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THE RELEVANCE OF RADIATION SHIELDING

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INTRODUCTION

Radiation is the transfer of thermal energy by electromagnetic waves. (Nolan, 1995). According to Him the electromagnetic waves in the visible portion of spectrum are called light waves. These light waves have wavelengths that vary from about 0.38×10^{-6} m for violent light to about 0.72×10^{-6}m for red light. Above visible red light there is an invisible, infared portion of electromagnetic spectrum. The wavelength range from 0.72×10^{-6}m to 1.5×10^{-6}m for near infrared, from 1.5×10^{-6} to 5.6×10^{-6} for middle infared, and from 5.6×10^{-6}m for up to 1×10^{-3}m for far infared. Most, but not all, of the radiation from a hot body falls in the infared region of electromagnetic spectrum. According to lea, Radiation is the emission of electromagnetic waves (light) with any frequency from low frequency radio to gamma rays. According to Jane's Radiation is the emission and propagation of energy. Generally, radiation can be defined as the transfer of thermal energy from one body to another by electromagnetic waves. Due to biological effect of radiation, these interaction are extremely complex. It is well known that excess exposure to radiation, including sunlight, x-rays and all nuclear radiations can destroy tissues. Exposure radiation could cause leukemia, chromosomal breakage, bone necrosis, bone cancer, mutation of genes, cataracts of the eye lens e.t.c. the main way of protecting the cell is to shield it from exposure to ionizing radiation and this lead us to what is called radiation safety.

RADIATION SAFETY

Radiation safety through conscientious work habits, protective measures, and adequate radiation shielding is important for hospitals and clinic. It is almost, always necessary to add a dense material such as lead sheet to the walls in large and busy hospital. Because of the large workload. However, in small hospital and clinic, where few x-ray examination are made each day: it is often the case that the common building materials such as adobe, brick or concrete will provide more that adequate shielding provided that the walls are of sufficient thickness.

RADIATION SHELDING

Alpha, beta, gamma, and x-rays can pass through mater, but can also be absorbed or scattered in varying degrees, depending on the material and on the type and energy of the radiation. Medical x-rays images are possible because bones absorb x-rays more than soft tissues. Strongly radioactive sources are often stored in lead boxes to shield the local environment from the radiation, on that note, Radiation shielding can defined as the act or science of protecting people and the environment from the harmful effect of ionizing radiation which include both particles radiation and high energy radiation. Ionizing radiation is widely used in industries and medicine but presents a significant health hazard. It also causes microscopic damage to living tissue, resulting in skin burns and some radiation sickness at high exposures and statistically elevated risk of cancer, tumors, and genetic damage at low exposures. Furthermore, radiation protection can be subdivided into occupational radiation protection which is the protection of workers. Medical radiation protection which is the protection of patients and the radiographer, and public radiation protection which is the protection of individual members of the public and of population as a whole. The types of exposures as well as government regulation and legal exposure limits are different for each of these group of radiation that has already been short listed above, so they can be considered separately in the case of this study Different types of ionizing radiation behave in different ways, so different shielding techniques are used, while in some cases , improper shielding can actually make the situation worse, when the radiation interacts with the shielding material and creates secondary relation that absorbs in the organism more readily.

PURPOSE OF THE STUDY

Following the first radiation fatality which occurred in 1904, just nine short years after x-rays first discovered by Wihelm roentgen. By 1910, there had been hundreds of cases of severe x-ray burns, some leading to death. It took the x-ray community more than 30 years from the time of roentgen's discovery to start practicing basic radiation protection (Bushong, 1991). Based on the fact mentioned above, this particular study will centre much on the effective ways in which radiation protection (radiation shielding) in particular can be done in order not to be harmful to both human being and its surrounding environment. Apart from that, the study also focuses on different types of radiation and the type of shielding material that can applied to achieve its best effectiveness in protection and as well as its importance. Furthermore, the researcher's intention is focused on how dangerous ionizing radiation ie medical radiation in particular can be to human being and also the ways in which the best form of radiation shielding as a form of protection can be obtained for the different types of radiations and as well its importance. For this reason, the researcher was able to discover the three cardinal principles of radiation protection which include: Reducing the time of radiation exposure, keeping as much distance between the source of radiation and person being exposed, and placing a shielding material between the person being exposed and the source of radiation. The cardinal principles of radiation shielding were first created for use in nuclear activities but they can reduce patient and technologist radiation dose when used properly in diagnostic radiology (bushing, 1993), proper x-ray beam collimation, and appropriate radiographic technique selection including kilo voltage power (k_v p) and milliamperage seconds (mAs) should also utilized to decrease radiation dose (Bushong, 1999).

In Summary, the Purpose of the Study Include:

1. To know how radiations can be shielded
2. To know the extent to which radiation shielding helps in protecting against radiation exposure.
3. To know how radiation is been protected on human.
4. To provide adequate protection for personnel of radiation installation.
5. To reduce high levels of exposure that can destroy the body's ability to repair itself from infections.
6. To know the effectiveness of radiation shielding in protecting against radiation exposure.

SCOPE OF THE STUDY

Radiation shielding is a form of protection technique, which helps to protect people and the environment from the harmful effect of radiation. But for the study our research will be on its importance, in which based on the data collected through my survey and some other materials from library and internet I was able to understand that, the effectiveness of a good shielding material can be achieved by increasing the thickness of the material ie when added thickness are used, the shielding multiplies. This is done in order to reduce the intensity of radiation and thereby reducing its harmful effect. A part from that, the effectiveness of shielding material can also achieved by increasing the distance between the shielding materials and source of radiation.

SIGNIFICANCE OF THE STUDY

Knowing that radiation shielding is all about protecting people and environment from harmful effect of ionizing radiation which includes skin burn, DNA mutuation, cancerous tumors and genetic damages. The importance of this study is aimed at providing the public with the information about radiation (medical radiation), how it affected human being and its surrounding environment, and the knowledge for safety measures i.e. how to shield or protect radiations in such a way that it cannot be harmful to both human being and its surrounding environment.

In summary, the significance of the study includes:

1. It has been shown that radiation shielding as a form of protection reduces the risk of over 20 types of cancer, respiratory diseases, skin burns, vomiting of the blood etc caused by the ionization from radiation.
2. Radiation is an important risk factor for non- melanomia skin cancer and cataracts.
3. Radiation protected biological has important effect on human health both beneficial and harmful.

ADVANTAGE OF RADIATION SHIELDING

1. It helps to protect people from radiation damages.
2. It provides adequate protection for personnel's in radiation installation.
3. It helps in reduction of background noise for detectors.
4. people can be protected from the acute and chronic effect of radiation
5. Mutation can be prevented.

DISADVANTAGES

Improper shielding can actually made the situation worse, when the radiation interacts with the shielding material and creates secondary radiation that absorbs in the organisms more readily.

LITERATURE REVIEW

TYPES OF RADIATION

There are three principal types of ionizing radiation; alpha, beta and gamma radiation. They are all emitted from the nucleus of an unstable atom.

ELECTROMAGNETIC SPECTRUM

Some Emitters	Transmitter	Infrared lamp	Flame	Quartz lamp	X-ray tube	Cobalt 60
Long wavelength	Radio wave	Infrared	Visible	Ultra-violet	X-rays	γ -rays
Order of wavelength	100m(long) & 1cm (short)	10^{-4}cm	10^{-5}cm	10^{-6}cm	10^{-8}cm	10^{-9}cm
Some detectors	Aerial	Photo-transistor	Eye	Luminious paint	Photographic plate	Geiger muller tube

ELECTROMAGNETIC WAVES:

An electromagnetic spectrum is composed of γ-rays, x-rays, ultraviolet radiations, light radio waves. The main interest is to know radiation emits by electromagnetic spectrum that can affect human being and its environment and as well its protection. Thermal radiation emitted by the agitation associated with the temperature of the matter is commonly known as heat and light. Our bodies may be poor detector of heat, but our human eyes are very sensitive detector of light. The wavelength of thermal radiation is from 0.2 to 100μm.

