CHAPTER ONE

INTRODUCTION

:Introduction .1.1

In this research, the researcher looked for the most effective materials in protection from radiation, especially in the dia3Wgnostic X-ray departments. In most cases, high-density materials are more effective than low-density for blocking or reducing .the intensity of radiation

The diagnostic x-ray is thus one of the most valuable tools used in modern health care. Although individual doses are usually small, in total exposure, diagnostic x-rays account for the major portion of man-made radiation exposure to the general population. However, with well-designed, installed and maintained x-ray equipment, and through use of proper procedures by trained workers, unnecessary exposure to patients can be reduced significantly, with no decrease in the value of medical information derived. To the extent that patient exposure is reduced, there is, in general, a decrease in the exposure of machine and other health care personnel . The need for radiation protection exists because exposure to ionizing radiation can result in dangerous effects that manifest themselves not only in the exposed individual but in his descendants as well. These effects are called somatic and genetic effects, respectively. Somatic effects are characterized by observable changes occurring in the body organs of the individual exposed. These changes may appear within a time frame of a few hours to many years, depending on the amount and duration of exposure of the individual. Genetic effects are an equal cause for concern at the lower doses used in diagnostic radiology. Although the radiation doses may be small and appear to cause no observable damage, the probability of chromosomal damage in the germ cells, with the consequence of mutations giving rise to genetic defects, can make such doses significant when considered for a very large population. (Minister of Public Works and Government .(Services Canada 2000

In the planning of any medical x-ray facility, account must be taken of the expected maximum workload of the equipment, of use factors of the barriers and of occupancy factors for areas adjacent to the facility. Allowance should be made for possible future changes in any one or all of these parameters, such as increased operating kilo voltage and workload, or modifications in techniques that may require ancillary equipment and an increase in the degree of occupancy of surrounding areas. Certain basic principles must be observed when determining the shielding requirements for a room used routinely for diagnostic radiology, including fluoroscopy and special procedures. These are as follows: The radiation levels in controlled areas that are occupied routinely by radiation workers only, must be such that no radiation worker is occupationally exposed to more than 20 mSv per year, The radiation levels in uncontrolled areas must be such that no person can receive more than 1 mSv per year. In general, radiation levels in the immediate vicinity of x-ray equipment are such that the above limits would be exceeded even at very low workloads. Reduction in radiation intensity can be accomplished by a suitable combination of distance from the sources of radiation and physical shielding barriers, provided that radiation workers or the general public are restricted from all areas in which the respective maximum permissible dose could be exceeded. The shielding required to reduce radiation levels to within the acceptable limits may be computed on the basis of distance, maximum tube potential (kilovoltage), workload (W), use factor (U) and occupancy factor (T) . To ensure that the radiation levels are always below acceptable limits the maximum possible workload should be used in the calculations. Also, due consideration should be given to possible future increases in use and occupancy factors and x-ray tube potential. Other areas where x-ray equipment is used less frequently, such as operating theatres, recovery rooms, emergency wards, etc., may require special consideration. However, the same basic principals of distance, time, and shielding still apply in determining the protection needs. (Minister of Public Works and .(Government Services Canada 2000

:The problem of study .1.2

Due to the cost and lack of the shielding materials , it is important to search for avialable, cheap and effective materials in order to use as shielding material in the diagnostic x-ray departments to decrease the radiation hazard and protect the . workors

:Objectives 1-3

:General obgective 1-3-1

The main objective of this study is to study type Shielding Materials used in the diagnostic x-ray departments in khartoum state and evaluate this Shielding .Materials, according to the international standards

:Specific objectives .1.3.2

- To find out the effectiveness of shielding material used in the diagnostic x-ray .departments in khartoum state
- To compare the shielding materials used in the diagnostic x-ray departments in .khartoum state with the international parameters or standards

:Over view of the study 1.4

This thesis consist of five chapters, Chapter one which is an introduction , objectives of the study, Chapter two Literature review and theoretical background, Chapter three materials and methods , Chapter four results and Chapter five .discussions, conclusion , recommendations, references

Chapter Two

Literature Review

:X-ray room Design .2.1

X- ray rooms must be large enough for the equipment must have sufficient space for patient transport (wheel chair, gurney or trolley, etc.) and for staff to transfer patient to x-ray examination table (if inpatient facility), should have at least one patient change cubicle accessible from outside the room, and must locate the operator’s console where the primary beam will never be directed towards it, but (where the patient can be easily observed. (Holm , 2000

