7. X-ray diagnostic equipment

The production and use of X-rays

When a stream of electrons is accelerated by an electrical potential to a very high speed and then decelerated and absorbed by hitting a target material, X-rays are produced. Thus the main requirements for producing X-rays are:

- a source of electrons,
- a source of electrical potential,
- an appropriate target material.

X-rays are invisible. Because of their high energy and short wavelength they can penetrate almost all materials, but are absorbed to a different extent by different tissues. In the human body, absorption is high for bones, and low for muscles and other soft tissues. These differences in absorption can be shown on a photographic film as differences in density: the result is a radiograph. Thus, radiographic examination consists of irradiating a part of the patient with a uniform beam of X—rays and recording the emerging rays on a double emulsion film sandwiched between a pair of fluorescent screens. The screens convert the X-rays into light, which in turn exposes the X-ray film. The screens and the film are enclosed in a cassette for protection from daylight. After the exposure, the film must be processed, manually or automatically, in a darkroom by means of developer and fixer solutions.

X-ray examinations should be ordered only by physicians or experienced clinical health workers. "Routine" examinations are seldom indicated. A few of the more common indications and examinations that can be performed with diagnostic X-ray equipment are listed below (this is not a complete list).

- *Skeleton:* for fractures, and bone and joint diseases, e.g., arthritis, tumours.
- *Head*: for trauma and infections, e.g., sinusitis.
- *Chest*: for tuberculosis, pneumonia and other respiratory infections, heart disease, tumours, pleural diseases, and trauma.
- *Abdomen*: for trauma, intestinal obstruction, calculi, contrast urography, cholecystography, and problems in pregnancy, if ultrasound is not available.
- *Soft tissues*: for foreign bodies and calcifications, e.g., parasites.

Examinations with contrast media are recommended only when an experienced physician is available to carry out and interpret such examinations, and to treat the possible complications of contrast injections.

Components of the X-ray system

The components of an X-ray diagnostic system are:

- the X-ray tube, X-ray generator, tube stand (support), examination table (patient support), and control unit;
- accessories such as cassettes, intensifying screens, and film;
- darkroom equipment and other supplies for processing the exposed film;
- radiation protection devices.

X-ray tube

X-rays are produced in an X-ray tube. In all X-ray tubes, the source of electrons is a heated filament made of tungsten wire, the cathode. The area that is bombarded by the electrons is called the focal spot, and it is part of a metal body called the anode. The high voltage between the cathode and the anode sets the electrons in motion.

The anode and the cathode are sealed into a glass envelope, the tube, in a vacuum. This glass X-ray tube is enclosed in a casing made of aluminium, and lined with thin sheets of lead to prevent leakage of radiation. The tube is fixed in the casing at its anode end. The metal case protects the tube from mechanical shock, and also protects the users from radiation and electrical risks. The amount of protection has to be in accordance with international standards. The X-ray beam leaves the housing through a plastic-covered aperture called the tube port, or window.

X-ray generator

The purpose of an X-ray generator is to provide the high voltage that is applied to the X-ray tube for the production of X.-rays. There are several types. One older type of generator, in common use in small X-ray departments, is the single-phase generator. In large hospitals, with a very good mains power supply, a more powerful three-phase generator may be installed. Recent developments indicate that, in the future, most X-ray generators will be frequency-converter, multipulse generators. These generators use a direct current (DC) source and convert the DC to alternating current (AC) with a higher frequency than the mains. These generators are much smaller, lighter and less expensive than conventional generators, and produce a high quality X-ray beam.

Usually, an X-ray generator has a number of fuses to safeguard the various circuits and their components. The fuses may be of different ratings and types, according to their use. They are usually mounted in the ‘control unit, except in larger generators.

Tube stand (tube support, tube column)

The function of the tube stand is to support the X-ray tube so that it can be used with the X-ray beam in a horizontal or vertical position, or at an angle.

