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Quality Control Handbook

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INTERNATIONAL SOCIETY
OF RADIOGRAPHERS AND
RADIOLOGICAL TECHNICIANS.

QUALITY CONTROL HANDBOOK

for technicians in radiography using simple X-ray equipment and manual film processing

INTRODUCTION

A Quality Control Course was held in Harare in 1983 under the auspices of the Zimbabwien Ministry of Health with co-operation from the World Health Organization (WHO) and the International Society of Radiographers and Radiological Technicians (ISRRT). The technicians attending the course who represented eleven African countries recommended that there should be a handbook on Quality Control to help technicians in countries using simple X-ray equipment including the Basic Radiological System (BRS) and manual processing to undertake quality control tests.

In response to this request this handbook gives guidance to technicians who have had some training in radiography and are keen to introduce quality control so as to maximise information in their radiographs. We hope the handbook will be translated into other languages for the benefit of those not familiar with English.

The authors who formed a Working Party for this Handbook have enjoyed contributing from their knowledge and experience of radiography in many countries throughout the world.

Members of the Working Party included:-

Miss Marion Frank
Miss Patricia Goodchild
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Miss Sybil Stockley - Editor

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The following publications were used for reference:-

Quality Assurance in Diagnostic Radiology	WHO Geneva	1982	
A Basic Quality Assurance Programme for Small Diagnostic Radiology Facilities	National Center for Devices US Department of Health and Human Services		FDA 83-8218
A Technician's Darkroom Manual (A Watson) 6th ISRRT Teachers' Seminar Nigeria.	Secretary General ISRRT	1980	
Manual of Darkroom Techniques Basic Radiological System.	WHO Geneva	1985	
Proceedings of the Quality Assurance Course in Diagnostic Radiology. (1983)	MOH, Harare	1983	
A Glossary of Physics, Radiation Protection and Dosimetry in Diagnostic Organ Imaging.	ISRRT WRET	1985	

CONTENTS

Personal notes

2. SETTING STANDARDS FOR LOCAL WORKING CONDITIONS

In this section of the handbook information is given on the preparation of the X-ray equipment and film processing that must be undertaken before starting a Quality Control programme.

It is important that the procedures are performed and the necessary action taken to solve any problems before starting the quality control programme.

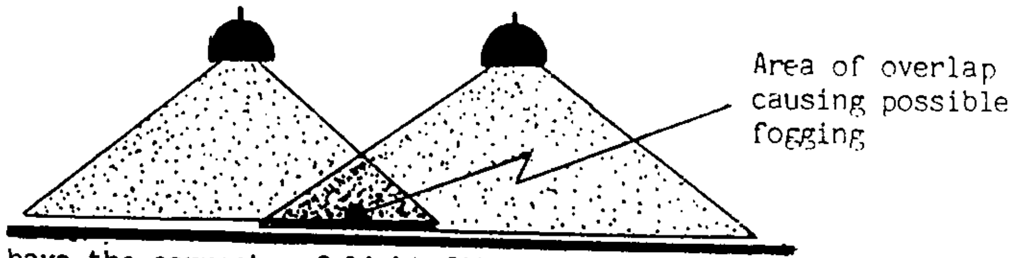
2.1 The Darkroom

Thoroughly clean all surfaces, tanks, cupboards, drying cabinets and keep them in this condition by cleaning them regularly.
Make sure that there is no fogging on the films from white light, safelights or X-radiation. (Tests for checking the presence and source of any fogging are described in Tests 3.2.1.). Smoking should not be permitted in the darkroom because of the risk of fogging films.
It should be realised that if an exposed film has a high fog level due to poor storage conditions, this will cause loss of image quality which cannot be corrected.

2.1.1. Safelights should be examined before testing to see if they:

(a) have the correct bulb fitted. It should be a 15 watt bulb, if this is not available a 25 watt bulb may be used. If a 25 watt bulb is fitted it is very important to check whether there is any safelight fogging. The safelights are normally fitted 130 cm (4 feet) above the bench or 210 cm (7 feet) above the floor if they are ceiling mounted. The height of the safelight may have to be increased if there is safelight fogging on the films through the unavoidable use of a higher wattage bulb.

(b) are not too close together so that the illuminated area from one lamp is overlapped by another (see diagram). If the light from two safelights overlaps the brightness of the illumination may be great enough to fog the films.



(c) have the correct safelight filter fitted to suit the type of film being used and that it is not cracked or badly fitting so that unfiltered light from the lamp can get out to fog the film. It is important to check that there is no light getting out around a loose fitting electrical connection.

2.1.2. The Timing Clock should be checked weekly to make sure that it measures the time accurately and indicates clearly when the selected time is over.

To check the clock:

It should be operated in white light by setting the time to be checked to the usual development time and watching to see that the clock starts as soon as the starting lever or button is operated, that it continues for the set time and sounds the alarm when the time is complete.
The time interval should be checked by comparing it with a watch or another clock.

The checks described should be done several times to see that the clock operates correctly every time. Inconsistency in operation is a very serious problem as it will give non-standard development time leading to an increase in the number of repeat radiographs.

If the timed interval is consistently wrong, either too long or too short, the clock can be used as an allowance can be made by the operator for the error. But if the clock gives inconsistent results, it should not be used until is is repaired.

If no clock is available standard development can be achieved by leaving the film in the developer whilst counting up to a particular number which has been checked to take the required length of time.

2. Processing Equipment

2.2.1. The Manual Processing Unit

Before setting standards for a quality control programme, new solutions of developer and fixer should be mixed, following very carefully the manufacturer's instructions to ensure the correct concentration and activity of the solutions (information on chemical mixing is given in 2.4.1.). The processor must be thoroughly cleaned before the new solutions are put into the tanks and the water flow checked to ensure adequate rinsing and washing of the films. (Details of how to check the water flow is given in Test 3.2.2.).

To clean the processor

1. Switch off any cooling or heating equipment in the processor.
2. Drain the developer, rinse and wash tanks and the water jacket.
3. Pour the fixer from its tank into a container for silver recovery.
4. Remove the developer, the fixer and the rinse tanks. Wash out the tanks with water and scrub until clean, use different brushes for the developer and fixer tanks.
5. Make sure that the waste pipes and overflow pipes are clear and check that the water runs away freely.
6. Wash and scrub the water jacket and replace the drain plugs.
7. Replace the tanks in the water jacket taking care to replace them in their correct position and replace their drain plugs.
8. Mix new developer and fixer solutions, according to the manufacturer's instructions using different stirring sticks for the developer and fixer solutions. Refill the tanks taking great care not to contaminate the developer with the fixer through spillage during the filling of the tanks.

9. Switch on the heating or cooling equipment as soon as the water jacket has been refilled.
10. Wipe over the outside of the processing unit with a damp cloth to remove any chemical splashes.
11. Check that the solution temperatures are at the normal working temperature before beginning any tests. Remember to stir the tanks before taking the temperature. Because it may take an hour or more for the temperature to reach their working temperature, it is a good plan to to make up the solutions at the end of the day and leave them overnight to ensure that they are at their normal temperature for use the next morning.

Pollution of the district

Remember that used fixer contains silver compounds and where possible the silver should be recovered. The fixer solution should not be emptied down a drain which is connected to a cess pit or septic tank, as this will make the tank less efficient. If the drains are connected to the town sewage works the fixer should always be diluted with other waste water so that the silver concentration is low.

2.2.2. Utensils used in the Darkroom

Mark all utensils used for holding or mixing chemicals so that only utensils marked 'DEVELOPER' are used for mixing or holding developer, and utensils marked 'FIXER' are only used for utensils holding fixer. This is important, otherwise the developer and fixer solutions may become contaminated and will not work correctly.

All utensils used for developer and fixer solutions should be made from stainless steel, plastic or hardened rubber. Enamel containers may be used provided the enamel is not chipped and showing areas of metal, this metal will react with the processing solutions and spoil them.

.3. Water Supply

It is essential to have an adequate water flow to rinse and wash the films effectively so that the films can be satisfactorily processed to give them a long life as part of the patient's records. Water flow is checked by the test described in 3.2.2.

If there is any possibility of the water supply failing, a reserve tank of water should be kept beside the processing unit. A spare processing tank is ideal for this purpose. The water in this tank must be changed frequently so that is clean when it is needed.

Processing can continue when the water supply stops providing the films are rinsed in clean water, properly fixed, rinsed again in the reserve tank containing clean water and then thoroughly washed as soon as the water supply returns. Remember to change the water in the reserve tank as soon as the supply returns so that it is ready for the next time it is needed.

2.4. Solutions

Processing chemicals produce fumes, so it is important to see that the darkroom is well ventilated.

2.4.1. Preparing chemical solutions

Manufacturer's solutions or powders must be used from the stock in strict date rotation (oldest stock first).

Instruction on the preparation of the solution must be followed exactly. Failure to do so may make the solution unuseable.

i.e. solutions must be made up by adding the concentrated solutions (powders) in the correct order;

all concentrates must be diluted to the correct level;

chemical mixing must continue for the stated period (2 to 3 minutes) using a clean mixing stick kept specifically for the solution being prepared (developer stick for developer solution, fixer for fixer);

chemicals must be added gradually with continuous stirring taking particular care when mixing powders that they do not get spread into the air.

Mixing should take place in a well ventilated, draught free room particularly if powders are being used. Ideally solutions should be prepared outside the darkroom if powders are being used to avoid the risk of contamination of surfaces by dry powder.

The person preparing the new chemicals should wear protective clothing (coat/gown, gloves, mask and eye protectors).

When mixing take care to avoid splashing and contaminating nearby surfaces or chemicals. Any spillage should be cleaned up immediately.

Any errors in mixing procedure may mean that the solution must be thrown away.

The date of solution preparation should be recorded.

Before use all solutions of mixed chemicals must be checked for temperature and activity, see Test described in 3.2.3..

Remember to wash the hands after preparing chemicals to prevent skin irritation or contamination.

2.4.2. Developer

To determine the optimum development time for an X-ray film

It is important to determine the development time which should always be used to give the film's maximum density without a raised basic fog when the manufacturer's recommended temperature is not possible because of local conditions.
The method described here must be undertaken at the temperature which can be maintained for the period during which radiographs are taken. If the temperature varies greatly during the course of the day or over a period of time it will be necessary to repeat the procedure over the range of temperature variation.

Equipment required: Six sensitometric test strip prepared as described elsewhere
Thermometer
Film clips or pins to allow the strips to be suspended in the processing solutions
Stirring stick

Method:

1. After stirring the developer solution the temperature is measured and recorded. The temperature of the solution should be the normal temperature in which radiographs are processed.
2. In safelight illumination, the six strips are attached to individual clips and then placed in the developing solution.
3. The timing clock is started immediately after the strips are placed in the developing solution.
4. After ½ minute development strip 1 is removed from the developer, rinsed and placed in the fixer.
After another ½ minute (1 min development) strip 2 is removed
After another ½ minute (1½ min development) strip 3 is removed
After another ½ minute (2 min development) strip 4 is removed
After another ½ minute (2½ min development) strip 5 is removed
After another ½ Minute (3 min development) strip 6 is removed.
The films strips are carefully identified with a number so that the development time for each strip is known.
5. After the normal fixing and washing the film strips are dried and mounted in order on an X-ray viewing box with the steps placed at the same level as shown in the diagram.

7. If the developer temperature varies because of local conditions, it will be necessary to perform this procedure over the range of temperatures which have to be used. The results of this series should be charted as shown below. The chart is then used to determine the proper development time for a radiograph processed at a particular temperature.

Temperature - development time chart	
Temperature of developer	Development time

2.4.3. Fixer

In order to ensure permanence of the image, the fixer clearing time of the unexposed areas must not exceed 3 minutes so that the total fixing time being twice the clearing time can be 6 minutes.

The clearing time can be determined by the test described in 3.2.4.. It is important that this test is performed before starting a Quality Control programme to make certain that the fixer solution is not already exhausted.

2.5. Cassettes and Intensifying Screens

2.5.1. Cassettes

(a) Labelling

Cassettes should be labelled with a letter or a number for easy identification. The intensifying screens inside the cassette should be marked with the same number.

(b) Cleaning

The outside of the cassettes should be cleaned frequently with a damp soaped cloth and then wiped with a clean cloth and left to dry. Care must be taken not to have the cloth too damp so that there can be no possibility of water leaking into the cassette.

(c) Tests

Check the cassette for screen contact and light leakage. The tests are described in 3.2.5.

2.5.2. Intensifying Screens

(a) Mounting and marking

The screens should always be fixed into the cassette with the tape supplied by the screen manufacturer or by sellotape, any other adhesive may show on the films.

(b) Cleaning and inspecting

Regular cleaning and inspection are essential to avoid artifacts which can cause marks on the films. Any unusual problems may require a radiograph to be taken using the cassette to locate the damaged area. When an artifact is seen on the processed film the identifying number on the film will enable the correct cassette and screens to be found.

Cleaning and checking by:

1. Unloading the cassette in the darkroom.
2. Looking at the screens in white light to see if there is any dirt, scratches or discolcration present.
3. Checking that the mounting of the screens within the cassette is still firm. If the screens require refixing use only the manufacturer's tape or sellotape. other adhesives may show on the films.
4. Using a clean damp soft pad of cotton wool and mild white soap clean the screens using a circular motion.
5. Removing any remaining soap with a clean damp pad of cotton wool.
6. Standing the cassette upright and half open in a dust free area allows the screens to dry completely before the cassette is reloaded with film.
7. Before reloading check the screens to see that there are no streaks on their surfaces, if there are clean them again with water.
8. Checking that the screens can be identified easily by their letter or number.
9. Recording the date of cleaning of the cassette and its screens.

(c) <u>Checking the speed of the intensifying screens</u>

Intensifying screens must be checked for speed when they are first used and every year they are in use so that exposure factors can be adjusted to give the correct density on the film. Failure to do so may result in increased repeat films. Details of the test are given in 3.2.6.

2.6 **Film hangers (frames)**

Cleaning and inspecting

1. Scrub with a hard brush using hot water to remove chemicals.
2. Rinse and dry.
3. Check for any damage to clips, distorted shape or broken corners.
4. Note the date of cleaning and the action to be taken with damaged hangers.

