

PART I

Introduction

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Introduction

It is preferred to call this a **workbook** rather than a manual or textbook, because the intent is to, not only give technical information, but to set practical exercises that students can work through, responding to specific questions. Above all, the students should feel that they have actually carried out the tasks themselves and will be more confident to teach others and ensure that these exercises continue to be carried out in their respective areas.

The topic of this workbook is routine maintenance and repairs. The material is designed to assist in the maintenance of equipment, and provide guidelines for locating equipment problems. In many cases this will allow local correction of fault situations. Where external assistance is required, good communication of the diagnosed problem will assist in reducing delay, or multiple service calls.

Routine maintenance

The overall maintenance programme; put in place to ensure that a comprehensive range of maintenance procedures are systematically carried out.

Fault diagnosis and repairs

The means by which the cause of incorrect equipment operation may be located. This includes adjustment where required, and simple repairs.

A Routine Maintenance Programme should be comprehensive, looking at all aspects of the work involved in ensuring equipment is properly maintained, and capable of producing accurate results. Such a programme can be cost effective, and contribute to minimum failure of equipment. By encouraging local staff to be actively involved in maintenance or minor repairs, delays and expensive service calls may be considerably reduced.

The ultimate responsibility for setting up, running, evaluating and taking remedial action lies with the head of department, although appropriate delegation may be necessary. It is important that someone

accepts that responsibility and ensures that the programme happens effectively.

This workbook will be used by radiographers and radiological technologists as well as other medical and technical staff members involved in diagnostic imaging, to:

- achieve a good working knowledge of equipment maintenance routines;
- adopt a logical and practical approach to diagnosing equipment problems;
- on returning to their respective areas after completed training, teach other members of their staff to carry out the routines or techniques that they have learned;
- assist in establishing, or implementing, a suitable routine maintenance programme;
- be encouraged to directly carry out adjustments or minor repairs, or provide suitable assistance to other staff as needed;
- provide accurate reporting of problems to seniors or service engineers;
- assist in establishing criteria for equipment replacement, where it is not cost effective to continue maintenance.

Expected benefits

It is expected that after going through the training and experiences discussed in this workbook, the knowledge and skills will be put into practise. If so:

- Heads of departments will find that the standard of radiography will be maintained at the highest level.
- There will be fewer equipment failures. This reduces costs.
- Where a failure does occur, local hospital staff may be able to repair without an expensive service call.
- When an external service call is required, the service technician can arrive fully informed to deal with the situation, together with appropriate equipment or parts. This will reduce the possibility, and expense, of repeated visits.

- Where work is carried out by an external service organization, the maintenance inspection will ensure this has been carried out fully and effectively.
- Work environments will be improved. Tasks will become easier.
- Repeat films will be kept to a minimum. Staff job satisfaction will increase.
- Patients will receive less radiation and less inconvenience.
- A record and audit trail will exist as proof of high standards.

Achieve some of these, and this workbook has been worthwhile!

What this workbook aims to achieve

- Provide the knowledge and skills required for maintenance of imaging equipment.
- Increase awareness, interest and understanding of maintenance issues.
- Enable radiographers to establish and continue to carry out an effective preventive maintenance programme.
- Provide the knowledge tools to assist in diagnosing equipment problems.
- Provide the knowledge and encouragement to carry out adjustments and minor repairs.
- Raise equipment performance standards.
- Reduce maintenance and service costs.
- Reduce the possibility of equipment malfunction causing injury.
- Improve job satisfaction through correctly functioning equipment.

Summary of the content of this workbook

- Background information.
- A questionnaire seeking information about each student, and their own department.
- A pre test of student's knowledge.
- 13 modules related to routine maintenance of X-ray equipment.
- 14 modules concerned with fault diagnosis and repairs.
- A separate module, concentrating on the film processor.
- A revision of X-ray equipment design and operation.
- 17 tasks the student must perform.
- A list of suitable tools and test equipment, and how to make simple test tools.
- Useful charts and forms.

- Copies of routine maintenance check sheets.
- Advice on teaching methods.
- Health and safety issues.
- A post test of student's knowledge.
- Glossary of terms.
- Reference list.

How to use this workbook

The entire workbook can be used for self-study or self-assessment, ideally as working material during a work shop or a seminar with individual tutors for the students. In either case, however, the book should be approached as indicated below.

The section headed STUDENT'S OWN DEPARTMENT, should be completed by the student *before commencement of the study or course*. This takes the form of a questionnaire which, when completed should give the tutor a background knowledge of the student and their work environment. This background information will allow the tutor to apply the correct emphasis when providing and supervising the training.

The student must complete a PRE TEST prior to starting the course. This is an assessment of the student's relevant knowledge *before the course*. This will be compared to the results of a similar POST TEST completed by the student after completion of the course. These tests are for student information and course evaluation only and are not used in student assessment.

The section on TEACHING TECHNIQUES first gives a broad overview of teaching methods. This is followed by the recommended approach to teaching with this workbook. Both tutor and student should read this section. This is a reprint from the WHO 'Quality assurance workbook' and is included here for convenience.