There are six basic kinds of tube support

- integrated with the control unit and the transformer (e.g., a standard ward unit, or mobile unit, for use in hospitals);
- a column mounted on floor rails alone;
- a column mounted on floor rails, but also with a ceiling rail;
- a fixed column with a tube rotating around a central axis (e.g., a "C-arm", or a modified "C-arm" type, as used in the WHO Basic Radiological System);
- a column forming an integral part of the X-ray table;
- a carriage suspended from the ceiling, moving on rails.

With all these tube supports, except the "C-arm" or modified "C-arm", a separate vertical cassette holder, or chest stand, is needed for upright chest radiography.

Chest stand

The chest stand is a holder for cassettes that is used to examine patients in the erect position, for chest or other radiography. It must hold the size of cassette used for chest examinations, and be adjustable in height, strong and rigid. It may incorporate an anti-scatter grid (either fixed or movable) and should be able to hold cassettes either in front of the grid or behind it. With some types it is also possible to orient the cassette at an angle to the vertical.

Grid (anti-scatter grid)

When an X-ray beam passes through a patient, some of the X-rays continue in a straight line (the direct beam) and other X-rays are scattered in different directions. If the scattered X-rays reach the film, they will distort and spoil the image. The grid is a metal screen that absorbs almost all the scattered X-rays, i.e., those that did not pass through the patient in a straight line from the anode of the tube. The grid is properly called an "anti-scatter grid" or a "secondary radiation grid". The grid may be stationary or it may be incorporated in a "bucky" mechanism, which makes the grid move during the exposure and blurs out the image of grid lines.

All grids are delicate and very expensive: they are easily damaged, and are useless if bent. If not part of the equipment, they should be supplied either coated in plastic (tor protection), or as an integral part of a cassette. Once damaged they cannot be repaired, but with proper care they will have a long life.

Examination (X-ray) table (patient support)

The examination table is used for X-ray examinations when the patient is lying down. It must be rigid, with a top permeable to X-rays, approximately 2.0 m X 0.65 m in size, and approximately 0.7 m from the floor. It must be able to support a patient weighing 110 kg without appreciable distortion. It should be impervious to fluids, resistant to scratching, and easy to clean. It may incorporate a "bucky" with a grid (see above). It may be fixed or mobile; it mobile, it must have good brakes.

Control unit

The control unit includes the meters, or digital indicators, that provide information on the state of the electricity supply, the chosen values of kV and mA' s (or mA and time), and the exposure switch. Often, the control unit is located outside the X-ray room. For busy X-ray rooms, this is recommended. If the control unit is located inside the X-ray room, a radio-opaque protection screen, large enough to protect a standing operator, should be an integral part of the control unit, or should surround it. There should be a lead glass window so that the patient can be watched during the examination.

Cassettes, intensifying screens, and films

Cassettes are the light-proof, rigid containers that enclose the X-ray film, to protect it from light. Within the cassette are two intensifying screens that fluoresce and produce visible light when irradiated by X-rays. The film is placed between the two intensifying screens, inside the cassette The cassettes must be strong, rigid, and durable. They must provide firm pressure so that there is good contact between the film and the screens, but must be easy to open in the dark.

Darkroom equipment and supplies

A darkroom for the manual processing of X-ray films should have a master processing tank filled with water, in which two smaller tanks are supported to hold chemicals (developer and fixer). Running water is desirable, but alternatively the water can be changed frequently. If the workload is large enough, for example more than 15-20 patients per day, an automatic film processor may be needed. There must be a "dry" workbench, a film marker, safelights, and a thermometer. If manual processing is used, film-hangers and a ‘timer-clock are also needed. If powdered chemicals are to be used, two auxiliary buckets for mixing, and mixing rods, will be required. Note, however, that powdered chemicals must never be mixed inside the darkroom.

Radiation protection devices

The essential radiation protection devices include a shielded control booth, outside the X-ray room, or a protective screen (large enough to protect a standing operator), with a lead equivalence of at least 0.5 mm, and with a lead glass window. There must also be leaded protective aprons, and leaded gloves, with lead equivalence of at least 0.25 mm, plus leaded rubber or leaded plastic strips with a lead equivalence of at least 0.5 mm, for use as gonadal shields.

