacturer's part numbers for ordering purposes.
  - Lists of all consumables, accessories, and spare parts received, including the quantity of each, the part numbers for ordering purposes, and the price of each.
- At the successful completion of the initial training sessions (this is the training of users and maintainers undertaken when new equipment arrives), the Commissioning Team issues the accessories and consumables for immediate use to the relevant user department, together with the new equipment.
- The Commissioning Team gives a copy of the Register of New Stocks form, and the remaining, unissued, items to the Stores Controller so that they can be entered into the stores system according to the standard procedure (*Section 6.2*).
- The Stores Controller sets up the correct stock cards (bin cards) so that the stores reordering system can come into effect automatically.
- The Stores Controller enters the stores code for each item on the Register of New Stocks form, and provides the relevant user departments and the HTM Manager with lists of the new items received and their stores codes for ordering purposes.
- The HTM Manager files the Register of New Stocks form with the stores codes in the relevant equipment files (see *Guide 5* on maintenance management), and provides this information to the Specification Writing Group if they need assistance with updating specifications and detailing future purchase contracts (see *Guide 3* on procurement and commissioning).
- The stocks of equipment accessories, consumables, and spare parts should be issued and reordered according to the procedures given in *Sections 6.2 and 6.3*.

Register of New Stocks Form

To be completed by the Commissioning Team						*To be completed by the Stores Controller*
Type of stock	**Description**	**Part number**	**Quantity**		**Unit price (US $)**	**Stores Code**
			Expected	**Arrived**		
1. Equipment Type: Manufacturer: Local supplier:	 Single-bottle Suction pump, model: VP25 Eschmann Bros and Walsh Ltd Address: Peter Road, Lancing, West Sussex, BN15 8TJ, UK Tel: 00 44 1903 753322, Fax: 00 44 1903 767841 None	 82-157-07	 3	 3	 715.00	
2. Accessories and consumables already given to users during commissioning	Polysulfone jars, two-litre Rubber type jar top assembly Sealed disposable bacterial filter Connecting tube Right-angled connector	744093 743057	3 3 6 3 3	3 3 6 3 3	68.35 62.16	
3. Consumables	Sealed disposable bacterial filter (4 x box of 10)	82-961-70	3	3	62.40	
4. Spare parts	Disposable hydrophobic filters Suction tubing, anti-static neoprene 6.35mm id (per metre) Fuse 2-Amp delay 034-342 Jar top assembly (VP458) Filter assembly 3413/Y Vacuum control valve Vacuum gauge Semi rotary switch green new type Poly jar Right-angled connector (filter to tube) 'O'-ring Diaphragm Valve assembly Plate, upper diaphragm Connector, inlet/exhaust Plate, lower diaphragm Screw M6 x 57 Float valve cage assembly Valve seat, rubber, float valve Tubing, neoprene 6.53mm id (per metre)	 82-929-14 696766 712954 711776 712949 743077 696499 744093 745261 743044 745259 743043 745258 745267 743042 733589 733506 710828	9 6m 6 3 6 3 4 10 4 2 4 2 2 2 2 2 4 6m	9 6 6 3 6 0 3 0 4 10 0 0 0 0 0 0 0 0 0 0	 3.75 1.85 86.95 15.40 1.50 33.60 16.85 68.35	

Figure 23: Example of a 'Register of New Stocks' Form

ANNEX 6: SAFETY AND CALIBRATION TESTING INSTRUMENTS

Some instruments provide basic tests, while others are designed for more complex procedures. *Box 64* provides some advice on the types of test instruments required, which are bench-top instruments. Not every HTM Team or workshop needs all of them: it will depend on the skill levels of the staff. However, anyone maintaining or repairing medical equipment needs some form of medical equipment safety tester – either a basic one made from common bench tools or a commercially available product for comprehensive testing. Other smaller hand tools used for testing purposes are included in the regular tool kits for maintenance staff – see *Guide 5* on maintenance management.

BOX 64: Example of Safety and Calibration Testing Instruments by Type of Work and Skill Level

Type of work	Instrument	Skill level
Electrical	insulation tester ('megger' meter) mains socket wiring tester phase tester	Basic
	continuity tester three-phase tester	Specialist
Electronic	multimeter	Basic
	bench-top power supply counter/timer function generator oscilloscope	Specialist
Medical equipment	ammeter and earth break box (instead of MES tester) electronic thermometer standard mercury BP apparatus	Basic
	defibrillator analyzer/tester ECG simulator electro-surgical unit (ESU) analyzer medical electrical safety (MES) tester/analyzer[1,2] non-invasive BP monitor tester oxygen analyzer oxygen flow meter monitor patient simulator, multi-parameter, two-channel pH meter standards phosphorescent strip pressure/vacuum meter spectrophotometer standards X-ray line resistance meter X-ray mAs meter X-ray phantoms	Specialist

Continued opposite

BOX 64: Example of Safety and Calibration Testing Instruments by Type of Work and Skill Level (continued)

Type of work	Instrument	Skill level
Medical equipment	gas analyzer ultrasound therapy unit output (precision) test balance ventilator tester	Advanced specialist – very expensive and only required in the largest workshops

Note:

1. The medical electrical safety (MES) tester/analyzer should include an IEC 60101-1 test load
2. A portable appliance tester (PAT) could possibly be used instead of an MES – something is better than nothing. However, it cannot necessarily go down to the correct sensitivity for medical equipment or check for patient probe leakage. Use of a PAT requires specialist advice in order to be aware of its limitations.

ANNEX 7: MAINTENANCE WORK REQUEST/JOB FORM

Figure 24 shows an example of a form that can be used both to request maintenance work (by the user department or the HTM Manager), and to record the work undertaken (by the maintenance staff). Thus it keeps together the records of the request and the response made. Its multiple copies are filed by the user department and the HTM Team so that each can monitor progress with requests (see *Guide 5* on maintenance management).

Figure 24: Example of a Work Request/Job Form

Work Request/Job Form

Note: this is a triplicate form – 1st sheet is the User File copy
2nd sheet is the Maintenance Progress File copy
3rd sheet is the Equipment/Section History File copy

For User Department Only

Facility: _____ Date: _____

Location: _____

Person making request/In-charge (Full name, Position, Contact): _____

_____

Equipment task: _____ Inventory no. _____

Fault description: _____

_____

Equipment/Work order received by: _____ Date: _____

Equipment returned to (Full name): _____ Date: _____

For HTM Team Only

Allocated to: _____ Section: _____

Type of service: _____ PPM _____ Repair _____

Serial no. _____

Work undertaken: _____

_____

_____

Reasons for failure: wear and tear: _____ mains unstable: _____ dirt: _____

contamination (water, oil): _____ user error/handling: _____ faulty installation: _____

other (specify): _____

Materials used: _____ Quantity/Cost: _____

_____

_____

Test results: _____

Work time: _____ Travel time: _____

_____

Why not completed: _____

_____

Completed by: _____

Maintainer's signature: _____ Date: _____

ANNEX 8: TYPICAL EQUIPMENT LIFETIMES

Different organizations have tried to estimate typical equipment lifetimes for healthcare technology. This annex contains the results from two different sources – the American Hospital Association, and the GTZ (German Government Technical Aid Agency).

