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Document No.	**TITLE**		
E / NABH / SJH / SOP/ 26	**Radiation Safety Manual for Radio diagnosis**		
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Function	**Name**	**Designation**	**Signature**
Prepared By	Dr.Charu Paruthi Dr.Anuradha Sharma	NABH Nodal Officers, For Radio diagnosis	
	Mr. Manjit Rai Bahl	RSO Radio diagnosis	
Reviewed By	Dr. Amita Malik Dr. K. C. Tamaria	HOD, Radio diagnosis Nodal Officer NABH	
Approved By	Dr. SV Arya	Medical Superintendent	03/01/2022

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1. Introduction

Many radiological modalities make use of X-rays for image production, which are a type of ionizing radiation. These are known to cause dose related and non-dose related side effects on the human body. Some groups like pregnant females and children are especially vulnerable to radiation side effects.The amount of radiation exposure in radiology is usually within the safe range. However, it is of paramount importance for everyone working with radiation to be aware of the safety precautions to be followed by the working personnel, patients and general public.

There are safety regulations directed by the Atomic Energy Regulatory Board (AERB) and steps towards its implementation, including equipment installation and maintenance, which need to be complied by everyone working with X-ray producing equipment. This manual contains the details of the radiation safety measures in place in the Radiology Department at Safdarjung Hospital.

2. Purpose

This manual provides information about the policies and processes for diagnostic radiation safety within the hospital facilities in order to fulfill following objectives:

a) The use of all x-ray sources are done in a manner to avoid any harm to health and safety of all staff, patients and environment.

b) Compliance with AERB regulations concerning x-ray is ensured by adhering with the procedures and recommendations included in this manual.

3. Scope

This Safety Manual describes the control of hazards, promotion and implementation of safety measures for the patients and staff in hospital.

The main purpose of this manual is to scrutinize radiation exposures to ensure that all exposures are justified and necessary exposures are kept as low as reasonably achievable (ALARA) with keeping in levels with certain specified limits.

4. Definitions

- **Absorbed Dose:** The amount of energy imparted to matter by ionizing radiation per unit mass of irradiated material. The unit of absorbed dose is the Gray (Gy)
- **ALARA:** As Low As Reasonably Achievable.
- **Calibration:** The check or correction of the accuracy of a measuring instrument to assure proper operational characteristics.
- **Critical Organ:** The organ or tissue that is most susceptible to irradiation which will result in the greatest hazard to the health of the individual.
- **Declared Pregnant Worker:** A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.
- **Dose Rate:** The radiation dose delivered per unit of time
- **Dosimeter:** A portable instrument for measuring and registering the total accumulated exposure to ionizing radiation.
- **Gray:** The international SI unit of absorbed dose in which the energy is equal to one Joule per kilometer.
- **Half Value Layer:** The thickness of any specified material necessary to reduce the intensity of an X-ray or gamma ray beam to one – half its original value.
- **Inverse Square Law:** The intensity of radiation at any distance from a point source varies inversely as the square of that distance.
- **Ionizing Radiation:** Any radiation capable of displacing electrons from atoms or molecules, thus producing ions.
- **Occupational Radiation Dose:** The dose received by an individual in the course of employment.
- **Radio sensitivity:** The relative susceptibility of cells, tissues, organs, organisms, or other substances to the injurious action of radiation.

- **Sievert:** The international (SI) of dose equivalent.
- **Thermo Luminescent Dosimeter (TLD):** Crystalline materials that emit light if they are heated after they have been exposed to radiation.

5. Abbreviations:

- **AERB:** Atomic Energy Regulatory Board
- **BARC:** Baba Atomic Research Center
- **ALARA:** As Low As Reasonably Achievable
- **RSO:** Radiation Safety Officer
- **Gy:** Gray
- **Pb:** Lead
- **mSv:** Millisievert
- **TLD:** Thermo Luminescent Dosimeter
- **NOC:** No Objection Certificate
- **SSD:** Source – Skin Distance

6. Policy

A policy is a statement fact or action that is accepted by the Radiation Safety Committee as necessary in order that consistency in the use of facilities or practices may prevail.

