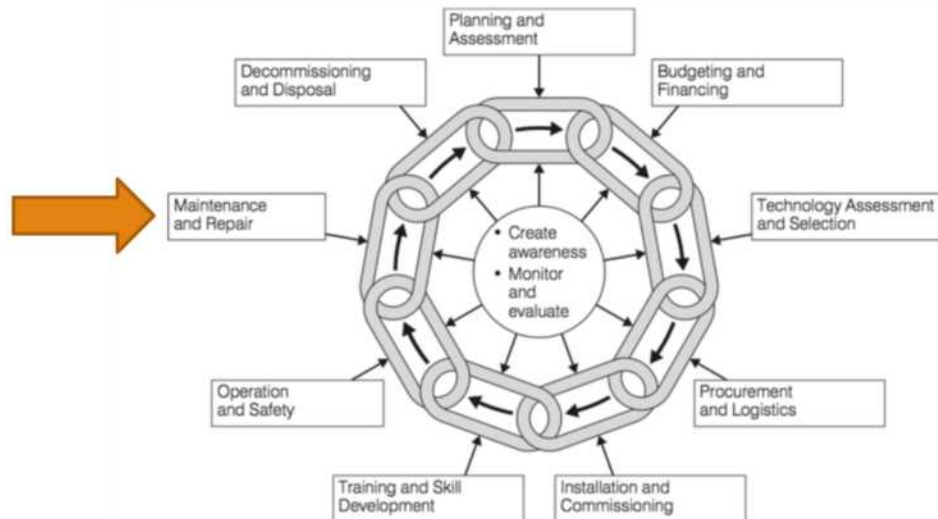


# Preventive Maintenance and Calibration

- Carry out preventive maintenance
- Write preventive maintenance procedures
- Manage maintenance (preventive) programs
- Ensure availability of preventive maintenance consumable and calibration kits
- Ensure availability of test equipment
- Calibrating test equipment
- Prepare record of works done on medical equipment



Unit B 9.5 Carrying out preventive maintenance and calibration of medical equipment

Module 279 09 B Medical Equipment Management and Maintenance

# Preventive maintenance: intro

PPM is a series of actions carried out on equipment with the aim of preventing breakdowns and ensuring the equipment is operational and safe.

PPM enables the HTM staff to:

- catch problems before they become crises
- prevent breakdowns
- save money, as PPM is cheaper than making repairs
- make sure that equipment is fully operational
- guarantee accuracy and reliability (the autoclave sterilizes, the laboratory results are correct)
- Increase availability of equipment and reduce downtime
- extend the life-span of equipment
- reduce equipment running costs
- **ensure the equipment is safe**, for patients, users, and

maintenance staff.



**Prevention is Better Than a Cure**

There is a great deal of paperwork involved if you want the PPM system to work, with its schedules, timetables, planning, and prioritizing, but it is worth the effort.

# Good Preventive Maintenance saves costs!

## Experience in Chile

*In a Chilean hospital, in-house planned preventive maintenance was introduced and cost monitoring improved (carried out by the existing staff without significant extra cost). Within a year, the expenditure on repairs by external contractors dropped by more than 65 per cent.*

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

# Planned Preventive Maintenance at three levels

by **the Users** (of the equipment): the simpler duties (training!)

by **Technicians** (in-house) the bulk of the work, with basic training.

by **Specialist Technicians**: either well trained in-house technicians or, for some sophisticated equipment: staff from the manufacturer or service agent.

PPM Wall Calendar Timetable												
Months	J	F	M	A	M	J	J	A	S	O	N	D
Suction Machine			PH b						PH b			
Infant Incubator		PH b						PH b				
Autoclave	PH b			PH q			PH b			PH q		
Electrode Boiler	DT m	DT q	DT m	DT m	DT q	DT m	DT m	DT q	DT m	DT m	DT q	DT m
Plumbing Installations	EB m	EB m	EB m	EB m	EB m	EB m	EB m	EB m	EB m	EB m	EB m	EB m
Key: b = 6-monthly (bi-annual)    q = 3 monthly (quarterly)    m = monthly												

Planned !