:Design Principles .2.1.1

For a safe radiation environment, there are certain principles and considerations separation of different functional areas helps control access Public areas (waiting, change etc.), Staff areas (offices, meeting rooms etc) and Work areas (radiation rooms, dark rooms, labs.) Control of public access to work areas, work areas will normally be controlled areas, therefore public can only access when being examined or treated. Flow of staff to, from, and within work areas - separate from public areas. Consideration of spaces adjacent to radiation areas, including above and below, Storage space required (always need more than anticipated!!) Lab, teaching, and meeting areas, Film processing and storage, location relative to radiation areas ,chemical storage and disposal ,ventilation (glutaraldehyde fumes) , (silver recovery and bulk film storage . (Holm , 2000

: Location .2 .2.1

The x-ray room can be located anywhere within your clinic. Ideally, the x-ray room would be located on an outside corner that has two outside walls. This will reduce the costs of lead lining. It is preferable that you have one door and no windows. If there are windows, location and dimensions will be critical for placement of tube and/or bucky stands. Windows will need shades to reduce light to enable you to see the collimator light field for patient positioning. (Holm , .(2000

:Size .3 .2.1

To minimize the size of the room required and maximize efficiency in your x-ray department, it is recommended that a compact system be utilized. A minimum space of eleven-feet-long by eight-feet-wide (11x8) is suggested for the x-ray unit, but size specifications of your unit will dictate the ultimate size of the room .(required. We can place certain systems in a much smaller room. (Holm , 200

:Power supply and standard frequency .2.1.4

When choosing your site, check for adequate power before purchasing property or signing a lease. You may be able to negotiate the cost of bringing proper power to the building if it is not already in place. (H.E Johns and J.R. Cunningham, 4th ed.) The walls, floors, ceilings and other material constructions of the x-ray room shall have a protective value such that the radiation transmitted through them will not lead to exposures of persons to levels in excess of the requirements for non-radiation personnel and members of the public . In recognition that it should not be assumed that proximity to an x-ray facility is going to be the only source of radiation exposure to a member of the public, the levels of radiation in areas of public access outside x-ray rooms should not lead to doses in The workers position at the x-ray controls shall be so shielded and located that the radiation levels there are ALARA principle, social and economic considerations being taken into account, and in any case these levels shall not lead to exposures of persons to levels in excess of the requirements for radiation personnel access of 0.3 mSv to any member of the public in any one year. (Minister of Public Works and .(Government Services Canada 2000

: Standard barriers .2.1.5

:Primary x-ray barriers 2.1.5.1

All primary barriers in standard diagnostic x-ray facilities shall have a lead equivalence of 2.0 mm with an allowable tolerance of ± 10%. The primary barrier shall extend at least 300 mm beyond each boundary of the area normally exposed to the primary x-ray beam. The lead equivalence stated shall be applicable for all the kilovoltages applied to the x-ray tube or tubes in the x-ray room. The shielding shall be uniform throughout the barrier and be effective over all openings and penetrations in the barrier. (NRL C5, January 1994).

2.1.5.2 Secondary x-ray barriers:

All secondary barriers in standard diagnostic x-ray facilities shall have a lead equivalence of 1.0 mm with an allowable tolerance of ± 10%.The lead equivalence stated shall be applicable for all the kilovoltages applied to the x-ray tube or tubes in the x-ray room. The shielding shall be uniform throughout the barrier and be effective over all openings and penetrations in the barrier. (NRL C5, January 1994)

2.1.5.2 Interactive room layouts:

In certain cases you may not be familiar with the imaging equipment your institution plans to install. Our 3D interactive room layouts (IRL) let you see the equipment as it looks in a standard room layout. (http://www.thomasnet.com/articles/custom-manufacturing-fabricating/radiation-shielding-materials).

2.2. Shielding Materials for X-ray Departments:

Shielding is placed around x-ray units and x-ray rooms to maintain exposures of workers and members of the public below prescribed limits and at levels as low as reasonable achievable (ALARA) within these limits. Since x-ray beams have a spectrum of energies, the usual shielding calculations with photon attenuation coefficients and buildup factors do not produce accurate results since these are based on monoenergetic photons. Instead, measurements of the reduction in transmission of x-rays generated at different values of kVp have been performed, and the data have been developed into empirical relationships be- tween exposure,

kV_p, and barrier thickness. (http://www.thomasnet.com/articles/custom-manufacturing-fabricating/radiation-shielding-materials).

X-ray equipment must be installed in adequately shielded rooms to ensure that public in the vicinity of the x-ray installations are not exposed to x-ray radiation. The adequacy of shielding depends on the material and thickness used for this purpose. Different materials can be used for shielding. However, brick or concrete are considered the best materials, as they are easily available, economical, and have good structural strength. While lead is a suitable shielding option for energies encountered in diagnostic x-rays, it is a weak structural material with tendency to lose uniformity and needs periodic radiation survey to ensure its continued adequacy. Also, Lead poses a serious environmental hazard and the use of it is being discouraged the world over. Recently, many new materials are being used/developed as potential shielding materials, as an alternate to Lead.