6.1 Fulfillment of Policy

Overall responsibility of radiology department that commitments made in this policy are actively carried out will be taken care by the Radiation Safety Committee. Safety for building, equipment & people is followed for internal and external environment. Efficient layout, supporting staff and overall function of the center supports to:

- Reduce environmental hazards and risks
- Prevent accident and injuries
- Maintain safe condition for patients, staff and attendants

- Maintain environment that is sensitive to patient needs for comfort, social interaction, and positive distraction
- Maintain environment that minimizes unnecessary environmental stresses for patients, staff and attendants.

7. Radiation Safety Committee:

Safdarjung Hospital administration is continuously striving to improve patient's care quality and safety. To address the issues related to radiation safety and training on safe practices of staff and faculty working in the Department that are using radiation source for diagnosis and management of patients in the Hospital, and to fulfil the NABH standards requirement, a committee of following faculty and staff representing Hospital administration and concerned department is constituted.

1. Medical Superintendent Chairman.
2. HOD Radiotherapy Member
3. HOD Nuclear medicine Member
4. HOD Radio diagnosis Member
5. Dr Vikas Yadav, Radiotherapy **Member Secretary**
6. Dr Padma A Namgyal, Nuclear medicine **Member Co-ordination**
7. Mr. Manjit Rai Bahl,RSO, Radio diagnosis Member
8. Dr Shilpee Kumar, Member Quality Cell
9. Ms. Poornima Kushawa, RSO, Radiotherapy Member
10. RSO (Burns & Plastic) Member
11. RSO (Neurosurgery) Member
12. RSO (CTVS) Member
13. RSO (Dental) Member
14. RSO (Cardiology) Member

15. RSO (CIO) Member

All members are responsible for safety of their department which ultimately provides radiation safety in the entire center.

7.1 Responsibility of the Safety Committee - Evaluation of the various safety aspects of hospital and give its feedback to the Director.

- Provide guidance and direction in all phases of the Safety Program.
- Pro-active safety risk assessments of the clinical and clinical support area of hospital.
- Facilitate the Environmental monitoring rounds.
- Advise management of unsafe conditions or of non-compliance with regulation and standards.
- Conduct ongoing safety education.
- Responsible for proposing/revising safety policies
- Periodic assessment of the following inventory:
    - Environmental (lighting, dusts, gases, sprays, noises).
    - Hazardous material (flammable and caustic).
    - Equipment (biomedical equipment etc.).
    - Power equipment (motors, generators etc.).
    - Electrical equipment (switches, breakers, fuses, outlets, connections).
    - Hand tools.
    - Personal protective equipment (Radiation safety aprons etc.).
    - Personal service/first aid supplies (Medical Check Up).
    - Fire protection equipment (alarm and extinguisher).
    - Walkways/ ramp.
    - Transportation equipment (Ambulances).
    - Containers (hazardous waste bags).
    - Structural openings (windows, doors, stairways).
    - Buildings/structures (floors, roofs, walls, ramp).
    - Miscellaneous.

Each report will record pertinent safety violations, noncompliance items, and observe deficiencies.

8. Regulatory Requirements in Diagnostic Radiology

8.1: Regulatory Framework:

AERB was constituted in 1983 for carrying out the regulatory and safety functions envisaged in the Atomic Energy Act, 1962. Main Functions of AERB are:

- Safety assessment for granting license
- Regulatory Inspections
- Development of regulatory safety documents

AERB Safe CodeNo. AERB/RF-MED/SC-3 (Rev. 2) contains seven sections and two appendices:

Sections: 1. Introduction

2. Design Requirement for X-ray Equipment

3. Regulatory Requirements for Manufacturers of X-ray Equipment and X-ray Tubes

4. Regulatory Requirements for Suppliers of X-ray Equipment and X-ray Tubes

5. Regulatory Requirements in Use of X-ray Equipment

6. Responsibilities of Employer, Licensee, RSO and Radiation Worker

7. Requirements for Occupational Radiation Protection

Appendices: Appendix-I - Design Specifications for X-ray Equipment

Appendix-II - Design Specifications for Radiation Protection Devices

The following x-ray equipment are covered in this Code:

• Radiography (Fixed, Mobile, Portable), Interventional Radiology, C-Arm

• Dental radiography [Dental (intra-oral), OPG, Dental CBCT]

•Computed Tomography, mammography, Bone Mineral Densitometer

8.2Pre-requisites for obtaining license for operation of X-ray equipment:

• X-ray Room Layout and Shielding Requirements

• Staffing Requirements

• Radiological Safety Officer (RSO)

• Radiation Protection Devices

• Personnel Monitoring Service

• Quality Assurance (QA) Requirements

Procurement of X-ray Equipment: The employer of X-ray facility shall procure NOC validated/ Type Approved X-ray equipment from authorized supplier(s) and after obtaining procurement permission from the Competent Authority.