ALPHA PARTICLES

Alpha particles are positively charged particles. They are easily stopped by paper or skin, and only hazardous if alpha emitting materials are swallowed or breathed into the body. Most of alpha radiation is not able to penetrate human body.

BETA PARTICLES

Beta particles are electrons and have a greater penetrating power than alpha particles, but can be stopped by this layer of water, glass or metal. However, beta emitting material can be hazardous if taken into the body.

GAMMA AND X-RAY

There are electromagnetic radiation similar to light and radio wave but with shorter wave lengths. They are very penetrating and heavy shielding materials like lead and concrete are needed to stop them. Gamma radiation is easily deflected by survey meters with sodium iodine detects probe.

NEUTRONS

Neutrons are particles with no charge. They are neutral, and because of this, they can penetrate many materials very easily. They do not produce ionization directly but their interaction with atoms can give rise to alpha, beta, gamma or x-rays which produce ionization. Neutron can only be stopped by thick masses of concrete, water or paraffin.

NON-PENETRATING (NON IONIZING) RADIATION

Non penetrating radiation doesn’t pass through your skin. A large dose of no penetrating acclimation may burn your skin similar to the way severe sunburn dose..

RADIATION EXPOSURE

The radiation exposures covered by the basic safety standard (BSS) encompass the exposure, both normal and potential of:

- Workers pursuing their occupations (occupational exposure);
- Patients in diagnosis or treatment (medical exposures);
- Members of the public.

The radiation exposures are therefore divided into three categories.

i. Occupational exposure, which is defined as all exposures of workers incurred in the course of their work (with the exception of exposures excluded from the BSS and exposures from practice or sources excepted by the BSS).

ii. Medical exposure, which is defined as exposure incurred:

- By patients as part of their own medical or dental diagnosis or treatment;
- By persons, other than those occupationally exposed, knowingly while voluntarily helping in the support and comfort of patients;
- By volunteers in a programmed of biomedical research involving their exposure, which is defined as exposure incurred by members of the public from radiation sources, excluding any occupational or medical exposure and the normal local natural background radiation but including exposure to authorized sources and practice and from intervention situations.

ABSORBED DOSE

The absorbed dose D is defined as the quotient of $d\bar{\Sigma}$ by dm, where $d\bar{\Sigma}$ is the mean energy imparted to matter of mass dm:

$$D = \frac{d\bar{\Sigma}}{dm}$$

The S.i unit for D is 1j/kg and its name is the grey (Gy). The older unit of dose is the rad, representing 100 erg/g (i.e. 1Gy = 100 rad)

RADIATION PROTECTION QUANTITIES

The absorbed dose D is the basic physical dosimetry quality, but it is not entirely satisfactory for radiation protection purposes because the effectiveness in damaging human tissue differs for different types of ionizing radiation. In addition to the absorbed dose, other dose related quantities have been introduced to account not only for the physical effects but also for the biological effects of radiation upon tissue. These quantities are organ dose, equivalent dose, effective dose, committed dose and collective dose.

ORGAN OF DOSE

The organ dose is defined as the mean D_T in a specified tissue or organ T of human body, given by:

$$D_T = \frac{1}{M_T}\int_{M_V} D\,dm = \frac{\Sigma_T}{M_T}$$

Where;

$M_T =$ mass of the organ or tissue under consideration

$\Sigma_{T=}$ total energy imparted by radiation to that tissue or organ.

EQUIVALENT DOSE

The equivalent dose H_T is defined as:

$H_{T=} W_R D_{T,R}$

Where;

$D_{T,}$ R is the absorbed delivered by radiation type R averaged over a tissue or organ T.

W_R is the radiation weighting factor for radiation type R.

For x-rays, **γ**-rays and electron W_R=1; and for proton W_R=5; for particles W_R = 20; and for neutrons W_R ranges from 5 to 20, depending on the neutron energy. The S.i unit of equivalent dose is j/kg and its name is the sievert (S_V); the old unit is the rem and the relationship between the two units is 1 S_v =100 rem.

EFFECTIVE DOSE

The effective dose E is defined as the summation of tissue equivalent doses, each multiplied by the appropriate tissue weighting factor w_T, to indicate the combination of different doses to several different tissues in a way that it correlates well with all stochastic effects combined.

Mathematically

$E = \Sigma W_T H_T$

Where

W_T= weighting factor

H_T= equivalent dose

COMMITTEE DOSE

When radionuclide are taken into the body, the resulting dose is received throughout the period of time during which they remain in the body. The total dose delivered during this period of time is referred to as the committed dose and is calculated as a specified time integral of the rate of receipt of the dose.

COLLECTIVE DOSE

The collective dose relates to exposed group or population and is defined as the summation of the products of the mean dose in the various groups of exposed people and the number of individual in each group. The unit of the collective is the man-Sievert (Man-S_V).

RADIATION EFFECTS

It is known that x-ray radiation is harmful, the effects of ionizing radiation can either be classified as stochastic (random) or deterministic (non-random). Through radiation shielding, deterministic effects may be reduced. Radiation dose from diagnostic procedures is controlled by government agencies because of the risks associated with stochastic effects. (Koehler, and Natarajan, 2007). All modern radiation shielding guidelines are based upon the linear dose response model without a threshold. This model states that as radiation dose increases, radiation risk also increases and there is no threshold. Because stochastic effects have no identified threshold, even small dose may cause biological harm. Hereditary effects, cancer, and leukemia some examples of stochastic effects. (Seeram, 1999).

RADIATION ABSORBED DOSE

Radiation absorbed dose (RAD) is the unit of absorbed energy or dose. This unit is applicable to any type of material; however some types of radiation such as alpha and beta particles produced more biological change than x- radiation or gamma dose. In order to account for the same radiation absorbed dose causing different biological effects, the rad equivalent man (REM) was developed. The REM is the product of the quality factory assigned to a given type of radiation and the absorbed dose in RADS. The quality factor for x- radiation is one; therefore IRAD of x- radiation equals IREM of x- radiation (ROSSI, 1992).

MAXIMUM PERMISSIBLE DOSE

Maximum permissible dose was a term used in the past to describe the maximum dose of radiation that was felt to be safe for an individual to receive. The term maximum permissible dose is no longer used today because no dose is considered permissible. The principle of keeping each individual's dose as low as reasonably achievable (ALARA) is used and the National council on Radiation protection (NCRP) recommends radiation dose equivalent limits. Prior to 1987; the formular is 5 (N-18) rem, when N equals the age of the radiation worker (absorber) in years, was used to formulate the maximum life time whole body dose equivalent in 1987, the NCRP established new recommendations for maximum whole body dose equivalent. The new formular of IREM x age in years, reduces the amount of radiation a worker may receiver over their life time. Jefferies, (1994) studies show that as the recommended maximum has been decreased, radiologic technologists exposure has decreased as well. Technologists in the 1980s received as much as 35 times less radiation exposure than technologists that worked prior to 1939 (simon etal, 2004).

RADIATION SICKNESS

Radiation sickness is illness that occurs from exposure to a large amount of radiation. The exposure may be in series of dose overtime (chronic) or in a single large dose (acute). Exposure to large doses of radiation can cause severe illness, and in some cases death. The larger the dose, the greater your risk of cancer, and other adverse health effects, including cataracts and mental retardation in children whose mothers were exposed during pregnancy (NAS, 1990). Causes of radiation exposure may be accidental or intentional. Intentional sources of radiation exposure could occur if terrorists blew up a nuclear power plant, set off a nuclear bomb or detonated a so called dirty bomb (Emanuel, 2008). Routine cases of exposure to artificial.