2.2.1. Purpose of Shielding:

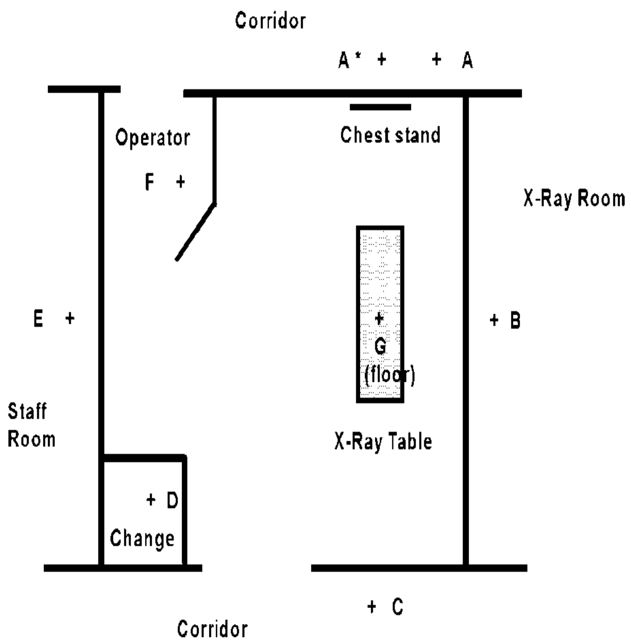
To protect the patients ,the x- Ray department staff ,visitors and the public and persons working adjacent to or near the X Ray facility.

2.2.2. Shielding Design:

Data required include consideration of Type of X Ray equipment, usage workload , Positioning whether multiple tubes/receptors are being used Primary beam access, operator location ,Occupancy of Surrounding areas. The type of equipment is very important for the following reasons, where the X- Ray beam will be directed ,the number and type of procedures performed,the location of the radiographer (operator) , the energy (kV_p) of the x- Rays. Usage different x- Ray equipment have very different usage. e.g , a dental unit uses low mAs and low (~70) kVp, and takes relatively few x- Rays each week. A CT scanner uses high (~130) kVp, high mAs , and takes many scans each week. Positioning; The location and orientation of the X- Ray unit is very important: distances measured from the equipment (inverse square law will affect dose), the directions of the primary X Ray beam . will be used depend on the position and orientation

:Fig(1) shows typical Room Layout

.A to G are points used to calculate shielding



.(https://rpop.iaea.org/RPOP/RPoP/.../RPDIR-L12_Shielding_WEB.ppt)

:Standard x-ray room shielding .2.2.3

All x-ray rooms should have affixed wall at a position close to the x-ray controls, a permanent dated notice stating the nature and lead equivalence of any shielding materials in or on the walls or constructions, including the protective barrier at the controls and its window. x-ray room shall be deemed to comply with the :requirements ,if the shielding complies with the following

All walls, ceilings, floors and barriers internal to the x-ray room shall satisfy the requirements for a secondary barrier, and any wall, ceiling or floor or part of these to which the primary x-ray beam is usually directed shall satisfy the requirements for a primary barrier. When a wall or other construction is common between two adjoining x-ray rooms : It shall meet the requirements of a secondary barrier, Such areas of the wall as are required to be primary barriers in either room shall be so shielded in each room. A secondary barrier shall be constructed at the controls of every x-ray machine to protect the workers . Means shall be provided for viewing the patient from the x-ray machine controls. Any viewing window in this barrier shall be of the same lead equivalence as the barrier. (NRL C5 , January 1994).

2.2.4. Barrier materials :

2.2.4.1. Primary barriers :

An acceptable primary barrier may be one of the following:

Lead sheet of nominal total thickness 2 mm. The lead sheet may be used as such, sandwiched between two layers of plywood ("Plymax"), or bonded to decorative laminate boar. Double thickness of barium plasterboard (plasterboard incorporating barytes) . Each thickness shall have a lead equivalence of 1 mm ± 0.1 mm at 100 kVp, Concrete, solid concrete block or concrete block filled with grout or sand, and having a total thickness of not less than 150 mm, double thickness of standard solid building bricks, having a total thickness of not less than 150 mm, any other building material whose thickness used in the construction leads to a lead equivalence of 2 mm ± 0.2 mm. (NRL C5 , January 1994).