Operation of X-ray Equipment: No diagnostic X-ray equipment shall be operated for patient diagnosis unless License for operation is obtained from the Competent Authority.

8.2.1 Requirements for Room Layout of X-ray Equipment

- The room housing X-ray equipment shall have an appropriate area to facilitate easy movement of staff and proper patient positioning.
- Appropriate structural shielding shall be provided for walls, doors, ceiling and floor of the room housing the X-ray equipment so that radiation exposures received by workers and the members of the public are kept to the minimum and shall not exceed their respective dose limits.

- The control console of computed tomography equipment shall be installed in a separate room located outside but adjoining to computed tomography room and provided with appropriate shielding, direct viewing and oral communication facilities between the operator and the patient.
- Interventional Radiology equipment room shall have an adjoining control room with appropriate facilities for shielding, direct viewing and oral communication facilities between the operator and the patient.
- In case of room housing radiography equipment, chest stand shall be located in X-ray room such that no significant stray radiation reaches at control console/entrance door/ areas of full time occupancy such that the dose limits to radiation worker and members of public are not exceeded.
- Mobile X-ray equipment, when used as fixed X-ray equipment, shall comply with all the requirements of those of fixed X-ray installation.
- Movement of mobile X-ray equipment shall be restricted within the institution for which it is registered.
- A permanent radiation warning symbol and instructions for pregnant/likely to be pregnant women shall be posted on the entrance door of the X-ray installation, illustrating that the equipment emits X-radiation when energized.
- X-ray equipment installed in a mobile vehicle, shall be provided with an appropriate shielding enclosure to ensure adequate built-in protection for persons likely to be present in and around the vehicle. Shielding shall be provided around the equipment from all the sides up to height of 2 m from external ground surface.

8.2.2 Staffing Requirements

- X-ray installations shall have a radiologist/related medical practitioner/ X-ray technologist with adequate knowledge of radiation protection, to operate the Xray equipment.
- All installations having X-ray equipment with fluoroscopy facility, computed tomography and all establishments performing special procedures, shall have the services

of a qualified radiologist or related medical practitioner, with adequate knowledge of radiation protection for interpretation and reporting.

8.2.3 Radiological Safety Officer (RSO)

• X-ray department shall have a RSO approved by the Competent Authority.

• The RSO may either be the employer himself/herself or an employee to whom the employer shall delegate the responsibility of ensuring compliance with appropriate radiation safety/regulatory requirements applicable to his X-ray installation(s).

• The minimum qualification and training shall be as prescribed by the Competent Authority as given below:

License category DR facilities (CT and IR)

(a) Radiologist/Related Medical Practitioner, Or

X-ray Technologist passed from a recognized institution with three years working experience in the field of CT/IR facility. Or

Institutions, where radiotherapy or nuclear medicine facility is available, AERB approved Radiological Safety Officer can be designated as RSO of DR facility subject to submission of undertaking by that RSO for ensuring radiation safety in DR facilities, and An approval from competent authority

Registration category DR facilities

Appropriate Registrant shall be assigned the responsibilities of RSO subject to furnishing "Undertaking" that he/she is familiar with the regulatory requirements and radiation protection aspects of medical X-ray installation.

8.2.4 Radiation Protection Accessories

Appropriate radiation protection devices such as barrier, apron, goggles, and thyroid shields shall be used during operation of X-ray equipment. These devices shall be verified periodically for their shielding adequacy.

•Mobile Protective Barrier (MPB)- 1.5 mm Lead Eqv
• Lead Aprons - 0.25 mm Lead Eqv
• Rubber hanging Flaps (In IR)-0.5 mm Lead Eqv
• Lead Glass window- 2 mm Lead Eqv

8.2.5 Personnel Monitoring Service

Personnel monitoring services shall be provided to all the radiation workers handling diagnostic X-ray equipment.

8.2.6 Quality Assurance (QA) Requirements

QA programs are designed to ensure that the radiology equipment can yield the desired diagnostic information. Quality control techniques used to test the components of the radiological system and verify that the equipment is operating satisfactorily.
The end user shall ensure that periodic QA (once in two years) of X-ray equipment is carried out by agencies authorized by the regulatory body.