2.7. **Film viewers (illuminators)**

1. Clean the outside of the film viewer after the electric plug has been removed from the socket or the supply switched off. Use a damp cloth and some mild soap. Leave to dry before switching on again.
2. Make sure all the fluorescent tubes are operating correctly and give an even overall illumination.
3. Every 6 months an electrician or other approved person should clean the inside of the film viewer box and the back of the plastic or glass front. At the same time the fluorescent tubes should be cleaned and checked.

2.8 Storage

2.8.1. Unexposed film storage

It is essential to store the unexposed film correctly both in in the main (long term) film store and in the darkroom (short term) film store.

(a) Long term film storage

1. Check expiry date on the boxes as they arrive.
2. Mark the boxes with their date of arrival and record the details on a stock sheet.
3. Organise the store so that the oldest films are always used first, ensuring strict rotation of the stock.
4. Stack the films vertically to eliminate unnecessary pressure marks on the films.
5. Make sure the room in which films are stored is well ventilated. The shelves should be made of wooden slats, to reduce the amount of condensation produced.
6. The boxes of film should not be stored on the floor.
7. Keep the temperature of the store as low as possible, ideally between 10^{o} - 18^{o}C. If the normal room temperature is very high, films should if possible be stored in a refrigerator.
8. Make sure that the store is dry.
9. Ensure that the store:
   - (i) does not contain hot pipes,
   - (ii) is not situated near to a chemical store or where fumes may enter the store,
   - (iii) is not situated where there may be a possibility of exposure to X-radiation.
10. As the boxes of films are used, record their use for stock control, so keeping a running total of stock received and stock used.

11. Cover any windows with shutters or blinds if the sun can enter the store through the windows.
12. Record the temperature in the store.
13. Store the boxes of similar film size together.
14. Keep the store locked. Allow access to authorised person only.

(b) Short term film storage

1. If possible store films in a lockable hopper, preferably one which will switch off the white light when the hopper is opened.
2. Store the films vertically in the original film box.
3. Never store too many films in the hopper.
4. Have well defined sections in the hopper for the different film sizes. Have a plan displayed so that staff unfamiliar with the layout of the films can find the films needed to load the cassettes.
4. Place a warning on the front panel of the hopper stating:

   "DO NOT OPEN IN WHITE LIGHT"
5. Do not reseal packs of films if the humidity is high.

2.8.2. Chemical storage

(a) Long term storage

1. Mark the chemicals with the date of arrival and record on a stock sheet.
2. Place the chemicals on a shelf which is not too high. Too high a shelf can cause lifting problems.
3. Use a well ventilated room for storage.
4. Use stock in strict rotation, oldest first.
5. Check regularly for leaks or spillage. Wipe up any chemical spill immediately.
6. If possible keep the room temperature between 10^{o}-$18^{o}C$.
7. Make sure that the room does not contain hot pipes.
8. Never store chemicals in direct sunlight.
9. Keep the store locked, allow only authorised persons to enter.

(b) Short term storage

1. Only keep a small stock of chemicals in the darkroom.
2. Store well away from the working area.

2.9 X-ray Equipment

2.9.1. Generators

(a) Check that the equipment is earthed either by a copper tape attached to the metal covers of the unit or by an earth conductor carried in the mains cable of a mobile unit. Further details are given in 2.10.1.

(b) See that the generator output always gives a similar density for the same exposure factors.

(c) In units other than capacitor discharge units, see that the film density is similar when the mAs remains the same but the mA and time are altered:

e.g.	20 mAs	=	100 mA	x	0.2 sec
	20 mAs	=	200 mA	x	0.1 sec

The tests for checking (b) and (c) are described in 3.2.7.. Remember that tests to set standards should be performed using 50, 70 and 90 kVp as the output may not vary at 50 kVp but may vary a lot at a higher kVps.

2.9.2. X-ray tubes and High Voltage Cables

(a) See that the X-ray tube is securely attached to its support and that the delineator or cone fixing block is also securely fixed.

(b) The high voltage cables which connect the X-ray tube to the generator should be examined to see that they are not damaged or acutely bent. Remember that cables should never be pulled, bent or twisted as this will cause serious damage to the electrical conductors they contain and their electrical safety.

2.9.3. Tables, Stands and Tube Supports

(a) Before making any exposure make sure the brakes and locks are on and working so that there is no movement during the exposure.

(b) Check that the column is perpendicular see test described in 3.2.8..

(c) Check the alignment of the tube and the bucky table. The test is described in 3.2.8..

2.9.4. Cones, Light Beam Diaphragms and other Beam Limitors

Large amounts of scattered radiation, if allowed to reach the film, will give poor contrast, i.e. a very grey image. Some loss of detail may occur.

Accurate collimation of the beam ensures that only the area under examination is irradiiated, so that the patient dose is kept to a minimum and the image has the density and contrast to give maximum information. It also ensures that all of the part under examination is included in the exposed area and is not 'cut off' by the light beam diaphragm, due to faulty alignment of the X-ray beam and the light field.

It should be remembered that some types of X-ray tube will cause 'cut off' at very short focus-to-film distances.

(a) Cones

Cone coverage should be determined when setting standards so that the field size they will cover at the normal focus-to-film distance is known. The field size should be recorded on the cone. See the test described in 3.2.9.

(b) Light beam diaphragms (delineators)

(i) Check that the radiation field is the same as the area illuminated by the light from the delineator, see the test described in 3.2.9..

(ii) Check that the scales on the delineators are correct, because the scales will be needed if the lamp fails to illuminate the field, see the test described in 3.2.10..

(iii) Check that the delineator lamp is correctly fitted and that the bulb is the correct type with the correct wattage and its filament in the same position and of the same shape as the bulb it replaced otherwise the illuminated field will be produced in a different place.

(c) Another cause of beam limitation

If a very short focus-to-film distance is used when a large area is to be exposed, the X-ray field will be smaller than the field illuminated by the delineator. It is the design of the X-ray tube and the fixed diaphragm which casues this limitation of the X-ray field. The limitation is overcome by using a longer focus-to-field distance. The test described in 3.2.11. will show whether there is any field limitation at the focus-to-film distance selected.

2.9.5. Grids

(a) A loose (stationary) grid

First inspect the grid to see if it is damaged or not flat (distorted) and see that it is clearly marked with its tube side and the direction of the lead slats. Then ckeck radiographically that it gives an even density over its area by using the test described in 3.2.12.

(b) A grid fixed in a Bucky and moving during the exposure

(i) Check the grid for uniformity using the test described in 3.2.12.

(ii) If the grid is of a type which requires setting before every exposure, it is important to check that the time taken for the grid movement is longer than the exposure time as described in the test given in 3.2.13.

2.10 Safety

2.10.1 Electrical Safety

(a) Earthing of electrical equipment

Earthing is provided by connecting the metal covers on the X-ray equipment to earth by a copper conductor.

This conductor may be:

(i) a copper tape attached to the metal covers of the X-ray table, tube support, transformer and control unit and connecting them to earth.

MAKE SURE THE TAPE REMAINS SECURELY ATTACHED.

(ii) an earth conductor carried in the mains cable of a mobile unit which is connected at the unit end to the parts requiring earthing and at the other end to the earth conductor in the plug socket. Remember that the use of adaptors or extension cable breaks the continuity of the earth conductor and so should never be used unless there is no alternative. However, if an extension cable has to be used remember that the cable must be of the same thickness as the unit's mains cable and that the earth connection at both ends must be securely attached.

REGULARLY EXAMINE THE CABLE FOR DAMAGE AND CHECK THE CONNECTIONS AT BOTH ENDS LOOKING AT THE CONDITION OF:

(a) the protective insulating cable cover. If there is any cut or damage this should be repaired or replaced at once.

(b) the junction between the cable and the plug top. The insulating cable cover must be held securely, so that the conductors contained within the cable cover are not exposed.

(c) the plug top casing. If this is cracked or broken it must be replaced at once.

(d) the earth terminal within the plug must be securely fixed. Every 6 months an electrician or a person permitted by their employer to undertake electrical repairs should check the earth connection in the plug. If the plug rattles when shaken it should not be put into the socket until it has been checked by an electrician or the person permitted to undertake electrical repairs.

NOTE - damage can be prevented by careful handling of the equipment and its cables. Care must be taken not to strain, crush or bend sharply the cables when the equipment is moved.

(b) Fuses

Electrical equipment is fitted with fuses as safety devices to prevent currents in excess of their normal value passing through the circuit. Therefore it is very important to fit a fuse of the correct value. If a fuse fails it may be replaced with another of the same value once, if it fails again there must be a fault in the circuit which must be found and corrected. NEVER increase the value of the fuse, this is a very dangerous thing to do.

Some X-ray mobile equipment has a special plug, normally red and marked 'X-ray Only', this must not under any circumstances be fitted to other equipment. It is a special plug without a fuse. It is specially designed to allow the very, very short X-ray exposures to be made but is dangerous for ordinary electrical equipment which does not have the special safety devices included in X-ray equipment.

(c) Plugs and sockets

If possible all sockets should have switches so that the electrical supply can be switched off before the plug is removed. Remember, never remove a plug by pulling on the cable. To switch off is good practice, it will avoid sparking in the socket and so prevent damage to the socket.

Sockets must be placed well away from water and should not be in a place where water can be spilt on them or dripped on them should there be a leak.

If darkroom equipment, such as film viewers (illuminators) have to be switched on and off, a cord switch should be fitted so that the operator, whose hands may be damp, does not have to touch the actual equipment but only the cord to operate the switch.

If a plug or a socket gets old or worn or if the fuse connector does not grip the fuse ends tightly, the plug, its connecting pins and/or the socket may get very hot. If this occurs the plug and/or its socket may need replacing, although another cause of this heat may be the attachment of electrical equipment requiring more power than the wire supplying the socket is able to carry safely. Therefore if a plug and/or a socket is found to be hot get expert help to find the cause.

(d) Equipment covers

Equipment containing electrical parts must be enclosed in covers. These covers ensure that the live parts cannot be touched. The container is designed to make sure that the parts are separated from each other and from the cover. Therefore covers should always be securely fixed in position and if damaged should be removed after the equipment has been disconnected from its electrical supply and a check made to see that the dent has not pushed the parts closer to each other or to the outside cover. If damage is found inside the unit it must be put right by an electrician and any dent in the cover knocked out. Remember to check that the earth connection is still attached when a metal cover is refixed.

(e) Cleaning

Never use water or even a damp cloth to clean electrical equipment. Use a non-flammable polish such as a car polish which is available locally.

(f) Repairs

Repairs should only be undertaken by people who are trained and have the approval of their employers to undertake such work.

(g) Electrical fire

Electrical equipment, through a fault, short circuit or overloading may become so over-heated that it reaches such a high temperature that fire can occur. If smoke or a hot smell is noticed, the equipment must be disconnected from its electrical supply immediately. Any fire in electrical equipment will generally go out as soon as the supply is switched off because it does not normally contain burnable material. However, if the fire has ignited surrounding material it should be put out with a fire extinguisher. A CO_2 or dry powder extinguisher must be used on an electrical fire. Water should NEVER be used on an electrical fire. Dry sand can be used if there is nothing else. Remember if a fire occurs call for assistance at once, evacuate everyone to a safe place and close all doors.

Because of the fire risk, burnable dust should not be allowed to collect inside containers of electrical parts and air should be able to circulate freely around the equipment so that heat is unable to build up within the equipment.

2.10.2. <u>Mechanical Safety</u>

Tidy the X-ray room and darkroom so that there is no risk of injury to patients or staff.

Check:

(a) Fixtures are securely attached to the wall, ceiling or floor.

(b) Locks and brakes operate efficiently.

(c) That knobs and covers are securely fixed in position so that no patient or operator can trap their fingers or injure themselves in any way. Any screws which are found to be missing should be replaced by others of the same length.

(c) Check that the cone and light beam delineator are securely attached to the X-ray tube and that the tube is securely attached to its support.

2.10.3. Radiation Safety

(a) Check the lead rubber used to cover a part of a cassette to make sure no radiation passes through it when using the normal exposure factors for a limb. If the rubber is not thick enough, use another layer of lead rubber otherwise the film will be fogged.

(b) Lead rubber aprons

Inspect the apron to make sure that there are no badly damaged areas, remember that when the apron is being worn even small splits may open up to make a large hole necessitating repair or replacement. Slits can be pulled together and held securely with adhesive strapping to prevent any separation. If a repair of this sort is undertaken the area of the apron should be X-rayed to see that no radiation passes through.

2.10.4. Chemical Safety

Processing chemicals are a hazard because they can cause skin irritation and produce fumes which may be inhaled. Therefore, good ventilation of the darkroom is essential and wherever possible processing solutions should be prepared outside the darkroom this is particularly important when powdered chemicals are used. For however careful the person is mixing the powder into the water some powder will rise into the air and may be inhaled or deposited on darkroom surfaces possibly causing contamination of the solutions.

Protective clothing: rubber gloves, mask, apron and goggles should be worn when mixing chemicals. Hands should always be washed immediately after contact with the processing solutions. If a chemical splashes into the eyes, the eyes should be bathed at once in clean water.

Used fixer solution should always be disposed of carefully the silver compounds in the solution will pollute the environment, see Section 2.2.1.

3. MAINTAINING STANDARDS OF QUALITY

Standards are maintained by regularly undertaking the tests described in this section of the handbook. The performance of the X-ray and processing equipment is assessed to see if there are any changes in image quality before the deterioration can be seen in the films of patients and before repeat films become necessary. In addition, if a change in exposure factors or processing time becomes necessary in order to maintain film quality, the appropriate tests should be carried out at once to see what is the cause of the change.

The results of all the tests and the action taken on any faults discovered must be carefully recorded and any films kept for future reference. Comparison with previous test results will often show a gradual deterioration which can be corrected before it is noticeable in the normal routine work.