LIST 1: The American Hospital Association (AHA)

Source: American Hospital Association, 1998, 'Estimated Useful Lives of Depreciable Hospital Assets', American Hospital Association, Chicago, USA

The AHA's extensive list reflects how equipment lasts within the United States' healthcare system, whether it was manufactured in the US or abroad.

Their list was compiled following:

- discussions with manufacturers of healthcare equipment
- discussions with various hospital department managers
- analysis of actual retirement practices for actual hospital assets.

Their list is made up of a series of tables of different categories of equipment determined by the equipment's role in the health facility.

Part One: Estimated Useful Lives of Land Improvements, Buildings, and Fixed Equipment

Table 1: Land Improvements

Land improvements are assets of an above-ground or below-ground nature, found in the land area contiguous to and designed for serving a health care facility. The asset cost would include a proportionate share of architectural, consulting, and interest expense for newly constructed or renovated facilities.

Item	Years
Bumpers	5
Culverts	18
Fencing	
Brick or stone	25
Chain-link	15
Wire	5
Wood	8
Flagpole	20
Guard rails	15
Heated pavement	10
Landscaping	10
Lawn sprinkler system	15
Parking lot, open-wall	20
Parking lot gate/s	3
Parking lot striping	2
Paving (including roadways, walks,and parking)	
Asphalt	8
Paving (including roadways, walks, and parking) (continued)	
Brick	20
Concrete	15
Gravel	5
Retaining wall	20
Shrubs and lawns	5
Signs, metal or electric	10
Snow-melting system	5
Trees	20
Turf, artificial	5
Underground utilities	
Sewer lines	25
Water lines	25
Waste water treatment system	20
Water wells	25
Yard lighting	15

Table 2: Buildings

Buildings are structures consisting of building shell, exterior walls, interior framings, walls, floors, and ceilings. The asset cost would include a proportionate share of architectural, consulting, and interest expense for newly constructed or renovated facilities. In assigning the estimated useful lives in this table, the following factors were considered: the type of construction, the functional utility of the structure, recent regulatory or environmental changes, and the general volatility of the health care field.

Item	Years
Boiler house	30
Garage	
Masonry	25
Wood frame	15
Guardhouse	15
Masonry building, reinforced concrete frame	40
Masonry building, steel frame	
Fireproofed	40
Nonfireproofed	30
Masonry building, wood/metal frame	25
Metal-clad building	20
Multilevel parking structure	25
Reinforced concrete building, common design	40
Residence	
Masonry	25
Wood frame	25
Storage building	
Masonry	25
Metal garden-type	10
Wood frame	20

Table 3: Building Components

Building components are assets that are a part of the building shell or interior construction. The asset cost would include a proportionate share of architectural, consulting, and interest expense.

Item	Years
Canopies	15
Carpentry work	15
Caulking	5
Sealants	5
Ceiling finishes	
Acoustical	8
Gypsum	10
Plaster	12
Computer flooring	10
Corner guards	10
Cubicle tracks	10
Designation signs	5
Doors and frames	
Automatic	10
Hollow metal	20
Wood	15
Drapery tracks	10
Drilled piers	40
Floor finishes	
Carpet	5
Ceramic	20
Concrete	20
Hardwood	10
Floor finishes (continued)	
Quarry	20
Sealer	5
Terrazzo	15
Vinyl	10
Folding partitions	10
Loading dock bumpers and levelers	10
Magnetic/MRI shielding	10
Millwork	15
Overhead doors	10
Partitions, interior	15
Partitions, toilet	15
Railings	
Freestanding (exterior)	15
Handrails (interior)	15
Roof covering	10
Skylights	20
Storefront construction	20
Wall covering	
Paint	5
Wallpaper	5
X-ray protection	10

Table 4: Fixed Equipment

Fixed equipment includes assets that are permanently affixed to the building structure and are not subject to movement but have shorter useful lives than that of the building. The asset cost would include a proportionate share of architectural, consulting, and interest expense.

Item	Years	Item	Years
Benches, bins, cabinets, counters, and shelving, built-in	15	Laminar flow system	15
Cabinet, biological safety	15	Lockers, built-in	15
Canopy-ventilating for laundry ironer	15	Mailboxes, built-in	20
Central dictation system	10	Medicine preparation station	15
Coat rack	20	Mirrors, traffic and/or wall mounted	10
Conveyor system, laundry	10	Narcotics safe	20
Cooler, walk-in	15	Nurses' counter, built-in	15
Curtains and drapes	5	Pass-through boxes	15
Emergency generator set	20	Patients' consoles	15
Generator controls	12	Patients' wardrobes and vanities, built-in	15
Hood, fume	15	Projection screens	10
Fire protection in hoods	10	Sink and drainboard	20
ICU and CCU counters	15	Sterilizer, built-in	15
Illuminator		Telephone enclosure	10
Multifilm	10		
Single	10		

Table 5: Building Services Equipment (overleaf)

Building services equipment refers to mechanical components or systems designed for the building(s), including air conditioning, electrical elevators, heating lighting plumbing sprinklers, and ventilating. The asset cost would include a proportionate share of architectural, consulting and interest expense for newly constructed or renovated facilities.