# Preventive maintenance: role of user: examples

---

- ◆ 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).

# Preventive maintenance: role of technical staff: examples

---

test for electrical and mechanical trustworthiness:

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



# Preventive maintenance: technical staff: electrical safety

---

The electrical installation must be regularly inspected and tested by electricians, using the correct test instruments. To guarantee the safety of installations, 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.

# Preventive maintenance: role of technical staff: example

---

## Analyzer, Electrical Safety

1. **Inspect** exterior of equipment for damage or missing hardware.
2. **Inspect** the power cord, strain relief and plug/s for any signs of damage.
3. Turn unit off, open user accessible covers and **inspect** unit for damage.
4. **Clean** unit interior components and exterior with vacuum or compressed air.
5. **Inspect** interior for signs of corrosion or missing hardware. **Repair** as required.
6. **Inspect** electrical components for signs of excessive heat or deterioration.
7. **Verify** correct operation of all buttons, controls, displays and/or indicators.
8. **Verify** correct operation of unit in all functional modalities.
9. **Clean** exterior of unit including all accessories, cables, controls and displays.
10. Refer **calibration** to outside vendor.

American Society for Healthcare Engineering (ASHE)  
Medical Equipment Maintenance Protocols

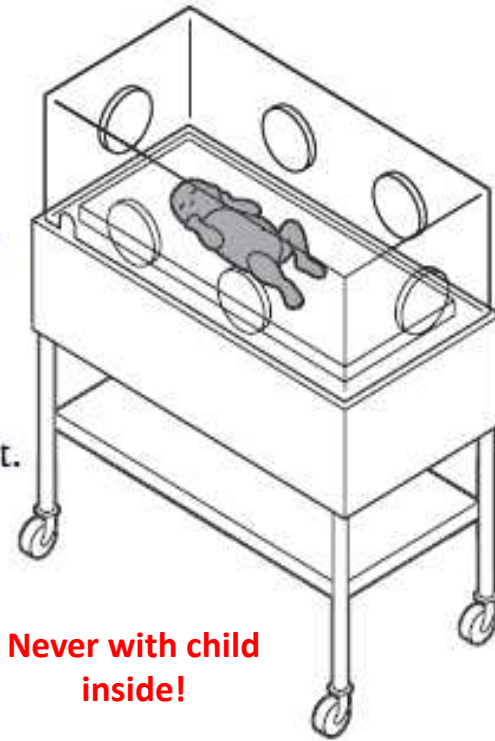
# Preventive maintenance: role of technical staff: example

## Infant Incubator

Note: these instructions assume that the equipment users are undertaking the necessary daily PPM tasks (see *Annex 4*).

### Every six months

- ◆ Check the physical condition of the power cord, connectors, and plugs.
- ◆ Check the integrity of the electrical grounding of the unit.
- ◆ Check the mechanical integrity of controls and switches.
- ◆ Inspect the condition of the oxygen and air inputs.
- ◆ Check the water level gauge and inspect the distilled-water compartment.
- ◆ Clean or replace the water and air filters.
- ◆ Check the temperature indicator and thermometers, according to the manufacturer's specifications.
- ◆ Check the over-temperature cut-off alarm.
- ◆ Check the power failure alarm.
- ◆ Check the fan failure alarm.
- ◆ Check the operation of the unit. Warm up the unit to a temperature setting on the temperature control, and check the temperature reached with an external thermometer.
- ◆ Check the canopy for any breakages.
- ◆ Clean the inside and outside of the unit, according to the manufacturer's instructions.



**Never with child  
inside!**

# Preventive maintenance: role of technical staff: example

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Some tasks will require **Manufacturer's service**

- Highly sophisticated equipment
- Calibration of anesthesia vaporizers
- Software upgrades
- Items under contract

# Managing PM programs

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PPM schedules (protocols, or lists of activities) need to be developed separately for both **users** and **maintainers** (technical staff).