2.4.2. Secondary barriers:

An acceptable secondary barrier for general diagnostic radiology may be one of the following: Any primary barrier, Lead sheet of thickness not less than 1 mm , barium plasterboard of 1 mm lead equivalence, any building material, such as brick or concrete whose use in construction leads to a thickness having a lead equivalence of 1 mm ± 0.1 mm, Lead glass or lead acrylic of 1 mm lead equivalence, Plain glass of 1 mm lead equivalence (typically a thickness of at least 100 mm of glass) . Materials which offer a limited absorption of x-rays and are not to be regarded as shielding materials, except possibly for mammography facilities, include plaster boards based on calcium compounds, "gibraltar" board and similar boards based on calcium compounds and pumice, hardboards, decorative wallboards, laminated plastics boards, fibre-reinforced cement boards, timber linings. A qualified health physicist shall be consulted to establish the acceptability or not of non-standard building materials.For new or altered x-ray facilities, the licensee shall send to the National Radiation Laboratory a statement of the position and degree of shielding actually installed, and a copy of the qualified health .(physicist's report where this was done. (NRL C5 , January 1994

:Specification Shielding Materials in X-ray Departments .2.3

:General Shielding Properties 2.3.1

Radiation shielding is based on the principle of attenuation, which is the ability to reduce the photon beams e.g x-ray , passing through a barrier material. (Nasiru .(Imam Zakariya, 2014

:X-ray Shielding .2.3.2

In most cases, high-density materials are more effective than low-density alternatives for blocking or reducing the intensity of radiation. However, low-density materials can compensate for the disparity with increased thickness, which is as significant as density in shielding applications. Lead is particularly well-suited for lessening the effect of gamma rays and x-rays due to its high atomic number. This number refers to the amount of protons within an atom, so a lead atom has a relatively high number of protons along with a corresponding number of electrons. These electrons block many of the gamma and x-ray particles that try to pass through a lead barrier and the degree of protection can be compounded with thicker shielding barriers. However, it is important to remember that there is still potential for some rays making it through the shielding, and that an absolute barrier may not be possible in many situations. To first approximation shielding reduces the intensity of radiation exponentially depending on the thickness. This means when added thicknesses are used, the shielding multiplies. For example, a practical shield in a fallout shelter is ten halving-thicknesses of packed dirt, which is 90 cm ((3 ft) of dirt. (F. Tessier, and H. Shen,2012

:Lead .2.3.2.1

High physical density - small space requirements

High atomic number - good shielding for low energy X Rays ,Relatively expensive ,Difficult to work with. . (http://www.thomasnet.com/articles/custom-manufacturing-fabricating/radiation-shielding-materials).

:Concrete 2.3.2.2

Cheap (when poured at the time of building construction) Self supporting - easy to use , Relatively thick barriers required for megavoltage radiation, Variations in density may occur - needs checking ,Other shielding materials, Walls, bricks, wood, any structure used for building ,High density concrete (density up to 4g/cm^3 as compared with around 2.3 for normal concrete) ,Composite materials, e.g., metal bits embedded in concrete (e.g. Ledite). (http://www.thomasnet.com/articles/custom-manufacturing-fabricating/radiation-shielding-materials).

:Shielding calculation in x-ray department .2.4

Based on NCRP Report No 147, Structural Shielding Design for Medical X-Ray Imaging Facilities (2004), Assumptions used are conservative, so over-shielding is common. Software is available, giving shielding in thickness of (various materials. (Douglas J. Simpki, 2007

:NCRP 147 .2.4.1

Provides methods to calculate the thickness of shielding needed to decrease the kerma in a shielded area to P/T,P = the weekly permitted kerma in the occupied area,T = the occupancy factor, the average fraction of time that the maximally exposed individual is present while the x-ray beam is on. NCRP 147 provides ,K^1, the average kerma expected for a patient procedure 1 m from the x-ray tube in the primary beam and, 1 m from the patient from secondary (scatter and leakage) radiation. Then, the unshielded weekly kerma, K_0 at : distance d for N patient procedures per week is

$$K_0 = \frac{K^1 N}{d^2}$$

$$B(x) = \frac{P/T}{K_0} = \frac{(P/T)\, d^2}{\left(K^1 N\right)}$$

Then the acceptable thickness, x, of a shielding barrier will be that which provides transmission, B, not in excess of

.(Douglas J. Simpki, 2007)

:Radiation Shielding Parameters .2.4.2

How can we calculate the required attenuation factor A (and therefore the barrier thickness B) by putting these parameters together_Equipment type ,Workload W, Target dose D, Use factor U, Distance d ,Occupancy of area to be shielded T and Limit value in area to be shielded P. (NCRP Report No. 49. July .(15, 1 99

:P - Design dose per week

Usually based on 5 mSv per year for occupationally exposed persons (25% of dose limit), and 1 mSv for public.occupational dose must only be used in controlled areas, i.e., for radiographers, radiologists, and other radiation workers. Film storage areas (darkrooms) need special consideration, Long periods of exposure will affect film, but much shorter periods (i.e., lower doses) will fog film in cassettes. A simple rule is to allow 0.1 mGy for the period the film is in storage - if this is 1 month, the design dose is 0.025 mGy/week. Remember we must shield against three sources of radiation. In decreasing importance, these are scattered radiation (from the patient) , .(primary radiation (the X Ray beam) leakage radiation (from the X Ray tube

(M Petrantonakt, C Kappas and G Panayiotakis, 1999)