Item	Years
Air-condition equipment	
Centrifugal chiller	15
Compressor, air	15
Condensate tank	10
Condenser	15
Controls	10
Cooler and dehumidifier	10
Cooling tower, concrete	20
Wood	10
Duct work	20
Fan, air-handling and ventilating	20
Metal	20
Piping	20
Precipitator	10
Pump	10
Air-conditioning system	
Large (over 20 tons)	10
Medium (5-20 tons)	10
Small (under 5 tons)	5
Air curtain	15
Antenna system	10
Boiler	20
Deaerator system	15
Boiler smokestack, metal	20
Clean-air equipment	15
Clock system, central	15
Co-generation plant, generator powered	15
Door alarm	10
Door-closing devices, for fire alarm system	15
Electric lighting and power	
Composite	18
Conduit and wiring	20
Emergency lighting system	15
Feed wiring	20
Fixtures	10
Switch gear	15
Transformer	30
Elevator	
Dumbwaiter	20
Freight	20
Passenger, high-speed automatic	20
Passenger, other	20
Emergency generator	20
Controls	12
Energy management system, computer based	10
Escalator	20
Fans, ceiling-mounted	10

Item	Years
Fire protection system	
Fire alarm system	10
Fire pump	20
Smoke and heat detectors	10
Sprinkler system	25
Tank and tower	25
Furnace, domestic	15
Heating, ventilating, and air conditioning (composite system)	15
Heat pump system	10
Humidifier	15
Incinerator, indoor	10
Insulation, pipe	15
Intercom system	10
Laboratory plumbing, piping	20
Magnetic door holders	10
Medical gas system (composite system)	15
Nurse call system	10
Oil storage tank	20
Oxygen, gas, and air piping	20
Paging system	20
Physicians' in-and-out register, built-in	10
Plumbing, composite	20
Fixtures	20
Piping	25
Pump	15
Pneumatic tube system	15
Radiator	
Cast-iron	25
Finned tube	15
Sewerage, composite	25
Piping	20
Sump pump and sewerage ejector	10
Solar heating equipment	10
Surge suppression system	15
Telephone system	10
Television antenna system	10
Television satellite dish	10
Temperature controls, computerised	10
Unit heater	10
Vacuum cleaning system	15
Water fountain	10
Water heater, commercial	10
Water purifier	10
Water softener	10
Water storage tank	20
Water wells	25

Part Two: Estimated Useful Lives of Major Movable Equipment

Major movable equipment is defined as assets that are generally assigned to a specific department within the health care facility, but with the capacity of being relocated. The assets have a minimum useful life of at least three years and a unit cost sufficiently large to justify the expense of maintaining an equipment ledger.

Note: Included within the departmental listings are assets that may be considered to be minor equipment (for example, surgical instruments with a three-year life assignment). Minor equipment may be defined as assets that are relatively small in size and unit cost and have high usage. They are generally found in the obstetrics, surgery, and dietary departments.

Table 6: Administrative Departments

Administrative Departments consist of administration, barber shop, board room, admitting, business office, communications, data processing, education, facilities management, finance, foundation, graphics, home health, human resources infection control, library, lobby, marketing, medical education, medical records, medical staff facilities, nursing administration, pastoral care, patient education, physician on-call rooms, public relations, quality assessment and improvement, social services, and volunteer services departments.

Item	Years
Beepers, paging	3
Bench, metal or wood	15
Binder, punch machine	10
Bookcase, metal or wood	20
Bulletin board	10
Cabinet file, metal or wood	15
Camera	5
Cathode-ray tube (CRT)	3
Chair	
Arm	15
Conference	15
Executive	15
Folding	10
Guest	15
Side	15
Check signer	10
Clock	10
Collator, electric	10
Computer	
Laptop	3
Large	5
Micro	5
Mini (personal)	3
Computer disk drive	5
Computer networking equipment	
Controller	5
Hub	5
Modem	5
Mux unit	5
Server	5
Token ring	5
Computer printer	5
Computer software	3
Computer terminal	5
Credenza	15
Data printing unit	5
Data storage unit	
Mechanical	10
Nonmechanical	15
Data tape processing unit (including controller, drive, and tape deck)	5
Desk, metal or wood	20
Dictating equipment	5
Display cases	20
Duplicator	5
Facsimile transmitter	3
Files	15
Electric rotary	15
Legal	15
Regular	15
Filing system, portable	20
Imprinter	
Address	5
Embossed plate	10
Integrator	10
Intercom	10
Label maker	10
Library furniture	20
Mailing machine	10
Microfilm unit	10

Continued overleaf

Table 6: Administrative Departments (continued)

Item	Years
Microphone	5
Microprojector	10
Organ	10
Paper burster	8
Paper cutter	10
Paper shredder	5
Paper shredder	5
Partitions, movable office	10
Photocopier	
Small	3
Large	5
Piano	20
Projector	
Overhead	10
Slide	10
Video	5
Recorder, tape	5
Safe	20
Scale, postal	10
Screen, projector	10
Settee	12
Shelving, portable, steel	20
Sofa	12
Stamp Machine	10
Stapler, electric or air	10
Stencil machine	10
Stereo equipment	5
Table	
Folding	10
Metal or wood	15
Television receiver	5
Time recording equipment	10
Transcribing equipment	5
Typewriter, electric	5
Valet, office	15
Video cassette recorder/player	5
Walkie-talkie	5
Water cooler, bottle	10
Word processor	
Large	5
Small	5
Work station	10

Table 7: Nursing Departments

Nursing departments consist of cardiac care, chemical dependency, intensive care, medical/surgical care, neonatal intensive care, nursery, pediatrics, pediatric developmental disabilities, and psychiatric units.

Item	Years
Bassinet	15
Bath	
Sitz	10
Whirlpool	10
Bed	
Birthing	15
Electric	12
Flotation therapy	10
Hydraulic	15
Labor	15
Manual	15
Orthopedic	15
Bench, metal or wood	15
Bin, metal or wood	15
Blood pressure device, electronic	6
Bookcase, metal	20
Cabinet	
Bedside	15
File	15
Instrument	15
Metal or wood	15
Pharmacy	15
Solution	15
X-ray	15
Central supply furniture	15
Chair	
Blood drawing	10
Dental	15
Executive	15
Folding	10
Geriatric	10
Hydraulic, surgeon's	15

Continued opposite

Table 7: Nursing Departments (continued)

Item	Years
Chair (continued	
Kinetron	15
Podiatric	15
Shower/bath	10
Specialist's	15
Chart rack	20
Chart recorder	10
Clothes locker	
Fibreglass or metal	15
Laminate or wood	12
Computer, caridial output	5
Credenza	15
Crib	15
Croupette	10
Defibrillator	5
Desk, metal or wood	20
Doppler	5
Dresser	15
Food service furniture	15
Frame, turning	15
Housekeeping furniture	15
ICU and CCU furniture	15
Infant care center	10
In-service education furniture	15
Insufflator	5
Labor and delivery furniture	15
Laboratory furniture	15
Lamp	
Bilirubin	10
Emergency	10
Lawn and patio furniture	5
Light	
Delivery	15
Examining	10
Portable, emergency	10
Natural childbirth backrest	10
Nursing service furniture	15
Operating room furniture	15
Operating stool	15
Ophthalmoscope	10
Osmometer	7
Otoscope	7
Ottoman	10
Patient monitoring equipment	10
Phototherapy unit	10
Physicians' in-and-out register, portable	10
Physiological monitor	7
Pump, breast	10
Scale, baby	15
Settee	12
Shelving, portable, steel	20
Sofa	12
Stall Bars	15
Table	
Anaesthetic	15
Autopsy	20
Electrohydraulic tilt	10
Examining	15
Folding	10
Food preparation	15
Fracture	15
Instrument	15
Light	15
Metal	15
Obstetrical	20
Operating	15
Orthopedic	10
Overbed	15
Pool	10
Refrigerated	10
Therapy	15
Traction	10
Urological	15
Wood	15
Telemetry unit, cardiac	5
Thermometer, electric	5
Ultrasonic fetal heart monitor	7
Work station	10