9. X-Ray Safety Policies

Orientation of safety rules to each technician operating x-ray equipment including adherence to the operating technique required for the safe operations of the particular x-ray machine.

- All the X–ray equipment meets design certification and type approval by AERB.
- Site approval plan is obtained from AERB wherever required.
- Safety equipment as Lead aprons, thyroid shields are made available wherever required.
- During radiographic exposure, the radiographer stands behind the protective lead barrier.
- TLD badges as monitoring devices are provided to all radiation workers.

- Permit only authorized personnel/ individuals required for the medical procedure or for equipment maintenance in the radiographic room during an exposure.
- Radiographers should not hold the patient during radiation exposure, except in a life-threatening situation. If a patient is to be held during the X-ray exposure, non-radiation workers or members of the patient's family may be asked to perform his duty. For this, the assistant is to wear protective aprons (at least 0.25 mm lead equivalent).
- Protect reproductive organs during radiation exposure and avoid pregnant women from getting exposed to radiation as far as possible. Use fetal protection measures.
- Collimate x-ray beam limitation to the region of interest.
- Regular Servicing & calibration of X–ray equipment by authorized service engineer.

9.1 General Radiation Protection

- Radiographers should take necessary steps in reducing radiation dose to the patient.
- Identify the correct patient for the correct examination.
- Provide the necessary radiation protection and close the X-ray room door properly.
- Give proper instructions to the patients and select the appropriate exposure factor.
- Ask h/o pregnancy for all female patients aged 18 to 45 years

9.2 SOP for TLD Badge Services

- The office of Dr Rajiv Sharma Addl. M. S. & HOD Radiotherapy will work as nodal office for services related to TLD Badge.
- The RSO working in Radio diagnosis Department will work as nodal officer for services related to TLD Badge till regular Medical Physicist /RSO joins in Radiotherapy Department.
- The Medical Physicist /RSO working in Radiotherapy will coordinate with RSO Radio diagnosis.
- The Packets of new TLD Badge of all the departments will be received by the nodal office/nodal officer from Ultra tech Ltd.
- The nodal office/nodal officer will send the packets of new TLD Badge to all departments.

- The RSO of respective department will be fully responsible for distribution and collection of TLD Badge from individual.
- The RSO of respective department will send the packet of used TLD Badge to nodal office/nodal officer.
- The nodal office/nodal officer will send the packets of used TLD Badge to Ultra tech Ltd. through store.
- The store will dispatch the packets of used TLD Badge to Ultra tech Ltd. and send the receipt/ intimation to nodal office/nodal officer.
- The RSO of respective department will maintain the list, record and reports of TLD Badge and same will be shared with nodal office/nodal officer.
- All the bills related to TLD Badge from Ultra tech Ltd. will be received by nodal office/nodal officer.
- The nodal office/nodal officer will send bills of Ultra tech Ltd for TLD Badge services to respective department for verification.
- The RSO of respective department after verifying, send bills of Ultra tech Ltd to the nodal office/nodal officer timely so that payment will be released on time to avoid delay in TLD Badge services.
- After the verification of bills, nodal office/nodal officer will send the bills to accounts department for payment to be released to Ultra tech Ltd.
- The accounts department will send a copy of payment receipt to nodal office/nodal officer for record.
- **For any issue regarding TLD Badge, nodal officer may be contacted.**

10. Operation of X-ray producing Equipment

- Wear appropriate Personal Radiation Protection devices where there is risk of radiation exposure.