3.1 Test equipment including specialised test tools and sensitometric strips

3.1.1. Test equipment

This is a list of equipment which will be required to undertake the tests described in this handbook

Timing clock
Photographic thermometer
Scissors
Film clips for suspending film strips in the processing chemicals
2 stirring sticks for processing chemicals, 1 for the developer 1 for the fixer
Key or some small metal marker
Pencil
Paper for recording data
6 coins
Cardboard sheet to cover films used for tests (24 x 30 cm)
Prepared sensitometric strips in a light tight container
Clean cotton wool
Mild white soap
Adhesive labels or sticky paper for labelling
Paper tape or sellotape
Ruler 30 cm in length and a 1 metre rule or stick
Plumb line (string with an attached weight)
2 lead rubber sheets
Metal markers to identify films
Metal washer or a small coin
Box of paper clips
Plastic bucket for use as a water phantom
Large diameter bowl or spirit level
4 three inch lengths of wire bent to form a right angle
Spinning top, this may be made as described in 3.1.2 if one cannot be brought
Cassette with intensifying screens selected for testing purposes and clearly marked as such - this cassette can still be used for normal radiography.

3.1.2. (a) Making a simple hand operated spinning top

The disc is made from:

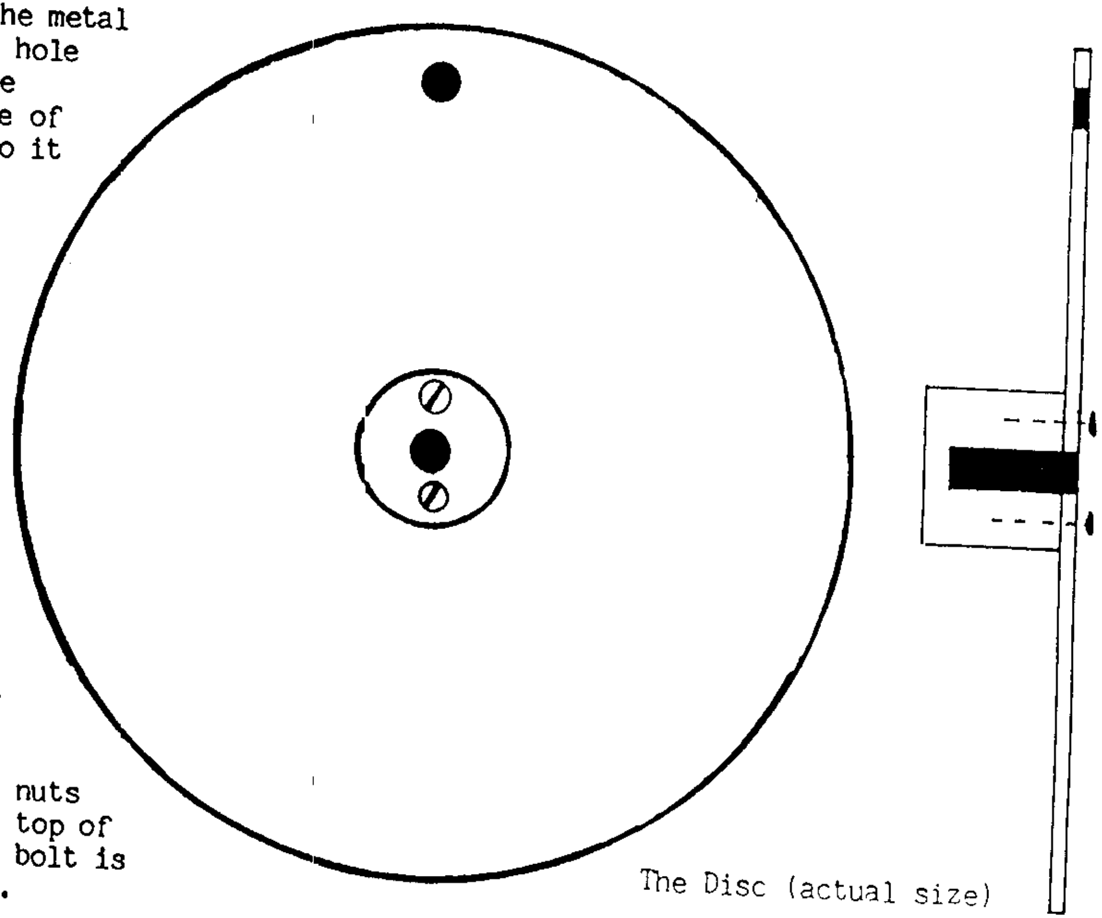
A mild steel or brass (not aluminium) disc 100 mm in diameter, 2-3 mm thick with a 20 mm stick stuck in its centre, if strong glue is not available the metal disc may be secured to the wooden one with screws.

The diagram shows how the metal disc has a 5 mm central hole bored through it and the attached wood has a hole of the same size bored into it for 15 mm (not right through)

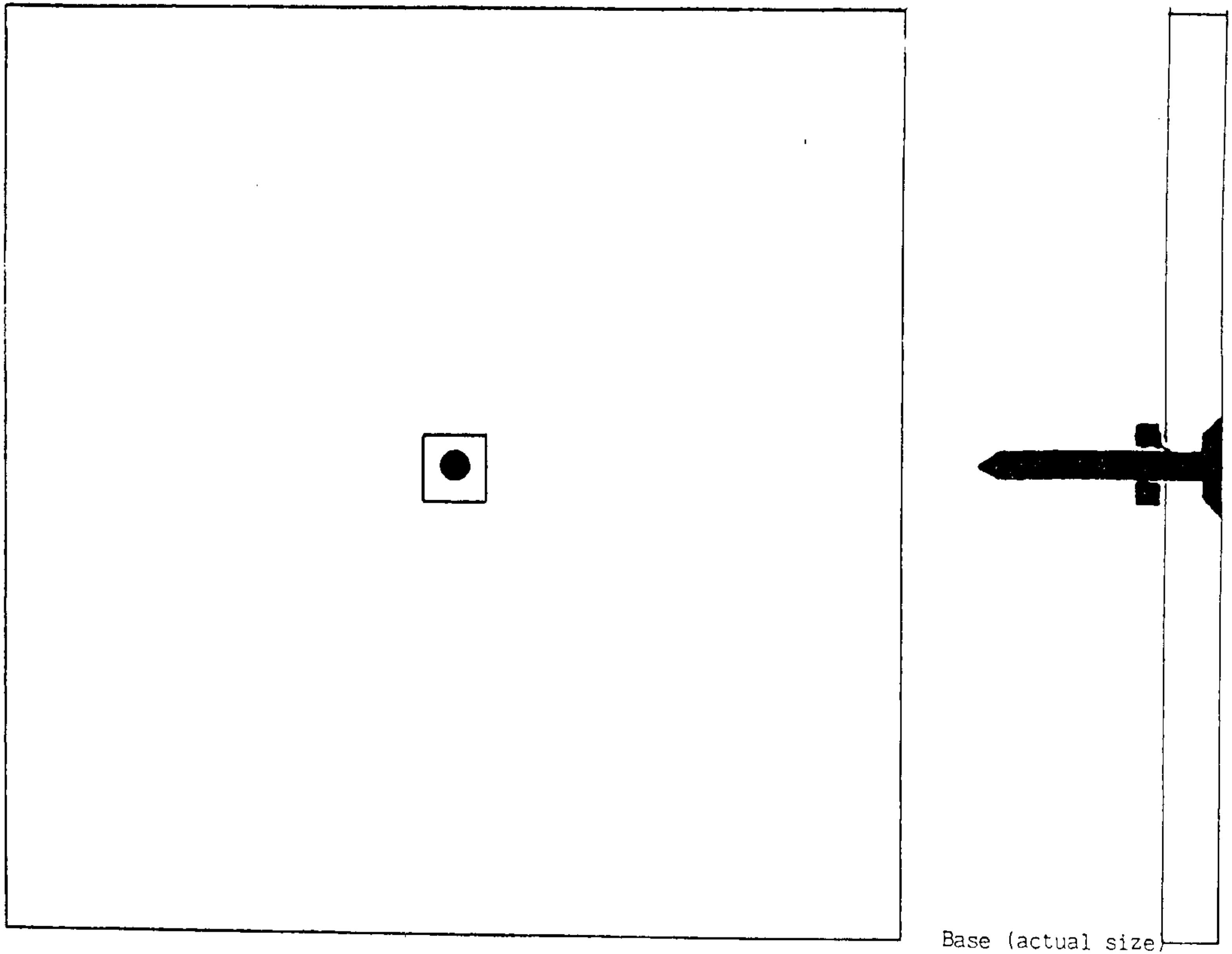
A further 5 mm hole is drilled through the metal disc 10 mm from the edge of the disc.

The base has:

A wooden base 150 mm square with a bolt 45 mm long and 3 mm thick put through a central hole. The bolt head is recessed into the base so that it does not project above the surface. The bolt is secured in position by 2 nuts tightened up against the top of the base. The tip of the bolt is filed to give it a point.



The Disc (actual size)



Base (actual size)

To assemble and operate:

Place the metal disc on top of the upright bolt with the point projecting up through the metal disc into the wooden disc.

To use, the base is placed on a loaded cassette. The disc is rotated on the bolt by the finger and thumb. The radiographic exposure is made after the speed of rotation of the disc has reduced to a slow rate.

Note: the operator must make the disc rotate quickly at first so that he/she can make the X-ray exposure from a safe position.

This simple manually operated spinning top is quite satisfactory for checking the timer of a 2 or 4-pulse unit but cannot be used for capacitor discharge units or medium frequency units.

(b) The Water Phantom

To provide an attenuating object which will be available in all departments, a water phantom is used in the tests requiring comparison between quantities of radiation. It replaces the aluminium step wedge in the quality control tests described in this handbook.

Preparation of the Water Phantom : It is important that the same water container is used for every test since the container will itself attenuate the X-ray beam to some extent. A plastic bucket is an ideal container.

The bucket is filled to a depth of 10 cm with clean water. Having measured the depth of water it is recommended that the water level is permanently marked on the inside of the bucket with waterproof ink or paint and the bucket marked to indicate that it is the one to be used for quality control tests thus the attenuation factor will always be the same.

The exposure factors must be determined by experiment because of the different types of equipment and materials which are used in departments. The aim is to obtain a Density of 1 under the water phantom using a kVp of 80 and a standard focus-to-film distance of 100 cm or the distance normal used. Several exposures with different mAs values using a low mA setting may be needed before the density of 1 is obtained. Once the correct exposure factors have been determined these must be carefully recorded so that exactly similar exposure factors can be used each time the test is repeated.

A density of 1 can be assessed adequately for these tests in the following way - a newspaper is placed beneath the film density, if the print can just be read by reflected light through the film the density is approximately 1.

The eye is sensitive to small variations in density when it is around 1 so assessment of results is generally made by viewing a density of around 1.

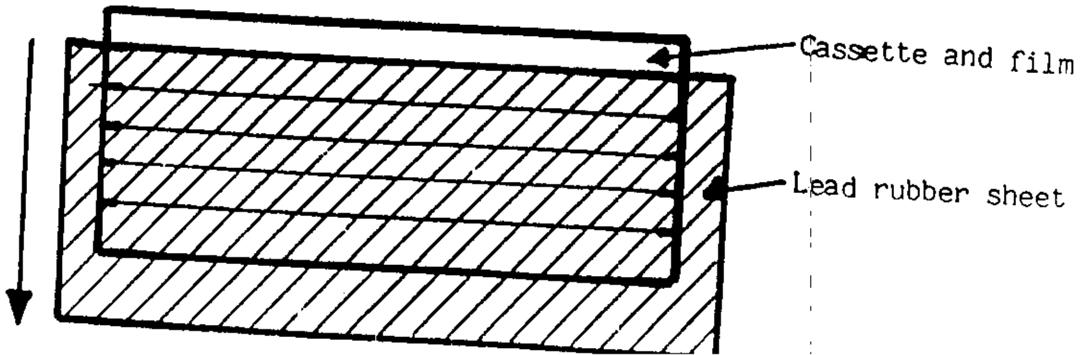
3.1.2. Production of sensitometric test strips

Sensitometric test strips are produced by cutting a film into strips to ensure that the amount of exposure received by each is exactly the same so that any variation shown after development must be due to development changes.

Equipment required: A cassette with intensifying screens and the film used for normal work. Ideally the cassette should be long and should be marked so that the same cassette can be used every time.
A sheet of lead rubber, large enough to cover the cassette.
Adhesive tape and scissors.

Method:

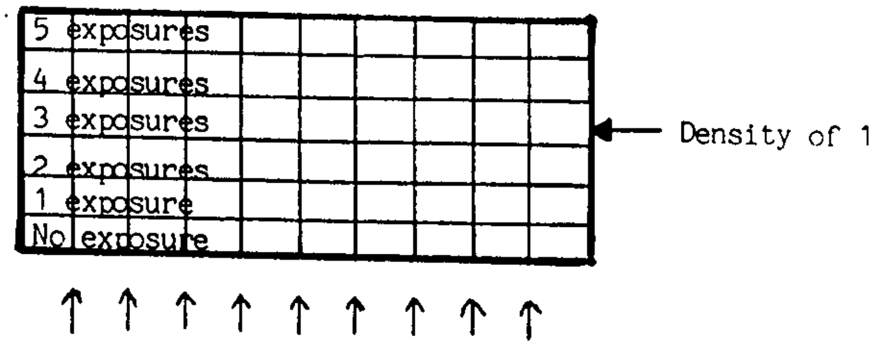
1. The cassette is marked by tape into six equal strips as shown in the diagram. It is then placed on the table and centered to the X-ray tube at a focus-to-film distance of 100 cm.
2. The lead rubber is placed over the cassette shielding the whole cassette apart from the first strip as shown in the diagram.
3. An exposure is made using the lowest kVp and mAs available. These factors may need adjustment if the densities produced on the film are not satisfactory. The aim is to produce a density of 1 on the centre strip. A density of 1 can be judged by placing a newspaper under the film if the denist is 1 it will just be possible to read the type by reflected light. If the lowest available factors produce too high a density a focus-to-film distance of 200 cm should be used.



4. A second exposure using the safe factors is made after the lead rubber has been moved down to uncover 2 strips (the one already exposed and the next).

5. Exposures are made each time the rubber is moved to uncover another strip until one last strip remains covered. The strip is not exposed and so can be used to assess the amount of basic fog present after development.

6. When the exposures are complete the film is cut into strips about 3 cm wide. The cut must be across the exposed strips so that each piece has a series of densities on it. The collection of strips are stored in a light tight box in the darkroom ready for use.