They should provide guidelines for all types of equipment, covering the tasks to be undertaken in :

- **Care and cleaning**
- **Safety procedures**
- **Functional and performance checks**
- **Other maintenance tasks**

These schedules should include timetables showing the **frequency** with which the activities must take place

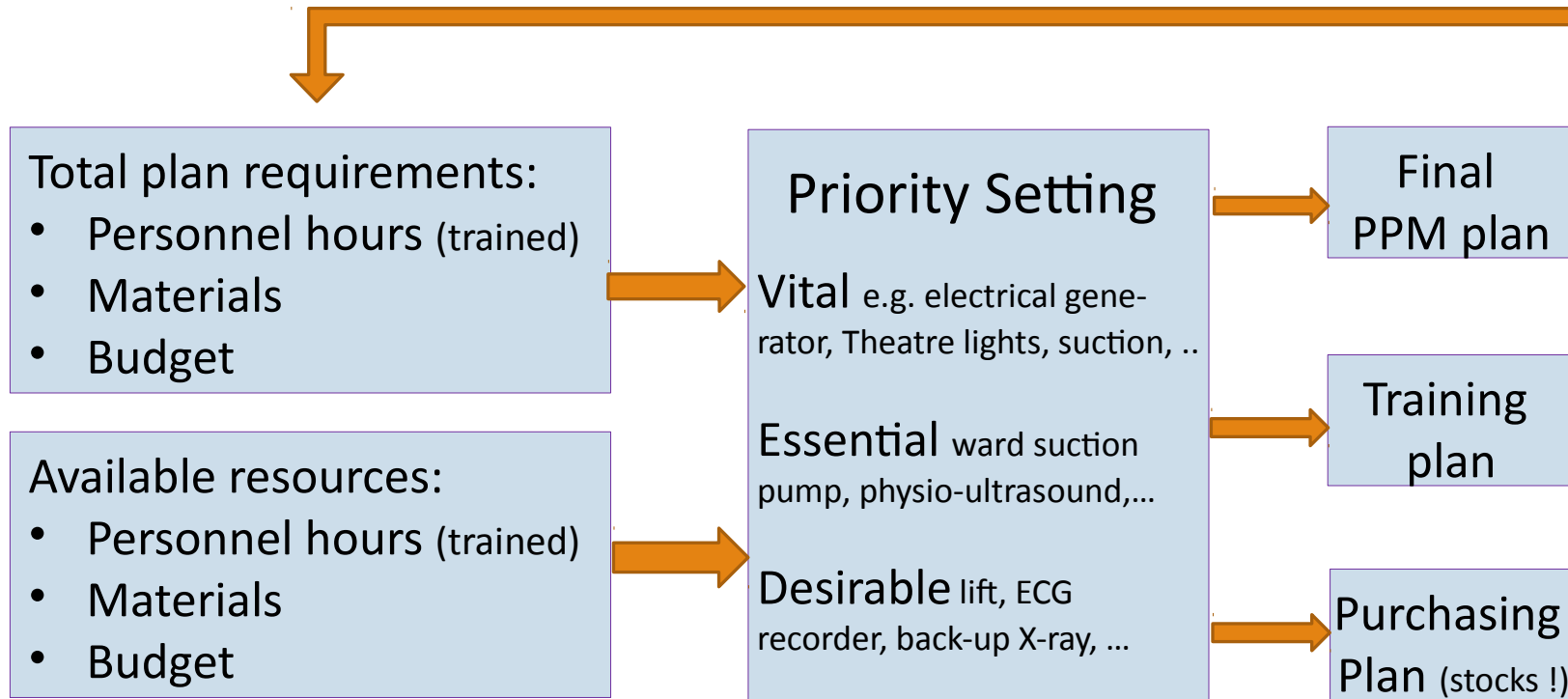
# Developing PPM Schedules

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 <i>Box 7</i> ).
Some PPM schedules and timetables have already been developed by international agencies and other sources (see <i>Annex 2</i> ).	Try to get hold of these resources (see <i>Box 7</i> 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 PPM schedules.	The HTMWG's training sub-group ( <i>Section 1.2</i> ) 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 <i>Annex 2</i> ).	Investigate this software if your organization wishes to use computerized maintenance systems ( <i>Section 4.1</i> ).