- Wear TLD badges when working with radiographic equipment. Wear the badge issued for the current time period and under the lead apron. (TLD badges card is to be properly inserted into the cassette holder).
- Only individuals whose presence is necessary should be in radiographic room during exposure. All such individuals who are subject to direct scatter radiation shall be protected by aprons of not less than 0.25 mm lead equivalent.
- Mechanical restraining devices are to be used when a patient or film must be held in position of radiography. If a patient must be held by an individual, that individual is protected with appropriate shielding devices of at least 0.25 mm lead equivalence for whole body protection and at least 0.5 mm lead equivalence for any part of the holder's body that is exposed to x-ray beam.
- Collimate the x-ray beam to the smallest area consistent with clinical requirements and align accurately with the patient and film.
- Always stand behind the barrier for protection during radiographic exposures at permanent radiographic installations and stand as far as possible (at least 6 feet) from the patient when operating the mobile equipment.
- Place Image intensifier closest to the region of interest for better image quality and reduced risk from potential hazards.
- Take special precautions to minimize exposure of the embryo or fetus in patients known to be or suspected being pregnant where radiology investigation is absolutely necessary.
- Do not perform abdominal radiographic imaging on a pregnant or potentially pregnant patient without the approval of a qualified physician. Although it is the responsibility of the referring physician to determine the pregnancy status, those operating diagnostic x-ray equipment will ask all patients of childbearing age whether or not they are pregnant and the date of their last menstrual period. This information is to be recorded on the study requisition prior to examination.
- Shield the abdominal region if the x-ray procedure does not include the abdomen or pelvis of the pregnant or potentially pregnant patient, with at least 0.25 mm lead equivalence and then perform the examination without regard to pregnancy.

- Get TLD (Thermo luminescent dosimeter) devices checked quarterly.
- Minimize radiation exposure by using shorter exposure time, doubling the distance and use of appropriate shielding to reduce the dose rate.

10.1 Procurement of equipment:

Scientific method of procurement as per specifications, conforming to the regulatory requirement and from approved suppliers for radiological investigations including Image intensifier, digital radiography. QA check on all equipment is done.

- Information and registration to the PC-PNDT office for procurement, installation and return of the machines under buy back scheme or sale of the equipment is provided.
- All equipment required for investigations as well as for resuscitation of adults and pediatric patients is available, including Blood pressure, pulse-oximeter, laryngoscope, anesthesia machine, defibrillator, pressure injectors etc.
- Proper records are maintained in the inventory with invoice of the machine with warranty CMC/AMC contract, list of spares etc.

10.2 Installation of equipment

- Readiness of space, UPS, electric connections etc.
- Check as per packaging list and rule out any short supplies or damages.
- Installation done by service engineer followed by IQ, OQ, PQ.
- Performance of calibration and validation by engineers
- Handed over the equipment for use
- Make a history sheet of equipment with all details and put in the inventory list.

10.3 Training of Technicians

- Training on operation of equipment
- Switching on and off the machine
- Basic cleaning and daily maintenance

10.4 Preventive Maintenance

- A list of all equipment requiring maintenance/calibration is prepared and maintained.
- Identification of the equipment by name, type, location, applicable service requirements, date of maintenance service done and maintenance due date.
- The history sheet contains the preventive maintenance frequency and calibration requirements and break down maintenance details.
- Preventive maintenance of equipment is carried out by the service engineers designated by the principals as per CMC/AMC contract.
- Follow the PPM schedule in conjunction with the user department on the availability of the machine to conduct the preventive maintenance by the CMC/AMC Company.
- Communicate the date and time for preventive maintenance in advance to the user departments for release of their equipment.
- The availability of necessary spares, consumables, tools and necessary materials are ensured by an advance planning, through CMC/AMC Company.
- After completion of maintenance, the OK report is taken from the user department.
- Record all preventive maintenance works done in the equipment history sheet maintained for all equipment. The department head collects and documents the Service report of the maintenance conducted on the equipment by the AMC service engineer.
- The following is checked when maintenance is done –
    - Physical condition of the equipment/ facility
    - Maintenance report verification

- Maintenance / service report to be obtained from service agency and after verification marked as OK/Not OK.

10.5 Complaint/Breakdown

- In case of breakdown of any equipment, the user department notifies the concerned department authority about the problem.
- The authorized person enters the details in the Equipment Breakdown record register and identifies the status of the equipment whether under annual /comprehensive maintenance contract (AMC/CMC) or not.
- In case the equipment is not under AMC/CMC, the authorized person informs head of department for further action to be taken.
- If the equipment is under AMC the company is informed. Time, date and complaint number is noted in the equipment breakdown register.
- The company service engineer will report to the maintenance manager / department in charge who is then shown the location of the faulty equipment.
- When the service engineer from the company rectifies the defect, the record in the equipment history is updated with the required information and equipment is validated by the service engineer.
- In case the fault can be repaired on the spot, the service engineers rectify the fault and then validate the equipment fitness for its functioning in the service report.
- The date at which the part is installed and equipment starts functioning is recorded in the equipment history sheet by radiographer or engineer. If the machine parts cannot be repaired at hospital and machine is required to be taken to the service center, a receipt for the equipment part is provided by the service engineer with details of the parts collected. The same is to be kept in record by the Maintenance manager.
- After the fault is rectified and the equipment part is brought back to center, the maintenance manager ensures that the equipment part is installed in the equipment by the service engineer.