Cut into a number of strips

3.2. Tests for checking performance, detecting faults and the action to be taken

3.2.1. Tests for Fogging

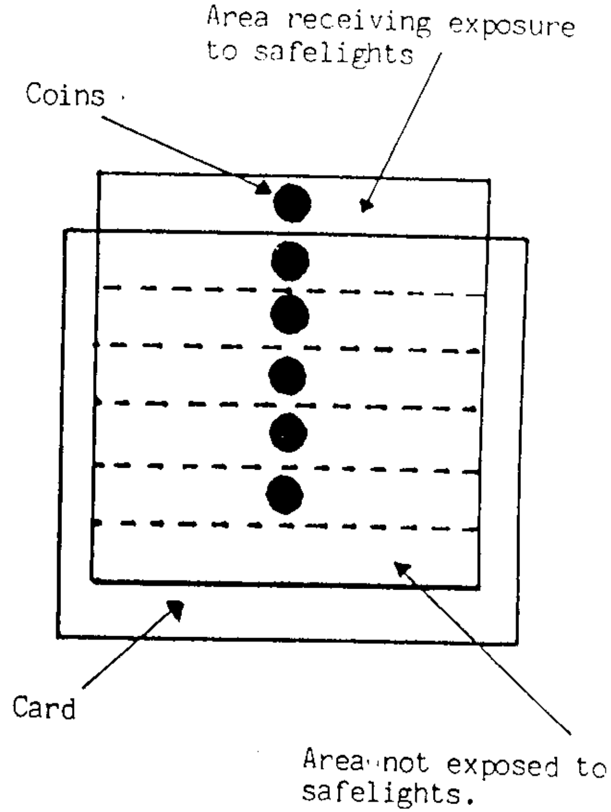
(a) Safelight fogging

When films show an overall increase in basic fog, usually noticed in unexposed areas of the developed film, the safelights should be checked.

Equipment required: X-ray film
a piece of card large enough to cover the film
6 coins
a timing clock or watch

Method:

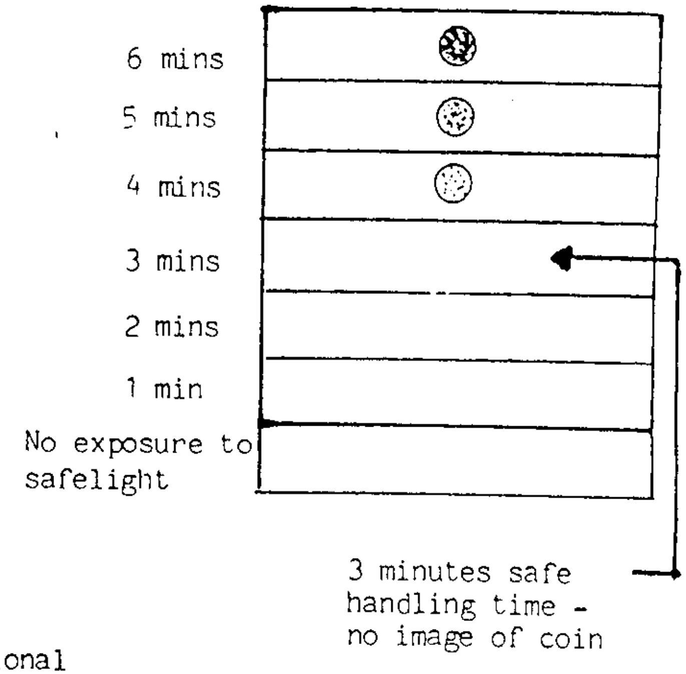
1. In the darkroom without the safelights switched off remove a film from the box or hopper and place it on the work bench where the cassettes are generally unloaded.
2. Place 6 coins on the film as shown in the diagram. Cover the film and the coins with the card.
3. Switch on all the safelights.
4. Start the clock and immediately move the card to expose the first coin to the safelight illumination.
5. After 1 minute uncover the next coin by moving the card.
6. After another 1 minute expose the next coin and continue until all coins have been exposed to the safelights. The last strip of film without a coin upon is not uncovered.
7. Cover the whole film with the card.
8. Switch off the safelights and process the film in the usual way.



Interpretation:

9. Examine the processed film. If the outline of the coins can be seen this will show that there is safelight fogging present. The length of time that a film can be safely left in safelight illumination can be determined by examining the film and noting the longest time the film can be exposed to the safelight without showing any outline of the coin. This time is known as the 'safe handling time'.

10. The safe handling time will normally be about 3 minutes. This time is long enough for the cassettes to be unloaded, films identified and placed in the developer. If the time is shorter than this fogging may occur unless the films are handled very quickly within the shorter handling time If the time is much longer it indicates that the safelight illumination is too low making work in the darkroom more difficult than is necessary.



Action:

11. If the safe handling time is too short raise the height of the safelights or reduce the wattage of the safelight bulbs. If the safe handling time is longer than necessary an additional safelight can be added but never increase the bulb wattage of existing safelights or lower them to less than 130 cm (4 feet) above the work surface.

NOTE exposed films are more sensitive to safelight illumination than unexposed films so if there is still a problem with safelight fogging after this test has been performed repeat the test using a film which has received an X-ray exposure of the lowest kVp and mAs possible. This test will show a slightly shorter safe handling time.

(b) <u>White light fogging</u>

Any daylight or artificial light entering the darkroom may fog the films so it is important to look for any light leakage into the darkroom.

Light fogging may produce overall fogging or it may produce unusual images on radiographs because other darkroom equipment' has prevented the light reaching part of the film.

To check for light leakage it is necessary to:

1. Enter the darkroom and switch off all the lights including the safelights.
2. Make sure that all blinds and doors are fully closed.
3. Remain in the darkroom for 10 minutes so that the eyes are fully adapted to the dark.
4. Then look for light entering the darkroom, paying particular attention to the surrounding of doors, windows, extractor fans and where pipes enter and leave the darkroom. In addition to a close inspection around the doors, etc. remember to inspect the doors and windows etc. from the position where films are handled.
5. If there is any doubt about a light leak, place a film with a piece of paper or card over part of its area and leave it in the suspect area for about 3 minutes. Then develop the film. If light has fogged the film this will be obvious by an increase in density in the unprotected area.

Action:

6. Carefully seal all holes to prevent any light entry. Light entering around a door or window can be stopped by fitting an additional strip of wood around the door or window frame.

(c) Radiation fogging

(i) Test for presence of fogging in the cassette pass through hatch

Method:

1. Fix a key with adhesive tape on the outside of a cassette making sure that the key is on the edge of the cassette nearest to the X-ray room. Place it in the hatch.

2. Leave the cassette in the hatch for a week or the time taken to make 100 exposures.

3. Process the film in the usual way.

Interpretation:

4. Examine the film, if there is an image of the key on the film there has been radiation reaching the film in the hatch. If the image is very clear repeat the test waiting for only 10 exposures before processing the film.

Action:

5. If the key is seen clearly after 10 exposures additional protective material must be be fitted to the door of the hatch on the X-ray room side as soon as possible. This will take time to arrange and so that work can continue cassettes should be stored elsewhere where there is no risk of fogging.

6. If fogging only occurs after 100 exposures it is only necessary to make sure that only those cassettes which are used frequently are kept in the hatch.

(ii) <u>Fogging of unexposed films in the hopper or their boxes</u>

Method:

1. Fix a key on the X-ray room side of the hopper or on the outside of the film box facing the X-ray room.

2. After 100 exposures or a week develop the film closest to the X-ray room.

Interpretation:

3. If the film shows an image of the key this shows that radiation is reaching the film. If the image is very clear repeat the test developing the film after 10 exposures. If the outline is shown on the film it indicates a serious radiation leak.

Action:

4. If an image is shown on either test the unexposed film stock in the darkroom should be stored somewhere else where there is no risk of fogging until the cause of the radiation leak is found and corrected by additional protective measures.

3.2.2. Test of water flow

Method:

1. Empty, rinse and wash the water tank thoroughly, remember that drainage pipes may require cleaning.
2. Replace the plug and fill the tank with the inlet tap (valve) opened to its normal position. Note the time taken to fill the tank.

Interpretation:

3. Calculate how many times the tank can be filled in one hour.

   i.e. If the tank takes 15 minutes to fill it can be filled four times in an hour.

   4 changes an hour

   Ideally the wash tank should have 4 changes an hour.

Action:

4. If the flow rate has fallen to below 4 changes an hour or less than is normal, water filters and pipes should be checked to see if they are restricting the water flow.
5. Repeat the test after every effort to improve the flow has been made by cleaning and clearing the pipes so that any improvement can be noted and should there be further deterioration in the water supply this will be noticed before it is reduced to a totally unsatisfactory supply.
6. Unfortunately, a restricted water flow is most commonly the result of low pressure in the hospital water supply, a situation over which the X-ray technicians have no control.

Note: in areas where frequent water failure occurs the technician should keep a reserve supply of clean water in a container in the darkroom so that even if the water supply fails adequate rinsing and washing of the films can take place by changing the water in the tank using the water from the container. Remember to change the reserve water supply in the container frequently and note when this is done.

3.2.3. <u>Test for developer activity</u>

The activity of the developer affects the density, contrast and amount of basic fog of the radiograph. Therefore it is important to check its activity regularly. As a minimum tests on activity must be made at least once a week and after the developing solution has been replenished or renewed. Without a standard level of activity control the quality of the radiographs cannot be achieved.

Method:

1. Stir the developer and check its temperature. If the temperature is not correct, the solution must be warmed or cooled by varying the temperature of the water jacket, not by adding ice or hot water to the developer itself.
2. When the temperature is correct, develop one of the sensitometric strips prepared as described in 3.1.2..
3. Mark the strip with the date.

Interpretation:

4. Compare the strip with those processed previously, see how the most dense and the least dense strips compare with similar steps on the previously developed strips. The unexposed area of the strip is compared to assess the level of basic fog.

Action:

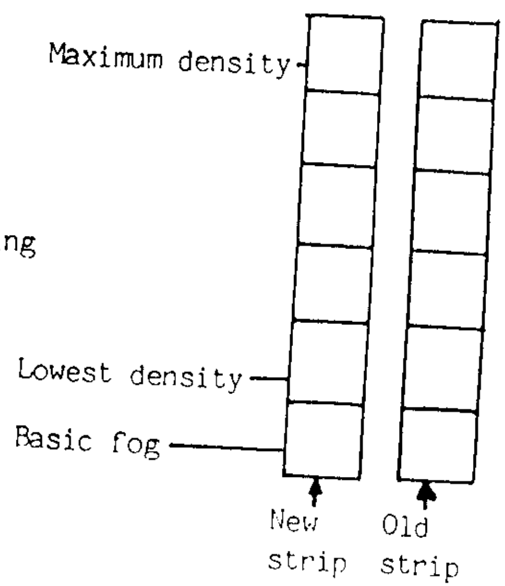
5. Keep the strip for comparative purposes.
6. <u>If the density is lower than the previous strip</u>

   The developer may be exhausted, or incorrectly prepared by using too much water in the mixture or diluted by the addition of water to replenish the solution instead of using a replenishing solution.
7. <u>If the density is greater than on previous strips</u>

   The developer may have been 'topped-up' with a replenishing solution which is too strong or too much has been added because of poor drainage of films as they are lifted from the developer.
8. <u>Higher basic fog level than previously seen on strips</u>

   Increased basic fog may be due to developer exhaustion or chemical contamination.

<u>Compare</u>



3.2.4. Test for light leakage into a cassette

If fogging is seen on the edge of a film it may be due to a damaged cassette allowing light to enter through the damaged area. If cassettes and screens are identified by numbers or letters as suggested in 2.5.1. it will be easy to find the suspect cassette and then the fault should be confirmed by the following test.

Method:

1. Load the suspect cassette with an unexposed film.
2. Leave the cassette in a well lit or sunny place. Turn the cassette after an hour so that the other side of the cassette receives direct light.
3. Remove the film from the cassette for processing but before putting it in the developer, mark the film with pencil to identify the hinge, open side and top of the cassette using H for hinge, O for open side and T for top.
4. Process the film in the usual way.

Interpretation:

5. When the film is dry examine it for fogging around the edge. If fog is seen locate the light leak by means of the pencilled letters. An edge of 0.5 cm around the film can be disregarded but this cassette must be watched as the damage may well extend until it is significant.

Action:

6. If significant fogging is found, repair the damage if possible. Repairs cannot often be made unless the hinge or the clip are the cause. If a repair cannot be made the cassette must be replaced. If there is difficulty or delay in obtaining replacement cassettes it may be possible to continue using the cassette by keeping it unloaded until just before it is to be used.

3.2.5. Test for film/screen contact

An increase in unsharpnes of the radiograph may be due to poor contact between the film and the intensifying screens. If cassettes are identified and the unsharpness is found on radiographs taken with a particular cassette, the unsharpness is almost certainly due to this fault. To confirm the fault the following test should be performed.

Equipment required:

a large number of metal paper clips

Method:

1. Place the suspect cassette on the table and centre the tube over it using the normal focus-to-film distance. Collimate the beam to just cover the area of the cassette.
2. Spread the paper clips over the cassette making sure that there are clips on every part of the cassette.
3. Place a metal marker on the top, hinge and open side of the cassette so that the location of the fault can be found.
4. Using 55-60 kVp and an mAs to give a density of about 1 (a medium grey) expose the film.
5. Process the film in the usual way.

Interpretation:

6. When the film is dry examine the film carefully to see if some of the paper clip images are unsharp compared with the rest of the clips. If there are a number of unsharp clip images then this is an area where there is poor contact.

Action:

7. Generally it is not posible to correct this fault unless it is due to faulty clips or hinges of the cassette. As information is lost if the radiographic image is unsharp the faulty cassette should not be used again. A replacement must be requested.

Note: the most frequent cause of damage is careless handling or excessive pressure applied unevenly on the cassette.

3.2.6. Tests for assessing the speed of films and film/screen combinations

(a) To compare the speed of a new type of film with the normal film

It is important to know the speed of a new film compared with the previously used film so that the exposure factors can be adjusted to avoid repeat examinations.

Equipment required:

Cassette with intensifying screens
New film to be tested and film already in use
Sheet of lead rubber
Pair of scissors and a pencil

Method:

1. In the darkroom put an old and the new type of film on top of each other and cut them in half. Write on each half to identify them. Place half of the old film and half from the new side by side in the cassette.
2. Place the cassette on the table top and using the lead rubber expose the cassette in strips using an exposure similar to that used to produce the sensitometric strip (3.1.2.) but this time double the total mAs every time a new strip is uncovered. 5 strips should be produced.
3. Process both half films taking care that they have exactly the same development time.