Maintenance and repair in the X-ray department

X-ray equipment is complex and expensive: although minor maintenance can be done by hospital staff, routine servicing and repairs after a breakdown usually require trained personnel. Nevertheless, a regular routine of cleaning and checking will help to maintain efficiency and often provides early warning of developing faults.

Installation

Because X-ray equipment produces ionizing radiation and uses a high-voltage electric current, there are strict international and, usually, local rules governing all aspects of any department. These include specifications for room size, electricity supply, radiation exposure, and many other important details.

X-ray equipment should be installed only by trained X-ray engineers; even the transfer of used equipment from one site to another should be done only by trained staff. It may seem expensive, but incorrect installation may result in even more expenditure, and may be hazardous to hospital staff and patients.

Warranties and service contracts

The warranty given with all equipment must be carefully checked.

Service contracts should be part of the initial purchasing agreement. It is recommended that there be two routine, scheduled maintenance visits every year (at 6-month intervals) for at least 5 years from the date of installation. The first visit (at 6 months) should be without charge to the purchaser.

A written schedule of the maintenance required should be provided by the manufacturers, and each item should be completed, dated, and signed by the service engineer during each visit.

Log books

Log books are essential for proper maintenance. Quality control will be successful only if careful records are kept.

The front page should contain telephone numbers (and fax numbers, if available) of service personnel and suppliers or manufacturers for all the equipment, including films, chemicals, and accessories.

Every item, large and small, in the X-ray department should have a written record in the log book providing:

- the make, model number, and name of the equipment;
- specifications for the generator, tubes, and all other items, including accessories; date of installation (and by whom); total cost of the equipment and the installation (shown separately);
- address of supplier, manufacturer's agent, and local service engineer;
- a list of the technical service manuals provided;
- details of any variation or modification from the standard equipment.

Thereafter every service visit, fault, repair, change, spare parts supplied and their warranty, and any other event should be recorded and dated.

Similar records should be kept when items such as lead aprons are routinely tested, and concerning any other similar departmental maintenance (for example, the regular cleaning of intensifying screens, cassettes, etc.).

Tools for the X-ray department

Mechanic's tools:

- standard and cross-head screwdrivers, with insulated handles,
- coarse and fine insulated pliers,
- shift spanners and sockets (matched to the equipment),
- oil can, with light machine oil.

Quality assurance equipment:

- step wedge and spinning top,
- densitometer and sensitometer, if funds permit.

Spares:

- fuses for the main switches and electricity supply boxes,
- fuses for the X-ray room and darkroom lights and sockets,
- 15 and 25 watt bulbs for the darkroom,
- 40, 60, and 100 wait bulbs for the X-ray room, or fluorescent tubes and starters as appropriate,
- replacement tubes or bulbs for the X-ray film illuminators (viewing boxes).

Do not keep a spare X-ray lube at the hospital; it will deteriorate even when not used and the warranty will become invalid.

Daily maintenance schedule

X-ray room

Clean the floor, sweep, and wash or polish, if necessary.

Clean the X-ray table and controls. **Do not** use water on the X-ray equipment: use a dry cloth, adding spirits if marks must be removed[1]

If the X-ray table is on wheels, move it away from the other equipment. It can then be cleaned with soap and water if necessary, provided there are no electrical connections.

Darkroom

Manual processing

Remove any films that have been left in the washing tank overnight. Wipe clean around the edges of the main tank. Make sure the washing water is clean and flows freely, and is at the correct level. Top up the developer and fixer from stock bottles.

Each morning and again each afternoon, measure the temperature of the developer, and adjust the processing time accordingly.

[1]It is very important to remove traces of contrast material and plaster from the table top (they may show on radiographs) and to clean off blood or other contaminants, but water cannot be used where there are electrical connections.

Replace all film hangers on their hooks. If any have been in the water overnight, wipe each one before hanging if above the dry bench.

If there is a separate film drier, remove all films and hangers. Check to make sure that no film has fallen to the bottom of the drier (remove any other material that may be there).