- The date at which the part is installed and equipment starts functioning is recorded in the equipment history sheet.
- The break down time and the spares details is recorded.
- The response time of the AMC/CMC service engineer is recorded.
- After the service, the machine is thoroughly tested by the user department.
- Once the user department signs the service report and finds it OK, it is put in use again.

10.6 Calibration

- As per the frequency stipulated the equipments are calibrated internally or through the CMC/AMC provider or through the third party agency or through the government agency.
- *All the necessary certificates are maintained.*
- Most of the calibration is done with the periodic prevention maintenance schedule.

The history record is upgraded with calibration codes.

10.7 Documentation

Each equipment history sheet should be updated with following details

- Name of machine
- Name of manufacturer
- Serial no.
- Date of Installation
- Certificate of Registration/license
- AMC /CMC record.
- Record of periodic quality control check
- Record of downtime, repair & replacement of parts

11. Control of Patient Exposure

The risk to the individual patient from a single radiographic examination is very low. However, the risk to a population is increased by increasing the frequency of radiographic examinations and by increasing the number of persons undergoing such examinations. For this reason, it is important to reduce the number of radiographs taken, the number of persons examined radiographically, and the doses associated with the examinations.

To accomplish this reduction, it is essential that patients should be subjected to only necessary radiological examinations and when a radiological examination is required, it is essential that patients be protected from excessive irradiation during the examination. This can be done by adhering, as much as possible, to certain basic recommendations presented below:

- The prescription of an x-ray examination of a patient must be based on clinical evaluation of the patient and should be for the purpose of obtaining diagnostic information.

- X-ray examinations must not be performed if there has been no prior clinical examination.
  - It should be determined whether there have been any previous x-ray examinations which would make further examination unnecessary.
  - When a patient is transferred from one physician to another, any relevant radiographs should accompany the patient &should be reviewed by the consulting physician.
  - When prescribing a radiological examination, the physician should specify precisely the clinical indications and information required.
  - The number of radiographic views required in an examination, should be kept to the minimum practicable, consistent with the clinical objectives of the examination.
  - Before performing x-ray examinations on females of child bearing age, the patient must be asked whether there is any chance that they may be pregnant. Care must be taken to protect the fetus from radiation when the x-ray examination is not avoidable. Radiological examinations of the pelvic area in women of childbearing age should be undertaken in the ten-day period following the onset of menstruation, since the risk of pregnancy is very small during this period.
  - If a radiograph contains the required information, repeat procedures should not be prescribed simply because the radiograph may not be of the "best" diagnostic quality.

11.1 Guidelines for Minimizing Radiation Exposure to Patients – Pediatric Imaging

- Note: All guidelines as indicated under section "Guidelines for Minimizing Radiation Exposure to Patients – General Diagnostic Imaging" will apply for Pediatric Imaging with the following additional guidelines:
- The risk of cancer from radiological exams accumulates over a lifetime; each exam contributes to lifetime radiation exposure. Children have longer life expectancy and, thus, more time to manifest radiation-related cancer. Because there is a reported increase in the use of radiological examinations in children, careful adherence to the guidelines is important. More than adults, children are susceptible to low levels of radiation because they possess many rapidly dividing cells. In rapidly dividing cells, the repair of mutations is less efficient than in resting cells. When radiation causes DNA mutations in a rapidly dividing cell, the cell cannot sufficiently repair the damaged DNA and continue to divide; therefore, the DNA remains in disrepair.
- Careful positioning: Positioning can also account for unnecessary radiation exposure to sensitive organs. For example, when making a radiograph of the hand, the patient's gonads may be exposed to excessive radiation due to improper positioning. Simply turning the patient away from the table can eliminate any exposure to the gonads.
- The use of a poster anterior (PA) projection or an AP projection can affect radiation dose. For example, A PA projection should be used for a scoliosis series of young female patients because their breast tissue is extremely sensitive to the development of radiation-induced breast cancer. When the examination is performed using a PA projection, the breast tissue receives the exit dose of radiation as opposed to the entrance dose. This can reduce the mean glandular dose to the breast tissue by as much as 98%. On the other hand, a premature neonate in an isolate may be restricted to an AP projection. In this case, the patient receives a greater radiation dose.
- Because radiation exposure is directly proportional to the time of exposure (total exposure = exposure rate x time), Exposure time should be kept as short as possible to minimize patient exposure and to reduce the chance of patient movement.