Radiation: Living near a nuclear power plant undergoing medical tests, such as x-ray to cause any damage (Darby etal 1987). Treatment for radiation sickness is designed to relieve the signs and symptoms.

SIGNS AND SYMPTOMS

The signs and symptoms of radiation sickness may include: Nausea and vomiting, diarrhea, skin burn (radio dermatitis), weakness, fatigue, loss of appetite, fainting, dehydration, inflammation (swelling, redness or tenderness) of tissues, bleeding from your nose, mouth, gums or low red blood cell count (anemia), Hair loss (Ron et al 1989). The signs and symptoms of radiation sickness and their severity depend on how much radiation you receive and which tissue are exposed. The way in which you receive radiation by breathing in radioactive material, by ingesting it with food or water, or by being exposed to intense beams of radiation. Also has an effects on the signs and symptoms of radiation sickness.

RADIATION PROTECTION

The ionizing radiation used in diagnostic radiography is potentially harmful but if proper protects measures are taken the risk is small compare with the benefit to the patient. It is essential to ensure that the radiation dose received by the patient is the minimum require to provide the necessary diagnostic information.

BASIC CONCEPT OF RADIATION PROTECTION

The three cardinal principles of radiation protection include: Reducing the time of radiation exposure, keeping as much distance between the source of radiation and the person being exposed, and placing a shielding material between the person being exposed and the source of radiation. The cardinal principles of radiation protection were first created for use in nuclear activities, but they can reduce patient and technologist radiation dose when used properly in diagnostic radiology (Bushong, 1993), proper x-ray beam collimation, and appropriate radiographic technique selection including kilovoltage power (K V_P) and milliamperage seconds (M A_S) should also be utilized to decrease radiation dose (Bushong, 1991). The new trend in radiography today is computed radiography (CR). CR system have gradually replaced most conventional film screen systems (FS), in many parts of the world. CR systems have post processing advantages over FS by being able to correct under exposed or overexposed images without having to repeat the examination. Most CR systems have the ability to correct an over exposed images processing algorithms before the image is even displace. Because of this, the patient may be overexposed without the technologist ever knowing about it. In most CR equipment, there are numerical systems to allow the technologist to know if the patient was over exposed (Brindhaban & Khalifah, 2005). It has been said that some technologists routinely over expose patients because the images look very crisp and clear, and they do not get rejected by the interpreting radiologist. This philosophy of imaging goes against ALARA principles (Gregoire, 2006), and against American Resitry of Radiologic Technologists (ARRT) standard of ethics. ARRT code of ethics number seven states, "the radiologic technologists uses equipment and accessories, employ techniques procedures, performs services in accordance with an accepted standard of practice and demonstrate expertise in minimizing radiation exposure to the patient, self, and other number of the health care team "(ARRT, 2006). Recent studies have shown that most x-ray exposure using CR may be reduced by as much as 50%. Also, there is a need for quality control processes that cannot only track technologist repeat rates, but can also pinpoint technologist that are consistently overexposing patients with CR equipment (Gregoire, 2006). Apart from new trend in computed radiography today reviewed above, time, distance and shielding are the three basic concepts apply to all types of ionizing radiation when we develop regulations or standard that limits how much radiation a person can receive in a particular situation, we consider how these concept might affect a person.

TIME

The amount of radiation exposure increases and decreases with time people spend near the source of radiation. In general, we think of the exposure time as how long a person is near radioactive material. Its easy to understand how to minimize the time external (direct) exposure. Gamma, and X-rays are primary concern for external exposure. However, if radioactive material gets inside your body, you can’t move away from it, you have to wait until it decays or until your body can eliminate it. When this happens, the biological half-life of the radionuclide controls the time of exposure. Biological half life is the amount of time it takes the body to eliminate one half of the radionuclide initially present. Alpha and beta particles are the main concern for internal exposure.

HOW DOES EPA USE THE CONCEPT OF TIME IN RADIATION PROTECTION

When we set a radiation standard that assumes an exposure over a certain period, we are applying the concept of time. For example, we often express exposures interms of a committed does. A committed does the one that accounts for continuing exposures over long periods of time (such as 30, 50, or 70, years). It refers to the exposure received from radioactive material that enters and remains in the body for many years. When we assess, the potential for exposure in a situation, we consider the amount of time a person is likely to spend in the area of contamination. For example, in assessing the potential exposure from radon in a home, we estimate how much time people are likely to spend in the basement.

DISTANCE

The farther away people are from a radiation source, the less their exposure. How close to a source of radiation can you be without getting a high exposure? It depends on the energy of the radiation and the size (or activity) of the source. Distance is a prime concern when dealing with gamma rays, because they can travel long distances. Alpha and beta particles don’t have enough energy to travel very far. As a rule, if you double the distance, you reduce the exposure by a factor of four. Havling the distance, increase, the exposure by a factor of four.

WHY DOES EXPOSURE CHANGE MORE RAPIDLY THAN THE DISTANCE

The area of circle depends on the distance from the centre to the edge of the circle (Radius). It is proportional to the square of the radius. As a result, if the radius doubles, the area increases four times let us think of radiation source as a bare light bulb. The bulb gives off light equally on every direction, in a circle. The energy from the light is distributed evenly over the whole area of the circle. When the radius doubles, the radiation is spread out over four times as much area, so the close is only one four as much. In addition, as the distance from the source increases so does the likely hood that some gamma rays will lose their energy. Let us take for instance, the exposure of an individual sitting 4 feet’s from a radiation source will be one of ¼, the exposure of an individual sitting 2 feets from the same source.

HOW DOSE EPA USE THE CONCEPT OF DISTANCE IN RADIATION PROTECTION

In this case, we also consider in anlaysing the potential exposures from a source. If a person is at a contaminated site, or working around radioactive material, we asses how the exposures vary if the person is closer to, or further away from the source of radiation.

MAXIMIZE DISTANCE TO MINIMIZE DOSE

Many radiation sources are "point sources" (the radiation appears to emits from one spot some distance away). The radiation dose from these sources can be significantly reduced by applying the protective measure of "distance" as demonstrated in figure 1.2. The dose a person receives from an external radiation source is inversely proportional to the square of the distance from the source ($1/d^2$). Therefore, if the dose rate at one foot is 100 millrem/hour, the dose rate at 10 feet would be $1/10^2$ of that, or 1 millirem/hour. Some ways to increase the distance on a job are:

- using extension tools
- utilizing remote operating stations and
- staying away from hot spots.

  In summary, staying as far as possible from a source of radiation will minimize the effect of radiation, because the activity will disperse and become less concentrated (in most case) as it moves away from the point of release.

SHIELDING

The greater the shielding around a radiation source, the smaller the exposure.Sheilding simply means having something that will absorb radiation between you and the source of the radiation. But using another person to absorb the radiation doesn't count as shielding. The amount of shielding required to protect against different kinds of radiation depends on how much energy they have.

ALPHA

A thin piece of light material, such as paper or even the dead cells in the out layer of human skin provides adequate shielding because alpha particles can't penetrate it. However, living tissue inside body, offers no protection against inhaled or injested alpha emitters.

BETA

Addition covering for example heavy clothing, is necessary to protect against beta emitters. Some beta particles can penetrate and burn the skin.

GAMMA

Thick, dense shielding such as lead is necessary to protect against gamma rays. The higher the energy of the gamma ray, the thicker the energy of the gamma ray, the thicker the lead must be. X-rays pose a challenge, so, x-ray technicians often give patients receiving medical or dental x- rays a lead apron to cover other parts of their body.