The section on HEALTH AND SAFETY draws attention to all the health and safety issues appropriate to an X-ray department and how to make the work environment a safe and healthy one. This is an extract from the WHO 'Quality assurance workbook', edited for use with this workbook.

The workbook is divided into modules

- The modules are in three groups.
 - a. Routine maintenance of X-ray equipment.
 - b. Fault diagnosis and repairs of X-ray equipment.
 - c. The automatic film processor, routine maintenance, fault diagnosis and repairs.
- The student should work through one module at a time, studying the technical information and testing methods.

- **Note.** Although the modules are designed as individual projects, due to the complexity of this workbook, it will be necessary at times to refer to other modules. Where this is required, a note is inserted pointing to the first page of the reference module.
- At the end of each module, tasks have been set. The student must carry out each task and answer the questions asked, and the teacher/tutor where available, will comment or correct these.

The APPENDICES contain information on making **simple test tools, report forms, record sheets, and test result sheets** for use in the student's own department. The APPENDICES also contain information from the WHO 'Quality assurance workbook'. This includes **sensitometry, teaching techniques, and health and safety**. The GLOSSARY contains a list of terms found in the text, with meanings. The REFERENCES provide a source of further reading.

When used in the scope of a work shop or seminar, The POST TEST must be answered, on completion of the course. The workbook is then handed to the tutor for final assessment.

The student is encouraged to:

- complete all pre reading, discuss the material with colleagues and fill in the questionnaire, 'STUDENT'S OWN DEPARTMENT', before starting the course;
- carry out the PRETEST immediately before starting the course;
- carry out the POST TEST immediately upon completion of the course/self-study.

In daily routine work the workbook and newly gained knowledge and expertise should be used to establish a routine maintenance programme, and train colleagues under the direction of their department manager.

Questionnaire

Student's own department

In order for this course to meet your needs, your tutor must know something about yourself, and the department in which you work. Please answer the following questions in the spaces provided, before you commence the course.

1. Hospital name and address. _____

2. Your name and address. _____

3. Your education qualifications. Please include details of any additional training. _____

4. How many X-ray examination rooms are there? _____

5. How many mobile or portable X-ray generators are there? _____

6. Tell us what X-ray equipment you have. Eg, general-purpose table with Bucky etc. Please include the type, make and model number.

Room 1 _____

Room 2 _____

Room 3 _____

Mobile or portable units _____

4. How many darkrooms are there? _____

5. State the type of film processor in each darkroom. e.g. type, make, model, processing cycle.

Darkroom 1

Darkroom 2

6. How many staff act as radiographers? _____ Qualified radiographers? _____ Others? _____

7. How many darkroom technicians are there? _____

8. Does your hospital have access to an electronics service technician? _____

9. Does your hospital have an electrician? _____ With electronics knowledge? _____

10. Do you already run any form of preventive maintenance programme. Yes/No _____

11. If 'Yes', state here what you do, including details of any external assistance.

13. Is all the X-ray / processor equipment operating at a satisfactory level? _____ If not, describe areas requiring attention. Include equipment waiting parts or further service.

14. Including all equipment, what is the total number of days 'out of action' for last year? _____

15. What was the average time 'out of action'? _____ And the maximum time? _____

16. List any test equipment or quality control test tools you have.

17. If you have any issues relating to maintenance, or fault diagnosis / repairs, please state them here.

Pre test

The student must complete this test before starting the course. The intention is to test your knowledge on the topics covered by this workbook before the course, or before starting studying the work book.

Name and address

Hospital name and address

Instructions

This is a multiple-choice test. In each question you are given three possible answers.

Read each question carefully.

Indicate the answer that you feel is the most accurate by placing an 'X' in front of the letter preceding it.

Example:

A personal radiation monitor (TLD) should be worn

- a) Outside a lead rubber apron.
- X** b) Under a lead rubber apron.
- c) There is no need to use one when wearing a lead rubber apron.

Answer: b)

All questions must be answered

1. What is meant by the term 'preventive maintenance'?
 - a) Maintenance must be carried out by tradesmen only.
 - b) Maintenance is not required.
 - c) Maintenance to reduce equipment failure.
2. What is meant by the term 'quality assurance'?
 - a) The equipment is covered by a maintenance policy.
 - b) A repair is guaranteed for three months.
 - c) A system that attempts to maintain a high standard of work in all areas.
3. What is meant by the term 'trouble shooting'?
 - a) A method to diagnose a problem.
 - b) How to deal with under performing staff.
 - c) The X-ray generator fails to expose.
4. To check if the light field and the X-ray field of a collimator are correctly aligned:
 - a) Look into the collimator mirror.
 - b) Place metal markers on the face of a loaded cassette to indicate the light field and make an exposure.
 - c) Adjust the collimator knob to the film size as indicated on the collimator.
5. An aluminium disc is often inserted between the collimator and the X-ray tube. The purpose of this disc is to:
 - a) Adjust the spacing between the collimator and the X-ray tube.
 - b) Prevent light from the tube filament shining through the collimator.
 - c) Filter low energy X-ray photons.
6. An 'mAs' control is used in:
 - a) An automatic exposure control.
 - b) Single knob adjustment of time and mA.
 - c) Automatic regulation of mA as kV is adjusted.
7. The term 'space charge' relates to:
 - a) High-energy cosmic radiation, causing film fog.
 - b) A 'cloud' of electrons around a heated filament.
 - c) The rental fee for a private X-ray practice.
8. A 'relay' is:
 - a) A competitive sports event.
 - b) A replacement of floor covering.
 - c) An electromagnetic switch.
9. An 'interlock' is:
 - a) A safety device to prevent incorrect operation.
 - b) The door locks for entry to the X-ray room.
 - c) A device to prevent tampering.