- Shielding should always be used provided that they do not interfere with the area of interest. Specific areas of shielding are as follows:
    - **Gonads**: Germ cells may have no dose threshold at which radiation produces mutations. Gonad shielding is required for both boys and girls in pediatric imaging. Whenever the gonads lie within 5 cm of the collimation line & do not interfere with the anatomy of interest, gonad shielding (at least 0.5 mm lead equivalence) should be used. Also, the gonad region should be positioned as far from the radiation beam as possible.
- **Eyes**: In radiography of the head, the eyes can receive large doses of radiation. The use of a PA projection rather than an AP projection can reduce the exposure 20 to 30-fold.

- **Thyroid**: Because visualization of the airway is important in chest radiographs, shielding the thyroid is not practical. However, it may be of some value in dental radiography.
- Collimation reduces the amount of scattered radiation; more importantly, collimation reduces the irradiated volume, thus limiting the patient's effective dose. In pediatric radiography, the radiographer must collimate to the anatomical area of interest.

11.2Guidelines for Minimizing Radiation Exposure to Patients in Fluoroscopic Procedures

Note: All guidelines as indicated under section "Guidelines for Minimizing Radiation Exposure to Patients – General Diagnostic Imaging" will apply for Fluoroscopically Guided Procedures with the following additional guidelines:

In view of the relatively high exposure that results from fluoroscopy, such procedures should only be carried out when an equivalent result cannot be obtained from radiography. Fluoroscopy must not be used as a substitute for radiography.

Fluoroscopy must only be carried out by a radiologist or physician properly trained in radioscopic procedures or by a properly trained technologist under immediate supervision of physician or radiologist.

- All fluoroscopic procedures should be carried out as rapidly as possible with the smallest practical x-ray field sizes.
- Image intensification must be used in order to reduce patient exposure. Image intensifiers can significantly reduce both irradiation rate and irradiation time. However, the operator must monitor the x-ray tube current and voltage on equipment with automatic brightness control, since both can give rise to high values without the knowledge of the operator, particularly if the gain of the intensifier is decreased.
- Cine fluorography produces the highest patient doses in diagnostic radiology because the x-ray tube-voltage and current used are generally higher than those used in fluoroscopy. Therefore, this technique should not be used unless significant medical benefit is expected.

11.3 Guidelines for Minimizing Radiation Exposure to Patients – Mobile X-ray Procedures in multiple bed suites (e.g. ICU)

Note: All guidelines as indicated under section "Guidelines for Minimizing Radiation Exposure to Patients – General Diagnostic Imaging" will apply for Mobile X-ray Procedures in the multiple bed suites (OR, ICU) with the following additional guidelines:

- Carry enough protective aprons to ensure that the patient has one for added shielding.
- Label and handle each cassette carefully to avoid repeats.

12. Reduction of Staff Exposures

The objective of a safety program is not to provide absolute protection from any level of radiation exposure, no matter how small. It is, however, directed towards reducing exposures to staff and members of the public to a level that carries low risk. This series of guidelines is provided as protection for occupational health care workers. These safe-working practices are to be combined with specific policies of the WRHA and personal good sense in order to achieve radiation exposures that are ALARA.