HOW DOES EPA USE THE CONCEPTS OF SHIELDING IN RADIATION PROTECTION

This concept is applied, when we take into account the type of shielding that might be provided by the soil when we access sites that have been contaminated or used for disposal of radioactive materials. We also account for the shielding provided by buildings for a person working or living at a site that has been cleaned up.

MAXIMIZE SHIELDING TO MINIMIZE DOSE.
Shielding is one of the most effective means of reducing radiation exposure. The example in figure 1.3 shows that the installation of one half-value layer(half-thickness) of shielding will reduce the dose rate by a facto of two at a set distance from the source of radiation. By locating the shielding as close as possible to the source, dose rates can be reduced in a large area, and this reduces the dose to many workers (some of which, perhaps, could not reduce their exposure time or work further from the source).

TYPES OF SHIELDING
The two major types of shielding at the plans are installed and temporary shielding.

INSTALLED SHIELDING
Installed shielding is permanent shielding installed at the plant for the purpose of reducing the radiation levels in some areas. An example of permanent shielding is the concrete shield walls located in the containment.

TEMPORARY SHIELDING
Temporary shielding is the type of shielding that can be placed near the source to reduce the radiation levels in large areas. It can also be shaped as needed to provide the maximum shielding effectiveness. It can take the form of lead sheets, lead bricks, or bags filled with lead shoot. See figure 1.4.

RELATIVE EFFECTIVENESS OF VARIOUS SHIELDING MATERIALS
Materials differ in their ability to shield (absorb) radiation. Lets take for instance the relative effectiveness of four common shield materials (lead, iron, concrete and water) for gamma radiation. To have the same gamma radiation exposure level at the outside of each material, it takes about twice as much iron as lead, about twice as much concrete as iron, and about three times as much water as concrete. A thumb rule that can be used is that it takes 2 inches of lead to reduce the dose by a factor of 10. Therefore, if a radiation detector measured the dose rate at a certain distance to be 100 millirems/hour, 2 inches of lead would reduce the dose rate to 10 millirems/hour. This value is called a tenth-value thickness of lead. To accomplish the same reduction using the other materials would require 4 inches of iron/steel, 8 inches of concrete, or 24 inches of water. These values are only thumb rules. The exact amount of materials required depends upon the energy of the radiation (gamma ray) that is been shield against.

RECOMMENDED SHIELDING FOR RADIO NUCLIDES

Types of radiation	Permanent	Temporary
Beta radiation	Aluminum, plastic	Aluminum, plastic, wood, rubber, cloth
Gamma, x-rays, and positions	Lead, iron, lead glass, heavy aggregate concrete, ordinary concrete and water.	Lead, iron, lead glass, concrete block, water lead equivalent fabrics such as gloves(for diagnostic x-ray machines only)

SOME RADIATION SHIELD MATERIALS AND THEIR AREA OF APPLICATION

The list below among others are some examples of radiation shielding materials and various area of application.

1. Lead bricks for ballast and radiation shielding.
2. Lead foil: radiation shielding for doors, frames and walls
3. Lead brankets: Lead wool blankets for the nuclear industry, used monthly for radiation shielding.
4. Lead wall: Lead brick radiation shielding for l-block shield in PET application.
5. Stainless steel lead container: ideal for storing radioactive lab. Wastes. Shielding is 1/8 or ¼ in thick lead.
6. Poly 15 gallons drum: ideal for beta or gamma waste storage available with 1/8 lead, ¼ lead, and without lead.
7. Lead pigs: Lead pigs of various thicknesses, ideal for storing radioactive isotopes.
8. Sharps shields containers: shield with lead for disposal of used syringes that contains low level energy gamma radiation.
9. Beta/Gamma flip-top bins shielded acrylic bins for the safe ejection of pipette tips/tubes with minimal hand exposure to the radioactive contents.
10. Rolling shields: shielding used for radiation therapy procedures.
11. Lead glass: radiation shielding used in x-ray rooms.
12. Gamma waste storage boxes: Boxes provide excellent sample visibility while offering protection against gamma emitters.
13. Rad guard lead underwear: Shield by stands for radiation emitted from Brach therapy patients.
14. Lead line gloves: This reduces radiation 10-30% of alternation at 60kev to 125kev.
15. Benchtop shields Gamma: Vertical angle shields ranging from 0.5 to 1.5 mm pb equivalent.
16. Lead Acrylic clear acrylic shield used for gamma and x-rays radiation.
17. Water tanks: Radiation shield fabricated with aluminum plate.
18. Lead glass: Used to shield eyes from radiation, prescription and non-prescription are available.
19. Mobile shields: For shielding personnel from x-ray radiation.
20. Lead aprons: For x-ray technicians and patients.
21. Lead vinye soft radiation shielding for gamma and x-ray radiation.
22. Borated polyethylene in assorted thickness of 4*8 sheets for neutron radiation shielding.

WORKLOAD DISTRIBUTION IN A SMALL HOSPITAL OR CLINIC

The workload in a typical large hospital's radiographic room may be 500 to 600 millampere minutes per week. In a typical small hospital the workload may be one-tenth of that of the large hospital. The estimated workload distribution in a small hospital, arranged according to the x-ray beam is shown in table 1.2. The kv setting have been divided into only the four (minimum) values of 55, 70,90 and 120kv. Because of the small total number of examination per week, it was not practical to consider more kv settings. The category of 55kv covers all lower kv examinations in the range of 45-55kv. The few examination at 80kv (mainly for contrast studies) will fall into the 70kv or 90kv categories.

Any refinement in the results of the calculation achieved by dividing into more kv categories would be insignificant. Because the workload distribution for a WHIS-RAD is unique (the kv settings are limited) and well-defined; the distribution shown in table 1.2 is considered to provide a more realistic result than would be obtained by using average workload obtained from a nationwide survey. The fixed source-to-image distance of 140cm of the WHIS-RAD requires lower mA_S values for chest examinations(at the high kv setting) and high mA_S values for table examinations(at the lower kv settings) than in the average hospital. This situation leads to less shielding being needed for radiation barriers related to a room with a WHIS-RAD because the radiation shielding properties of a barriert are highly dependents on the kv being used.

THE WHIS-RAD X-RAY ROOM

The minimum size of x-ray examination room recommended is 16 m^2 Gerald, p.4. (2011) the operator's control area, dark room, or computed radiology (CR), or digital radiology (DR) equipment area, and the office are additional. An example drawing of a 16m^2 X-ray room showing the equipment layout is shown in figure 1.6

SHIELONG CALCULATION EXAMPLE FOR A NEW SMALL X-RAY FACILITY NOT ATTACHED TO AN EXISTING HOSPITAL OR STRUCTURE AS SHOWN IN FIGURE1.6

In reference the figure 1.6 Only the floor and area behind wall number I are exposed to the primary X-ray beam. The facility is on the ground level and there is no occupied space beneath it. The areas behind all the other walls are exposed only to secondary radiation. As stated in NCRP report number 147 (section 42.4), calculation of shielding for installations with variable table locations and orientations (for example primary radiation from the cross table examinations, scattered and leakage radiation from over table examinations and scattered radiation from chest examinations) is a surprisingly difficult, and number some, problem. To handle the calculations efficiently the calculation program, XRAY BARR, which was created by Douglas J. Simpkin has been used ratter than the equations and graph of NCRP NO 147. In these calculations using X RAY BARR program, the WHISRAD workload was considered as emanating from 3 different "component" X-ray tables.

Table Number 1: Horizontal X-ray beam for examinations at 12okv and 90 kv (chest and abdomen); At the fixed distance of 140cm, the film size will usually be 35.5cm X43cm (Area 2 1526cm^2),

Table Number 2: Horizontal X-ray beam for examinations at 70 kv (abdomen and skeleton); At the fixed distance of 140cm, the film size will usually be 24x30 cm or 18x43cm. (Area 2 720-774cm^2).