10. A 'spinning top' is used to:
 - a) Check kV accuracy.
 - b) Check exposure time accuracy.
 - c) Check mA accuracy.
11. A 'stepwedge' is used to:
 - a) Calibrate the height of the tomograph fulcrum.
 - b) Make comparative measurements of radiation output.
 - c) Assist in patient positioning.
12. Before attempting to replace a fuse, you should:
 - a) Check the fuse rating.
 - b) Inform the chief radiographer.
 - c) Ensure the main power isolation switch is turned off.
13. When making an exposure via a Bucky:
 - a) The grid should move immediately X-rays are produced.
 - b) The grid should commence movement when the exposure button is pressed, and exposure occurs after the grid is in position.
 - c) The Bucky should commence operation as soon as the preparation button is pressed.
14. The first aid treatment for a processing chemical splash in the eye is:
 - a) Blink continuously for at least 30 seconds.
 - b) Wash the eye thoroughly with water.
 - c) Wipe the eye with a tissue.
15. Developer temperature should be checked:
 - a) Only if the film densities appear different.
 - b) Daily.
 - c) Once a week.
16. Replenishment rates in automatic processors are checked by:
 - a) Referring to the operator's manual.
 - b) Measure the relative decrease of level in the replenishment supply tank.
 - c) Diverting the replenishment pump output into a graduated flask.
17. Automatic processing temperature should be:
 - a) 20°C
 - b) 25°C
 - c) 35°C
18. A sensitometer:
 - a) Is used to measure sensitivity of film to light.
 - b) Is used for printing a test strip onto film for film processor monitoring.
 - c) Checks the developer concentration in the processor.
19. If the focal length of the grid fitted to a wall Bucky is too short for the required distance:
 - a) The film will be dark in the centre, and light at the sides.
 - b) The film will be light in the centre, and dark at the sides.
 - c) Grid lines will appear.
20. Before using a multimeter to test continuity, you should:
 - a) Touch the test leads together to ensure the meter reads 'Zero ohms'.
 - b) Fit a new battery to the meter.
 - c) Ensure the power isolation switch for the X-ray room is turned off.
21. During preparation for an exposure, which item should *not* occur?
 - a) X-ray tube anode rotation.
 - b) Adjustment of kV output.
 - c) X-ray tube filament heating.
22. The maximum possible anode rotation speed for a low-speed tube operating at 50Hz is:
 - a) 2500 RPM
 - b) 3000 RPM
 - c) 5000 RPM
23. A high-speed tube has a 'brake' cycle at the end of an exposure. This is to:
 - a) Reduce unnecessary noise in the X-ray room.
 - b) Increase bearing life.
 - c) Prevent damage caused by 'resonant periods' as the anode slows down.
24. The woven metal sheath of the high-tension cable is to:
 - a) Shield against the possibility of transmitting electronic interference into other equipment during an exposure, especially with a high-frequency generator.
 - b) Increase the resistance to wear, and act as a deterrent to rat damage.
 - c) In case there is a fault in the cable insulation, the metal sheath provides a safe electrical conduction to ground.

25. When exposing a large format film, a reduction in film density to one side of the film is noticed. This is probably due to:
- a) The dwell time of the processor is incorrect.
 - b) Heel-effect of the X-ray tube.
 - c) Poor film screen contact.
26. All exposures suddenly show an increase in film density. The most possible cause is:
- a) An increase in developer temperature.
 - b) The generator kV calibration is incorrect.
 - c) The processor fixer has become diluted.
27. You have a choice of three X-ray tubes as a replacement. They are identical except for the anode angle. Which tube will have the highest output?
- a) 7 degrees
 - b) 12 degrees
 - c) 16 degrees
28. Again, considering the same X-ray tube, which will give the best film coverage?
- a) 7 degrees
 - b) 12 degrees
 - c) 16 degrees
29. A capacitor discharge mobile has:
- a) A non-linear X-ray output.
 - b) A similar output to a single-phase generator.
 - c) Long exposure times.
30. A spinning top test is made of a single-phase self-rectified (Half wave) portable generator operating on 50 Hz. Twenty dots appear on the film, indicating an exposure time of:
- a) 0.02 seconds
 - b) 0.2 seconds
 - c) 0.4 seconds