If there are film carriers for wet films, empty the bottom tray, and clean the tray and the rack.

Automatic processor

Turn the electric power switch on and check the temperature after 10 minutes. Turn on the water and check the water pressure.

Check the levels of the developer and the fixer in the storage tanks. Some of the large automatic processors also have a washing agent; check this as well.

When the first films are processed, watch the indicators of chemical flow (usually near the delivery end of the processor) and check that the films are properly processed, washed, and dried. If there are clean, dry, but discarded films from previous work, feed one or two of them through the processor at the start of each day. This will ensure that the rollers are working well. Do no not use any bent, stiff, or distorted film.

Film testing

In busy departments it is important to run a test strip through the processor every day at the same time, for example at 10:00. Strip films can be purchased ready to use: alternatively, they can be manufactured in the darkroom. The best method is to expose areas of the film to a constant light source from a sensitometer and then develop the film. The test strip can also be made with an X-ray machine, but a generator of reproducible output must be used. In the latter case, to make a strip film, put a standard film in a 24 cm X 30 cm cassette (or larger). Position the cassette on the X-ray table, closing the collimator, or light beam, to the film size. Cover a strip 3 cm X 24 cm at one end of the cassette with a leaded rubber sheet. Put the step wedge on the other part of the cassette. Give the exposure normally used for a postero-anterior view of an adult wrist. Take the film out of the cassette in the darkroom, cut the film into strips so that each strip has a part of the covered section and also includes each step of the step wedge. Regardless of the method used to obtain the test strips, take one strip and feed it through the processor; it may be necessary to fasten the strip to a large-size discarded film to ensure that it moves through the processor smoothly. Store the other strips in a light-proof box in the darkroom. Repeat the processing of one strip of film every day at the same time. Compare the processed strip films against a viewing box; they should be identical if the processor is working properly. The covered section of the film should be quite clear, proving that the film was not fogged before the X-ray exposure. If there is a densitometer, read the values for density, at each step, on both films. This is more accurate than visual comparison. On a daily basis, it is only necessary to read three steps; the base and fog (lightest), and those corresponding approximately to optical densities 1.0 and 2.0. It is important to record the results, and useful to plot the results and to indicate on a graph the tolerances accepted.

Dry bench

Every morning wipe the dry bench with a clean cloth, remove any dust and pieces of film or paper. Dispose of any film wrapping paper, empty film boxes, name marking strips, request forms, etc‘ Leave the dry bench clear of all unwanted items.

Remove from the darkroom any white coats, plates, cups, books, or other items that should not be in the darkroom at any time! Put them in their proper place.

Mobile X-ray unit or ward unit

Remove any dirt or dried liquids that may have splashed on to the mobile X-ray unit (e.g., in the operating room or emergency room) but do not use water. Use a dry cloth, adding spirit if necessary, but make sure that no liquid runs into the gaps around the control knobs or the edges of the meters.

It the unit is battery-powered, check the battery meter, or other indicator, on the control unit to make sure that the batteries are fully charged.

If the electrical connecting plug, or socket, gets hot after an exposure has been made, or during battery recharging, make sure the wires connecting the cable to the plug are not loose. Only do this when the plug is not in the socket.

Recharge the unit every night by connecting it to the power outlet; leave it connected during the day also, when not in use.

Office

File any returned X-ray films. If there are written reports, file them with the films, or send them to the records department as required. Complete the register with details of any late examinations from the previous day or night. Make up envelopes, and file any films taken the previous day that have not yet been properly organized. File the request form with the films.

Weekly maintenance schedule

On the first working day of each week, the following items should be checked.

X-ray room

Check that the equipment for use in case of fire is in the correct place. There should be:

- one fire extinguisher for electrical fires (water must not be used).
- sand in a bucket, or in sand bags.