Table Number 3: Vertical x-ray beam for examinations at 90, 70, and 55kv (skeleton, abdomen, chest and extremities). At the fixed distance of 140 cm, the film size could be any of those available up to 35.5x43cm. (Area n 1526cm^2) details of the expected workload distribution are shown in table 1.2

Area behind wall number 1 (see figure 1.6 reference point number 1). All the radiation output with the beam in the horizontal position is directed at wall number 1. this is from standing erect examinations of the chest and from cross-table lateral examinations of the abdomen, chest, and skeleton. The total workload in the horizontal position is 27.75mA- min per week. Of this, 3.75 mA-min is at 90 kv (Table Number 1) and 24mA min at 70 kv (table number 2). The area behind wall number 1 is not occupied and it is most likely that access to this area will be restricted. However, it is assumed (to be conservative for the calculation) that a grounds keeper might infrequently be in the area i.e the occupancy factor (T) is for an uncontrolled area = 0.02m Gy per week. The distance to the person to be protected is approximately 3.6 meters (depending on the thickness of the intervening wall).

Area Behind wall number 2 (see figure 1.6 reference point number 2).
This wall is never exposed to the primary x-ray beam. It is only exposed to secondary radiation. The area behind wall number 2 is not occupied and it is most likely that access to this area will be restricted. However, it is assumed (to be conservative for the calculation) that a groundkeeper might infrequently be in the area, i.e the occupancy factor (T) = 1/40. The shielding design goal (P) is for an uncontrolled area = 0.02mGy per week. The distance to the person to be protected is approximately 1.9 m.

Area Behind wall number 3 (see figure 1.6 reference points numbers 3 and 4).
This wall is never exposed to the primary X-ray beam. It is only exposed to secondary radiation. The area behind wall number 3 might be occupied for short periods of time by patients or by staff in-transit. It is not expected that work areas for either staff of the x-ray facility or other hospital departments will be located here. Shielding calculations were made using occupancy factors (T) of 1/20 and 1/8 and the shielding design goal (p) for an uncontrolled area of 0.02 mGy per week. However it is emphasized these are for compansion purposes, only, and that it is very unlikely that the same person would be in this space for either 2 or 5 hours per week for an entire year. The distance to the person to be protected is approximately 2.9 meters for scattered radiation and 1.8m for leakage radiation.

Area behind wall number 4-at the operator's console (see figure 1.6 reference point number 5A).
This wall is never exposed to the primary x-ray beam. It is a controlled area. The occupancy factor (T) is 1 and the shielding design goal (p) is 0.1 mGy per week. The distance to the person to be protected (operator) is approximately 2.4m for both scattered radiation and for leakage.

Area behind wall number 4 at the darkroom technician's area (see figure 1.6 reference point number 5B)
This wall is never exposed to the primary x-ray beam. It is a controlled area. The occupancy factor (T) is 1 and the shielding design goal (p) is 0.1 mGy per week. Relevant factors such as distance from the x-ray tube (leakage), scattering source (patient) field size, and scattering angle are the same as for the operator's console area and the shielding requirement will be the same.

Area behind wall number 4-at the operator's console area for protection against forging of film in loaded cassettes (see figure 1.6 reference points numbers 6 and 7)
A design limit of 5 microgray (5 μGy) during the entire time of storage, which is assumed to be one day, is used. The required amount of shielding is calculated for two assumed distance of the loaded cassettes from the secondary radiation sources: 2.4 meters and 4.0 meters.

Wall number 4-in the darkroom area for protection against fogging of unexposed film (see figure 1.6 reference points numbers 8 and 9)
A design limit of 0.1 mGy during the entire time of storage, which is assumed to be one month, is used. The required amount of shielding is calculated for two alternate positions of the dry-bench, and consequently, two assumed distances of the unexposed film from the secondary radiation sources: 2.4 meters and 4.0 meters.

Results and Analysis of the Shielding Calculations
The results and analysis of the shielding calculation are shown in Table 1.3. For the protection of humans, in either controlled or uncontrolled areas, no additional shielding beyond that provided in the back of the WHIS-RAD cassette holder (0.8mm lead) or in the walls, if they are made of locally available materials equivalent to about 4cm of concrete (of density 2.2 g.cm^3), is needed at any clinically feasible workload, i.e Up to 30,000 examination per year (G.P. HANSON; 2011). For the protection of unexposed film in the darkroom, at a distance of 2.4 meters from the secondary radiation sources, (leakage and scatter sources assumed to be at the same distance) a wall of about 4cm of concrete is sufficient up to a workload of 18,000 examinations per year. If the distance is increased to 4 meters, the 4cm concrete wall would be sufficient for any chronically feasible workload. The protection of film in loaded cassettes that are stored in the operator's console area requires the most shielding. At the lowest expected workload of 3,000 examinations per year, 0.47mm of lead would be required if the distance from the secondary radiation sources were 2.4 meters. If the distance were increased to 4.0 meters; then 0.26mm of lead would be required. Compagnon, G. (2006) British Journal of Radiology. If a storage bin with 0.5mm of lead shielding was provided (constructed) at a distance of 4.0 meters from the secondary sources, as shown in figure 1; the workload could reach about 9,000 examinations per year (or about 36 per day) without excessive exposure to the loaded cassettes. If 1.0 mm of lead were used, the workload could reach about 60,000 examination per year or about 240 examinations per day. The storage bin type of solution for unexposed film in cassettes or unexposed CR cassettes is highly recommended, along with strong and clear administrative/departmental rules for the x-ray operator.

EFFECTS OF LACK OF RADIATION SHIELDING ON THE LIVES/INHABITANTS OF THE AREA WHERE NUCLEAR WASTE HAVE BEEN DUMPED IN NIGEIA

1. Lack of radiation shielding on the area where nuclear wastes have been dumped will cause potential exposures of human to high-level radioactive waste which can be dangerous, even deadly.

2. Some radioactive wastes such as certain type of transonic waste can cause biological effects E.g gene mutation in human which as a result of directly inhaled or ingested of radionuclide contained in the waste.
3. Lack of radiation shielding on the live of the areas where nuclear wastes have been dumped leads to dramatically increase in cancer rate, birth defects and sterility to the occupants of the area.

MATERIAL AND METHODS

In this research work (importance of radiation shielding practice). The method used is survey method in which based on the method, Dose rate meter 6150AD was used to measure radiation dose rate emanating from xr200 X-ray source when radiation shielding material (lead) of different thickness (mm) is placed between the source of radiation at distance apart. The dose rate 6150 AD is a digital radiation meter which incorporates the working principle of the Geiger muller tube for radiation detection and measurement. The Geiger muller tube generates a purlse of electrical current each time radiation passes through the tube and causes ionization. The dose rate meter counts ionizing events and display the results on the liquid crystal display (LCD). The dose rate meter was held one meter before the shielding material. The XR200 is a portable, pulsed x-ray source. X-rays are produced by bombarding a tungsten anode with electrons. Each pulse lasts 60 nanoseconds, with a peak voltage output of 150kv. It can be set for 1-99 pulses. It is recommended to fire the unit no more than 200 pulses every four minutes, up to the maximum duty cycle of 3000 pulses per hour. Use beyond the duty cycle will damage unit. Eight reading (S) was taken for lead shielding material of different thickness. The reading was taken when the distance between the source and the shielding materials is placed at 8cm apart from the most sensitive place on the monitor, so that there is room to place all 14 millimeters of lead, between the source and the monitor. Based on their observations a sketch of a qualitative graph of radiation dosage (rem) Vrs the number of layers of shielding is shown in figure 1.1 while table 1.1 gives the summary of the results. Dosage in rem while thickness is in millimeters. From the eight reading taken, first reading or count was taken when there is no shielding material place between the source of radiation and the measuring device while the other ones was taken when led shielding material of different thickness which is ranging from 2, 4, 6, 8, 10, 12, 14 millimeters was used as a shielding material between the source and the Dose rate meter 6150 AD. Apart from that, material is also from library and internet which is related to the course of this study.