user, maintainer, specialist



- man-hours
- consumables
- replacement items
- cleaning materials
- calibration kits
- test equipment



subtract what is required for Corrective Maintenance !

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		
Microscope		EB					PH				m					m		
Refrigerator	PH	EB	EB	PH	EB	PH					w	w	w	m	w	w	w	m

Key: q = 3 monthly (quarterly) m = monthly w = weekly

# Managing PM programs: Gradual Introduction

---

## Set Equipment Priorities

PPM Priorities dependent on the Risk and the Impact of the Risk of failure

## Start gradually

Limit PPM plans to availability of qualified personnel

Give Priority to equipment with known PPM prescriptions

Start with annual PPM and move to semi-annual and quarterly, as required

## Include new Equipment

Investigate PPM needs during commissioning; write procedures as required

Make sure that PPM requirements are part of new purchases

## Expand slowly

Add more equipment in PPM schedules as time becomes available

Set realistic, achievable goals

# Planning tool

or on paper ....  
(???)

Current User - tabsadmin | Create Planned Maintenance Schedule | Create Advanced Planned Maintenance Schedule

Assets/Buildings to create Schedule for...

- 151 Milton Park, 174a Milton Park, 175 Milton Park, 177 Milton Park, 180 Milton Park, 18C Milton Park, 20 Milton Park, 200 Milton Park, 205A Milton Park

Start Date: 24/09/2009 | Years: 10

Start/Est. Time: 09:00 | 0 | His

Estimated Cost: £0.00 | Auto Repeat:

Order Number:

Cost Code:

Job Desc. 1: Air Handling Plant Ancillaries

Job Desc. 2: Air Handling Plant Ancillaries

Job Desc. 3: Air Handling Plant Ancillaries

Job Desc. 4:

Job Desc. 5:

Job Desc. 6:

Job Desc. 7:

Job Desc. 8:

Job Desc. 9:

Job Desc. 10:

Job Desc. 11:

Worker: Unspecified

Priority: Unspecified

Location:

Comments:

### Planned Maintenance Advanced Schedule Builder 2009-10

September							October							November							December						
Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
	1	2	3	4	5	6			1	2	3	4							1		1	2	3	4	5	6	
7	8	9	10	11	12	13	5	6	7	8	9	10	11	2	3	4	5	6	7	8	7	8	9	10	11	12	13
14	15	16	17	18	19	20	12	13	14	15	16	17	18	9	10	11	12	13	14	15	14	15	16	17	18	19	20
21	22	23	24	25	26	27	19	20	21	22	23	24	25	16	17	18	19	20	21	22	21	22	23	24	25	26	27
28	29	30					26	27	28	29	30	31		23	24	25	26	27	28	29	28	29	30	31			
														30													
January							February							March							April						
Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
				1	2	3	1	2	3	4	5	6	7	1	2	3	4	5	6	7				1	2	3	4
4	5	6	7	8	9	10	8	9	10	11	12	13	14	8	9	10	11	12	13	14	5	6	7	8	9	10	11
11	12	13	14	15	16	17	15	16	17	18	19	20	21	15	16	17	18	19	20	21	12	13	14	15	16	17	18
18	19	20	21	22	23	24	22	23	24	25	26	27	28	22	23	24	25	26	27	28	19	20	21	22	23	24	25
25	26	27	28	29	30	31								29	30	31					26	27	28	29	30		
May							June							July							August						
Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
					1	2		1	2	3	4	5	6				1	2	3	4							1
3	4	5	6	7	8	9	7	8	9	10	11	12	13	5	6	7	8	9	10	11	2	3	4	5	6	7	8
10	11	12	13	14	15	16	14	15	16	17	18	19	20	12	13	14	15	16	17	18	9	10	11	12	13	14	15
17	18	19	20	21	22	23	21	22	23	24	25	26	27	19	20	21	22	23	24	25	16	17	18	19	20	21	22
24	25	26	27	28	29	30	28	29	30					26	27	28	29	30	31		23	24	25	26	27	28	29
31																					30	31					