Replace any supplies that have been used, e.g., cotton wool, sterile dressings, bandages. Check the contents of the emergency drug cupboard. Check that there are sufficient contrast drugs (for urography and cholecystography) and the necessary sterile syringes, needles, and skin cleaner. It the department undertakes fluoroscopy, check the supply of barium and all other items for gastrointestinal studies (enema tubing, cups/mugs, etc.). Order the replacement stores, as necessary, from the central store or pharmacy.

Instructions for cardiopulmonary resuscitation and for dealing with reactions to contrast drugs should be fixed on the wall of the X-ray room — always

Darkroom

Manual processing é

In addition to the daily tasks (page 126), film boxes and add new boxes of films from the store, if necessary.

Automatic processor é

Lift the lid of the processing compartment,‘ and lift out the developing racks. Wash the racks in clean water. Wipe and replace them. Be careful not to spill chemicals on the floor or elsewhere; damage may result.

Lift out the fixer racks. Wash them in clean water. Wipe and replace them.

Wipe up any liquid (water or chemicals) that has been spilt on the floor or the outside of the processor.

Monthly maintenance schedule

On the first working day of each month, the following maintenance should be carried out.

X-ray room

Perform the daily and weekly tasks, as applicable.

If the tube column runs on rails, clean the rails and the wheels of the column. Remove all dirt, fluff, etc.

Darkroom

Manual processing

The processing chemicals must be changed at least each month. Whenever the chemicals are changed, the tanks must be thoroughly cleaned.

Switch off any heating or cooling system and stop the running water. Empty all the tanks. Wash and scrub all the tanks, including the master tank, with a brush and running water. Mix new developer and fixer solutions. Use different rods for mixing the developer and {he fixer. The developer is an alkaline solution, while fixer is acid. Do not allow even a few drops of the chemicals to get into the wrong tank or container.

Refill the chemical tanks with the new solutions: the developer must always be in the same developing tank, and the fixer in the same fixer tank as before. Never interchange tanks. Refill the master tank with water.

Automatic processor

Turn off the water and the electricity supply. Clean the racks as on the weekly schedule. Clean the developer and fixer tanks (using separate brushes for each tank). Refill with fresh chemicals following the manufacturer's instructions. Turn on the processor and the water supply.

Silver recovery

With either manual or automatic processing, collect fixer or silver, according to the manufacturer’s or recovery company's instructions. If the fixer is to be transported to a central depot, it should be put into airtight containers.

Office

Add up the monthly totals of all entries in the patient register. For example, the total number of patients radiographed, the number of adults, the number of children, the number of chest radiographs, skeletal radiographs, etc., during the preceding month. Also, determine the total number of examinations.

Calculate the total number of X-ray films of each size used during the preceding month and check the stock of unused film, film envelopes, and chemicals. Order stocks as necessary.

Six-month maintenance schedule

Every six months, in addition to all previous routine maintenance, the following maintenance should be carried out.

X-ray room

Check all the moving parts on the equipment, particularly the brakes on the tube column and on the mobile patient support If the brakes are mechanical, clean where possible. If the brakes are electric, and not working properly, request service. Do not continue to use equipment with poorly functioning brakes, since patients or staff may be hurt. Check all floor rails, wheels on examination table, and clean as necessary.

Collimator alignment

Check the collimator alignment. If the collimator does not have a light beam, centre the tube on the middle of a 24 X 30 cm cassette, accurately placed in, or on, the cassette holder. Set the diaphragm for one size smaller (for example

18 X 24 cm). Make an exposure equal to that for a postero-anterior view of an adult hand. Develop the film and examine it on a viewing box. The square defined by the collimator should be clear cut and exactly the same distance inside the edge of the film all around. It the alignment is not exact, check to see if the tube casing has rotated, or it the collimator is loose. Tighten screws if necessary. (See below for tube rotation.)

Repeat the procedure with a horizontal X-ray the position used for a chest radiograph of an erect patient.

If there is a light-beam collimator, choose the same size cassette, 24 x 30 cm. Centre the cassette exactly in, or on, the cassette holder, centre the tube on the cassette, and narrow the illuminated area by about 2 cm all around the inside of the edges of the cassette. Then expose and process the film as above. Take another cassette of the same size and repeat the procedure with a horizontal X-ray beam, and with the cassette holder in the position used for a chest radiograph of an erect patient.