RESULTS

Eight measurements was recorded for the lead of different thickness, placed at a distance between the source and the Dose rate meter 6150AD. Table 1.1 gives the summary of the results.

Distance (CM)	Thickness (mm)	Dosage (rems)
1.00	0.00	600.00
2.00	2.00	300.00
3.00	4.00	150.00
4.00	6.00	75.00
5.00	8.00	37.00

6.00	10.00	18.00
7.00	12.00	9.00
8.00	14.00	4.60

TABLE 1.1 SUMMARY OFF THE RESULT

Anaterny examined adults and children	**Generating potential (kv)**	**Number of exams per week**	**Percent of exams**	**MAs per radiography (average)**	**Number of projections per exams (average)**	**Total mAs per exams (average)**	**Partial Weekly workload x use factor MA. Min**
X –ray beam in horizontal direction							
Abdomen and skeleton	70	6	10	160	1.5	240	24.00
abdomen	90	1	2	125	1	125	2.10
chest c	90	3	5	3.0	1	3	0.15
Chest	120	18	30	5.0	1	5	1.15
X-ray beam in vertical direction							
Extremity	55	17	28	2.5	2	5	1.5
Abdomen, chest and skeleton	70	12	20	80	1	80	1.6
Skeleton	90	3	5	125	1.5	188	9.4
Totals		60	100				54.65

TABLE 1.2 EXPECTED DISTRIBUTION OF RADIOGARPHIC EXAMINATION IN A SMALL HOSPITAL OR CLINIC PERFORMING APPRIOXIMATELY 3,000 EXAMINATIONS PER YEAR OR ABOUT 60 PER WEEK.

A	**B**	**C**	**D**	**E**	**F**
No	Item	Threshold Work	Workload where	Workload	Comments
		Load, at which, need some shielding it not zero	Shielded 15 0.5mm lead, or equivalent	Where shielding needed 15 1.0mm lead, or equivalent	Not 1: T = occupancy factor and p = Design dose in millisievert (m S_v) per week.
1	Wall No 1 (primary Beam), if T = 1/40 T = 0.025; p = 0.02	WL x 1 0.132mm lead 1.4cm concrete	WL x 10 0.499mm lead 4.48cm concrete	WL x 70 1.01mm lead 8.7cm concrete	Note2:WL X 1 = 3000 exams per year
2	Wall No 2, if T = 1/40 ie T= 0.025; p = 0.2	WL x 10 0.028mm lead 0.35cm concrete	WL x 250 0.490mm lead 4.1cm concrete	Note relevant (already at WL x 250)	Note 3: The clinical capacity of a single WHIS-RAD unit is about 6,000 general radiographic exams per year,

					ie WL x 2; assuming 300 work days per year
3	Wall No 3 and Door, 4 T = 1/8 and p = 0.02	WL x 2 0.10mm lead 1cm concrete	WL x 20 0.530mm lead 4.3cm concrete	WL x 70 1.04mm lead 7.6cm concrete	Note 4: An occupancy factor of 1/40 means that for 1 hour per week every week of the year, the same member of the public is occupying the area while the x-ray table is activated.
4	Wall No 4, operator and also any Darkroom Helper. T = 1.0 and p = 0.1	WL x 2 0.028mm lead 0.35cm concrete	WL x 50 0.491mm lead 4.1cm concrete	WL x 250 0.972mm lead 7.3cm concrete	
5	Wall No 4, film in operator's area in loaded cassettes at 2.4m distance from secondary source	WL x 1 0.259mm lead 2.5cm concrete	WL x 3 0.488mm lead 4.1cm concrete	WL x 20 1.06mm lead 8.0cm concrete	Note 5: Regarding the primary x-ray beam (item); because the cassette includes 0.8mm lead, no additional shielding has to be provided by wall I until more than WL x 10 is exceeded. This greatly exceeds the chemical capacity of the room
6	Wall No 4, film in darkroom unused bosccs at 2.4m distance from secondary source.	WL x 1 0.12mm lead 1.3cm concrete	WL x 6 0.493mm lead 4.1cm concrete	WL x 40 1.06mm lead 7.9cm concrete	

TABLE 1.3 RESULTS AND ANALYSIS OF THE SHIELDING CALCULATIONS

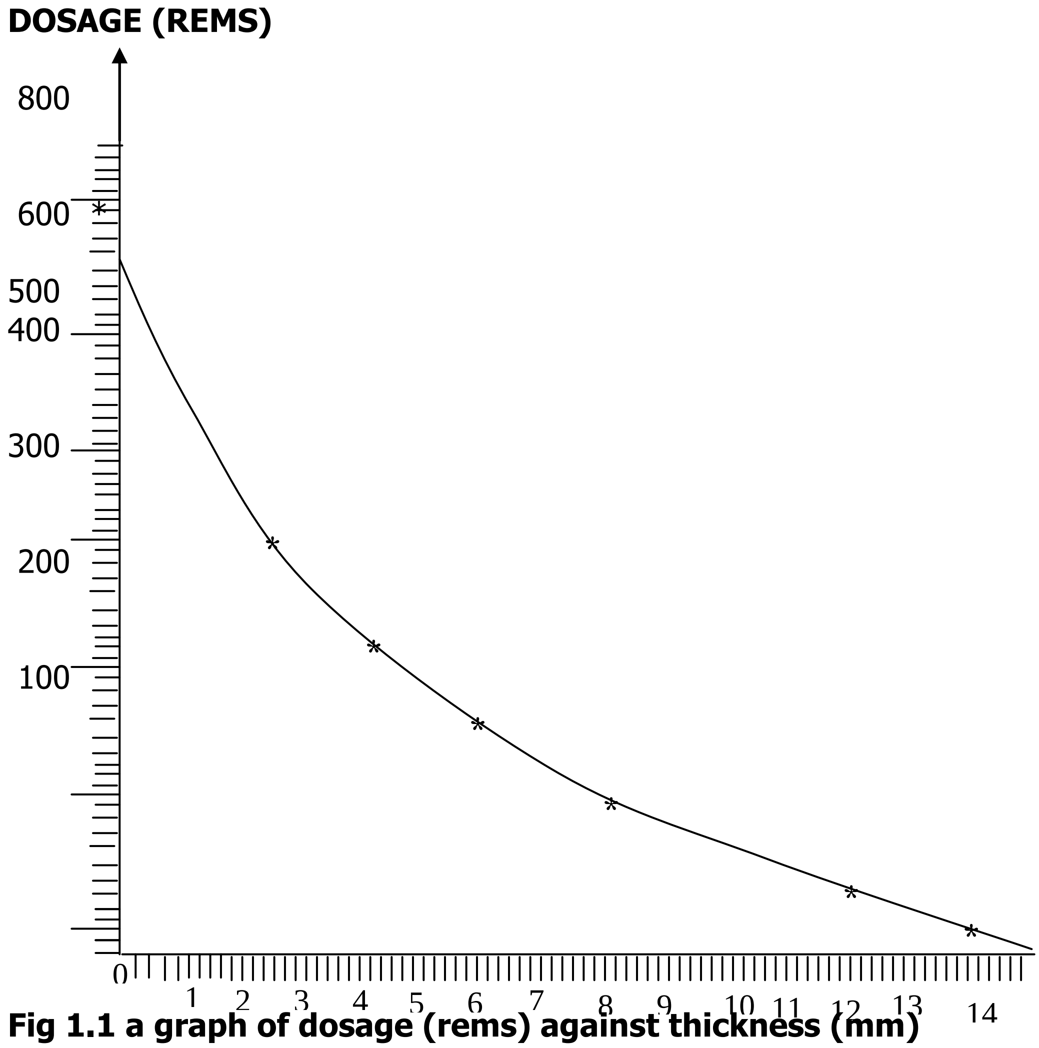


Fig 1.1 a graph of dosage (rems) against thickness (mm)