Interpretation:

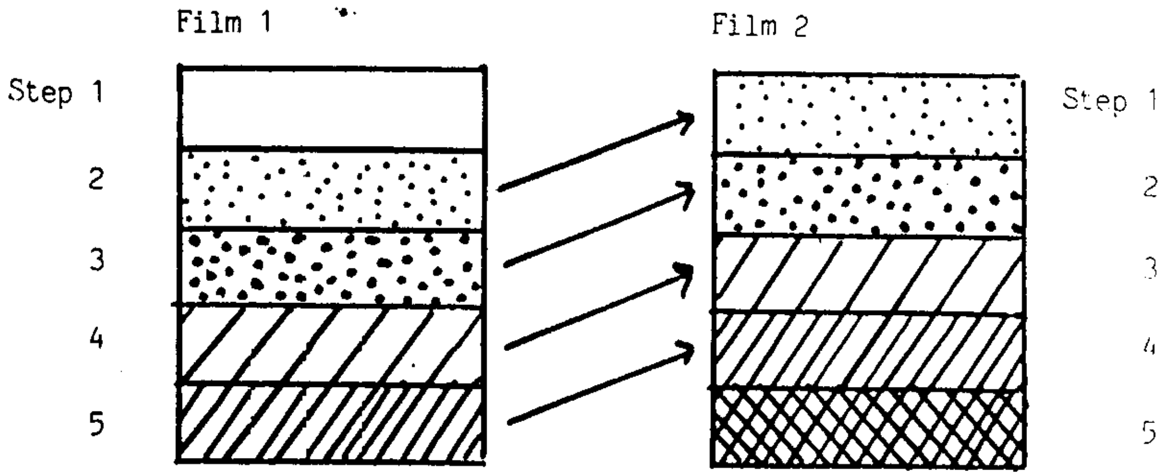
4. When dry compare the two half films. If the strip with a density of 1 is in the same position on each half the films are of the same speed. If not move the strips until the density of the strips match.

Action:

5. If there is a variation of one step then the new film is ½ or twice the speed of the old film and the mAs must be halved or doubled when using the new film. If there is a 2 step difference the mAs required will be a quarter or 4 times the old mAs. (See the diagrams)
6. Record the exposure factors for future use.

Example 1

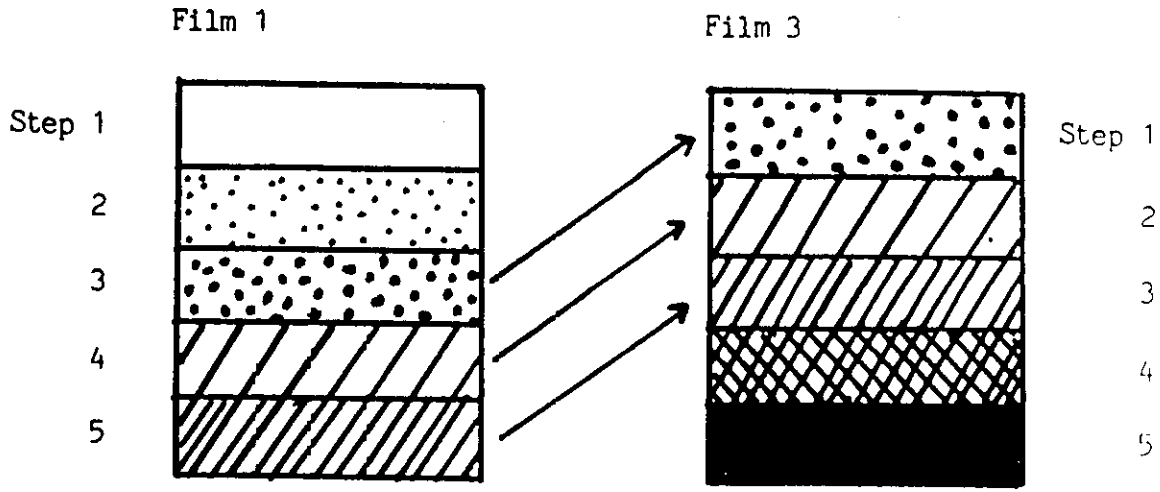
Step	Exposure
1	2 mAs
2	4 mAs
3	8 mAs
4	16 mAs
5	32 mAs



Film 2 is 1 step faster. Therefore for Film 2 to have the same density as Film 1 1/2 the mAs is required.

Example 2

Step	Exposure
1	2 mAs
2	4 mAs
3	8 mAs
4	16 mAs
5	32 mAs



Film 3 is 2 steps faster than film 1. Therefore for Film 2 to have the same density 1/4 of the mAs is required

(b) <u>Test to compare the speed of two film/screen combinations</u>

In order to set the exposure factors for a new combination of film and intensifying screens it is useful to be able to multiple or divide the mAs values used with the original film and screens to give the same density. The factor by which the exposure is increased or decreased is a measure of the change in speed of the film/screen combination.

Equipment required:

Cassette with the usual film/screen combination
Cassette with the new film/screen combination
2 sheets of lead rubber large enough to cover 2 cassettes
Metal markers to identify the films.

Method:

1. Place the two cassettes side by side on the table top at the normal focus-to-film distance.
2. Collimate the beam to cover both cassettes.
3. Place the lead rubber sheet across both cassettes leaving a strip of the cassettes uncovered. The strip should be 1/5 of the length of the cassettes. Place metal markers on the cassettes to identify their films.
4. Expose the strip to the factors used in the test to check film speed. Record this exposure for future use.
5. Cover the exposed strip with the other lead rubber sheet. Uncover the next 1/5 of the cassette and expose this strip to twice the mAs of the previous strip.
6. Continue to expose one strip after another giving each strip twice the mAs of the previous one until all 5 strips have been exposed.

7. Process the films.

Interpretation:

8. When the films are dry compare the strips of density. If the strips in a similar position have the same density the speed of the combination is the same. If the density of one film is similar to the next strip on the other the new film/screen combination is twice as fast or half as fast as the old film.

Action:

8. Once the factor is determined label the cassette with the factor so that the exposure change necessary to give the same density can be calculated.

3.2.7. Testing the generator

(a) Test to check the consistency of the X-ray generator

It is important to check that the X-ray generator produces the same photographic density every time the same exposure factors are selected. This test should be performed at the beginning of a Quality Control Programme and every 3 months as part of the programme. If patients' films show unexplained differences in density during the day this test should be performed several times during the day to show whether inconsistent equipment performance is the cause.

Equipment required:

Water phantom as described in 3.1.2.
Metre rule
Loaded cassette - always use the same cassette for this test.

Method:

1. Position the water phantom on the loaded cassette.
2. Centre the X-ray tube over the cassette. Collimate the beam to just cover the area of the cassette using a focus-to-film distance of 100 cm.
3. Check that the mains compensator is correctly set.
4. Expose the film to the factors used in 3.1.2.
5. Process in the usual way.

Interpretation:

6. When the film is dry compare the density of the film exposed through the water phantom with those produced on previous occasions. The images will have similar density if the generator is giving a consistent output.

Action:

7. Mark the film with the exposure details and the date and time of the exposure. Store the film for future use as a basis for comparison.

8. If the film shows an inconsistent result ask the X-ray engineer to correct the fault. If a series of films taken on one day show that the density difference is the same on every film work may continue whilst waiting for the engineer by making allowance for the difference by adjusting the exposure factors. If the density is different on all the films the equipment should not be used as it will be impossible to avoid repeat films.

(b) <u>Test to check that the photographic effect of the mAs remains the same when the mA and time are changed</u>

When there is need for a shorter time to stop patient movement it is usual to increase the mA to give the same mAs value with a shorter time. This test should be undertaken regularly to ensure that for any mAs value there is no difference in photographic density when different mA settings are used. Unless this is so repeat exposures may be necessary to obtain the expected photographic result.

Equipment required:

Water phantom
Metre rule
Loaded cassette
Two pieces of lead rubber sheet
Metal markers to identify images.

Method:

1. Position the water phantom over one third of the loaded cassette after covering the remaining two thirds of the cassette with lead rubber.

2. Identify the area to be exposed with a metal marker.

3. Centre the X-ray tube over the uncovered part of the cassette, collimating the beam to the uncovered area using a focus-to-film distance of 100 cm.

4. Check that the mains voltage compensator is correctly set.

5. Expose the film using the exposure factors given in 3.1.2.

6. Cover up the exposed area and uncover the second third of the cassette covering up the two remaining thirds. Expose this section of the film through the water phantom using the same mAs but a different set of time and mA values. Expose the film again on the last third using another set of mA and time to give the same mAs value. An example of three sets of exposure are given below:

Exposure 1	10 mAs	50 mA	0.2 sec
Exposure 2	10 mAs	100 mA	0.1 sec
Exposure 3	10 mAs	200 mA	0.05 sec

Note: always check using the highest mA regularly used as this is often the one with greatest variation.

7. Process the film in the usual way.

Interpretation:

8. Examine the film - if the generator output is satisfactory the three images of the water phantom will have similar density. If not there may be a fault in the time or mA delivered. Which of the 2 factors at fault may be determined by checking the timer as described in 3.2.7. if the generator is a 1 or 2-pulse unit (self or full-wave rectified unit). The B.R.S. timer cannot be checked with the simple test described in 3.2.7. so it will be difficult to decide whether the mA or time value is at fault. However, if all three densities are different the fault is most likely to be mA.

Action:

9. Record the exposures and keep the film for the engineer to examine so that he will have a better idea of the fault. If there is a very marked difference in density on one third of the film do not use this setting until it has been corrected.

(c) Test to check the accuracy of the X-ray timer of a 1 or 2-pulse unit

The timers of a 3-phase, capacitor discharge and B.R.S. (Medium Frequency) units cannot be checked by this method.

This test should be performed routinely as part of a Quality Control programme and when films show density inconsistency and other causes such as processing faults have been eliminated. It should always be undertaken when exposure changes are being made which involve the use of very short exposure times as inconsistency in timing is much more obvious when exposures are under 0.05 sec.

Equipment required:

Manually operated spinning top
Loaded 24 x 30 cm cassette
Two sheets of lead rubber

Method:

1. Place the spinning top on the left hand quarter of the cassette.
2. Cover the remaining three quarters of the cassette with lead rubber
3. Centre the X-ray tube to the centre of the spinning top using a focus-to-film distance of 100 cm. Collimate the beam to cover the spinning top.
4. Set the exposure to 70 kVp 100 mA and 0.1 sec or the shortest time used for any radiographs or the time which is thought to be inaccurate.
5. Manually spin the top and make the exposure. It is important to spin the top at a speed that will separate the images of each generated pulse of radiation and not too fast to spread the pulses over more than one revolution. The correct speed can be estimated by spinning the top rapidly and then waiting for it to slow down until the hole in the top can be seen. An exposure made at this point should produce a film on which the spots of radiation can be counted.

6. Move the spinning top to the next quarter and repeat the exposure using the same exposure time and then move the top twice more to the third and fourth quarters repeating the same exposure. When the four exposures have been made process the film in the usual way.

Interpretation:

7. The film will show four images having a series of spots forming an arc. The separation of the spots has no significance, it only indicates the speed of rotation of the disc.

8. The accuracy of the timer is checked by counting the number of spots. If the mains supply has a frequency of 50 Hz (50 cycles per second):

   (a) a one-pulse unit (self rectified) unit will generate 50 pulses of radiation in one second (50 spots on the film) Therefore for 0.1 sec exposure time 5 spots should be produced (see the diagram)

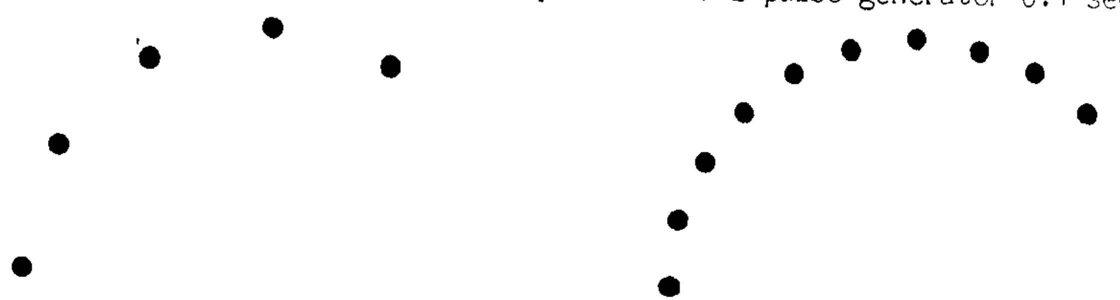
   (b) a two-pulse (full-wave rectified) unit will generate 100 pulses of radiation in one second (100 spots on the film) Therefore for 0.1 sec exposure 10 spots should be produced (see the diagram)

   Other exposure times will of course produce different numbers of spots.

   A mains supply having 60 Hz will give 60 pulses of radiation in one second giving 60 pulses of radiation from a one-pulse unit, 120 pulses from a two-pulse unit.

   Diagram to show the spots produced by:

   (a) 1-pulse generator 0.1 sec exposure (b) 2-pulse generator 0.1 sec exposure



Action:

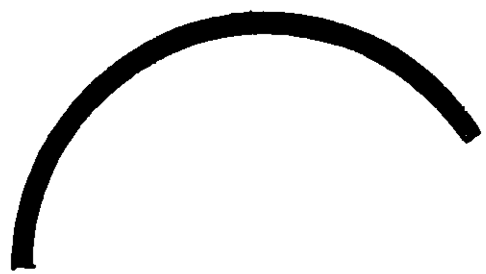
9. If the number of spots on the film are not the number expected, this will indicate a timing inaccuracy. If all four images show the same number of spots this will show that there is a fault but at least it happens on every exposure. Errors in timing should be corrected as soon as possible. If the engineer cannot come for some time a decision must be made as to whether it is right to risk many repeat exposures and continue using the unit or whether it is reasonable to continue working making allowance for the error.

A consistent error shown by the same incorrect number of spots on every image can be allowed for by modifying the exposure time to produce the required image density.

If the error is inconsistent and only happens on one or two time settings these can be avoided.