Incorrect collimation

Misalignment will be shown by the exposed area being closer to one edge of the film than the other. There are two common causes. The tube housing may have rotated, or the collimator may be loose. Most tubes are held in place by two circular bands, which can be loosened or tightened by screws. Collimators are fastened to an X-ray tube on a base plate, often with four screws. These can become loose. Alignment of either the tube or the collimator can be more difficult than it sounds. Repeated check films may be necessary, particularly when there is no light beam collimator.

If the alignment is only slightly out, it is probably better to check that the screws are tight and then make no adjustment. If the alignment is badly out and cannot be corrected easily, notify the service engineer.

X-ray room and X-ray generator

Check the generator output. If there is a step-wedge, use it to make exposures at 55, 90, and 120 kV with a constant mA s, but varying mA and time. For each value of mA- s, the densities should be similar at each level on films developed in the same way, in the same chemicals, at the same time.

If there is no step-wedge, use any partially radiation-translucent object, for example, several ball point pens with metal covers. Expose the film, using different exposure factors, and process as described above. Visual comparison will show any marked discrepancies.

Check the timer. This can be done by using a metal spinning-top that has a small hole in the disc. The top is placed on a 24 X 30 cm cassette and centred under the X-ray tube. The cassette is shielded with leaded rubber so that only 1/4 of it is exposed. Twist the top so that it is spinning quite fast, and make an exposure at 55 kV, 100 mA, 0.1 sec. Repeat this procedure on each quarter of the film. The images should all show the same number of dots. For a single-phase X-ray unit, if the line frequency is 60 Hz, there should be 12 dots for each exposure. The number will vary with the design of the X-ray generator, but should be the same for each exposure with the same machine.

This is a very simple test, and not very accurate for complex 3-phase units. However, it does give a reasonable guide, and if there are discrepancies the service engineer should be notified. It cannot be used for frequency converter multipulse generators, but these should remain accurate.

Darkroom

All the intensifying screens should be cleaned at least every 6 months. If the department is busy, clean them every 3 months.

First, clean and dry your hands. Then, in the darkroom, using the safe-light without any white lights, open all cassettes, remove the films and replace them in lightproof film boxes, with the matching sizes of unused films. Put the lids on the boxes. Turn on the white light, or take the cassettes into the X-ray room, open them and dust the inside carefully with a light, soft brush. Then carefully clean the screens, using warm clean water, cotton wool, and good quality soap or washing solution. (Do not use the sort of detergent recommended for washing clothes or saucepans.) Do not use too much water; use a damp pad of cotton wool with a very small amount of soap. Remove any soap residue, using another cotton wool pad. Dry with yet another cotton wool pad. Then leave the cassette open in a dust-free, darkened room (e.g., the darkroom) for several hours.

Never let water or soap flow over the edges of the screens. This will damage both the screen and the felt pad underneath it.

Check the screen—film contact. This can be done without any special equipment by carefully checking the definition of the lungs (especially the small blood vessels in the lungs) on a good quality chest radiograph. All areas should be equally well defined. Smaller cassettes can be checked by looking at the clarity and definition of any image, comparing the centre with the edges.

A standard, commercially available, thin metal grid that has been precisely perforated with small, well-defined holes is a better way to check screen-film contact. This is placed in front of a cassette, and the film is exposed, using an exposure equal to that for a postero-anterior view of an adult hand. The small holes should all be well defined on the processed film and the overall density should be the same. If it is impossible to obtain such a thin metal grid, a wire mesh screen could be used instead.

Uneven definition, or uneven density, can be due to poor contact between the screens and the film. Underneath the back screen, there are felt pads and these may be worn or flattened by long use. Alternatively, the cassette may be damaged and warped, or not fastening properly.

Inspect the cassette first. Check that the hinges are intact and that the cassette opens and closes smoothly. Check that the edges are exactly aligned. Check that the locks for the cassette are all working properly. It there are spring pressure straps, check that they are symmetrical and engaging properly.