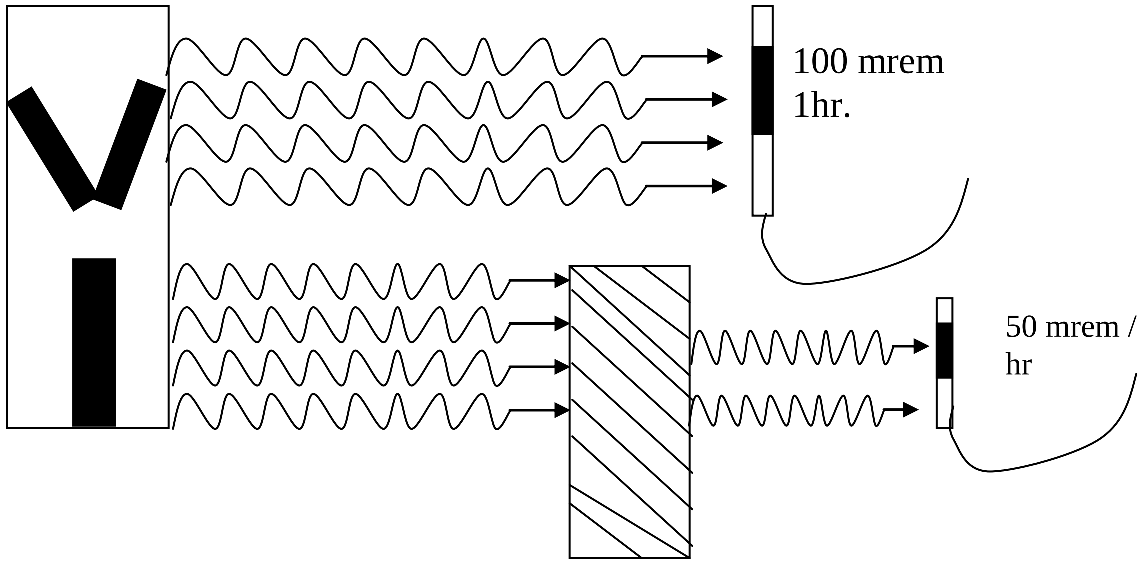


Fig 1.2 maximize Distance to minimize Dose

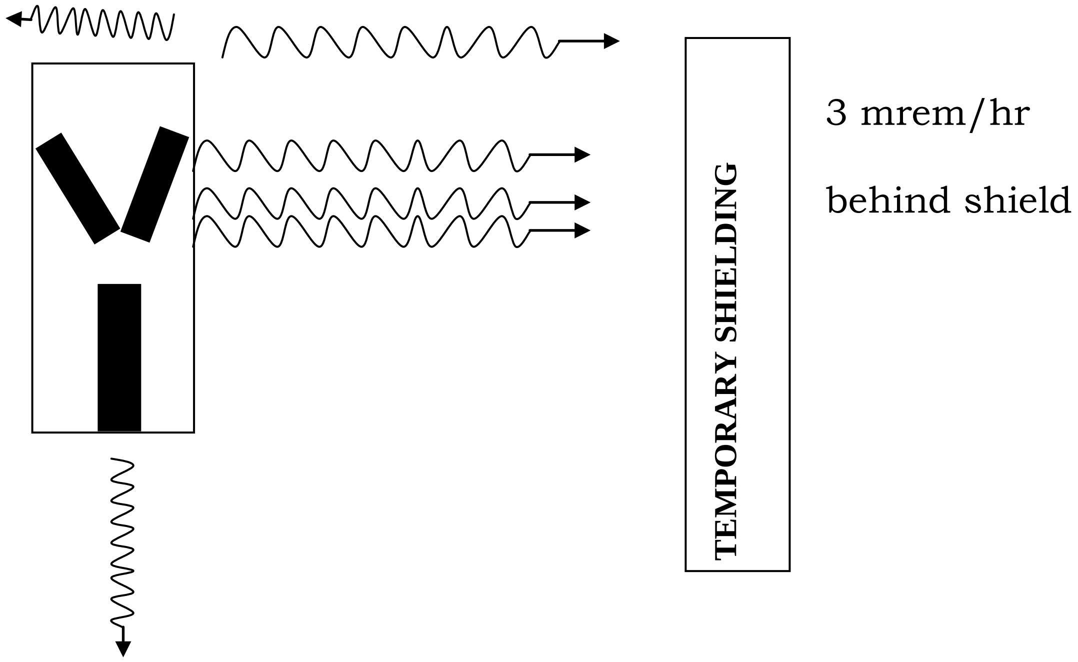
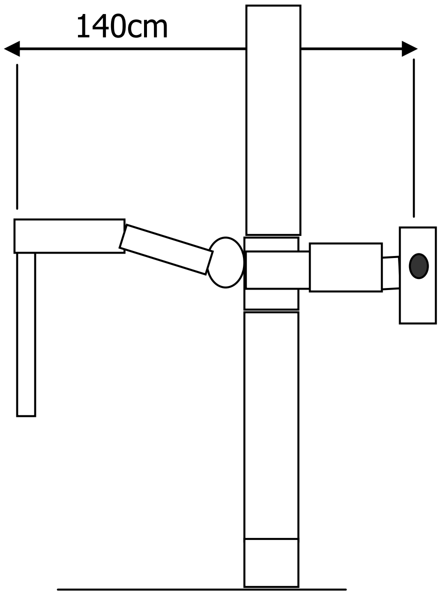
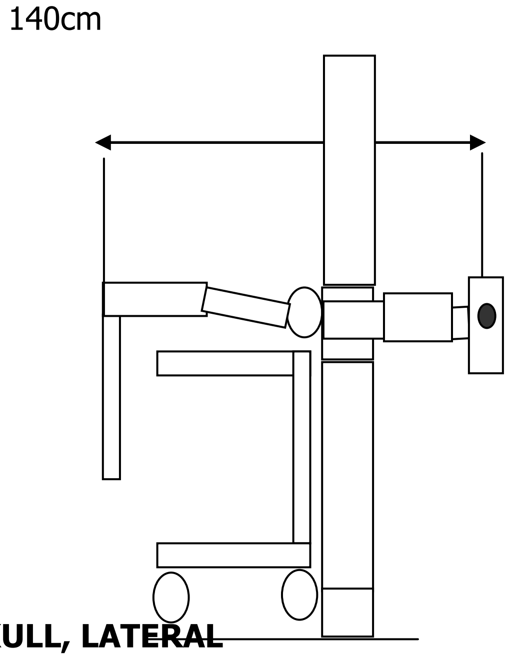