U - Use factor

Fraction of time the primary beam is in a particular direction i.e.: the chosen calculation point,must allow for realistic use. For all points, sum may exceed 1. For some x- ray equipment, the x- ray beam is always stopped by the image receptor, thus the use factor is 0 in other directions, e.g., CT, fluoroscopy, mammography, For general radiographic and fluoroscopic equipment the primary beam is usually intercepted by the image detector, This reduces shielding requirements. For radiography, there will be certain directions where the x- ray beam will be pointed, towards the floor, across the patient, usually only in one direction , toward the chest Bucky stand ,The type of tube suspension will be important, e.g.: ceiling mounted, .floor mounted, C-arm etc

T - Occupancy

T = fraction of time a particular place is occupied by staff, patients or public, Has to be conservative. Ranges from 1 for adjacent offices and work areas , to 1/20 for public .toilets and 1/40 for outdoor areas with transient traffic

W - Workload

A measure of the radiation output in one week, Measured in mA-minutes, Varies greatly with assumed maximum kVp of X Ray unit. Usually a gross overestimation, Actual dose/mAs can be estimated,For example: a general radiography room The kV_p used will be in the range 60-120 kVp, The exposure for each film will be between 5 mAs and 100 mAs, There may be 50 patients per day, and the room may be used 7 days a week. Each patient may have between 1 and 5 films, Assume an average of 50 mAs per film, 3 films per patient ,Thus W = 50 mAs x 3 films x 50 patients x 7 days

mAs per week 52,500 =

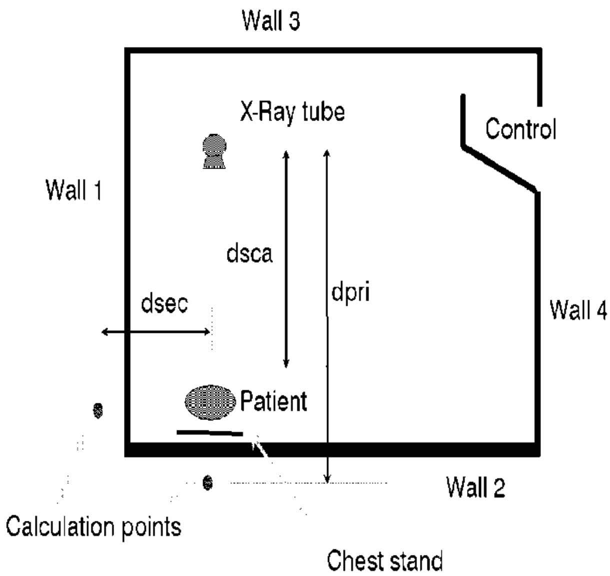
mA-min per week 875 =

We could also assume that all this work is performed at 100 kVp , Assume an average of 50 mAs per film, 3 films per patient. Thus W = 50 mAs x 3 films x 50 patients x 7 days

mAs per week 52,500 =

mA-min per week 875 =

.We could also assume that all this work is performed at 100 kVp



Radiation Shielding Parameters

.(Anna Benini17 April 2011)

All x- ray tubes have some radiation leakage - there is only 2-3 mm lead in the housing Leakage is limited in most countries to 1 mGy hr^{-1} at 1 meter, so this can be used as the actual leakage value for shielding calculations Leakage is specified at the maximum rated continuous tube current, which is about 3-5 mA .at 150 kV_p for most radiographic x- ray tubes

:Room Shielding - Multiple X -Ray Tubes .2.4.4

Some rooms will be fitted with more than one X Ray tube (maybe a ceiling-mounted tube, and a floor-mounted tube) Shielding calculations must consider the .(total radiation dose from the two tubes.(Dr Thure Holm, 2000

Calculate shielding thickness or exposure rates for x-ray radiation .2.4.5 :using the equations

The simplest method for determining the effectiveness of the shielding material is using the concepts of half-value layers (HVL) and tenth-value layers (TVL). One half-value layer is defined as the amount of shielding material required to intensity to one-half of the $HVL = \frac{\ln 2}{\mu} = \frac{0.693}{\mu}$ reduce the radiation .unshielded value

The symbol μ is known as the linear attenuation coefficient and is obtained from standard tables for various shielding materials. One tenth-value layer is defined as the amount of shielding material required to reduce the radiation intensity to one- .unshielded value tenth of the

$$TVL = \frac{\ln (10)}{\mu} = \frac{2.3026}{\mu}$$

Both of these concepts are dependent on the energy of the photon radiation and a .chart can be constructed to show the HVL and TVL values for photon energies