An error of 10% is not really noticeable on a radiograph so by avoiding short exposures an error of one or two spots can be ignored until the error can be corrected. Some older units have timers which cannot be expected to give accurate exposures below 0.05 sec.

10. If the image of the spinning top shows an arc formed by a solid line (no separate spots) the unit must be a three-phase, capacitor discharge or B.R.S. (medium frequency) unit whose timer cannot be checked by the simple manually operated spinning top. The diagram below shows the arc produced by one ot these units.



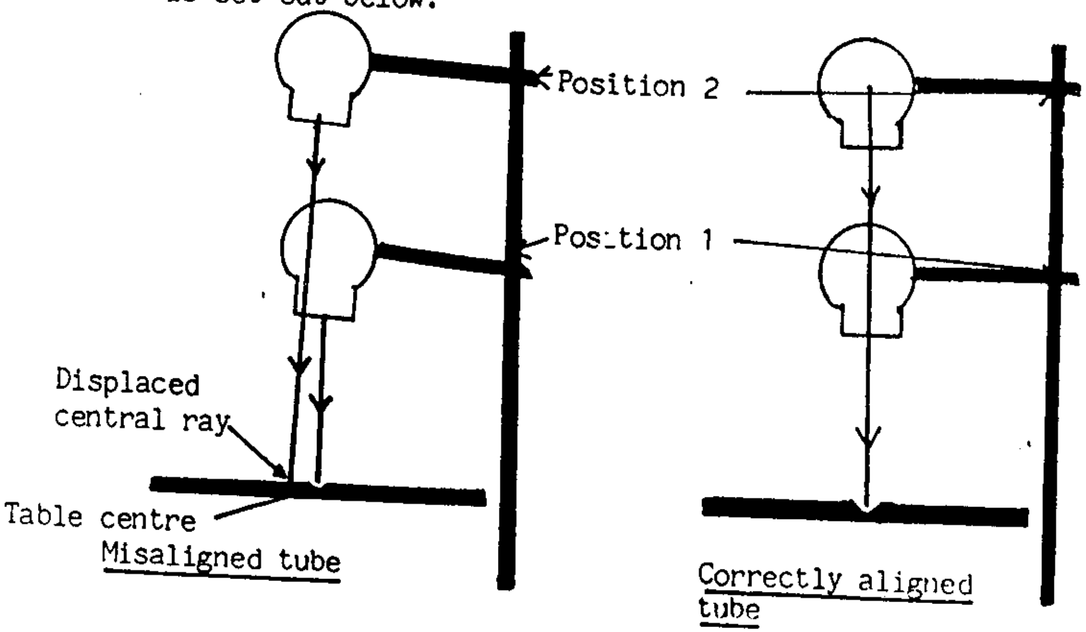
3.2.8. Tests to check the alignment of the X-ray tube column and the table

(a) Test to check the alignment of the X-ray beam to the table

It is important to check that the central ray of the X-ray beam is perpendicular to the table top when the X-ray tube is locked in the usual position for over-table radiography.

Method: - for a tube fitted with a light beam delineator

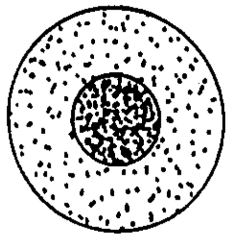
1. Check the co-incidence of the irradiated field with the illuminated area as described in 3.2.10. If an error is found this should be corrected first before proceeding with the alignment tests.
2. Switch on the light beam delineator.
3. Bring the tube almost down to table level, adjust the position of the tube so that the centre of the illuminated area is on the centre line of the table.
4. Move the tube slowly up to the top of the column, watching to see if the centre of the illuminated area remains over the centre over the table. If the area moves from the centre there is misalignment of the X-ray beam to the table and its cause should be sought by the tests is set out below.



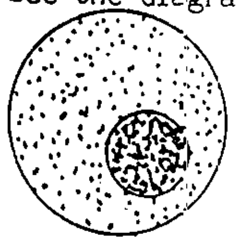
5. Move the tube column along the table and repeat the same procedure. If the illuminated area is centered correctly at one end and not at the other, it indicates that the tube column (support) track is not parallel to the table top. This check of the track and table alignment will only be necessary when the table and/or tube column is moved or replaced.

Method 2: - for a tube without a light beam delineator

1. Fit the smallest cone, centre the X-ray tube to a cassette on the table top, mark the film, left, right, back and front.
2. Using the shortest focus-to-film distance make an exposure, with the factors necessary to give a density of 1..
3. Keep the cassette and tube column in the same position, raise the tube to the top of the column and make a similar exposure.
4. Process the film in the usual way.
5. Examine the film, if the densest area of the film is in the centre of the outer density, the alignment is correct. If it is not central the central ray of the X-ray beam is mis-aligned. See the diagram below.



Correct alignment



Incorrect alignment

Action:

6. The central ray may be misaligned because:

   (a) the tube column is not vertical
   (b) the cross arm, if there is one, is not horizontal
   (c) the X-ray tube has slipped in its mounting ring
   (d) the table is not level
   (e) The table and the tube column (support) track are not parallel

   The cause of the misalignment must be sought, merely adjusting one of the above at random to align the beam will cause many radiographic problems. Therefore follow up the tests described above with the others in this section until the real cause if found.

(b) <u>Test to check that the column is vertical</u>

Equipment:

A plumb bob (a weight on the end of a string)

Method:

1. Hold the string end against the tube column making sure that the string is hanging unobstructed. Check that the column is parallel to the string.
2. Repeat the check with the string held on the column one quarter of the way round the column from the first position. Check the column against the string.

Action:

3. If the column is parallel to the string from both aspects, the column is vertical. If it is not the engineer may be able to adjust the column to correct the lean on the column.

(c) <u>Test to check that the table top is horizontal</u>

Equipment required:

A large diameter bowl or bucket containing 5 cm depth of water or a spirit level
A ruler.

Method:

1. Place the bowl of water on the table top, measure the depth of water around the edge of the bowl. If the table is horizontal the depth of water will vary across the bowl.

2. Repeat the check at the other end of the table.

Action:

3. If the depth varies the table can sometimes be made level by putting some packing pieces under the legs. This is done by gradually increasing the thickness of the packing by using thin packing pieces and checking between each additional layer.

(d) <u>Test to check that the cross-arm is horizontal</u>

Equipment required:

A metre rule

Method:

1. Measure the distance between the cross-arm and the table top at the from of the cross-arm and at the back. The arm is horizontal if the distance is the same at both ends.

Action:

2. If the arm is not horizontal it will be necessary to get the engineer to adjust it. Whilst waiting for the engineer, work can continue by carefully centering the X-ray beam over the centre of the table with the focus-to-film distance at its normal value and performing all work in the centre of the table.

(e) Checking the alignment of the tube in its mounting

After performing the three tests 3.2.8. (b),(c) and (d) and finding no fault, the only cause remaining for the first fault in 3.2.8. (a) there must be slippage of the tube within its mounting.

Action:

Send for the engineer.

3.2.9. Test of cone coverage and the determination of the cone factor

It is important to know the area covered by a cone at the usual working focus-to-film distance and have a way of determining the area covered when the focus-to-film distance is changed. Collimation of the beam to the area of interest avoids unnecessary radiation to the patient.

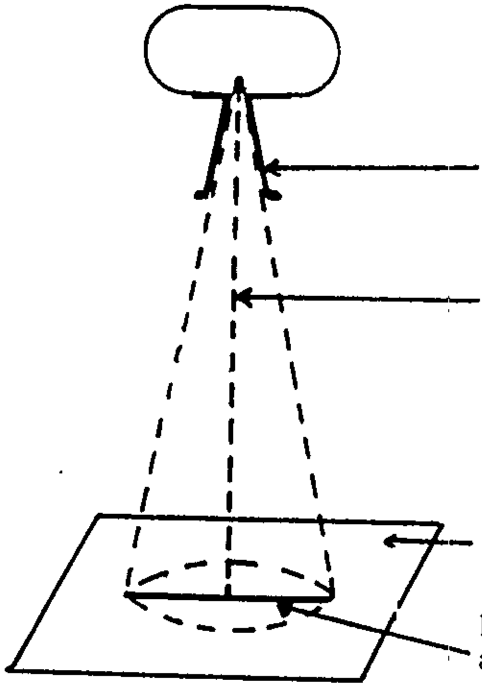
Equipment required:

Ruler
Label for marking the cassette
Sheet of paper for calculations
Loaded cassette of a size larger than the radiation field of the cone to be tested.

Method:

1. Centre the tube with the cone attached to the centre of the cassette using the focus-to-film distance.
2. Carefully measure the focus-to-film distance and write the measurement on the sheet of paper. The focus-to-film distance normally used should be the standard 100 cm.
3. Expose the film to give a density of 1 (medium grey).
4. Process the film in the usual way.
5. Measure the diameter of the exposed field. Record the measurement on the sheet of paper.
6. Fix the label on the cassette giving the focus-to-film distance used and the diameter of the area exposed. This information will be useful when the standard focus-to-film distance can be used.
7. Calculate the cone factor by the following method:

    Divide the focus-to-film distance by the diameter of the area irradiated. The answer to this simple calculation is the cone factor.
    e.g. 100 ÷ 20 (the diameter) = 5 Cone factor 5



Action:

8. The cone factor should be painted on the cone or printed on the label.

9. When the focus-to-film distance is not the usual length, the coverage of the cone is found by dividing the focus-to-film distance by the cone factor. The result of the division is the diameter of the field.

3.2.10. Test of alignment of the light beam delineator

It is important to check that the illuminated area of a light beam delineator co-incides with the area irradiated by the X-ray beam. If there is a difference between the light illuminated field and the X-ray beam the diaphragms are often opened to cover an unnecessarily large area to avoid repeats.

Equipment requirements:

Loaded cassette (24 x 30 cm recommended)
Ruler
Bendable wire (paper clips or thick fuse wire best)
Metal marker
Metal washer or small coin.

Method:

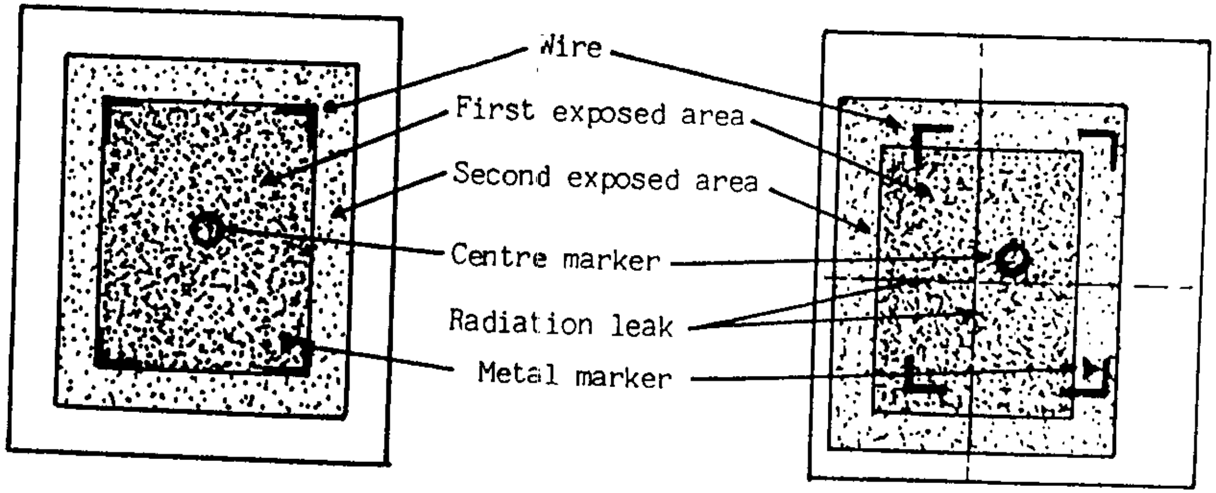
1. Place the cassette on the X-ray table. Centre the X-ray tube by means of the delineator light to the middle of the cassette at the focus-to-film distance of 100 cm.
2. Mark with the metal washer the centre of the illuminated area. Mark with the wire the corners of the illuminated area.
3. Place the metal marker in one corner to identify the corner of the film.
4. Expose the film to an exposure which will give a density of 1.
5. Open the diaphragms wider to cover a larger area using the delineator scales to set the size, make the smallest exposure possible with the cassette and X-ray tube unmoved between the exposures.
6. Close the diaphragms right up and make a third exposure on the cassette using the first exposure.
7. Process the film in the usual way.

Interpretation:

8. Examine the film. First look to see if the wires around the corners of the illuminated field co-incide with the irradiated area. If there is co-incidence the delineator is correctly aligned, if not the direction of the misalignment can be determined by the marker in the corner of the film.

Action:

9. An error of 10%, 1 cm in a 10 cm field is acceptable although not ideal. Anything more should be corrected as soon as possible. Next measure the outer irradiated field to see if its dimensions are those set. If not the scale requires correction. Finally examine the centre of the field. There should be no extra density on the film if the diaphragms close completely. If there is a denser line or a cross through the centre this indicates that there is radiation leak even though the diaphragms are fully closed.



Correctly aligned

Incorrectly aligned (misaligned)

10. This test should be performed with the X-ray beam directed horizontally to check that the mirror is securely fixed within the delineator box.

11. The test should also be performed occasionally with a very large cassette to check that there is no leakage from the outer edges of the delineator box.

3.2.11. Beam limitation by the X-ray tube

The design of the X-ray tube and its fixed diaphragm will restrict the field size if a short focus-to-film distance and a large film are selected. This limitation is intentional for it cuts the radiation field to the size of the largest film exposed at the normal focus-to-film distance. This ensures that the patient will not receive radiation around the edges of the largest film. It also ensures that there is an even density across the film.

This test should be performed after a new tube has been installed when it is not possible to expose the whole of a large film even when the light beam delineator diaphragms are opened as wide as possible. It should also be performed when there is less density at one end of the film than at the other. After a great deal of use the tube target wears so that the radiation delivered from the anode end of the tube becomes less than that from the cathode end. This effect is known as the anode heel effect.