24/09/2009

dr. Chris R. Mol, BME, NORTEC, 2015

# Ensure availability of preventive maintenance consumables and calibration kits

---

## Planning:

Purchasing  
Plan  
(stocks !)

- Having the right and enough stocks of consumables
- Ensure the availability of cleaning materials for PPM
- Ensure the availability of calibration kits

# Assure availability of test equipment

---

- Availability of test equipment
- Knowledge to use the equipment effectively
- Safety on the use of test equipment
- Ensure the test equipment is working properly

The BME Team will require adequate test instruments.  
See HTM Guide 5, Annex 6 for a list of the types of basic and complex testers that BME needs.  
Not all workshops need all of the instruments listed.

# Calibrating test equipment

---

## Training plan

- Knowledge of the calibrating equipment
- Effective use of calibrating equipment
- Safe usage of calibrating equipment
- Ensuring the calibrating equipment is working properly

# Prepare records of work done

---

- Record of the work done on equipment
- Record of spares used on equipment
- Record of consumables used on equipment
- Record when the equipment came to the workshop
- Record of the maintenance staff who worked on the equipment
- Record of the time taken to repair/doing the work
- Record of the verifying officer on completion of work

These records must be made for both Planned Preventive and Corrective Maintenance!

# Prepare records of work done on medical equipment

---

A **Maintenance Record System** helps the health service to keep track of the maintenance and repair work done. It provides the health service with important information regarding:

- how many jobs are being done at any one time
- how many jobs are still waiting to be started
- how the jobs are allocated to HTM Team members, and therefore who is overworked
- the details of the work done on each machine, and therefore what the history of the machine is
- what spare parts and materials are used, and therefore which stocks need to be replaced
- when a job is completed
- what the causes for delays are, and therefore what resources are needed to finish the work
- how busy the HTM Team is, and therefore how best to plan its work
- which jobs are still outstanding, and therefore how to prioritize the next week's work.

A maintenance record system must be linked to the equipment inventory code numbers.

# Data to store for each piece of equipment

---

## Equipment Inventory

- ◆ date inventory taken
- ◆ facility, department, section, and location/room
- ◆ type of equipment
- ◆ inventory code number (your own number)
- ◆ name of manufacturer
- ◆ model name and/or number
- ◆ manufacturer's serial number (factory number)
- ◆ year made or bought
- ◆ supplier bought from
- ◆ status/condition
- ◆ your property or leased

## Service History File

- ◆ address of the manufacturer and local agents
- ◆ address of the supplier and local representative
- ◆ technical ratings
- ◆ date when the warranty expires
- ◆ price paid
- ◆ any external funding agency involved
- ◆ stocks of consumables, accessories, and spare parts received
- ◆ results of inspection tests undertaken on commissioning
- ◆ frequency of planned preventive maintenance required
- ◆ details of any maintenance contract and maintenance contractor
- ◆ maintenance history

**PREVENTIVE MAINTENANCE CHECK LIST**

# Preventive Maintenance Check List

Zambia Medical  
Equipment Management  
Guidelines september  
2012

Equipment : Patient Monitor	Inventory Number:
Maker:	Model:
Technician	Periodical maintenance date/time:

No.	Activities	Check result	Note
1	Perform daily maintenance process for signs of damage or abnormalities. Check carefully by technician's eye.		
2	Cleaning and Lubrication (1) Clean overall of the equipment. Especially confirm the cleanness of paddle and display. (2) Clean ECG cable and electrode connection part.		
3	General Check (1) Inspect bumpy and missing screws. (2) Inspect overall physical damage. (3) Inspect patient cable and electrodes do not damaged or rusted. (4) Inspect all accessories (ECG cable, patient cable, NIBP cuff with tube, SpO2 sensor, temperature sensor etc.) and signs of damage		
4	Electrical Check (1) Inspect all cables, cords, plugs and connectors are not broken or damaged. Measure ground continuity. (2) Inspect power supply voltage. (3) Measure line voltage regulation. (4) If you have electrical leak tester, measure the leak current and confirm it is within the regulation. - grounding wire (normal/single failure) - exterior (normal/single failure) - patient leakage (normal/single failure)		
5	Function Check (1) Power ON and confirm lamp on and if there is no abnormal sound or vibration. (2) Inspect the equipment pass self check. (3) Inspect all switch and key work normally. (4) Record operational time/frequency from test menu (if this function equipped). - Operating time - Temperature adjusted operation time - Battery operation time - NIBP measurement frequency - Maximum internal temperature - Recording time		
6	Operation Check (1) If you have ECG simulator, connect it to the patient monitor and confirm ECG signal is displayed by I to III lead. If you do not have the ECG simulator, perform the test without input signal. (2) Inspect function of NIBP, SpO2, and temperature sensor manually.		
7	Trouble Shooting (1) All abnormal parts which are found on the periodical check should be replaced by consumables and spare parts of new or good condition.		

No.	Activities	Check result	Note
1	Perform daily maintenance process for signs of damage or abnormalities. Check carefully by technician's eye.		
2	Cleaning and Lubrication (1) Clean overall of the equipment. Especially confirm the cleanness of paddle and display. (2) Clean ECG cable and electrode connection part.		
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5	<p>Function Check</p> <p>(1) Power ON and confirm lamp on and if there is no abnormal sound or vibration.</p> <p>(2) Inspect the equipment pass self check.</p> <p>(3) Inspect all switch and key work normally.</p> <p>(4) Record operational time/frequency from test menu (if this function equipped).</p> <ul style="list-style-type: none"> <li>- Operating time</li> <li>- Temperature adjusted operation time</li> <li>- Battery operation time</li> <li>- NIBP measurement frequency</li> <li>- Maximum internal temperature</li> <li>- Recording time</li> </ul>		
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7	<p>Trouble Shooting</p> <p>(1) All abnormal parts which are found on the periodical check should be replaced by consumables and spare parts of new or good condition.</p>		

**DAILY MAINTENANCE INSTRUCTIONS**

(PATIENT MONITOR)

# Daily Maintenance Instructions

Zambia Medical Equipment  
Management Guidelines  
september 2012

<b>Daily and before use:</b>	
1. Cleaning checking:	Check the equipment is clean. Especially, all connectors, surface, and display of equipment should be clean. (On detail, please refer to instruction manual.)
2. General inspection:	Visually inspect unit, all switches, connections, and accessories (Patient cable, Disposable electrode, NIBP set, SpO2 probe, and Power cable) for signs of damage or abnormalities. Check cleanness of them.
3. Accessory checking:	Verify all accessories (Patient cable, Disposable electrode, NIBP set, and SpO2 probe) are ready to use.
4. Functional checking:	Verify all switch work normally
5. Operational checking :	Verify equipment pass self test at power on. There is no abnormal sound or vibration when operated. And ECG wave, heart rate, SpO2 etc. are displayed normally.
<b>Daily and after use:</b>	
6. Cleaning checking :	Check that equipment and accessories are clean and no damage after every operation.

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# END

The creation of this presentation was supported by a grant from THET:

see <https://www.thet.org/>