The basic calculation al approach to photon shielding is to determine the existing exposure rate, decide on the desired exposure rate after shielding and then calculate how many HVL or TVL will be needed. The basic equation for using the HVL :concept is

$$I = I_0\left(\frac{1}{2}\right)^n$$

:where

$$I = shielded\ exposure\ rate$$

$$I_o = unshielded\ exposure\ rate$$

$$n = no.of\ HVLs = \frac{shield\ thickness\ (cm)}{HVL\ thickness\ (cm)}$$

The basic equation for :using the TVL concept is

$$I = I_0\left(\frac{1}{10}\right)^n$$

:where

$$I = shielded\ exposure\ rate$$

$$I_o = unshielded\ exposure\ rate$$

$$n = no.of\ TVLs = \frac{shield\ thickness\ (cm)}{TVL\ thickness\ (cm)}$$

) http://m ywebcl .(asses.net/Michael/eht/Module11/1113.html

Material and Methods

:Materials .3.1

Different thickness materials Lead , Concrete. Lead Glass and different kv_p

:Methods .3.2

: Study duration .3.2.1

. This study performed in period between desumber 2014 to march 2015

:Study place .3.2.2

The study was carried out in Khartoum state , Khartoum teaching hospital , . Bashaier teaching hospital , Khartoum advanced diagnostic center–Khartoum

:Sampling .3.2.3

where samples of lead and concrete were taken then measuring the thickness in cm which can be taken to use as radiation shielding materials in the diagnostic x-.ray departments

:The method of data collection .3.2.4

After data collection the resulting measurements was intered to Rad pro calculator to find out the most effective values to use as radiation shielding materials in the .diagnostic x-ray departments

:The technique .3.2.4.1

The study using Rad Pro Calculator 3.0 soft ware to performs shielding calculations to measure dose rate at a different thicknesses and different kvps by known tube output in this program input different kvp and input different thicknesses for Lead, Lead glass and councert. Thus input the the distance from the source to the patient (100 cm) and distance from the source to unit control.(200 .(cm

صورة البرنامجRad Pro Calculator 3.0

:method of data analysis used in search .3.2.5

After testing and comparing of different types of shielding materials the data was analize by computer to find out the best type of shielding materials that used in the diagnostic x-ray departments. After collecting , the data sheets were symbolized, .classified and analyzed by the computer

:The study variables .3.3

Kv_p, Thickness of shielding materials

:Ethical issues .3.4

No part of this study relies on data which normaly be collected from routine .scaning. NO patients

Chapter Four

Results

:Results.4.1

Table 4-1: shows measuring dose rate for different thickness at different kv_p by using Rad Pro Calculator 3.0 for department A

: Department A

Thickness/cm	Material	
20	Lead	msv/h
0.2	Lead glass	msv/
11	Concrete	ms

Table 4-2: shows measuring dose rate for different thickness at differen

Thickness	Material
20	Lead

0.2	Lead glass
11	Concrete

Graph4.2: shows relationship between kv_p and measuring dose rate

Table 4-3:shows measuring dose rate for different thickness at different kv_p by using Rad Pro Calculator 3.0 for department C

:Department C

thick	Material	Concrete	lead glass	lead	Kv_P

n es s	
0. 2	Lead
0. 1 6	Lead glass
1 0	Concrete

0.0000001 msv/hr 3	msv/hr 0	msv/hr 0	40
0.0000047 msv/hr	msv/hr 0	msv/hr 0.0000011	70
0.000017 msv/hr	msv/hr 0	0.00000011 msv/hr	100
0.000038 msv/hr	msv/hr 0	msv/hr 0.0000025	150

Graph 4-3: shows relationship between kv_p and measuring dose rate

Table 4-4: IAEA- measuring dose rate for different thickness at different kv_p by ,using Rad Pro Calculator 3.0 for department A

:Department A

Thickness/cm	Material
20	Lead
0.2	Lead

concrete	lead glass	lead	Kv
4.999 msv/hr	5 msv/hr	msv/hr 5	40
4.999	5	msv/hr 5	70

	glass	msv/hr	msv/hr		
11	Concrete	4.999 msv/hr	5 msv/hr	msv/hr 5	100
		4.999 msv/hr	5 msv/hr	msv/hr 5	150

Graph 4-4: shows relationship between kv_p and measuring dose rate

Table 4-5 : IAEA- measuring dose rate for different thickness at different kv_p by . using Rad Pro Calculator 3.0 for department B

:Department B

Thickness/cm	Material	concrete	lead glass	lead	Kv
20	Lead	4.999 msv/hr	5 msv/hr	msv/hr 5	40
0.2	Lead glass	4.999 msv/hr	5 msv/hr	msv/hr 5	70
11	Concrete	4.999 msv/hr	5 msv/hr	msv/hr 5	100
		4.999 msv/hr	5 msv/hr	msv/hr 5	150

Graph 4-5: shows relationship between kv_p and measuring dose rate

Table 4-6: IAEA- measuring dose rate for different thickness at different kv_p by .using Rad Pro Calculator 3.0 for department C