Table 8: Diagnostic and Treatment Departments

Diagnostic and treatment departments consist of ambulatory surgery, anesthesia, cardiac rehabilitation, catheterization laboratory, CT scan, ECT, EEG/EMG, emergency, employee health, enterostomal therapy, GI laboratory, hemodialysis, hyperbaric medicine, in vitro medicine, IV therapy, inpatient pharmacy, laboratory, lithotripsy, mobile air care, medical oncology, MRI, noninvasive cardiology, obstetrics, occupational therapy, physical therapy, postanesthesia care unit, radiation therapy, radiology, respiratory therapy, speech therapy, and surgery departments.

Item	Years
Accelerator	7
Alternating pressure pad	10
Amino acid analyzer	7
Amplifier	10
Anaerobe chamber	15
Analyzer, haematology	7
Anatomical model	10
Anesthesia unit	7
Ankle exerciser	15
Apnea monitor	7
Apron, lead-lined	47
Arthroscope	5
Arthroscopy instrumentation	3
Aspirator	10
Audiometer	10
Autoclave	10
Autoscaler, ionic	10
Bacteriology analyzer	8
Baci incinerator	5
Balance	
Analytical	10
Electronic	7
Precision mechanical	10
Basal metabolism unit	8
Bath	
Fluidotherapy	7
Paraffin	7
Serological	7
Water	7
Biochemical analysis unit	7
Biochromatic analyzer	7
Biofeedback machine	8
Biomagnetometer	7
Bipolar coagulator	7
Blood cell counter	5
Blood chemistry analyzer, automated	5
Blood culture analyzer	8
Blood gas analyzer	5
Blood gas apparatus, volumetrics	8
Blood transfusion apparatus	6
Blood warmer	7
Blood warmer coil	7
Bone surgery apparatus	3
Breathing unit, positive-pressure	8
Bronchoscope	
Flexible	3
Rigid	3
Carbon monoxide recorder/detector	10
Cardiac monitor	5
Cardioscope	8
Cart	
Emergency-isolation	10
Medicine	10
Caspar ACF instrument and plate system	7
Cassette changer	8
Cautery unit	
Dermatology	7
Gynecology	7
Cell freezer	7
Cell washer	5
Centrifuge	7
Centrifuge, refrigerated	5
Cerebral function monitor	7
Child immobilizer	15
Chloridiometer	10
Chromatograph, gas	7
Clinical analyzer	5
Clopay wrapping machine	10
Coagulation analyzer	5
Cold-pack unit, floor	10
Colonoscope	3
Colorimeter	7
Colposcope, with floor stand	8
Computer, clinical	5

Continued opposite

Table 8: Diagnostic and Treatment Departments (continued)

Item	Years
Computer-assisted tomography (CT) scanner	5
Conductivity tester	5
CO-oximeter	10
Cryoopthalmic unit, with probes	7
Cryostat	7
Cryosurgical unit	10
Cyclotron	7
Cystic fibrosis treatment system	10
Cystometer	10
Cystometrogram unit	10
Cystoscope	3
Decalcifier	10
Deionized water system	7
Densitometer, recording	5
Dental drill, with syringe	3
Dermatome	10
Diagnostic set	10
Diathermy unit	10
Digital fluoroscopy unit	5
Digital radiography unit	5
Diluter	10
Dispenser, alcohol	10
Distilling apparatus	15
Doppler	5
Dose calibrator	5
Dryer, sonic	10
Duodenoscope	3
Echocardiograph system	5
Echoview system	5
Electrocardiograph	7
Electrocardioscanner (Holter monitor scanner)	7
Electroencephalograph	7
Electrolyte analyzer	5
Electromyograph	7
Electrophoresis unit	7
Electrosurgical unit	7
Ergometer	10
Evacuator	10
Evoked potential unit	10
Exercise apparatus	15
Exercise equipment, outdoor	10
Exercise system, computer assisted	5
Exerciser, orthotron	10
Eye surgery equipment (phacoemulsifier)	7
Fibreoptic equipment	5
Fibrometer	7
Film changer	8
Film viewer	10
Flow cytometer	5
Fluid sample handler	5
Fluorimeter	10
Fluoroscope	8
Frame, turning	15
Furnace, laboratory	10
Gamma camera	5
Gamma counter	7
Gamma knife	10
Gamma well system	7
Gas analyzer	8
Gastroscope	3
Geiger counter	10
Generator	5
Gloves, lead-lined	3
Hand dynamometer	10
Heart-lung system	8
Heat sealer	5
Hemodialysis unit	5
Hemoglobinometer	7
Hemophotometer	10
High-density mobile film system	10
Holter	
Electrocardiograph	7
Electroencephalograph	7
Homogenizer	10
Hood, exhaust or Bacti	10
Hydrocollator	10
Hydrotherapy equipment	15
Hyfrecator	10
Hyperbaric chamber	15
Hypothermia apparatus	10
Image analyzer	5

Continued overleaf

Table 8: Diagnostic and Treatment Departments (continued)

Item	Years
Image intensifier	5
Immunodiffusion equipment	10
IMX analyzer	7
Incubator, laboratory	10
Inhalator	10
Intraarterial shaver	10
Iontophoresis unit	8
Isodensitometer	7
Isolation chamber	12
Isotope equipment	7
Isotope scanner	7
Kiln	10
K-pads	5
Kymograph	10
Lamp	
Deep-therapy	10
Infrared	10
Mercury quartz	10
Slit	10
Laparoscope	3
Laryngoscope	3
Laser, coronary	2
Laser, surgical	5
Laser positioner	5
Laser smoke evacuator	5
Lifter, patient	10
Linac scalpel	5
Linear accelerator	7
Lithotripter, extracorporeal shock-wave (ESWL)	5
Magnetic resonance imaging (MRI) equipment	5
Mammography unit	
Fixed	5
Mobile (van)	8
Marograph	7
Mass spectrophotometer	7
Microbiology analyzer	8
Microscope	7
Microtome	7
Microtron power system	7
Mirror, therapy	15
Muscle stimulator	10