12.1 Guidelines for Minimizing Radiation Exposure to Personnel – General Diagnostic Imaging

- An x-ray room must not be used for more than one radiological investigation simultaneously.
- Only those persons whose presence is essential for the imaging and well-being of the patient are to be in the room during x-ray exposure.
- Holding devices are to be used where practical to support children or weak patients. Patients' escorts or persons other that regular x-ray staff should be called upon to hold a patient if a holding device proves impractical.
- Where health care workers must be present during the use of X-rays, a lead apron must be worn. Shielding aprons are to have a lead equivalency of 0.5 mm lead.
- X-ray exposure should be controlled from a location within the shielded control booth.
- Irradiation of workers by direct beam should not be permitted unless the beam is attenuated by the patient or by a protective device (e.g. shielding screen). When using mobile equipment, technologist should be positioned such that the beam is directed away from them.
- Personnel must, at all times, keep as far away from the x-ray beam as practical. Radiation exposure of personnel by the x-ray beam must never be allowed unless the beam is adequately attenuated by the patient and by protective screens or protective clothing.
- Deliberate irradiation of an individual for training purposes or equipment evaluation must never occur.
- All workers who are likely to receive a radiation dose in excess of 1 mSv per annum require personal dosimeters.
- When a protective apron is worn, the personal dosimeter must be worn under the apron.
- If extremities are likely to be exposed to significantly higher doses, additional dosimeters should be worn at those locations on the body.
- A female operator should immediately notify her employer upon knowledge that she is pregnant, in order that appropriate steps may be taken to ensure that her work duties

during the remainder of the pregnancy are compatible with the recommended dose limits as stated in Table below.

- Doors to the x-ray room are to be closed while a patient is being imaged.
- X-ray machines which are energized & ready to produce radiation must not be left unattended.
- X-ray equipment must be operated only by individuals who are properly trained for the equipment and the procedures being performed.

- X-ray operators of new equipment are to receive adequate training in the equipment prior to imaging of patients.

Applicable Body Organ or Tissue	Radiation Workers (mSv)	Members of the Public (mSv)
Whole Body	20	1
Eye Lens	150	15
Skin	500	50
Hands	500	50
All other organs	500	50

12.2 Guidelines for Minimizing Radiation Exposure to Personnel in Fluoroscopic Procedures

Note: All guidelines as indicated under section "Guidelines for Minimizing Radiation Exposure to Personnel – General Diagnostic Imaging" will apply for Fluoroscopically Guided Procedures with the following additional guidelines:

- All persons, with the possible exception of the patient, required to be in the room during a fluoroscopic procedure should wear protective aprons. Lead shields or curtains mounted

on the fluoroscopic unit are not a sufficient substitute for the wearing of protective clothing.

- Protective gauntlets should be worn by the radiologist during palpation in every fluoroscopic examination. During fluoroscopy, palpation with the hand should be kept to a minimum.

13. Quality Assurance in Diagnostic/ Interventional Radiology

Sr No	Name of QA Test	Tolerance
1	Congruence of radiation and optical field	| a1 | + |a2 | ≤ 0.02 of S
2	Central Beam Alignment	Central Beam Alignment < 1.5°
3	Effective Focal Size Measurement	f < 0.8 mm +0.5 f 0.8 ≤f≤1.5 mm +0.4 f f > 1.5 mm +0.3f
4	Accuracy of potential (kVp)	± 5 kV
5	Accuracy of exposure time	% Error ± 10%
6	Linearity of radiation output	CoL< 0.1
7	Output consistency	CoV<0.05
8	Exposure rate at table top	Exposure Rate without AEC mode ≤ 5 cGy/Min Exposure Rate with AEC mode ≤10 cGy/Min
9	Minimum Total Filtration	1.5 mm Al for kV ≤70 2.0 mm Al for 70 ≤kV ≤100 2.5 mm Al for kV >100
10	Leakage from X-ray tube Housing	1 mGy in 1 hour for R&F equipment 0.02 mGy in one hr for mammography 0.25 mGy in one hour for dental (intra-oral) unit
11	Performance of Imaging System	High contrast resolution : Mesh pattern of 30 lines/inch or bar pattern of 1.5 lp/mm must be resolved Low contrast resolution : 3.0 mm hole pattern

		must be resolved

14. Quality Assurance for Computed Tomography Equipment

S. No.	Parameters tested	Tolerances
1	Alignment of Table to Gantry	± 5mm
2	Gantry tilt	± 20
3	Table indexing accuracy	± 1mm
4	Slice thickness	± 1mm
5	Accuracy of kV	± 5kV
6	Linearity of mA	
7	Accuracy of irradiation time	Error ≤ ± (10 % + 1 ms)
9	Total filtration (100 kVp)	HVL> 2.7 mm Al
10	Output consistency	COV ≤ 0.05
11	Radiation dose test	± 20%
12	Noise	± 15%
13	CT number uniformity	± 4HU
14	CT number linearity	± 4HU
15	Low contrast resolution	5.0 mm at 1% contrast
16	Spatial resolution	0.5 lp/cm at 10% contrast
17	Radiation leakage	< 1mGy in one hr