:Department C

Thick ness/c	Material
0.2	Lead
0.16	Lead glass
10	Concret e

concrete	lead glass	lead	Kv
4.999 msv/hr	5 msv/hr	msv/hr 5	40
4.999 msv/hr	5 msv/hr	msv/hr 5	70
4.999 msv/hr	5 msv/hr	msv/hr 5	100
4.999 msv/hr	5 msv/hr	msv/hr 5	150

Graph 4-6: shows relationship between kv_p and measuring dose rate

Chapter Five

Discussion& Conclusion & Recommendations

:Discussion .5.1

The study done in three different departments of Diagnostic X-ray in Khartoum State, from December2014 to March 2015. The study using Rad Pro Calculator 3.0

soft ware to performs shielding calculations to measure dose rate at a different thicknesses and different kvps by known tube output in this program input different kvp and input different thicknesses for Lead, Lead glass and councert. Thus input the the distance from the source to the patient (100 cm) and distance from the source to unit control.(200 cm). The table one shows measuring dose rate for different thickness at different kv_p by using Rad Pro Calculator 3.0 for department A , graph One shows relationship between kv_p and measuring dose rate. Table two shows measuring dose rate for different thickness at different kv_p by using Rad Pro Calculator 3.0 for department B, graph two shows relationship between kv_p and measuring dose rate, Table three shows measuring dose rate for different thickness at different kv_p by using Rad Pro Calculator 3.0 for department C, graph three shows relationship between kv_p and measuring dose rate, Table four, five and six shows IAEA- measuring dose rate for different thickness at different kv_p by using Rad Pro Calculator 3.0 for department A, B and C, graph four, five and six show relationship between kv_p and measuring dose rate. The result analysis by using Excel program.. The study illustrated that the dose rate for the Lead shielding in Diagnostic X-ray Departments was 5msv/hr at 40kvp ,this dose rate the agrees with the IAEA is 5msv/hr , at 70 kvp 5msv/hr in department A and B, in department C was 4.999 msv/ hr is very a little bet agrees, at 100kvp 5msv/hr, this dose rate the agrees with the IAEA in three departments, ate 150 kvp this dose rate the agrees with the IAEA in three departments. The dose rate for Lead glass shielding in Diagnostic X-ray Departments was 5msv/hr, at 40 kvp at 70 kvp 5msv/hr, at 150 kvp5msv/hr, this dose rate the agrees with the IAEA in three departments. at 100 kvp4.999 msv/ hr is very a little bet agrees. The dose rate for concrete shielding in Diagnostic X-ray Departments was 4.999 msv/ hr at 40 kvp , at 70 kvp 4.999 msv/ hr , at 100 kvp 4.999 msv/ hr ,at 150 kvp 4.999 msv/ hr this .dose rate is very a little bet agrees.The study readings agrees with IAEA records

:Conclusion .5.2

The researcher studied lead, lead glass and concrete as shielding materials used as efficient materials for radiation protection in Diagnostic X-ray Departments Increasing the thickness of the shielding materials reduce radiation Comparing the three departments in the studied area. The design of shielding for an X -ray room is a relatively complex task, but can be simplified by the use of some .standard assumptions

Record keeping is essential to ensure traceability and constant improvement of .shielding according to both practice and equipment modification

:Recommendations .5-3

The study recommended that Shielding materials should be available to protect the patient , public and staff. Shielding should be used where appropriate and .practicable to limit the exposure of body tissues

It is particularly important that special effort to be made to protect the blood-forming organs, gonads and thyroids of children. shielding, where necessary, floors, walls, ceilings and doors on the basis of maximum expected x-ray tube potentials (kilo-voltages), workloads (output), use and occupancy factors; .providing a control booth for the protection of the worker

The control booth, and the viewing window in the booth, must have shielding properties such that no worker is occupationally exposed to more than 20 mSv per year. It is very important to keep records of shielding calculations, as well as .details of inspections and corrective action taken to fix faults in the shielding

Further studies should be done including other materials to be available as .effective shielding materials in the diagnostic x-ray departments