Item	Years
Nebulizer	
Pneumatic	10
Ultrasonic	10
Nephroscope	7
Neurological surgical table headrest	10
Neutron beam accelerator	8
Noninvasive CO2 monitor	7
Optical readers	5
Orthotron system	10
Orthourological instruments	10
Oscilloscope	7
Oven	
Paraffin	10
Sterilizing	10
Oximeter	10
Oxygen analyzer	7
Oxygen tank, motor, and truck	8
Pacemaker, cardiac (external)	5
Pacing system analyzer	7
Panendoscope	10
Parallel bars	15
Pelviscope	7
Percussor	5
Perforator	10
Peripheral analyzer	10
pH gas analyzer	10
pH meter	10
Phonocardiograph	8
Photocoagulator	10
Photography apparatus, gross pathology	10
Photometer	8
Physioscope	10
Pipette, automatic	10
Plasma freezer	10
Platelet rotator	20
Positron emission tomography (PET) scanner	5
Proctoscope	3
Prothrombin timer, automated	8
Proton beam accelerator	7
Pulmonary function analyzer	8

Continued opposite

Table 8: Diagnostic and Treatment Departments (continued)

Item	Years
Pulmonary function equipment	8
Pulsed oxygen chamber	10
Pulse oxymeter	7
Pump	
Infusion	10
Stomach	10
Suction	10
Surgical	10
Vacuum	10
Radiation meter	8
Radioactive source, cobalt	5
Radiographic duplicating printer	8
Radiographic-fluoroscopic combination	5
Radiographic head unit	5
Rate meter, dual	10
Refractometer	10
Refrigerator, blood bank	10
Resuscitator	10
Retractor	5
Rhinoscope	3
Rinser, sonic	10
Rotoosteotome unit	10
Saw	
Autopsy	10
Neurosurgical	10
Surgical, electric	10
Scale	
Bed	10
Chair	10
Clinical	10
Scale, metabolic	10
Scintillation scaler	8
Sensitometer	10
Seriograph, automatic	8
Shaking machine (vortexer)	8
Sharpener, microtome knife	10
Sigmoidoscope	3
Signal-averaged EKG	5
Simulator	5
Single-photon emission computed tomography (SPECT) Scanner	5
Sinuscope	7
Skelton	10

Item	Years
Slide stainer, laboratory	7
Spectrophotometer	8
Spectroscope	10
Sphygmomanometer	10
Spirometer	8
Stand	
Basin	15
Intravenous	15
Irrigating	15
Mayo	15
Steam-pack equipment	10
Stereo tactic frame	5
Sterilizer, movable	12
Steris sterilization system	7
Stethoscope	5
Stress tester	10
Stretcher	10
Hydraulic	7
Surgical shaver	5
Tank	
Cleaning	10
Full-body	15
Hot-water	10
Therapy	15
TDX analyzer	7
Telemetry unit, cardiac	5
Telescope, microlens	10
Telescopic shoulder wheel	15
Telethermometer	10
Tent	
Aerosol	8
Oxygen	8
Thyroid uptake system	5
Tissue-embedding center	8
Tissue processor	7
Titrator, automatic	10
Tonometer	10
Totalap	10
Tourniquet, automatic	10
Tourniquet system	7
Traction unit	10
Transcutaneous nerve stimulator system	5
Transesophageal transducer	5

Continued overleaf

Table 8: Diagnostic and Treatment Departments (continued)

Item	Years
Treadmill, electric	8
Tube dryer	10
Tube tester	10
Ultrasound, diagnostic	5
Ultrasound unit, therapeutic	7
Vacuvette	10
Ventilator, respiratory	10
Vial filler	10
Vibrator	10
Video	
Camera	5
Light source	5
Monitor	5
Printer	5
Wheelchair	5
X-ray equipment	
Developing tank	10
Film dryer	8
Film processor	8
Furniture	15
Image intensifier	5
Intensifying screens	5
Silver recovery unit	7
X-ray unit	
Fluoroscopic	5
Mobile	5
Radiographic	5
Superficial therapy	5
Tomographic	5
Wiring	5

Table 9: Support Departments

Support departments consist of biomedical engineering, central sterile supply, dietary, engineering/maintenance, housekeeping/environmental services, laundry, materials management, security, and staff facilities departments.

Item	Years
Air conditioner, window	5
Ambulance	4
Automobile	
Delivery	4
Passenger	4
Battery charger	5
Bedpan washer	15
Blanket dryer	15
Blanket warmer	15
Bottle washer	10
Broiler	10
Burnisher, silverware	15
Cage, animal	10
Camera, identification	5
Camera, surgical	5
Camera, television monitoring, color or black-and-white	5
Camera, videotape, color or black-and-white	5
Can opener, electric	10
Capsule machine	10
Cart	
Food/tray, heated-refrigerated	10
Linen	10
Maid	10
Supply	10
Utility	10
Cash register	5
Central data processing unit	10
Clock	10
Coffee maker	5
Compactor, waste	10
Compressor, air	12
Conveyor, tray	10
Cooker, pressure, for food	10
Cooler, walk-in, freestanding	15
Cutter, cloth, electric	10
Cutter, food	10
Dish sterilizer	10
Dishwasher	10
Disinfector	15

Continued opposite

Table 9: Support Departments (continued)

Item	Years
Dispenser	
Butter, refrigerated	10
Milk or cream	10
Drill press	20
Dryer	
Clothes	10
Hair	5
Drying oven, paint shop	10
Enlarger	10
Extractor, laundry	15
Floor-buffing and polishing machine	5
Floor-scrubbing machine	5
Floor-waxing machine	5
Folder, flatwork	15
Food chopper	10
Freezer, ultracold	10
Fryer, deep-fat	10
Garbage disposal, commercial	5
Glassware washer	8
Griddle	10
Grinder, food waste	10
Helicopter	4
Hoist, chain or cable	15
Hot-food box	15
Hotplate	5
Humidifier	8
Ice cream freezer	10
Ice cream (soft) machine	10
Ice cream storage cabinet	10
Ice cube-making equipment	10
Indicator, remote	10
Intercom	10
Ironer, flatwork	15
Kettle, steam-jacketed	15
Key machine	10
Laminator	10
Lathe	15
Lawn mower, power	3
Linen press	15
Linen table	15
Linen washer	15
Lint collector	15
Loom	15
Lowerator	10
Mannequin	10
Marking machine	10
Meat chopper	10
Mixer, commercial	10
Nourishment ice station	8
Oven	
Baking	10
Microwave	5
Roasting	10
Packaging machine	10
Platform	12
Paint spray booth	15
Paint-spraying machine	10
Paper baler	15
Parking lot sweeper	5
Pipe cutter-threader	10
Planer and shaper, electric	10
Plate-bending press	10
Platemaker	
Computerized	5
Noncomputerized	10
Popcorn machine	8
Power supply	10
Press, laundry	15
Printing press	10
Range, domestic	10
Refrigerator	
Domestic	8
Commercial	10
Undercounter	10
Remote control receiver	10
Rotary tiller	10
Sanitizer	10
Saw	
Band	10
Bench, electric	10
Meat-cutting	10
Scaffold	10
Scale, laundry	
Movable	10
Platform	15