It the cassette is satisfactory, the lack of pressure is probably due to the felt pads inside the cassette, behind the back screen. Alternatively, the screens themselves may be loose.

Screens must be fastened by double-sided adhesive tape. Ordinary adhesive tape or glue will damage the screen. When replacing the screens or pads, fasten the front screen (which will be clearly marked "front screen") by first putting double sided tape all around the inside of the front of the cassette. The front of the cassette is the smooth. sunken side, without any outside attachments. Put the front screen into the well of the cassette, with the emulsion side upwards. Put the back screen on top of it, with the fronts of the screen surfaces in contact. Fasten the adhesive tape all around the border of the back of the screen and put similar double-sided adhesive tape around the inside border of the cassette. Put the new felt pad (plastic pads are not satisfactory) exactly in position on the back of the cassette and close the cassette. Fasten, and leave closed for 24 hours without film.

Care of screens

It is important to know the following:

- Screens deteriorate when exposed to light. Keep cassettes closed.

- Screens deteriorate with normal use over 3-5 years.
- Screens are easily scratched. Never touch the surface of the screen with your fingers, and always keep the screens clean.
- Liquid, especially chemicals and sweat, damages screens. Keep cassettes away from the processing tanks. Dry your hands before opening a cassette.
- To allow easy identification when screen marks appear on films, the back screen of each cassette should be marked by writing a small number in one corner, inside. Screen damage will show as a similar "shadow" on the same part of the finished films, for many different patients.
- All screens in a department should be replaced at the same time (because the X-ray exposure needed to produce the same quality of radiograph changes as the screens deteriorate).

Lead aprons and gloves

Each item should be numbered when new and recorded in the log book.

Every 6 months, each item of protective lead clothing must be tested for defects. Check by looking for cracks, tears, blisters, or- other signs of wear. It there is a small tear, secure the edges with strong adhesive strapping. Then put the damaged area over a cassette and give a normal postero-anterior wrist exposure. Process the film, and look for a black line, which ‘would indicate incomplete protection. Any damaged item that fails this test should be discarded (after a replacement has been acquired).

If fluoroscopy is available, each item can be tested using the fluoroscope; cracks will be seen immediately. This is a good way to test double-layered items, such as gloves; these should be rotated while being tested in this way.

Some types of lead apron have an outer plastic cover and the leaded rubber is not visible. These must be carefully palpated for irregularities and tested in the same way by X-raying any doubtful areas. Some lead gloves have removable leather covers, which must be taken off the inner glove before examination for damage.

Twelve-month maintenance schedule

X-ray room

Turn off the generator at the mains switch.

Visually check all the cables for cracks or irregularities, especially where a cable is bent. Check the cable—socket connections; make sure they are not loose or corroded.

Check the X-ray tube and the transformer (the other end of the cables from the ray tube) for signs of oil leakage.

Check the earthing cables (connected to the table, the tube stand rails, etc.) for looseness, damaged insulation, or any sign of wear.

These checks should, of course, be routinely made by the service engineer every 6 months, but it is also a good idea for the X-ray staff to make these visual checks at least every 12 months.

Be careful with X-ray equipment. It can be dangerous.

Do not open the side or other panels on any part of the equipment. Only a service engineer will be able to correct any fault inside. If someone with authority insists on opening the panels, turn off the mains switch on the wall first.

Before sending for the service engineer

If the films have varied in density—too light or too dark, or inconsistent

- Are the chemicals too old? Do they need changing?
- Have you checked the temperature of the chemicals, and are you developing the films accordingly?
- Are the films developed using a timing-clock? And for the correct time for each temperature?
- Are you using a different make of film?
- Are the screens in the cassettes of different speeds? (If so, label the outside of the cassette "Fast", "Slow" or "Medium".)
- Are the screens inserted in the cassette the correct way round? The front screen should be on the side which will be nearest to the patient.
- Are the screens fixed properly? The film must lie between the screens.
- It there is an automatic processor, is the unit running smoothly? Are the chemicals fresh? Is the temperature correct?