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Appendices

Fig 2-1-6: shows the interactive room layout

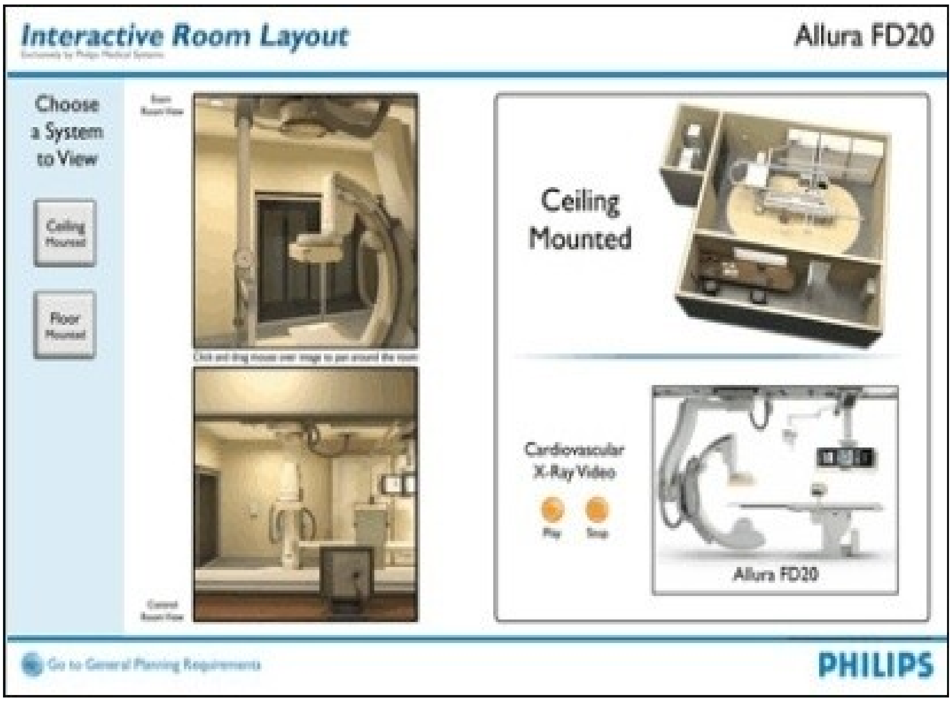
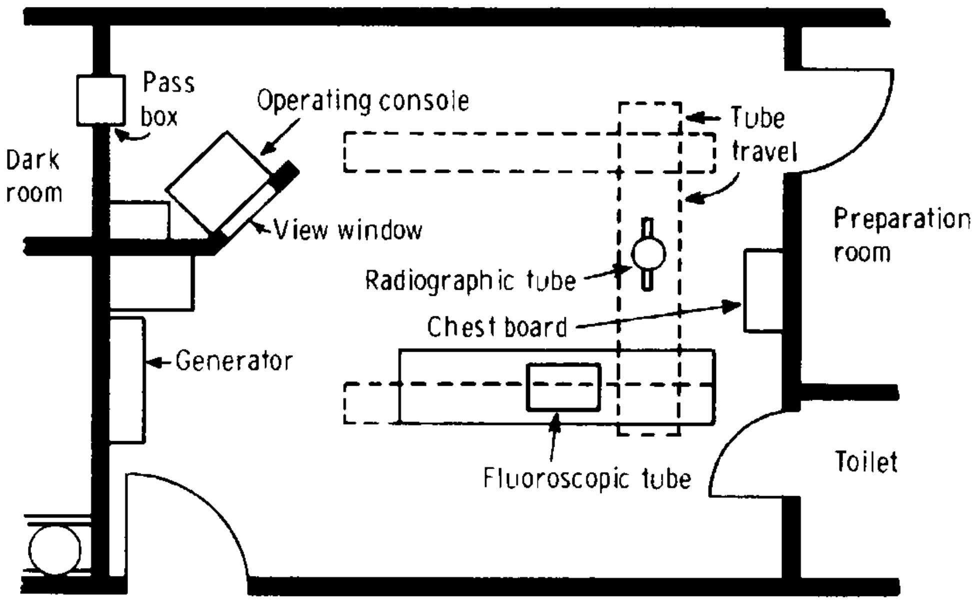


Fig. 2.1.6.2 Typical Room Design



Fluoroscopy Room Operator’s Area Fig.2.1.6.3

Table 2.3.2.1: **Half-Value Layers**

Halving ,Mass [g/cm²]	,Density [g/cm³]	Halving ,Thickness [inches]	Halving Thickness/the Half ,value layer [cm]	Material
12	11.3	0.4	1.0	Lead
20	7.86	0.99	2.5	Steel
20	3.33	2.4	6.1	Concrete
18	1.99	3.6	9.1	Packed soil
18	1.00	7.2	18	Water
16	0.56	11	29	Lumber or other wood
18	0.0012	6000	000 15	Air

Table 2.3.2.2

Table 2.3.2

Water (g/cm³ 1.0)	Concrete 2.4) (g/cm³	Iron 7.86) (g/cm³	Lead 11.35) (g/cm³	Photon Energy (keV)
			(HVL (cm	
7.2	3.3	1.0	0.38	500
9.8	4.5	1.5	0.86	1000
12.0	5.6	1.8	1.2	1500
14.0	6.4	2.1	1.3	2000
17.5	7.9	2.4	1.5	3000

Table 2.4.2

(Occupancy (NCRP 147

occupancy	area
1	work areas, offices , staff rooms
5\1	Corridors
20\1	Toilets , unattended waiting rooms
40\1	Outdoor areas with transient