Continued overleaf

Table 9: Support Departments (continued)

Item	Years
Sewing machine	15
Shears, squaring, floor	12
Shoulder wheel	20
Simulator	5
Slicer	
Bread	10
Meat	10
Snowblower	5
Steamer, vegetable	10
Telephone, cordless	5
Telephone equipment for deaf	5
Telephone monitors	10
Telephone system	10
Television monitor	5
Television receiver	5
Toaster, commercial	10
Tractor	10
Truck (automotive)	
Forklift	10
Multipurpose filling	15
Pickup	4
Van	4
Truck (hand)	
Hot-food	10
Tray	12
Ultrasonic cleaner	10
Urn, coffee	10
Vacuum cleaner	8
Vegetable peeler, electric	10
Vending machine	10
Vise, large bench	20
Warmer	
Dish	10
Food	10
Washing machine	
Commercial, small	10
Domestic	10
Linen, large	15
Welder	10
Wire tightener-twister	10

LIST 2: The GTZ (German Government Technical Aid Agency)

Source: Halbwachs, H (GTZ), 2000, 'Maintenance and the Life Expectancy of Healthcare Equipment in Developing Economies', in *Health Estate Journal*, March 2000, pp 26-31

The GTZ list contains estimates for fewer equipment items, but it more closely reflects the realities in developing countries.

The GTZ used a particular research method (a Delphi survey – see source paper) to obtain and analyze feedback from 23 experts from 16 different country backgrounds. The experts were made up of hospital engineers, bio-medical engineers, a public health doctor/manager, health physicists, and an health economist. Rather than providing exact lifetimes, this approach provides a range for the lifetime that depends on the quality of the initial equipment and how well it has been maintained.

Reproduced here is a table containing a summary of their findings.

Table Summarizing GTZ's Findings

Equipment type	Lifetime in years			
	Poor quality makes		Good quality makes	
	Poorly maintained	Well maintained	Poorly maintained	Well maintained
Air-conditioner (window type)	3	5 – 7	5 – 6	10 – 12
Anaesthetic machine (Boyles)	2 – 5	5 – 10	5 – 10	10 – 15
Centrifuge	3 – 4	7 – 8	6 – 9	10 – 12
Generator (diesel)	3 – 6	9 – 10	10 – 12	18 – 20
Generator (petrol)	2 – 5	5 – 10	6 – 15	10 – 20
Microscope	3 – 6	5 – 10	6 – 10	10 – 20
Oven, hot air (laboratory)	2 – 6	5 – 8	6 – 10	10 – 15
Refrigerator (electrical)	3 – 5	5 – 8	5 – 8	10 – 15
Refrigerator (kerosene)	4	4 – 8	5 – 10	10 – 17
Sphygmomanometer (aneroid)	1 – 3	2 – 3	2 – 5	5 – 10
Sphygmomanometer (mercury)	1 – 2	3 – 5	3 - 5	8 – 10
Sterilizer, bench-top (horizontal)	3 – 5	5 – 8	6 – 10	10 – 14
Sterilizer, floor-standing (vertical)	3 – 6	5 – 12	8	14 – 15
Suction pump (electrical)	1 – 3	5 – 7	5 – 8	10 – 15
Truck, pick-up	2 – 4	3 – 6	4 – 8	7 – 12
Washing machine (electrical)	2 – 4	5	6	8 – 11

ANNEX 9: FORM FOR REGISTERING WRITTEN-OFF EQUIPMENT

Figure 25 shows a form that can be used to register when equipment is condemned and written-off. It acts as both a record for the health facility to take the item off their inventory, and a record for the Board of Survey to organize the destruction or disposal of the item in an appropriate way.

Figure 25: Example 'List of Expendables to be Written Off' Form

List of Expendables to be Written Off

Board of Survey **Serial number**

List of expendable items in charge of ..... (department), at ..... (health facility)

which have been broken,damaged, or become permanently unserviceable through fair wear and tear during the period from (1) ..... to (2) .....

	Description of article broken, damaged or unserviceable	Number	Original cost, if known, or estimated original cost	Explanation	Opinion of maintenance staff in charge on condition	Decision of Head of Department regarding disposal/ destruction
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
		Total cost				

Authorised by ..... and ..... Processed by .....

(Department Head) (Maintainer in charge) (Stores)

Disposed of/destroyed by ..... Date .....

(Board of Survey)

ANNEX 10: SOURCE MATERIAL/BIBLIOGRAPHY

Albert Browne International Ltd, 1996, 'TST technology data sheets: assorted', Browne sterilisation monitoring systems', Albert Browne International Ltd, Cowfold, UK

Albert Browne International Ltd, 1997, 'Browne sterilisation monitoring systems', Albert Browne International Ltd, Cowfold, UK

American College of Clinical Engineering, 2000, 'The role of health care technology in enhancing patient safety by reducing medical errors in medicine', ACCE White Paper: Draft 2, ACCE, Plymouth Meeting, USA

American Society for Hospital Engineering, 1998, 'Estimated useful lives of depreciable hospital assets', 2nd edition, American Hospital Association, Chicago, USA

Amonoo-Larston R, Ebrahim G, Lovel H, and J Rankeen, 1996, 'District health care: Challenges for planning, organization and evaluation in developing countries', 2nd edition, Macmillan, ISBN: 0 333 57349 8

Berg H, 1992, 'Medical equipment in developing countries: Two neglected issues – planning and financing', WHO Document WHO/SHS/CC/92.2, WHO, Geneva

Bloom G H, and C L Temple-Bird, 1988, 'Medical equipment in sub-saharan Africa: A framework for policy formulation', IDS Research Report Rr19, and WHO publication WHO/SHS/NHP/90.7, ISBN: 0 903354 79 9