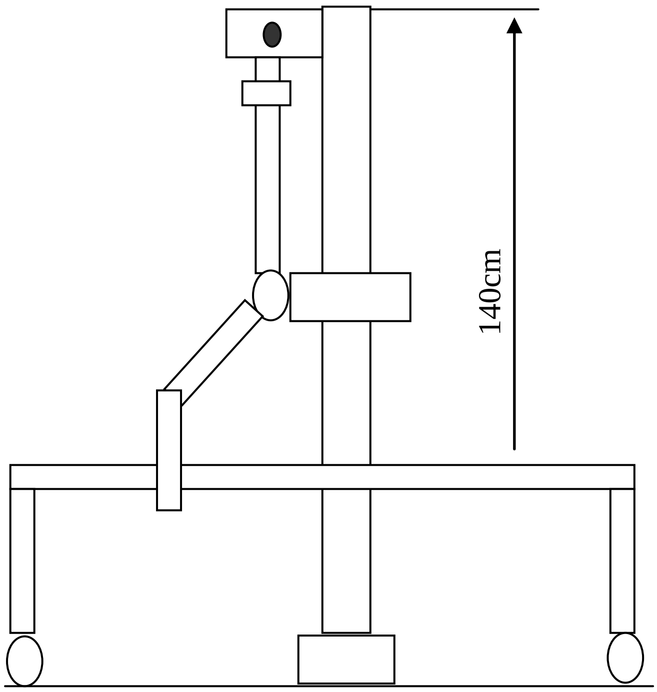
Fig 1.4 temporary shielding

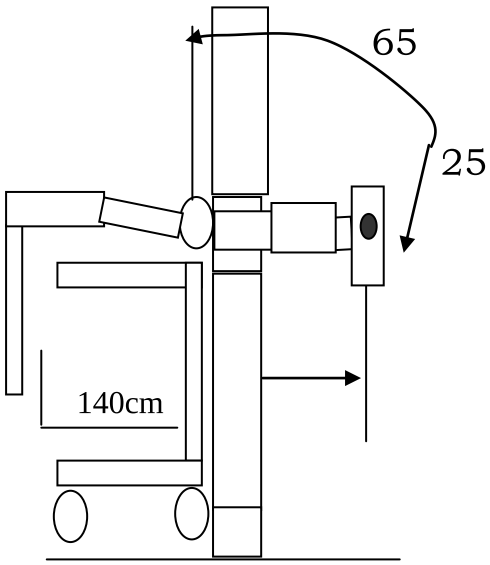




CHEST, STANDING ERECT

SKULL, LATERAL

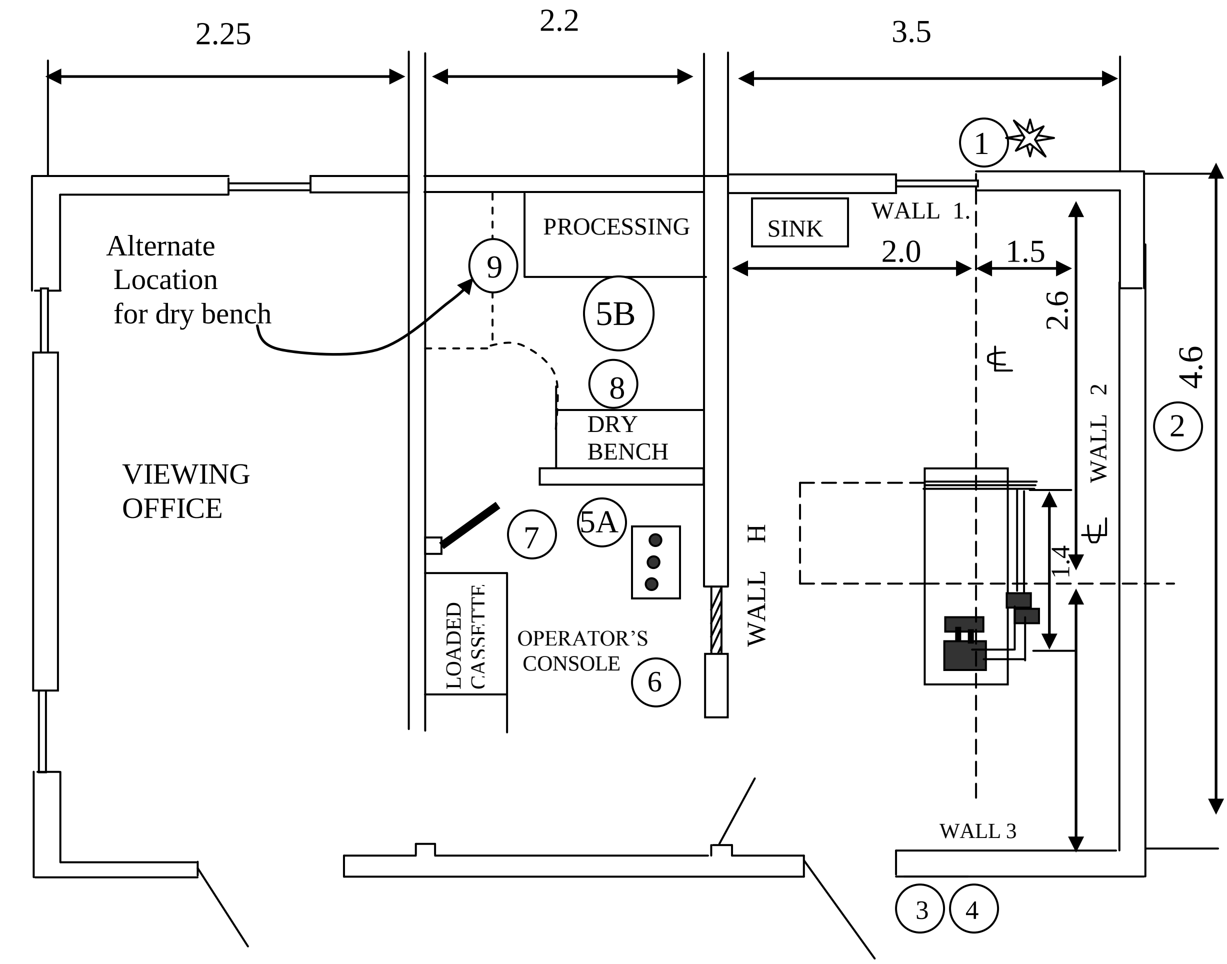




HIP JOINT, LATERAL

ABDOMEN, SUPINE

FIG 1.5 ILLUSTRATION OF VARIOUS POSITIONS OF THE WHIS-RAD X-RAY TUBE. G.P. HANSON; MARCH 2011



SCALE 1:50 0 1 2 3 4 5 **METERS**

- Number refer to items listed in accompanying shielding calculation resume; table 1.3

Fig 1.6 EXAMPLE SMALL (16 SQUARE METERS) X-RAY EXAM ROOM WITH WHIS-RAD G.P. HANSON; MARCH 2011

CONCLUSION, SUGGESTIONS AND RECOMMENDATION

The analysis of the data collected in the course of this research work, has revealed that shielding reduces the amount of radiation that is been exposed to human being from the data obtained in table 1.1, we can see that, when there is no shielding material place between the source of radiation, the amount of radiation that is emanating from x-ray as it was read by the dose rate meter 6150AD is very high (600 rems) which is high enough to the extent that it can kill the person that absorbed it immediately. But, when shielding material is placed between it, the dosage reduces by factor of two and continuously till it is 4.60 rem which is within the maximum permissible limits. Apart form that we should also increase the distance between the source of radiation as we know that radiation dose from a source can be significantly reduced by applying the protective measure of distance as demonstrated in fig 1.2 the dose a person receives from an external radiation source is inversely proportional to the square of the distance. From the source (1/d2). As well we should also reduce the time of exposure. This research work suggested that no level of radiation exposure is free of some associated risk. However, the total dose (sum of internal and external dose) should be minimized, since the overall risk is proportional to the total dose. In some cases, this may mean accepting a small intake of radioactive material to reduce the external dose. Thus, principle of radiation safety is to keep the level of exposure as low as reasonably achievable, (ALARA) which can be achieve by applying all the rules and regulations that govern radiotherapy (Basic principle of radiation protection). Note that the limits for whole body is 5 rems/years and maximum exposed organ is (50 rems/years) apply to total dose.

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