Equipment required:

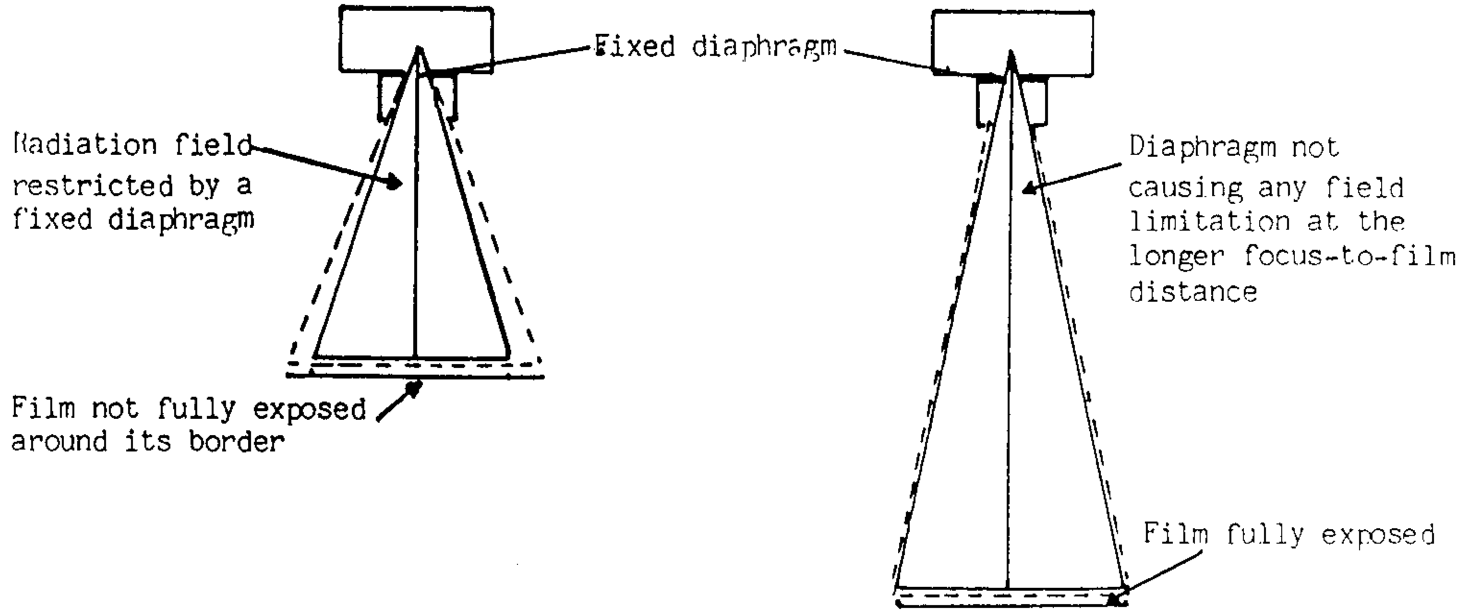
The largest film in use.
A metre rule

Method:

1. Place the large cassette on the table with the tube centered over it at the normal focus-to-film distance.
2. Open the diaphragms of the delineator to cover the large film or fit the largest cone available.
3. Expose the film to give a density of 1.
4. Process the film in the usual way.

Interpretation:

5. Examine the film. See if the radiation covers the whole film. If it does not repeat the test using a focus-to-film distance twice the normal distance. The film can be put on the floor to obtain the distance. See the diagrams.



6. Examine the second film. If the film is now fully irradiated there is some beam limitation at the normal focus-to-film distance.

7. Finally look at the film and see if the density is equal at both ends if not there is an anode heel effect.

Action:

8. If the tube is limiting the field the use of a longer focus-to-film distance will overcome the problem. But ask the engineer to check the fixed diaphragm size, it may be unnecessarily restricting and a slightly larger one could be fitted. If the tube is new it may be that a steep-angle tube has been fitted in error.

9. The anode heel effect cannot be corrected and if the density difference is causing many repeat examinations the tube will have to be replaced but whilst waiting for this to be arranged work can continue on smaller films where the effect is much less noticeable and will not make the films unacceptable.

3.2.12. Test for grid uniformity

This test is performed to check that the grid gives a uniform density over its area.

Equipment required:

Grid to be tested
Loaded cassette of the same size as the grid
Metre rule
Metal marker

(a) Test for a grid is fitted in a bucky

1. Place the cassette in the cassette tray.
2. Place the metal marker on the cassette to indicate on the film its position in the cassette tray
3. Centre the X-ray tube to the table and bucky using the normal focus-to-film distance.
4. With the grid stationary expose the film to give a density of 1.

Interpretation:

5. Examine the processed film to see whether the density is even over its area. If not one of the following may be the cause:

   (a) The grid has been fitted upside down
   (b) The grid is being used at the incorrect distance
   (c) The X-ray beam is not at right angles to the grid (angled across the lead slats).
   (d) Damage causing distortion in its shape.

Action:

6. Correct any of the faults in the list given above and then repeat the test to see if the fault is cleared. Report any fault which cannot be corrected. A distorted grid can rarely be corrected so it is most important to store the grid correctly so that it cannot be damaged.

(b) <u>Test for a loose grid (stationary grid)</u>

1. Inspect the grid for obvious damage
2. Place the cassette under the grid
3. Identify with the metal marker the position of the grid on the film.
4. Expose the film to give a density of 1
5. Process the film

Interpretation and action as described in Test (a)

3.2.13. Test for Bucky movement

This test is to check that the grid in the bucky is moving throughout the whole exposure.

Equipment required:

Cassette loaded with film
Metre rule

Method:

1. Place the cassette in the cassette tray
2. Centre the X-ray tube to the centre of the table over the grid using the normal focus-to-film distance.
3. Collimate the beam to the size of the film
4. Set the exposure factors to give a density of 1
5. Select the bucky. If the bucky has to be set before every exposure pull the lever and set the grid movement time, this type of bucky is known as a single-stroke bucky.
6. Expose the film and process as usual.

Interpretation:

7. Examine the film. If there are grid lines on the film, the grid is not moving during the exposure or it is only moving for part of the exposure or moving erratically.

Action:

8. Check that nothing is obstructing the grid movement by removing the cassette and looking at the underside of the grid. Sometimes a letter or some other object jams the movement of the grid over the cassette.
9. Check the electrical supply to the grid
10. If it is a single stroke bucky the grid lines may be seen if the grid is moving too slowly. If the grid moves too quickly it will cut the exposure time and give under exposed films, so check the grid movement timer. Rapid uncontrollable grid movement is usually caused by loss of oil from the cylinder controlling the grid movement.

3.2.14. Test to check that a lead rubber sheet stops the X-rays

It is important to check that a lead rubber sheet effectively absorbs the radiation falling upon it to ensure that no radiation can pass through it to fog the film beneath which is to be used for another radiographic projection.

Equipment required:

Loaded cassette
Metal object
Lead rubber sheet to be checked.

Method:

1. Place the lead rubber sheet to be tested on a loaded cassette.
2. Place the metal object on the lead rubber sheet.
3. Centre the X-ray beam to the cassette and collimate to the cassette size.
4. Expose the cassette to the exposure usually used for a radiograph of a limb.
5. Process the film in the usual way.

Interpretation:

6. Examine the film. If an image of the metal object can be seen, the lead sheet is not thick enough to completely absorb the radiation and will cause an overall fog on the film before the second projection is made upon it.

Action:

7. If fogging is found it will be necessary to add another layer of lead rubber sheet to form an effective radiation blocker.
8. Repeat the test with the additional thickness to check that with the extra thickness there is no radiation reaching the film beneath the sheet.

4. PROBLEM SOLVING

In this section consideration is given to the correction of the most common problems affecting the radiographic image. The effect upon the image is given and possible causes suggested.

4.1 <u>If the films are too dark</u>

(a) <u>Check whether all films are affected</u>, if yes:

Check if the:

Mains compensator is correctly set;

Developer temperature or its activity is too high;

Development time is too long for the temperature of the solution;

Level of fog is high, due to storage, safelight, white light, radiation or chemical fog;

Speed of the films has been changed with the introduction of a fresh supply.

(b) <u>Check if only some of the films are affected</u>, if yes:

Check if the:

Exposure factors are correct;

Grid was omitted when the exposure factors allowed for its use or a different grid requiring a low exposure was used;

Effect is only found on one mA setting indicating that this particular setting requires adjustment;

Effect is only found on one timer setting indicating that this particular time setting requires adjustment;

Effect only found with certain kV settings indicating that these require adjustment

New intensifying screens have been used which are faster than those used previously.

4.2 <u>If the films are too light</u>

(a) <u>Check whether all films are affected</u>, if yes

Check if the:

Mains compensator is correctly set or the mains supply is too low;

Mains connection to see if a long extension cable was used the extra length of cable may reduce the supply to the unit this may need to be allowed for by increasing the kilovoltage to allow for the loss;

Developer temperature or its activity is too low;

Development time is too short for the temperature of the solution;

Speed of the films has changed with the introduction of a fresh supply.

(b) <u>Check if only some of the films are affected</u>, if yes

Check if the:

Exposure factors are correct;

Effect is only found on one mA setting indicating that this requires adjustment;

Effect only found on one timer setting indicating that this requires adjustment;

Effect only found with certain kV settings indicating that these require adjustment;

Correct film/screen combination has been selected for the exposure chosen;

New intensifying screens have been used which are slower than those used previously.

4.3. <u>If the film is blank</u>

(a) <u>If the film is completely blank</u>:

Check if the:

Film processed was taken from the wrong cassette;

X-ray unit was switched on;

Correct X-ray tube was selected and the beam directed towards the film;

Diaphragms were not completely closed.

(b) <u>If the film is blank along one edge</u>

Check that the:

Developer level was not too low to cover all the film;

Light beam delineator was not correctly aligned with the X-ray beam;

Diaphragm and cassette were not correctly colour matched when using the B.R.S. unit;

Position of the film within the cassette was not correct when through shortage a small film was used in a larger cassette.

4.4. <u>If the film is black all over</u>

Check if the:

Cassette was opened in white light;

Safelight housing was allowing white light to enter the darkroom;

Darkroom door was opened by mistake whilst the cassette was being unloaded.

4.5 If the film is partially blackened

Check if the:

Cassette is letting in light through damage or failure to close the clips and this is reaching the film and fogging it;

Film hopper or film box has been opened in white light to fog the top edge of the films;

Cassette has been partially exposed to radiation;

White light from the flame of a match used to light a cigarette in the darkroom whilst the films are being loaded or unloaded and this is fogging the film;

Safelight filter is cracked allowing white light from the bulb within the housing to fog the film.

4.6. If the films has streaks on the top of the film

Check that the:

Developing solution has been well stirred after the addition of replenishing solution.

4.7. If the film has bands or spots of uneven density

Check if they:

Co-incide with the adhesive securing the intensifying screens to the cassette, if they do this shows that the adhesive is the wrong type causing localised fogging.

4.8. If the film is totally fogged (grey all over)

Check if there is:

Safelight fogging

Radiation fogging

Chemical fogging

Storage fogging.

4.9. <u>If the film image is blurred</u>

Check if there is:

Patient, tube support or cassette movement during the exposure;

Poor contact between the intensifying screens and the contained film (a fault which is easy to isolate for it will always arise when the same cassette is used).

4.10. <u>If the film is cloudy all over</u>

Check if the:

Film is properly fixed;

Fixer is exhausted.

4.11. <u>If the film is cloudy in patches</u>

Check if the:

Level of the fixing solution is too low to fully cover the film;

Films were stuck together during processing (the patches will be circular).

RECORDS

A Test/Check programme with its references to the Handbook and some methods of recording results and actions are given in this section. These ideas may be useful when a record book is being prepared for use in the local department.

It is important that such a record book is prepared as it will become a valuable source of reference and ensure that tests are performed as part of the Quality Control Programme.

TEST/CHECK PROGRAMME

Task		Frequency d	w	m	3m	nec	Handtook reference	Personal comments
Darkroom preparation		*					2.1	
Safelights	Bulb wattage					*	2.1.1.(a) } 3.2.1.	
	Filter					*	} 3.2.1.	
	Housing					*	2.1.1.(c) } 3.2.1.	
Timing clock accuracy			*				2.1.2.	
Water supply	Flow			*			2.3. 3.2.2.	
	Reserve supply	*					2.3.	
Manual processing unit							2.2.1.	
	Water jacket cleaning			*			2.2.1.	
	Tank cleaning			*			2.2.1.	
Developer	Temperature	*					2.4.2.	
	Activity	*					3.2.3.	
Fixer	Clearing time	*					2.4.3.	
Film hangers	General condition				*		2.6	
	Cleaning				*		2.6.	
Film viewers	General condition			*			2.7.	
	Cleaning - outside			*			2.7.	
	- inside					*	2.7.	
	Cond. of fluorescent tubes				*		2.7.	

d - daily
w - weekly
m - monthly
3m - three monthly
nec - as and when necessary

TASK/CHECK PROGRAMME

Task		Frequency d	w	m	3m	nec	Handbook reference	Personal comment
Film hopper	General condition				*		2.8.1.	
	Electrical connection				*			
Cassettes	General condition			*			2.5.1.	
	Labelling			*			2.5.1.(a)	
	Cleaning			*			2.5.1.(b)	
	Light leakage test					*	3.2.4.	
Intensifying screens								
	General condition			*			2.5.2.	
	Mounting and marking					*	2.5.2.(a)	
	Cleaning and inspecting			*		*	2.5.2.(b)	
	Film/screen contact					*	3.2.5.	
	Film/screen speed					*	2.5.2.(c) 3.2.6.	
Film	Storage					*	2.8.1.	
	Speed					*	3.2.6.	
Generator	General condition	*						
	Earthing			*			2.9.1.(a) 2.10.1.	
	Consistent output							
	Same exposure factors				*	*	2.9.1.(b) 3.2.7.(a)	
	Same mAs different mA				*	*	2.9.1.(c) 3.2.7.(b)	
	Exposure time				*	*	3.2.7.(c)	

TEST/CHECK PROGRAMME

Test	Frequency d	w	m	3m	nec	Handbook reference	Personal comments
X-ray tube and cables							
General condition		*				2.9.2.(b)	
Secure fixing		*				2.9.2.(a)	
Beam limitation					*	2.9.4.(c) 3.2.11.	
Cones and light beam delineators							
General condition		*				2.9.4.	
Cone and cone coverage					*	2.9.4.(a) 3.2.9.	
Light beam delineator		*			*	2.9.4.(b)	
Co-incidence of light & X-rays				*	*	3.2.10.	
Tables, stands and tube supports						2.9.3.	
General condition		*				2.9.4.	
Brakes and locks		*			*	2.9.3.(a)	
Alignment of tube and table				*	*	2.9.3. 3.2.8.	
Mains cables and extension cables							
General condition		*			*	2.10.1.(a)	
Secure terminals		*			*	2.10.1.(c)	
Grids General condition			*		*	2.9.5.	
Uniformity				*	*	3.2.12.	
Bucky movement				*	*	3.2.13	
Lead rubber - General condition				*	*	2.10.3. 3.2.14.	