If the films are “grey” or fogged where they should be clear

- Is the bulb in the darkroom safelight more than 25 watts?
- Is the safelight filter damaged? Has it got too hot and changed colour? Are there any cracks, especially at the edges?
- Is the safelight too close to the dry bench in the darkroom?
- Are the films fresh? (Check the date on the box.)
- Have the films in the box been exposed to X—rays? Has the box of films, or a cassette, been in the X-ray room while patients were being radiographed?
- Is the temperature of the chemicals too high? Is the fixer too old?
- Is light leaking into the darkroom? (Stay in the darkroom with the door closed for 10 minutes and look around.)

If there are marks on all the films

Marks in the same place on films of the same size.

- Look at the outside of the front of the cassette. Is anything stuck to it? Have any liquids left a residue on it? (For example, barium, intravenous contrast medium, or iodine.)
- Open the cassette in the darkroom, take out the film and put it into a film box. Close the box. Turn on the white light. Check the screens, front and back, for

marks, scratches, or stains. Clean the screen if possible. If the mark cannot be removed, carefully draw a circle around it with a pencil or ball-point pen. This will show on the film, but the doctors will know that it is a film fault and not something wrong with the patient. Replace the screens as soon as possible.

- If there are no marks on the cassette or screens, and the film fault is a "dark" mark on the films after processing, check the box in which the unexposed films were delivered, or are kept. A small hole or crack in the box may allow light to mark the film. This is unlikely, but if there is no other explanation it should be considered.

If the mark on the film changes its position it is nearly always due to a small loose piece of paper inside the cassette.

Whenever faults appear on film and the cause is not found, keep the films to show to the service engineer

General rules

- There is no reason for anyone other than a trained X-ray service engineer to open the side or other panels of any item of X-ray equipment. If you are tempted to open any part of the X-ray equipment, resist. If required to open the equipment, turn off the mains electricity supply first—switch off both the switch on the control panel and the mains switch on the wall of the room.
- All moving parts of equipment should move smoothly, not or jerkily. Never force any item that does not move properly. When there is a problem with movement, check to see if there is any dirt or other obvious cause. Never force control knobs to turn. It a knob will not move easily, turn off the generator, wait 5 minutes, turn it on again and try once more. If unsuccessful, turn off the mains switch and send for the service engineer.
- The rotating anode tube makes a humming noise when it is turned on and is working. After an exposure the tube will go on running, gradually slowing down after a few minutes. If it stops suddenly, or if it makes a strange noise, or it the noise increases or sounds "rough", stop using the tube, and send for the service engineer. If the tube does not start rotating you cannot make an exposure at all. Send for the service engineer and warn him or her in advance that a new tube may be necessary.
- If any meter or light on the X-ray equipment does not work normally, contact the service engineer, tell him or her what is happening, and ask for advice. It may, or may not, be serious. Try not to use the equipment until you have consulted the service engineer.
- Water (or almost any liquid other than oil) and electricity must not be mixed. Keep water and other liquids well away from X-ray equipment. If any fuse blows and it can be easily replaced, use exactly the same type of fuse to replace it. Turn off the mains switch first. Never use a stronger fuse than the original one. If the same fuse blows soon after it has been replaced or repaired, or if other fuses blow quite soon after the first one, turn off the unit and send for the service engineer. Any unusual heat, smell of burning, smoke, or sparking is an indication to turn off the mains switch at once. Do not turn it on again until the service engineer is available.
- In case of fire, turn off the mains switch at once. Do not try to see what is burning or where the fault is. Do not turn the switch on again.

Do not put water or water spray on any electrical fire. Use sand or a specially designated fire extinguisher. If possible, turn off the mains switch first.

If there is a fire brigade or other professional help in the vicinity, get someone to contact them. If there is increasing smoke or heat, leave the room at once, close the door and give the fire alarm.

Battery-powered generators

For battery-powered generators, see Annex 1, pages 143—144.