British Medical Association, 1989, 'Code of practice for sterilisation of instruments and control of cross infection', BMA London, UK, ISBN 0 7279 0274 1

CEN, 'European Norm (EN) 285: Steam sterilizers – large sterilizers', Committee European de Normalisation, www.cenorm.be

CEN, 'European Norm (EN) 554: Sterilization of medical devices – validation and routine control of sterilization by moist heat', Committee European de Normalisation, www.cenorm.be

Centers for Disease Control and Prevention, USA (CDC) website: www.cdc.gov

Collins C (ed), 1988, 'Safety in clinical and biomedical laboratories', Chapman and Hall, London, UK, ISBN: 0 412-28370-0

Cripps N, 1990, 'Sterilization in UK hospitals', in *11th IFHE Congress 1990*, International Federation of Hospital Engineering

David Y, and T Judd, 1993, 'Medical technology management', BioPhysical Measurement Series, SpaceLabs Medical Inc., Washington, USA, ISBN: 0 9627449 6 4

Deller A., 1990, 'Notes on electrosurgery', Centre for Medical Electronics, St.Bartholomew's Hospital, London, UK, unpublished

Deller A., 1994, 'Notes on electrical safety', Centre for Medical Electronics, St.Bartholomew's Hospital, London, UK, unpublished

ECHO, 2001, 'Medical supply catalogue 2001/02', ECHO International Health Services Limited, Coulsdon, UK

ECRI, 2005, 'Health devices alerts database', Emergency Care Research Institute Products, ECRI, Plymouth Meeting, USA

Elford J, 1992, 'How to look after a refrigerator', Healthlink (formerly AHRTAG), ISBN: 0 907320 07 4

Ellis J, 1999, 'Human resources policy and procedure manual: KANDO hospital management project', Ministry of Health Zambia/DFID, Ziken International Consultants Ltd, Lewes, UK

Eschmann, 1975, 'Matburn GX series operation table instruction manual', Eschmann Bros. and Walsh Ltd., Lancing, UK

Eschmann, 1980, 'DV110 series portable high/low vacuums surgical suction units: User handbook', Eschmann Bros. and Walsh Ltd., Lancing, UK

Eschmann, 1989, 'Sterilization techniques and cross-infection', Eschmann Bros and Walsh Ltd Equipment Division, Lancing, UK

Eschmann, 1990, 'J4 operation table instruction manual', Publication No. T-IM27A, Eschmann Bros. and Walsh Ltd., Lancing, UK

Eschmann, 1992, 'VP25 portable high vacuum suction unit: User handbook', Eschmann Bros. and Walsh Ltd., Lancing, UK

Eschmann, 1996, 'SES 2000 autoclave service manual ST-SM8', Eschmann Bros. and Walsh Ltd., Lancing, UK

European Committee for Electrotechnical Standardization (CENELEC) website: www.cenelec.org

European Committee for Standardization (CEN) website: www.cenorm.be

FAKT, 1995, 'The equipment management cycle: A new tool for planning health care technical services', FOCUS No.12, June 1995, FAKT, Stuttgart, Germany

Haddon B, 1995, 'Annual work planning', Paper 401 in *Making hospitals work better, volume II: Working papers on hospital management and organisation – KANDO hospital management project*, Ministry of Health, Zambia/DFID, Ziken International Consultants, Lewes, UK

Haddon B, 1995, 'Monitoring targets and work performance', Paper 402 in *Making hospitals work better, volume II: Working papers on hospital management and organisation – KANDO hospital management project*, Ministry of Health, Zambia/DFID, Ziken International Consultants, Lewes, UK

Halbwachs H, 1992, 'Health care equipment for developing countries: The conflict between needs and interests', GTZ, Eschborn, Germany

Halbwachs H, 1993, 'Maintenance and the district health system: Approach and perspectives', in *Maintenance for Health Systems: Report of the 4th GTZ Workshop in Dakar, Senegal, September 1993*, GTZ, Eschborn, Germany

Halbwachs H, 2000, 'Maintenance and the life expectancy of healthcare equipment in developing Economies', pp 26–31 in *Health Estate Journal*, March 2000

Halbwachs H, 2001, 'Physical assets management and maintenance in district health management' GTZ, Eschborn, Germany

Halbwachs H, and A Issakov (eds), 1994, 'Essential equipment for district health facilities in developing countries', GTZ, Eschborn, Germany

Halbwachs H, and R Werlein, 1993, 'Training health personnel to operate health-care equipment: How to plan, prepare and conduct user training – A guide for planners and implementors', GTZ, Eschborn, Germany

Health and Safety Executive, 1989, 'Essentials of health and safety at work', HMSO Books, London, UK, ISBN: 0 11 885494 1

Huys J, 1996, 'A guide to power conditioning and power back-up', produced by FAKT, Basler Mission, and HEART Consultancy, Stuttgart, Germany

Huys J, 2003, 'Sterilization of medical supplies by steam, volume 1: General theory', 2nd edition, HEART Consultancy, Renkum, The Netherlands, ISBN: 90 75829 04 3

International Electrotechnical Commission (IEC) medical electrical safety standards IEC 60101, website: www.iec.ch

Jantsch F, and H Vest, 1999, 'Management of solid and liquid waste at small healthcare facilities in developing countries', GATE-Information Service, Division 44: Environmental Management, Water, Energy, Transport, GTZ Eschborn, Germany

Johnstone P, and J Ranken, 1994, 'Management support for primary health care: A practical guide to management for health centres and local projects', FSG Communications Ltd, Cambridge, UK, ISBN: 1 87118 02 4

Kaur M, and S Hall, 2001, 'Medical supplies and equipment for primary health care: A practical resource for procurement and management', ECHO International Health Services Limited, Coulsdon, UK, ISBN: 0 9541799 0 0

Kwankam Y et al, 2001, 'Health care technology policy framework', WHO Regional Publications, Eastern Mediterranean Series 24: Health care technology management, No.1, ISBN: 92 9021 280 2

Lee P, 1995, 'Get it right!: A guide to maintenance, safety precautions and hygiene of medical equipment', draft, ECHO International Health Services Ltd, UK, unpublished

Linden E van der, 1996, 'MOHSS laundry services feasibility study: First draft – Namibia integrated health programme', Trend Line Economic and Management Services, Windhoek, Namibia

Maurer I, 1990, 'Hospital hygiene', 3rd Edition, Edward Arnold, London, UK, ISBN: 0 7131 4443 2

McGloughlin B, 1999, 'Finance and procurement policy and procedure manual: KANDO hospital management project', Ministry of Health Zambia/DFID, Ziken International Consultants Ltd, Lewes, UK