DAILY CHECK RECORD

Week ending ____________

Item	Check	Acceptable range of Result	Actual result	Comment/Action	Initial
Developer	Temperature		Mon Tues Wed Thurs Fri		
	Activity		Mon Tues Wed Thurs Fri		
Fixer	Activity		Mon Tues Wed Thurs Fri		

MONTHLY CHECK RECORD

Item	Checks	For month ending	Task completed by (initials)	Comments
All cassettes All hangers	All checks (see separate check list) Shape Clips			
All cassettes All hangers	All checks (see separate check list) Shape Clips			
All cassettes All hangers	All checks (see separate check list) Shape Clips			
All cassettes All hangers	All checks (see separate check list) Shape Clips			

CASSETTE/INTENSIFYING SCREEN CHECK RECORD

Cassette Identification No ____________ Date of First Use ____________

Cassette Size ____________ Date Fitted ____________

Intensifying Screen Type ____________

Item	Check/Task	For month Ending	Task Completed by (Initials)	Comments
Cassette	Hinge Fastening General condition Cleaning			
Intensifying Screens	General condition Screen/Film contact Cleaning			
Cassette	Hinge Fastening General condition Cleaning			
Intensifying Screens	General condition Screen/Film contact Cleaning			
Cassette	Hinge Fastening General condition Cleaning			
Intensifying Screens	General condition Screen/Film contact Cleaning			

6. EXPLANATION OF WORDS AND TERMS USED IN THE HANDBOOK

A.

Absorption of radiation	the loss of some radiation as it passes through an object
Access	entry into a room or place
Accessories	additional pieces of equipment
Activity of a solution	the liveliness of the action of a developer or fixer solution
Adaptor	a device to allow an electrical plug to fit into a different type of electrical socket
Airlock	air bubble in a pipe stopping the flow of a liquid
Alignment	parts in correct position to one another
Aluminium step wedge	a step-like piece of aluminium to assess the penetrating power of an X-ray beam through different thicknesses of aluminium
Artifact (artefact)	an image that should not be present
Assess	to judge, to find out
At random	not following a proper order
Attenuating object	an object that will absorb radiation e.g. water

B.

Basic Radiological System (W.H.O.)	terms used by W.H.O. to describe simple X-ray equipment where the X-ray tube and cassette holder are joined together
Blurred	not sharp
Bucky	a moving grid, short for 'Potter Bucky diaphragm

C.

Cable	insulated electrical wire or lead
Calculation	mathematical sums

C. (cont.)

Capacitor discharge unit	a mobile unit using condensers for electrical charge, it is independent of supply from the electrical mains during the exposure.
Chemical contamination	accidentally making developer or fixer solution impure because other chemicals have been added
Circuit	the route of electrical current flow
Clearing time	the time taken by the fixer solution to remove unexposed silver from the film
Concentration	strength of the solution
Condensation	small drops of water, like sweat, appearing in a room when there is poor ventilation
Cone	metal device fitted to the X-ray tube port/exit to limit the X-ray beam
Conductor	wire which conducts electricity
Collimator	X-ray beam limiting device or a light beam delineator
Connecting pins	pins providing electical connections in an electric plug
Consistency	keeping the same standard or result
Contrast	the amount of difference between black and white
Cross-arm	the horizontal arm on the X-ray tube column supporting the X-ray tube
Current	movement of electricity

D.

Damp	slightly wet
Data	facts, information
Date rotation	putting objects with the earliest date at the front to be used first
Delineator	see collimator
Density	film blackening
Density inconsistency	resulting in different densities
Densitometer	device for measuring film blackening

D. (Cont)

Deterioration	getting worse, not as good as before
Developer exhaustion	loss of activity of the developer through use and othercauses
Development time	the time a film should remain in the developer to give the best results. The time will change with changes in the temperature of the developer
Device	an object, a piece of equipment
Diaphragm	a sheet of lead inside the delineator which can be be adjusted to give different areas of radiation
Discoloration	loss or change of colour
Dosimetry	measuring of radiation
Distortion	change of shape

E.

Earth terminal	the third pin on an electical plug which connects the equipment to the earth when the plug is put in the socket
Earthing	a means of conducting electricity to earth
Efficient	doing things well
Eliminate	to get rid of
Error	mistake
Evaluate	to judge, to assess
Extension lead	an extra lenght of electrical cable

F.

Field size	area covered by radiation
Film hanger	frame for holding the film during processing
Fixture	object fixed to the wall or the floor
Flammable	burns easily
Fluoroscopy	viewing the image on the fluorescent screen (screening)
Fluorescent tube	electric light tube
Focus-to-film distance (f.f.d.)	distance from the focal spot in the X-ray tube to the film
Fog film	unwanted greyness or blackening on the film
Fog basic	slight colouring or density on unexposed parts of the film
Fog chemical	discoloration, greyness due to over development, or contanimation of developer or fixer
Fog radiation	accidental exposure to X-rays causing greyness or blackening of the film
Fog white light	accidental exposure to light causing blackness on the film
Frequency of 50 Hz	frequency of the electrical supply
Full wave rectified unit	converts 1 pulse of electricity per cycle to provide 2 pulses of radiation per cycle
Fuse	Wire or device in the electrical circuit that breaks the circuit when overloaded so protecting the electrical equipment and its wiring

G.

Grid	device placed between the patient and the cassette to absorb scattered radiation

H.

Hopper	see film hopper
Horizontal	level with the horizon or flat ground
Humidity	dampness of the air

I.

Illuminated field	area lit by the light from the collimator or light beam diaphragm
Image	picture or pattern on the film
Image quality	standard of excellence of the picture
Inadequate	not enough
Inconsistent	not keeping the same standard or result
Inhale	to breathe air into the lungs
Insulated cable cover	cover for an electrical cable to prevent electric shock
Interpretation of results	explain the results
Irradiated	exposed to radiation
Irritation	unpleasant sensation or soreness
Isolate	to separate

L.

Lead markers	lead letters to place on film during exposure

L. (Cont)

Lead slats	narrow strips of lead in a grid
Light beam diaphragm	beam limiting device with light to show the irradiated area
Light leakage	unwanted light in the darkroom or in a cassette

M.

Mains compensator	means of adjusting the electrical supply to the X-ray unit
Maximise	to make as great as possible
Minimal	smallest possible
Misalignment	not in correct position or not in line
Modifying	changing
Mounting ring	metal ring holding the X-ray tube to the cross-arm

O.

Optimum	the best

P.

Pass through hatch	a cupboard in the wall between the darkroom and the X-ray room for cassettes
Performance	action
Permanence	something that will last for a long time. For ever

P. (Cont)

Perpendicular	vertical
Plug socket	electrical outlet in the wall for an electrical plug
Plumb line	heavy weight on the end of a piece of string used to give a vertical
Pressure marks	marks on film due to weight. The marks are usually dark marks
Procedure	a certain way of doing things
Processing of films	development, fixing washing and drying of films after exposure
Processor	machine for film processing
Pulse, 1 or 2 pulse unit	pulses of radiation per cycle of electricity

Q.

Quality control	measurement and control programme to make sure that good standards are kept
Quality assurance programme	planned programme to judge and manage a good radiographic service

R.

Radiograph	an exposed and processed X-ray film with an image
React	act in the opposite way
Record	to put down facts in writing
Racks	several rollers fixed together for moving films in an automatic processor

R. (Cont)

Replenishing solution	solutions added to the developer or the fixer to top up to the level and maintain the activity
Residual	remaining
Rinse	a short wash
Radiopaque markers	metal markers that do not let radiation pass and therefore show on the developed film

S.

Safelight	coloured light in the darkroom that will not fog the films
Safelight filter	removeable coloured cover in a safelight changing the white light to coloured light
Safe film handling time	maximum time a film can be exposed to safelight without fogging the film
Scattered radiation	radiation going in different directions
Screen contact	closeness of the intensifying screens to the film in the cassette
Self rectified unit	X-ray unit giving one pulse of electricity per cycle
Sensitive film	unexposed film which is affected by light and radiation
Sensitometric test strip	film exposed to different known amounts of light or X-rays cut into strips for testing developer activity
Setting standards	using a good example against which others can be judged or measured
Silver recovery	removal of silver from used fixer
Solutions	mixture of chemicals with water
Source of reference	a place of information

S. (Cont)

Specifications	written details describing a task or a piece of equipment
Spinning top	see Section 3.1.2.
Starter solution	chemicals added to freshly made developer in an automatic processor. It slows down its activity
Stationary grid	see Grid
Stock sheet	sheet of paper with details of the number of fils, etc. held in store
Strapping	strips of sticky plaster for binding things together.

T.

Test film	film used for checking developer activity, film/screen speed and film fogging
Test strips	test film cut in strips
Top up	to fill the developer tank to the correct level

U.

Uniformity	the same all over
Unsharpness	not sharp, blurred
Utensils	container or tool

V.

Vary	to change

V. (Cont)

Ventilated	fresh air circulation in a closed room
Vertical	upright, straight up and down, at right angles to the horizontal
Visual assessment	judging something by what you see

W.

Water jacket	water surrounding the developer and fixer tanks
Water phantom	a container with a measured amount of water used as a test object for judging the absorption of radiation.
Wooden slat shelves	shelves made from strips of wood with gaps between the strips so that air can circulate between them.

APPENDIX A

THE CARE OF A SIMPLE AUTOMATIC PROCESSING UNIT

Automatic processing units are supplied with manufacturer's instructions giving information on cleaning, daily maintainance and routine use. Insist on seeing these instructions. These instructions and any other literature on the processor should be kept near the machine for easy reference.

Before setting standards for a quality control programme, new solutions should be mixing following very carefully the manufacturer's instructions to ensure the correct concentration and activity of the solutions. (Information on chemical mixing is given in Section 2.4.1.).

The old solution must be emptied out and the processor and replenishment tanks thoroughly cleaned before the new solutions ate put into the tanks. See Section 2.4.3. on the disposal of the fixing solution.

The water flow rate must be checked to ensure adequate washing of the films

To clean the processor

1. Empty the processing solutions from the processor tanks and the replenishment tanks.
2. Remove the developer racks, drain them and place them in a safe place. Rinse the tank with running water using a brust to clean off any chemical deposits. Repeat the procedure with the fixer tank.
3. Using fresh water soak each rack for 20 minutes. Use a brush to remove any chemical deposits. To help remove dirt from the inside rollers gently rock the rack from side to side to allow the water to run in and out of the racks. Remember do not contaminate one set of racks with the water draining from another otherwise the solutions will be contaminated.
4. Wipe over the drier rollers with a clean damp cloth.
5. Wash out the replenisher tanks
6. Replace the racks in the processor and close the drain stop cocks.

7. Mix the new developer and fixer solutions in their replenishment tanks if these are large enough. If not use two large plastic containers, one for the developer and one for the fixer. Refill the tanks in the processor. Read the chemical manufacturer's instructions to see whether a starter solution has be added to the developer. If needed add as instructed.

8. Switch on the processor, allow it to warm up to the operating temperature. Turn on the water supply to the processor. Remember automatic processors cannot be used without running water.

<u>Daily care of the processor</u>

Check the level of the developer and the fixer solutions in their replenishment tanks. Do not allow a solution to fall below the level of the tank outlet as this may cause an airlock and prevent replenishment of the processor tank.

<u>Weekly care of the processor</u>

Processing racks must be cleaned weekly

Method:

1. Remove the racks, rinse with running water.
2. Using a soft brush, clean off all chemical deposits.
3. Always use the splash guard between the developer and fixer tanks and the drip tray when removing or replacing the racks to prevent fixer dripping into the developer tank as the developer solution can be seriously contaminated by the addition of small amounts of fixer.
4. Soak the wash rack for 20 minutes, then shake it to allow the water to run in and out of the rack for 5 minutes to remove any chemical deposits on the inside rollers.
5. Check the tension of the chain to make sure the rollers turn freely.
6. Replace the racks, make sure they are put back properly.
7. Check that the recirculation pumps are working by looking at the surface of the solutions a slight movement of the surface shows that they are working.

8. Check that the dryer air tube slits are clean.
9. Remove all cover panels, wipe them with a damp cloth and clean all visible parts of the machine to remove any splashes of chemical.

PROBLEM SOLVING

Section 4 lists a number of problems which arise with manual processing and some of these also apply to automatic processing. There are some other causes of problems which only apply to automatic processors and these are given below:

A. If the films are black

   1. White light turned on before the film has fed into the processor.
   2. The film exposed to white light on the feed tray.
   3. The lid of the processor not on properly.

B. If the films are too black

   1. The developer is being over replenished
   2. The developer temperature is too high
   3. The developer has been incorrectly made up so that it is too concentrated (not enough water).

C. If the films are completely blank

   1. The developer tank is empty.
   2. The developer tank filled with fixer by mistake
   3. The developer or replenishment tank filled with water by mistake.

D. If the films are too light

   1. Under replenishment of the developer.
   2. Developer temperature too low.
   3. Films fed into the processor before it reached its correct working temperature.
   4. Developer made up incorrectly so that it is too dilute (too much water).

E. <u>If the films are wet or damp</u>

1. No electrical supply to the drier.
2. Drier heater not working.
3. Drier tubes or slits blocked.
4. Developer under replenished. Either the replenishment tank is empty or the replenishment rate is too low.

F. <u>If the film is grey all over and lighter than expected</u>

1. Fixer tank empty.
2. Fixer under replenished. Either the replenishment tank is empty or the replenishment rate is too low.
3. No water in the wash tank.
4. No water supply.

G. <u>If the rollers in the processor are not moving</u>

1. The lid of the tank not on firmly.
2. Processor not switched on.

Most manufacturer's handbooks give information on the problems which may occur and how the problem can be overcome.