Medicines and Healthcare Regulatory Agency of the UK (MHRA) website: www.mhra.gov.uk

MHRA, 2005, 'Medical device alerts series', Medicines and Healthcare Regulatory Agency Products, MHRA, London, UK

Ministry of Health of Botswana, 1991, 'Central medical stores ordering lists 1991/1992', MOH, Gaborone, Botswana

Modi N, 1986, 'A guide to phototherapy for neonatal hyperbilirubinaemia', Air-Shields Vickers, Basingstoke UK

Muis B, Bruijn ACP de, Drongelen AW van, and J Huys, 2001, 'Optimalisation of the process for manually operated jacket steam sterilizers', RIVM report 318902011, RIVM/Dutch Institute for Public Health and the Environment, Bilthoven, The Netherlands

Neureiter J, and A Tschank, 1989, 'Technician's handbook for hospital engineering', Kenyan-Austrian Development Cooperation, Ministry of Foreign Affairs, Austria

Nikon, 1991, 'Alphaphot-2 YS2-H binocular microscope: User instruction manual', Nikon, Tokyo, Japan

Paton J, Green B, and J Nyamu, 1996, 'The division for the supply of medical spare parts in the health system of Kenya', Ministry of Health, Nairobi/GTZ, Eschborn, Germany

Pearson A, 1995, 'Medical administration for frontline doctors: A practical guide to the management of district-level hospitals in the public service or in the private sector', 2nd edition, FSG Communications Ltd, Cambridge, UK, ISBN: 1 871188 03 2

Picken D, and M Bennett, 2002, 'De Montfort University design of very low cost incinerators for emergency situations in developing countries', in *Collected papers of the seminar on appropriate medical technology for developing countries: 6 February 2002*, IEE Healthcare Technologies Professional Network, IEE, London, UK, Ref.No: 2002/057

Pruss A, Giroult E, and P Rushbrook, 1999, 'Safe management of wastes from health-care activities', WHO, Geneva, Switzerland

Remmelzwaal B, 1997, 'The effective management of medical equipment in developing countries: A series of five papers', FAKT, Stuttgart, Germany

Remmelzwaal B, and E de Villiers (eds), 2002, 'Where there is no technician: A practical guide for users of medical equipment', Ministry of Health and Social Services, Windhoek, Namibia

Röttjes M, 1995, 'If not in use – switch off!: Guidelines and key recommendations for a sustainable and cost-effective energy supply for health facilities in remote locations', FAKT, Stuttgart, Germany

Safe Injection Global Network (SIGN) website (2003): www.SIGN@who.int

Sages Engineering Consultants, 1999, 'Electrical survey of health facilities: Summary of report', Ministry of Health, Ghana/DFID, Sages, Accra, Ghana

Skeet M, and D Fear, 1995, 'Care and safe use of hospital equipment', VSO Books, London, UK, ISBN: 0 9509050 5 4

Temple-Bird C L, 1990, 'Equipment management course notes: Postgraduate diploma in medical electronics and medical equipment management', Department of Medical Electronics and Physics, Medical College of St. Bartholomew's Hospital, London, UK, unpublished

Temple-Bird C, 2000, 'Practical steps for developing health care technology policy', Institute of Development Studies, University of Sussex/Ziken International Consultants, Lewes, UK, ISBN: 1 85864 291 4

Temple-Bird C, Bbuku T, and the Equipment and Plant Sub-Group, 2000, 'Equipment management policies and procedures manual: KANDO hospital management project', Ministry of Health, Zambia/DFID, Ziken International, Lewes, UK

Temple-Bird C, Bbuku T, and F Kamanga, 1995, 'Proceedings of the planning workshop to develop maintenance systems: Annex V of the October 1995 consultancy report – KANDO hospital management project', Ministry of Health, Zambia/DFID, Ziken International Consultants, Lewes, UK

Temple-Bird C, and H Halbwachs (eds), 1991, 'Spare parts and working materials for the maintenance and repair of health care equipment: Report of workshop held in Lübeck, August 1991', GTZ, Eschborn, Germany

Temple-Bird C, and B Kidger, 1997, 'Technical assessment of medical equipment supplied under DFID assistance: Report of the May/June 1997 consultancy mission for the Ghana health sector aid programme', Ziken International Consultants Ltd, Lewes, UK

Visser P, 1995, 'Infection control', Paper 501 in *Making hospitals work better, volume II: Working papers on hospital management and organisation – KANDO hospital management project*, Ministry of Health, Zambia/DFID, Ziken International Consultants, Lewes, UK

Visser P, 1995, 'Sterile packing in the CSSD', Paper 502 in *Making hospitals work better, volume II: Working papers on hospital management and organisation – KANDO hospital management project*, Ministry of Health, Zambia/DFID, Ziken International Consultants, Lewes, UK

Ward C S, 1985, 'Anaesthetic equipment: Physical principles and maintenance', 2nd Edition, Baillière Tindall, London,UK, ISBN: 0 7020 1008 1

West of Scotland Health Boards, 1985, 'Acceptance and routine testing of medical electrical equipment', Test and Check Procedures Book 5, Physicare, Glasgow, UK

WHO, 1987, 'Interregional meeting on the maintenance and repair of health care equipment: Nicosia, Cyprus, 24-28 November 1986', Geneva, Switzerland, WHO/SHS/NHP/87.5

WHO, 1998, 'District hospitals: Guidelines for development', 2nd edition, WHO Regional Publications: Western Pacific Series No 4, Manila, Philippines, ISBN: 92 9061 117 0

WHO, 1994, 'Maintenance and repair of laboratory, diagnostic imaging, and hospital equipment', WHO, Geneva, Switzerland, ISBN: 92-4-154463-4

WHO, 2000, 'The world health report 2000: Health Systems – Improving Performance', WHO, Geneva, Switzerland, ISBN: 92 4 156198 X

WHO, 2004, Health care waste management website: www.healthcarewaste.org

WHO, Department of Health Service Provision, Presentation slides on healthcare technology management, WHO, Geneva, Switzerland

WHO, Expanded Programme on Immunisation (EPI), 1984, 'Logistics and cold chain for primary health care: Technician's handbook for compression refrigerators – Part D, How to keep stocks of spare parts', No 20, WHO, Geneva, Switzerland, EPI/LOG/84/20

WHO, Expanded Programme on Immunisation (EPI), 1984 – 1987, 'Refrigerator use, maintenance and repair series', WHO, Geneva, Switzerland, EPI/LOG/84/14 – 19,21,22,25,26 and EPI/TECH.HB/A – H

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